Final Report

for
APEC Low Carbon Model Town Project (LCMT) Phase 2
Feasibility Study for Samui Island, Thailand

submitted to

Asia-Pacific Economic Cooperation

Asia-Pacific Economic Cooperation (APEC)
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EEC ENGINEERING NETWORK

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LCMT SAMUI ISLAND
APEC LOW CARBON MODEL TOWN PROJECT

AAPEC LCMT Project Phase 2: EWG 18/2011A

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1. APEC Low Carbon Model Town Project

1.1 APEC Low Carbon Model Town Project Background

The main purposes of LCMT Initiatives are to plan, develop and implement the concrete roadmap in order to lower the carbon emission from the selected town while the natural resources are effectively utilized and the economic growth still remains.

Low Carbon Model Town Initiatives were set out by APEC after the 9th APEC Energy Ministers Meeting (EMM9). The LCMT perspective is meant to be an effective model implemented to quantify how effective the local community performs and how much effect to the environment in terms of carbon emission as a main goal and targets in accordance with other indicators. LCMT initiatives will pave a way for long term sustainable development paralleling with the increase in economic values.

Following the Phase 1 conducted at Yujiapu CBD in China, the extensive concept of LCMT will be deployed in APEC Economies. For LCMT Phase 2, SAMUI Island low carbon town development project in Surat Thani province, Thailand was selected, and confirmed at the EWG 42 Meeting in Kaohsiung, Chinese Taipei.

The characteristic of Yujiapu CBD (phase1) is different from SAMUI Island (Phase 2). The construction in Yujiapu has just started in recent years, but there is being planned as a Financial CBD (3.6 km^2, population of about 500,000 persons) in future. SAMUI Island is already developed resort island (228 km^2, residents 60,000 persons and Visitors 1,000,000 persons per year). APEC LCMT Project has the purpose of realization LCMT at various location areas in APEC economy.

1.2 SAMUI Low Carbon Town Definition and Adaptation

The key objectives of the "Feasibility Study" for SAMUI LCMT Phase 2 are understood to be

1.2.1 To develop the Low-Carbon Guideline for categories of low carbon town design challenges, which is intended to be a guide to the principles and implementation of low carbon town design in APEC Economies

1.2.2 To provide central and local Thai government officials as well as developer of the SAMUI Island low carbon town project with valuable advice on how to design an attractive and innovative low carbon development plan

1.2.3 To assist in the implementation of the concepts in selected Low Carbon Model Town development project by providing feasibility study and policy review of this development project

1.2.4 To provide specific selection of mitigation measures in each category of low carbon design challenges

1.2.5 To facilitate the promotion of low carbon development concept throughout APEC Economies

Some activities related to carbon emissions from SAMUI Island can be considered as the major causes for carbon emissions and existing relevant problems in SAMUI Island.

Carbon emission on SAMUI Island comes from various sources such as energy use (for commercial and residential buildings), industries, transportations and waste disposal. This contribution of carbon emission is not well measured, but can be observed that the proportion of carbon emission is from commercial building for accommodating tourists and transportation for traveling both inland and sea. Adaptation of "The Concept of the Low-Carbon Town in the APEC Region" (LCT concept) for SAMUI Island would then focus on reduction measures not only on supply side but also on demand side. On supply side the adaptation of high efficiency electricity generating system, utilization of renewable energy sources and untapped energy sources will be studied. Meanwhile, the adaptation of low carbon building, environmental management and eco-life style concept will be identified for demand side management. Low Carbon Traveling concept for transportation system would contribute significantly to CO_2 reduction for SAMUI Island. Town structure planning will be studied in two aspects, visualization and adaptation of green areas and non green areas as sustainable town initiative.

2. SAMUI Island Characteristics and Conditions

2.1 Geography & Climate Conditions

SAMUI Island has following operational conditions.

Location and Area

- North-East of Surat Thani Province with 20 km distance from the main land
- Total area of 228 km^2

  - Fifty four percent (54%) - mountain and hilly area in the central part and uninhabitable
  - Thirty three percent (33%) - plane area
  - Eight percent (8%) - beaches
  - Five percent (5%) - low land

Climate

- Tropical weather
- Averaged temperature of 29 °C with
- Highest averaged temperature of 37 °C in April and May
- Lowest averaged temperature of 21 °C in December and January

2.2 People and Community

SAMUI is an island and a district under Surat Thani province. The areas are divided into 7 sub-districts and contain various numbers of populations. Table 2-1-Table 2-2 shows the number of registered population and households in each sub-district including its growth rate.

Population

TABLE 2-1 : Number of registered population Unit : Persons

Sub-district	2005	2006	2007	2008	2009	Growth Rate
Ang Thong	9,287	9,563	9,865	10,018	10,055	2.48%
Lipa Noi	4,049	4,189	4,283	4,396	4,453	2.42%
Taling Ngam	5,065	5,113	5,095	5,210	5,245	1.06%
Na Mueang	4,172	4,258	4,372	4,469	4,500	2.02%
Maret	7,254	7,386	7,553	7,668	7,726	1.88%
Bo Phut	11,200	12,064	12,988	13,768	14,085	6.09%
Mae Nam	6,244	6,413	6,724	6,963	7,137	3.36%
Total	**47,271**	**48,986**	**50,880**	**52,492**	**53,201**	**3.19%**

Source : Registration Office

TABLE 2-2 : Number of registered households Unit : Households

Sub-district	2005	2006	2007	2008	2009	Growth Rate
Ang Thong	4,006	4,287	4,566	4,693	4,771	5.04%
Lipa Noi	1,818	2,000	2,146	2,204	2,243	6.65%
Taling Ngam	1,719	1,886	2,037	2,170	2,219	7.21%
Na Mueang	1,399	1,563	1,914	2,074	2,127	11.99%
Maret	4,638	5,190	5,734	5,995	6,135	8.93%
Bo Phut	9,195	11,115	12,483	13,658	13,982	13.66%
Mae Nam	3,799	4,473	4,979	5,242	5,373	10.64%
Total	**26,574**	**30,514**	**33,859**	**36,036**	**36,850**	**10.11%**

Source : Registration Office

As shown in the Table 2-1 the most populated sub-districts are Ang Thong and Bo Phut. However, there are unregistered populations living in SAMUI Island. The unregistered population immigrating from other places in Thailand for working are approximately 100,000 persons.

Sub-districts
1. Ang Thong
2. Lipa Noi
3. Taling Ngam
4. Na Mueang
5. Maret
6. Bo Phut
7. Mae Nam

FIGURE 2-1 SAMUI Sub-district Locations

Figure 2-1 shows the location of sub-districts. The east side of SAMUI is more developed than the west side. The community in this area is highly populated. Most of hotels and resorts locate a long the coast line in east side.

Visitors

The record of number of visitors to SAMUI is shown in Table 2-3

TABLE 2-3 : Summary of Visitors of SAMUI

	2006	2007	2008	2009*	2010*
Visitors (persons)	**1,030,623**	**1,059,642**	**845,010**	**898,555**	**785,281**
Tourist	1,021,444	1,051,337	835,370	892,784	780,811
Excursionist	9,179	8,305	9,640	5,771	4,470

Remark * 2009 and 2010 had political problems causing decreases in the number of visitors

From the Table 2-3 the averaged visitors to SAMUI is around 1,000,000 persons per year.

2.3 Socio-economic

Economics Values

SAMUI economy relies on tourism business

- The average expenditure of visitors and tourists is 102.98 USD/person/day in 2010

- The averaged revenue from tourists is 307.61 million USD/year in 2010

TABLE 2-4 : Summary of Visitors and Revenues of SAMUI

	2006	2007	2008	2009*	2010*
Visitors (persons)	**1,030,623**	**1,059,642**	**845,010**	**898,555**	**785,281**
Tourist	1,021,444	1,051,337	835,370	892,784	780,811
Excursionist	9,179	8,305	9,640	5,771	4,470
Average Length of Stay (Day)	**4.56**	**4.48**	**n/a (4.00)**	**8.32**	**3.82**
Average Expenditure (USD/Person/Day)					
Visitor	**100.12**	**99.47**	**139.31**	**104.63**	**102.98**
Tourist	3,006.38	2,986.50	4,184.51	3,140.29	3,091.44
Excursionist	1,635.25	1,570.13	2,331.00	1,313.45	1,789.71
Revenue (Million USD) **					
Visitor	467.21	468.97	509.30	777.89	307.61

Remark * 2009 and 2010 had political problem causing decreases in the number of visitors
** Exchange rate 30 baht/USD

2.4 Town Structure and Infrastructure

Commercial Buildings

- Hotels and resorts have 15,012 rooms in 2010, with an average occupancy rate of 33.59%
- Stores, residence and office buildings

TABLE 2-5 : Summary of Visitors and Revenues of SAMUI

	2006	2007	2008	2009*	2010*
ACCOMMODATION ESTABLISHMENTS					
Establishments	360	403	425	425	425
Rooms	13,290	14,405	15,404	15,404	15,012
Occupancy Rate (%)	68.29	64.23	50.17	39.14	33.59
Average Length of Stay (Day)	7.42	7.42	n/a	6.08	4.99
Number of Guest Arrivals	**840,076**	**853,475**	**739,404**	**737,611**	**750,496**

Remark * 2009 and 2010 had political problem causing decreases in the number of visitors

The direct and indirect emissions generated from infrastructure which is currently installed in SAMUI Island can be described as follows

➲ **Electricity Supplies**

Primary energy use in *SAMUI* Island is electricity purchased from PEA (Provincial Electricity Authority). This electricity is generated by power generation facility in the main land and transmitted through submarine feeders in order to supply to loads via a power transmission line. The energy demand recorded historically increases from 28.4 MW in 2000 to 95 MW in 2012.

The electricity consumption is mostly for commercial and residential buildings. The energy consuming equipment includes air conditioning system, lighting system, water treatment system and others.

It is observed that current electricity facilities will be critically short of supplies. Therefore, the expansion projects to serve higher energy demand must be invested. The new investment can be seen as good opportunities to adopt the low carbon emission technology such as power generation with cogeneration.

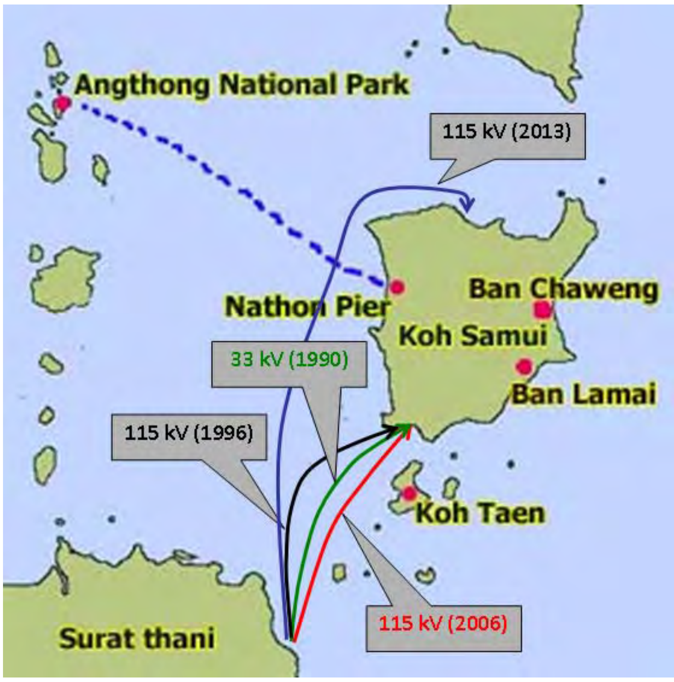


FIGURE 2-2 Existing Submarine Cable for electrical power supply

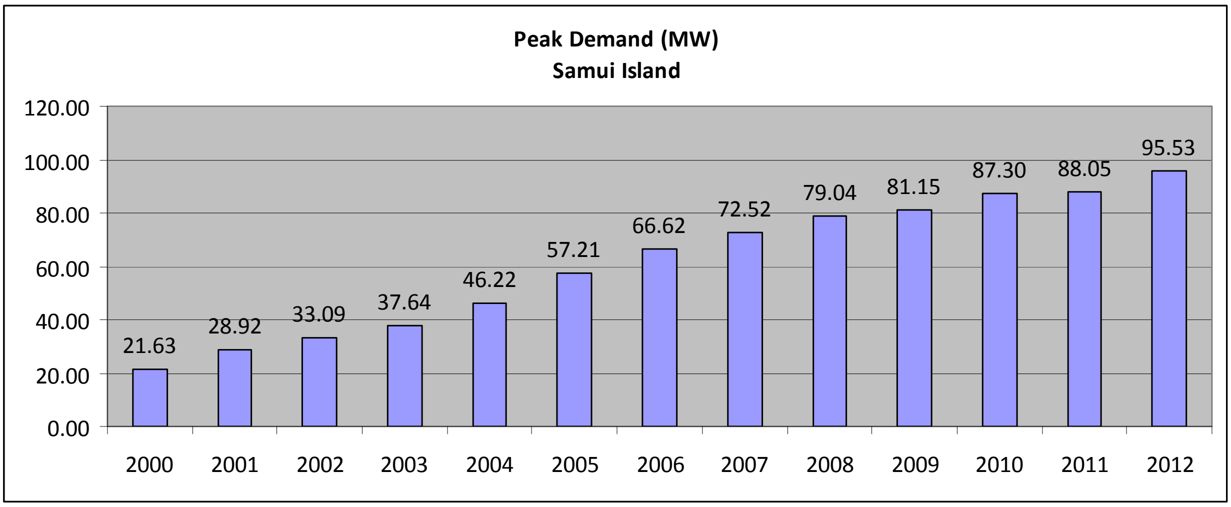


FIGURE 2-3 Peak Demand Profile of SAMUI

TABLE 2-6 : Electricity Consumption and Share

Sector	Consumption kWh/year	Percentage
Households	125,040,000	24.00%
Business/Industry	369,910,000	71.00%
Government/Public	15,630,000	3.00%
Others	10,420,000	2.00%
Total	**521,000,000**	**100.00%**

➲ **Fuel Supplies**

The major fuel is consumed in transportation system such as cars, planes, boats etc. All types of transportation contribute to carbon emission. The inappropriate and inefficient transportation system can cause higher emission. This depends on city plan for infrastructure such as numbers of roads, public transportation, vehicle types as well as traveling behaviors.

In addition, fuel combustion for heating equipment such as boilers, furnaces and households also contribute to carbon emission.

It is observed that current infrastructure for transportation is either not well-developed or inefficient use. Traffic re-design will serve the town expansion and emit less carbon dioxide. Fuel switching from conventional fuel to natural gas or bio-diesel is also an attractive solution. Fuel supplied to SAMUI Island is by ships or boats for sea transportation while for inland transportation, it is done by bulk trucks or tanks to the site storage. This can increase the emissions.

TABLE 2-7 : Fuel Consumption and Share by Type

Fuel Type	Consumption liters/day	Consumption [2)] liters/year
Gasohol 91	6,050	2,208,250
Gasohol 95	18,388	6,711,620
E20	1,233	450,045
Diesel	56,024	20,448,760
Gasoline 91	32,303	11,790,595
Gasoline 95	50	18,250
Total	**114,048**	**41,627,520**

TABLE 2-8 : Emission Share by Energy Type in 2010

Summary	Consumption	Unit	Energy Content MJ/year	Percentage
Electricity	521,000,000	kWh/year	1,875,600,000	57.06%
Fuel	41,627,520	liters/year	1,411,451,204	42.94%
Total			3,287,051,204	

Commercial Buildings and Households

The electricity consumption for commercial buildings accounts for 70% while 24% belongs to households.

Fossil fuels such as diesel, fuel oil and etc. are consumed for providing heat for several purposes used in commercial buildings and transportation. Diesel consumption accounts for 62% of total thermal consumption and 17% share for gasoline used for vehicles while 12% of heavy fuel oil share used for heating equipment in commercial buildings. The hotels and resorts use heat for hot water for guests or steam for laundry while LPG is used for cooking in households.

➲ **Hotels and Resorts**

There are approximately 425 hotels and resorts (around 15,012 rooms) on the island locating close to the beaches.

The primary energy consumption of buildings will be used for air conditioning systems, lighting and electric water heating etc. From experience in engineering design and audit, 60%-70% of total energy consumption belongs to HVAC system and 15% will be accounted for lighting system.

The potential for energy management of the building provide high opportunities for carbon emission reduction though higher energy efficiency equipments and renewable energy such as solar heating or cooling to replace conventional boiler and electric chiller etc.

➲ **Residential**

The energy used for residential is the same as hotels and resorts. Air conditioning system, lighting system and electric water heating are primary energy consumers for these households.
It is observed that some areas are manageable for utility share. This arrangement can significantly reduce carbon emission from energy use and effectively lead to green community.

Industries

There are not many factories located in *SAMUI* Island. There are around forty three factories are registered which are categorized as small and medium enterprises (SME). The products from those factories are mainly to serve area consumption and few exported products. Consequently, industrial sector is not the major source for carbon emissions.

Agriculture

There are 180.28 km^2 or 112,671 rais (18,027 hectare) for agriculture on SAMUI Island. The major plantations are coconut trees and durian trees while the major livestock is chicken farms, duck farms and others.

It is observed that waste to energy from agricultural residues can be manageable and economically viable. EEC Engineering Network will provide technology evaluation for recovering this type of waste and increasing its economic value while reducing environmental impacts from unused residues.

Waste

Waste disposal has threatened SAMUI Island due to increasing numbers of tourists. The general waste in SAMUI Island can be divided into two types

- Solid Waste

  The main sources of solid waste are from households and commercial buildings. Depending on its composition of waste and waste treatment system, the emission from solid waste mainly occurs at disposal site. For example if waste is treated by landfill the potential emission is methane from anaerobic decomposition. However, if the incineration is used, emission will be carbon dioxide, hydrocarbon, sulfur dioxide etc.

  The existing disposal system comprises of two (2) incinerators (70 tons per day each). A forecast for the development in MSW generation at the island indicates a need for handling of more than 350 ton/day in 2030. The existing waste composition is:

  - 40% incombustible and plastic
  - 25% dry combustible
  - 30% food waste with high moisture
  - 5% other

It becomes obvious that these incineration plants will soon lack treatment capacity. MSW will be piled up and threatening heath in the nearby area.

- Waste Water

Currently, there are three areas in SAMUI Island which have installed wastewater collection system and centralized wastewater treatment facility - Nathon area, Lamai area and Chaweng area.

The existing collection system and wastewater treatment facilities were all constructed in 2004 but none of them is presently in operation due to the delay in property transfer and the lack of operating budget. The service area of the existing collection system is not covered all area in those communities resulting in wastewater is discharge into natural waterway and causing environmental problems. The wastewater from these communities is treated by old-style on site treatment system which has low treatment efficiency.

Infrastructure

Transportation System

As one of the most popular tourist destination island in Thailand, SAMUI Island is easy to get to by boat, or airplane. There are numerous boats from Surat Thani province on the mainland as well as from neighboring islands Phangan and Tao. The SAMUI international airport is served primarily by Bangkok airways which flies to and from SAMUI Island with seven domestic and international destinations. Thai airways (TG) also offers daily flight from/to Bangkok-SAMUI Island.

Once reaching to the island, there are many ways of getting around SAMUI. Rental bicycles, motorbikes, and cars (both with and without drivers), two-seat rows bus (Called songtaew in Thai) and taxis are easily available for getting around and between beaches.

By Train:

The train station in Surat Thani is serviced by trains from cities to the north and south, including Bangkok and Hat Yai. From Surat Thani minibus or songtaew transfer to the boat pier is required to get a ferry to SAMUI.

By Car:

As many of the ferries connecting mainland Surat Thani and SAMUI are car ferries it is possible to rent a car and drive to SAMUI. From Bangkok to Surat Thani the trip takes from 8 to 10 hours; from Phuket or Hat Yai the journey is 5 and 6 hours respectively. Once in Surat Thani, the ferry piers are another hour from the town.

By Bus:

Numerous busses from throughout Thailand, including Bangkok and Phuket, service Surat Thani town, the capital of the mainland province that includes SAMUI Island. From Bangkok it is 11 hours bus ride. From Surat Thani minibus or songtaew transfer to the boat pier is required to get a ferry to SAMUI Island, although some tour operators will provide transfers in a bus-boat package. Busses arriving late at night may miss the last ferry to SAMUI Island so it is often preferable to take an overnight bus to Surat Thani and then catch a morning ferry to SAMUI Island.

By Air:

Bangkok Airways offers direct, non-stop air services between SAMUI (USM) and Bangkok, Chiang Mai, Krabi, Pattaya (U-Tapao), Phuket, Hong Kong, and Singapore. Flying time between SAMUI and Bangkok is under an hour; flights between SAMUI and Phuket or Pattaya are under 45 minutes.

Thai Airways offers limited domestic service to and from SAMUI; Berjaya Air connects SAMUI and Kuala Lumpur; and Firefly provides service from Penang and Kuala Lumpur to SAMUI Island.

By Boat

From Surat Thani there are piers serviced by two major ferry companies: Ratcha Ferry and Seatran Ferry, which shuttles between Surat Thani's Don Sak pier and SAMUI Island

Road System on SAMUI

- Highway Road No. 4169, Ring Road, total distance 50.1 kilometers, the most traffic
- Highway Road No. 4170 Connecting road from Bann Sraket-Hua Thanon, total distance 16.3 km
- Highway Road No. 4171 Bo Phut Junction-Chaweng Beach Road, total distance 4.8 km, the second most traffic
- Highway Road No. 4173 Connecting Road between Ring Road and Highway No. 4170, total distance 3.3 km
- Highway Road No. 4174 Lipa Noi Junction – Ferry port Road, total distance 3.4 km, the third most traffic
- Rural Road, Wat Samutharam- Hospital Entrance Junction Road, total distance 1.5 km
- Rural Road, Tong Tanode – Bann Pung Ka, total distance 1.317 km
- Rural Road, Pru Kum – Bann Mae Nam, total distance 1.20 km

FIGURE 2-4 Main Road on SAMUI Island

3. Low Carbon Town Concept for SAMUI Island

3.1 SAMUI Island Low Carbon Development Concept

There are many driving factors to consider low carbon development for SAMUI Island. Like other islands around the world which are rich with natural resources and its beautiful location which become popular place for visiting, tourism industry becomes the main revenue for economic growth.

SAMUI Island recently becomes very popular to Thai and foreign tourists. The demands for energy consumption as well as other food and supplies are drastically increased. The growth of economy is fast and not well planned infrastructure will eventually threaten the local community and ecology system.

Most of the areas on SAMUI Island have already been developed. People on SAMUI Island have their own culture and living life style. Therefore, development of low carbon concept on SAMUI Island will focus on the development of not only technical aspect but also people's lifestyle and activity aspect as well. SAMUI Island development concept will then be branding as:

"The first low carbon island of people oriented"
"people participate, people be leaned, people be pleased

The Carbon Emission on SAMUI Island comes from various sources such as energy use for commercial and residential buildings, industries, transportations and waste disposal. This contribution of carbon emission is not well measured, but can be observed that the proportion of carbon emission is from commercial building for accommodating tourists and transportation for traveling both inland and sea. Adaptation of "The Concept of the Low-Carbon Town in the APEC Region" for SAMUI Island would then focus on reduction measures not only on supply side but also on demand side. On supply side the adaptation of high efficiency electricity generating system, utilization of renewable energy sources and untapped energy sources have been recommended. Meanwhile, the adaptation of low carbon building design into both existing and new construction phase, environmental management and eco-life style concept has also been identified for demand side management. Low Carbon Traveling concept for transportation system would contribute significantly to CO_2 reduction for SAMUI Island. Town structure planning will also be studied in two aspects, visualization and adaptation of green areas and non green areas as sustainable town initiative. One of characteristics of low carbon methodology in SAMUI should be described with eco-life style that encourages low carbon management, because the energy density in SAMUI tends to be lower than kind of Central Business District.

3.2 High Level Vision

SAMUI Island encounters many threats as its economic growths. Developing SAMUI with LCMT concept as an implementing methodology can lead SAMUI to achieve High Level Vision. LCMT FS in SAMUI Island would be expected to take an initiative for showing the prototype consisting resort tourism growth and low carbon development. SAMUI Island currently is facing three aspects of threats;

- **Social & Human** : social and culture of community change, health impact from waste management and living life style
- **Environment & Resources** : overuse of resources, unprotected natural resources, energy efficiency is not well improved and no clear and no strong implementation of land use plan
- **Economic** : income distribution, inefficient supplies chain & logistics

With posted SAMUI Island problems, SAMUI Island Low Carbon Development High Level Vision will meet values in three (3) aspects –

FIGURE 3-1 : SAMUI Island's LCT Development Values

3.3 Carbon Emission Baseline

3.3.1 Business As Usual of SAMUI Island

Selecting Base Year

The economy of SAMUI Island depends largely on tourism industry. Therefore the number of tourists will reflect the actual energy consumption and revenue. Based on statistics information of energy consumption, the arbitration of base year can be selected. However, the following considerations are taken into account for selecting base year and for future emission forecast.

- Use most complete of information that related to carbon emission categories – energy consumption of electricity and fuel.
- During 2nd Quarter of 2008- 1st Quarter of 2009, there is political crisis and world economics recession that impact the number of tourists as a result GDP was dropping and regain in 2010 After Y2010 the economic is expected to slowly regain.

Historical record of GDP in Thailand

Thailand GDP has been reporting continuously. From Y2000–Y008 the Thai GDP was 1.5% on the average as shown in the Figure 3-2. Until Y2008-Y2009, because of the political conflict, the economy is downturn to negative GDP and seem to be regained in the following year. However the growth is not consistent and again the political conflict causes the drop in Thai GDP.

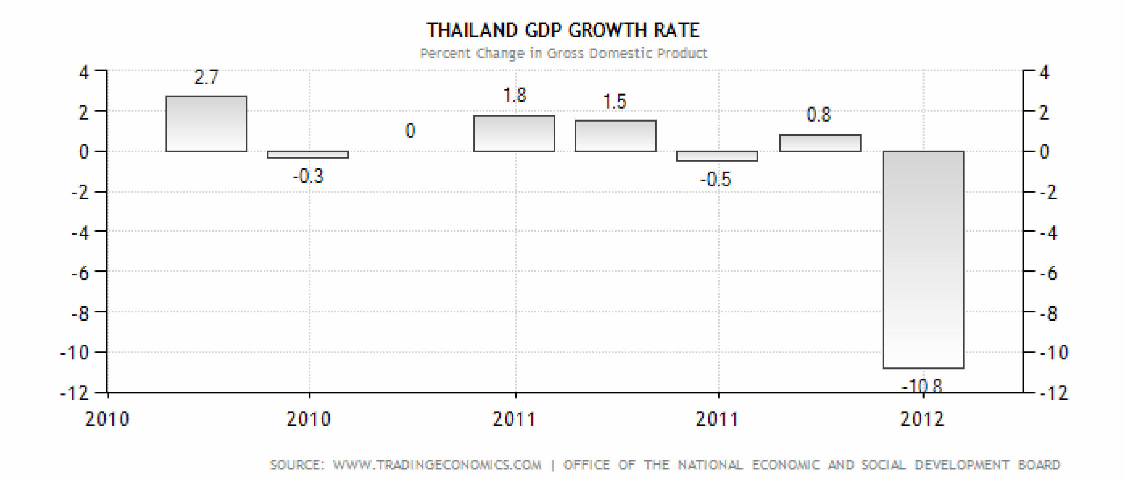


FIGURE 3-2 : Thailand GDP Growth Rate from Y2000 – Y2012

Thailand GDP Projection

In order to calculate carbon emission for Business As Usual, Thailand GDP projection will be used for parameters impact the carbon emission such as

- Energy demand growth – both electricity and fuel consumption
- Number of tourists
- Revenues

Thailand's Power Development Plan or PDP is one of the reliable sources for reference in order to predict the growth rate of SAMUI Island for energy consumption. Therefore, as used for national power development planning, the projection of energy consumption will use the same GDP. From the below Figure 3-3 the GDP projection is shown.

FIGURE 3-3 : Thailand GDP Growth Rate Forecast from Y2010 – Y2030
Source : Third revision for Power Development Plan from Y2010-Y2030, http://www.eppo.go.th/power/PDP2010/PDP2010-rev3.pdf

Thailand' CO_2 Emission (tons) per Capita

Thailand economy has been growing continuously as well as resource consumption. The country's energy consumption has been increased significantly as the result of increasing carbon dioxide emission. Table 3-1 indicates the carbon dioxide emission per capita from 1.7 ton CO_2 per capita in 1990 to 4.1 ton CO_2 per capita 2007.

TABLE 3-1 : Carbon dioxide per capita of Thailand

Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita (CDIAC)		Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita (CDIAC)	
1990	1.7	1999	3.2
1991	2	2000	3.2
1992	2.2	2001	3.4
1993	2.4	2002	3.6
1994	2.7	2003	3.8
1995	3	2004	4
1996	3.3	2005	4.1
1997	3.4	2006	4.2
1998	3	2007	4.1

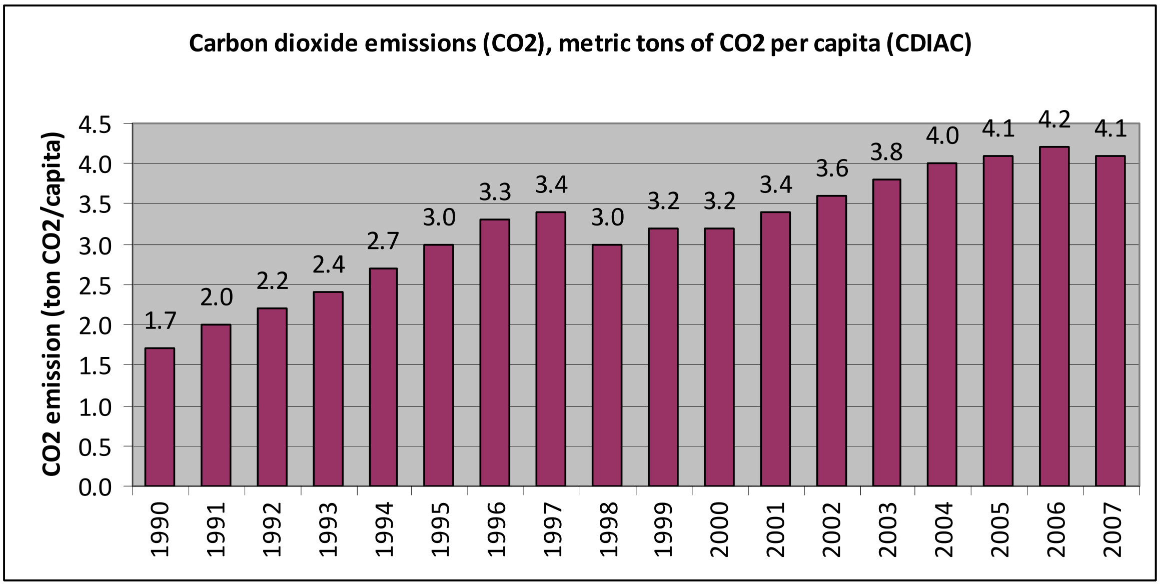


FIGURE 3-4 : Thailand CO2 Emission per Capita from Y1990 – Y2007

Assumption used for Emission Analysis

In order to analyze the carbon emission on SAMUI Island, the method for future emission calculation which relates to energy consumption from Y2011 t0 Y2030 will be employed. Table 3-2 and Table 3-3 indicate method and values in the calculation.

TABLE 3-2 : Parameters List for Carbon Emission Analysis

Parameters	Method for Forecasting	Value
Power Demand	Use Power Consumption Historical data from Y2000-Y2010 to make a trend line	See TABLE 3-3
Fuel Demand	Same figure as Power Demand Forecast	See TABLE 3-3
Population	Use Registered Population Historical data from Y2005-2009 to make a trend line	3.20%
Tourists	Same figure as Power Demand Forecast	See TABLE 3-3
Revenue	Same figure as Power Demand Forecast	See TABLE 3-3
Vehicles		

TABLE 3-3 : Growth Rate Forecast using Historical Power Demand for Future Projection since Y2011-2030

Year	% Growth Rate
2011	4.64%
2012	5.57%
2013	4.69%
2014	3.91%
2015	3.20%
2016	2.56%

Year	% Growth Rate
2021	6.15%
2022	5.68%
2023	5.26%
2024	4.89%
2025	4.56%
2026	4.26%

Year	% Growth Rate
2017	1.96%
2018	1.38%
2019	0.83%
2020	0.29%

Year	% Growth Rate
2027	3.99%
2028	3.75%
2029	3.52%
2030	3.32%

Baseline Emission from Energy Consumption in Y2010

The carbon emission of SAMUI Island is largely based on the energy consumption from the tourists for all activities.

Electricity Consumption

Electricity is imported from the grid which is provided by PEA. This electricity consumption is indirect carbon emission source but its use contributes to the emission at the power plant.

Electricity Consumption on SAMUI Island in Base year 2010 is shown in Figure 3-5.

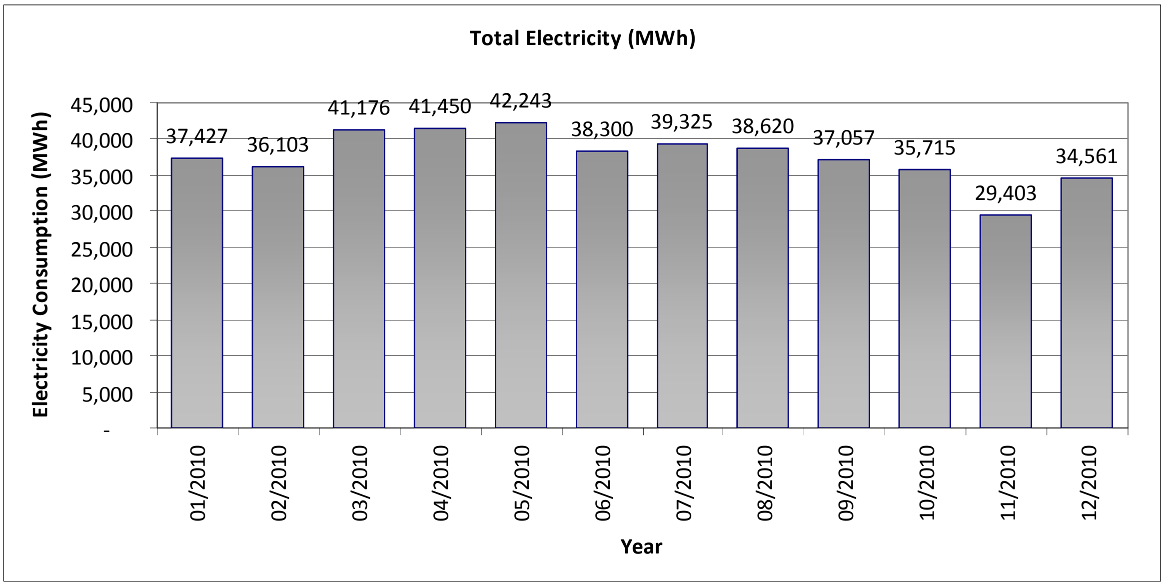


FIGURE 3-5 : Electricity Consumption on SAMUI Island in Base year 2010

As seen above electricity profile in Y2010 by monthly, the electricity peak demand occurs in March till May due to the summer time in Thailand. The total electricity in Y2010 is 451,378,952 kWh per year. This energy consumption can be broken down to type of service that defined by PEA as shown in Table 3-4.

TABLE 3-4 : SAMUI's Electricity Consumption by Type of Service in Base Year 2010

Description	Electricity Consumption (kWh)
Residential < 150 kWh	7,477,921
Residential > 150 kWh	97,462,716
Small General Service	67,638,371
Medium General Service	52,757,886
Large General Service	25,544,040
Specific Business	181,027,835
Government Offices & NPO	7,851,277
Agricultural Pumping	0.00
Temporary	11,787,594
Total Consumption	451,378,952

Source : Provincial Electricity Authority (PEA)

Remark :

Residential	Applicable to dwelling, monasteries, churched of any religion including its compound through a single Watt-hour meter.
Small General Service	Applicable to business, business-cum-residential, industrial, government industrial institutions, state enterprises or others include its compound with a maximum 15-minute integrated demand of less than 30 kW through a single Watt-hour meter.
Medium General Service	Applicable to business, industrial, government industrial institutions and state enterprises including its compound, with a maximum 15-minute integrated demand of at least 30 kW but less than 1,000 kW. and average energy consumption in the last 3 consecutive months not exceeding 250,000 kWh. /month through a single demand meter.
Large General Service	Applicable to business, industrial, government institutions and state enterprises including its compound, with a maximum 15-minute integrated demand of 1,000 kW and over or average energy consumption in the last 3 consecutive months exceeding 250,000 kWh per month through a single demand meter.
Specific Business	Applicable to hotel, guest house or other businesses providing lodging to customers including its compound with a maximum 15-minute integrated demand of 30 kW. and over through a single demand meter.
Government Offices & NPO	Applicable to government institutions or those established by the Local Administrative Act, non-profit organizations offering free of charge service, places conducting religious ceremonies including its compound with average consumption in the last 3 consecutive months not exceeding 250,000 kWh per month through a single watt-hour meter, but excluding state enterprises, embassies, places for activity related to a foreign country or international organizations.

Agricultural Pumping	Applicable to government agricultural agencies, officially recognized farmer groups, agricultural co-operatives or farmers operating water pumps for agricultural pumping through a single Watt-hour meter.
Temporary	Applicable to temporary use for construction, bazaars, fairs and places without registration number including the consumption is not subject to the conditions set forth in PEA's Rules and Regulations through a single Watt-hour meter.

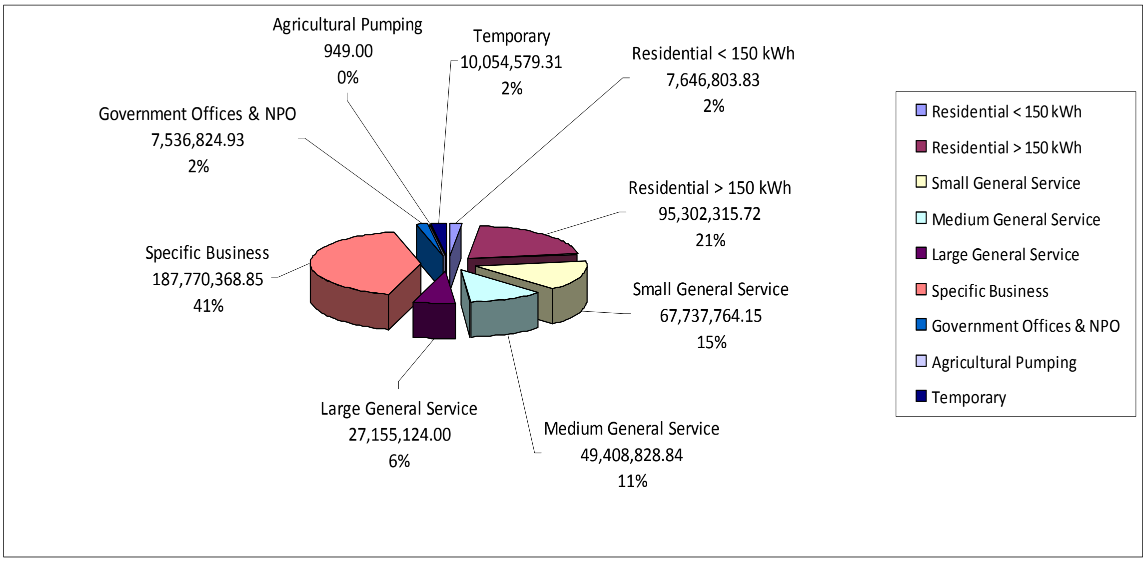


FIGURE 3-6 : Electricity Share by Service Type on SAMUI Island

Source: Provincial Electricity Authority, PEA

From historical record on electrical energy consumption in base year 2010, the energy consumption in each system that consume electrical energy by type of service has been formulated and estimated as shown in Table 3-5. The energy share in each system for residential sector is referenced from the study of EGAT while the energy share in each system for commercial sector is averaged from several types of building in this sector.

TABLE 3-5: Electricity share by Type of Service and System in Base Year 2010

System	Residential Sector	Commercial Sector	Other Sector
Air Conditioning (Split Type)	48,592,321.88	151,883,876.81	5,105,788.75
	9.9%	31.0%	1.0%
Air Conditioning (Chiller)	0.00	43,455,201.79	0.00
	0.0%	8.9%	0.0%
Refrigeration	20,389,527.46	28,316,519.77	0.00
	4.2%	5.8%	0.0%
Hot Water	3,169,064.47	24,436,128.15	0.00
	0.6%	5.0%	0.0%
Pump	3,169,064.47	15,940,046.25	255,289.44
	0.6%	3.3%	0.1%
Fan	10,636,477.71	9,287,029.20	170,192.96
	2.2%	1.9%	0.0%
Lighting	17,061,070.08	46,717,961.92	1,276,447.19
	3.5%	9.5%	0.3%
WWT	0.00	10,631,584.44	255,289.44
	0.0%	2.2%	0.1%
Other	10,722,941.14	23,717,799.84	14,222,686.89
	2.2%	**4.8%**	**2.9%**

The electricity share by type of service and system can be compared as shown in Figure 3-7a to Figure 3-7b.

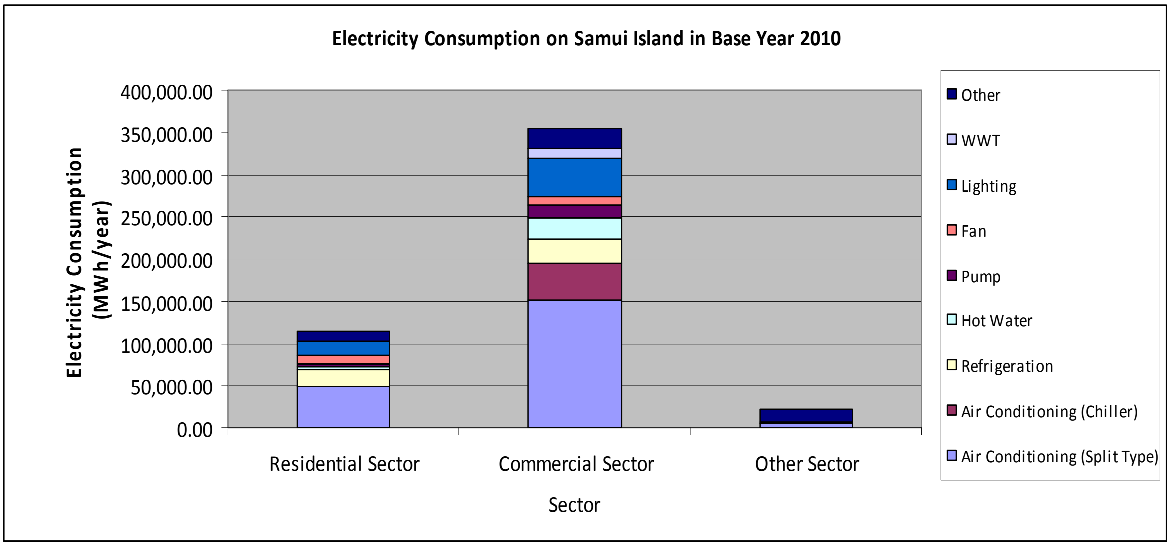


FIGURE 3-7a: Electricity Consumption by Service Type and System on SAMUI Island

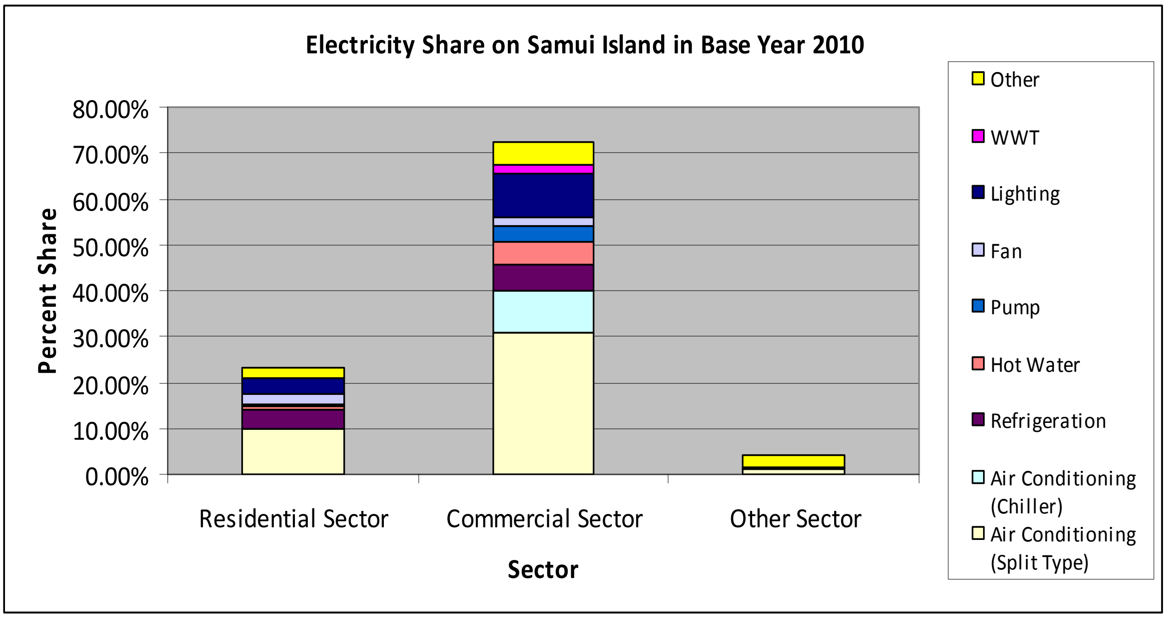


FIGURE 3-7b: Electricity Share by Service Type and System on SAMUI Island

The largest share of electricity consumption is from air conditioning system in both residential and commercial sectors. In order to set the carbon emission target, this energy consumption will be analyzed to identify the carbon emission reduction measures.

Fuel Consumption

Fuel consumption on SAMUI Island is for transportation use. The carbon emission is from direct combustion in the motor engines. The fuel consumption in Y2010 is shown in Table 3-6.

TABLE 3-6: Fuel Consumption in Base year 2010

Fuel Type	Fuel Consumption (Liters/y)
Gasohol 91	2,208,250
Gasohol 95	6,711,620
E20	450,045
Diesel	20,448,760
Gasoline 91	11,790,595
Gasoline 95	18,250
Total	**41,627,520**

3.3.2 Carbon Emission Forecast

Analysis of Power Peak Demand and Electricity consumption from Y2010 to Y2030

In order to forecast the growth of power demand for SAMUI Island, the historical data of power demand and supply capacity will take into consideration. The power supply of SAMUI Island is though the submarine cable and has its limit capacity, therefore, the growth of SAMUI Island itself has some factors from this limitation.

The historical power demand from Y2000 – Y2010 is plotted and analyzed for its trend. It is found that the growth of power demand and its electricity consumption can be shown in Table 3- 7.

TABLE 3-7 : The Electrical Power Demand using historical record from Y2010 to Y2030

Year	% Growth Rate	Estimated Peak Load (MW)	Forecasted Electricity (kWh)
2010		94.60	489,412,310
2011	4.64%	99.20	513,210,372
2012	5.57%	105.05	543,497,026
2013	4.69%	110.22	570,235,701
2014	3.91%	114.71	593,426,394
2015	3.20%	118.50	613,069,107
2016	2.56%	121.61	629,163,840
2017	1.96%	124.04	641,710,592
2018	1.38%	125.78	650,709,363
2019	0.83%	126.83	656,160,154
2020	0.29%	127.20	658,062,964
2021	6.15%	135.54	701,222,301
2022	5.68%	143.70	743,449,375
2023	5.26%	151.69	784,744,185
2024	4.89%	159.49	825,106,732
2025	4.56%	167.11	864,537,016
2026	4.26%	174.55	903,035,037
2027	3.99%	181.81	940,600,794
2028	3.75%	188.89	977,234,289
2029	3.52%	195.79	1,012,935,520
2030	3.32%	202.51	1,047,704,488

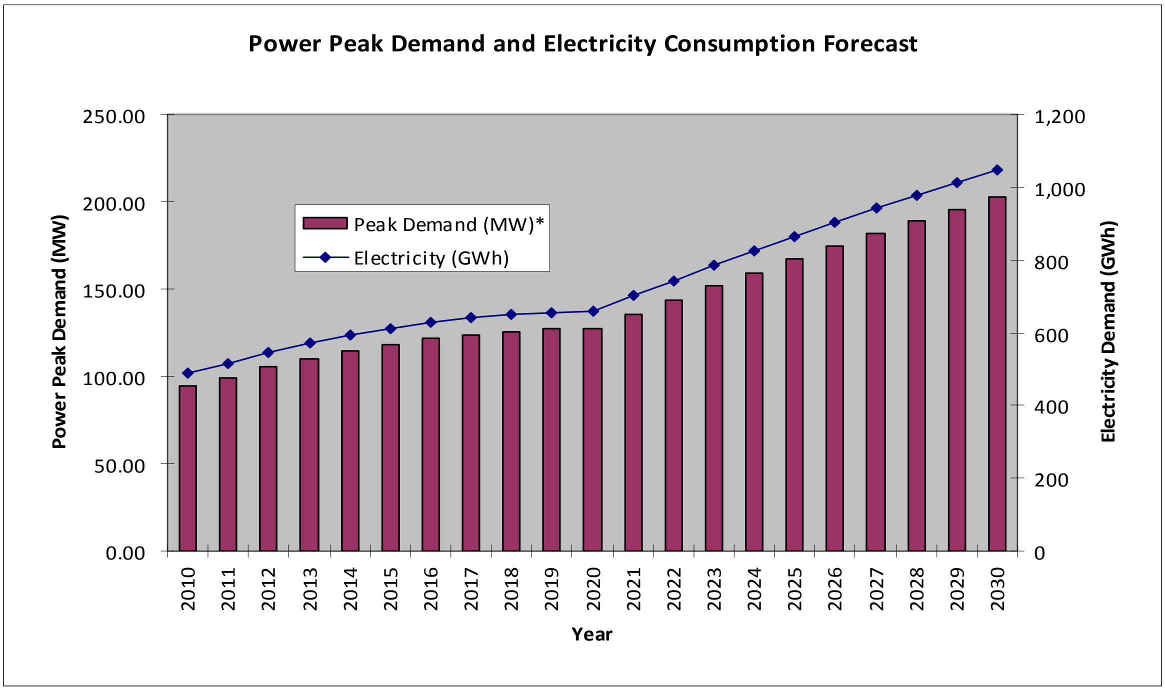


FIGURE 3-8 : Power Peak Demand and Electricity Consumption Forecast on SAMUI Island

Based on the electricity consumption data collected from Provincial Electricity Authority, PEA as shown in Figure 3-8, the largest consumers are from hotels and resorts and from the survey the energy share can be broken into systems and forecast for Y2020 and Y2030 have been made as shown in Table 3-8.

TABLE 3-8 : Electricity Share by System on SAMUI Island

System	Energy Consumption (kWh)		
	Y2010	Y2020	Y2030
Air Conditioning (Split Type)	205,581,987.44	276,425,192.60	440,097,575.10
Air Conditioning (Chiller)	43,455,201.79	58,429,790.83	93,026,286.85
Refrigeration	48,706,047.23	65,490,068.72	104,266,981.48
Hot Water	27,605,192.62	37,117,895.31	59,095,538.88
Pump	19,364,400.15	26,037,339.69	41,454,145.17
Fan	20,093,699.87	27,017,954.86	43,015,386.20
Lighting	65,055,479.19	87,473,487.29	139,266,863.77
WWT	10,886,873.88	14,638,472.21	23,305,965.93
Other	48,663,427.86	65,432,762.80	104,175,744.51

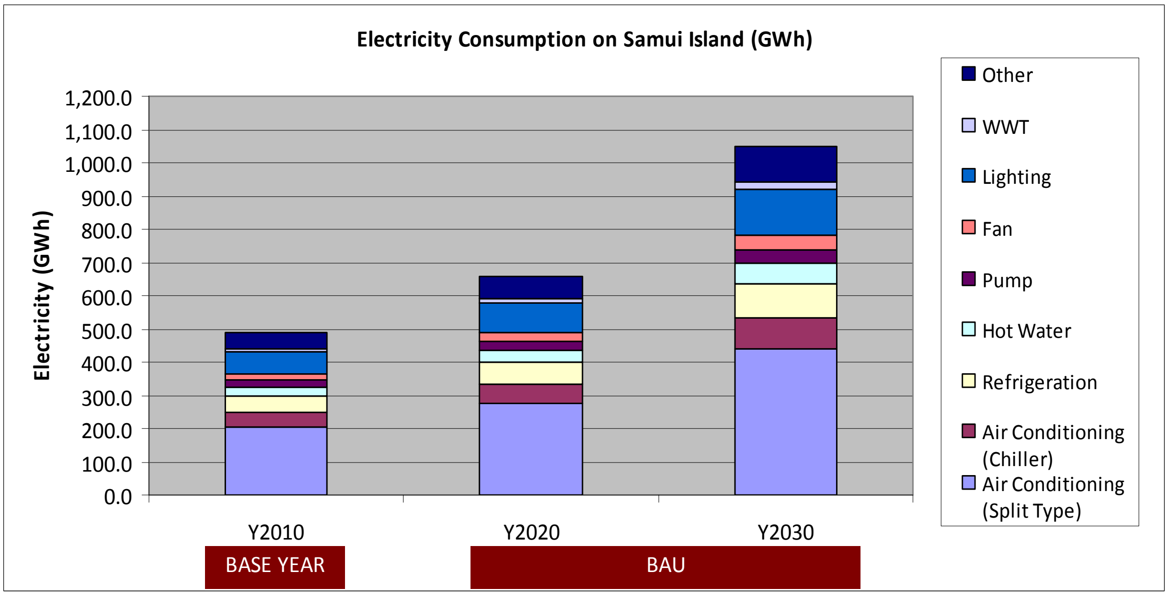


FIGURE 3-9: Electricity Consumption in Base Year , Y2020, and Y2030

<u>Analysis of Fuel consumption from Y2010 to Y2030</u>

Fuel consumption on SAMUI Island is primarily used for inland transportation. Since there is no adequate time series information of fuel consumption, the prediction of fuel consumption is expected to be the same as electricity growth as described in the previous section as well as the increasing number of tourists which is the main drivers for fuel consumption. For transportation of air and sea, these modes of transportation are trans-boundary and no data of fuel consumption is present, therefore the emission from those modes will be excluded.

Table 3-9 shows the results that use national GDP to estimate fuel consumption and carbon emission.

TABLE 3-9 : The Fuel Demand Forecast using Historical Data from Y2010 to Y2030

Year	% Growth Rate	Fuel Consumption (Liters/yr)						Total Fuel Consumption (Liters/y)
		Gasohol 91	Gasohol 95	E20	Diesel	Gasoline 91	Gasoline 95	
2010		2,208,250	6,711,620	450,045	20,448,760	11,790,595	18,250	41,627,520
2011	4.64%	2,310,649	6,812,294	456,796	20,755,491	11,967,454	18,524	42,321,208
2012	5.57%	2,439,411	7,152,909	479,635	21,793,266	12,565,827	19,450	44,450,498
2013	4.69%	2,553,796	7,517,707	504,097	22,904,723	13,206,684	20,442	46,707,449
2014	3.91%	2,653,597	7,946,217	532,830	24,210,292	13,959,465	21,607	49,324,008
2015	3.20%	2,738,618	6,711,620	450,045	20,448,760	11,790,595	18,250	42,157,888
2016	2.56%	2,808,675	7,022,844	470,914	21,396,989	12,337,336	19,096	44,055,854
2017	1.96%	2,863,590	7,414,196	497,156	22,589,347	13,024,841	20,160	46,409,290
2018	1.38%	2,903,191	7,761,852	520,468	23,648,574	13,635,583	21,106	48,490,774
2019	0.83%	2,927,308	8,065,180	540,807	24,572,744	14,168,452	21,931	50,296,422
2020	0.29%	2,935,773	8,323,588	558,135	25,360,054	14,622,409	22,633	51,822,592
2021	6.15%	3,116,466	8,536,515	572,413	26,008,793	14,996,467	23,212	53,253,866
2022	5.68%	3,293,478	8,703,421	583,604	26,517,318	15,289,678	23,666	54,411,165
2023	5.26%	3,466,787	8,823,782	591,675	26,884,031	15,501,122	23,993	55,291,390
2024	4.89%	3,636,375	8,897,082	596,590	27,107,359	15,629,891	24,193	55,891,490
2025	4.56%	3,802,225	8,922,808	598,315	27,185,741	15,675,086	24,263	56,208,438
2026	4.26%	3,964,321	9,471,996	635,141	28,858,989	16,639,867	25,756	59,596,070
2027	3.99%	4,122,648	10,009,994	671,216	30,498,146	17,584,993	27,219	62,914,216
2028	3.75%	4,277,193	10,536,740	706,537	32,103,020	18,510,350	28,651	66,162,491
2029	3.52%	4,427,944	11,052,176	741,099	33,673,435	19,415,839	30,053	69,340,546
2030	3.32%	4,574,889	11,556,250	774,900	35,209,231	20,301,367	31,423	72,448,060

As shown in Table 3-9, the fuel consumption is expected to be increased from 41,627,520 liters in Y2010 to 51,822,592 liters in Y2020 and 72,448,060 liters in Y2030 respectively. Diesel and Gasoline 91 are the main fuel used on SAMUI Island for transportation sector.

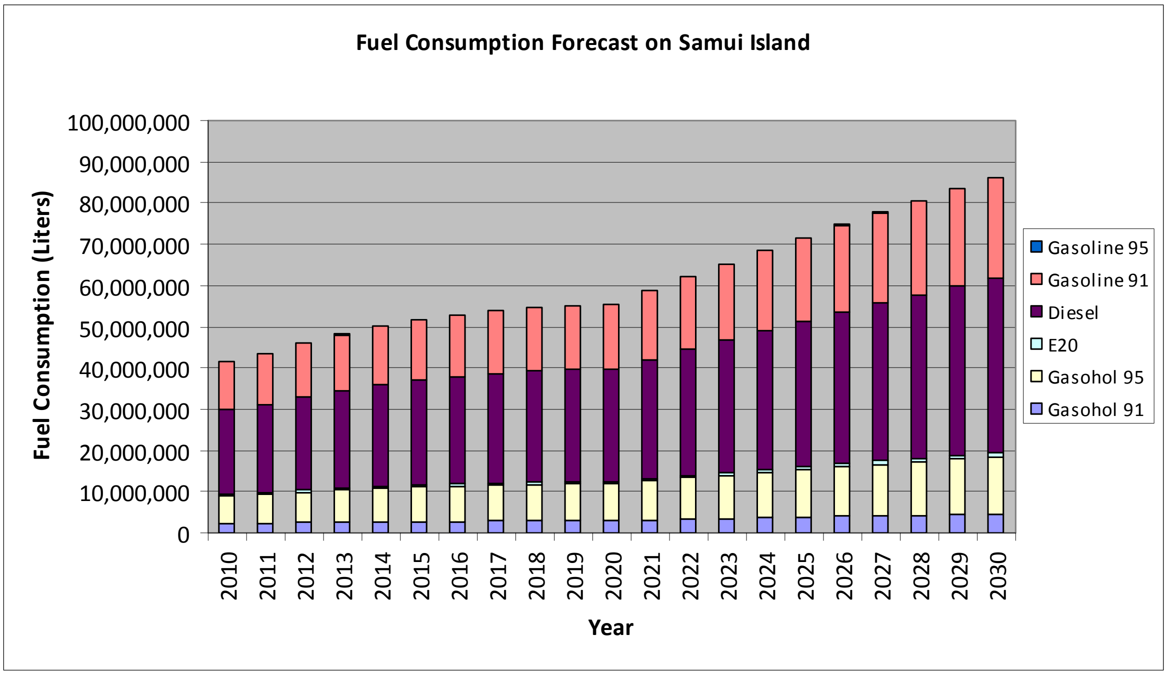


FIGURE 3-10 : Fuel Consumption Forecast on SAMUI Island

TABLE 3-10 : Carbon dioxide emission on SAMUI Island from Y2010 to Y2030

Year	% Growth Rate	Emissions (ton CO_2/year)						Total Emissions (ton CO_2/year)
		Gasohol 91	Gasohol 95	E20	Diesel	Gasoline 91	Gasoline 95	
2010		4,817	14,642	982	55,186	25,722	40	101,388
2011	4.64%	5,041	15,321	1,027	57,745	26,915	42	106,090
2012	5.57%	5,322	16,175	1,085	60,962	28,415	44	112,002
2013	4.69%	5,571	16,933	1,135	63,821	29,747	46	117,254
2014	3.91%	5,789	17,595	1,180	66,315	30,909	48	121,836
2015	3.20%	5,974	18,158	1,218	68,440	31,900	49	125,739
2016	2.56%	6,127	18,623	1,249	70,191	32,716	51	128,956
2017	1.96%	6,247	18,987	1,273	71,563	33,355	52	131,477
2018	1.38%	6,333	19,250	1,291	72,553	33,817	52	133,295
2019	0.83%	6,386	19,410	1,301	73,155	34,098	53	134,403
2020	0.29%	6,405	19,466	1,305	73,367	34,196	53	134,791
2021	6.15%	6,799	20,664	1,386	77,882	36,301	56	143,088
2022	5.68%	7,185	21,837	1,464	82,306	38,363	59	151,215
2023	5.26%	7,563	22,987	1,541	86,637	40,382	63	159,172
2024	4.89%	7,933	24,111	1,617	90,875	42,357	66	166,958
2025	4.56%	8,295	25,211	1,690	95,020	44,289	69	174,573
2026	4.26%	8,648	26,285	1,763	99,071	46,177	71	182,016
2027	3.99%	8,994	27,335	1,833	103,027	48,021	74	189,285
2028	3.75%	9,331	28,360	1,902	106,890	49,821	77	196,381
2029	3.52%	9,660	29,360	1,969	110,657	51,577	80	203,302
2030	3.32%	9,980	30,334	2,034	114,329	53,289	82	210,049

When the electricity and fuel consumption is forecasted, the result of carbon emission is straightforward calculated from its relevant emission factors as shown in Table 3-11.

TABLE 3-11: Emission Factor for Electricity and Fuel

Grid Emission Factor (ton CO_2/MWh)
0.5690

Emission Factor of Fuel (ton CO_2/liter)					
Gasohol 91	Gasohol 95	E20	Diesel	Gasoline 91	Gasoline 95
0.0022	0.0022	0.0022	0.0027	0.0022	0.0022

The total emission from energy consumption for both electricity and fuel consumption on SAMUI Island is calculated and shown in Figure 3-11.

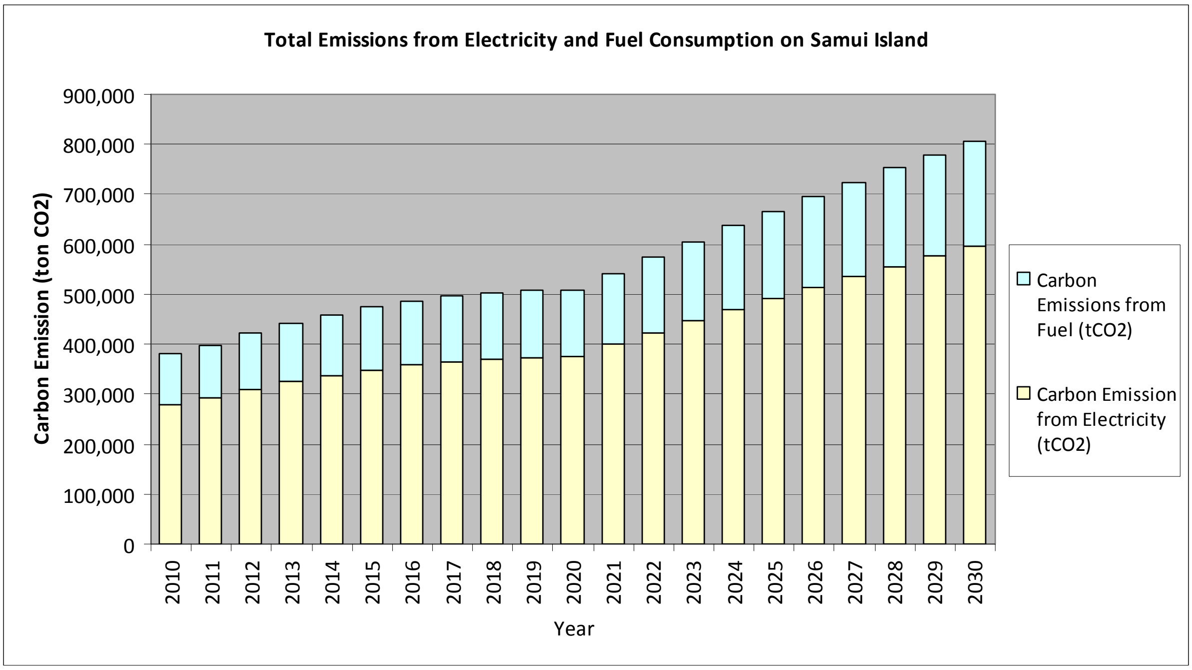


FIGURE 3-11: Total Carbon Emission from Electricity and Fuel Consumption Forecast

The total emission in Y2010 is 379,864 tons while the emission in Y2020 is 509,229 tons which increases 25.4% compared with Y2010 and 806,193 tons which increases 52.88% compared with Y2010 respectively.

FIGURE 3-12 indicates the total carbon emission in the base year (2010) and estimate Business As Usual emission in Y2020 and Y2030 for comparison.

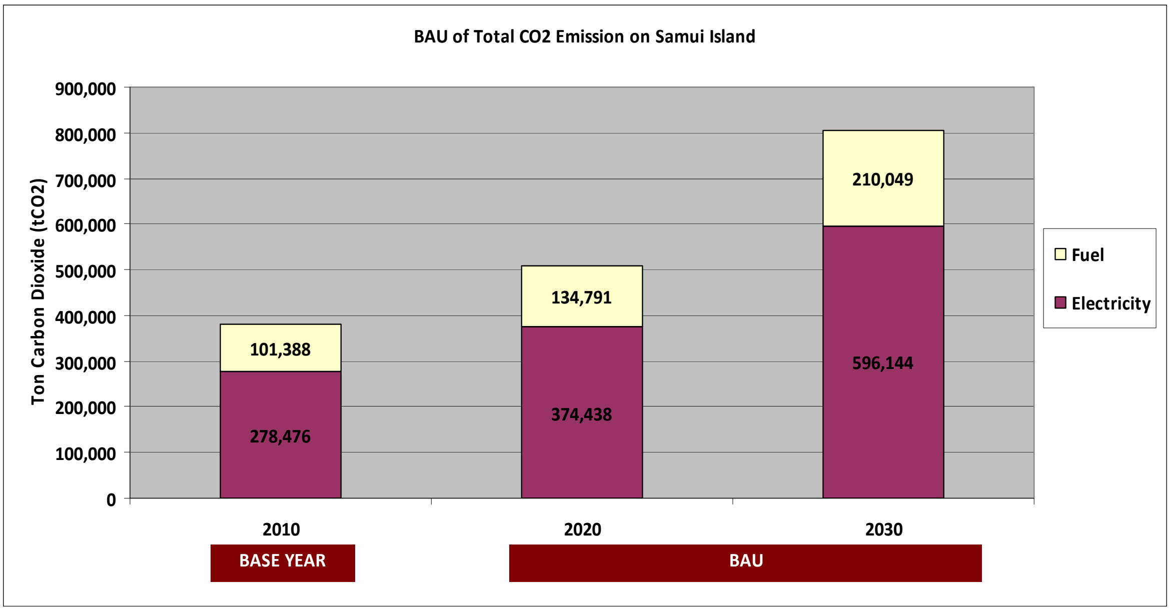


FIGURE 3-12 : Total Carbon Emission

Carbon Emission per Capita

Carbon emission is a direct measurement for low carbon definition. This carbon emission is derived from energy consumption (both electricity and fuel) on SAMUI Island. Since energy consumption is proportional to numbers of tourists each year. Therefore once, the energy consumption is measured, the carbon emission is calculated.

Population on SAMUI Island consists of locals, immigrants, tourists and visitors. Tourists are the largest. Therefore in order to reflect the carbon emission per capita, the number of tourists on the average per day will be used for carbon intensity calculation. The following formula is used.

CO_2 emission per capita = Total CO_2 emission/(number of tourists per day plus number of registered population)

TABLE 3-12 : Carbon Emission per Capita on SAMUI Island

Year	Carbon Emission from Electricity per capita	Carbon Emission from Fuel per capita	Total Carbon Emission (ton CO_2/capita)
2010	4.0	1.6	5.6
2020	4.4	1.5	5.9
2030	4.6	1.6	6.2

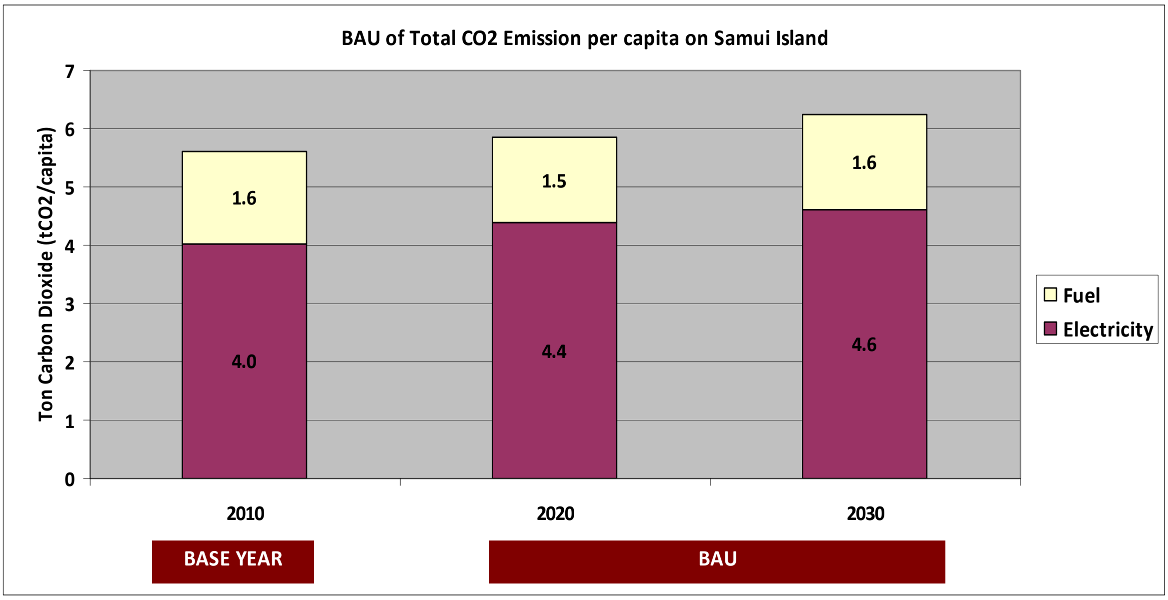


FIGURE 3-13 : Total Carbon Emission per capita

Carbon Emission per Revenue

An alternative carbon emission index is carbon emission per revenue. The same principle as carbon emission per capita, SAMUI's revenue depends on number of tourists traveling to SAMUI. Therefore the revenue directly reflects the carbon emission as well as per capita.

TABLE 3-13 : Carbon Emission per Revenue on SAMUI Island

Year	Per Revenue (ton CO_2/mil. USD)
2010	1,164.5
2020	1,310.8
2030	1,259.9

However, carbon emission per revenue index may not be easily measured. Therefore, it will be used when information is available.

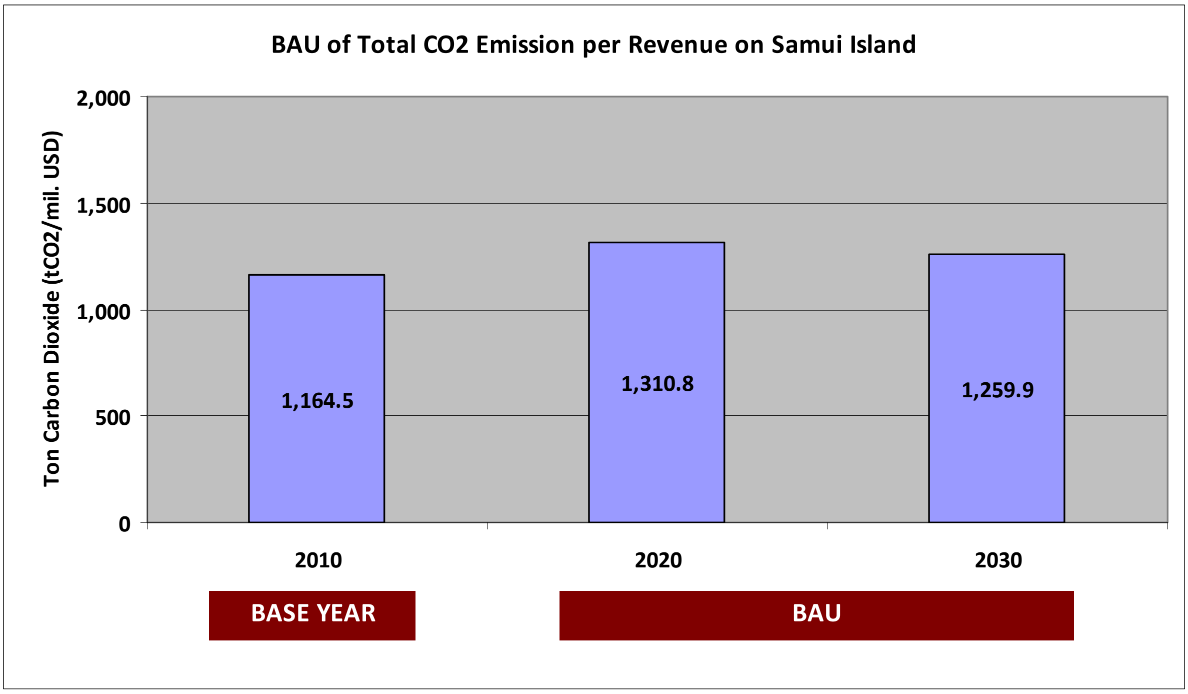


FIGURE 3-14 : Total Carbon Emission per revenue

3.4 Comprehensive and Systematic Methods for the Study of Low Carbon Development

Moving to low carbon emissions through the diffusion of specific low-carbon measures is important. However, there is a limit to what can be done to lower the entire Island's carbon output through individual responses.

In order to promote low carbon, both the energy demand side and supply side must be considered. Study at the city level is possible. Even if the supply side lowers carbon emissions, overall emissions can increase if energy consumption rises on the demand side.

Because of this, a "hierarchal approach" will be adopted. A hierarchal approach takes low-carbon measures for the entire Island in the following order: demand side, supply side, transportation, area energy management, and eco life style. This mechanism contributes to a shift to low carbon development better than the implementation of individual technologies/measures does.

The hierarchal approach can be demonstrated as shown in Figure 3-15

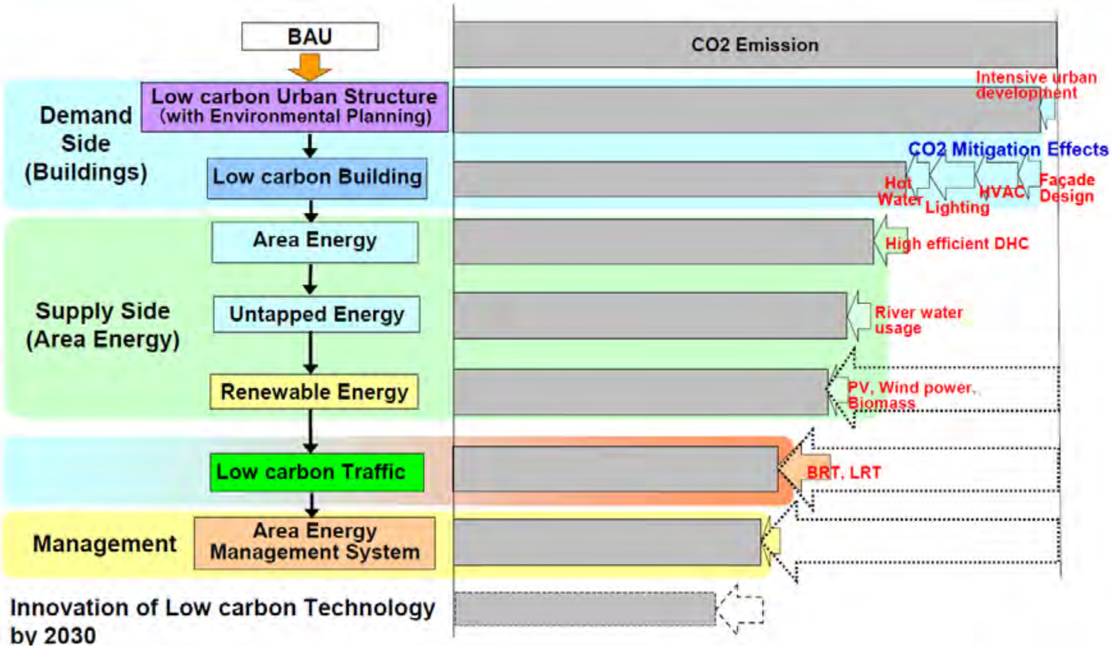


FIGURE 3-15 : Hierarchal Approach for Low Carbon Development

3.5 Carbon Emission Reduction Targets

Methodology

Carbon emission reduction targets for SAMUI Island has been configured with consideration of it's implementation and an appeal to stakeholders. Carbon emission reduction targets are configured by Main Target, Direct Index (as sub target) and Indirect Index. These targets are quantitative and able to visualize.

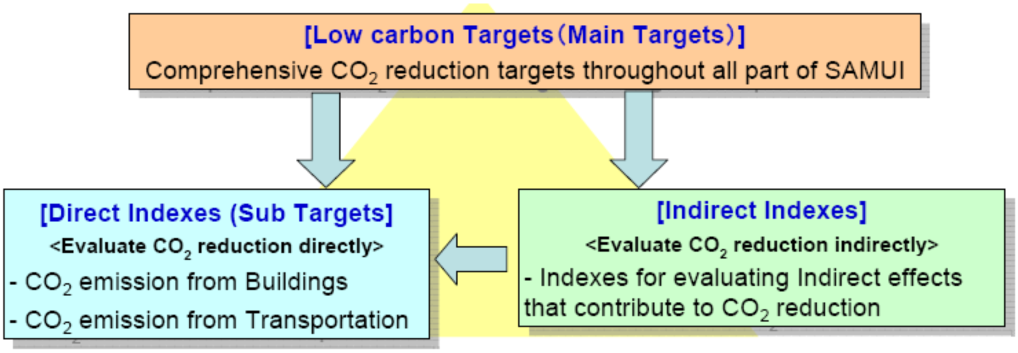


FIGURE 3-16 : Concept of Low Carbon Target Setting

Main Target

At this stage, Y2010 is selected as base year for target setting. Carbon emission reduction by 35.9% in Y2020 and 49.6% in Y2030 compare to Y2010 has been set as mid term and long term target for SAMUI Island respectively. Mid term and long term targets for SAMUI Island is shown in Figure 3-17a toFigure 3-17b.

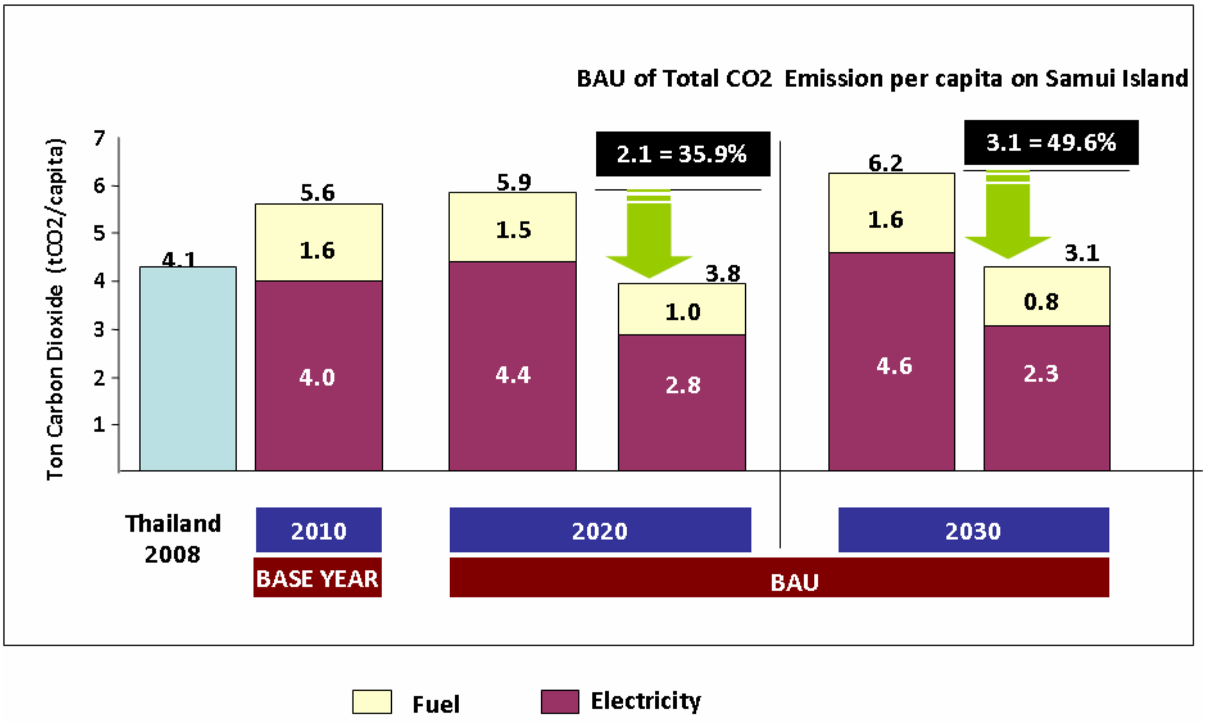


FIGURE 3-17a : Main Target for SAMUI Island - Carbon Emission per capita

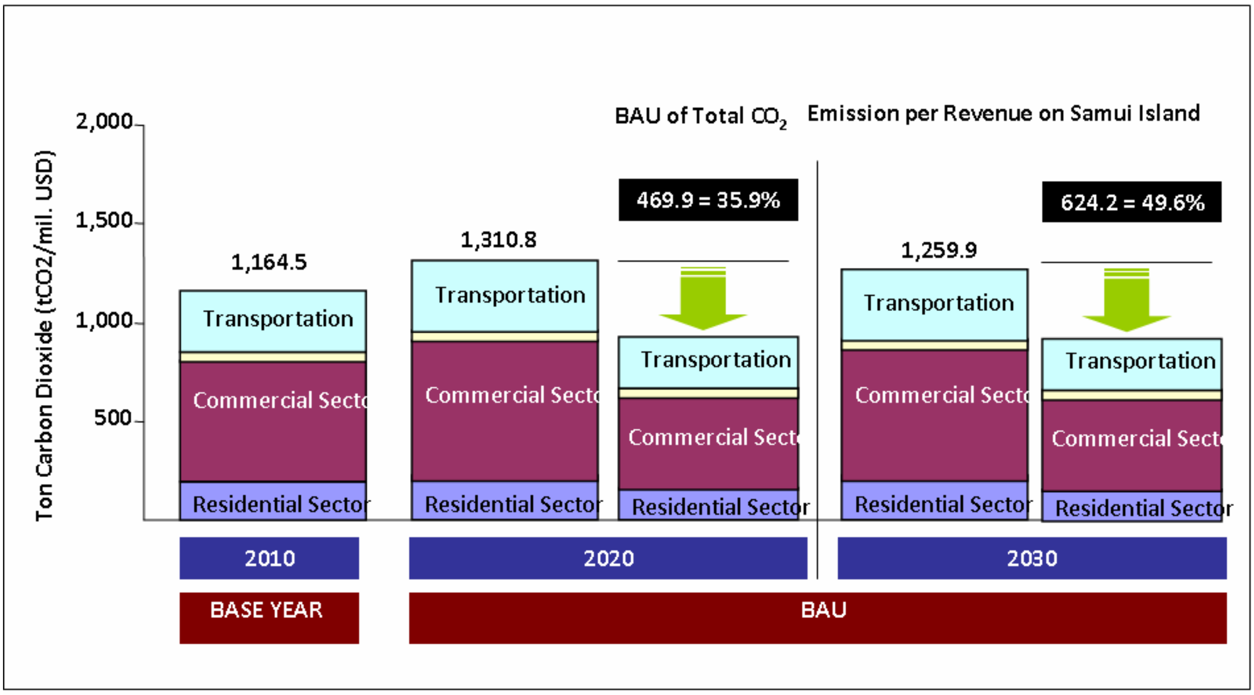


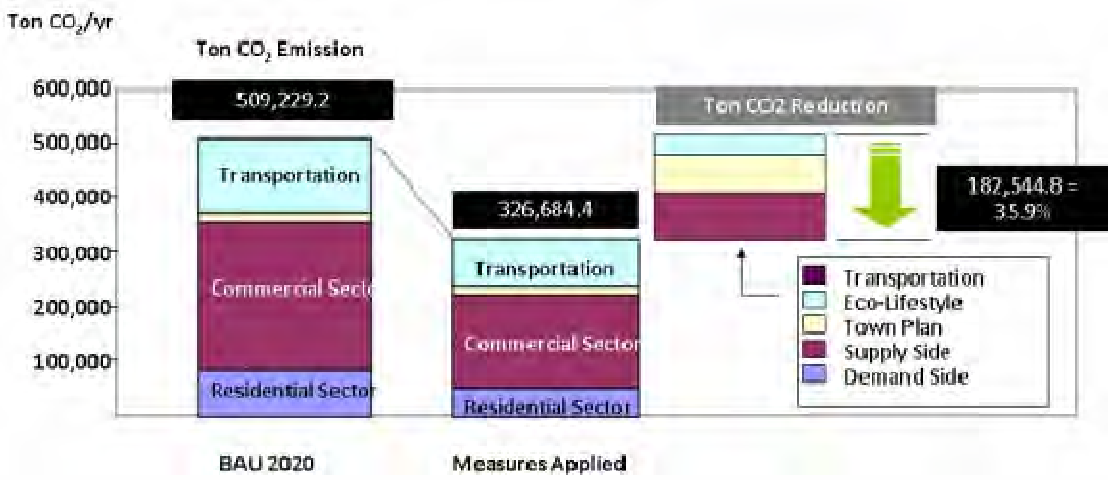
FIGURE 3-17b : Main Target for SAMUI Island - Carbon Emission per revenue

3.5.1 Target Setting

Direct Carbon Emission Index

Carbon emission is one of the key indexes in the study and directly impact to climate change. Electricity and fuel consumption reduction is considered as key sources of emission. Therefore, the direct carbon emission can be quantified if energy consumption is quantified. As shown in Figure 3-18, the target of carbon emission reduction compared with BAU 2020 and BAU 2030 are 35.9% and 49.6% respectively.

Carbon Emission Reduction on SAMUI Island



Carbon Emission Reduction on SAMUI Island

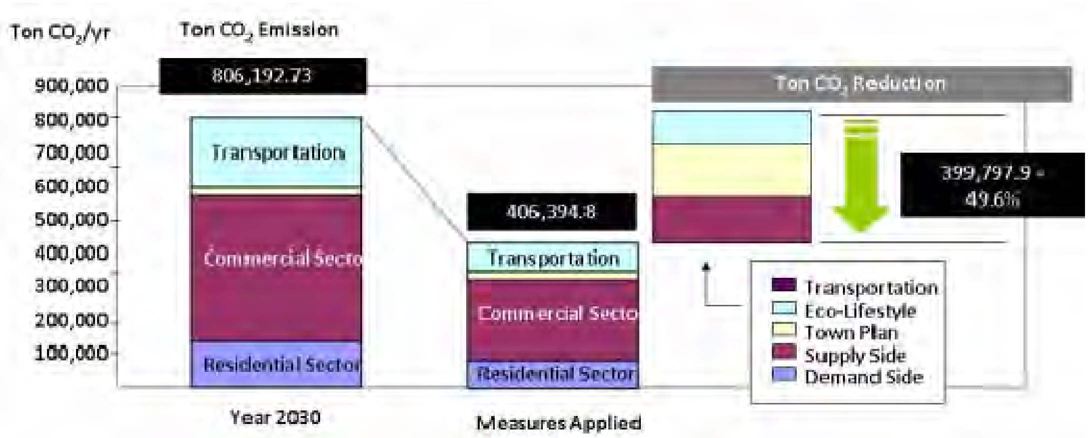


FIGURE 3-18 : Main Target compared with BAU in 2020 and 2030

Indirect Index

Indirect indexes are set out for localized key performance measurement in each category.

C1 : Town Structure Planning for Low-Carbon Development

No.	Sub-indexes	Unit	2020	2030
1	Re-forestation*	Acres	400	988**
2	Public Green Space (parks, recreation)	% Increase	10%	20%

Remarks

* Currently, SAMUI Island has total area of forest is 11.12 sq.km (2,747.752 acres). which is just 4.85% of the whole SAMUI Island

** Deforestation in SAMUI is 4 sq.km. (988 acres)

C2 : Transportation Planning

No.	Sub-indexes	Unit	2020	2030
1	Public transportation	% Increase number of tourists using public transportation	10%	10%
2	No. of EV Motorcycles	% increase of EV motorcycles	10%	30%
3	No. of EV cars, buses	% increase of EV cars, buses	10%	10%

C3 : Area Energy Planning

No.	Sub-indexes	Unit	2020	2030
1	Capacity of Electrical Power generated on SAMUI Island	MW of Electricity generation	45 MW	45 MW

C4 : Area Energy Management

No.	Sub-indexes	Unit	2020	2030
1	Smart Buildings	Number of buildings install smart building system	164	316
2	Smart Home	Number of households install smart meter system	13,982	36,850

Remarks

The smart grid is implemented prior Y2020, therefore, it is foreseen that the smart buildings and houses will be implemented to be effectively managed the demand and supply energy utility

C5 : Renewable Energy

No.	Sub-indexes	Unit	2020	2030
1	Power production from renewable energy	MW of Electricity generation	85.9	85.9

C6 : Untapped Energy Use Planning

No.	Sub-indexes	Unit	2020	2030
1	Power production from untapped energy	MW	4.67	4.67

C7 : Low Carbon Building

No.	Sub-indexes	Unit	2020	2030
1	Area of implementation of low carbon	Square meters	255,000	480,000
2	Number of Commercial buildings applied for low carbon or green certificates (ex; TREES, Green Leaf)	% Increase of buildings (hotels, resorts)	15%	30%
3	Areas of green space (Hotels, Resorts)	% of total area	5%	10%

C8 : Eco-Life Style

No.	Sub-indexes	Unit	2020	2030
1	Water consumption	% Reduction	10%	10%
2	Material consumption (*Other materials excl. fuels and water)*	% Reduction	15%	15%
3	Waste generation	% Reduction	15%	15%
4	Reusing rate	% of Total waste generation	15%	15%
5	Recycling rate	% of Total waste generation	15%	15%
6	Repairing rate	% of Total waste generation	15%	15%
7	Employment opportunity from eco-lifestyle measures (Number of workers)	Numbers of workers employed	3,000 workers	5,000 workers
8	Social and cultural value	Number of eco-services and eco-activities which provide a program/tour for visitors to gain social and cultural	50 Eco-services & 50 Eco-activities	100 Eco-services & 100 Eco-activities in 2050

No.	Sub-indexes	Unit	2020	2030
		value from local communities in SAMUI Island		
9	Community participation	Number of SAMUI Citizens involving in eco-services, eco-hotels and eco-activities	20,000 SAMUI population	30,000 SAMUI population

C9 : Environmental Planning

No.	Sub-indexes	Unit	2020	2030
1	Waste separation	% Reduction	15%	15%
2	Rainfall water reserves	% Increase of water reserves (by volumes)	10%	10%

4. Summary of Low Carbon Measures for SAMUI Island

4.1 Categories of Low Carbon Measures

Low Carbon Measures for SAMUI Island can be divided into 9 categories as following;

1. Town Structure Planning
2. Transportation Planning
3. Area Energy Planning
4. Area Energy Management
5. Renewable Energy
6. Untapped Energy Use Planning
7. Low Carbon Building
8. Eco-Lifestyle
9. Environmental Planning

Detail of each low carbon category has been provided on the next following chapters (Chapter 5 to Chapter13).

4.1.1 Town Structure Planning (Detail provided in Chapter 5)

SAMUI Island has implemented a comprehensive plan for town structure planning since 2006. However, the enforcement was not successful. In this regard, realization of low carbon measures on town structure planning is recommended and should be integrated into the new revision of town structure planning. Conceptualization of Low Carbon measures on town structure planning includes the visualization and adaptation of greenery areas and non greenery areas as followings;

Visualization and Adaptation of Greenery Areas – involve the increasing of greenery areas that would be able to absorb CO_2 in the atmosphere. The improvement of greenery areas on SAMUI Island will cover three major areas namely; Forests, Orchards and Urban Plant Areas.

Visualization and Adaptation of Non-Greenery Areas – involve the reducing of source of CO_2 emission. The improvement of non-greenery areas will cover five concepts namely; Compact Mixed Use Nodes, Green Integrated Utility System (GIUS), Original community + Neighborhood community+GIUS, Connecting nodes and Non-automobile Oriented Community.

4.1.2 Transportation Planning (Detail provided in Chapter 6)

Transportation on SAMUI Island is mainly depending on road system. Tourists travel on SAMUI Island by rental cars, taxis, rental bikes and two-row seats bus (Song Taew). Normal traveling modes for residences are personal cars and two-row seats bus. Fuel consumption for transportation on SAMUI Island is contributed to around 42 % of total energy consumption on the island. Six policies for development and maintenance of transportation system on SAMUI Island are recommended as followings.

1. Upgrading public transportation
2. Diffusion of low carbon vehicles and developing charging stations
3. Developing the space for bicycle and pedestrian
4. Traffic congestion reduction by road improvement
5. Providing appropriate sightseeing information system
6. Mobility Management

4.1.3 Area Energy Planning (Detail provided in Chapter 7)

Primary energy use in SAMUI Island is electricity purchased from Provincial Electricity Authority or PEA. This electricity is generated on the main land and transmitted through submarine feeders to SAMUI Island. The energy demand increased from 28.4 MW in Y2000 to 95 MW in Y2012. The maximum capacity of the existing submarine feeders is 93 MW with extension plan to be 193 MW by Y2013. The peak demand recorded early this year has already been reached the maximum capacity of 93 MW and expected to reach the PEA's extension capacity of 193 MW by Y2028.

It is observed that current electricity facilities have been critically short of supplies. Therefore, the expansion projects to serve higher energy demand must be invested. This is an opportunity to adopt the low carbon emission technology to produce the electricity for the island such as Combine Cycle Power Plant (CCP), Renewable energy generation from wind and solar.

4.1.4 Area Energy Management (Detail provided in Chapter 8)

As demand of electricity on SAMUI Island will be rapidly growth in the next decade. Variety of electricity supply sources such as solar, wind etc. should be introduced and implemented on SAMUI Island. Therefore, SMART Grid System would be introduced to efficiently manage electricity demand and supply on the island. SMART Grid System will assist in utilizing the electricity supply sources, monitor and real time manage the load of large electricity consumers.

4.1.5 Renewable Energy (Detail provided in Chapter 9)

Renewable Energy is another source of energy that can be utilized on the island. Solar energy, wind and small hydro power are the three major renewable energy sources that are recommended for SAMUI Island. Solar energy can be used to produce electricity through solar PV farm and solar PV rooftop connecting to the grid. Individual street lighting also can be able to utilize electricity from single solar panel. Variety of small hydroelectric power stations also can be installed along the rivers and canals in the island.

4.1.6 Untapped Energy Use Planning (Detail provided in Chapter 10)

Large amount of solid waste has been generated daily on SAMUI Island. The Municipal Solid Waste (MSW) has been burnt using incinerators at the central plant. Large amount of waste heat produced by the incinerators has been rejected to the atmosphere. Heat recovery from the exhaust of the incinerators is recommended to produce electricity to be used in the incinerator plant and nearby areas. Kitchen waste is another untapped energy source that can be utilized by converting to biogas.

4.1.7 Low Carbon Building (Detail provided in Chapter 11)

The major electricity user on SAMUI Island is commercial building sector. Commercial building includes hotels, resorts, department stores or superstores and convenient stores consume electricity for more than 60 % of total electricity consumption on SAMUI Island. Low carbon building measures are recommended for this group of electricity users. Low carbon building guideline or programme is recommended as a tool to encourage the building owners to build or renovate their own buildings to meet with the guideline and get certification from the programme.

4.1.8 Eco-Lifestyle (Detail provided in Chapter 12)

The development of eco-lifestyle measures are different from one of the low carbon measures in the previous categories. For eco-lifestyle, they are stakeholder-driven measures (bottom-up approach). Other low carbon measures are technology-driven and primaily based on top-down approach. The key stakeholders in SAMUI Island include visitors, Samui citizens and business operators/owners. Eco-lifestyle measures include the SAMUI Low Carbon Logo, SAMUI Low Carbon Center, Eco-points programme, Encouraging 3R x 2 principle, Eco activities and Eco events.

4.1.9 Environmental Planning (Detail provided in Chapter 13)

SAMUI Island is facing with several environmental issues due to rapidly growth in the number of visitors. In this regard, environmental issues including water supply management, waste water management and solid waste management are recommended.

TABLE : 4-1 Summary of Carbon Reduction Measures

Categories	Measures
1. Town Structure Planning	1. Visualization and Adaptation of Green Areas 1.1 Forest 1.1.1 Protection of the Existing Trees 1.1.2 Forest Restoration 1.2 Orchards 1.2.1 Protection of the Existing Plant 1.2.2 Replacement with Economic Plant holding higher CO_2 Absorption Rate 1.3 Urban Plant Areas 1.3.1 Development of Comfortable and Greenery Walk Pass and Street 1.3.2 Improvement of Building Envelope by Using Bio-façade 1.3.3 Adding Trees in Public Spaces and Airport Areas 1.3.4 Adding Trees in Resort Areas 1.3.5 Adaptation toward Comfortable and Greenery Beaches

Categories	Measures
	2. Visualization and Adaptation of Non Green Areas : Sustainable Town Planning 2.1 Compact Mixed Use Nodes 2.2 Green Integrated Utility System (GIUS) 2.3 Original community + Neighborhood community + GIUS 2.4 Connecting nodes 3. Visualization and Adaptation of Walkable Areas 3.1 Non-automobile Oriented Community
2. Transportation Planning	1. Upgrading public transportation 2. Diffusion of low carbon vehicles and developing charging stations 3. Developing the space for bicycle and pedestrian 4. Traffic congestion reduction by road improvement 5. Providing appropriate sightseeing information system 6. Mobility Management
3. Area Energy Planning	1. Combined Cycle Power Plant (CCP)
4. Area Energy Management	1. Smart Grid 2. Micro Grid
5. Renewable Energy	1. Solar Energy 1.1 Outdoor Lighting : Street and Car park lighting 1.2 Solar Rooftop 1.3 Solar Farm 2. Wind Energy 3. Small hydro power plant
6. Untapped Energy Use Planning	1. Use of waste heat from incinerator to generate electricity 2. Use of biogas from kitchen waste to generate electricity
7. Low Carbon Building	1. Low Carbon Building Guideline 2. Low Carbon Measures for building 2.1 Load Reduction 2.2 Increasing Equipment Efficiency 2.3 Management 2.4 Passive Design 2.5 Operation and Maintenance
8. Eco-life style	1. Eco-Logo 2. Low Carbon Center 3. Eco-Point Programme 4. Encouraging “3R x 2” Principle 5. Eco-Activities for all stakeholders 6. Eco-Events
9. Environmental Planning	1. Water Supply Management 2. Waste Water Treatment Management 3. Solid Waste Water Management

4.2 Summary of Carbon Reduction

Expected total amount of carbon reduction from all measures in topic 4.1 are 399,797.90 ton/year. Details of carbon reduction of each category can be summarized as shown in Table 4-2

Table 4-2 : Summary of Carbon Reduction for SAMUI Island

Item. No.	Categories	Carbon Emission Reduction (ton CO_2/yr)		Investment Cost (Million USD)
		2020	2030	
1	C1 : Town Structure Planning	86,795.00	236,096.04	20.14
2	C2 : Transportation Planning	-	50,348.00	126.45
3	C3 : Area Energy Planning	28,390.82	28,390.82	64.52
4	C4 : Area Energy Management *	Included	Included	20.98
5	C5 : Renewable Energy	26,765.20	26,765.20	418.40
6	C6 : Untapped Energy	16,326.02	16,326.02	35.81
7	C7 : Low Carbon Building	11,537.00	21,717.00	131.59
8	C8 : Eco-Life Style	12,730.73	20,154.82	23.86
9	C9 : Environment*	Included	Included	21.00
Total		**182,544.77**	**399,797.90**	**862.75**

Remark

* Carbon emission reduction for area energy management and environment categories are considered as indirect emission included in other related categories

5. Town Structure Planning for Low-Carbon Development

5.1 Overview SAMUI Town Structure and its Future Plan

SAMUI Island Municipality has implemented a comprehensive plan of SAMUI Community since 2006, July. This comprehensive plan has expired since 2011, June. In this comprehensive plan, town structure is divided into 12 types, but in more general speaking, there are 6 groups of town structure; e.g. residential, industry, agriculture, institution, recreation, and conservation. The type of agriculture is the dominating area (Figure 5-1).

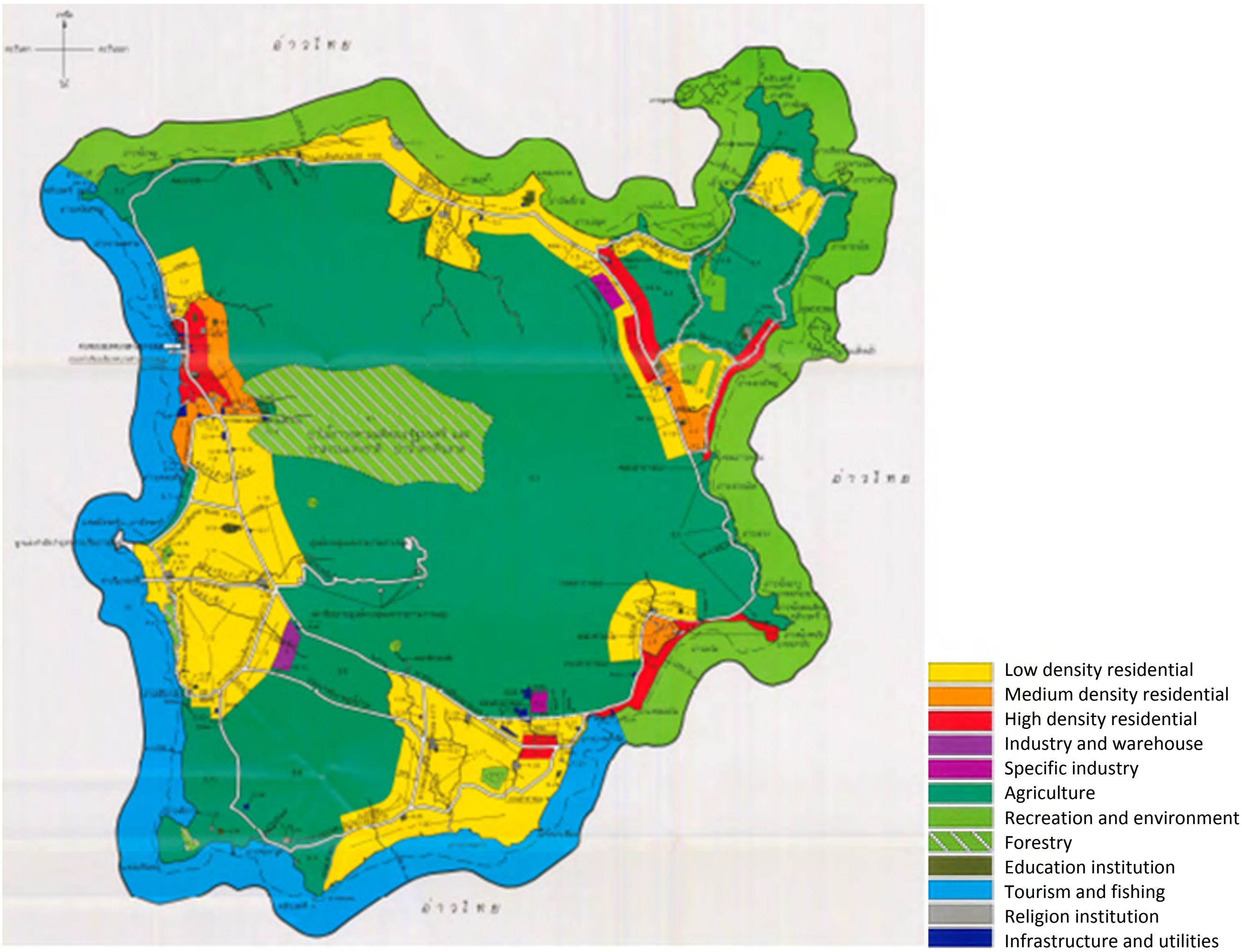


FIGURE 5-1: comprehensive plan of SAMUI Community

Source: http://www.skyscrapercity.com/showthread.php?t=805294&page=67

Although the comprehensive plan had been implemented, the enforcement was not successful. That is because there have been significant changes in economic, social, and environmental aspects, which are not according to the plan. Therefore, SAMUI Island contains various types of problem. For example, from the result of workshop seminar on SAMUI Island urban planning, on December 9, 2011, the Urban Planning Association Civic Network in SAMUI District publicized that there are a lot of urban problems such as shallow flooding, discharging wastewater into the sea, air and water pollution caused by incinerator, traffic congestion, beach encroachment, and inappropriate land use (Figure 5-2). This organization further claimed that such problems are coursed by urban sprawl without proper management (http://www.nathoncity.com/paper/5702).

FIGURE 5-2: Traffic Congestion inappropriate land use and beach encroachment in SAMUI Island

In addition to the above problems, SAMUI Island Municipality aims to transform itself into the special administrative entities, especially focusing tourism. Therefore, it needs the new comprehensive plan that supports its development toward sustainability in terms of town development, environment, and tourism development. To create the new comprehensive plan, SAMUI Island Municipality set the following policy.

1. Promote and develop SAMUI Island community to be a vital tourism destination in the upper part of Southern Thailand, and The Gulf of Thailand, in both regional and national levels.
2. Promote and develop SAMUI Island community to be a hub of local management and administration.
3. Promote eco-tourism and support the roles in agriculture with tourism development.
4. Promote housing and commercial development in the manner that is corresponding with community expansion, social and economic system of SAMUI Island District, Surat Thani Province.
5. Promote and develop sufficient and standard social welfare, public utilities and public facilities.
6. Preserve the traditional settlement character, lifestyle, art, culture, and ritual that make the community's identity.
7. Conserve the environment and natural resources according to sustainable development approach.

Accordingly, the municipality set the measures and methods in the development of new comprehensive plan to achieve the above policy as follows.

1. Specify the area for preserving and promoting original communities and main tourism communities.
2. Conserve and promote tourism that has identity to be the hub of sea tourism in Southern Thailand, The Gulf of Thailand side. The sustainable development approach, with local people's participation in the development, shall be seriously used for good quality of life.
3. Specify land use and promote the conservation of mountains, forest, coast, natural water source, and ecological system.
4. Preserve the crucial zones for religious, culture, ritual, and other public uses.
5. Specify the areas and support the conservation and promotion of agriculture as well as the unique and famous agricultural products of SAMUI Island.
6. Specify land use according to the communities' roles at various levels, and allow the communities' expansion only at the specified main center and sub center, by providing balanced transportation system with public utilities and public facilities in the said areas.

In this report, we divide town structure into 2 types; namely green and non-green area, for visualization and adaptation presented in the next topic.

5.2 Low Carbon Town Structure Plan Visualization and Adaptation

There are two approaches to reduce CO_2: to reduce the CO_2 emission at the source and to absorb CO_2 in the atmosphere. The green areas help absorb CO_2 in the atmosphere, while the sustainable town planning of non-green areas help reduce the CO_2 emission at the source.

5.2.1 Visualization and Adaptation of Greenery Areas

The increase of carbon reduction capacity may also involve the increase of green areas; i.e. the planting of trees, to combat the CO_2 emission from human activities, because trees consume CO_2 and produce oxygen. However, there is a lot of debate around this option, regarding the volume of CO_2 a tree consumes, the duration for a tree to process the expected amount of CO_2, and the died ratio of tree to be considered in planting, for example. Nonetheless, it is absolutely worthwhile to conserve trees and to plant more trees on our planet, as it gives benefits more than just the CO_2 reduction. (Bloch, n.d.)

In this part, green areas are forest, orchards, and urban plant areas.

1) Forest

In 1961, forest area occupied 53.33% of the whole Thailand, more than half of the country (Kru O, n.d. cited Supapan Na Bangchang). From 1973-2008, while forest area decreased nationwide from 43.21% to 33.44% of the whole Thailand, forest area in the southern region slightly increased from 26.07% to 27.03% of the whole south. In Surat Thani Province, approximately, there is no change from 2004 to 2008 as the forest area covers between 29.15% and 29.94% of the whole Surat Thani (Forest Information Center, 2012). In SAMUI Island, the total area of forest is 11.12 km^2. (1,110 hectares) which is just 4.85% of the whole SAMUI Island. This Figure shows that the forest was drastically destroyed and transformed into orchards. Although, normally forest has less CO_2 absorption capability than plantation (EPA, 2005), forest maintains full ecological system that give more varieties of benefit to humankind. Also, forest is a significant kind of carbon storage. If the forests are destroyed or disturbed, the carbon will be released to the atmosphere. Therefore, the protection of the existing trees and forest restoration are very crucial activities for SAMUI Island's environment.

There are two areas of forest in SAMUI Island. Both of them are located on the mountains around the island's central part. First, the Hin Lad Waterfall National Reserved Forest (Figure 5-3a) has the area of 11.10 km². (1,110 hectares). Second, Na Muang Waterfall Forest Park (Figure 5-3b) has the area of 0.02 km². (2 hectares). The major trees include Iron Wood, Yang, and Malacca Teak (Surat Thani forestry officer, 2012) as shown in Figure 5-4.

These trees are slow-growth kind of indigenous tree, and they reflect that the general forest in SAMUI Island is the mix of tropical Rain forest and dry evergreen forest. However, according to the Surat Thani forestry officer (2012), these forests have natural- abundance level just 30-35% that make the number of forestry areas in SAMUI Island reduce to 7 km^2 (700 hectares) for CO_2 calculations.

FIGURE 5-3a: Hin Lad Waterfall and Na Muang waterfall

Source http://www.phuketneophoto.com

FIGURE 5-3b: Na Muang waterfall

Source http://www.thetrippacker.com

FIGURE 5-4 : Iron Wood, Yang, and Malacca teak

Source http://www.biogang.net, http://www.takuyak.com, http://www.sandalwood.9nha.com

The existing forest normally has inconsiderable rate of CO_2 absorption, but it has substantial carbon storage capability. Carbon can be stored in above-ground biomass, below-ground biomass, and dead organic matter. However, Faculty of Forestry, Kasetsart University (2011) suggests, for Clean

Development Mechanism (CDM) in small forest plantations, only carbon storage in above-ground biomass and below-ground biomass capability can be considered. Since there is no data of SAMUI Island's forest carbon storage, we use the average number of total carbon storage in above-ground biomass and below-ground biomass measured in many tropical rain forests and dry evergreen forests of Thailand, which was gathered by Forestry Research Center, Faculty of Forestry, Kasetsart University (2009), in estimation of the existing SAMUI Island's carbon storage. That average number is 154.53 tons/hectare. Therefore, by 7 km^2. (700 hectares) **SAMUI Island's forestry areas, carbon storage number is about 108,000 tons.**

To calculate the SAMUI Island's forestry areas' CO_2 absorption rate, we use the rate of 0.95 tons of CO_2/Rai/year (5.91 tons of CO_2/hectare/year) for slow-growth kind of indigenous trees as suggested by Faculty of Forestry, Kasetsart University (2011). Therefore, **SAMUI Island's forestry areas has CO_2 absorption rate of 3,507 tons of CO_2 /year.** This rate is to be used when conducting cost-benefit analysis of forest restoration projects in SAMUI Island.

Note that there are ten major canals in SAMUI Island. In the past, of course, there were mangrove forests, according to natural conditions. However, many kinds of modern development have largely destroyed mangrove forests, such as construction of leisure place at many canals' estuary and development of housing and resort projects along the canals (Figure 5-5 and 5-6). In the time of this study, there is no available data to show amount of remaining mangrove forests.

FIGURE 5-5: Construction of leisure place at Lipa Yai canal's estuary

Source : http://webboard.serithai.net/topic/6262

FIGURE 5-6: Conditions of banks of Chaweng canal

Source : sophiabooks.blogspot.com and serithaitour.blogspot.com

As mentioned earlier, the protection of the existing trees and forest restoration are very crucial activities for SAMUI Island's environment. This report offers some practical measures as follows.

1.1) Protection of the Existing Trees

In SAMUI Island, although the total area of forest is 11.12 km². (1,112 hectares), the natural abundance level of the forest nowadays in SAMUI Island is just 30-35% that make the number of forestry areas in SAMUI Island reduce to 7 km². (700 hectares), which is just 3% of the whole SAMUI Island. Therefore, we should not lose this amount any longer. In general, participation by local people is essential to any conservation effort. However, most participatory processes, involve a number of similar steps or phases (Figure 5-7), which often take very long period to achieve a good result of conservation, and participatory processes require initiators. In Thailand, according to Jiradechakul (2007), many successful cases of natural resource conservation programmes were initiated by group of conscious local people with help of non-governmental organization (NGO). To compare, in SAMUI Island, there are "Love Chaweng Group" and "Love Lamai Group", the groups of conscious local people, recently established to take care of the environment in urban areas, but there is no serious help of NGO (Best Care International (Thailand) Co Ltd., 2010 and Thintip, 2010). Therefore, **the establishment of community forest conservation network** should be the first measure to start participatory processes in protecting the existing trees of SAMUI Island.

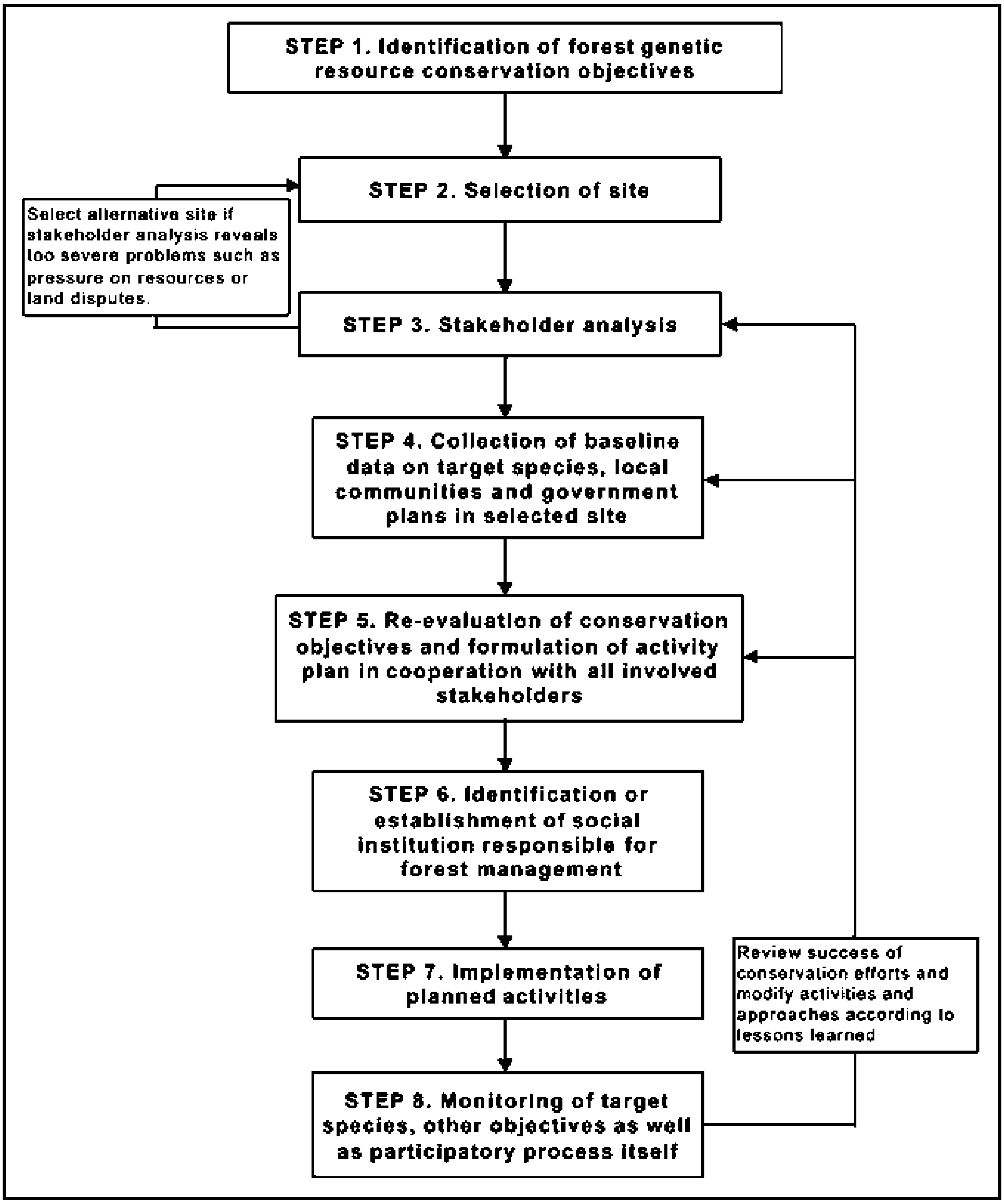


FIGURE 5-7: A model participatory process for conserving forest genetic resources

Source: Isager, Theilade, and Thomson (2001)

It is important to make a place for all community environmental conservation network's activities, including forest conservation and low-carbon activities. Kanchanapisek Conference Hall, opposite of main pier at Nathon, is recommended to be the low-carbon center for community environmental conservation network. However, its exterior renovation should be done, using Green wall to reflect more 'low-carbon' and 'green' image (Figure 5-8 to 5-11).

By using this measure, we could increase the possibility to keep CO_2 absorption rate at existing rate of 3,507 tons of CO_2/year. The investment of exterior renovation is estimated at 640,000 Baht.

FIGURE 5-8: Low-carbon Center renovation examples

Source: http://www.cleantechloops.com/what-are-green-buildings/(left) and http://architecture4us.com/house/green-building-construction-by-samyn-and-partners/(right)

FIGURE 5-9: Green walled building example at Buddy Oriental SAMUI Beach Resort

FIGURE 5-10: Kanchanapisek Conference Hall before proposed renovation

FIGURE 5-11: Kanchanapisek Conference Hall after proposed renovation

1.2) Forest Restoration

This measure includes forest restoration on mountains and at canals' Estuary. To bring back the natural abundance of the **forest on mountains**, about 4 km². (2,500 rais or 400 hectares) forest area must be in the reforestation programme. This programme should be prepared as Clean Development Mechanism (CDM) project for possible carbon credit in the future. According to Faculty of Forestry, Kasetsart University (2011), the suitable size for CDM project is 1,754 – 3,509 rais (281 – 561 hectares) of slow-growth kind of indigenous trees. So, the 2,500 rais (400 hectares) reforestation size at SAMUI Island fits in such range. Faculty of Forestry, Kasetsart University (2011), suggests **the indigenous trees** (namely, Iron Wood, Yang, and Malacca teak at SAMUI Island) **should be planted** at least 100 trees/rai (625 trees/hectares). After planting, the trees should be looked after and made use of in the gentle way, during the 20-year project duration. More importantly, as shown by Figure 5-12 and 5-13, **community forest system and "Tree Bank" programme** of the Bank for Agriculture and Agricultural Cooperatives (Bangkok Post, 2012) or the same one of the civic sector (Choonaem, 2010) should be set up to ensure the sustainable life of trees as the local planters can earn substantial income in the long term if they take good care of the trees.

FIGURE 5-12: Tree Bank

Source: http://www.oknation.net/blog/TREE-BANK

FIGURE 5-13: The success of tree bank idea

Source: http://www.tvburabha.com/tvb/home/program_detail.asp?id=742&cate=22 (left) and http://www.baac.or.th (11951-4-rayong5.jpg) (right)

At canals' estuary, the best choice to restore estuary areas and banks should be **planting mangrove forest**. According to Faculty of Forestry, Kasetsart University (2011), Mangrove can intake 2.75 tons of CO_2/rai/year (17.25 tons of CO_2/hectare/year) that is more than slow-growth kind of indigenous trees on the mountains. If planting mangrove is not possible due to the drastic change of soil structure by modern development, planting **Coconut and Palm** could be used for replacement that can intake 2.49 tons of CO_2/Rai/year (15.69 tons of CO_2/hectare/year)[1]. From our field survey, we estimate 25 rais (4 hectare) of canals' estuary to be planted with mangrove and 25 rais (4 hectare) to be planted with coconut and palm.

As shown by Figure 5-14 and Table 5-1, by using this measure, we can gain absorption rate at 1,002 tons of CO_2/year from 2015 to 2020 and 1,504 tons of CO_2/year from 2021 to 2030, in addition to the existing forest's absorption rate.

[1] These numbers belong to oil palm (Faculty of Forestry, Kasetsart University, 2011) that are used herein for the purpose of rough estimation.

FIGURE 5-14: Locations of tree banks and reforestation areas

TABLE 5-1 : CO_2 absorption rate from restoration on mountains and at canals' estuary

Types	Recovered Forest				Absorption Rate		Additional Gain (tons of CO_2/ year)		Cost (Baht)
	2020		2030				2020	2030	
	(1)	(2)	(1)	(2)	(3)	(4)			
Indigenous	1,000	160	1,500	240	0.95	5.94	950	1,425	Tree Bank 350,000
Mangrove	10	1.6	15	2.4	2.75	17.19	27	42	Planting 90,000
Coconut and Palm	10	1.6	15	2.4	2.49	15.56	25	37	
						Total	**1,002**	**1,504**	**440,000**

Remark: (1) Measured in Rai
(2) Measured in hectare
(3) Measured in tons of CO_2/Rai/year
(4) Measured in tons of CO_2/hectare/year

2) Orchards

SAMUI Island's area of 227 km². (142,031 rais or 22,700 hectare) is used for plantation most. The total area of plantation is 97,083 rais (15,533 hectare). The areas for planting each type of trees are: Coconut 84,310 rais (13,490 hectare), Durian 11,037 rais (1,766 hectare), Long kong 828 rais (132 hectare), Mangosteen 702 rais (112 hectare), and Rambutan 206 rais (33 hectare), (SAMUI Island's Academic Officer in Agriculture, 2012).

Since there is no data of carbon storage in orchards, we use the number of carbon storage in Oil palm that is 27.98 kgCO_2e/tree/year (U-sabye, 2012). With the density of plating at 22 trees/rai (137 trees/hectare), **carbon storage number in orchards here is 0.62 tonsCO_2e.**

To calculate the SAMUI Island's orchard areas' CO_2 absorption rate, we use the Oil palm's rate of 2.49 tons of CO_2/Rai/year (15.69 tons of CO_2/hectare/year) as suggested by Faculty of Forestry, Kasetsart University (2011). Therefore, **SAMUI Island's orchard areas has CO_2 absorption rate of 241,737 tons of CO_2/year.** This rate is to be used when conducting cost-benefit analysis of economic plant replacement projects in SAMUI Island.

Followings are some practical measures to deal with CO_2 matters in orchard areas.

2.1) Protection of the Existing Trees

According to the SAMUI agricultural official (2012), the coconut trees were originally planted in the predecessor's period, and have been replanted from time to time. Nowadays, the amount of coconut trees tends to decrease due to housing and resort development, pest, and declining sale price of coconut fruit. To conserve the coconut trees, SAMUI Island Municipality and private sector set up "The First Row Coconut Project". This project aim is to replant coconut trees in the old orchards and beaches. In addition, if farmers do not want to keep coconut planting, SAMUI Island Municipality offers "The Para Rubber Tree Planting Promotion Project" to replace the destroyed trees around the foothill areas with 1,000 rais (160 hectare) of Para rubber trees, as this kind of tree gives good economic return. Meanwhile, durian, Long kong, and Mangosteen planting normally has given good economic return as the farmers manage their orchards following the Good Agricultural Practices (GAP) of The Food and Agriculture Organization of the United Nations (FAO), with help of Department of Agricultural Extension in conducting their "GAP Project".

Although it seems that there is no problem in protection of the existing trees in orchard areas because there are many government projects as strong measures, additional measure to make even better economic return to prevent the farmers' sale their lands to real estate developers. This measure is **promotion of traditional home gardens, best classified as a "Multistory" tree gardens** (Figure 5-15) especially in coconut orchards that, mostly in SAMUI Island, remain a lot of vacant spaces (Figure 5-17). Being one of the Southern Thai's local wisdom, these are mixed-tree plantations consisting of conventional forest species and other commercial tree species. So, if the farmers follow this wisdom, they will earn income in every season as various fruit trees give the yields in different seasons. **Pond fishery** should also be added to make more complete farming and income according to "New Agriculture Theory" of King Rama 9. However, initial measure should include **taking local farmers to learn from successful communities** as the driving force for local farmers' motivation. There are many successful communities in Surat Thani and nearby province such as Nakonsrithammarat. In addition, **community forest system and "Tree Bank" programme**, as mentioned, should be set up to ensure the sustainable life of trees and substantial income of the local planters.

FIGURE 5-15 "Multistory" tree gardens with pond fishery

Source: http://www.bansuanporpeang.com/node/9845 (above) http://www.hotelsguidethailand.com (below)

As coconut is the tallest tree, we aim to add 30,000 rais (4,800 hectare) of eatable and multipurpose trees that are at medium height and 20% of this area with trees at low height[2] to existing coconut orchard. Also, we aim to add eatable and multipurpose trees that are at low height to the area 20% of 4,000 rais (640 hectare) remaining fruit orchard. As shown in table 5.2, by using this measure, we can gain absorption rate at 34,175 tons of CO_2/year from 2015 to 2020 and 57,993 tons of CO_2/year from 2021 to 2030.

[2] Medium height trees are such as durian and Mangosteen. We use the CO_2 absorption rate of multipurpose tree at 1.47 tons of CO_2/Rai/year or 9.17 tons of CO_2/hectare/year (Faculty of Forestry, Kasetsart University, 2011, p. 50) for calculation. Low height trees are such as Fern, Aloe Vera, Anthurium. We use the CO_2 absorption rate of Silver Evergreen at 0.51 g of $CO_2/m^2/h$ (Puangchit, n.d. cited Rawee et al., 1994) for calculation.

TABLE 5-2 : The CO_2 additional absorption rate from protection of the existing trees

Types	Area				Absorption Rate		Additional Gain (tons of CO_2/ year)		Cost (Baht)
	2020		2030				2020	2030	
	(1)	(2)	(1)	(2)	(3)	(4)			
Coconut Orchard									- Tree bank **700,000** - Learning from successful communities **430,000**
medium height	10,000	1,600	20,000	3,200	1.47	9.17	14,700	29,400	
low height	2,000	320	4,000	640	7.15	44.68	14,300	28,600	
Fruit Orchard									
low height	800	128	-	-	7.15	44.68	6,000	-	
Total							**35,000**	**58,000**	**1,130,000**

Remark: (1) Measured in Rai
(2) Measured in hectare
(3) Measured in tons of CO_2/Rai/year
(4) Measured in tons of CO_2/hectare/year

2.2) Replacement with Economic Plant Holding Higher CO_2 Absorption Rate

According to U-sabye (2012), Para rubber tree can absorb 47.42 $kgCO_2e$/tree/year, which is about double more than carbon storage in Oil palm. Faculty of Forestry, Kasetsart University (2011) reveals that Para rubber tree has rate of 4.22 tons of CO_2/rai/year (26.39 tons of CO_2/hectare/year), while Oil palm has rate of 2.49 tons of CO_2/rai/year (15.69 tons of CO_2/hectare/year). However, Oil palm should be planted for bio-diesel production to support vehicles using clean energy in SAMUI Island. In addition, Berg (2009) shows that Radiata Pine tree has rate of 15-26 tons of CO_2/hectare/year, while Navaratna (2012) publicizes Pine trees have been planted in 60 million rais (9.6 million hectare) of Georgia State, the USA, (Figure 5-16) as Georgia's Center of Innovation (COI) for Energy proved that they can produce a lot of bio-energy from pine tree in various kinds, especially bio-diesel and ethanol fuel for vehicle. Although technology of bio-energy production from pine tree in Thailand is not reliable, we still recommend planting pine tree to increase CO_2 absorption capacity, to diversify eco-system, and to supply for other use such as local construction and Biomass energy production, as the pine tree is a kind of fast growing tree suitable for economic forestry.

FIGURE 5-16: Pine tree plantation near Waycross, Georgia

Source: http://www.sciencephoto.com/media/176977/enlarge

So, by those figures, Para rubber tree and pine tree should be the best plants for replacement to gain higher CO_2 absorption rate. Therefore, as an additional measure, SAMUI Island Municipality's **Para Rubber Tree Planting Promotion Project should be expanded into "Multistory" tree gardens** to increase Para Rubber Tree beyond 1,000 rais (160 hectare) of the municipality's original target. Also, the **promotion of Oil palm and Pine tree planting** in the appropriate places, like **in big vacant areas in coconut orchards** (Figure 5-17), should be done as world demand for Para rubber sometimes decreases drastically. Moreover, between the lines of oil palm and Pine tree, eatable and multipurpose trees that are at low height should be inserted to increase economic benefits.

FIGURE 5-17: Spaces in Coconut orchard for creating "Multistory" tree gardens (left) and big vacant areas in coconut orchard for pine tree planting (right)

For CO_2 absorption rate calculation, we estimate 30,000 rais (4,800 hectare) of Oil Palm and Pine tree should be planted in big vacant areas in coconut orchards with 20% of trees at low height in this area. Also, we estimate 4,000 rais (640 hectare) of Para Rubber tree should be inserted to existing fruit orchards. As shown in Table 5-3, by using this measure, we can gain absorption rate at 45,526 tons of CO_2/year from 2015 to 2020 and 88,942 tons of CO_2/year from 2021 to 2030.

TABLE 5-3: The additional CO_2 uptake rate from Replacement with Economic Plant

Types	Area				Absorption Rate		Additional Gain (tons of CO_2/ year)		Cost (Baht)
	2020		2030				2020	2030	
	(1)	(2)	(1)	(2)	(3)	(4)			
Coconut Orchard									
Oil palm and pine tree	10,000	1,600	20,000	3,200	2.49	15.69	25,000	50,000	39,000,000
low height	2,000	320	4,000	640	7.15	44.68	14,500	28,500	500,000
Fruit Orchard									
Para Rubber tree	1,500	240	2,500	400	4.22	26.38	6,500	10,500	11,200,000
Total							**46,000**	**89,000**	**50,700,000**

Remark: (1) Measured in Rai
(2) Measured in hectare
(3) Measured in tons of CO_2/Rai/year
(4) Measured in tons of CO_2/hectare/year

3) Urban Plant Areas

Refurbishment of urban plant areas can help absorb carbon. In addition, it helps create image of "Low Carbon Town". This way requires small financial investment. This report offers the concepts of Development of Comfortable and Greenery Walk Pass and Street; Improvement of Shop-houses by Using Bio-façade; Adding Trees in Resort Areas; and Adaptation toward Comfortable and Greenery Beaches.

3.1) Development of Comfortable and Greenery Walk Pass and Street

3.1.1) Trees on footpath Most walk passes and streets in SAMUI Island's urban area are narrow and look dry. Also, there are many public utility cables in the air. FIGURE 5-18 shows the comparison of most footpath and streets with the more greenery ones in the example town. However, there are some rooms to plant trees both sides of the streets. Faculty of Forestry, Kasetsart University (2011) suggests the plants such as Golden Shower, Broad Leaf Mahogany, White Cheesewood, Burmese Rosewood, Queen's Crape Myrtle, Indian cork tree, to help absorb CO_2 in urban areas. It is estimated **664 trees could be planted on the footpath** that has more than 2 meter width, while these trees can absorb 1.21 tons of CO_2/Rai/year (7.52 tons of CO_2/hectare/year). Therefore, starting from 2015, we can gain the total of 18 tons of CO_2/Rai/year (112.5 tons of CO_2/hectare/year) from this kind of planting, and we can estimate cost about 400,000 Baht which including maintenance cost as shown in Table 5-4.

TABLE 5-4 : The additional CO_2 absorption rate from trees planted on the footpath

Road	Total distance (kilometre)	Estimate distance (kilometre)	Amount of trees in 2015	Absorption Rate (tons of CO_2/ year)	Cost (Baht)
Chaweng-Choeng Mon	3.10	0.93 (30%)	155	4	100,000
Angthong	1.33	1.33 (100%)	222	6	130,000
Chaweng-Lake	1.72	1.72 (100%)	287	8	170,000
			Total	**18**	**400,000**

FIGURE 5-18: walk passes and streets in SAMUI Island (left) VS. more greenery ones (right)

Source: www.gotoknow.org (right FIGURE)

3.1.2) Plant on steel structure For the footpath that has less than 2 meter width, it is impossible to plant those big trees on the footpath. The steel structure with climbing plants on (Figure 5-19) should be installed instead of big trees. In addition, there are three piers at Nathon beach. Two of them have no shade for walkway (FIGURE 5-20) and therefore need covered-ways like the one at municipality's pier 2 (Figure 5-22). After the new covered-ways are completed, all three covered-ways (with the water supply that already in place nowadays) should be covered up with climbing plants Figure 5-21 and 5-23) to create green image of SAMUI Island at the first entry of the island, as the existing plan of SAMUI municipality to improve the landscape of Nathon pier (Figure 5-24) still does not include planting and new covered ways that are suggested by this report. Climbing ylang-ylang and Blue Trumpet are recommended plants for this strategy.

FIGURE 5-19: Existing steel structure with climbing plants, on footpath in SAMUI Island

FIGURE 5-20: Two piers at Nathon beach with no shade for walkway (before)

FIGURE 5-21: **Two piers at Nathon beach with shade for walkway (after)**

FIGURE 5-22: Covered-ways at municipality's pier 2 (before)

FIGURE 5-23: Covered-ways at municipality's pier 2 (after)

FIGURE 5-24: Views from existing plan to improve the landscape of Nathon pier

Source: http://www.nathoncity.com/

It is estimated **4,592 m^2 of these plants to be potted on 1-meter width steel structure on the footpath that has less than 2 meter width, and on one side of the three covered-ways toward the piers**. This plant has CO_2 absorption rate at 19.48 tons of CO_2/Rai/year (121.25 tons of CO_2/hectare/year). Therefore, starting from 2015, we can gain the total of 124 tons of CO_2/Rai/year from this kind of planting and we can estimate cost about 11,200,000 Baht which including maintenance cost, as shown in Table 5-5.

TABLE 5-5: The additional CO_2 absorption rate of trees planted on the footpath

Road	Total distance (km.)	Estimate distance (km.)	Estimate areas		Absorption Rate (tons of CO_2/ year)	Cost (Baht)
			(1)	(2)		
Chaweng-Choeng Mon	6.2	4.3 (70%)	2.2	0.35	42	3,800,000
Route 4169 (Nathon)	1.4	1.4 (100%)	0.7	0.11	14	1,200,000
piers at Nathon beach	0.65	0.65 (100%)	0.4	0.06	8	900,000
Chaweng-Lake	4.94	4.94 (100%)	3.0	0.48	60	5,300,000
				Total	**124**	**11,200,000**

Remark: (1) Measured in Rai
(2) Measured in hectare

3.1.3) Green wall Greenery Walk Pass and Street could be done also by creating green walls. The economical green walls should be created by installing wire mesh with climbing plants (Figure 5-25) on the fences of public properties such as temples and government offices (Figure 5-26). However, the easier and cheaper way is just to **plant Ficus Pumila on the walls** (Figure 5-27), as Ficus Pumila walls exist in many SAMUI's locations.

FIGURE 5-25: Wire mesh with climbing plants

Source: http://research.rdi.ku.ac.th/forest/Publish.aspx?PublishID=3677

FIGURE 5-26: Example of walls in SAMUI that should be transformed to green walls

FIGURE 5-27: Ficus Pumila on the walls

Source: http://www.tup.ac.th/pasinee/maipra/4sleep/3teentuckair_ped.html

As the example of the improvement shown by Figure 5-28, the green wall's estimated area is 400 km². This amount of trees can absorb 1.89 tons of CO_2/year (at the rate 19.98 tons CO_2 /Rai/year or 7.99 tons CO_2 /hectare/year) [3].

[3] These numbers belong to Ficus Pumila tree (Sunakorn and Kasemsap, 2011) that are used herein for the purpose of rough estimation.

FIGURE 5-28: Example of walls in SAMUI Island after being transformed to green walls

3.1.4) Highway trees The last way in the development of comfortable and greenery walk pass and street is to plant trees along the SAMUI's major ring road (state highway no. 4169). In this report, the area both sides of this road running thru countryside areas are considered as urban area too. It is found that there are a lot of **vacant areas along the state highway no. 4169 where trees should be planted** to improve its greenery condition. So, we estimate 50% of the ring road distance could be added by trees. The number of trees to be planted is 8,333, which is about 189 rais (30.24 hectare). This amount of trees can absorb 229 tons of CO_2/year (at the rate 1.21 tons of CO_2/Rai/year or 7.52 tons of CO_2/hectare/year).

FIGURE 5-29 : little greenery state highway no. 4169 in countryside areas

Source: http://www.teedin108.com/land/view/28054 (left)

FIGURE 5-30 : little greenery state highway no. 4169 in urban areas

FIGURE 5-31 : Example of greenery state highway

Source: http://www.oknation.net/blog/print.php?id=137021 (left) and http://www.thaimtb.com/cgi-bin/viewkatoo.pl?id=122335 (right)

The total figure is 373 tons of CO_2/year that could be gain by development of comfortable and greenery walk pass and street, starting from 2015, as shown in Table 5-6.

TABLE 5-6 : CO_2 absorption gain by comfortable and greenery walk pass and street development

Items	CO_2 absorption rate	Cost (Baht)
trees on footpath	18	400,000
plant on steel structure	124	11,200,000
green wall	2	30,000
Highway trees	229	2,300,000
Total	**373**	**13,930,000**

3.2) Improvement of Building Envelope by Using Bio-façade

Growing trees to absorb Carbon dioxide is a fundamental effort to mitigate global warming, but was always limited in high density city. Climbing plants on wall (Figure 5-32) can also be a solution to increase green area and absorb Carbon dioxide as much as growing trees or shrubs on ground, if receive enough sunlight, by occupying much less ground area. The research found that, the maximum amount of CO_2 uptake of 1x1 m Thunburgia grandiflora wall is 20 ppm per 10 seconds[4] (Sunakorn and Kasemsap, 2011). As the density of CO_2 is 1.98 kg/m^3, the maximum amount of CO_2 uptake by Thunburgia grandiflora wall is 0.000002 m^3. So, we estimate that the maximum amount of CO_2 uptake is 0.00000396 kg/10 seconds or 12.49 kg/m^2/year or 19.98 tons CO_2/rai/year or 124.9 tons CO_2 /hectare/year.

FIGURE 5-32 : Bio-façade used at Kasetsart University

http://pr.ku.ac.th (left) http://www.biofacade.com (right)

In SAMUI Island, **the existing non-attractive public buildings**, such as district office, public housing, and municipality office buildings **should be partly covered by Bio-façade** (Figure 5-33 and 5-34). Also, for private buildings that have available walls for Bio-façade (Figure 5-35 and 5-36), in the long term, Samui Municipality should **provide incentives to the private building owners, who install Bio-façade,** such incentives as subsidizing the initial cost and water supply for irrigation because Bio-façade makes various benefits for public. Not only can it absorb CO_2, it can lower the surrounding

[4] ppm = parts per million : PPM is a term used in chemistry to denote a very, very low concentration of a solution. One gram in 1000 ml is 1000 ppm and one thousandth of a gram (0.001g) in 1000 ml is one ppm.

temperature and prevent the heat transfer into the building that increases energy savings for public, for example.

FIGURE 5-33: Public housing, and municipality office buildings to be partly covered by Bio-façade

FIGURE 5-34: District office before and after improvement by using Bio-façade

FIGURE 5-35: Example of private buildings that have available walls for Bio-façade

FIGURE 5-36: Private buildings after improvement by using Bio-façade

For CO_2 absorption rate calculation, we estimate 690 m². of private buildings in Chaweng Beach neighborhood (10 times of buildings in above FIGURE) and 920 m². of District office, public housing, and Municipality office buildings in Nathon neighborhood. This can absorb 20.11 tons of CO_2/year, and we can estimate cost about 1,800,000 Baht which including maintenance cost, as shown in Table 5-7, starting from 2015.

TABLE 5-7: The additional CO_2 absorption rate from using Bio-façade

Neighborhood	Total areas (m^2)	Absorption Rate (tons of CO_2/ year)	Cost (Baht)
Chaweng	690	9	800,000
Nathon	920	11	1,000,000
	Total	**20**	**1,800,000**

3.3) Adding Trees in Public Spaces and Airport Areas

Airport areas and a lot of public spaces in SAMUI Island contain large areas, remaining spaces for adding trees. The additional trees should give various benefits to the public and airport owners as an incentive for participating in this CO_2 reduction program. There are many multipurpose trees could be used such as Cassod Tree, Siamese neem Tree, Tamarind, Pine tree, and, of course, Coconut (Figure 5-37 to 5-40).

FIGURE 5-37: Example of the areas in SAMUI Island airport for adding trees

FIGURE 5-38: The areas in SAMUI Island airport before and after adding trees

FIGURE 5-39: Example of public spaces around municipality office, hospital, transportation center, temple, and district office for adding trees

FIGURE 5-40: Space around district office before and after adding trees

For CO_2 absorption rate calculation, we estimate number of trees to planted is 845. This amount of trees can absorb 23 tons of CO_2/year[5],

[5]We use the CO_2 absorption rate of urban tree at 1.21 tons of CO_2/Rai/year or 7.52 tons of CO_2/hectare/year (Faculty of Forestry, Kasetsart University, 2011, p. 50) that are used herein for the purpose of rough estimation.

as shown in Table 5-8, starting from 2015. And we can estimate cost about 484,000 Baht which including maintenance cost.

TABLE 5-8 : The additional CO_2 absorption rate from adding trees in public spaces and airport areas

Public Space	Total distance (kilometre)	Amount of trees	Absorption Rate (tons of CO_2/ year)	Cost (Baht)
airport	2.64	440	12	247,000
district office	0.072	12	0.3	7,000
municipality office	0.15	25	0.7	15,000
hospital	5,000 (km^2)	140	4	83,000
transportation center	0.2	33	1	19,000
Chaweng-Lake	0.86	194	5.2	114,000
	Total	**845**	**23**	**484,000**

3.4) Adding Trees in Resort Areas

A lot of resorts in SAMUI Island contain large areas. However, there is a little number of resorts that are really full of trees, with climbing plants on many of them and eatable garden, like Chaweng Garden Beach Resort (Figure5-41). So, from comparison with Chaweng Garden Beach Resort, most resorts in SAMUI Island still have remaining spaces for adding trees (Figure 5-42) and have existing large trees for climbing plants. The additional trees should give various benefits to the resort owners as an incentive for participating in this CO_2 reduction programme. There are many multipurpose trees could be used such as Cassod Tree, Siamese Neem Tree, Tamarind, pine tree, and, of course, coconut. Also, there are many climbing plants could be used such as ferns and orchids.

For CO_2 absorption rate calculation, we estimate areas to plant Multipurpose trees[6] of 160 rais (25.71 hectare). This amount of trees can absorb 154 tons of CO_2/year in 2015 and 81 tons of CO_2/year in 2020. The estimated areas to plant climbing trees[7] is 10 rais (1.61 hectare). This amount of trees can absorb 130 tons of CO_2/year in 2015 and 68 tons of CO_2/year in 2020. Then these two kinds of trees

[6] We use the CO_2 absorption rate of multipurpose tree at 1.47 tons of CO2/Rai/year or 9.17 tons of CO_2/hectare/year (Faculty of Forestry, Kasetsart University, 2011, p. 50).

[7] The CO_2 absorption rate of Thunburgia grandiflora as the climbing tree is at 19.98 tons CO_2 /Rai/year or 124.9 tons of CO_2/hectare/year (Sunakorn and Kasemsap, 2011) that are used herein for the purpose of rough estimation.

can absorb 284 tons of CO_2/year and 149 tons of CO_2/year in 2020, and cost of initial investment is 1,040,000 Baht which including maintenance cost, as shown in Table 5-9, starting from 2015.

FIGURE 5-41: Chaweng Garden Beach Resort's trees, Climbing plants, and Eatable garden

FIGURE 5-42: Resorts with remaining spaces for adding trees

TABLE 5-9: The additional CO_2 absorption rate of adding trees in resort areas

Resort Areas	Total area		Estimated area		Absorption Rate (tons of CO_2/ year)		Cost (Baht)
	(1)	(2)	(1)	(2)	2015	2020	
Multipurpose trees							
Chaweng	323.86	51.82	64.77	10.36	62	33	320,000
Maenam	196.28	31.40	39.26	6.28	38	20	200,000
Lamai	283.37	45.34	56.67	9.07	54	28	280,000
Total					**154**	**81**	**800,000**
Road	**Total area**				**Absorption Rate (tons of CO_2/ year)**		**Cost (Baht)**
	(1)		(2)		**2015**	**2020**	
Climbing plants							
Chaweng	4.05		0.65		52	28	100,000
Maenam	2.45		0.39		32	17	60,000
Lamai	3.54		0.57		46	23	80,000
Total					**130**	**68**	**240,000**
				Total	**284**	**149**	**1,040,000**

Remark: (1) Measured in Rai
(2) Measured in hectare

3.5) Adaptation toward Comfortable and Greenery Beaches

Although there are a lot of large trees, mostly Tropical or Sea almond, along the line of the beaches, many areas are vacant, or remain rooms to insert large trees (Figure 5-43). Therefore, beaches also become target for adaptation in this CO_2 reduction program. Also, in addition to the municipality's program, "The First Row Coconut Project", lower-level trees such as Frangipani and Crinum Lily (Figure 5-44), that give more shade or "green" character on the beaches should be planted while the newly planted large trees are not grown up.

FIGURE 5-43: Large trees and remaining spaces for adding trees

FIGURE 5-44: Half Flower (left) and Crinum Lily (right)

Source: http://www.magnoliathailand.com (left) http://www.faed.mju.ac.th (right)

FIGURE 5-45: Environment of the beach after adding trees

For CO_2 absorption rate calculation, we estimate distance 3 km. for Chaweng and 3 km. for Lamai (70% of total distance), then estimate areas to plant Coconut tree, Frangipani and Crinum Lily tree[8]. As shown in Table 5-10, by using this measure, we can gain absorption rate at 43 tons of CO_2/year starting from 2015 to 2020 (at 40%) and 59 tons of CO_2/year from 2021 to 2030 (at 60%). And we can estimate cost about 1,400,000 Baht which including maintenance cost.

[8] We use the CO_2 absorption rate of multipurpose tree as Frangipani at 1.47 tons of CO_2/Rai/year or 9.17 tons of CO_2/hectare/year (Faculty of Forestry, Kasetsart University, 2011, p. 50). And we use the CO_2 absorption rate of Silver Evergreen as Crinum Lily at 7.15 tons of CO_2/Rai/year or 44.68 tons of CO_2/hectare/year (Puangchit, n.d. cited Rawee et al., 1994) that are used herein for the purpose of rough estimation.

TABLE 5-10: The additional CO_2 absorption rate of adding trees in beaches

	Estimated distance (kilometre)	Amount of trees	Estimated Area		Absorption Rate (tons of CO_2/ year)		Cost (Baht)
			(1)	(2)	2020	2030	
Chaweng							
Coconut	3.0	332	16.59	2.65	17	24	260,000
Frangipani	3.0	498	11.31	1.81	7	9	240,000
Crinum Lily	1.5	-	0.56	0.09	2	2	340,000
Total					**26**	**35**	**840,000**
Lamai							
Coconut	2.8	221	11.06	1.77	11	16	170,000
Frangipani	2.8	332	7.54	1.21	5	6	160,000
Crinum Lily	1.0	-	0.37	0.06	1	2	230,000
Total					**17**	**24**	**560,000**
				Total	**43**	**59**	**1,400,000**

Remark: (1) Measured in Rai
(2) Measured in hectare

In summary, the measures in visualization and adaptation of green areas could gain 700 tons of CO_2/year in 2015, 85,701 tons of CO_2/year in 2020, and 148,563 tons of CO_2/year in 2030 by the investment of 71,564,000 Baht, as shown in Table 5-11. Maintenance cost for every item is totally 1,320,000 Baht/year.

TABLE 5-11: The overall additional CO_2 absorption rate

Measures	Additional Gain (tons of CO_2/ year)			Accumulation (tons of CO_2/ year)		Cost (Baht)
	2015	2020	2030	2020	2030	
1.1) Protection of the Existing Trees	-	3,507		3,507	3,507	640,000
1.2) Reforestation	-	1,002	1,504	1,002	2,506	440,000
2.1) Protection of the Existing Trees	-	35,000	58,000	35,000	93,000	1,130,000
2.2) Replacement with Economic Plant Holding Higher CO_2 Absorption Rate	-	46,000	89,000	46,000	135,000	50,700,000
3.1) Development of Comfortable and Greenery Walk Pass and Street	373	-	-	373	373	13,930,000
3.2) Improvement of Building Envelope by Using Bio-façade	20	-	-	20	20	1,800,000
3.3) Adding Trees in Public Spaces and Airport Areas	23	-	-	23	23	484,000
3.4) Adding Trees in Resort Areas	284	149	-	433	433	1,040,000
3.5) Adaptation toward Comfortable and Greenery Beaches	-	43	59	43	102	1,400,000
Total	**700**	**85,701**	**148,563**	**86,401**	**234,964**	**71,564,000**

5.2.2 Visualization and Adaptation of Non-greenery Areas: Sustainable Town Planning

1) Original Communities Overview

There are 5 major communities and 3 more potential towns indicated by population density (Figure 5-46). The 5 major communities are:

- Nathon community, in Ang Thong sub-district which has total population of 10,224 people, 5,009 households and density is 364 persons/ km²
- Mae Nam sub-district which has total population of 7,374 people, 5,742 households and density is 234 persons/ km²
- Chaweng community, in Bo Phut sub-district which has total population of 14,499 people, 14,746 households and density is 242 persons/ km²
- Lamai and Hua Thanon community, in Ma Ret sub-district which has total population of 8,006 people, 6,479 households and density is 367 persons/ km²

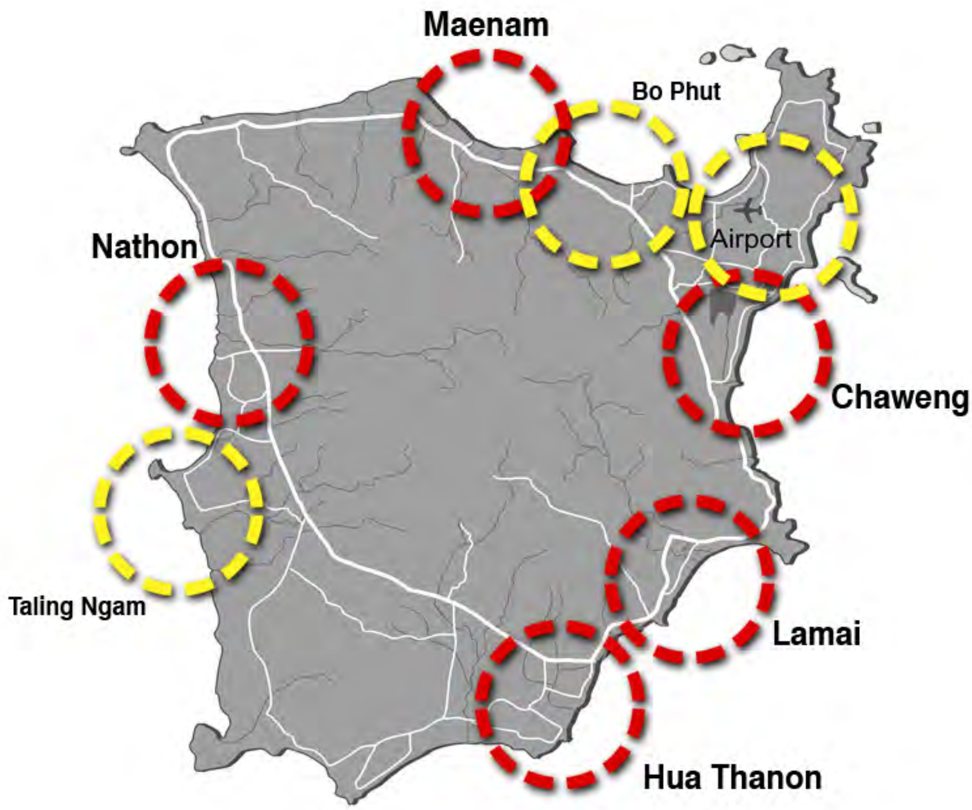


FIGURE 5-46 : 5 major communities and 3 more potential towns on SAMUI Island Map

Considering potential areas :

- Fisherman's Village (or Baan Bo Phut) in Bo Phut sub-district, with SAMUI Airport, is a significant area for both business and community development.
- Taling Ngam sub-district, which has a total population of 5,349 people, 2,382 households, representing a density is 195 persons/ km²

These communities are different in several aspects (natural landscape, beach, culture, activity, etc.). The difference makes each community unique and contributes to the island's charm. In the past 10 years, when SAMUI has become one of the world's most desirable tourist destinations for its natural beauty and image of small-picturesque island villages secluded from the outside world, people have been pouring down to this small piece of land in the middle of the sea some came for vacations some for permanent living.

Tourism Authority of Thailand (TAT) evaluated the capabilities of a number of tourists' visits on SAMUI Island in 2010. It found that there were approximately 800,000 tourists, or an average of 3,000 tourists per day (http://www.tourisminvest.tat.or.th).

However, before that year, Thailand Institute of Scientific and Technological Research (TISTR, 1995) suggested that, SAMUI Island should have a limited number of hotel rooms at no more than 8,000 rooms in 1999 and 11,000 rooms in 2004 in order to maintain tourism capacity.

The suggested figures differ from the real ones as in 2003, 2007, 2010 and 2012 number of rooms was 10,913 14,405 15,012 and 20,000 rooms respectively; which can be seen that the number of hotel rooms was increasing rapidly at a maximum point. According to this rate, the number of hotel rooms will increase to 28,800 rooms in 2020 and 45,400 rooms in 2030 when calculated from 1.35 percent increasing rate per year through the forecast period (http://www.tourisminvest.tat.or.th).

Consequently, the great amount of tourists draws in businesses, workers, migrants, and several unimaginable activities; while local facilities such as roads, infrastructures, and energy supplies were barely prepared and unmanaged. The example of existing infrastructures is as follows.

- Distribution of electricity in SAMUI Island was 152,473,089 kW by the distribution of housing segment 36,436,589 kW, business and industry segment 108,927,433 kW, government and public service 4,401,770 kW and others 2,707,279 kW. There were 16,541 electricity users in total.
- There are three 3 sub service stations:

  1) Office of the Provincial Electricity Authority SAMUI Island
  2) Mae Nam sub-district sub-station and
  3) Taling Ngam sub-district sub-station. In addition, EPA also plans to extend the power cable under the water to reserve electricity for whole SAMUI Island.

- Water supply on SAMUI Island has a total capacity of 925 cubic meters per hour. Water production is 7,370,990 cubic meters per year. The amount of water available was 5,850,280 cubic meters per year. There were 10,933 water users.
- Water Supply Authority has extended water service around the Island and rushing the construction of reservoirs and water systems. There was a large source of raw water in the Chaweng swamp with the area of 443 rais (0.709 km^2). In addition, there were Na Muang swamp 222 rais (0.355 km^2) and Krajood swamp 42 rais (0.067 km^2), and a construction of swamp extension for the city of Chaweng and Lamai in order to increase the ability of public water supply.

As shown above, although there are preparations to provide infrastructure for the future, uncontrolled growth of population density (Figure 5-47) may still cause a critical situation.

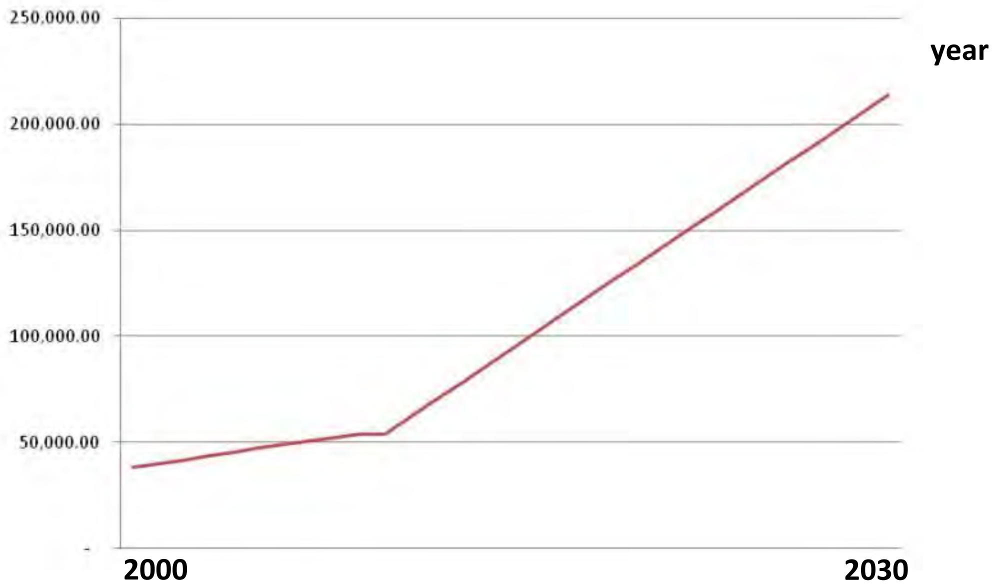


FIGURE 5-47 : Population Growth on SAMUI Island during the years 2000 - 2030

If this was going to continue without intervention, the island would soon be chaotic (Figure 5-48) and loose its unique identity and would probably be vanished from the tourist maps.

FIGURE 5-48 : Increasing of population density

Therefore, as an initial measure, the study of Tourism Carrying Capacity (TCC) should be considered to evaluate the current situation and to forecast the future that will lead the way in further development. "Tourism Carrying Capacity" is defined by the World Tourism Organization as “The maximum number of people that may visit a tourist destination at the same time, without causing destruction of the physical, economic, socio-cultural environment and an unacceptable decrease in the quality of visitors' satisfaction”--or other words--the maximum value of the impact of human activities conducted to allow the environment without degradation. By taking into account, the four areas, as follows, are linked as shown in FIGURE 5-49.

1) the biophysical,
2) the social and cultural,
3) social psychology, and
4) management

Table 5-12 shows parameters and criteria to assess their ability to get physical, facilities and psychology by using level of acceptable impact.

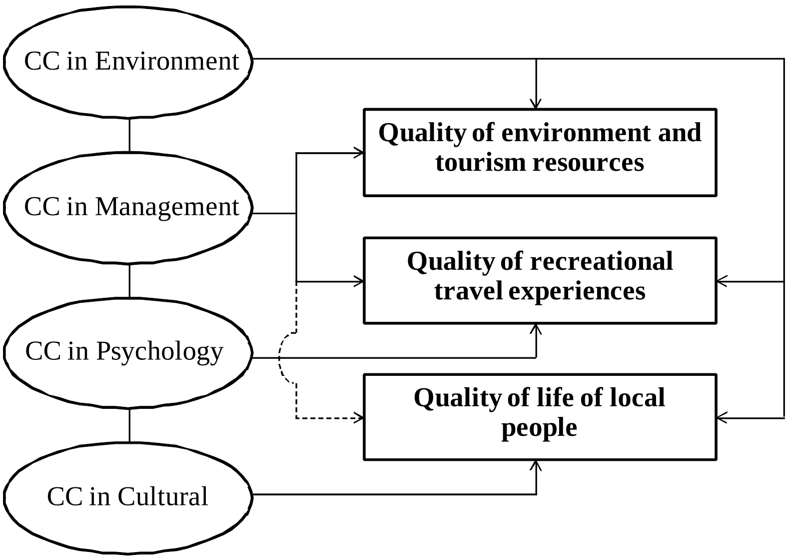


FIGURE 5-49 : Determination of the ability to support tourism from principles of sustainable tourism management.

TABLE 5-12: The capacity indicators and levels

Recreational capacity indicators	Recreational capacity levels		
	Below capacity	At capacity	Exceeding capacity
Physical Capacity			
Number of people at one time (PAOT) the space can accommodate	Less than 50% of the max. PAOT	50% to 80% of the max. PAOT	80% of the max. PAOT
Facility Capacity			
Number of people at one time (PAOT) the facility can accommodate	Less than 50% of the max. PAOT	50% to 80% of the max. PAOT	>80% of the max. PAOT
Psychological Capacity			
Perception of crowding, scale from 0-9	0-3	>3-5	>5

Source: Dachanee Emphandhu, 2006.

2) Visualization and Adaptation Guidelines

The city is a complex and changing matrix of human activities and environmental effects. To plan for a sustainable city requires the broadest understanding of the relationships between citizens, services, transport policies and energy generation, as well as of their total impact on the local environment and the larger geographic sphere. If a city is to create real sustainability then all these factors must be intertwined. There will be no environmentally sustainable cities until urban ecology, economics and sociology are factored into city planning. The achievement of this goal depends on motivating citizens. Tackling the global environmental crisis from the vantage point of each city brings the task within the "grasp of the citizen." Environmental issues are not distinct from social ones. Policies aimed at improving the environment can also improve the social life of citizens. Ecological and social solutions reinforce each other and build healthier, livelier, more open-mined cities. Above all, "sustainability means a good life for future generations."

The key lies in cities aiming at a circular "metabolism", where consumption is reduced by implementing efficiencies and re-use of resources is maximized. We must recycle materials, reduce waste, conserve exhaustible energies and tap into renewable ones. Since the large majority of production and consumption takes place in cities, current linear processes that cause pollution from production must be replaced by those that aim at a circular system of use and re-use (FIGURE 5-50). These processes increase a city's overall efficiency and reduce its impact on the environment. To achieve this, we must plan our cities to manage their use of resources, and to do this we need to develop a new form of comprehensive holistic urban planning.

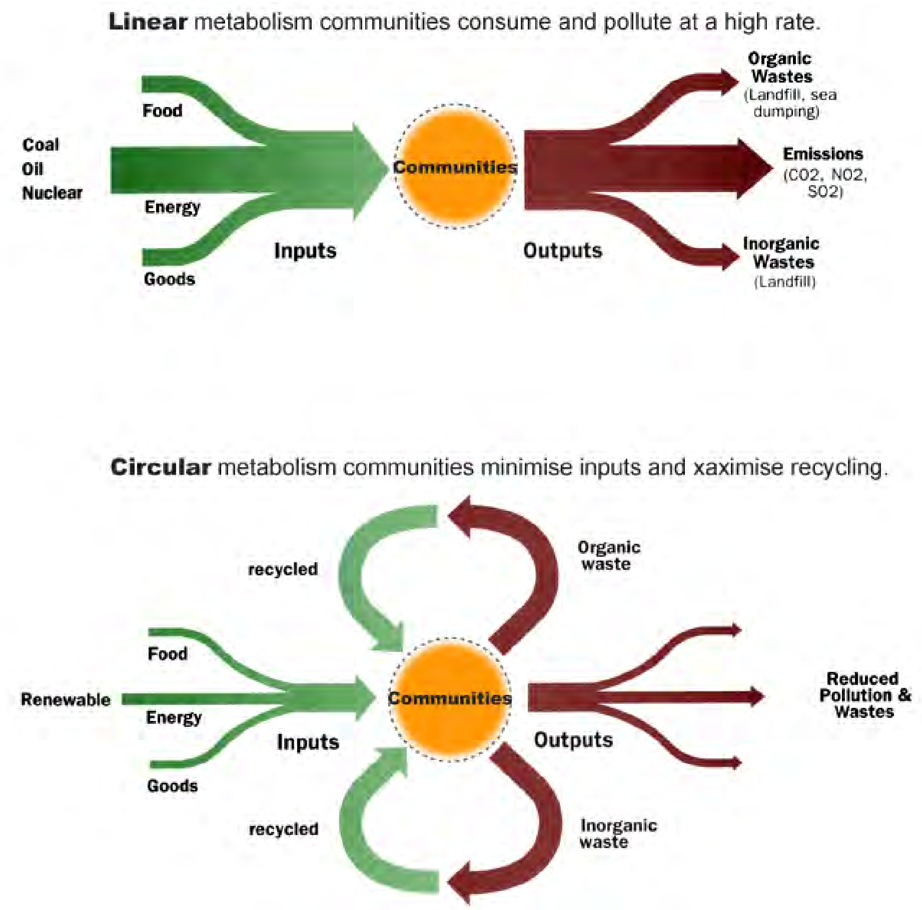


FIGURE 5-50 : Linear and circular metabolism communities system

2.1) Compact Mixed Use Nodes

We suggest an approach to urban sustainability that reinterprets and reinvents the "dense city" model. Beyond social opportunity the "dense city" model can bring major ecological benefits. Dense cities can through integrated planning be designed to increase energy efficiency, consume fewer resources, produce less pollution and avoid sprawling over the countryside. He introduces the idea of a "Compact City"—a dense and socially diverse where economic and social activities overlap and where communities are focused around neighborhoods (Figure 5-51).

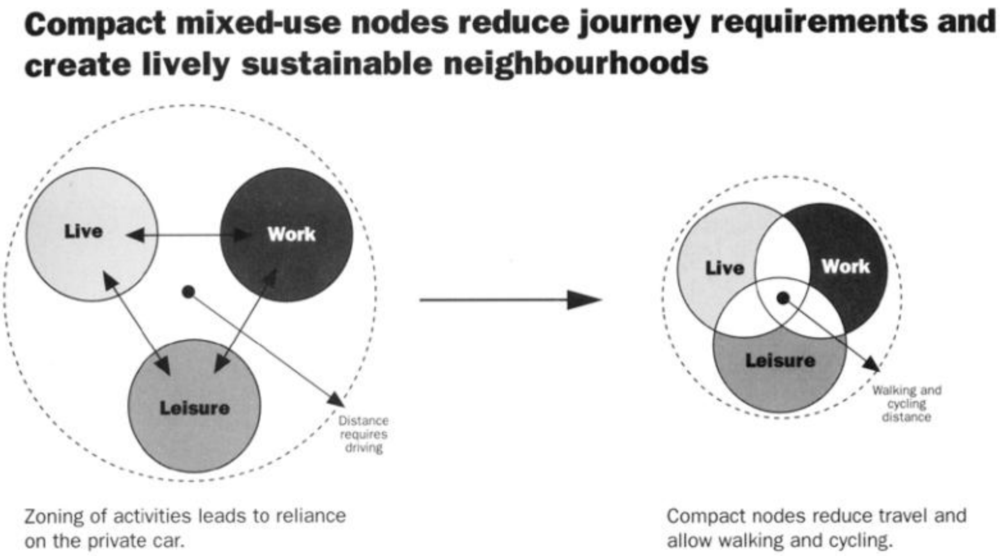


FIGURE 5-51 : Compact mixed use nodes

The creation of the modern Compact City demands the rejection of single-function development and the dominance of the car. The question is how to design a city in which communities thrive and mobility is increased—how to design for personal mobility without allowing the car to undermine communal life, how to design for and accelerate the use of clean transport systems and re-balance the use of our streets in favor of the pedestrian and the community.

The Compact City addresses these issues. It grows around centers of social and commercial activity located at public transport nodes. These provide the focal points around which neighborhoods develop.

The Compact City is a network of these neighborhoods, each with its own parks and public spaces and accommodating a diversity of overlapping private and public activities. Most importantly, these neighborhoods bring work and facilities within convenient reach of the community, and this proximity means less driving for everyday needs (Figure 5-52).

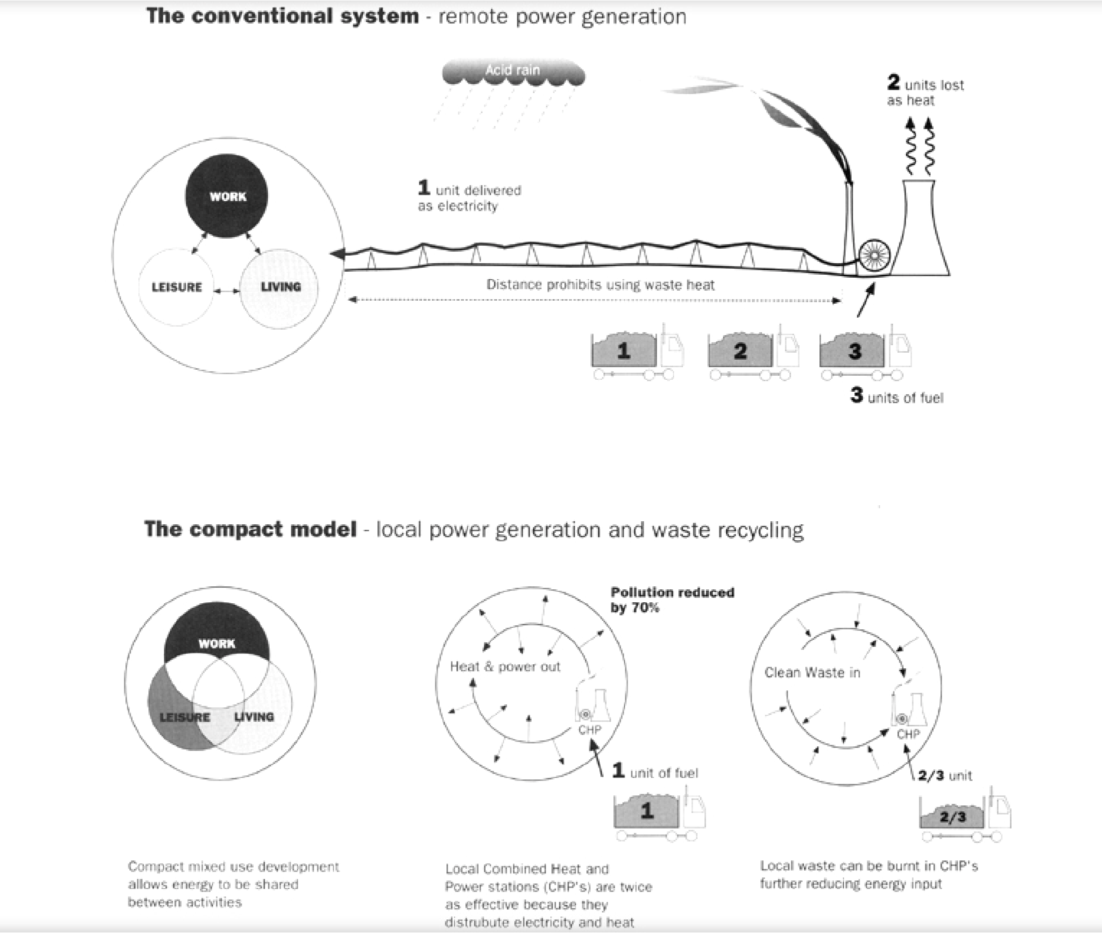


FIGURE 5-52 : The conventional system and the compact model

Mass transit systems can provide cross-town travel by linking one neighborhood center with another, leaving local distribution to local systems. This reduces the volume and impact of through traffic, which can be calmed and controlled, particularly around the public heart of neighborhoods. Local electric buses become more effective, and cycling and walking become more pleasant. Congestion and pollution in the streets are drastically reduced and the sense of security and conviviality of public space is increased.

Similar concept in worldwide practice nowadays is the Transit-oriented development (TOD). The U.S. Department of Transportation Federal Transit Administration explains:

"TOD is compact, mixed-use development near transit facilities and high-quality walking environments. The TCRP study concludes that the typical TOD leverages transit infrastructure to promote economic development and smart growth, and to cater to shifting market demands and lifestyle preferences. TOD is about creating sustainable communities where people of all ages and incomes have transportation and housing choices, increasing location efficiency where people can walk, bike and take transit. In addition, TOD boosts transit ridership and reduce automobile congestion, providing value for both the public and private sectors, while creating a sense of community and place."
(http://www.fta.dot.gov/12347_6932.html)

Also, the U.S. Department of Transportation Federal Transit Administration explains "Joint Development" as a subset of TOD.

"Joint Development refers to the development of real property that was purchased with FTA funds. More often than not, this real property is developed while maintaining its original public transportation purpose. This is done by placing residential, commercial, or community service development on, above, or adjacent to property that was purchased with FTA funds. Joint Development may include, but is not limited to, the following :

- *Commercial and residential development;*
- *Pedestrian and bicycle access to a public transportation facility;*
- *Construction, renovation, and improvement of intercity bus and intercity rail stations and terminals; and*
- *Renovation and improvement of historic transportation facilities."*

Renne (2008) reveals that, in successful TOD projects, government agencies from state-level government to local officials have leading roles to make development direction. For example, they have regulatory responsibilities for:

- the planning and implementation of transportation infrastructure
- deal with environmental, housing and finance, and economic development issues
- prioritize which zone, stations or transportation nodes should receive investment and redevelopment supports
- ensure the optimum use of land close to railway stations, bus terminals, transport interchanges and corridors containing frequent public transport services for residential, commercial and other intensive uses

2.2) Green Integrated Utility System

"Green Integrated Utility System" or GIUS (EEC Engineering Network, 2006) is a new concept that integrates all utility services, which needed for small community within one location. The main utility services to be in the GIUS include electricity generation, city water production, wastewater treatment, and solid waste disposal. In some GIUS where there is a demand for district cooling, the district cooling generation system could also be integrated within the GIUS (Figure 5-53).

GIUS should be placed near the community. This will reduce the community resistant especially for wastewater treatment plant and/or solid waste disposal system since the treatment plant and disposal facility will serve that community not other communities. Therefore, the resistant from NIMBY (Not in My Back Yard) shall be reduced. The main advantage of the GIUS includes:

- Reduce operating cost because all utility services within GIUS can supply and receive utilities from others. Waste heat from power generation could be used to produce cooling. Gas from garbage could be used for power generation. Treated waste water could be used for power plant water make up or could be used to fill in the water reservoir or for agriculture.

- Easy to manage for local authorities since all the services is in the same location.

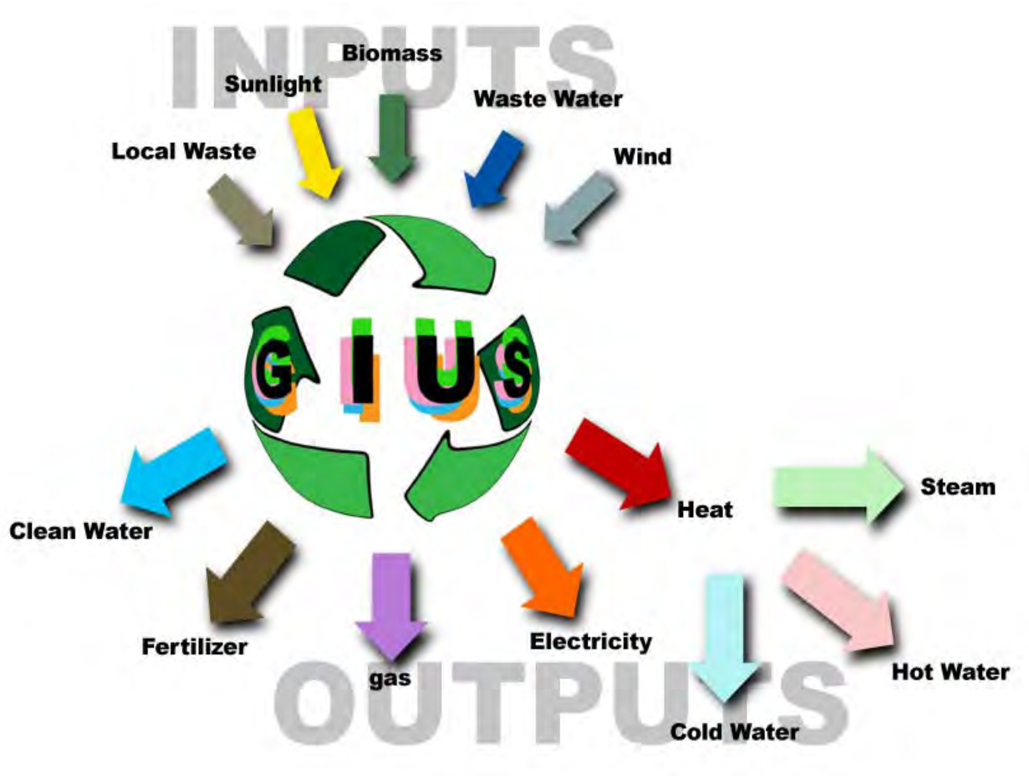
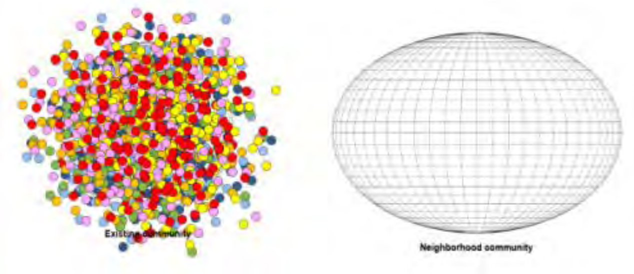
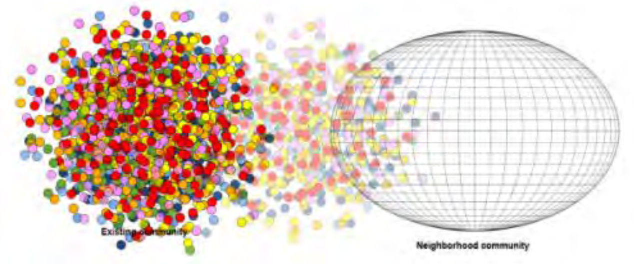


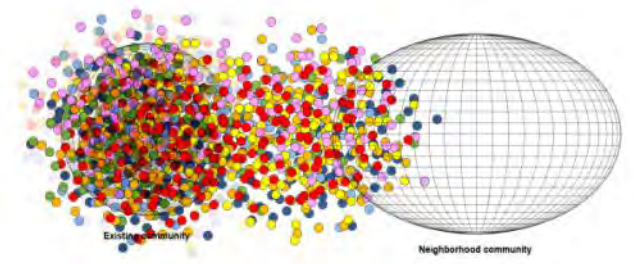
FIGURE 5-53 : Green Integrated Utility System

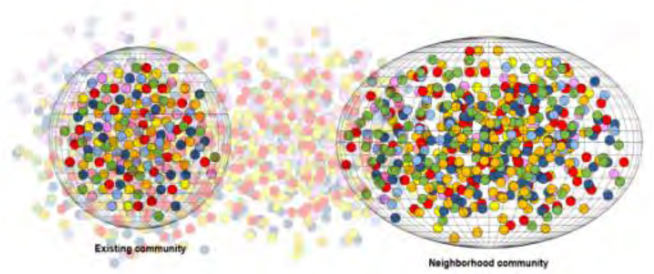
2.3) Original community + Neighborhood community + GIUS

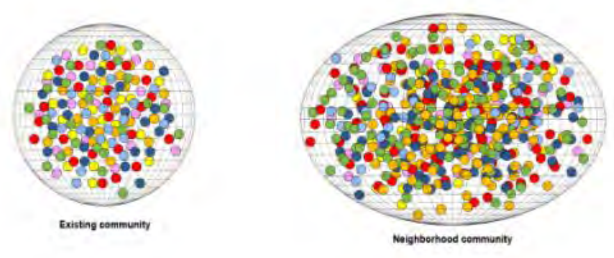
In this report, we propose a combined approach to community development. In order to prevent the original community from reaching the bursting stage, another town called “The Neighborhood Community - CN” is proposed. The neighborhood community is a town where all resources are well-managed. It is the town where people live and go to work as well as leisure in a short distance. It is the buddy town born to support the existing community (Figure 5-54).


Existing community
Neighborhood community


Existing community
Neighborhood community


Existing community
Neighborhood community


Existing community
Neighborhood community


Existing community
Neighborhood community

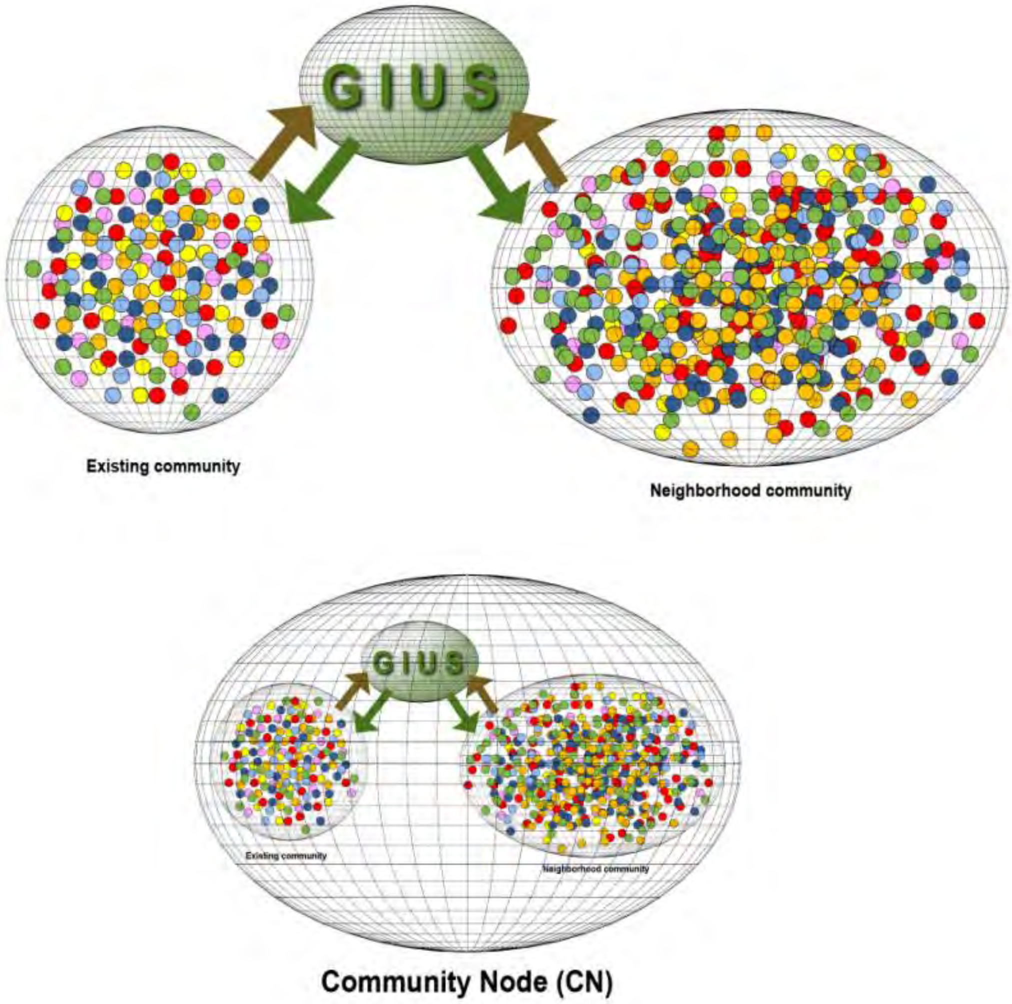


FIGURE 5-54 : Pairing with GIUS

We observed that some of the neighborhood communities have already emerged simultaneously near existing nodes such as the area around Pru Chaweng in the Chaweng Beach community. However, the neighborhood has no proper infrastructure and public facilities provided.

A Community node (CN) is a complete system where sustainable development is fully deployed although some of the G I U S components, such as a garbage incineration plant, are located outside the perimeter or in another town due to financial constraint and facility management.

2.4) Connecting nodes

Network of CN connected by mass transit reduces uses of personal cars. In addition, public transport can be more efficient and effective when converted into electric vehicles (EV).

Energy Reduce Compact city also can reduce energy consumption. Connection of Compact nodes, the compact nodes can be joined with mass public transportation, like trains.

The city built with comfortable and safe public space can bring diverse groups together and breed a sense of tolerance, awareness, identity, and mutual respect. Theoretical shift in the way cities do business and interact with the environment, arguing that many products come to market and are sold without figuring their social or environmental cost. The city of the future: one that is sustainable within its own environment; that can make a positive impact on its surroundings; that encourages communication among its citizens; that is compact and focused around neighborhoods; and that is beautiful, a city whose buildings and spaces spark the creative potential of its inhabitants. As our population grows larger, our planet grows smaller (Rogers and Gumuchdjian, 1998.)

FIGURE 5-54 shows how to connect the nodes in SAMUI Island.

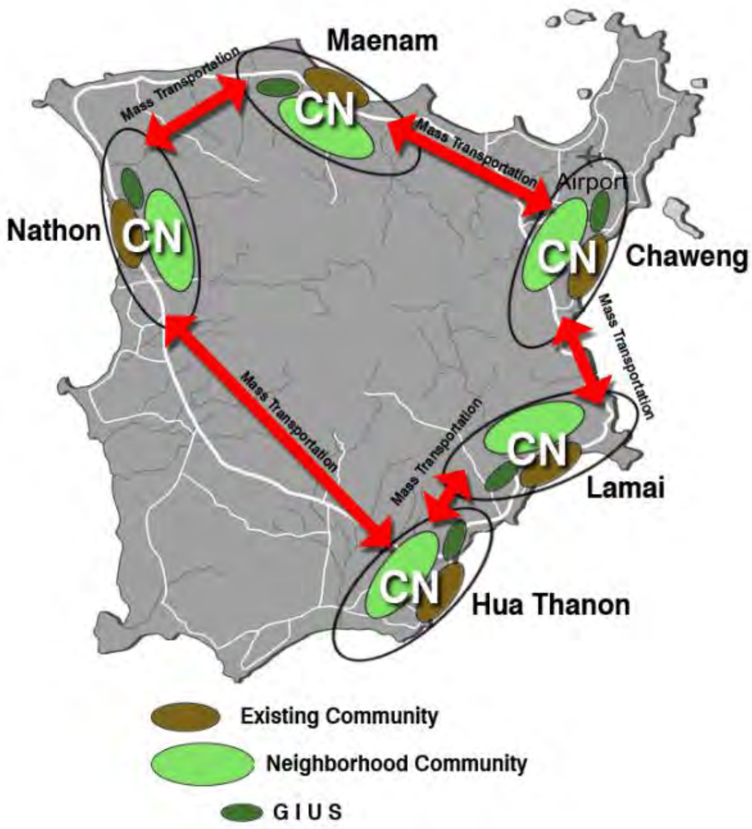


FIGURE 5-54 : Connecting nodes of SAMUI Island

3) Site selection

Chaweng Beach

In this study, the area of Chaweng Beach is selected to be the pilot town for the low-carbon town structure planning by the following criteria.

(1) Population density

Bo Phut district, which most of the activities occur in Chaweng beach town, has a population of 14,499. In term of density, it has reach 242 persons per square kilometer, which held the second rank after the governmental town of Nathon which accommodated 364 persons per square kilometer. This indicates the needs for more facilities and efficiency in land use.

(2) Number of hotel rooms

Since this is a tourist based community, number of hotel rooms was also taken into account,--the more the number of hotel rooms the greater the number of people working in the service sector would be. The amount of the staff engaged in hotel activity largely depends on the status of the hotel. According to the recommendations of the World Tourist Organization, the optimum number of staff per ten rooms in three star hotel-8 person, in four star hotel-12 person, in five star hotel-20 person. The number of hotel rooms in Chaweng ranging from small guesthouses to large corporate resorts was counted as approximately 3,000 rooms, meaning that there were at least 2,400 hotel employees churning in this area. Consequently, people who work in local markets, shops, food strolls, barber shops, etc., coexisted with the hotel staff. These working people need proper dwelling and a better living quality.

(3) The Beach

Chaweng Beach (Figure 5-55) is widely known to be the most beautiful beaches on the island for its white powder soft sand topping on nearly 3 kilometers long seashore. It is the most attractive natural feature, and therefore it is the foundation of every activity. It is an indicator to show that most tourists are likely to come to this popular beach.

FIGURE 5-55 : Chaweng Beach

Besides the natural beauty and variety of activities (Figure 5-56), there are intense number of commercial and business entities such as hotels, resorts, guest houses, shops, restaurants and spa centers operated in buildings, various types (Figure 5-57). These activities are massively more than those of the other beaches, which make Chaweng Beach the bustle beach, and the most popular place for tourists to visit and even for a long term stay.

FIGURE 5-56 : Chaweng Beach, which has a wide sandy and long continuous beach

FIGURE 5-57 : Building types along Chaweng – Cheong Mon Road, one-way street

Three Potential land types

In order to develop the pilot project for a neighborhood community which contains a residential mixed-use development, a transportation hub, as well as public facilities, some land area should be required. Three potential types of existing land are proposed as the followings:

- inefficient existing rental land
- vacant governmental land
- proximal undeveloped land

The exact positions of these lands are shown by Figure 5-58.

FIGURE 5-58 : Positions of land plots

Inefficient existing rental land

This type of land is characterized by its inefficient land use, for example, 1 storey ghettos, randomized shops and markets, winding small roads and alleys, and no proper infrastructure. Properties in this area are mostly rental-some are invaded.

Land that falls in to this category was found in the area between the island's main road and Pru Chaweng reservoir (Figure 5-59 and 60). This land plot has a total area of 28.76 rais (46,017 Nathon community, in Ang Thong sub-district which has total population of 10,224 people, 5,009 households and density is 364 persons/ km²

FIGURE 5-59 : Position of land plot number 1, nearby market area on Chaweng Yai Soi 13 Rd.

FIGURE 5-60: Surroundings of land plot number 1

Another piece of land that falls in to this category is the land at the corner of Pru Chaweng (Figure 5-61 and 62), which is a former shopping arcade then went bankrupted. The site has been left unattended. This land plot has a total area of 8.54 rais (13,663.7 Nathon community, in Ang Thong sub-district which has total population of 10,224 people, 5,009 households and density is 364 persons/ km²

FIGURE 5-61: Position of land plot number 3, on Chaweng 4 road

FIGURE 5-62: Surroundings of land plot number 3

Vacant governmental land

The Municipality of SAMUI Island possesses a vast piece of land around Pru Chaweng reservoir. This land was once a swamp. The government filled it up for future development then planned to dig some of it to expand the reservoir, yet here is still a large area left (Figure 5-63). This land plot has a total area of 29.06 rais (46,500 Nathon community, in Ang Thong sub-district which has total population of 10,224 people, 5,009 households and density is 364 persons/ km²)

FIGURE 5-63: Surroundings of land plot number 3

Proximal undeveloped land

Off the Island's main road, not far from the original Chaweng Beach community, located some vacant private properties (Figure 5-64). These properties are mostly on the land side of the road in the 500 meters wide yellow zone indicating the low-density residential area. These properties also have a potential to develop a mixed-use residential community. However, it may need some zoning adjustment to increase population density.

A piece of land was found on 4169 Road, the main road of SAMUI Island. This vacant land has a total area of 11.28 rais (18,043.92 Nathon community, in Ang Thong sub-district which has total population of 10,224 people, 5,009 households and density is 364 persons/ km^2)

Another land was found closer to the Chaweng Beach (Figure 5-65 and 66). It has a total area of 8.48 rais (13,571.75 Nathon community, in Ang Thong sub-district which has total population of 10,224 people, 5,009 households and density is 364 persons/ km^2)

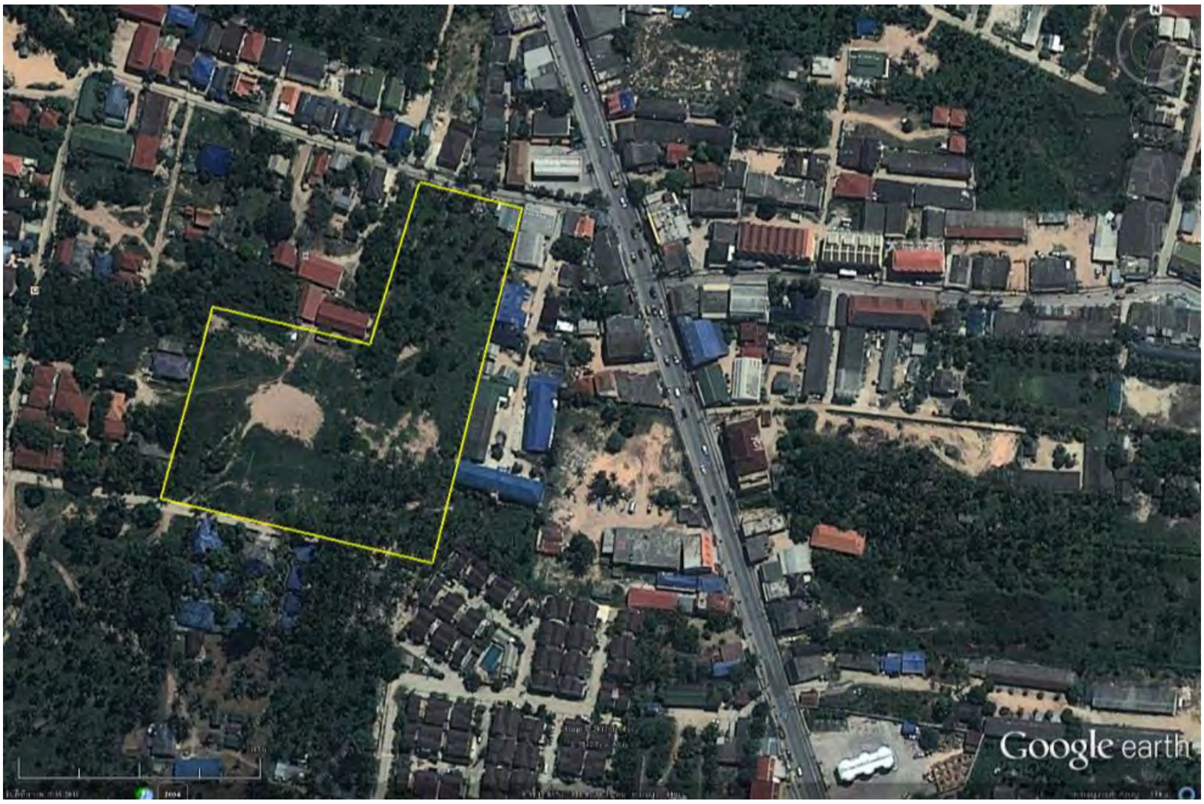


FIGURE 5-64: Position of land plot number 2, on 4169 Road

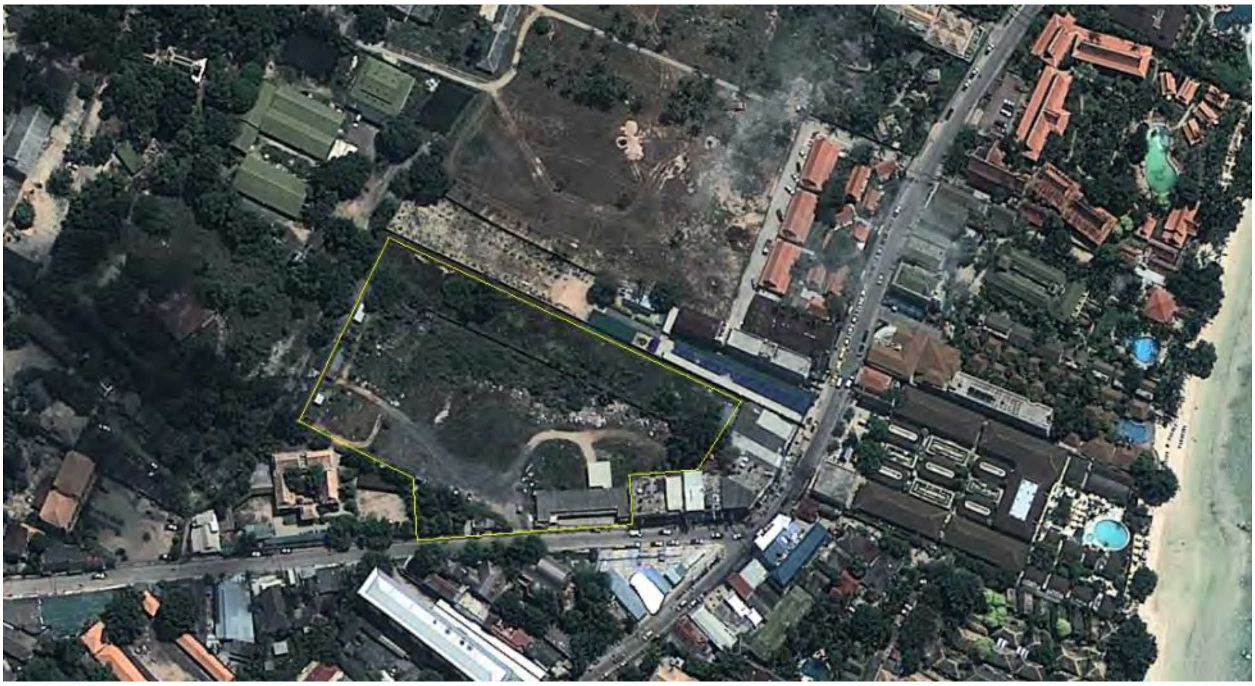


FIGURE 5-65: Position of land plot number 4, on Chaweng – Choeng Mon Road

FIGURE 5-66: Surroundings of land plot number 4

Establishing the neighborhood community

Following the concept of compact mixed use community, a lively neighborhood should grow around a transportation center. Medium income residential mixed-use development is proposed to be the starting point that will generate all activities in the community. Mixed-use development makes use of land efficiently. The advantages of mixed-use development are improving the quality of air and of life, a compact form of city that has fewer roads but more landscape public spaces. Parks, gardens, trees and other landscaping provide vegetation that shades and cools streets, courtyards and buildings. The overall effect of rich urban landscaping is to reduce the heat “bloom”, measurably reducing the need for air-conditioning, which can make for more efficient of energy. In addition, developing more compactly, mixed-use development, can reduce energy use and carbon dioxide (CO_2) emissions by reducing vehicle miles traveled (VMT) that shortening trip lengths and making alternative way of travelling for example transit and walking. This measure also mitigates urban sprawl into rural landscape that causes the increase of CO_2.

This can be done by encouraging multi-story buildings, instead of small 1-2 storey houses that currently exist, through the use of zoning regulation. A town with adequate green area, a lively neighborhood, roads with less automobiles, more walking oriented activity, and an environmental awareness community will grow from this point.

4) Residential mixed-use development

Mixed-use development is the use of a building, set of buildings, or neighborhood for more than one purpose. Since the 1920s, zoning in some countries has required uses to be separated. However, when jobs, housing, and commercial activities are located close together, a community's transportation options increase. In addition, mixed-use developments often have higher property values. Often located in existing urban areas or as part of a new town center, mixed-use development provides a range of commercial and residential unit sizes and options.

Throughout the late 20th century, it began to become apparent to many urban planners and other professionals that mixed-use development had many benefits and should be promoted again. As American, British, Canadian and Australian cities de-industrialized, the need to separate residences from hazardous factories became less important. Completely separate zoning created isolated "islands" of each type of development. In most cases, the automobile had become a requirement for transportation between vast fields of residentially zoned housing and the separate commercial and office strips, creating issues of Automobile dependency. In

1961, Jane Jacobs' influential The Death and Life of Great American Cities argued that a mixture of uses is vital and necessary for a healthy urban area.

Zoning laws have been revised accordingly and increasingly attempt to address these problems by using mixed-use zoning. A mixed-use district will often serve as the "downtown" area of a local community, ideally associated with public transit nodes in accordance with principles of transit-oriented development and new urbanism. Mixed-use guidelines often result in residential buildings with street front commercial space. Retailers have the assurance that they will always have customers living right above and around them, while residents have the benefit of being able to walk a short distance to buy groceries and household items or see a movie.

The following residential mixed-use projects are great examples for green buildings which respond to both technological and social aspects.

Heights on Capitol Hill, Seattle, USA

Heights Capitol Hill (Figure 5-67) is an example of projects that are nowadays developed to follow mixed-use guidelines and can be found throughout the United States' downtown areas.

FIGURE 5-67: Heights on Capitol Hill, Seattle, USA

The East Village Mixed-Use Development, Austin, USA

In the last decade, East 11th street in Austin has undergone a dramatic transformation. This project (Figure 5-68) was designed to pay respect to the world's current energy and natural resource crisis. In addition to integrating 11 retail stores, offices, and 20 residential apartments – nearly 1/4 of which are affordable homes – it was crucial to use the most efficient building materials and recycle construction waste.

With views of the city, the East Village has 2 rooftop gardens that can be enjoyed by anyone, and boasts a Rainwater collection system. The southern and western facades feature piles of photovoltaic panels, as well as a screen to mitigate excess solar gain – thereby maintaining a perfect balance. Inside, the best insulation has been used to increase the project's energy performance, no VOC paint was used whatsoever, and only low-impact indigenous plants were used for the landscaping.

FIGURE 5-68: The East Village Mixed-Use Development, Austin, USA

FIGURE 5-68: The East Village Mixed-Use Development, Austin, USA

Uwajimaya Village Apartment, Seattle, USA

Uwajimaya Village (Figure 5-69) is located in the heart of Seattle's Chinatown/International District. The 66,000 square foot retail space includes Seattle Uwajimaya Asian Food and Gift Market, Kinokuniya Bookstore, Washington Mutual Bank, Salon Juno, Paris Miki Optical, Savvy Asian Cosmetics and an Asian food court. Uwajimaya Village is also home to the Uwajimaya Village Apartments, a 176-unit apartment complex with a roof garden above the store.

FIGURE 5-69: Uwajimaya Village Apartment, Seattle, USA

FIGURE 5-69: Uwajimaya Village Apartment, Seattle, USA

Modern Richardson Apartment, San Francisco, USA.

The Richardson Apartments (Figure 5-70) takes over a former parking lot, which was one of the sites freed for development by the demolition of the collapsed Central Freeway. The apartments provide much needed supportive housing for San Francisco's homeless population and work to encourage a pedestrian, bike and transit friendly neighborhood. While the building itself is 65,000 sq ft, it is designed to look like a series of varied structures rather than one large one to break up the view from the street.

The ground floor houses a resident entrance lobby, retail space, a common lounge, a common mixed purpose room with a kitchen and a community health clinic. A large open courtyard with seating, tables, benches and plants provides space to gather and enjoy the outdoors. No car parking is provided, but plenty of secure bike parking is available. Above the ground floor are 120 studio apartments furnished with basic necessities like a bed, a dresser, a full kitchenette, an accessible or adaptable bathroom, and a secure telephone line to the front desk.

The Richardson Apartments were designed using the guidelines of Build It Green, Green Point and Green Communities. Sustainable features of the project include the use of reclaimed woods, a purifying bios wale in the court, and sunshades. The roof includes a living roof, allotment garden plots, solar arrays, seating and views of city hall. The project received its Green Point certification in February of 2012.

FIGURE 5-70: Modern Richardson Apartment, San Francisco, USA.

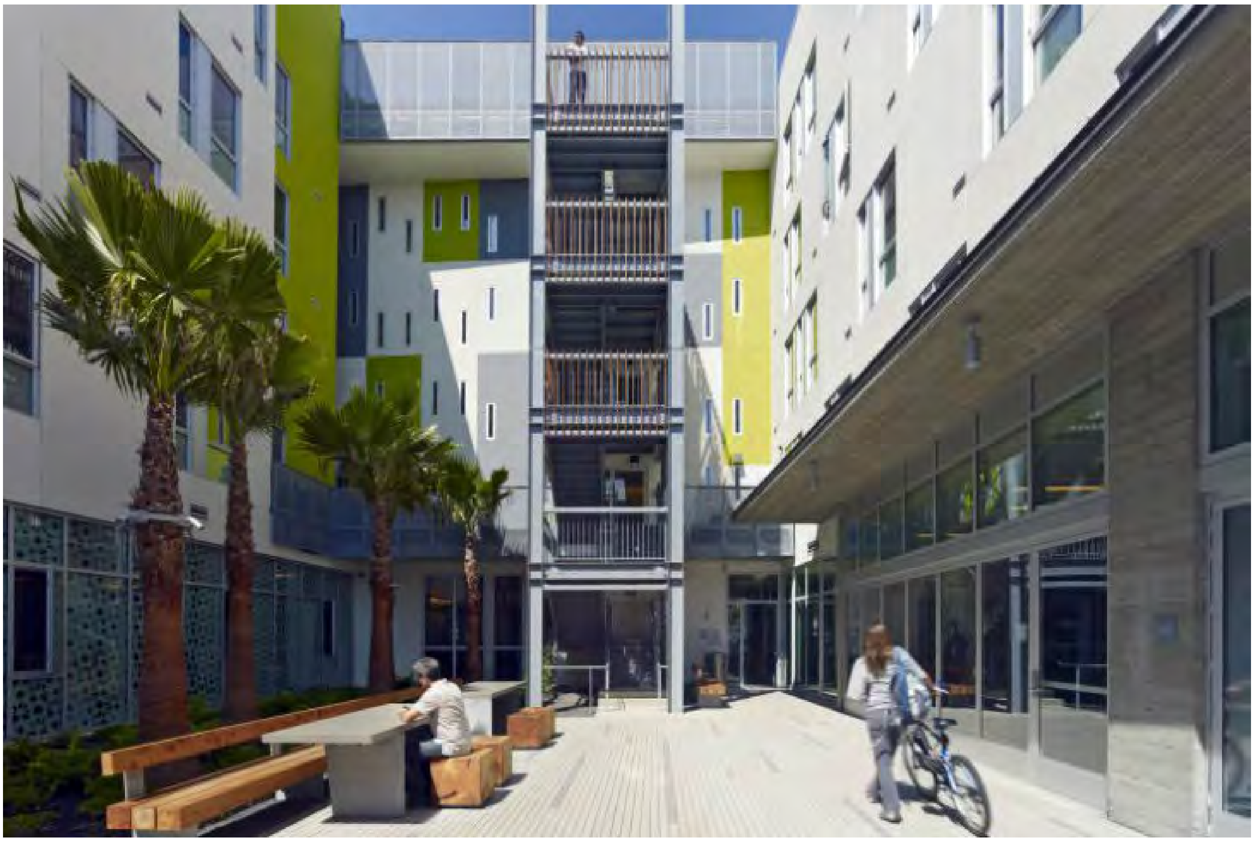


FIGURE 5-70: Modern Richardson Apartment, San Francisco, USA.

5) PROPOSAL FOR A SELECTED SITE

Since land plot #1 (Figure 5-71) is the closest site to the island's main road, we propose this location to be the transportation hub for the BRT running between major towns around the island, and some mixed-use development should grow around this area.

However, for the purpose of generic town prototype and to portray a clear picture of sustainable town planning for the neighborhood community, we propose land plot #2 to exercise our ideas (Figure 5-72). It is a private property situated in a close proximity of the original community of Chaweng Beach. The project should include some essential components that can generate a vibrant community, such as a park and ride area, an accommodation, a park, shops, and all daily life activities. At this point, we name it "Bird's Nest Project".

The primary target group for these community development sites is the hotel and resort employees in middle and high level positions. According to our survey, there is a high demand in this group as they want to leave "worker camps", their initial residence, and to own private properties. They earn more than 20,000 Baht/month salaries that create capability of buying middle-high condominium. However, there is no supply in nearby areas because the land price is too high for investment. If we can lessen the land price problem, this kind of project will be very successful, as location (closed to work place) and convenience always are the strongest factor for decision making of real estate buyers.

FIGURE 5-71: Land plot number 1, on 4169 Road

The example of Uwajimaya Village was chosen to be our model. Master plan for the Bird's Nest Project has then been laid out. It comprises of commercial space and parking lots on the ground floor while residential buildings, containing 500 units, are located from the second floor onward.

The car parking area should accommodate cars for the residents as well as shop customers. In addition, it should provide some spaces for park and ride usage. The total number of parking spaces should then be 123 lots plus

FIGURE 5-72: Land plot number 2, on Chaweng – Choeng Mon Road

spaces for 188 motorcycles. The number was calculated from building regulation and from actual count at the walking street side parking.

The special features of this project should be the park, roof garden, and vertical green façade which contribute to the "green" notion of the project. All the trees used in the landscape are native and should be local-grown to avoid transportation from the main land. These trees not only can absorb CO_2 but also shade hard surfaces and cool down air temperature. Some coconut trees are still used to strengthen local identity of SAMUI Island although they are not so good at absorbing CO_2. We also raise the building up to seven floors to allow more open space and to increase population density which consequently stimulates local economic amongst shops and all activities on the ground floor public area. Building materials should be local or recycled. These features then will make more economic senses of investment, eliminating the obstacle about land price as mentioned earlier.

As the number of hotel employees is calculated to be approximately 2,400 people- some would stay as couples or families. We then need at least 3 more sites of the same size to establish neighborhood communities. This site is the beginning…

The project detail is depicted as follows (Figure 5-73 to 75):

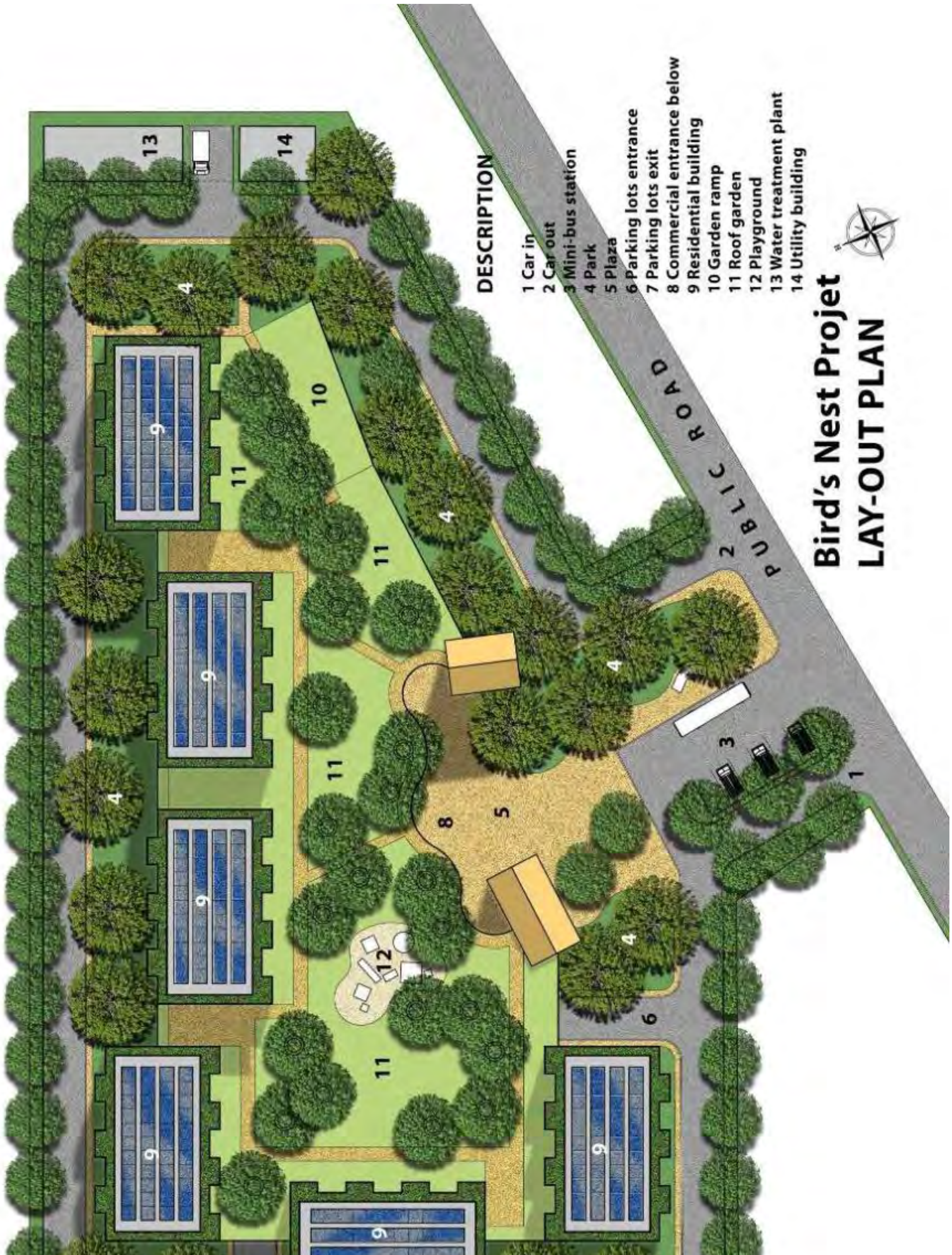


FIGURE 5-73: Master Plan

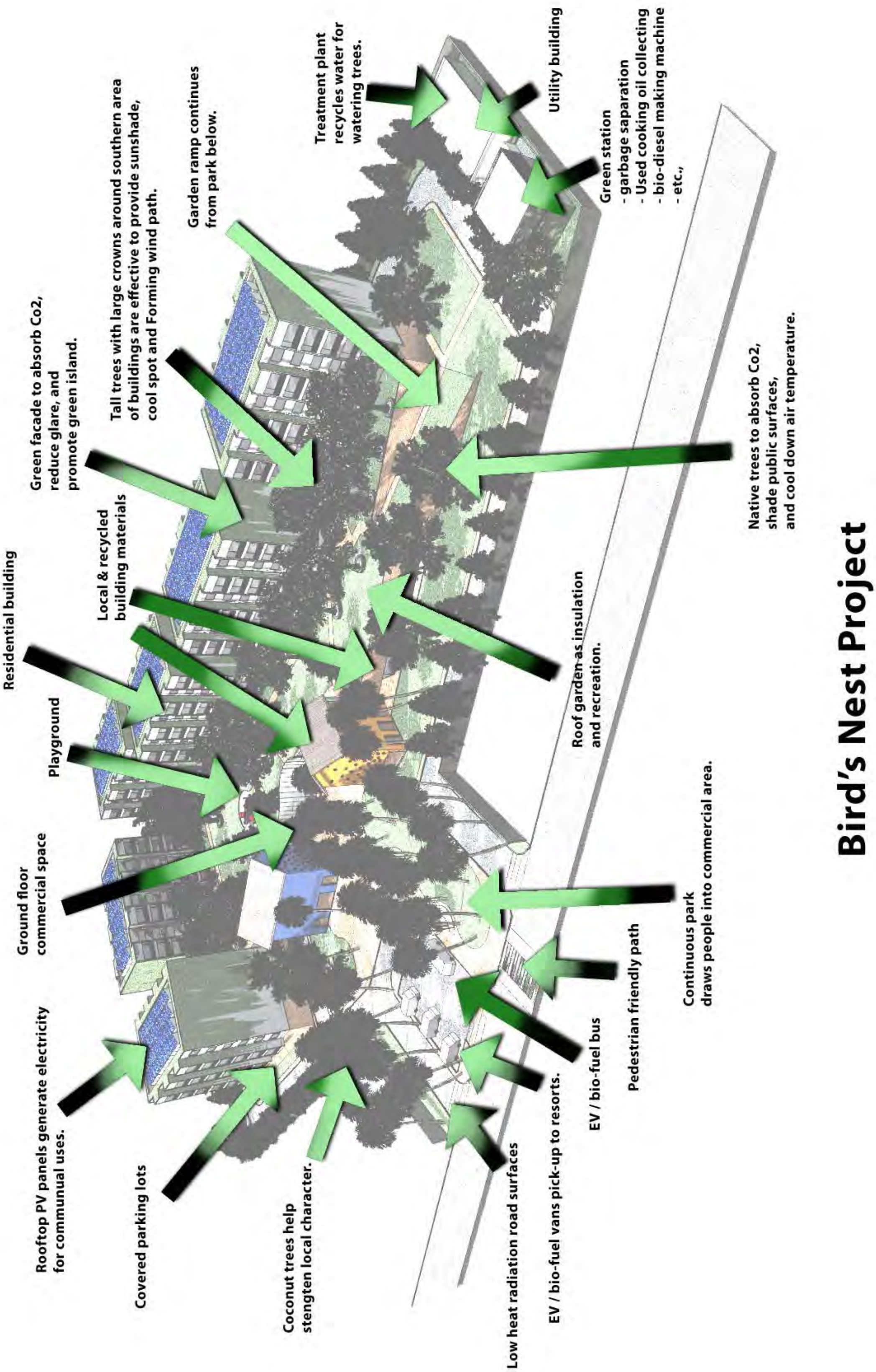


FIGURE 5-74: Design concept and perspective

FIGURE 5-75: Perspectives

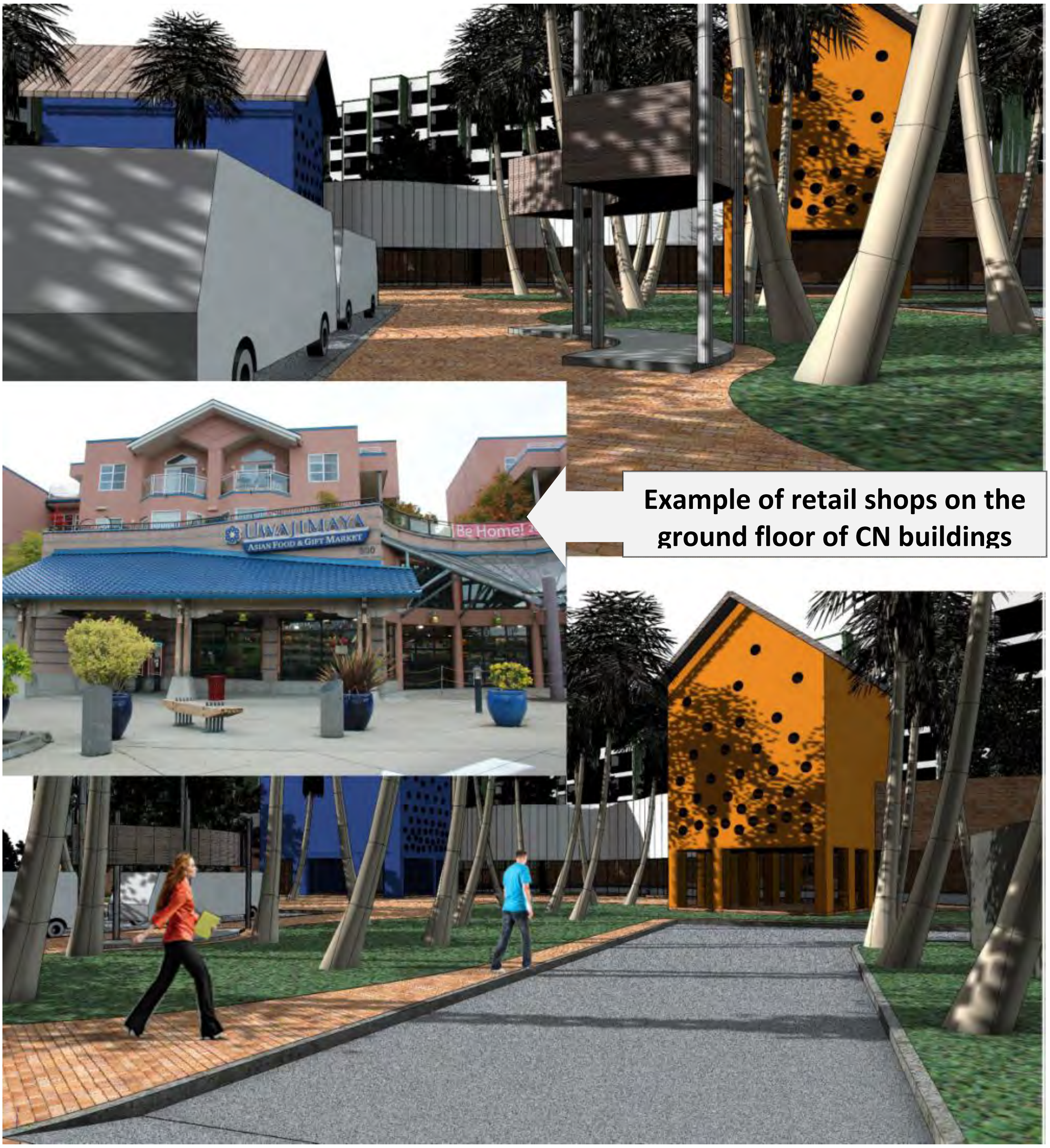


FIGURE 5-75: Perspectives

FIGURE 5-75: Perspectives

FIGURE 5-75: Perspectives

FIGURE 5-75: Perspectives

FIGURE 5-75: Perspectives

In addition, transportation link between CNs is necessary for increased convenience and shifting market demands and lifestyle preferences, especially the demand for private vehicle. Therefore, as shown by Figure 5-76, we propose shuttle bus services running between the 5 community nodes. Also, where the physical conditions allows for easy construction and less disturbance to the current traffic, we propose bike lane linking the nodes CN2, CN3, and CN5. Note that the extension of bike lane to the remaining nodes could be possible, but depending on more detailed study.

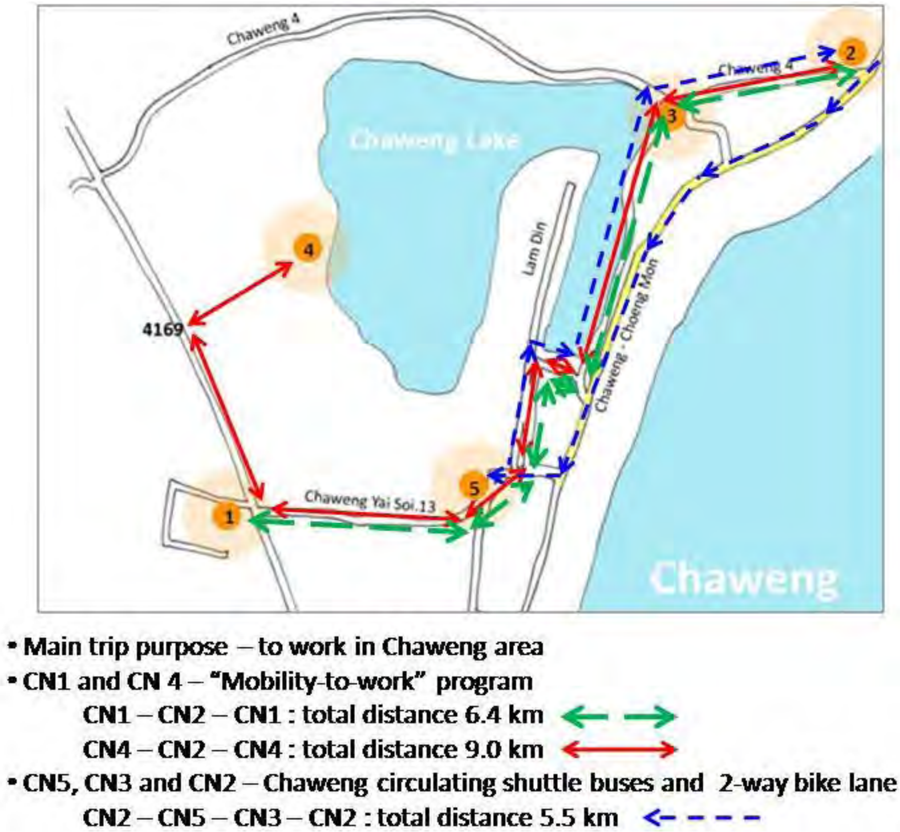


FIGURE 5-76: 3 shuttle bus routes

Main trip purpose of residents in the CNs is to work in Chaweng beach area. Since CN1 and CN4 are located further than walking distance from Chaweng beach, "Mobility to work" program is provided with 3 shuttle bus routes. The 1st route links from CN1 to CN2 and back to CN 1, the 2nd route links from CN4 to CN2 and back to CN4, and the 3rd route is circulating shuttle bus route that links CN2 to CN5, CN3 and CN2.

Figure 5-77 presents details of the 1st route i.e. CN1-CN2-CN1 route. Total distance is 6.4 km with 6 stops at CN1, a market, CN5, entrance to Chaweng beach, CN3 and CN2. For shuttle bus operation, the shuttle buses wait for 5 minutes at CN1 and CN2 during off-peak hour. During peak hours i.e. during 6-7am, 2-3pm, and 10-11am, the shuttle buses will not wait to provide fast services for the residents. Total travelling time is 20 minutes during peak hours and 25 minutes during off-peak hours. Bus frequency is 10 minutes during peak hours and 15 minutes during off-peak hours. Two bio-diesel minibuses with capacity of 21 passengers will be provided. Therefore, total investment cost is 2,400,000 Baht. Operation costs are 100,000 Baht/month of bio-diesel and 24,000 Baht/month of 3 drivers' salary.

FIGURE 5-77: 1st route (CN1-CN2-CN1)

Figure 5-78 presents details of the 2nd route i.e. CN4-CN2-CN4 route. Total distance is 9.0 km with 6 stops at CN4, a market, CN5, entrance to Chaweng beach, CN3 and CN2. For shuttle bus operation, the shuttle buses wait for 5 minutes at CN4 and CN2 during off-peak hour. During peak hours i.e. during 6-7am, 2-3pm, and 10-11am, the shuttle buses will not wait to provide fast services for the residents. Total travelling time is 25 minutes during peak hours and 30 minutes during off-peak hours. Bus frequency is 10 minutes during peak hours and 15 minutes during off-peak hours. Three bio-diesel minibuses with capacity of 21 passengers will be provided. Therefore, total investment cost is 3,200,000 Baht. Operation costs are 150,000 Baht/month of bio-diesel and 32,000 Baht/month of 4 drivers' salary.

FIGURE 5-78: 2nd route (CN1-CN2-CN1)

Figure 5-79 presents details of the 3rd route i.e. CN2-CN5-CN3-CN2 route. Total distance is 5.5 km with stops every 300 m. on Chaweng 1 road, CN5, entrance to Chaweng beach, CN3 and CN2. For shuttle bus operation, the shuttle buses wait for 5 minutes at CN2 during off-peak hour. During peak hours i.e. during 6-7am, 2-3pm, and 10-11am, the shuttle buses will not wait to provide fast services for the residents. Total travelling time is 20 minutes during peak hours and 25 minutes during off-peak hours. Bus frequency is 5 minutes during peak hours and 10 minutes during off-peak hours. Four bio-diesel trams with capacity of 25 passengers will be provided. Cost of the tram is 900,000 baht. Therefore, total investment cost is 2,400,000 Baht. Operation costs are 100,000 Baht/month of bio-diesel and 24,000 Baht/month of 3 drivers' salary.

To encourage people not to produce more CO_2 and enhance good health of the residents, bike lane will be provided along the 3rd route i.e. on Chaweng 1 road and Chaweng lake road, with 1-meter width each side, each traffic direction. As presented in Figure 5-80, we propose to install steel barrier and road paint as the basic improvement for safety. The cost for this improvement is 2,640,000 Baht. But to increase encouragement for people to use bike lane with comfort, “green roof”, i.e. the steel structure with climbing plants on, should be installed too. Note that CO_2 reduction with quantity and cost to install green roof and to plant additional big trees to create more shade along Chaweng 4 road and Chaweng lake road were calculated as shown earlier in the “Urban Plant Areas” section.

CN2 – CN5 – CN3 – CN2 : total distance 5.5 km

- Terminal at CN2, stop every 300 m on Chaweng 1 Rd., CN5, entrance to Chaweng beach, and CN3
- Waiting 5 minutes at CN2, no waiting during peak hours: 6-7am, 2-3pm, and 10-11pm
- Total travelling time: peak hour 20 minutes and off-peak 25 minutes
- Frequency: peak hour 5 minutes and off-peak 10 minutes
- 5 bio-diesel trams : 25 passengers/tram
- Cost 900,000 baht/tram - total investment costs 4,500,000 baht and bike lane cost 2,640,000 baht

FIGURE 5-79: 3rd route (CN2-CN5-CN3-CN2)

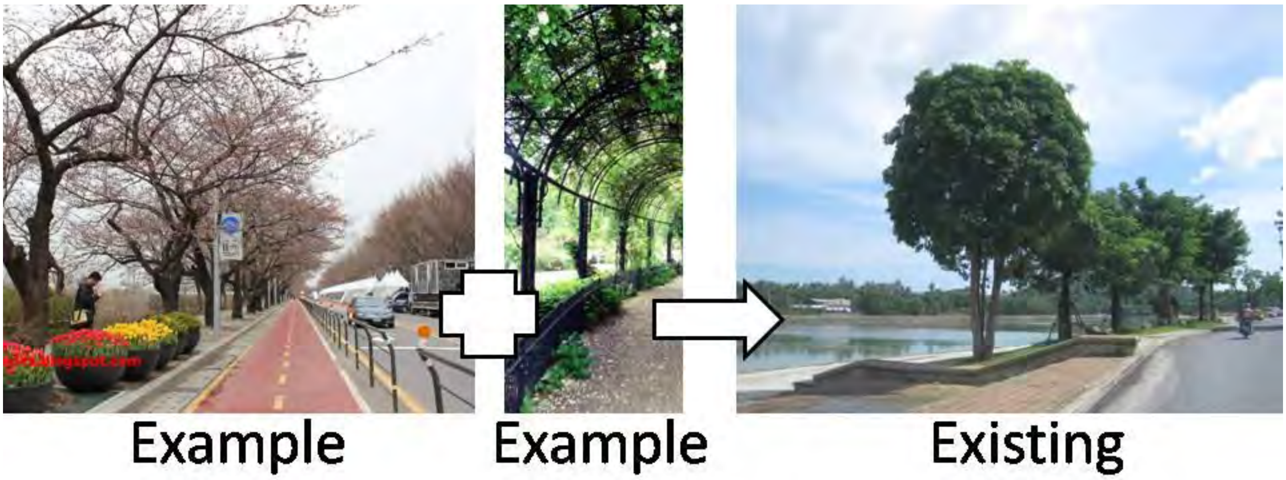


FIGURE 5-80: Bike lane links between CNs

CO_2 reduction calculation

The compact mixed-use node reduces distances significantly for government's providing of all facilities and services. It could simplify management of all the facilities and reduce friction loss in the pipelines. Tree shades could reduce heat radiation from public surfaces such as roads and pavements which reduce the use of air-conditioning devices. It slows down urban sprawl in to the rural landscapes. It improves quality of life effectively and it has a strong impact on human perception towards environmental awareness. As it is such a complex system of living lives and activities, the results of carbon reduction from all measures presented in this proposal might not be easily quantified. However, when it comes to the term of transportation, there are some significant numbers that we can count on.

Hotel employees play the major roles in all activities. Currently, their transport relies on private automobiles—mostly motorcycles. They lives in worker camps, bungalows, flats, apartments, or condominiums in the area far away where land price is much cheaper—some of the properties are hotel-owned staff camps. If this population could move into the neighborhood community and use EV or bio-fuel bus to work every day, the number of carbon-based travelling distance would reduce dramatically.

For Chaweng Beach, there are approximately 3,000 hotel rooms, from small guest houses to large corporate 5 star resorts, in the area. The amount of staff engaged in hotel activity largely depends on the status of the hotel. According to the recommendations of the World Tourist Organization, the optimum number of staff per 10 rooms in a three star hotel is 8 people, in a four star hotel it is 12 people and in a five star hotel it is 20 people. In this case, we use three-star hotel as average number. Therefore, there should be 2,400 employees circulating in this area. Assuming there is one motorcycle per one staff, and then there should be at least 2,400 carbon emitters on the roads. Therefore, as the average travelling distance between home and work is approximately 5 km., meaning 10km. for round trip, 2,400 motorcycles should run 24,000 km. daily in total. It can be estimated that CO2 emission is about 350.4 tons/year, with CO2 emission of a motorcycle at 40 g/km. According to the growth rate of hotel rooms, carbondioxide producing would be 504.44 tons/year in 2020 and increase up to 795.44 tons/year in 2030, as shown by FIGURE 5-81.

When it comes to the whole island, with the same growth rate, in 2030, we can forecast that there would be 41,600 hotel employees who can help to reduce 6,074 tons of CO2 per year. This is just from one aspect of CN development. There are a great number of co-related activities that should result in significant carbon reduction in a longer period.

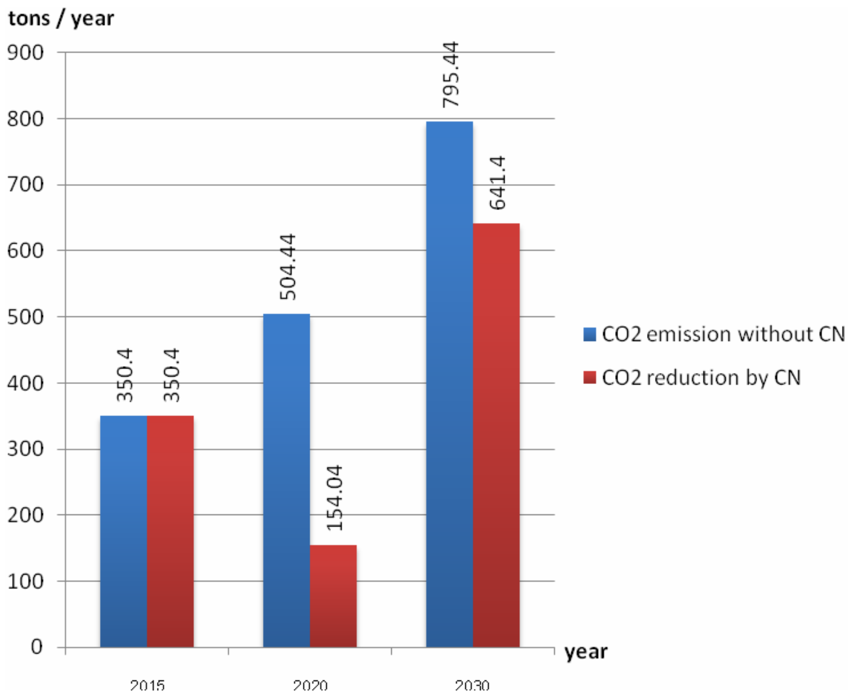


FIGURE 5-81: Carbon reduction from 2012-2020-2030

Number of planted trees in the project area can also be considered as carbon absorbers. According to absorption rate in the beginning of this chapter, it can be estimated that CO_2 absorption is about 394 tons of CO_2/ year in 2020 and 394 tons of CO_2/ year in 2030 as shown by Table 5-13.

TABLE 5-13: The CO_2 absorption rate from plants in all five neighborhood projects

Types	**Green Area**		**Absorption Rate**		**Absorption Rate (tons of CO_2/ year)**	
	rai	hectare	tons of CO_2/ rai/year	tons of CO_2/ hectare/year	**2020**	**2030**
Bio-facade	18	2.88	19.98	124.9	362	362
Coconut	8.25	1.32	2.49	15.69	21	21
standing timber tree	2.25	0.36	1.21	7.52	3	3
medium height tree	5.5	0.88	1.47	9.17	8	8
				Total	**394**	**394**

Remark 1. Absorption rate of bio-facade is not compatible and should not be compared to the ones of remaining three types of plants because the nature of planting of those plants is too different. For example, in the same amount of area, Coconut is planted about 6.00 meter far away from each other while the climbing plant grows all over the surface of bio-facade. Also, the methods of experiments are very dissimilar; see Sunakorn and Kasemsap (2011) and Faculty of Forestry, Kasetsart University (2011).

2. Purpose and benefit from each type of plants are so various, not only to absorb CO_2. For example, standing timber tree gives a lot of shade and lowers the surrounding temperature. Coconut gives fruits and unique image of SAMUI Island. Medium height tree gives flowers and house insects. At the same time, climbing plant on bio-facade protects the building surfaces from the heat of the Sun. When everything is combined, the bio-diversity and the beauty of landscape emerge. Furthermore, investment and maintenance cost of bio-facade is much higher than other types of plant. Therefore, the developers and government shall not support the projects that contain just bio-facade to gain high absorption rate.

3. Area of 6.25 Rai = 1 hectare or 10,000 sq.m.

Supporting CN

Creating a CN is a new approach to urban development especially on the Samui Island. Although local entrepreneurs have been well aware of environmental problems, they still unsure of how to make such a complex project like CN a success business and good for environment. In order to encourage these entrepreneurs and to pamper a CN until it is mature, some measures should be required. Measures to support creation of community node include reducing developers' cost and increasing consumer confidence.

Reducing Developers' Cost The measures are as follows.

1) Co-investment between private developer and public developer (National Housing Authority-NHA) to reduce the capital funds and loans for each party, and to reduce specific business tax (real estate trade) as NHA is exempt.
2) Developing company's income tax and property tax reduction and during the first ten years of community operation
3) Provide low-interest loan for developers who want to create a green building within a designated CN area
4) Green materials subsidy and procurement by NHA to reduce material costs and encourage green buildings in the community
5) Reduce tax for shops and businesses in the CN area for the first 3-5 years
6) Provide governmental fund for landscaping the above open spaces
7) Change of comprehensive plan regulation to increase the building high to 7 stories, according to the efficiency of equipment use and energy consumption in high-rise building, to make compact city, increasing the chance to make proper profits
8) Amend some zoning laws to increase open spaces for growing large trees and for recreational purposes while increasing more density residential buildings. This can be done through the use of FAR and OSR regulations
9) Providing sufficient infrastructures to support the green CN projects

Increasing Consumer Confidence The measures are as follows.

1) Publicize the benefits of community node and green building with the standard sale prices that can be compared to the prices all over the country
2) Provide low-interest loan for people to rent or to open retail shops within a designated CN area
3) Provide long-term loan for housing buyers who can make down-payment more than 20% or have very good financial background
4) Provide standard sale contract under regulation to control cost, quality, and time to handover the housing to customers

5) Providing green public transportation (bio-diesel bus and tram) and bike lane between housing and workplaces

6) Give some periodical green building certificates so as to maintain the building standard in the CN area. (A building which lacks to keep its green standard certified will lose financial supports from the above measures.) The cost of building evaluation should be subsidized by government.

Budget Estimation The investment cost for each CN is 505 Million Baht; therefore it is 2,525 Million Baht for budget of project development. Table 5-14 shows the investment on CN development should be subsidized by government.

TABLE 5-14: The subsidized budget to promote CN development (5 locations)

Item	Budget (Baht)
1) Low-interest loan for developers	30,600,000
2) Green materials	83,500,000
3) Business tax for shops and businesses for the first 3-5 years	12,300,000
4) Landscaping the above open spaces	35,000,000
Subtotal	**161,400,000**
1) Publicizing the benefits of community node	2,000,000
2) Low-interest loan for retail shop renters	8,800,000
3) Long-term loan for housing buyers	73,100,000
4) Bio-diesel bus	10,100,000
5) Bike lane	2,600,000
6) Green building evaluation for the first 10 years	2,000,000
Subtotal	**98,600,000**
Total	**260,000,000**

As described above, there is not much direct cost for supporting the development of CN since it can be done through urban planning and financial alleviation which needs sincere cooperation rather than getting the real amount of money. However, there is still some budget to be given to some items of development such as the detailed feasibility study and the improvement of infrastructures.

5.2.3 Visualization and Adaptation of Walkable Areas

1) Field Survey Results

To select walkable core areas, the survey of walkway physical environments in high density local communities, high density tourist areas, downtown commercial areas and transit zones in SAMUI was conducted during 14-15 July 2012. Two areas were selected namely Chaweng beach and Nathon commercial areas. Chaweng beach is the most famous tourist area and has the highest density of tourist activities. Nathon is the administrative center where the district office and other government agencies are located and the downtown commercial area where local people come for business and shopping. It is also the entrance to SAMUI and the most important transit zone where two ferry piers are located. However, walking environments in the two areas are not very pleasant for both the local and the tourists. Survey results of the two areas are described as the following.

A. Walking Environments in Chaweng Beach

- **Walkway Network**

Walkway network is located along road network. The road network in Chaweng Beach area includes Chaweng 1 road, Chaweng 4 road, Chaweng 13 road and Chaweng Lake road. Chaweng 1 Road is parallel to Chaweng Beach. Its function is a one-way local road from Chaweng 4 road to Chaweng 13 road but when it passes Chaweng 13 road, its function is a two-way local road that links to Route 4169. Chaweng 4 road and Chaweng 13 road are two-way local roads that link Chaweng 1 road to Route 4169. Chaweng Lake road is another two-way road along the lake front that links Chaweng 14 road to Chaweng 1 road. Chaweng beach road and walkway network are presented in Figure 5-82.

Chaweng 1 road has a lots of tourists walk along the road for shopping and dining at restaurants in the evening and becomes alive and lot of activities at night despise the fact that it is only a few tourists walking for exercise in the morning. The traffic is usually very light in the morning. There are motorcycles, cars, trucks, vans and pick-up trucks on the street. In the evening, traffic is busy, especially motorcycles. The average car speed found in the area is 40-60 kilometer per hour. However, there is no speed limited sign or speed control provided. Road-side parking only allows in some area on the left side of the road. There are a lot of motorcycles parking on the street, but only a few outdoor seating available and less at streetscape. The activities that found on Chaweng 1 are presented in FIGURE 5-83.

Figure 5-84 shows physical environments of Chaweng 4 road. It was found that a retail shop at the junction between Chaweng 1 and Chaweng 4 roads i.e. at the entrance to the one-way section, which is the most popular tourist area, makes the entrance unnoticed. Therefore, this area should be improved by removing the retail shop and providing a plaza with tourist information center and kiosks.

Physical environments and activities on Chaweng Lake road are presented on Figure 5-85 and 5-86. Since this road is very close to Chaweng 1 road, it can be used as a service road when Chaweng 1 road is closed from traffic. There are some points or shops that people can walk through between the two roads.

1. Chaweng 4 road connects Cheweng 1 road and Route 4169

2 The one-way road system starts at the intersection between Chaweng 1 and Chaweng 4 Road

3 Road-side parking is only allowed on the left side

FIGURE 5-82 : Chaweng Beach Road and Walkway Network

4. A one-way road connects Chaweng Lake road and Chaweng 1 road

5. Junction at Chaweng 1 road and Chaweng 13 road

6. The southern part of Chaweng 1 road

In the evening, lots of tourists walk along the road for shopping, dining at restaurants, and other activities.

A lot of motorcycles parking on the street, but only a few outdoor seating available and less at streetscape.

More shops and activities along the northern part i.e. the one-way section

Less shops and activities along the southern part of the road

FIGURE 5-83 : Activities on Chaweng 1 Road

An approach to one way section on Chaweng 1 road is blocked by the retail shops on Chaweng 4 road

A vacant land on Chaweng 4 road where can be developed as a parking space

FIGURE 5-84 : Physical Environments of Chaweng 4 Road


FIGURE 5-85 : Physical Environments of Chaweng Lake Road


Chaweng Lake road and Chaweng 1 road can be connected by walking through shops

A pavilion and plaza beside the lake

An abandon shopping area opposite the plaza

FIGURE 5-86 : Activities on Chaweng Lake Road

- **Walkways Conditions**

A continuous pedestrian walkway is provided on the both side of road. The walkway width is approximately 1.2 meters, however, in some area, the width is varies depending on the building's set back distance. The walkway surface is poorly maintained and the concrete block paved surface is uneven. Additionally, some store fronts using different surface materials and the level do not consistent with the exiting sidewalk. Curb cuts and slope transitions are found at some intersections, pedestrian crossings and driveways, but very steep and inadequate design - their level is not consistent with the walkway. FIGURE 5-87 shows walkway obstacles on Chaweng 1 road. Other obstacles that can be found on the walkways are as follows;

- The walkway is blocked due to the placement of phone booth, advertisement signs, information kiosk, electric poles and traffic signs.
- Some shops are illegally built on the sidewalk.
- Inadequate street gutter design on the sidewalk that can be harmful to pedestrian.
- Some street vendors utilize on the sidewalk as retail space
- Crosswalk, Pedestrian bridge, Traffic light, Crosswalk signal/sign are not provided
- There are not enough shade for the walkway, only a few shade tree and some shops that have an awning or canopies over their storefront.

Sidewalk is too narrow to accommodate pedestrians due to the placement of electricity poles. There is no seating area available; however, there are some spaces that can be arranged for a seating area.

No combination between the old walkway and the new set back

Sidewalk is blocked due to the placement of phone booth and spirit house.

Sidewalk is too narrow to due to the placement of electricity pole stand parked motorcycles.

FIGURE 5-87: Walkway obstacles in Chaweng Beach area

B. Walking Environments in Nathon District

- Walkway Network

Walkway network is located along road network. Road network in Nathon commercial area include Route 4169 and Chonvitee road. Route 4169 is the main road that located around the island as a ring road. Its function is an arterial road but when it pass Nathon commercial area, its function is also a one-way local road in the commercial district. Chonvitee road is another one-way road along the sea front that links to Route 4169 and makes a loop in the commercial area.

Route 4169 is a 5 meter two-lane ring road that located around the island. It's quite busy because it's the main road that links the piers to the other areas in SAMUI Island. There are cars, trucks, vans and pick-up trucks on the street. Cars are allowed to park on the left side and motorcycles are allowed to park on the right side of the road. There is a zebra crossing on the road that links the pier to Route 4169 but its marking fades away. The average car speed found in the area is 40-60 kilometer per hour, however, there is no speed limited sign or speed control provided. Along both sides of the road, there are shop houses, mix of old wooden and new brick shop houses with the average height of 2-3 stories. The activities on Route 4169 are presented in the Figure 5-88.

- **Walkways Conditions**

The walkway width on Route 4169 is approximately 1.2 meters, however, in some area, the width is varies depending on the building's set back distance. The walkway is uneven concrete block paved surface and poorly maintained. Additionally, some store fronts using different surface materials and the level do not consistent with the exiting sidewalk. Curb cuts and slope transitions are found at some intersections, pedestrian crossings and driveways, but very steep and inadequate design - their level is not consistent with the walkway and some shops put metal plate to make a small slope in front of their shop houses. No street vender but some shops use the walkway to display their products and services, especially shops that locate next to electric poles. Spaces between the poles and shops are too narrow to walk. Therefore, the shops use the spaces for their own benefits. Figure 5-89 presents walkway obstacles on route 4169. Other obstacles that can be found on the walkways are as follows;

- The walkway is blocked due to the placement of traffic signs, post box, electric poles and plant pots.
- Some shops are illegally built on the sidewalk.
- Inadequate street gutter design on the sidewalk that can be harmful to pedestrian.
- Some shops use the spaces between the poles and shops as their small gardens where they put plants pots.

C. Obstacles for Pedestrian

It can be concluded that the obstacles for pedestrian and disable people are as follows:

C.1 Physical conditions

1. The walkways are of inconsistent width and in some locations are too narrow, especially on the south part of Chaweng 1 Road as presented on Figure 5-90.
2. The walkway surface is uneven and poorly maintained. Also, some store fronts using different surface materials and the level do not consistent with the exiting sidewalk, as presented in Figure 5-91.
3. A marked crosswalk and crosswalk signals are not installed. The available crosswalk is not in good condition.
4. Curb ramps are not installed at the walkway where they are connected to the street level, as presented in Figure 5-92.

1. There is a zebra crossing on the road that links the pier to Route 4169 but its marking fades away

2. Cars are allowed to park on the left side and motorcycles are allowed to park on the right side of the road.

FIGURE 5-88: Nathon Commercial Area Road and Walkway Network

2 SAMUI Island District Office Entrance on Route 4169

4 Along both sides of the road, there are shop houses, mix of old wooden and new brick shop houses with the average height of

Curb cut is not installed on the walkway where it is connecting to the street level.

The walkway is blocked due to the placement of traffic sign, electric pole and post box.

Some store fronts use different walkway surface and the level is not consistent with the exiting walkway.

Some shops use the spaces between the poles and shops as their small gardens where they put plants pots, which narrowing the walkway.

Some shops put metal plate to make a small slope in front of their shop houses.

FIGURE 5-89: Walkway obstacles on route 4169

FIGURE 5-90: Narrow walkways on Chaweng 1 Road

FIGURE 5-91: Uneven, poorly maintained and unconsistent walkways on Chaweng 1 Road

Chaweng 1 Road Route 4169, Nathon commercial area

FIGURE 5-92: Curb ramps are not installed

5. The walkway in some locations is discontinuous because of the hotel entrance, restaurant entrance or intersection, as presented in Figure 5-93.
6. Walkways are blocked due to the placement of infrastructures such as electric poles and telephone booths, as presented in Figure 5-94.
7. Inadequate street gutter design on walkway that can be harmful to the pedestrian, as presented in Figure 5-95.
8. No street furniture or a seating area for pedestrian.
9. Street light is not consistent with pedestrian-scale.
10. No Shading on walkways.
11. Inappropriate traffic signs and barriers, as presented in Figure 5-96.

FIGURE 5-93: Discontinuous walkways on Chaweng 1 road

FIGURE 5-94: Obstructions on walkways

Chaweng 1 Road

Route 4169, Nathon commercial area

FIGURE 5-95: Inadequate street gutter design

FIGURE 5-96: Inappropriate traffic signs and barriers on Chaweng 1 road

C.2 Management issues

1. No speed limited sign indicates.
2. Some street vendors utilize on the sidewalk as retail space or some shops use the walkway to display their products and services, as presented in Figure 5-97.

Chaweng 1 Road

Route 4169, Nathon commercial area

FIGURE 5-97: Obstructions on walkways from shop activities

2) Measures to Develop the Walkable Areas at Chaweng Beach and Nathon

A. Concepts of Walkable Areas

To create pedestrian friendly walkable areas at Chaweng beach and Nathon, 5 concepts will be applied as the following.

1. Connecting places people want to go:

People in SAMUI mean both the local people and tourists. Walkways between the places in local communities and tourist areas should be constructed. Missing links must be completed. Where walkways are available but not in good conditions, physical improvements and maintenances are required. Where road spaces are not enough for walkway construction, “shared spaces” will be applied. This includes physical environments improvements and changing pavement materials and color.

2. Accessible to all:

Universal Design concept will be applied to improve walkways and pedestrian facilities as follows:

- Constructing or widening walkways to minimum 0.90 m for wheelchairs, and 1.2 - 2 m where possible
- Widening walkways in front of shops or bus stops to 3-4 m where possible to provide spaces for pedestrians and shoppers or passengers
- Improving walkway surfaces: non-slip, smooth, dry and flat
- Constructing curb ramp along the walkway and at intersections
- Installing audible traffic signals at main crossings
- Removing obstructions on walkways such as garbage bins, lamp posts, and telephone booths to ensure proper width for pedestrians and wheelchairs
- Installing guardrails and barriers where needed such as along steep walkway
- Providing ramps where walkway levels are changed
- Installing corduroy hazard warning surface where a path join a shared route and where necessary
- Installing blister at crossings, steps and where necessary

3. Creating pedestrian friendly and safe areas:

Traffic calming concept will be applied on collector and local roads to reduce motor vehicle speeds. Speed should be limited at 30 km/hr for safety of pedestrians and cyclists. The following traffic calming devices should be installed at appropriate locations.

- Gateways or entrance islands should be installed at entrances to the selected areas i.e. between arterial and collector/local roads

- Speed humps or speed tables should be installed at approach to zebra crossings
- Raised intersections should be installed at intersections in the areas
- Median refuges should be installed at zebra crossings on wide roads
- Curb extension should be installed on wide roads to narrow the roadway at crosswalk, especially on roads that have parallel- parking lanes

4. Improving pedestrian environments and sense of places

Urban and landscape design will be employed to improve pedestrian environments and create sense of places. The following facilities should be provided and well designed to show identity of SAMUI Island.

- Street furniture such as benches, drinking fountain, sunshade, public art, pedestrian-scale lighting
- Kiosks or spaces for street venders to create commercial activities along the walkways
- Spaces for landscape features. Trees for shading and plants for psychological and visual comfort of pedestrian
- Social spaces for people to interact i.e. places for standing, visiting and sitting. The social spaces can be open spaces such as plazas, courtyards and squares

5. Encouraging public activities

Establishing pedestrian streets where local people and tourist can join cultural and religious activities such as New Year, Song-kran and Chinese New Year festivals and other activities such as music and food festivals.

B. Physical Improvements

- **Suggestions for Improvements**

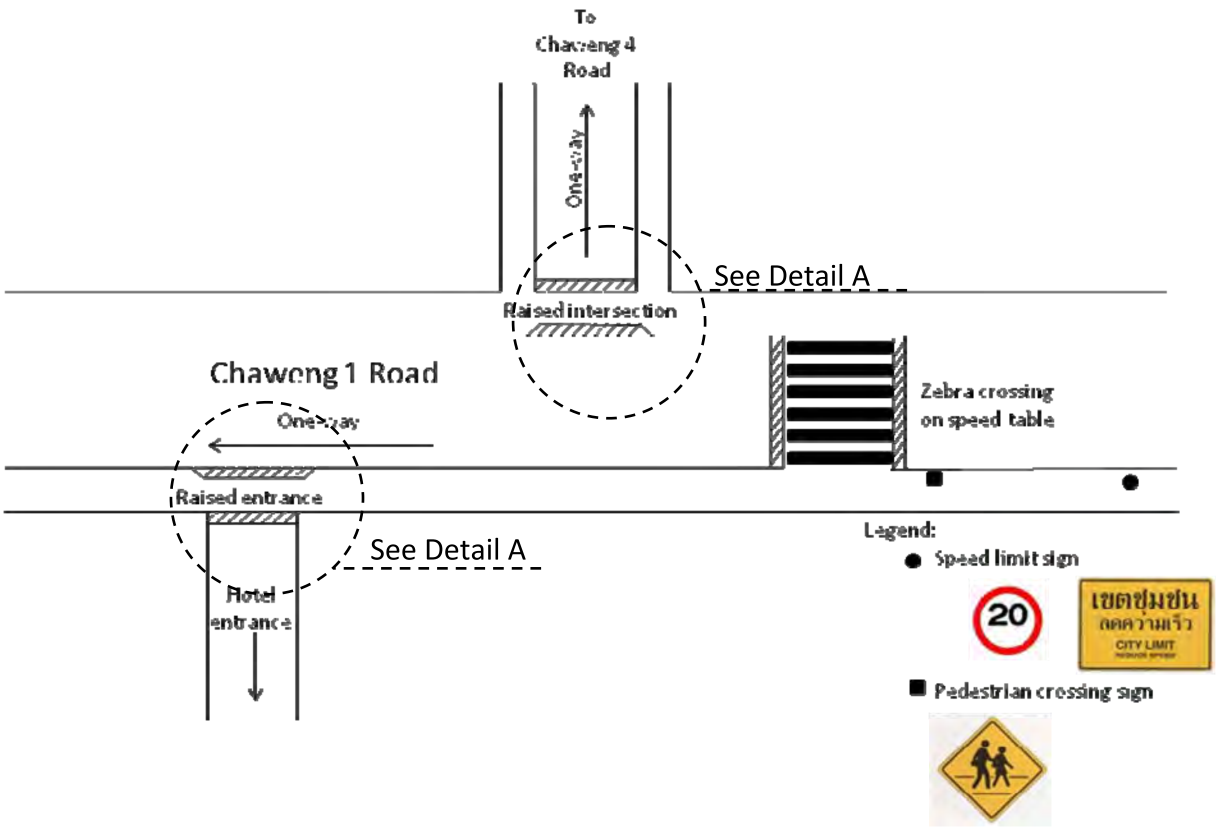
Physical problems on the walkways in Chaweng beach and Nathon areas should be improved to create pedestrian friendly walkable areas, as presented in Table 5-15

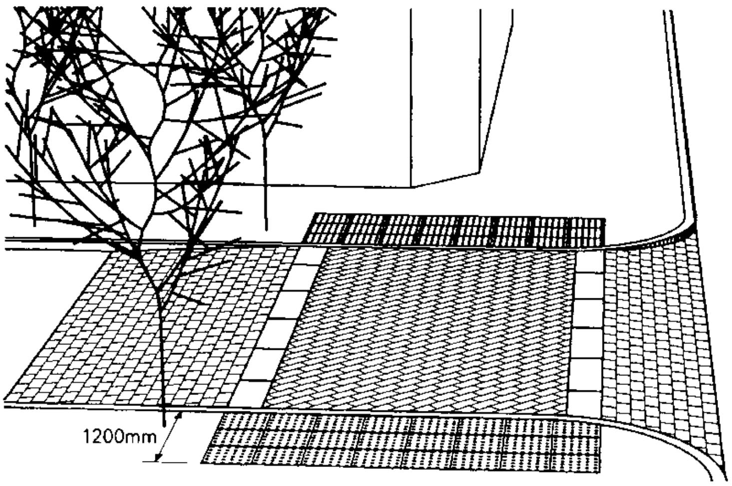
TABLE 5-15 : Suggestions for Physical Improvements

Physical conditions	Suggestions for improvements
Walkways width is inconsistent and narrow	- Widening walkways to minimum 0.90 meters, or 1.2 – 2 meters for wheelchair where possible.
The walkway surface is uneven and poorly maintained. Also, some store fronts using different surface materials and the level do not consistent with the exiting sidewalk	- Improving walkway surface by changing the pavement using the same material and constructed at the same level. - To make wheelchair and baby carriage movement easy, firm and regular surface with selected materials that smooth, dry, non-skid, no reflection, and has minimum number of expansion and contraction joint such as asphalt, concrete, and tile and brick laid in concrete is recommended. - Slope gradient should be equal to or less than or less than 3% (1:30)
A marked crosswalk and crosswalk signals are not installed.	- Installing crosswalk i.e. zebra crossing and traffic signals at main intersection such as intersection between Route 4169 and a road from the ferry pier i.e. in front of SAMUI Island district office, Nathon commercial area, as presented in FIGURE 5-98 - On Chaweng 1 road, zebra crossing should be installed at importation locations. Distances between the crossings should be around 200 m. - On local road i.e. Chaweng 1 road, the zebra crossing can be integrated with speed table to slow down the traffics and help drivers to see pedestrians, who are crossing the road, clearer, as presented in Figure 5-98
Curb ramps are not installed at the walkway where they are connected to the street level.	- Installing curb ramps at the intersection, walkway and driveway. For material, sand wash is recommended. - Slope of the curb ramp should be equal to or less than 1:12

Physical conditions	Suggestions for improvements
The walkway in some locations is discontinuous because of hotel entrances or an intersection.	- Walkways should be continuous. Surface at the hotel entrance or an intersection can be improved by being raised to the same level with the walkways, as presented in Figure 5-98. - The raised entrance will also make drivers drive slowly and provide safer conditions for pedestrians.
Walkways are blocked due to the placement of infrastructures such as electric poles and telephone booths.	- Removing obstructions on walkways to ensure proper width for pedestrian and wheelchair. - Most of the telephone booths are broken. They should be removed and replaced by Wi-Fi. - Where electric poles are located and walkway is too narrow, curb extension can be used to create more space for pedestrians, as presented in Figure 5-99 Note: If the electricity and telephones lines are moved to underground system, the curb extension may not be necessary.
Inadequate street gutter design on walkway that can be harmful to the pedestrian.	- Replacing the street gutters. For pedestrian safety, curb opening inlet and trench drain (slotted inlet) are recommended, as presented in Figure 5-100
No street furniture or a seating area for pedestrian.	- Providing street furniture, such as benches, drinking fountain, sunshade and public art should be installed where possible. - Street furniture should be well designed to represent sense of places. - At areas where buildings are set back from walkways, the walkways are wide enough for providing seating areas or pocket parks, as presented in Figure 5-101
Street light is not consistent with pedestrian-scale.	- Providing pedestrian-scale lighting. - Encouraging shops along the roads to provide lighting for pedestrian in front of the shops.
No Shading on walkways	- Providing spaces for landscape features. In some area, walkway is too narrow to plant trees for shading. Therefore, climber is recommended.
No speed limit sign indicates	- Installing speed limit sign. - On Route 4169 at Nathon area, speed should be limited

Physical conditions	Suggestions for improvements
	at not more than 40 km/hr. The speed limit sign should be installed at the entrance to the downtown commercial area, as presented in Figure 5-106 - Since Chaweng 1 road is crowded by tourists, speed should be limited at not more than 20 km/hr. for safety of pedestrians. The speed limit sign should be installed at the entrance to the one-way section on Chaweng 1 road.
Some street vendors utilize on the sidewalk as retail space or some shops use the walkway to display their products and services.	- Creating kiosks and spaces for street venders. - Closing Chaweng 1 road for pedestrian only and allow street venders to sell on the road. - Enforcement – display on walkway is not allowed
Inappropriate traffic signs and barriers.	- Removing inappropriate traffic signs and barriers. - Installing proper traffic signs at appropriate locations.





Detail A
Source: Access Board Research (2012)

FIGURE 5-98 : Walkway improvement on Chaweng road

Before After

FIGURE 5-99 : Curb extension at electric poles provides more space for pedestrians and wheelchairs

Before After

FIGURE 5-100 : Improvement of Street Gutter on Chaweng 1 Road

Before After

FIGURE 5-101 : Improving walking environments by providing a pocket park and shading

C. Creating "Chaweng Beach Walking Street"

Physical improvements on the walkways in Chaweng beach and Nathon areas can create pedestrian friendly walkable areas, but cannot encouraging public activities. In order to encourage public activities and provide social spaces, closing Chaweng 1 road from traffics is recommended. The closing will be implemented on the one-way section i.e. from the intersection between Chaweng 1 road and Chaweng 4 road to the intersection between Chaweng 1 road and Chaweng 13 road, as presented in Figure 5-101.

During the closing time, parking is not allowed on Chaweng 1 road. Tourists, car users and motorcycle users can park their vehicles at selected parking areas on Chaweng 4 road and Chaweng Lake road. The parking areas are located in walking distances to shops and hotels on Chaweng 1 road. In addition, shortcuts between Chaweng Lake road and Chaweng 1 road can be provided through retails shops and plaza, as presented in Figure 5-102 and 5-104 For pedestrian safety, zebra crossings should be provided on Chaweng 4 road.

For convenient of senior tourists, disable people or people who travel longer than the walking distance i.e. longer than 500 m., electric shuttle buses, as presented in Figure 5-103, should be provided free of charge. SAMUI municipality can organize the electric shuttle bus services by getting sponsorship from businesses in this area. Advertisements of these sponsors will be presented on the electric shuttle buses. With high number of business firms in this area, this service should be sufficient and able to cover its costs. The electric local buses should be operated in loop system that is Chaweng 1 road - Chaweng Lake road - Chaweng 4 road - Chaweng 1 road, as presented in Figure 5-102 For safety of the shuttle bus riders, zebra crossings should be provided at bus stops on Chaweng Lake road.

For hotel guests who use hotel pick up services from the ferry piers or the airport, the hotel vans can park at the provided parking area on Chaweng 4 road. To travel from the parking area to hotels on Chaweng 1 road, the hotels can arrange their electric cars such as golf cars or non-motorized vehicles such as rickshaws to pick up their guests. Hotel guests who travel by themselves can go to the hotels by riding the electric shuttle buses or walking.

The closing is separated into 3 periods according to tourism season in SAMUI that are low season, high season and peak season, as presented in Table 5-16. Figure 5-105 presents environments of Chaweng 1 road before and after implementation of “Chaweng Beach Walking Street”.

TABLE 5-16: Schedule for Chaweng Beach Walking Street

Duration	Operation	Closing time (days)
16 July – 31 Aug.: High season	Closing everyday from 5pm to 3am.	22
1 Sep. – 20 Dec.: Low season	Closing on Fri. and Sat. from 5pm to 3am.	14
21 Dec. – 10 Jan.: Peak season	Closing everyday from 11am to 3am.	14
11 Jan. – 30 April: High season	Closing everyday from 5pm to 3am.	50
1 May – 15 July: Low season	Closing on Fri. and Sat. from 5pm to 3am.	10

Total closing days = 110 days per year

Legend:

Chaweng Beach Walking Street
Parking Area
Electric shuttle bus route
Shortcuts between Chaweng 1 road and Chaweng Lake road

FIGURE 5-102: Concept of Chaweng Beach Walking Street

An example of an electronic shuttle bus.

Bio-diesel shuttle bus services in KU displays an advertisement of its sponsor on the bus.

FIGURE 5-103: Examples of shuttle bus services

An entrance at the back of "Living Plaza" where motorcyclists can park on Chaweng Lake road and walk through the plaza to Chaweng 1 road

An abandon retail shops that under renovation and will become a linkage between Chaweng Lake road to Chaweng 1 road

An abandon retail shops – Jun Pha Plaza that can be renovated and developed as a linkage between Chaweng Lake road to Chaweng 1 road

An existing one-way road and walkway links Chaweng Lake road to Chaweng 1 road

FIGURE 5-104: Locations of Shortcuts between Chaweng Lake Road and Chaweng 1 Road

Before After

Before After

FIGURE 5-105: Chaweng Beach Walking Street

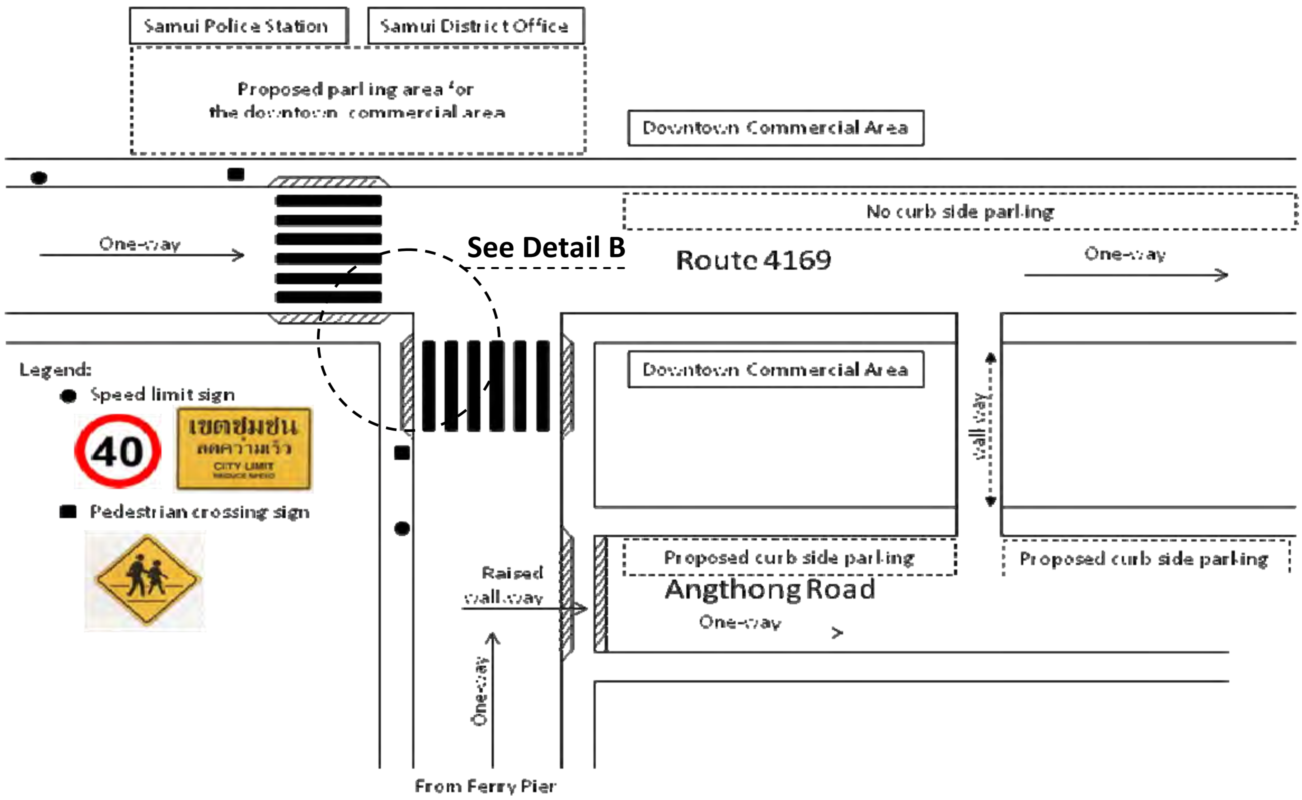
D. Providing "Parking Areas" at Nathon Commercial Area

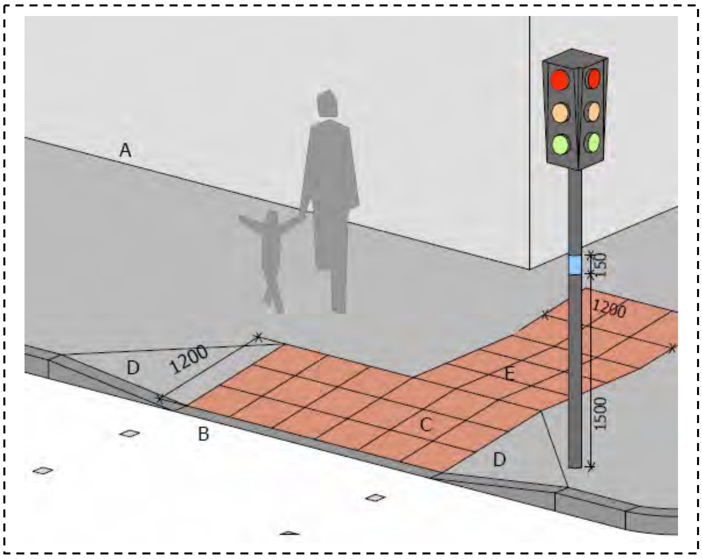
At present, curb side parking is allowed on the left side of Route 4169 at the down town commercial area. The parking obstructs traffics as well as blocks car drivers from seeing pedestrians who are crossing the road. Therefore, it is recommended to cancel the curb side parking from the intersection between Route 4169 and a road from the ferry pier to the intersection between Route 4169 and Ang Thong 3 road.

The new parking spaces are proposed at the parking lot in front of SAMUI district office and along Ang Thong road, which is a one way road that run parallel with the Route 4169, as presented in FIGURE 5-106 For safety and convenient of pedestrians, the roadway at Ang Thong road entrance should be raised at the same level with the walkway. In case of high demand for parking spaces, another parking space is recommended at Nathon Ferry Pier. Therefore, the existing plan to improve Nathon City should also consider providing parking spaces.

For safety of pedestrians, a zebra crossing with traffic signals at main intersection such as intersection between Route 4169 and a road from the ferry pier i.e. in front of SAMUI district office. At the approach to the zebra crossing, traffic signs showing speed limit and city limit “reduce speed” should be installed. A speed table is not recommended at the zebra crossing on Route 4169 because this route is the main road. Traffic calming devices are suitable on collector and local roads.

With the new parking spaces and physical improvements of the walkway, as presented in Figure 5-107, it is expected that local people and tourists, who come to the down town commercial area, and the residents who live in this area will work more regularly.





Key

A. Rear of pavement or building line
B. Dropped kerb to be flush with the carriageway, or subject to a max 6mm level difference and a rounded kerb edge. Red blister paving to full width of dropped kerb
C. Ramped section of pavement perpendicular to crossing to be 1 in 20 (max 1 in 12)
D. Flared sides or ramp to be max 1 in 11
E. L-shaped stem of blister paving to guide people to crossing point

Note:
- Red blister paving to full width of dropped kerb
- All dimensions in millimetres

Detail B
Source: Centre of Excellent in Universal Design (2012)

FIGURE 5-106: Improvement of Nathon Commercial Area

Before After

FIGURE 5-107: Physical Improvements on Walkway in Nathon Commercial area

3) Reduction of CO_2

To calculate CO_2 reduction in SAMUI district, amount of CO_2 emission from different types of vehicles was estimated. Data of number of household and number of vehicles in SAMUI district were also obtained in order to calculate vehicle occupancy in SAMUI district. Calculation of CO_2 reduction in Nathon commercial area and Chaweng beach areas is different. In Nathon commercial area, Route 4169 is the main road and most of traffics are generated by local people. Therefore, the calculation is based on vehicle occupancy i.e. number of household and number of vehicles in Ang Thong sub-district. In Chaweng beach area, Chaweng 1 road is a local road. Traffics in this area are generated by both local people who travel to work in this area and tourists who come to shops and restaurants. Then, the calculation is based on vehicle occupancy in Chaweng beach area and number of vehicles that pass and park along the one-way section on Chaweng 1 road i.e. the section that will be introduced as the walking street.

A. CO_2 Emission from Vehicles in Thailand

In Thailand, Nilrit and Sampanpanish (2012) conducted a research to determine the emission factor of CO_2 from in-use vehicles in Thailand. The in-use vehicles were tested on a chassis dynamometer by the Bangkok Driving Cycle. The in-use vehicles were separated into 4 groups that are:

1) heavy duty diesel vehicles such as buses
2) light duty diesel vehicles such as pick-ups and vans
3) light duty gasoline vehicles such as passenger cars
4) two wheels-motorcycles and three wheels (tuk tuks or Rickshaw) with four stroke engines

Table 5-17 presents amount of CO_2 emission from the four types of vehicles. It was found that the heavy duty diesel vehicles i.e. the buses produced the highest amount of CO_2 and the vehicles that use diesel fuel produced higher amount of CO_2 than the vehicles that use gasoline fuel.

Since data of vehicle types with fuel consumption in SAMUI district is not available, average CO_2 emission from different types of vehicles was calculated, as presented in Table 5-17. The average amount will be used for calculation of CO_2 Emission from Vehicles in SAMUI District.

TABLE 5-17: CO_2 Emission from In-use Vehicles in Thailand by Types and Fuel Consumption

Vehicle Types	Fuel Types	CO2 (g/km)	Average
Heavy duty diesel vehicles : buses	Diesel	1,150.1	1,215.5
	NGV	1,280.9	
Light duty diesel vehicles: pick-ups and vans	Diesel	307.2	290.5
	B2	338.1	
	B5	254.8	
	B20	301.6	
	B50	309.5	
	B100	231.9	
Light duty gasoline vehicles :passenger cars	Gasoline 91	170.2	179.5
	Gasoline 95	192.4	
	Gasohol 91	192.5	
	Gasohol 95	206.3	
	LPG	156.6	
	NGV	159.1	
Motorcycles	Gasoline 91	38.2	40.0
	Gasoline 95	41.4	
	Gasohol 91	40.4	
	Gasohol 95	40.1	
Tuk-Tuks or Rickshaw	LPG	76.5	76.5

Source: Prepared from Nilrit and Sampanpanish (2012)

B. CO_2 Emission from Vehicles in SAMUI District

According to types of vehicles registered in SAMUI district, CO_2 emission from each type of vehicles is estimated using data from the CO_2 Emission from In-use Vehicles in Thailand, as presented in Table 5-18.

TABLE 5-18: Estimated CO_2 emission from Vehicles in SAMUI District

Types of Vehicles	Estimated CO_2 emission (g/km)
Private Cars	179.5
Private Motorcycles	40.0
Minibuses (songtaew)	290.5
Public Buses	1,215.5
Minivans	290.5
Taxis	179.5
Motorcycle Taxis	40.0

C. Number of Households in SAMUI District

Data from Department of Provincial Administration (DOPA, 2112) shows that in the end of December, 2011, number of households in SAMUI District was 40,411. Nathon commercial area is located in Ang Thong sub-district where its number of households was 5,108, Chaweng beach area is located in Bo Phut sub-district where its number of households was 15,470, as presented in Table 5-19.

TABLE 5-19: Population in SAMUI District as of December 2011

Province/District/Sub-district	Population	Household
SAMUI District	61,318	40,411
Ang Thong Sub-district	10,763	5,108
Lipa Noi Sub-district	4,945	2,408
Taling Ngam Sub-district	5,573	2,461
Na Muang Sub-district	4,771	2,334
Ma Ret Sub-district	8,877	6,686

Province/District/Sub-district	Population	Household
Bo Phut Sub-district	18,169	15,470
Mae Nam Sub-district	8,220	5,944

Source: DOPA (2012)

D. **Number of Vehicle Registered in SAMUI District**

Number of vehicles registered in SAMUI districts in 2010, 2011 and 2012 is presented in Table 5-20. It was found that the highest number of vehicles is private motorcycles and the 2nd highest is private cars. For public vehicles i.e. public transportation, the highest numbers is taxis and the 2nd highest is minibuses (songtaew).

TABLE 5-20: Number of Vehicles in SAMUI Districts

	2010 (Car)	2011 (Car)	2012 (Car) Until May 30,12
Private Cars	14,004	15,248	12,168
Private Motorcycles	24,679	26,146	23,053
Minibuses (songtaew)	167	167	167
Public Buses	50	50	50
Minivans	80	80	120
Taxis	379	397	400
Motorcycle Taxis	50	50	50

E. **Vehicle Occupancy in SAMUI District**

- Number of household in SAMUI District in 2011 is 40,411 households.
- Number of private cars in 2011 is 15,248 cars
- Car occupancy is 0.38 cars/household
- Number of motorcycles in 2011 is 26,146 motorcycles
- Motorcycle occupancy is 0.65 motorcycles/household

F. CO_2 Reduction in Chaweng Beach Area in 2012

In Chaweng beach area, the calculation of CO_2 reduction is separated into 4 parts. The first part is calculated from number of vehicles in households in Bo Phut sub-district that will be reduced after the physical environments on the walkway along Chaweng 1 road are improved. It is assumed that when the physical environments are improved, some residents will walk to Chaweng beach area.

The second part is calculated from number of cars and motorcycles that will not allow to park along Chaweng 1 road i.e. the walking street when the "Chaweng Walking Street" is implemented.

The third part is calculated from number of the minibuses (songtaews) i.e. 167 minibuses that are not allowed to pass the walking street.

The fourth part is calculated from number of the minivans i.e. hotel vans that are not allowed to pass the walking street. Total minivans in SAMUI districts are 80 vans. It was estimated that 50% of hotels that have minivans are located in Chaweng beach area. Therefore, 40 minivans will not be allowed to pass the walking street.

- Number of Vehicles in Bo Phut Sub-district

- Number of household in Bo Phut sub-district is 15,470 households.
- Number of private cars in Bo Phut sub-district is 0.38 x 15,470 = 5,879 cars.
- Number of private motorcycles in Bo Phut sub-district is 0.65 x 15,470 = 10,056 motorcycles.

- **Number of Vehicles Reduction in Bo Phut Sub-district**

From aerial photograph, it is estimated that 20% of the households is located near the Chaweng beach area. Therefore, when physical environments on the walkway are improved, the walking street is implemented and the electric shuttle buses are provided, it can be forecasted that 20% of cars and motorcycles in households i.e. 1,176 cars and 2,011 motorcycles will be reduced in this area, as presented in Table 5-21.

On Chaweng 1 road, parking is allowed on the left side of road. Distance of the one-way section i.e. from the intersection between Chaweng 1 road and Chaweng 4 road to the intersection between Chaweng 1 road and Chaweng 13 road is approximately 2 km. Since curb side parking is not allowed at corners between the main road and local road and entrances to hotels, road length for parking is around 1.5 km. It is estimated 50% of parking spaces is for cars and the rest is for motorcycles. Therefore, this road section has capacity for 125 cars and 938 motorcycles. This amount of vehicles will be removed when the walking street is implemented, as presented in Table 5-21.

- **Amount of CO_2 Reduction in 2012**

It is assumed that the car and motorcycle users in Chaweng beach area travel between their home and the commercial area 2 trips per day, each trip length is 1 km by the electric shuttle bus, and total trip length is 2 km. If all of the car and motorcycle users park their vehicles at home and walk, the amount of CO_2 will be reduced 583,008 g/day or 212.80 tons/year, as presented in Table 5-21.

According to Table 5-16, the walking street is not implemented every day. Total days of implementation are only 110 days. Therefore, terminating the curb side parking will reduce CO_2 for 119,915 g/day or 13.19 tons/year, as presented in TABLE 5-19. CO_2 reduction from the minibuses (songtaew) is 97,027 g/day or 10.67 tons/year. CO_2 reduction from the hotel minivans is 23,240 g/day or 2.56 tons/year.

Total CO_2 reduction from improving physical environments and providing “Walking Street” at Chaweng beach area in 2012 is 823,190 g/day or 239.22 tons/year, as presented in Table 5-21.

TABLE 5-21: CO_2 Reduction in Chaweng Beach Area in 2012

	Total amount	Amount after Reduction	CO2 Emission (g/km)	CO2 Reduction (g/km/day)	CO2 Reduction (g/day)	CO2 Reduction (Tons/year)
Cars in households	5,879	1,176	179.5	211,056	422,112	154.07
Motorcycles in households	10,056	2,011	40	80,448	160,896	58.73
			Total	291,504	583,008	212.80
Parked cars	125	125	179.5	22,438	44,875	4.94
Parked motorcycles	938	938	40	37,520	75,040	8.25
			Total	59,958	119,915	13.19
Minibuses (songtaew)	167	167	290.5	48,514	97,027	10.67
Minivans	40	40	290.5	11,620	23,240	2.56
			Grand Total	411,595	823,190	239.22

G. **CO_2 Reduction in Nathon Commercial Area in 2012**

In Nathon commercial area, the calculation of CO_2 reduction is separated into 2 parts. The first part is based on number of vehicles in Ang Thong sub-district and numbers of vehicles that will be reduced after the physical environments on the walkway along Route 4169 in the commercial area are improved and the parking areas are provided. The calculation focuses only vehicles in the household i.e. the private cars and private motorcycles. The second part is calculated from numbers of cars and motorcycles that will not be allowed to park along the Route 4169 after the parking spaces are provided.

- **Number of Vehicles in Ang Thong Sub-district**

  - Number of household in Ang Thong sub-district 5,108 households
  - Number of private cars in Ang Thong sub-district is 0.38 x 5,108 = 1,941 cars
  - Number of private motorcycles in Ang Thong sub-district is 0.65 x 5,108 = 3,320 motorcycles

- **Number of Vehicles Reduction in Nathon Commercial Area**

Nathon commercial area is an urban area in SAMUI district. From aerial photograph, it is estimated that 50% of the households is located within 500 m. i.e. the walking distances from the commercial area. Therefore, when physical environments on the walkway are improved and the parking areas are provided, it can be forecasted that 50% of cars and motorcycles i.e. 971 cars and 1,660 motorcycles will be reduced in this area, as presented in Table 5-22.

On Route 4169 at Nathon commercial area, curb side parking is allowed. Cars are allowed to park on the left side and motorcycles are allowed to park on the right side of the road. Road length of this section is around 500 m. Since curb side parking is not allowed at corners between the main road and local road, road length for parking is around 400 m. Therefore, this road section can accommodate 67 cars and 500 motorcycles. When curb side parking is prohibited, this amount of vehicles will be removed from Nathon commercial area.

- **Amount of CO_2 Reduction in 2012**

It is assumed that the car and motorcycle users in Nathon commercial area travel between their home and the commercial area 2 trips per day, each trip length is 500 m i.e. the walking distance, and total trip length is 1 km. If all of the car and motorcycle users park their vehicles at home and walk, the amount of CO_2 will be reduced 240,605 g/day or 87.82 tons/year, as presented in Table 5-22. In addition, terminating the curb side parking will reduce CO_2 for 32,027 g/day or 11.69 tons/year, as presented in Table 5-22.
Total CO_2 reduction from improving physical environments and providing "Parking Areas" at Nathon commercial area in 2012 is 272,632 g/day or 99.51 tons/year, as presented in Table 5-22.

TABLE 5-22: CO_2 Reduction in Nathon Commercial Area in 2012

	Total amount	Amount after Reduction	CO2 Emission (g/km)	CO2 Reduction (g/km/day)	CO2 Reduction (Tons/year)
Cars in households	1941	971	179.5	174,205	63.58
Motorcycles in households	3320	1660	40	66,400	24.24
			Total	240,605	87.82
Parked cars	67	67	179.5	12,027	4.39
Parked motorcycles	500	500	40	20,000	7.30
			Total	32,027	11.69
			Grand total	272,632	99.51

H. **CO_2 Reduction from Implementation of Walkable Communities in SAMUI in 2012 and 2030**

After improvement of physical environments along walkways in Chaweng beach and Nathon commercial areas and implementation of "Chaweng walking street" and "Parking area", it is estimated CO_2 reduction in Chaweng beach area is 212.8 tons per year and CO_2 reduction in Nathon commercial area is 87.82 tons per year. Totally, CO_2 reduction from development of walkable areas in SAMUI is 300.62 ton per year in 2012.

In 2030, number of cars and motorcycles in households are forecasted using the same growth rate with Transportation Planning i.e. 1.2 for cars 1.0 for motorcycles. It is estimated that in 2030, CO_2 reduction from cars and motorcycles in households in Chaweng beach area will be 261.22 tons per year and CO_2 reduction from cars and motorcycles in households in Nathon commercial area will be 107.8 tons per year, as presented in Table 5-23

TABLE 5-23: CO_2 Reduction from Implementation of Walkable Communities in SAMUI in 2030

	2012			2030		
	No. of vehicles	CO2 Reduction (Tons/year)	CO2 Reduction (Tons/year/vehicle)	growth rate	No. of vehicles	CO2 Reduction (Tons/year)
Chaweng Beach Area						261.22
Cars in households	5879	154.07	0.026	1.2	7,287	190.97
Motorcycles in households	10056	58.73	0.006	1	12,028	70.25
Nathon Commercial Area						107.8
Cars in households	1941	63.58	0.033	1.2	2,406	78.81
Motorcycles in households	3320	24.24	0.007	1	3,971	28.99

4) Scheduling of Implementation and Costs Estimation

Development of walkable areas in SAMUI is separated into 4 phases as follows:

Phase 1: Improvement of physical environments on Chaweng 1 road – the one-way section

Phase 2: Improvement of physical environments on Chaweng 1 road – the rest of Chaweng 1 road

Phase 3: Implementation of “Chaweng Walking Street”

Phase 4: Improvement of physical environments and providing “parking spaces” in Nathon Commercial area

Chaweng beach area receives the priority because this area has higher number of pedestrians and Chaweng 1 road is the local road. Developing infrastructure on Chaweng 1 road will not affect general traffic on the island.

A. Cost Estimation for Phase 1: Improvement of Physical Environments on Chaweng 1 road – the One-way Section

Total distance of this road section is 2,100 m. The improvements include changing walkway surface to be in the same level and use the same materials. The selected pavement material should be “low impact development” materials i.e. porous surfaces that can help reduce surface flow and increase infiltration. This will also alleviate flood from rain water in Chaweng beach area.

For safety of pedestrians, zebra crossings on speed tables will be provided. Proper traffic signs such as speed limit and pedestrian crossing signs will be installed. Street gutters will be replaced. Street light at pedestrian-scale will be installed. To provide safer walkway and more spaces for pedestrians and for area beautification, the electricity and telephones lines will be removed and placed in the underground system. The unused telephone booths will be also removed.

To improve pedestrian environments and sense of place, two pocket parks with street furniture will be provided. It is recommended that electricity and telephone lines including cables should be removed underground. Cost of removing the cable utilities is estimated using costs in Bangkok as based cases i.e. around 75,000 baht/m for both sides of a road. Cost estimation for the 1st phase is described in Table 5-24. There are 3 different prices that depend on color of the porous blocks. Since the cost of removing the cable utilities is very high, total costs excluding the removing costs are also presented.

B. Cost Estimation for Phase 2: Improvement of Physical Environments on Chaweng 1 road – the Rest of Chaweng 1 road

Total distance of this road section is 1,500 m. The improvements are similar to the one-way section. However, a pocket park is not provided because the walkway in this section is not wide enough and number of pedestrians is not high. Cost estimation for the 2nd phase is described in Table 5-25. There are 3 different prices that depend on color of the porous blocks.

TABLE 5-24: Cost Estimation for Phase 1: Improvement of physical environments on Chaweng 1 road – the one-way section

ID	Item	Amount	Unit Price Baht)	Total price (Baht)
1	Walkway surface improvement (width 1.2 m length 2.1 km 2 sides)	5040		
	Option 1.1 Pavement material: Porous Block - Gray*	5040	771.87	3,890,225
	Option 1.2 Pavement material: Porous Block - Orange*	5040	871.87	4,394,225
	Option 1.3 Pavement material: Porous Block - Green*	5040	971.87	4,898,225
2	Installing curb ramps and warning blocks at intersections			116,986
	Curb ramp (width 0.9 m length 3.2 m, 30 locations i.e. 60 ramps)*	172.8	452	78,106
	Blister Tactile paving surface (size 0.4x0.4 per piece, 24 pieces per 1 location)**	720	54	38,880
3	Installing Zebra crossing on speed tables at every 200 m*			2,932,725
	Speed table (size 3.5 x 5 m = 17.5 sq m, 10 locations)*	175	13,287	2,325,225
	Zebra Crossing (size 3 x 5 m = 15 sq m, 10 locations)*	150	4,050	607,500
4	Removing unused telephone booths (4 units)***	4	5,500	22,000
5	Replacing street gutter (size 0.6 x 0.6 m, around 100 units)**	100	1,800	180,000
6	Providing street furniture at pocket parks (2 parks)**	2	35,600	71,200
7	Installing Solar Street light 2.20 m. high at every 20 m (210 units)**	210	7,700	1,617,000
8	Installing proper traffic signs (20 units)**	20	5,920	118,400
9	Removing cable utilities underground***	2100	75,000	157,500,000
10	Shipping and Transportation cost (10-Wheel truck) for 5 trips	7	12,789	89,523
11	Ferry Fare (10-wheel truck with driver and assistant)	14	1,900	26,600
	Total (Option 1.1) <u>excluding</u> cost of removing cable utilities underground			9,064,658
	Total (Option 1.2) <u>excluding</u> cost of removing cable utilities underground			9,568,658
	Total (Option 1.3) <u>excluding</u> cost of removing cable utilities underground			10,072,658
	Total (Option 1.1) <u>including</u> cost of removing cable utilities underground			166,680,781
	Total (Option 1.2) <u>including</u> cost of removing cable utilities underground			167,184,781
	Total (Option 1.3) <u>including</u> cost of removing cable utilities underground			167,688,781

Note: Prices at August 2012, 7% VAT is not included, * materials are available in Samui Island, * * materials are not available in Samui Island,
*** transportation costs are already included

TABLE 5-25: Cost Estimation for Phase 2: Improvement of physical environments on Chaweng 1 road – the rest of Chaweng 1 road

ID	Item	Amount	Unit Price (Baht)	Total price (Baht)
1	Walkway surface improvement (width 1.2 m length 1.5 km 2 sides)	3600		
	Option 1.1 Pavement material: Porous Block - Gray*	3600	771.87	2,778,732
	Option 1.2 Pavement material: Porous Block - Orange*	3600	871.87	3,138,732
	Option 1.3 Pavement material: Porous Block - Green*	3600	971.87	3,498,732
2	Installing curb ramps and warning blocks at intersections			77,990
	Curb ramp (width 0.9 m length 3.2 m, 20 locations i.e. 40 ramps)*	115.2	452	52,070
	Blister Tactile paving surface (size 0.4x0.4 per piece, 24 pieces per 1 location)**	480	54	25,920
3	Installing Zebra crossing on speed tables at every 200 m			2,052,908
	Speed table (size 3.5 x 5 m = 17.5 sq m, 7 locations)*	122.5	13,287	1,627,658
	Zebra Crossing (size 3 x 5 m = 15 sq m, 7 locations)*	105	4,050	425,250
4	Removing unused telephone booths (3 units)***	3	6,333	19,000
5	Replacing street gutter (size 0.6 x 0.6 m, around 100 units)**	100	1,800	180,000
6	Installing Solar Street light 2.20 m. high at every 20 m (150 units)**	150	7,700	1,155,000
7	Installing proper traffic signs (14 units)**	14	5,920	82,880
8	Removing cable utilities underground***	1500	75,000	112,500,000
9	Shipping and Transportation cost (10-Wheel truck) for 5 trips	5	12,789	63,945
10	Ferry Fare (10-wheel truck with driver and assistant)	10	1,900	19,000
	Total (Option 1.1) excluding cost of removing cable utilities underground			6,429,455
	Total (Option 1.2) excluding cost of removing cable utilities underground			6,789,455
	Total (Option 1.3) excluding cost of removing cable utilities underground			7,149,455
	Total (Option 1.1) including cost of removing cable utilities underground			119,012,400
	Total (Option 1.2) including cost of removing cable utilities underground			119,372,400
	Total (Option 1.3) including cost of removing cable utilities underground			119,732,400

Note: Prices at August 2012, 7% VAT is not included, * materials are available in Samui Island, * * materials are not available in Samui Island, *** transportation costs are already included

C. Cost Estimation for Phase 3: Implementation of "Chaweng Walking Street"

In this phase, main implementation cost is costs of providing the electric shuttle bus services. The costs of the electric shuttle bus services including investment cost i.e. cost of the electric shuttle buses and operation costs i.e. cost of electricity, a battery that needs to be changed every two year, and driver salaries.

- **Investment Cost : the Electric Shuttle Buses**

From FIGURE 5-101, total distance of the electric shuttle bus route is around 5 km. Electric shuttle bus stops are determined at every 200 m for convenience of senior and disable tourists. With speed limit at 20 km/hr and dwell time around 20 seconds at each bus stop, the electric shuttle bus takes around 30 minutes to complete the route. Frequency of the service should be provided for every 15 minutes. Therefore, 2 electric buses with capacity of 15 seats should be provided during regular hours. During peak hours, demands for shuttle bus services i.e. number of passengers will higher, another electric bus should be provided as a spare electric bus.

The electric shuttle bus spends around 8-12 hours for charging. After charging, it can provide services for 50 km. This means one electric shuttle bus can provide services for 5 hours/day. However, the electric shuttle bus services should be provided for 10 hours per day during high and low seasons (344 days per years), and 16 hours per day during peak season (21 days per year). Therefore, total 5 electric shuttle buses should be provided.

Cost of a 15 seat electric shuttle bus is around 550,000 baht. Therefore, total cost of the electric shuttle buses is 2.75 million baht. The electric shuttle buses cost can be covered by donations or sponsorships from business owners in Chaweng beach area.

- **Operating Costs**

  - **Electricity** One electric shuttle bus, which provides services for 50 km per day, has cost of electricity for 2,000 baht per month. Therefore, total 5 electric shuttle buses have cost of electricity for 10,000 baht per month.
  - **Driver salaries** The SAMUI Municipality can allocate its existing staff or recruit new drivers. At municipality level, driver salary is 5,760 baht with an additional for living cost of 2,440 baht, total 8,200 baht per driver. Therefore, total 5 drivers have cost of salaries for 41,000 baht per month.
  - **Batteries** A battery inside the electric shuttle bus needs to be changed every two years. Cost of the battery is 50,000 baht. Therefore, cost of batteries for 5 electric shuttle buses is 250,000 baht per two year i.e. 10,417 baht per month.

  Total operating cost is 61,417 baht per month. This cost can be covered by donations or sponsorships from business owners in Chaweng beach area.

D. Cost Estimation for Phase 4: Improvement of Physical Environments and Providing "parking spaces" in Nathon Commercial Area

Total distance of this road section is 700 m. The improvements include changing walkway surface to be in the same level and use the same materials. The selected pavement material should be "low impact development" materials i.e. porous surfaces that can help reduce surface flow and increase infiltration.

For safety of pedestrians, zebra crossings will be provided. Since Route 4169 is the main road and has high traffic volume, pedestrian traffic signals is recommended at the zebra crossings in front of SAMUI District Office. Proper traffic signs such as speed limit and pedestrian crossing signs will be installed. Street gutters will be replaced. Street light at pedestrian-scale will be installed.

Cost estimation for the improvement is described in Table 5-26. There are 3 different prices that depend on color of the porous blocks.

E. Summary of Costs for Development of the Walkable Areas

Total costs of development of the walkable areas are summarized in TABLE 5-27. The costs are separated into 6 rates depending on color of the porous blocks and whether the cable lines will be removed underground as the following. These costs are at August 2012, and 7% VAT, shipping and transportation costs for materials that are not available in Samui Island are included.

Total (Option 1.1) excluding cost of removing cable utilities underground	21,247,155 Baht
Total (Option 1.2) excluding cost of removing cable utilities underground	22,279,155 Baht
Total (Option 1.3) excluding cost of removing cable utilities underground	23,311,155 Baht
Total (Option 1.1) including cost of removing cable utilities underground	291,446,223 Baht
Total (Option 1.2) including cost of removing cable utilities underground	292,478,223 Baht
Total (Option 1.3) including cost of removing cable utilities underground	293,513,223 Baht

TABLE 5-26: Cost Estimation for Phase 4: Improvement of physical environments and providing "parking spaces" in Nathon Commercial Area

ID	Item	Amount	Unit Price (Baht)	Total price (Baht)
1	Walkway surface improvement (width 1.2 m length 0.7 km 2 sides)	1680		
	Option 1.1 Pavement material: Porous Block - Gray*	1680	771.87	1,296,742
	Option 1.2 Pavement material: Porous Block - Orange*	1680	871.87	1,464,742
	Option 1.3 Pavement material: Porous Block - Green*	1680	971.87	1,632,742
2	Installing curb ramps and warning blocks at intersections			38,995
	Curb ramp (width 0.9 m length 3.2 m, 10 locations i.e. 20 ramps)*	57.6	452	26,035
	Blister Tactile paving surface (size 0.4x0.4 per piece, 24 pieces per 1 location)**	240	54	12,960
3	Installing Zebra crossing at every 200 m (size 3 x 5 m = 15 sq m, 4 locations)*	60	4,050	243,000
4	Installing Pedestrian Traffic signals at the zebra crossing in front of Samui District Office**	4	-	665,000
5	Replacing street gutter (size 0.6 x 0.6 m, around 50 units)**	50	1,800	90,000
6	Installing Solar Street light 2.20 m. high at every 20 m (70 units)**	70	7,700	539,000
7	Installing proper traffic signs (14 units)**	8	5,920	47,360
8	Shipping and Transportation cost (10 Wheeler trucks) for 5 trips	5	12,789	63,945
9	Ferry Fare (10-wheel truck with driver and assistant)	10	1,900	19,000
	Total Nathon Physical Environment Improvements (Option 1.1)			3,003,042
	Total Nathon Physical Environment Improvements (Option 1.2)			3,171,042
	Total Nathon Physical Environment Improvements (Option 1.3)			3,339,042

Note: Prices at August 2012, 7% VAT is not included, * materials are available in Samui Island, * * materials are not available in Samui Island,

TABLE 5-27: Summary of Cost Estimation for Development of Walkable Areas

ID	Item	Investment Costs (Baht)	Operating Costs (Baht/month)
1	Improvement of physical environments on Chaweng 1 road – the one-way section		
	Option 1.1 excluding cost of removing cable utilities underground	9,064,658	
	Option 1.2 excluding cost of removing cable utilities underground	9,568,658	
	Option 1.3 excluding cost of removing cable utilities underground	10,072,658	
	Option 1.1 including cost of removing cable utilities underground	166,680,781	
	Option 1.2 including cost of removing cable utilities underground	167,184,781	
	Option 1.3 including cost of removing cable utilities underground	167,688,781	
2	Improvement of physical environments on Chaweng 1 road – the rest of Chaweng 1 road		
	Option 1.1 excluding cost of removing cable utilities underground	6,429,455	
	Option 1.2 excluding cost of removing cable utilities underground	6,789,455	
	Option 1.3 excluding cost of removing cable utilities underground	7,149,455	
	Option 1.1 including cost of removing cable utilities underground	119,012,400	
	Option 1.2 including cost of removing cable utilities underground	119,372,400	
	Option 1.3 including cost of removing cable utilities underground	119,735,400	
3	Implementation of “Chaweng Walking Street”	2,750,000	61,417
4	Improvement of physical environments and providing “parking spaces” in Nathon Commercial area		
	Option 1.1 excluding cost of removing cable utilities underground	3,003,042	
	Option 1.2 excluding cost of removing cable utilities underground	3,171,042	
	Option 1.3 excluding cost of removing cable utilities underground	3,339,042	
	Total (Option 1.1) excluding cost of removing cable utilities underground	21,247,155	61,417
	Total (Option 1.2) excluding cost of removing cable utilities underground	22,279,155	61,417
	Total (Option 1.3) excluding cost of removing cable utilities underground	23,311,155	61,417
	Total (Option 1.1) including cost of removing cable utilities underground	291,446,223	61,417
	Total (Option 1.2) including cost of removing cable utilities underground	292,478,223	61,417
	Total (Option 1.3) including cost of removing cable utilities underground	293,513,223	61,417

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6. Transportation Planning

6.1 Overview of Transportation in SAMUI Island

Current Situation of Transportation in SAMUI Island

6.1.1 Traffic conditions of travelers on the Island

- Tourists arrive at the Island by the airplane or ferry, and travel around the Island by taxi and motorbike. About 1 million travelers visit the Island every year.
- About 32% travelers to Thailand are from European countries and about 50% are from the East Asian nations.
- To visit the SAMUI Island, about 40% of travelers use an airplane and 60% use a ferryboat.
- 80% of travelers stay in the Eastern part of the Island, 10% in the Northern part, and 5% in the Western and Southern parts, respectively.
- It is considered that travelers use rental cars, taxis, private cars, rental bikes, and songtaew(two-row taxi).

TABLE 6-1 : Number of Tourists of Thailand by Regional Area

	2012		2011		%Δ
Nationality	**Number**	**%Share**	**Number**	**%Share**	**2012/2011**
East Asia	**3,639,510**	**49.53**	**3,428,840**	**49.96**	**6.14**
ASEAN	1,800,157	24.50	1,743,515	25.40	3.25
Europe	**2,394,113**	**32.58**	**2,192,887**	**31.95**	**9.18**
The Americas	**382,642**	**5.21**	**352,931**	**5.14**	**8.42**
South Asia	**370,839**	**5.05**	**361,341**	**5.27**	**2.63**
Oceania	**318,258**	**4.33**	**291,678**	**4.25**	**9.11**
Middle East	**183,892**	**2.50**	**190,001**	**2.77**	**-3.22**
Africa	**58,894**	**0.80**	**45,315**	**0.66**	**29.97**
Grand Total	**7,348,148**	**100.00**	**6,862,993**	**100.00**	**7.07**

FIGURE 6-1 : Percentage of access direction and stay area in SAMUI Island

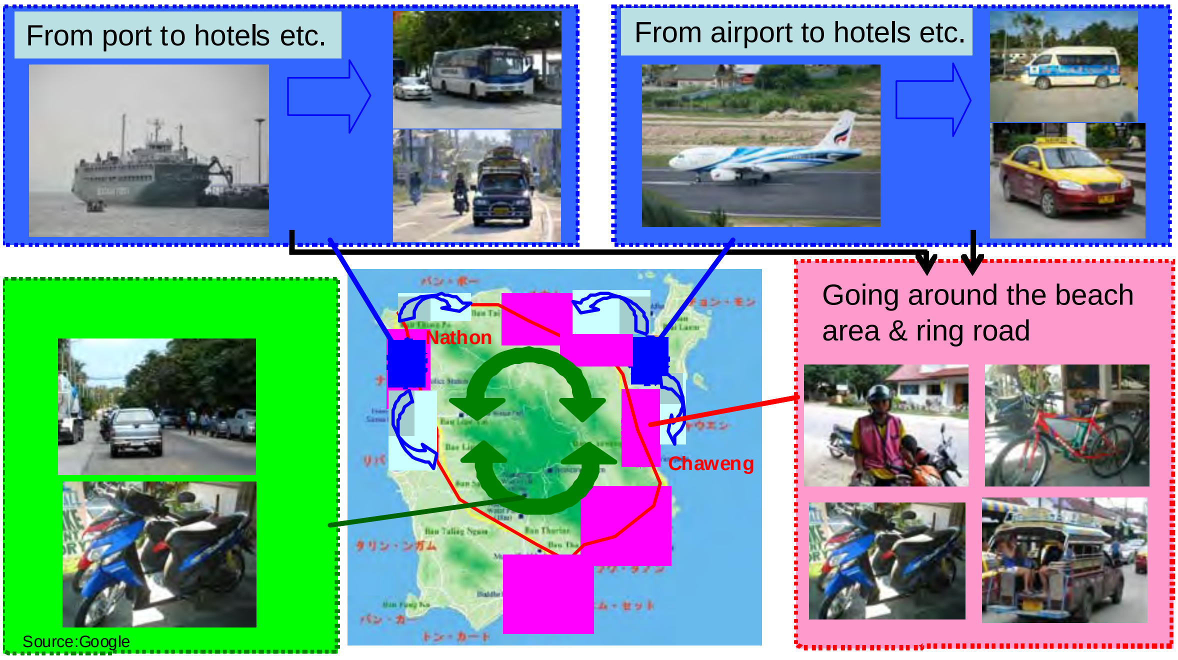


FIGURE 6-2 : Transportation in SAMUI Island

6.1.2 Population and the number of registered vehicles on the Island

- The total number of automobiles and bikes used on the SAMUI Island is about 36,000, including about 12,000 private automobiles, about 23,000 bikes, and about 600 buses, taxis, and vans.
- The population of the SAMUI Island is about 50,000. Assuming that one household has four, there are about 12,000 households on the Island, and one household has about one automobile and two bikes.

- From the above, it is considered that the residents of the Island mainly use automobiles and bikes as a means of transportation.

TABLE 6-2 : Number of Vehicles by Type

Type of Vehicles	Quantity	Percentage (%)
Personal Cars	**12,168**	**33.84%**
Motorcycles	**23,053**	**64.11%**
Bus	**50**	**0.14%**
Vans	**120**	**0.33%**
Taxi	**400**	**1.11%**
Total	**35,958**	**100%**

Category	2010		2011		2012 Until May 30,2012	
	Register in Samui (Number)	Register in other provinces (but use in Samui) - (Number)	Register in Samui (Number)	Register in other provinces (but use in Samui) - (Number)	Register in Samui - (Number)	Register in other provinces (but use in Samui) - (Number)
Private Car	8,743	5,261	9,600	5,648	10,050	2,118
Rental Car	N/A					
Private Motorcycle	19,382	5,297	20,551	5,595	21,130	1,923
Rental Motorcycle	N/A					
Public Transportations						
Minibus (two Rows)	167		167		167	
Public Bus	50		50		50	
Minivan	80		100		120	
Taxi	379		397		400	
Motorcycle Taxi	50		50		50	

6.1.3 Road development and maintenance situation

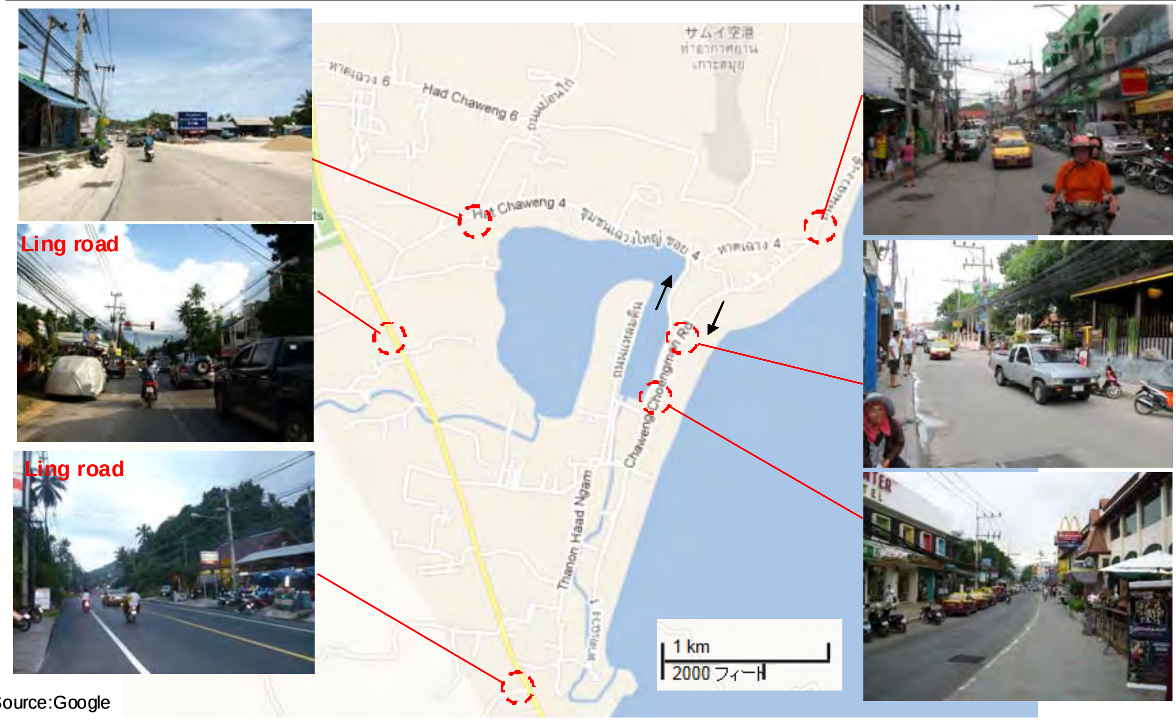
- Highway Road No. 4169, Ring Road, total distance 50.1 kilometers, the most traffic
- Highway Road No. 4170 Connecting road from Bann Sraket-Hua Thanon, total distance 16.3 km
- Highway Road No. 4171 Bo Phut Junction-Chaweng Beach Road, total distance 4.8 km, the second most traffic

- Highway Road No. 4173 Connecting Road between Ring Road and Highway No. 4170, total distance 3.3 km
- Highway Road No. 4174 Lipa Noi Junction - Ferry port Road, total distance 3.4 km, the third most traffic
- Rural Road, Wat Samutharam-Hospital Entrance Junction Road, total distance 1.5 km

- Rural Road, Tong Tanode – Bann Pung Ka, total distance 1.317 km
- Rural Road, Pru Kum – Bann Mae Nam, total distance 1.20 km

■Present Road Condition in Chaweng Area

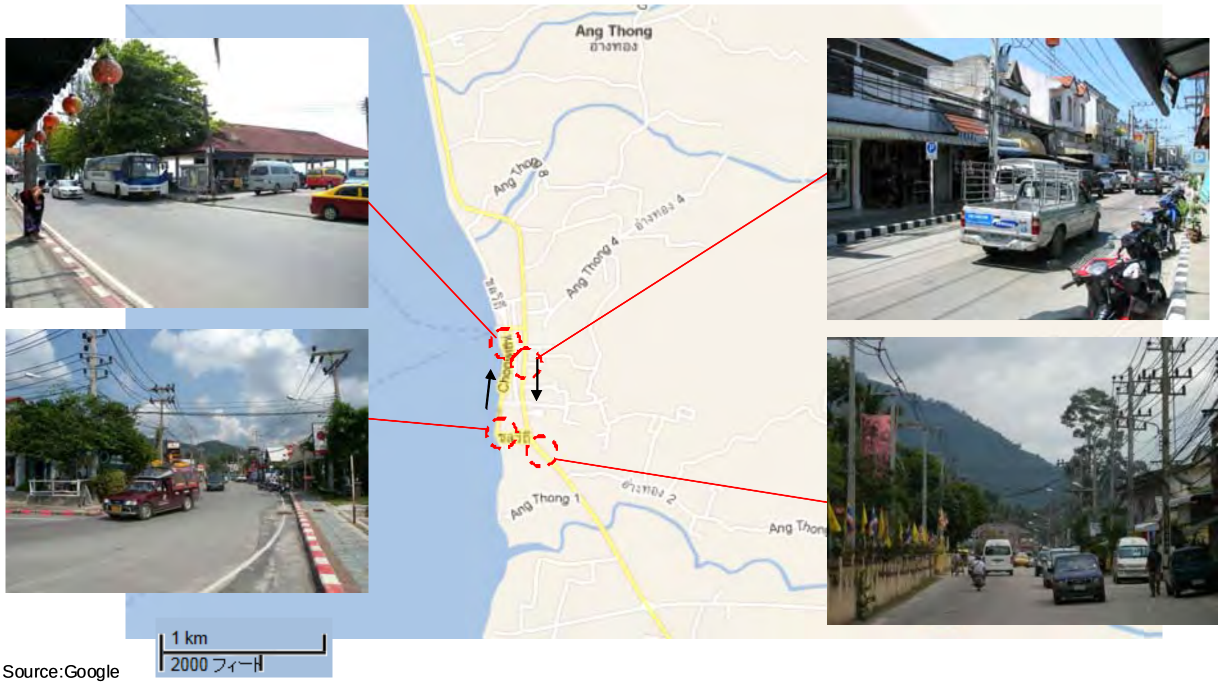
- ➢The trunk road (ring load) is double lane with wide road shoulder.
- ➢In the shopping quarter of Chaweng, the road's width is narrow and a lot of cars parked in the streets, therefore satisfactory pedestrian space is not secured.
- ➢Provisional countermeasure has been done by traffic restriction (one-way traffic).



Source:Google

■Present Road Condition in Nathon Area

➢In Nathon area, not only the road in town, but also the trunk road (ring load) is the one-way traffic instead of both directions.
➢Therefore, passage traffic is flowing in into a city area.



Source:Google

6.1.4 Development and maintenance situation of public transportation system

Three bus routes are used on the SAMUI Island.

■ Circulation Route

Nathon(station) >Mae Nam >Bo Phut >Chaweng to ChongMon(station) and run get back to >Lamai >Hua Thanon >Namuang(waterfall) >Ban Lipa Noi to Nathon(station)	Nathon(station) >Ban Lipa Noi >Namung(waterfall) >Hua Thanon >Lamai >Chaweng to ChoengMon(station) and run get back to >Bo Phut >Mae Nam to Nathon(station)

Nathon(station) >Mae Nam >Bo Phut >Bang Rak Pire >SAMUI Airport >Big Buddha >Ban Plai Laem(Wat Plai Laem) >Choengmon(station) and turn get back to in same route From Choengmon(station) To .. Nathon(station)

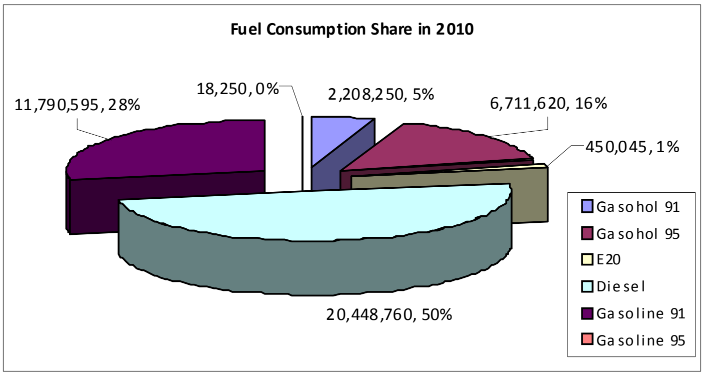
6.1.5 Fuel consumption by type in transportation field

The following TABLE shows each type of fuel consumed on the Island.

TABLE 6-3 : Number of Tourists of Thailand by Regional Area

Fuel Type	Consumption (Liters/y)	Emission (ton CO_2/y)
Gasohol 91	2,208,250	4,817
Gasohol 95	6,711,620	14,642
E20	450,045	982
Diesel	20,448,760	55,186
Gasoline 91	11,790,595	25,722
Gasoline 95	18,250	40
Total	**41,627,520**	**101,388**

Transportation	Consumption (liters/y)	Percentage
Airplane	48,000,000	24.00%
Public	24,000,000	12.00%
Personal Cars	120,000,000	60.00%
Others	8,000,000	4.00%
Total	**200,000,000**	**100.00%**



6.1.6 Matters to be studied in transportation field

From the present transportation situation mentioned above, matters to be studied toward creating low-carbon transportation facilities on the Island are shown in the TABLE below.

TABLE 6-4 : Matters to be studied toward low carbon transportation

	Inhabitant	Tourist		Freight traffic
		Domestic tourist	Foreign tourist	
The amount of movements	50,000 people	･100,000people/year ･Average stay 2.5days → 1,000people/day ※100,000people ×2.5days/365days	･700,000people/year ･Average stay 13.8days → 26,000people/day ※700,000people ×13.8days/365days	－
The purpose of movement	Commuting, shopping	Leisure		Conveyance of the goods from a mainland
Moving range	･Between areas ･Inside of an area	･The round trip from an airport and harbor to hotel ･around shopping quarter, such as Chaweng ･around a hotel		･From a harbor (Nantes area) to each district
Means of transportation	･Private car ･Motorbike	･Taxi ･Rentalcar ･Bus ･Bike taxi ･Rentalbike ･Private car etc.		･Freight vehicle ･Special vehicle
Subject	○Reservation of smooth movement between the areas in the area supporting everyday life →Dissolution of the confusion part in the shopping quarter, etc. →Exclusion of passage traffic into city area	○Maintenance of the traffic environment towards substantial leisure →Maintenance of the comfortable pedestrian environment in shopping quarter →Offer of sightseeing information intelligible with the information of transportation		○Reservation of smooth movement between the areas in the area supporting a physical distribution →Dissolution of the confusion part in the shopping quarter, etc.

6.2 Conceptualize Low Carbon Transportation Mode Shift

6.2.1 Basic philosophy of low-carbon transportation plan

Most of the CO_2 emissions from the transportation sector are derived from motor vehicles. CO_2 emissions from vehicles are represented as the product of traffic volume, distance traveled (trip distance) and emission intensity of automobiles. It follows that the low-carbon measures for the transportation sector will be based on measures to reduce values of these three factors by:

- Reducing traffic volume through promoting the shift to walking or bicycling and using mass transit systems such as trains, which have less per capita CO_2 emissions than automobiles
- Reducing the distance that needs to be traveled, for example, through promoting a compact city which shortens the commuting distance
- Reducing intensity of CO_2 emissions per unit distance traveled through improving the road conditions to reduce time spent in traffic, and introducing more fuel efficient vehicles

The effects of measures to reduce CO_2 emission may not be obtained as anticipated if the measures are implemented individually. It is recommended that measures are implemented in ways where the greatest synergetic benefits can occur. The most important alternative is to combine promotion of public transit systems with traffic demand management for motor vehicle. In addition, it is recommended practice to review how well the existing public transit facilities fit the requirement of the particular town.

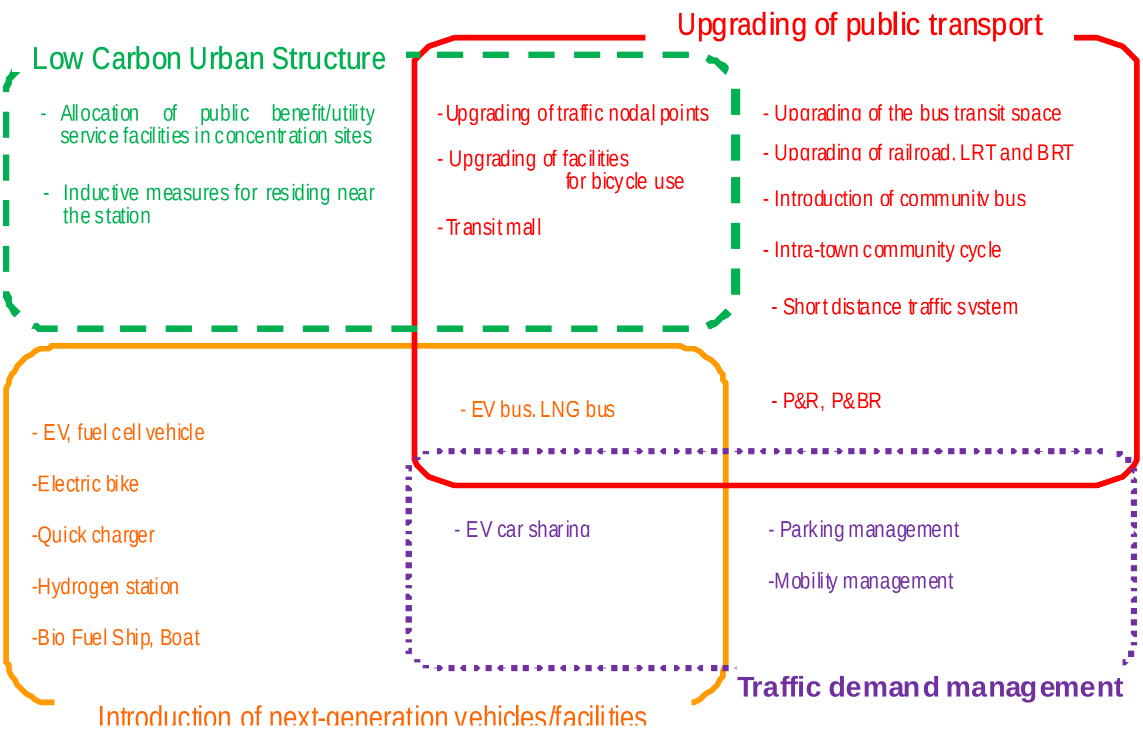


FIGURE 6-3 : Shows how these low carbon transport measures can be integrated in low carbon town structures.

6.2.2 Basic philosophy of low-carbon transportation plan on the SAMUI Island

The viewpoints for planning low-carbon transportation on the SAMUI Island are:

- Developing and maintaining transportation facilities and road space that can supply comfortable, convenient, and reasonable transportation services to tourists visiting the Island
- Developing and maintaining low-carbon transportation facilities that are easy to use for people living or working on the Island

- Lowering carbon emission on the entire Island by introducing low-carbon vehicles as much as possible

In light of the above philosophy and the present situation of the transportation facilities on the Island, the following six policies for development and maintenance shall be defined.

1. Upgrading public transportation
2. Diffusion of Low carbon vehicles and developing charging stations
3. Developing the space for bicycle and pedestrian
4. Traffic congestion reduction by road improvement.
5. Providing appropriate sightseeing information system
6. Mobility Management

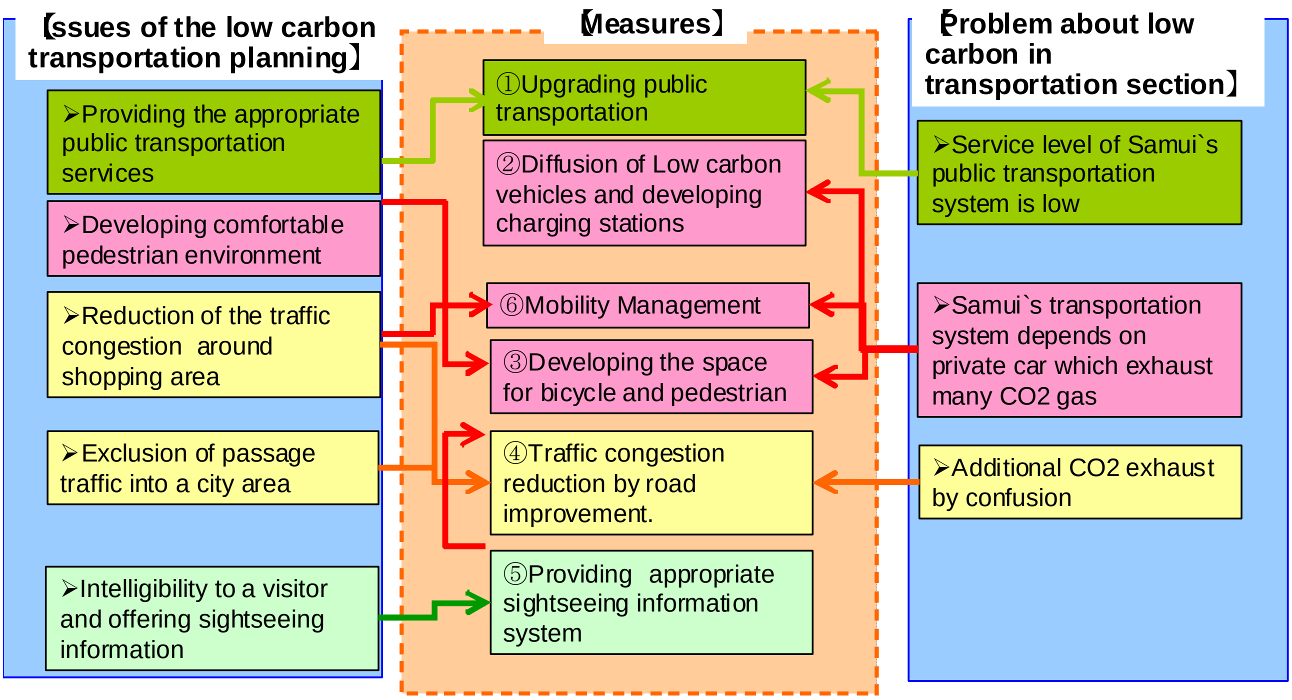


FIGURE 6-4 : Basic policy for low carbon transportation plan

6.3 Conversion of Public Transport and Networking

This section describes in detail the policies for CO_2 reduction mentioned in 6.2 above.

6.3.1 Upgrading public transportation

- Trunk bus roads using ring roads shall be developed and maintained for people to move between communities and from airports and ferryboat boarding points to hotels on the Island
- The transportation system shall use large buses and coupled buses which can carry many passengers.
- To ensure smooth bus operation, dedicated bus lanes shall be installed.
- Bus vehicles shall use biofuel such as biodiesel.

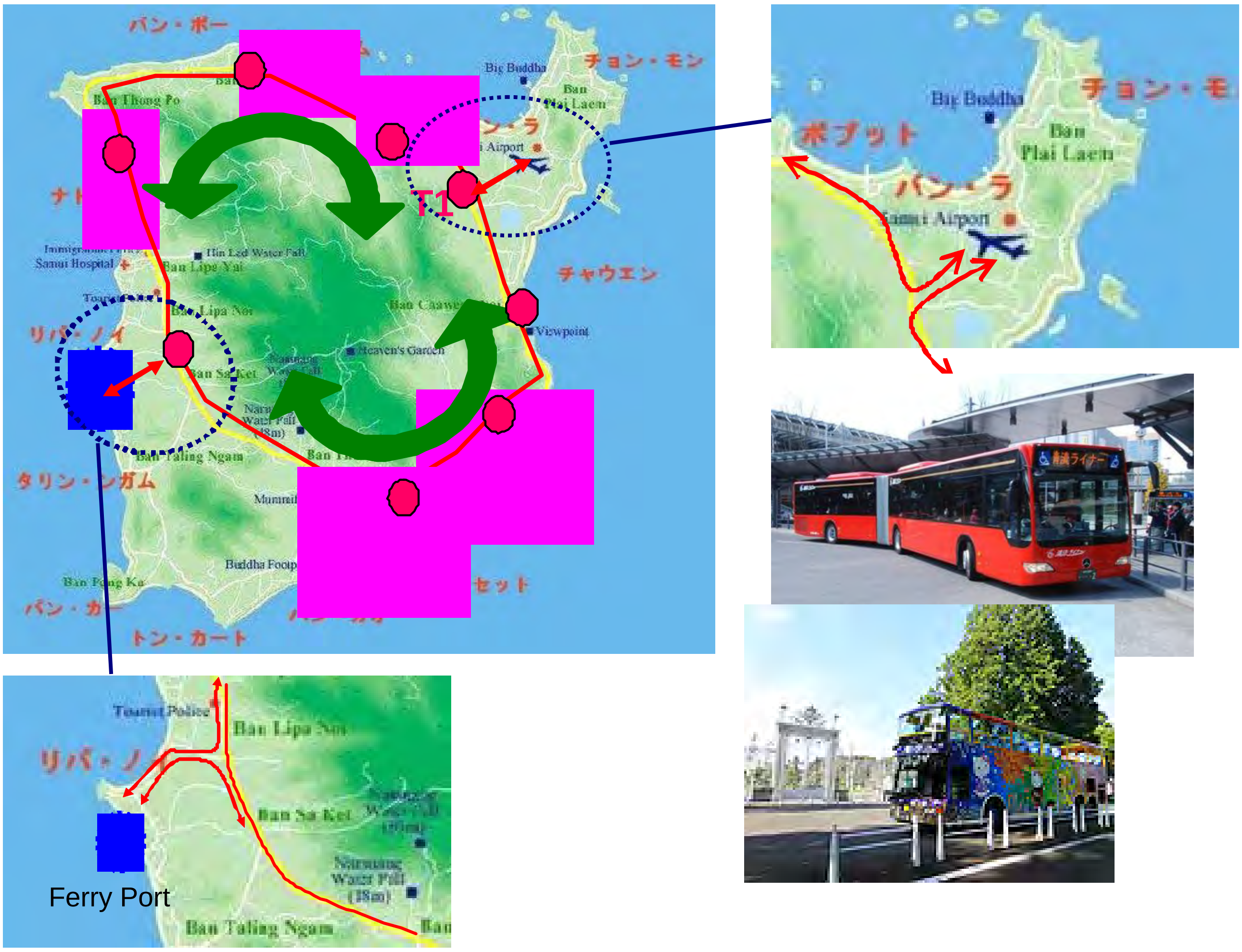


FIGURE 6-5 : Upgrading public transportation concept

6.3.2 Diffusion of Low carbon vehicles and developing charging stations

1. Replacement by low-carbon vehicles

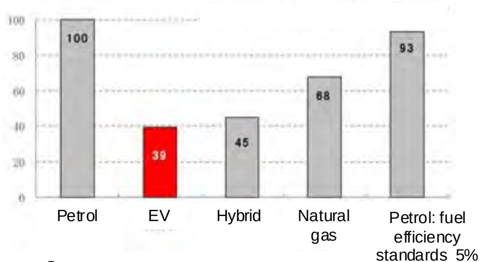
- Carbon emission shall be reduced by replacing private cars, taxis, and rental cars currently in use on the Island with EVs and low-carbon vehicles using biofuel
- EVs are suitable for being introduced to isolated areas and remote areas because the above weak points of EVs do not become obvious so much in these areas because the movement range of the residents and the necessary number of charging stations are naturally limited and the gasoline price is generally higher than the main land
- Replacing rental cars, which is one of the main transportation means, with EVs at resorts is considered a promising choice.
- The costs for introducing low-carbon vehicles are assumed to become a barrier to the introduction in some cases. In such cases, it is considered necessary to study refurbishing the existing vehicles.

■EV

Price	4,599,000 yen
Travel distance per 1 charge	160km
Charging time	14hours ※ 0.5hour (rapidly charge system)

■EV Bike

Price	240,000yen
Travel distance per 1 charge	43km (30km/h)
Charging time	6hours



【Comparison of Fuel Efficiency among Different Types of Vehicles】(1500cc class petrol passenger vehicle = 100)

■EV Bus

【Big Bus】

40persons
(cost:1mil US$)

【Mini Bus】

29persons
(cost:0.75mil US$)

FIGURE 6-6 : Example of low carbon vehicles

■ Convert used car into Electric Vehicle

2. Use of short-distance EVs

- An EV sharing system that use small-size EVs shall be introduced for short-distance movements such as from a hotel to beach and between communities.

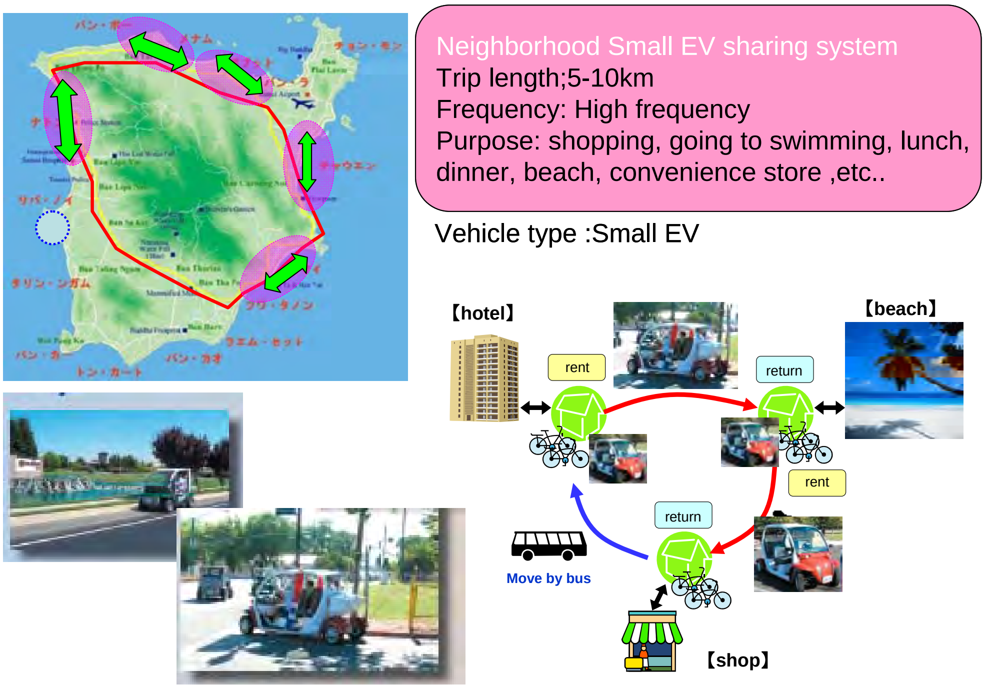


FIGURE 6-7 : Use of short distance EVs concept

6.3.3 Developing the space for bicycle and pedestrian

- In Chaweng and Lamai areas where travelers concentrate, developing a space in which tourists can safely and comfortably move around is expected to enhance the value of the areas as resorts and to reduce CO_2 by suppressing use of automobiles.

- Reduction of CO_2 can be expected by constructing on the Island bicycle roads through which bicycles can safely travel and thereby suppressing use of automobiles.

■ Bicycle lane

■ Bicycle rental stations

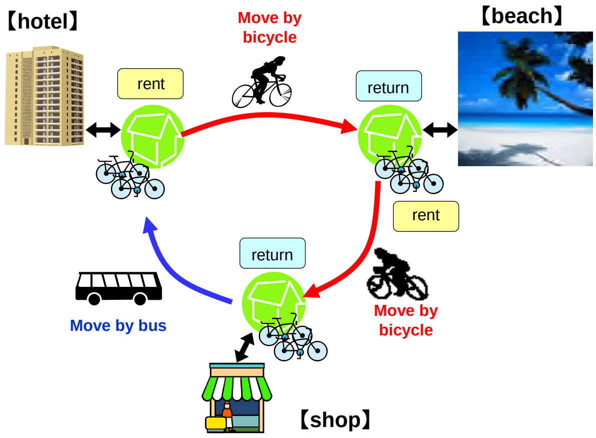


FIGURE 6-8 : Developing the space for bicycle and pedestrian concept

6.3.4 Traffic congestion reduction by road improvement.

- There is a possibility that congestion increases on roads such as ring roads due to an increase in population and thus in automobile traffic in the future. Therefore, an attempt to relax the future congestion shall be made by widening the width of the roads where congestion is expected and constructing bypass roads.

6.3.5 Providing appropriate sightseeing information system

- Necessary information, such as on the current position and the location of the main facilities, shall be provided to travelers from abroad, by making the best use of ICT, etc.
- Together with low-carbon vehicles such as EVs, navigation systems and information providing systems that use ICT shall be introduced to enhance the values added of the EVs and, at the same time, to promote use of low-carbon vehicles.

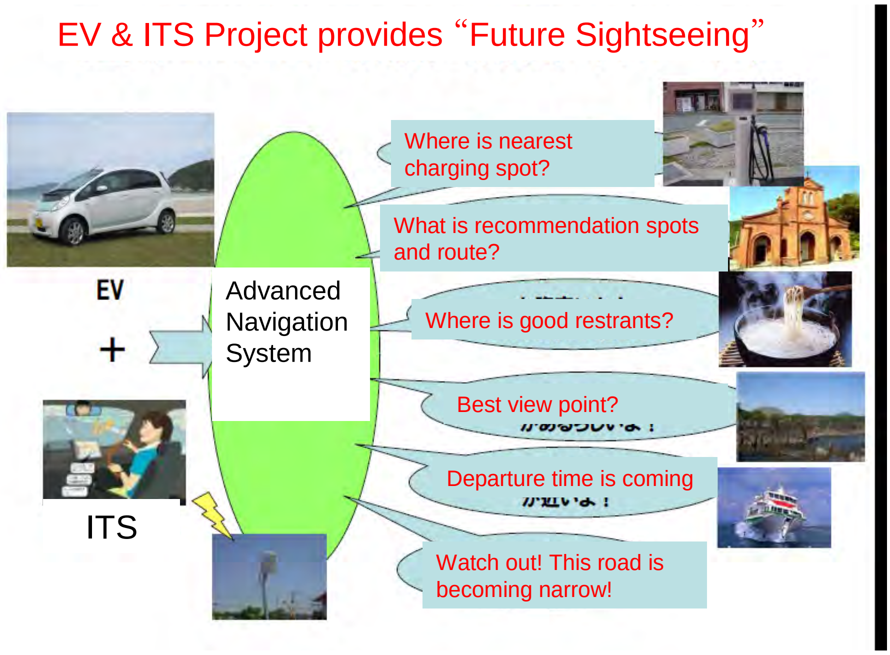


FIGURE 6-9 : Concept of sightseeing information system

6.3.6 Mobility Management

- Convenience of using public transportation on the Island shall be advertised and information shall be provided to users to encourage travelers to promote eco-life and to use public transportation.

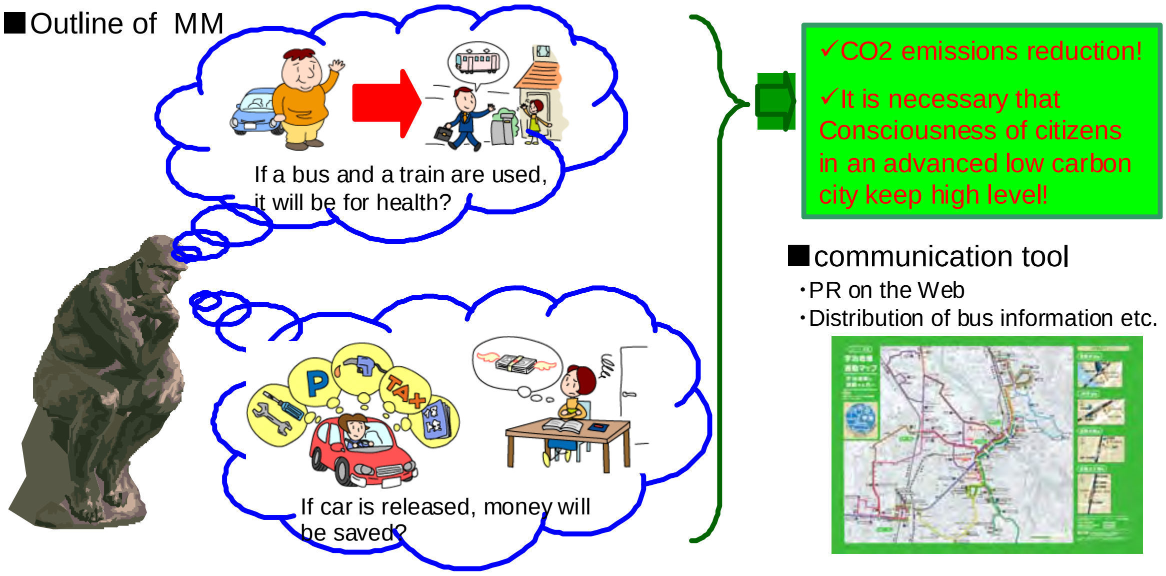


FIGURE 6-10 : Outline of mobility management

6.4 Carbon Reduction Analysis

6.4.1 Basic concept for estimating CO_2 emission

CO_2 in the traffic field is mainly emitted by automobiles. One reason for this is because, as compared with public transportation such as railways and buses, automobiles emit a large amount of CO_2 per person when they transport people.

CO_2 emitted by automobiles can basically be calculated as a product of traffic, travel distance, and emission factor (expression ①). To lower CO_2 emission in the traffic field, therefore, it will be effective to control traffic of automobiles, use public transportation that emits less CO_2, shorten travel distance, and reduce the amount of CO_2 emitted by a single automobile.

CO_2 emission ＝ Traffic (Traffic volume) × Travel distance (Distance traveled) × Emission factor (Emission intensity)・・・・・・・・(Expression ①)

The above expression ① can also be changed as follows:
Automobile-emitted CO_2 ＝ Traffic (unit・km) × Fuel efficiency (l/km) × CO_2 emission factor by fuel (kg-CO_2/l)

Based on the above, Table 6-5 shows measures for reducing CO_2 emission in the traffic field.

TABLE 6-5 : Measures to be introduced to traffic field

Classification of effect of reducing CO_2	Measure	Outline of measure
Use of public transportation that emits less CO_2 [Reducing traffic]	Promoting use of bicycles	▪ Encouraging use of bicycles, which emit no CO_2, instead of automobiles
	Mobility management	▪ Encouraging use of public transportation, such as buses, that consumes less transportation energy per person and per km, instead of automobiles
Reducing CO_2 emitted by single automobile [Improving emission factor]	Introducing electric vehicles	▪ Trying to reduce CO_2 emitted by each automobile by introducing electric vehicles that consume less transportation energy per person and per km
	Supplying information on sightseeing and collaboration with EVs	▪ Enhancing value added of introducing electric vehicles
	Use of bio-diesel, bio-ethanol, etc.	▪ Controlling emission of new CO_2 to atmosphere by using biofuel, which is created by absorbing CO_2 that exists in atmosphere all along, as fuel for automobiles, etc.
	Relaxing congestion by improving roads	▪ If congestion is relaxed, the travel speed of automobiles rise, the fuel efficiency increases, and thus the emission factor improves.

6.4.2 Estimating effect of respective CO_2 reducing measures

How to calculate the effect of reducing CO_2 of each of the abovementioned measures for reducing CO_2 in the traffic field is shown below. The effect of reduction of the respective measures is compared with BAU. How to estimate the effect in the following cases, including BAU, is shown below.

- Setting of BAU (Business as usual)
- Estimating effect of reducing CO_2 of respective measures

i) Improvement of public transportation
ii) Spread of low-carbon vehicles and development of charging stations (for electric vehicles and biofuel vehicles)
iii) Encouraging use of bicycles (*)
iv) Relaxing congestion by improving roads
v) Supplying sightseeing information and collaboration with EVs (*)
vi) Mobility management (*)

* These measures are effective for promoting spread of EVs and use of bicycles, as well as for reducing CO_2 emission. However, methods of estimating the effect of reduction have

not completely established yet. In this document, therefore, the effect of reducing CO_2 emission of those measures is not directly estimated.

6.4.3 Method of estimating effect of respective measures and tentative result

1） Case where no measure is taken (Buisness As Usual)

In the BAU case, nighttime population, land use, and the number of visitors in the target year are assumed, and CO_2 emission is estimated where each transportation facility is operated with the share of each transportation facility and fuel efficiency.

[Calculation expression]
CO_2 emissions(BAU)
＝traffic volume in a estimation year（car,bike）×average travel distance km/vehicle）
× CO_2 Emissions Coefficients （kg-CO_2/vehicle ・ km）
※When the fuel consumption sold to the transportation can be grasped, it is also possible to estimate by this date.
[Prerequisites for calculation]
CO_2 emission of each type of automobiles will be calculated and the total value resulting from the calculation will be assumed as the CO_2 emission because the vehicles account for the most part of CO_2 emitted by transportation on the SAMUI Island.
For this calculation, the above expression is altered as follows:
CO_2 emissions(BAU)
＝Number of registered automobiles of each type × Average number of times an automobile runs per day ×average travel distance（km/vehicle）
× CO_2 Emissions Coefficients （kg-CO_2/vehicle ・ km）
The number of registered automobiles of each type is as shown in the table below.

TABLE 6-6 : Number of registered vehicle (2012)

Unit: Vehicle unit

Personal Vehicle		Public transportation Vehicle			
Car	Bike	Taxi	Big Bus	Van	Mini Bus
12,000	23,000	400	50	120	170

[Number of automobiles to be owned in future]

It is assumed that the number of automobiles owned increases as show in the table below. These number is estimated based on the number of car vehicles of each type in Surat Thani province in year 1999~2012.

TABLE 6-7 : Future number of registered vehicle forecast (in 2030)

Unit: Vehicle unit

Personal Vehicle		Public transportation Vehicle			
Car	Bike	Taxi	Big Bus	Van	Mini Bus
37,400	44,300	1,000	100	300	400

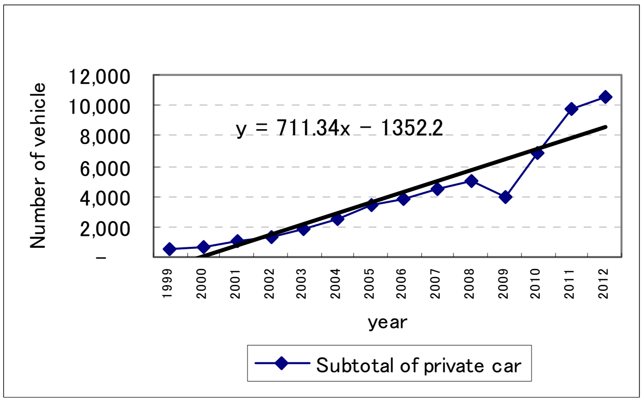


FIGURE 6-11 : Number of vehicle trend and estimation curve (Personal Vehicle)

[CO_2 emission calculation result]

Current(2012)	68,747 t-CO_2/year
BAU(2030) (2030/2012)	184,771 t-CO_2/year (2.7)

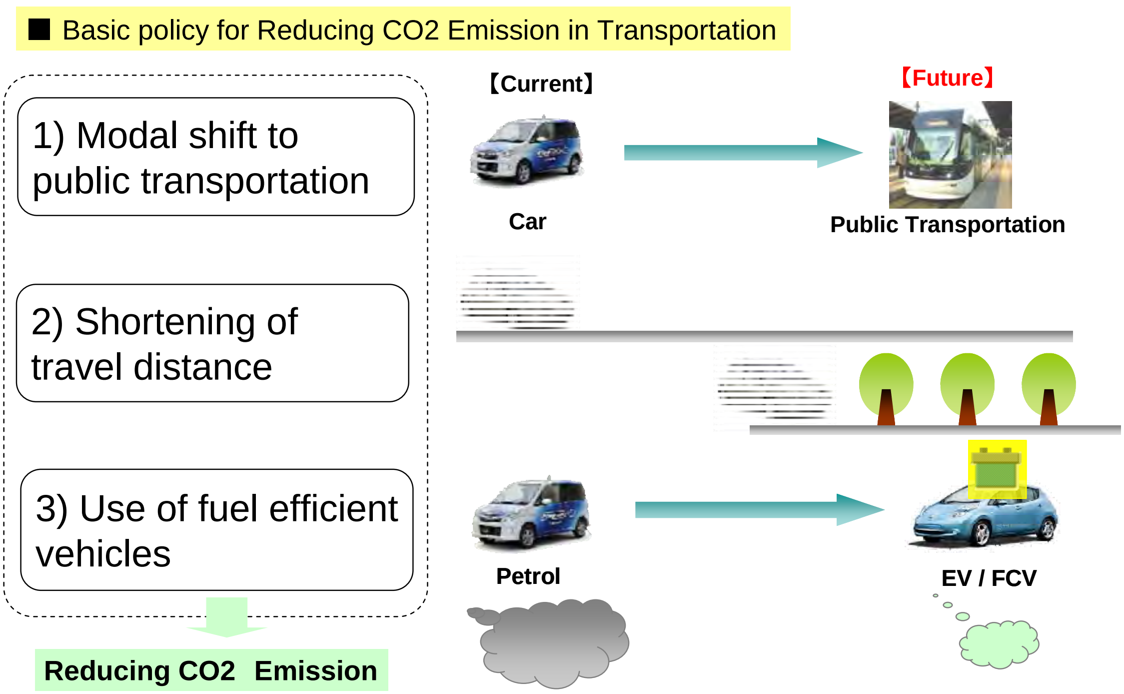
TABLE 6-8 : Estimation of CO_2 emission of current case and BAU

	Car type	Number of vehicle	×	the number of times	×	Trip distance of each type vehicle	×	CO2 emission indicator	=	CO2 emission	
		(Unite)				(km/unit)		(g-co2/unit·km)		(ton-CO2/year)	
Current (in 2012)	Personal car	12,000	×	2.5		20		179.5		39,311	
	Bike	23,000	×	2.5		20		40		16,790	
	Taxi	400	×	30.0		10		179.5		7,862	
	Big Bus	50	×	2.0		50		1215.5		2,218	
	Van	120	×	3.0		20		290.5		763	
	Mini Bus	170	×	2.0		50		290.5		1,803	68,747
Futur BAU (in 2030)	Personal car (gasolin)	37,300	×	2.5		20		179.5		122,190	
	Bike	44,300	×	2.5		20		40		32,339	
	Taxi	1,000	×	30.0		10		179.5		19,655	
	Big Bus	100	×	2.0		50		1215.5		4,437	
	Van	300	×	3.0		20		290.5		1,909	
	Mini Bus	400	×	2.0		50		290.5		4,241	184,771

2) Relation between CO_2 reduction policy and reduced CO_2

There are three methods of reducing CO_2 emitted by automobiles: i) promoting shift of the mode of transportation to the one that emits less CO_2, such as public transportation, ii) shortening the travel distance of automobiles, and iii) reducing CO_2 emission of each automobile.

The relation between these CO_2 reduction methods and reduced CO_2 is illustrated below.



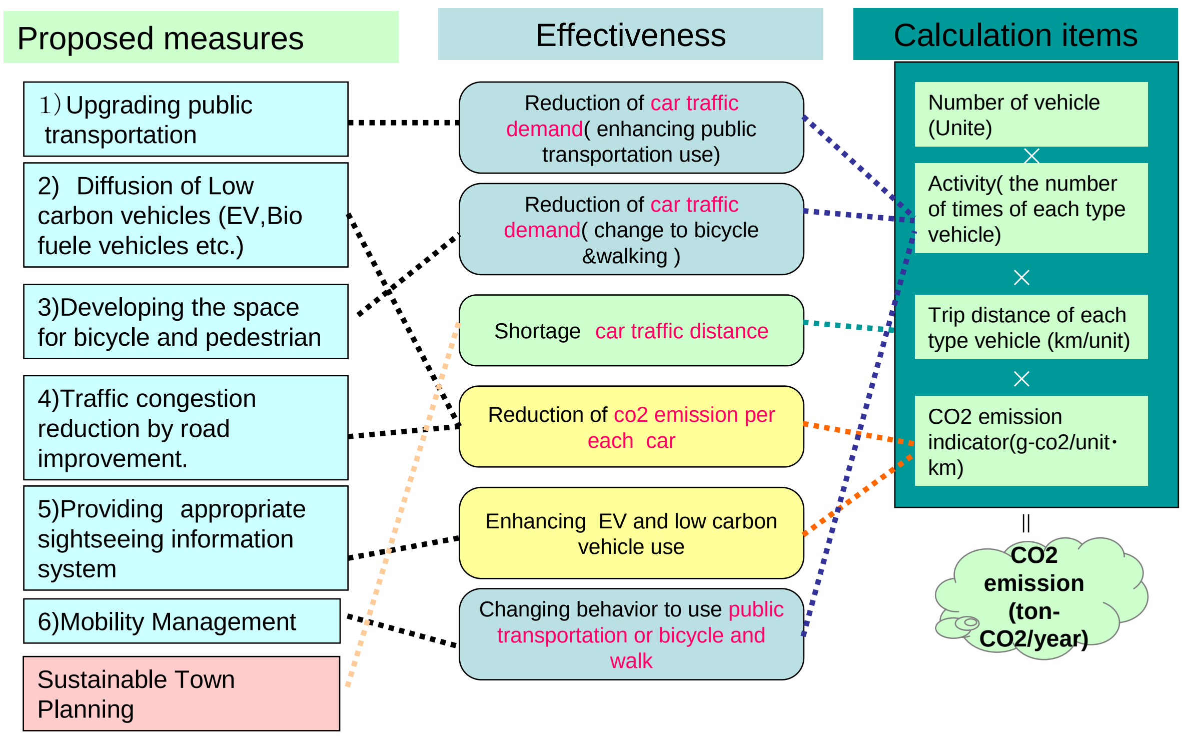


FIGURE 6-12 : Relationship between measures and calculation items

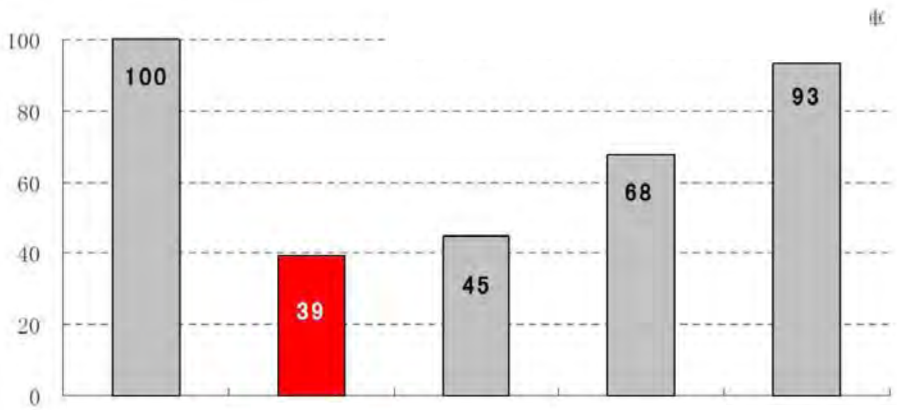
3) Diffusion of Low carbon vehicles and developing charging stations

■ Effect of introducing EV

When a gasoline vehicle and an electric vehicle are compared, the electric vehicle emits less than half of CO_2 emitted by the gasoline vehicle when both the vehicles travel the same distance.

Regarding the ratio of spread of electric vehicles, a ratio of spread on the SAMUI Island is assumed and the estimate is made.

(Reference: It is expected that about 10% of the total number of vehicles will be electric vehicles in 2030 in Japan.)



Petrol | EV | Hybrid | Natural gas | Petrol: fuel efficiency standards 5%

Source: Document compiled by Kanagawa Prefecture

FIGURE 6-13 : Comparison of fuel efficiency of electric vehicles

[Calculation expression]

The amount of CO_2 reduction

＝ number of EV vehicles × mileage (km/vehicle)

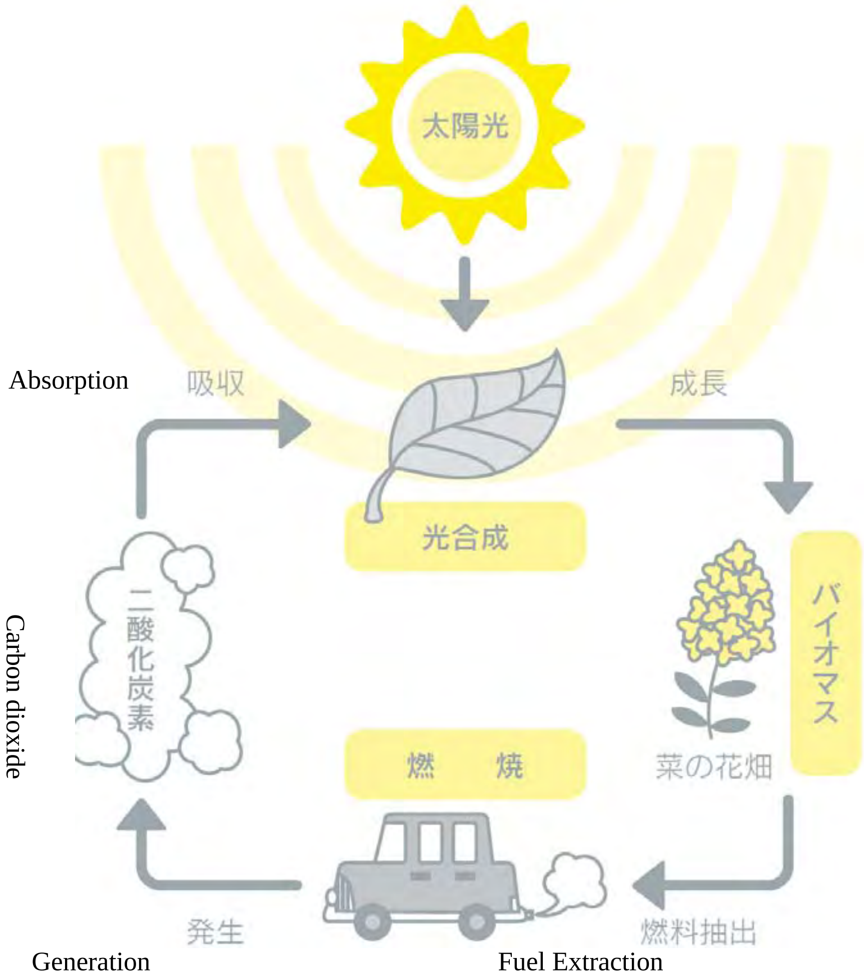
× (fuel efficiency of usual car (l/km) × CO_2 Emissions Coefficients (g-CO_2/l)

－ fuel efficiency of EV car （kWh/km）× CO_2 Emissions Coefficients (g-CO_2/kWh)

■ Using biofuel (Using Bio Fuel)

Biofuels such as bio-diesel are made from plants that are the original law materials and absorb from the atmosphere the CO_2 emitted by burning fuel, and CO_2 emitted by biofuel is not counted in the CO_2 emission in the energy field defined by the Kyoto Protocol (COP3). Accordingly, it is considered that CO_2 emission can be reduced by using biofuel instead of fossil fuels such as gasoline and light oil.

By replacing fossil fuels with biofuels, an effect of reducing CO_2 emission by the amount of a product of multiplying the conventional fuel that would not be used by a CO_2 emission coefficient can be expected.



Source: Bio-diesel Fuel Introduction Manual

FIGURE 6-14 : CO_2 generation and absorption cycle using Bio Fuel

[Calculation expression]
The amount of CO_2 reduction
= replaced energy consumption (Gasoline, Diesel etc.)
× CO_2 Emissions Coefficients (g-CO_2/l)

[Future number of low-carbon vehicle forecast]

- Assumption of rate of spread of EVs

It is considered that few EVs are available in Thailand today, but the rate of spread of EVs is assumed to reach 10% in 2030. In case of motorcycles, its coverage of E-bike in 2030 may reach more than EV cars is 30%. In that case, the number of EVs can be estimated as follows:

TABLE 6-9 : Future number of low carbon vehicle forecast (in 2030)

Unit: Vehicle unit

	Personal Vehicle		Public transportation Vehicle			
	Car	Motorcycle	Taxi	Big Bus	Van	Mini Bus
Total	37,300	44,300	1,000	100	300	400
Coverage	10%	30%	30%	10%	10%	10%
No. of EV	3,730	13,290	300	10	30	40

4) Developing the space for bicycle and pedestrian

By developing bicycle lanes and rental stations where bicycles can be freely rented and returned, and using bicycles and developing pedestrian spaces at places many sightseers visit, it can be expected that bicycles and walking that do not emit CO_2 are increasingly used instead of automobiles.

Regarding a policy that contributes to replacement of automobiles by bicycles, it is difficult to quantitatively define the effect of such a policy. Therefore, the effect of the policy of reducing CO_2 emission is not estimated in this document.

5) Traffic congestion reduction by road improvement.

Traffic congestion can be mitigated by improving roads such as widening roads and developing bypass roads. Moreover, the travel speed of automobiles increases, and this in turn reduces the fuel consumed (CO_2 emitted by burning fuel when an automobile travels 1 km). Consequently, CO_2 emission is reduced.

[Calculation expression]

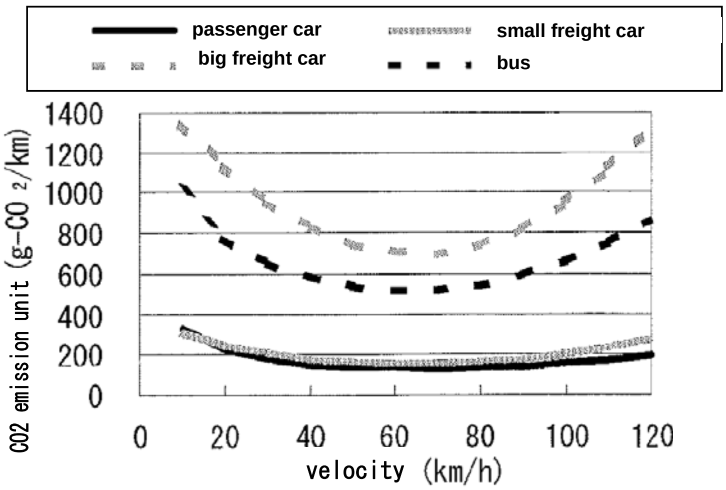
The amount of CO_2 reduction

＝ traffic volume pass the confusion point (vehicle)

× confusion range（km）

×（CO_2 Emissions Coefficients at confusion speed（kg-CO_2/vehicle ・ km）

－ CO_2 Emissions Coefficients at free speed（kg-CO_2/vehicle・km））



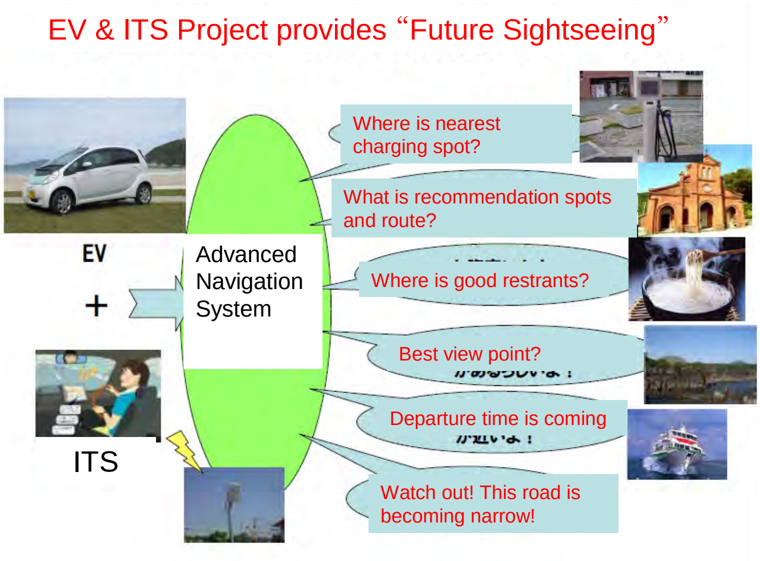
Reference: National Institute for Land and Infrastructure Management, MLIT

FIGURE 6-15 : Relationship between velocity and CO_2 emission

6) Providing appropriate sightseeing information system

An attempt shall be made to improve convenience for travelers when they move around and encourage use of electric vehicles by informing a navigation system equipped to an electric vehicle of the location where a rapid battery charger is installed and by supplying sightseeing information to the travelers.

This measure will contribute to promotion of spread of electric vehicles. However, its effect of reducing CO_2 emission is not estimated in this document because it is difficult to quantitatively express the effect of the measure.



7) <u>Mobility Management</u>

Use of public transportation and low-carbon vehicles shall be promoted by advertising the important of lowering CO_2 emission on the SAMUI Island to its residents and travelers and, at the same time, advertising easiness to use of public transportation by distributing the route map of buses, etc., to sightseers.

This measure will encourage use of public transportation instead of automobiles. However, its effect of reducing CO_2 emission is not estimated in this document because it is difficult to quantitatively express the effect of the measure.

8) <u>Estimating effect of reducing CO_2 of respective measures</u>

Table shows the result of CO_2 emission calculation if the two policies are applied.

① Improvement of public transportation

② Spread of low-carbon vehicles and development of charging stations (for electric vehicles and biofuel vehicles)

TABLE 6-10 : Estimating effect of reducing CO_2 of respective measures

	Amount of CO_2 emission	Reduction rate*1)
Current(2012)	68,747 t-CO_2/year	
BAU(2030)	184,771 t-CO_2/year	
Applied respective measure(①)	160,339 t-CO_2/year	(87%)
Applied respective measure(①+②)	134,423 t-CO_2/year	(73%)

*1) Reduction rate :CO_2 emission by each measures/BAU

6.4.4 Cost Estimation of respective measures

This section estimates the cost required for promoting use of public transportation and introducing EVs whose CO_2 emission effect has been earlier estimated.

1) Public transportation promotion policy

It is estimated as shown in the figure below that large-sized buses run on the ring road in the island. Items related to preparation and the approximate costs are shown in the table below. Note that these values are based on experiences in Japan and must be reviewed in detail in future.

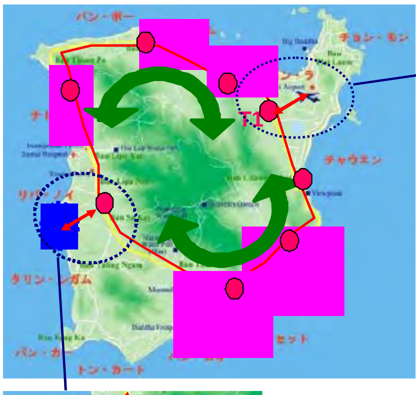
TABLE 6-11 : Cost estimation of constructing the infrastructures for trunk bus route

Infrastructure	Amount	Cost of unit	Cost(million Baht)
Improvement of trunk road	50km	3,500Bath/m	175
Constructing bus stops	30bus stops	300,000Bath/unit	9
Introducing new bus*1)	12 units	25 million Baht/unit	300
Total			259

*1) Bus type: Hybrid coupled bus

■ Upgrading public transportation

・Truck bus roads using ring roads shall be developed
・The transportation system shall use large buses and coupled buses which can carry many passengers.



Moving between communities and from airports and ferryboat boarding points to hotels on the island

2) <u>Promotion of introduction of EVs</u>

i) Preparation of infrastructure

As preparation of infrastructure, charging facilities will be prepared in the main districts of the island. The charging facilities will be established at the airport and ferryboat boarding points, and in the major communities.

Total number of electric vehicle is estimated approximately 4,100 units in 2030. Peak time demand number of EV which may require charge in outside area is estimated approximately 70 unite per hour. And if necessary charging time may be 30 minute by using quick charging machine, 35 charging machines will be needed in SAMUI Island. If three or four charging machines will be set in each charging station,10 charging stations will be needed .

TABLE 6-12 : Cost estimation of constructing the infrastructures for trunk bus route

Infrastructure	Amount	Cost of unit	Cost(million Baht)
Quick charging station	10units	6,200,000Baht/unit*1)	62
Total			62

*1) Three charging machines, roof with PV, Three parking lots

FIGURE 6-16 : Proposed location of charging station for EV

FIGURE 6-17 : Example of charging station (Saitama City, Japan)

FIGURE 6-18 : Example of characteristic designed roof with PV

3) Cost for introducing EVs

It is expected that the cost for introducing EVs differs depending on to what extent the administration is involved when individuals purchase an EV.

The cost is calculated in the following two scenarios:

<Scenario 1>

- The administration will totally assist the public transportation in purchasing the vehicles.
- It will help individuals with a subsidy of half the amount of the vehicle price.

<Scenario 2>

- The administration will subsidize the public transportation by paying half the vehicle price.
- It will help individuals purchase an EV by providing an amount equivalent to the difference from a gasoline-powered vehicle each time they buy an EV.

TABLE 6-13 : Cost estimation of introducing EV

<Scenario 1>

EV	Amount	Price of unit	Cost per unit	Cost (million Baht)
Personal car	3,730	1.0million Baht/unit	0.5 million Baht/unit	1,865
Bike	13,290	0.2million Baht/unit	0.1 million Baht/unit	1,329
Taxi	300	1.0million Baht/unit	1.0 million Baht/unit	300
Van	30	1.5million Baht/unit	1.5 million Baht/unit	45
Mini bus*1)	40		1.5 million Baht/unit	60
Total				3,599

*1) It is assumed that mini buses are replaced by vans when this estimation is updated.

TABLE 6-14 : Cost estimation of introducing EV

<Scenario 2>

EV	Amount	Price of unit	Cost per unit	Cost (million Baht)
Personal car	3,730	1.0million Baht/unit	0.3 million Baht/unit	1,119
Bike	13,290	0.2million Baht/unit	0.03 million Baht/unit	398.7
Taxi	300	1.0million Baht/unit	0.5 million Baht/unit	150
Van	30	1.5million Baht/unit	0.75milion Baht/unit	22.5
Mini bus*1)	40		0.75 million Baht/unit	30
Total				1,720.2

*1) It is assumed that mini buses are replaced by vans when this estimation is updated.

7. Area Energy Planning

The electrical consumption of SAMUI Island is increasing over the past several years. As shown in Figure 7-1, Peak demand forecast for SAMUI Island; it is estimated that the increase in energy demand will continue for the next twenty years. The power demand capacity is exceeding 93 MW power supply limit in Y2013. Even though the new substation will raise the limit capacity to 193 MW, the estimated demand will exceed the limit within Y2028.

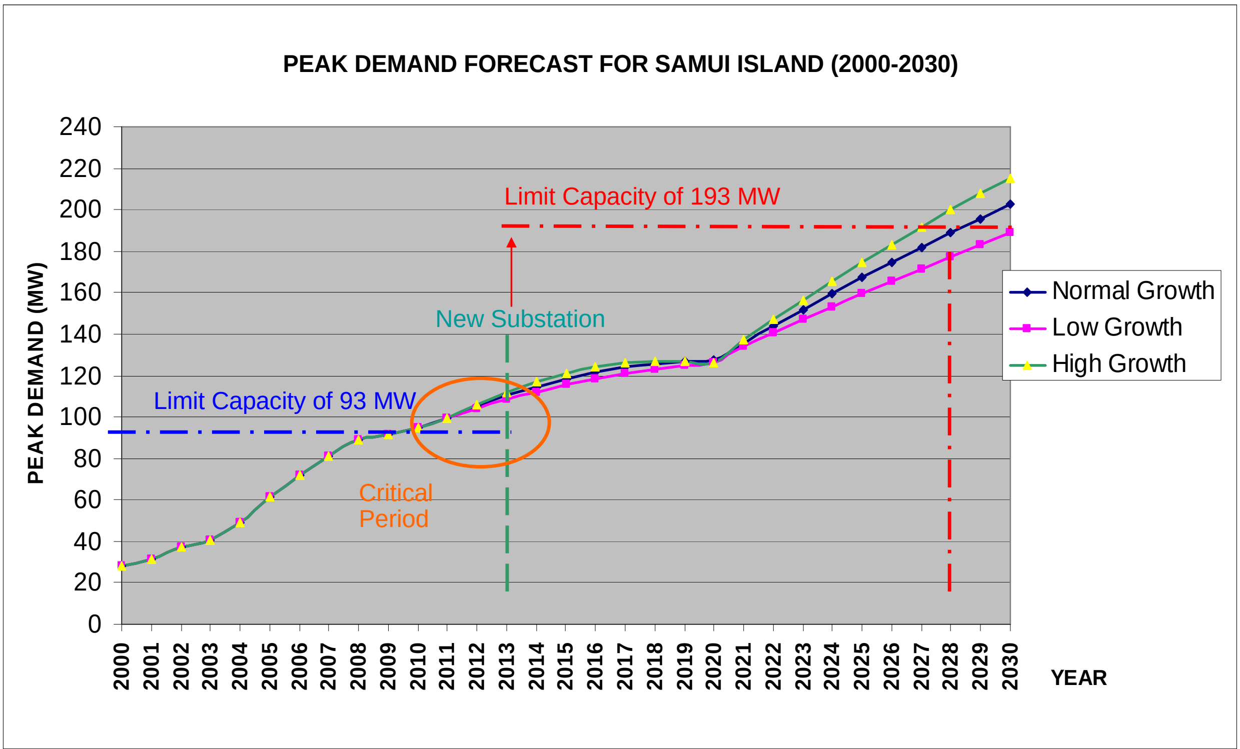


FIGURE 7-1 : Peak demand forecast for SAMUI Island

To overcome the excessive power supply problem in the near future, the power self-sustain solution is to manage power demand and supply. Power demand needs to be reduced as cites in the following chapters. Chapter 8 Area Energy Management presents the smart grid system that will encourage power's users to track and manage themselves the power consumption and also help authorities monitoring and controlling the power system. Chapter 9 Renewable Energy and Chapter 10 Untapped Energy Use Planning give a guideline for free and clean power opportunities. The solution, recommended, is the basically building design for Green Island that is emphasized in Chapter 11 Low Carbon Building.

We are looking for the opportunity of power generation on the island since it has less transmission loss and increase power reliability. The inline scattered community like SAMUI Island (see Figure 7-2 SAMUI Hotel Map) makes it harder to build many large power plants because space and water requirements are not suitable. Therefore micro power generation, not more than 1MW, is highlighted. The clean energy such as natural gas uses is also expected. The possibility we have seek for is appeared later in this chapter.

FIGURE 7-2 : SAMUI Hotel Map

7.1 Current Area Energy Consumption

The tourist island as SAMUI, the seashore area is overwhelmed and primed. The inland area is mostly agricultural and less condenses. We have group the potential area into beaches as the population load profile. Figure 7-3 Numbers of Hotel & Guest room in Each Area; shows that the most crowded hotel area is on Bo-Phut district, Chaweng Beach. Therefore we specify and push forward Chaweng Beach to apply Low Carbon measures as mentions later on.

In addition, we classify the hotels type as Figure 7-4 Number of Hotels with Number of Guest Room in Each Area. The figure appears that the typical hotel in SAMUI Island is less than 50 rooms (about 74% of overall hotels is less than 50 rooms). Emphasizing Bo-Phut district densely population by the numbers of large scale hotel (more than 100 rooms) are all located in this district.

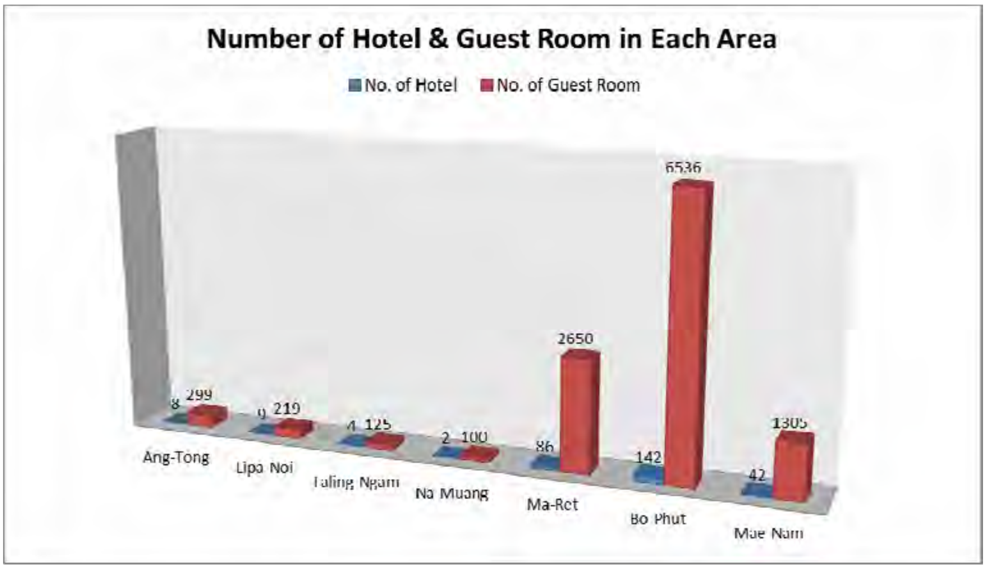


FIGURE 7-3 : Number of Hotel & Guest Room in Each Area

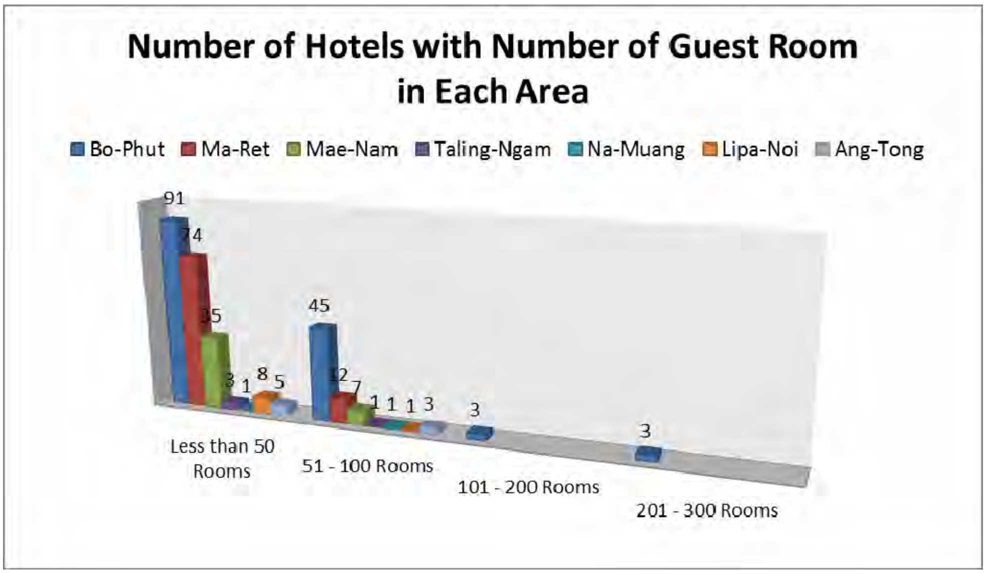


FIGURE 7-4 : Number of Hotels with Number of Guest Room in Each Area

*Information for Figure 7-3 and Figure 7-4 are dated on January 5th, 2009.

7.2 Carbon Reduction Measures

As mentioned before that we strive to reduce low carbon emission of the island by managing demand and supply sides. The demand side will be cited at the later chapters by Smart Grid and Low Carbon Building measures. In this chapter, we plan for the potential of power generation such as Combined Heat and Power plant (CHP), Combined Cycle plant (CCP) and Biomass Power plant. For the hot issue like renewable energy will be stressed in Chapter 9. Besides all stated before, the measure for natural gas pipeline will boost up Natural Gas Vehicle (NGV). In addition, solar energy can also produce cooling so called solar assisted air-conditioning. Table 7-1 is the Summary of Area Energy Planning Measures.

Due to the forecast on the electrical load demand, the power generation needed in Y2030 will be approximately 30-50 MW over the power supply capability (193 MW – refer to Figure 7-1). Thus, for self-sustain and power reliability, planning for 45 MW CCP, power generation on the island would be recommended. The renewable energy such as solar, wind and hydro (expected 85.9 MW) and untapped energy from waste (expected 3.9 MW) will be connected to the grid and backup in case of transmission line from the mainland fails. Moreover the supplementary onsite power supply such as 1 MW CHP, 1 MW Coconut Power Plant enhances onsite reliability.

7.2.1 Combined Cycle Power plant (CCP):

Combined Cycle Power Plant (CCP) generates power by two gas turbines and one steam turbine. The CCP diagram, Figure 7-5, shows the operation of the exhausting hot gas from gas turbines (GTs) will go through Heat Recovery Steam Generator (HRSG) producing steam for a steam turbine (ST). The expected CCP plant full load efficiency is as high as 55%. Moreover the plant will reduce transmission loss up to 3-5%, comparing to the mainland power transmission line.

The ratio of turbines is approximately 1:1:1 as the 45 MW power generation consists of 2x15 MW Gas Turbines and 1x15 MW Steam Turbine. The plant should be located around the existing 115 kV PEA Substation to ensure the rated power capacity or the maximum plant efficiency.

The 45 MW CCP's cost is approximately 1,700 Million Baht (excluding NG pipeline or NG tank farm in case of no NG pipeline available). The required area is 16 rais (25,600 m^2) included 12 rais (19,200 m^2) CCP plant and 4 rais (6,400 m^2) NG tank farm. Data calculated for tank farm is based on the gas turbine heat rate of 11.8 Mbtu/MW-hr, 365 day/24 hr of operation, so that the NG consumption is estimated at 240,580 m^3./day. The 7 days storage capacity costs 300 Million Baht. Therefore the total cost for CCP is 2,000 Million Baht.

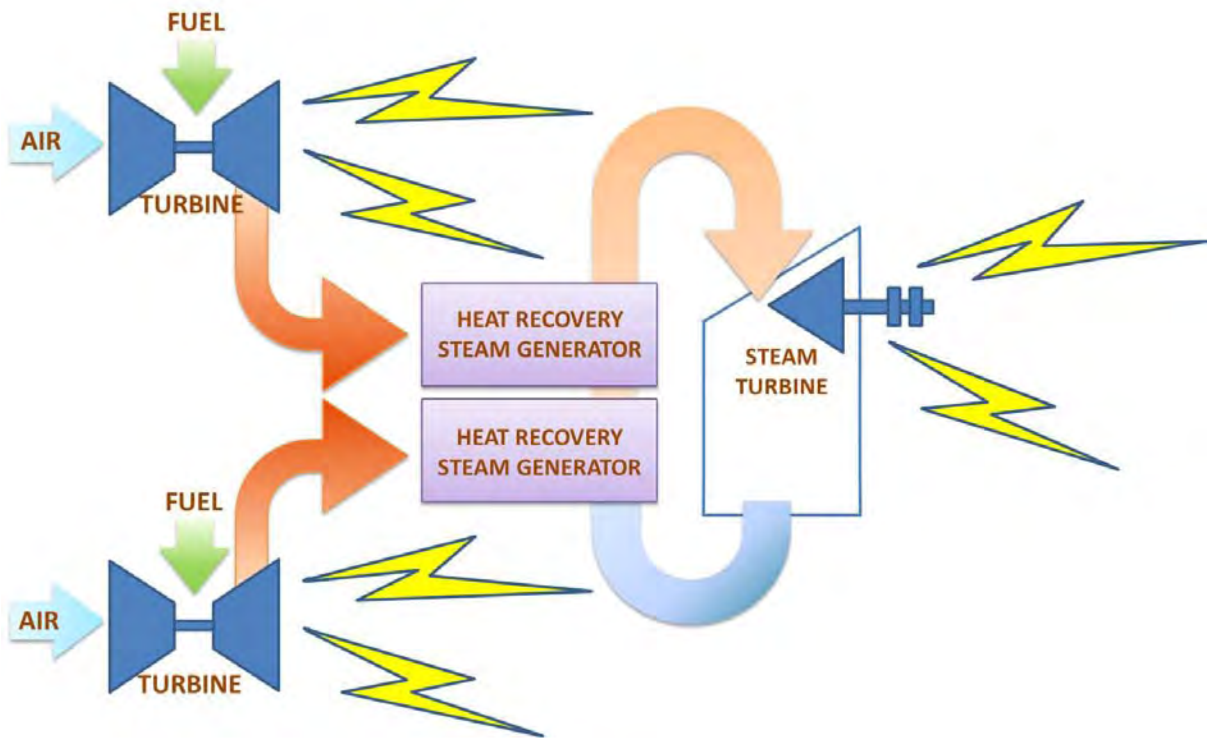


FIGURE 7-5 : Combine Cycle Power Plant (CCP)

7.2.2 Combined Heat and Power (CHP) plant

Combined Heat and Power Plant so called CHP, as its name, generates both power and heat in term of cooling, see Figure 7-6 CHP Diagram. The fuel goes to Gas Engine, normally 35% efficiency. The exhaust gas will then go to the absorption chiller which has an ability to turn exhaust gas and/or engine cooling water to chilled water for cooling system, efficiency 50%. Consequently the total plant efficiency is approximately 80-85% which is 50% higher than normal power generation plant.
(ref: http://www.northeastcleanenergy.org/whatischp/overview.php)

According to financial feasibility, the CHP size should be at least 1 MW and 250 RT cooling. CHP is suitable for district cooling which is from 1 CHP distributing power and cooling to a certain area by cable or piping transmission.

Refer to the survey report mentioned above, there are only a few hotels having more than 200 rooms (250RT required). Therefore CHP system might be proposed for a supermarket like TESCO Lotus or Big C. Nonetheless the CHP with district cooling is ready to serve, if there is any possibility for service provider selling power and cooling. In this case, Chaweng Beach (Bo Phut area) is the best location since it is highly density of hotels and facilities.

CHP is also beneficially in regulating peak load demand that will reduce overall island peak demand and onsite peak energy cost factor.

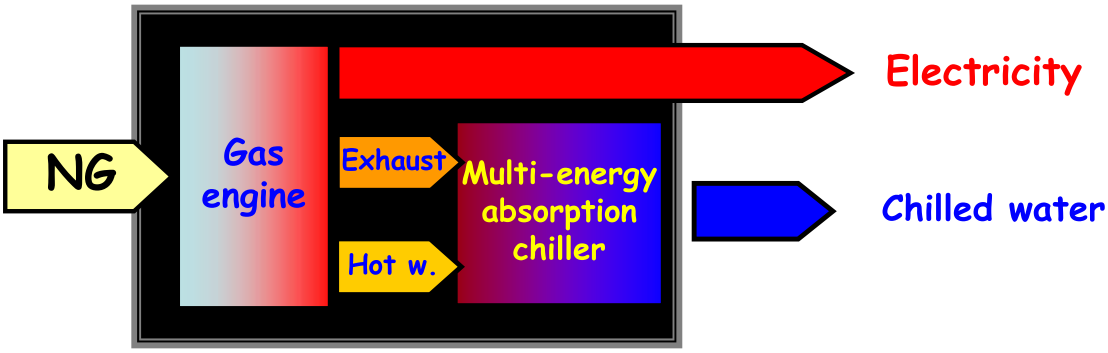


FIGURE 7-6 : Combined Heat and Power Plant (CHP)

7.2.3 Coconut Power Plant

SAMUI is well-known as the coconut island because SAMUI originally and locally grew coconut trees. Even though, at this moment, many local people turn to the tourist industry; coconut trees still cover about 69,000 rais (1,104 Million m^2) and more than 50,000 ton of coconuts are produced every year. People consume coconut water and coconut milk, the coconut shell and husk are left behind. These left over have a good heating value or about 9,000 kJ/kg which is high enough to be used as fuel source for biomass power plant.

1 MW power generation for coconut power plant requires 20 rais (32,000 m^2) area including fuel preparation area and 2 ton/hr of coconut feeding, at 20% plant efficiency. The estimated plant cost is 70 Million Baht.

7.2.4 Development of SAMUI natural gas pipeline and station for NGV

It is obvious that natural gas is one of reliable energy sources. However the natural gas pipeline installation relies on many factors such as environmental impact, cost and, for this case, availability of transmission line from mainland.

Thailand has a good opportunity for natural gas as having theirs own natural gas resource in the Gulf of Thailand, south of SAMUI Island. NG will then be distributed through stretching gas pipeline from the Gulf of Thailand to the separating plant in Khanom District, mainland. Nevertheless, the pipeline does not stretch enough to SAMUI. In any case that this NG pipeline does not reach SAMUI, NG Bulb may be required in concern of energy consumed for NG transportation.

During the project study, we have also found the difficulties in pipeline installation around the island such as transmission length, side road spacing for piping installation, soil density and stability, real estate price for station, etc. Therefore we would propose the main natural gas station at Thong Krut Beach which is the terminal point of gas pipeline from mainland or installed NG bulb in case of no transmission from mainland.

The natural gas will be used for CCP and vehicles including microbuses and boats. This will help reduce air pollutions caused by gasoline or diesel engine vehicles on the island.

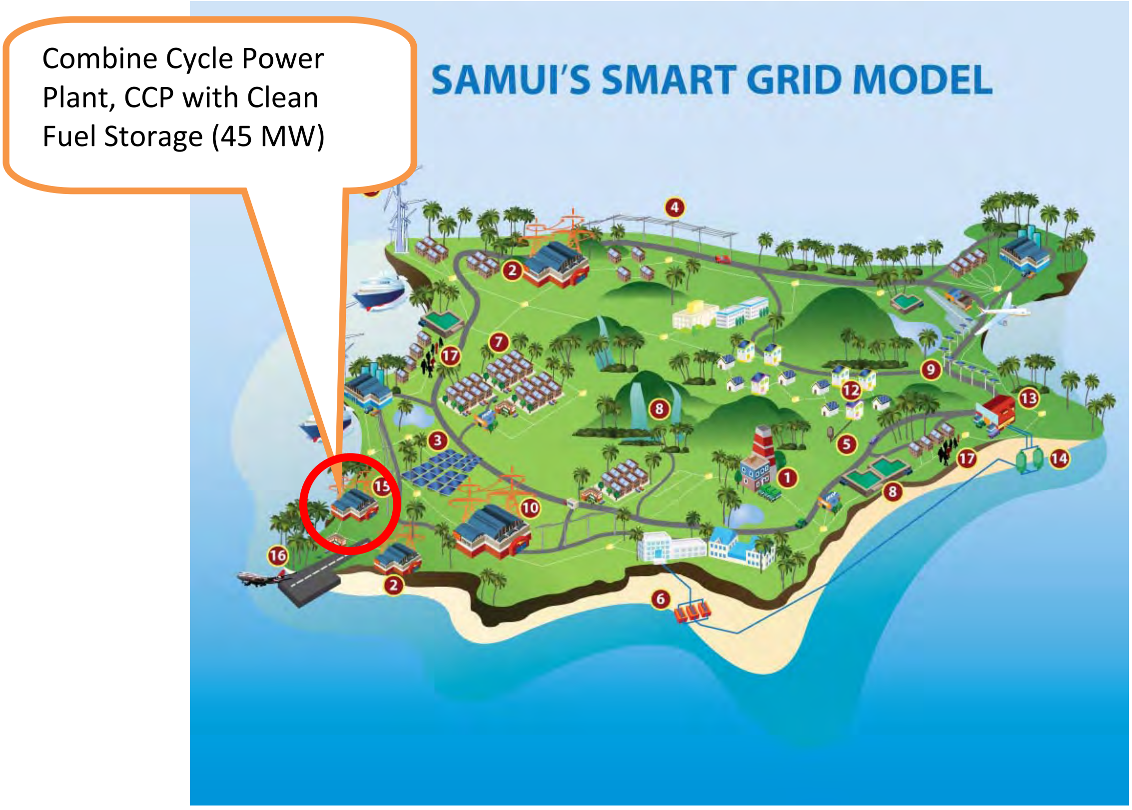


FIGURE 7-7 : Conceptualize of Electricity Power Plant Location on SAMUI Island

7.2.5 Solar Assisted Air-Conditioning

It is interesting that solar heat can produce cooling. The air conditioning system for thermally driven refrigeration technologies as described in Figure 7-8, Overview of the most common solar assisted air conditioning technologies, shows the components to complete the technology. The solar collectors such as vacuum tubes and flat plate collector collect solar heat and then distribute it through water or some chemical liquid component. Absorption chiller or Adsorption chiller will then convert heat to cooling.

In addition, adsorption chiller can operate at the lower heat source temperature than absorption chiller and has COP approximately 0.7. Therefore this type of cooling system is recommended for hotel and government office.

method	closed cycle		open cycle	
refrigerant cycle	closed refrigerant cycle		refrigerant (water) is in contact to the atmosphere	
principle	chilled water		dehumidification of air and evaporative cooling	
phase of sorbent	**solid**	**liquid**	**solid**	**liquid**
				
typical material pairs	water - silica gel	water - water/ lithiumbromide, ammonia/water	water - silica gel, water - lithiumchloride	water - calcium chloride, water - lithium chloride
market available technology	adsorption chiller	absorption chiller	desiccant cooling	close to market introduction
typical cooling capacity [kW cold]	adsorption chiller: 50-430 kW	absorption chiller: 15 kW - 5 MW	20 kW - 350 kW (per Module)	-
typical COP	0.5-0.7	0.6-0.75 (single effect)	0.5->1	>1
driving temperature	60-90°C	80-110°C	45-95°C	45-70°C
solar collectors	vacuum tubes, flat plate collectors	vacuum tubes	flat plate collectors, solar air collectors	flat plate collectors, solar air collectors

FIGURE 7-8: Overview of the most common solar assisted air conditioning technologies

(Source: Key Issues for Renewable Heat in Europe (KRES-H))

The potential of electricity generation on SAMUI Island is summarized as following Table 7-1

TABLE 7-1 : Potential of Electricity Generation on SAMUI Island

Power Generation Type	Capacity	Investment (Baht-(USD))	Input	Area required	Note
Combined Cycle Plant (CCP)	45 MW	2,000 MB (64.5 MUSD)	NG 240,580 m^3/D	25,600 m^2 (16 rais)	heat rate of 11.8 Mbtu/MW-hr, 365 day/24 hr of operation
Combined Heat and Power (CHP)	1 MW, 250 RT Cooling	35 MB (1.1 MUSD)	NG 9,600 m^3/D	800 m^2	heat rate of 11.8 Mbtu/MW-hr, 365 day/24 hr of operation
Solar PV Farm	35 MW (52.5 MWh/day)	3,500 MB (112.9 MUSD)	Sunlight	280,000 m^2 for solar panel and 280,000 m^2 for space between panel	Operating factor=0.3, and Operating 5 hours per day
Solar PV Rooftop	50 MW (75 MWh/day)	9,212.5 MB (297.1 MUSD)	Sunlight	385,000 m^2 (10 m^2/site)	Operating factor=0.3, and Operating 5 hours per day
Wind Turbine	0.24 MW	50 MB (1.6 MUSD)	Wind	Depend on location	Located along Nathorn Beach, see details in chapter 9
Small Hydropower	0.75 MW	75 MB (2.4 MUSD)	Water	Depend on location	See details in chapter 9
Untapped Energy					
Scenario 1: Waste management Process at the original site	1.64 MW	450 MB (14.5 MUSD)	Solid Waste 100 tons/day	27,200 m^2 (17 rais)	See details in chapter 10
Scenario 2: - Collection of all solid waste	3.28 MW	985 MB (31.7 MUSD)	Solid Waste 200 tons/day	59,200 m^2 (37 rais)	
: - Kitchen waste Sorting	0.64 MW	50 MB (1.6 MUSD)	Kitchen Waste 56 tons/day	6,400 m^2 (4 rais)	

8. Area Energy Management

8.1 Area Energy Consumption

Analysis on Electrical Energy Supply and Demand for SAMUI Island

SAMUI Island is the second largest island located in the Gulf of Thailand, and it is a very popular destination for visitors from around the world. Less than one hour's flying time from Bangkok, the island has wonderful beaches, waterfalls, forests, and the potential to remain one of the world's most popular destinations for vacations. It is expected that the island will enjoy unprecedented growth in the next decade, which seems to be good news in terms of increased wealth and greater employment for the island and the country. However, the main problem facing SAMUI currently is whether it could maintain in a position to support growth due to its limited natural resources and infrastructures.

The Provincial Electricity Authority (PEA) is in charge of electrical power distribution and customer services on SAMUI Island. At the beginning of development in 1960, a small diesel power plant had been used as a main power production supplying electricity for the whole island; however, it was shut down later due to its uneconomical operating cost. Since 1988, the first 33 kV submarine cables has been installed to transmit electrical power from Khanom Power Plant in Nakhon Sri Thammarat province (approximately 25 kilometers) to the island. This transmission line has become a main bloodline supplying electricity to the island with capacity of 17 MW for several years. Due to the rapid growth in economic development, electricity demand had exceeded its capacity. Consequently since 2000, the new 115 kV submarine cable has been installed adding up electricity power about 55 MW to the island. As a result, the total power supply capacity on the island has become 72 MW. Since 2006 the second 115 kV transmission cable has been installed to adding up electricity power about 76 MW. So, the total power supply capacity has become 148 MW.

Recently, the first 115 kV submarine cables were damaged resulting the total power supply capacity reduced to 93 MW. This 115 kV submarine cable need to be investigated and repaired by the manufacturer at the origin country, there was in the investigate process and no information for the complete of the process.

Since the power supply on SAMUI Island completely relies on the two submarine cables 33 kV and 115 kV, system reliability has become a critical problem for the island. The peak demand of electricity increase to be more than 93 MW since the early of this year,Y2012, during the investigated period, PEA had asked users for cooperation to reduce the unnecessary power. Large hotels and resorts had to run their standby generators to supply their demand in peak period where the peak demand of the island is reached the limited capacity.

Presently, the PEA is under installing another 115 kV submarine cable from the mainland to SAMUI Island at the new substation call “ SAMUI 2” on Mae Nam sub-district (approximately 50 kilometers) to supply area in the north of island and it is expected to be finished by the early of 2013. The extension project will increase power capacity to 193 MW.

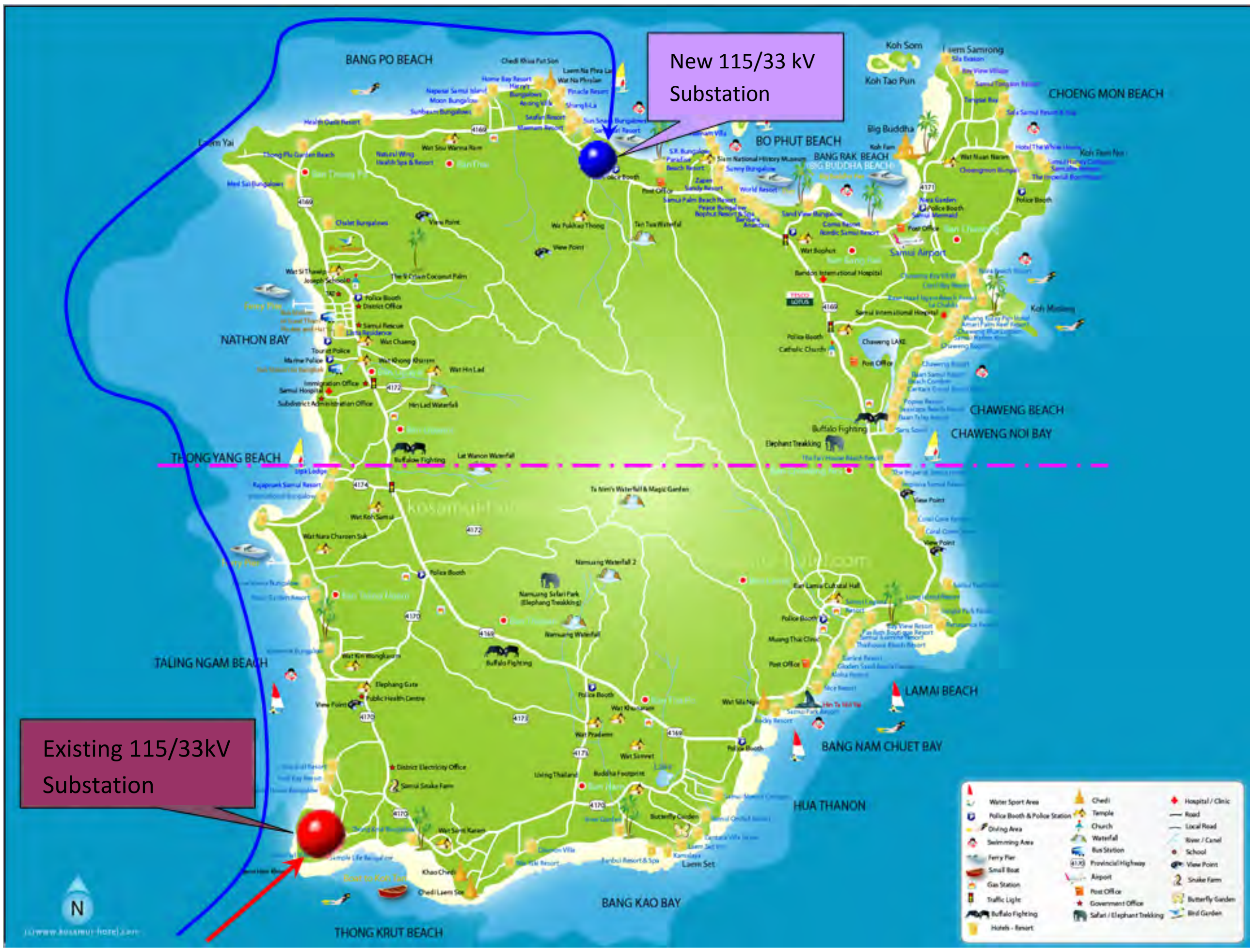


FIGURE 8-1 : Electrical submarine cables from mainland to SAMUI Island

Electricity Peak Demand Forecast For SAMUI Island

Historical peak demands retrieved from the PEA during 2007-2011 are shown in TABLE 8-1. Due to the rapid growth in numbers of tourists, electricity demand on the island has increased dramatically during the last several years. According to Table 8-1, every year the highest peak demand in SAMUI Island has happened 3 times, one is in April (Song-kran day), second is in September (Queen's Birthday) and third is in December (New year) because in these 3 periods there are the long holiday in Thailand

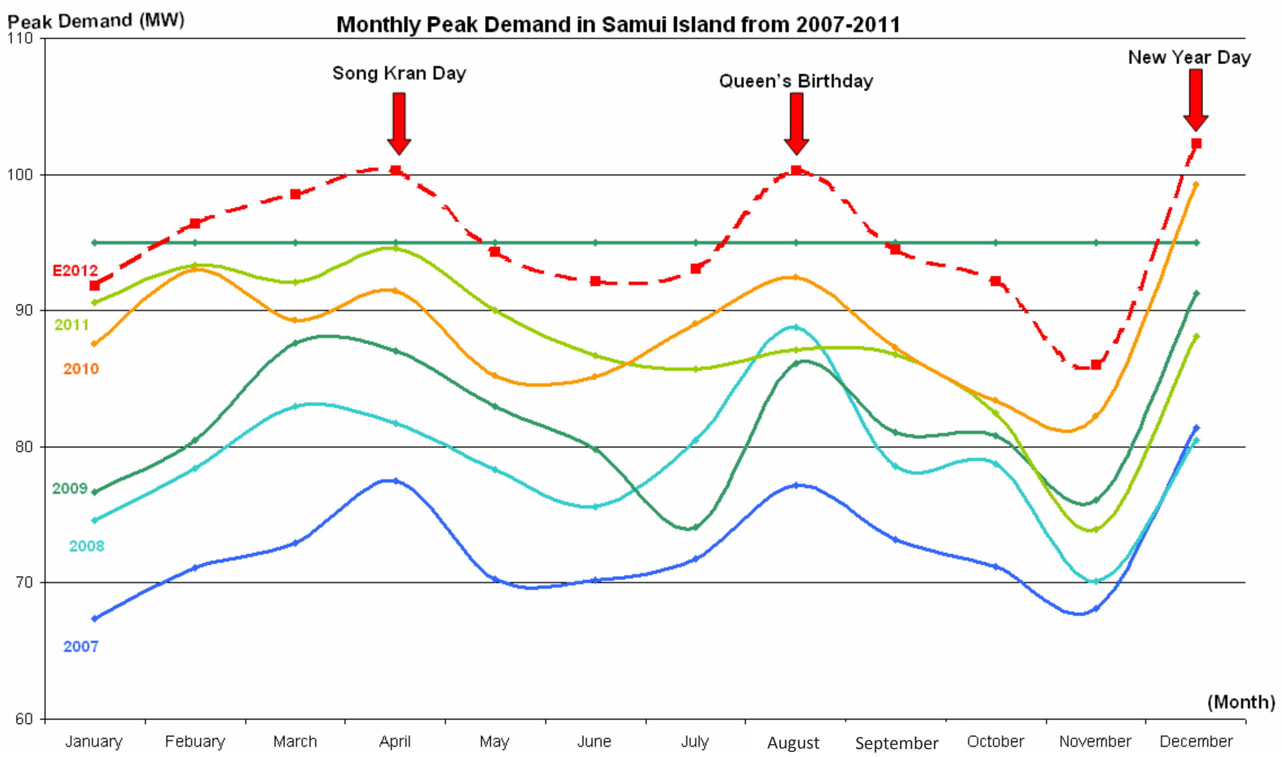


FIGURE 8-2 : Profile of electrical peak demand of SAMUI Island

The objective of this section is to forecast the electricity for SAMUI Island in the next 18 years (2012 – 2030). The demand forecast will be useful for the authorities in energy sector and also the policy makers to make a proper decision and long-term planning. In this analysis, a time series technique will be used to construct a demand forecast model. As a result, the forecast demand will be in term of electricity peak demand in MW

According to Table 8-1, peak demand at the end of 2000 was 28.4 MW, . Consequently, peak demand in December 2011 was 92.6 MW.

TABLE 8-1 : Historical Peak Demand

TABLE1 : HISTORICAL PEAK DEMAND

Year	Peak Demand (MW)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	19.60	14.40	14.50	19.60	19.20	17.60	25.40	26.90	26.30	24.90	22.70	28.40
2001	28.10	28.90	28.90	31.20	29.30	27.20	29.04	30.40	25.66	27.00	30.00	31.34
2002	29.19	31.51	33.85	33.98	33.61	32.11	34.25	34.25	33.14	32.28	31.81	37.07
2003	35.79	37.24	37.84	40.44	37.32	35.87	37.41	40.57	37.03	37.15	35.40	39.63
2004	40.00	42.24	44.66	48.68	46.87	44.53	46.03	49.18	47.09	45.73	44.11	55.47
2005	55.04	55.59	57.60	57.30	57.30	55.60	57.07	61.22	56.95	56.55	57.20	59.07
2006	64.84	63.42	67.50	70.40	65.09	65.90	68.70	72.20	63.80	64.00	64.20	69.40
2007	66.10	72.70	73.10	76.40	69.10	70.60	71.80	77.20	73.20	72.00	66.60	81.40
2008	74.60	78.40	83.20	81.80	77.70	74.70	80.50	88.40	78.40	78.70	71.50	80.60
2009	76.70	80.50	86.50	87.00	82.60	76.60	77.40	86.70	71.10	81.10	75.30	92.30
2010	90.60	93.30	91.90	94.60	86.30	88.80	84.80	87.10	86.70	82.50	73.90	87.10
2011	88.00	95.60	89.30	91.50	85.20	85.20	87.40	91.00	85.30	83.30	82.20	92.60
2012	92.80	96.00	97.80	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note: 1. Historical data retrieved from PEA

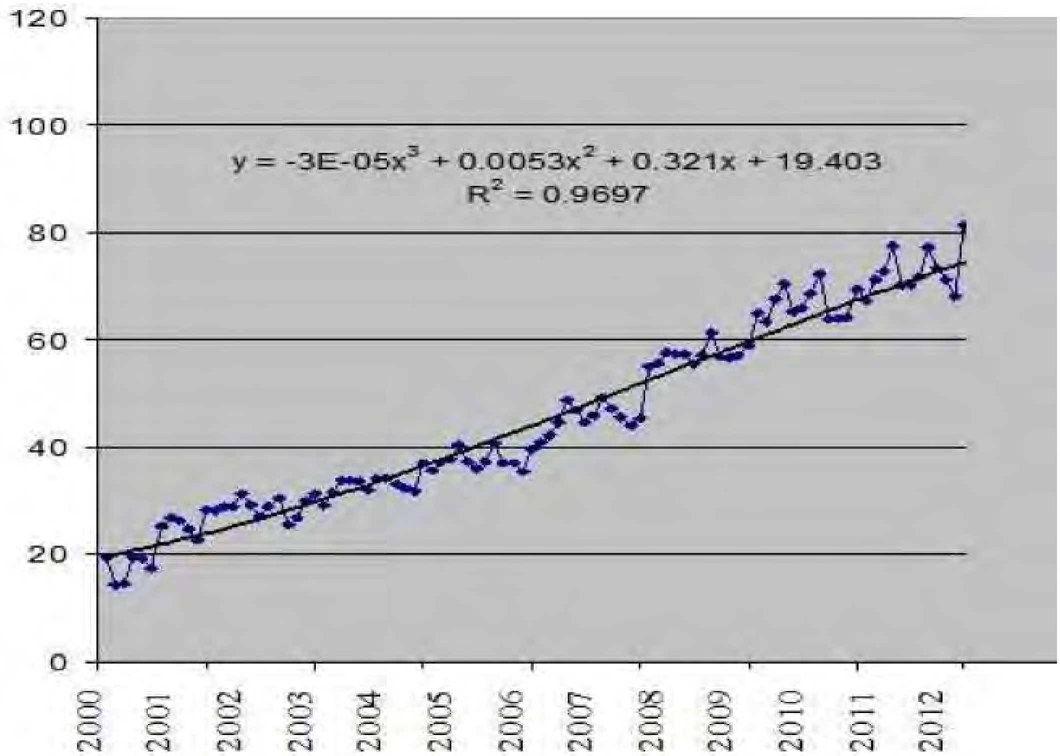


FIGURE 8-3 : Electrical peak demand equation created by using historical data

FORECAST METHODOLOGY

In this analysis, a moving average method will be used in smoothing out a time series so that a typical monthly index can be identified. Then, the historical data will be deseasonalized before performing a polynomial analysis. As a result, the trend line of the peak demand and energy demand can be described by the following equations.

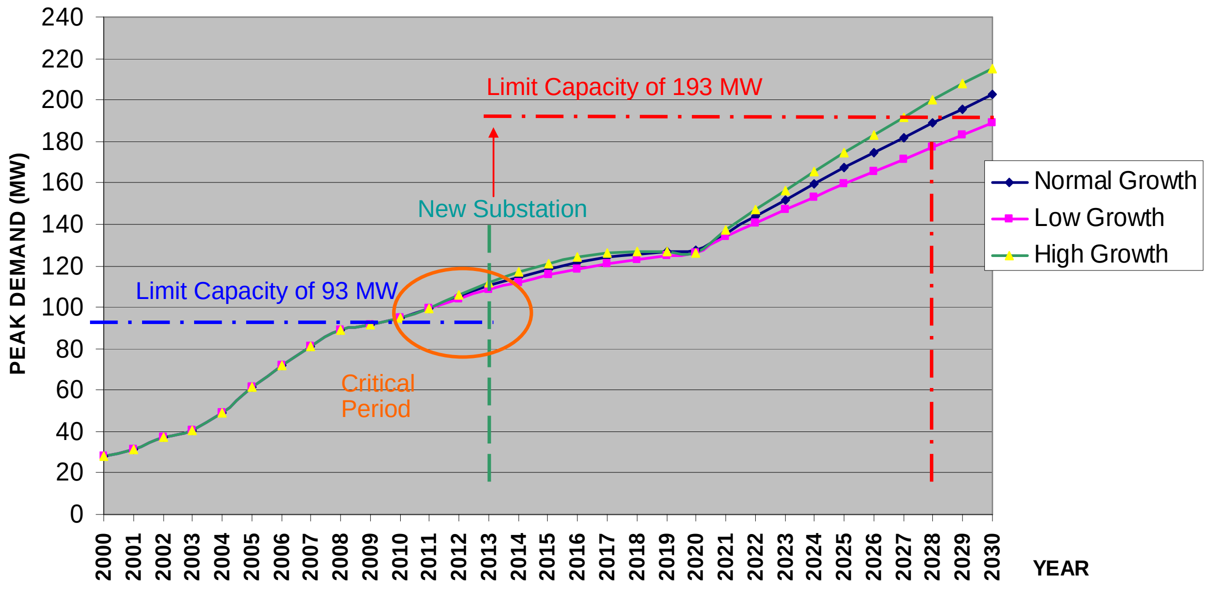
Peak Demand (MW) = -3E-05x3 + 0.0053x2 + 0.321x + 19.403

Where,
x = period of time, monthly
g = growth factor

According to the regression analysis, the R^2 value of the peak demand regression is 0.9697. The relatively high R^2 value demonstrates that the polynomial regression equation is a very good explanation of the previous demand. By using the polynomial equations to predict future values, the hidden assumption is that the trend of future demand will be in line with that of the past. However, this might not always be practical in some circumstances when there is a major change in economy or social. In fact, after the Asian tsunami tragedy on December 26, 2004, it is expected that investors will be more diversified and will shift some of their investments from Andaman coastal region to the Gulf of Thailand. Thus, according to the equations above, growth factor (g) has been added to reflex an expected growth in economic development when comparing with the past. In this analysis, growth factors for normal, low, and high growth economy are 1.00, 0.80, and 1.20, respectively. Lastly, the monthly forecast demand can be obtained by multiplying the predicted deseasonalized data with the monthly typical index in order to reflex seasonal variation.

For the forecast analysis, there are 2 period first is between 2012 to 2020 call "Mid term" in this period, the growth of demand will be slow because of economy and the limited of infra-structure on the island. The second is between 2020 to 2030 call "Long Term" in this period, the growth of demand will be speed up again after world economic change and the new investment of infra-structure.

FIGURE 8-4 : PEAK DEMAND FORECAST FOR SAMUI ISLAND (2000-2030)



FORECAST SUMMARY

Note that the energy demand obtained from the previous section represents just only the demand of the PEA's customers excluding loss in transmission, demand of free-of- charge customers, and energy supply for public lighting.

According to the peak demand forecast chart, peak demand for normal growth is expected to reach the current capacity of 93 MW by early of 2012, while the PEA's extension capacity of 193 MW will be completed by early of 2013. In this conjunction period, some major hotels would be asked to run their generators to supply their energy demand whenever the peak demand of the island is reached the limited capacity. However because of high growth economy, new peak demand will reach 193 MW by 2028.

Electrical Energy Consumption Characteristic of SAMUI Island
: DAILY LOAD FACTOR

Historical daily load curve retrieved from the PEA during 1st-15th August 2012 are shown as following chart;

FIGURE 8-5 : Daily load curve of SAMUI Island during 1st - 15th August 2012

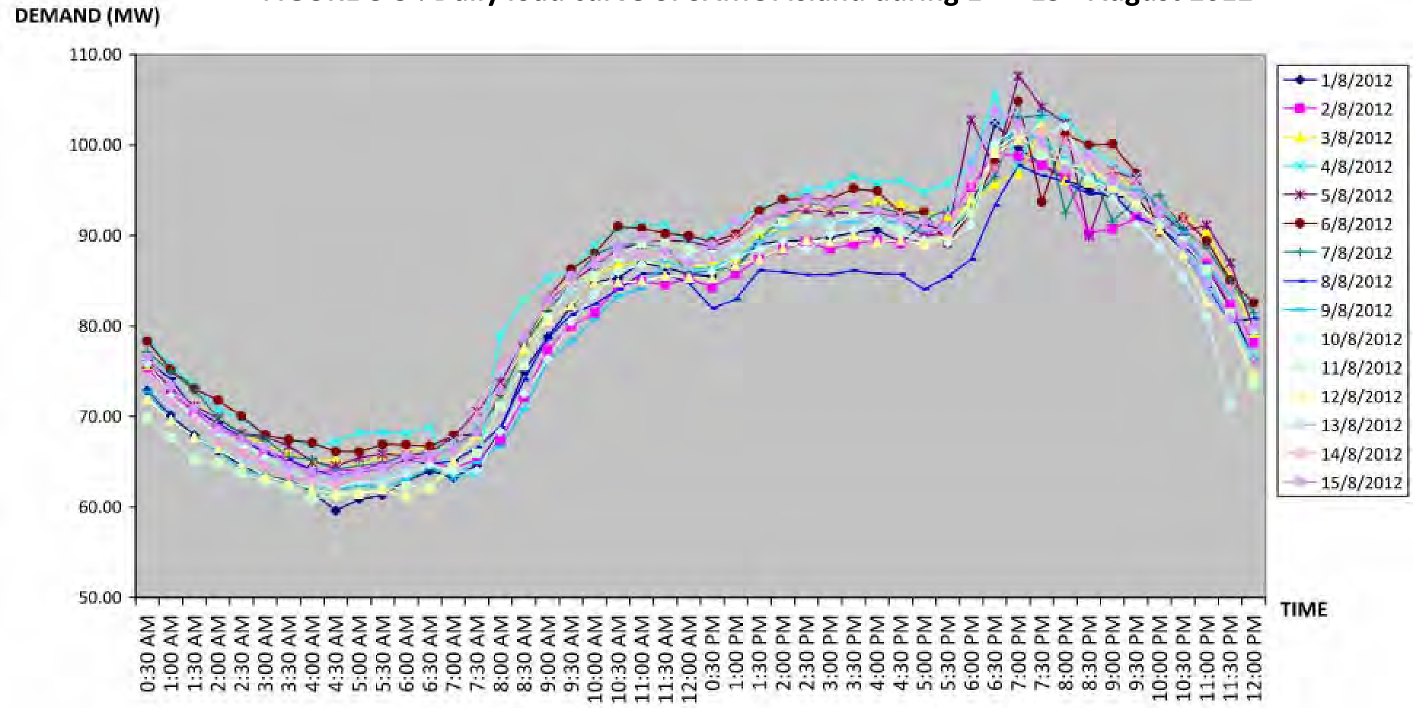


TABLE 8-2 : Daily Load Factor

	1/8/2012	2/8/2012	3/8/2012	4/8/2012	5/8/2012	6/8/2012	7/8/2012	8/8/2012
Maximum Demand (MW)	102.37	99.23	101.59	105.54	107.66	104.86	103.32	97.78
Energy Demand (MWh)	1939.57	1941.86	1994.60	2043.16	2015.35	2027.71	1997.88	1922.64
LOAD FACTOR	0.79	0.82	0.82	0.81	0.78	0.81	0.81	0.82

	9/8/2012	10/8/2012	11/8/2012	12/8/2012	13/8/2012	14/8/2012	15/8/2012
Maximum Demand (MW)	101.76	102.06	101.24	102.38	103.87	101.54	103.74
Energy Demand (MWh)	1944.25	1942.47	1951.05	1940.71	1984.37	1992.87	2000.75
LOAD FACTOR	0.80	0.79	0.80	0.79	0.80	0.82	0.80

According to Table 8-2, The daily load factor of SAMUI Island are in range 0.78-0.82

8.2 Smart Grid System

8.2.1 Introduction of Smart Grid for SAMUI Island

As demand of electricity on SAMUI Island will be rapidly growth in the next decade. Variety of electricity supply sources such as solar, wind etc. should be introduced and implemented on SAMUI Island. Therefore, SMART Grid System would be introduced to efficiently manage electricity demand and supply on the island. SMART Grid System will assist in utilizing the electricity sources; monitor and real time manage the load of large electricity consumers.

The Smart Grid represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability, and efficiency that will contribute to our economic and environmental health. The benefits associated with the Smart Grid include:

- More efficient transmission of electricity
- Quicker restoration of electricity after power disturbances
- Reduced operations and management costs for utilities, and ultimately lower power costs for consumers
- Reduced peak demand, which will also help lower electricity rates
- Increased integration of large-scale renewable energy systems
- Better integration of customer-owner power generation systems, including renewable energy systems
- Improved security

Functions of Smart Grid

1. Real time Simulation and Contingency Analysis
2. Distributed generation and Alternate Energy Sources
3. Self Healing Wide-Area protection and Islanding
4. Asset Management On-Line Equipment Monitoring
5. Peak shift and Peak cut during annual electricity consumption
6. Demand Response and Dynamic Pricing

8.2.2 The Smart Building

The major electrical energy consumers on SAMUI Island are commercial building including hotels, resorts and department stores. These commercial buildings should be equipped with the smart system interface with the proposed Smart Grid system of the island.

The Smart Grid interface between the building and energy provider via BMS (Building Management System) allow for automated and complex transfers of information between the building and energy provider.

In the smart building, many of appliances will be networked together, allowing users to access and operate them through BMS. The energy management software shall be provided as a minimum for the purpose of optimizing energy consumption while maintaining occupant comfort.

Energy waste can be eliminated by obtaining location information for individuals while ensuring building security, automatically controlling air conditioning and lighting, and visually representing energy usage. Such measures can also help ensure the security of the entire building.

Buildings that make building management more efficient and curb energy consumption, from the building overall down to an individual level - those are Smart Buildings.

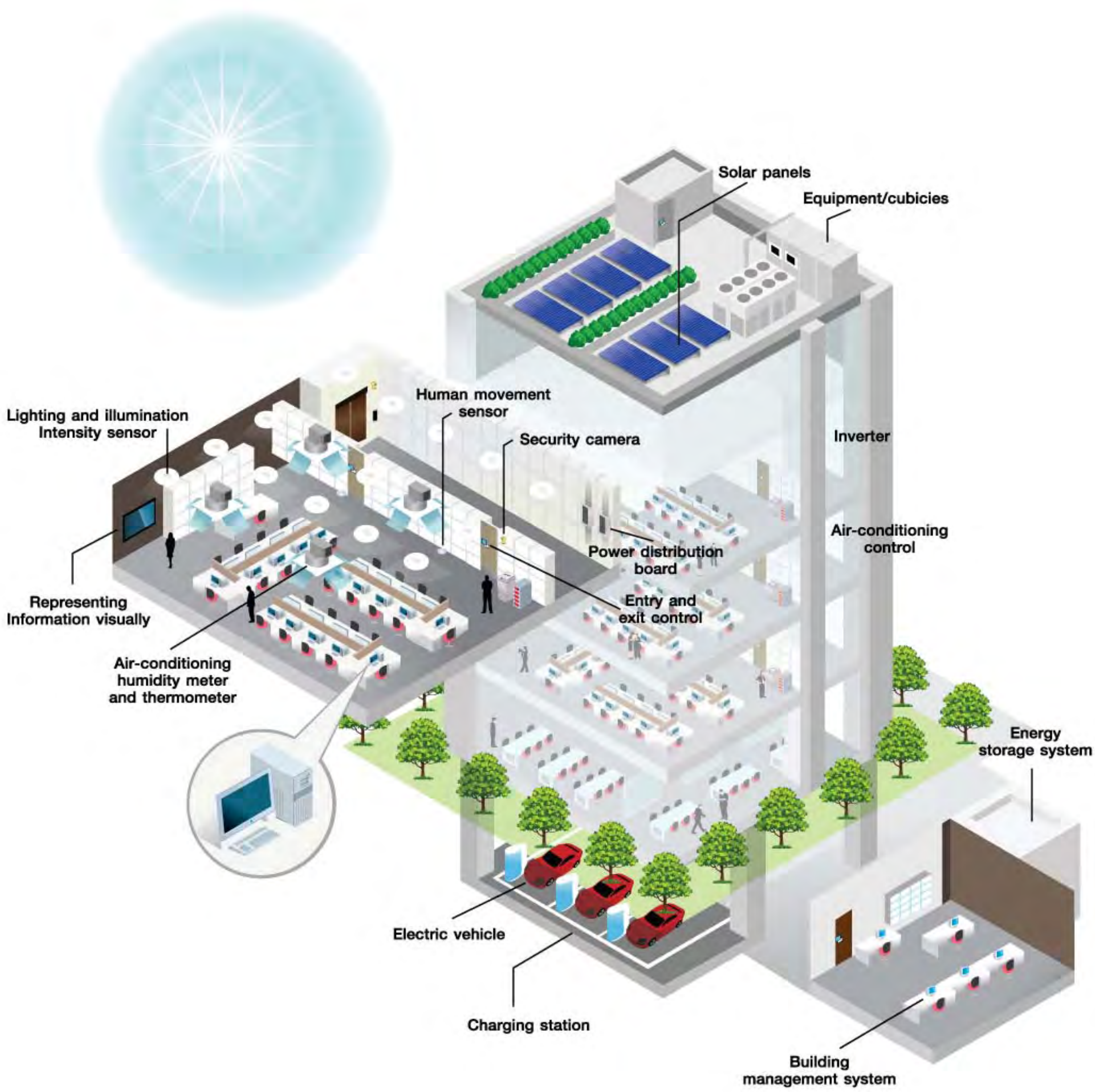


FIGURE 8-6 : Smart building concept

Enabled by technology, this smart building connects the structure itself to the functions it exists to fulfill:

- Connecting building systems
- Connecting people and technology
- Connecting to the bottom line
- Connecting to the global environment
- Connecting to the smart power grid
- Connecting to an intelligent future

8.2.3 The Smart Home

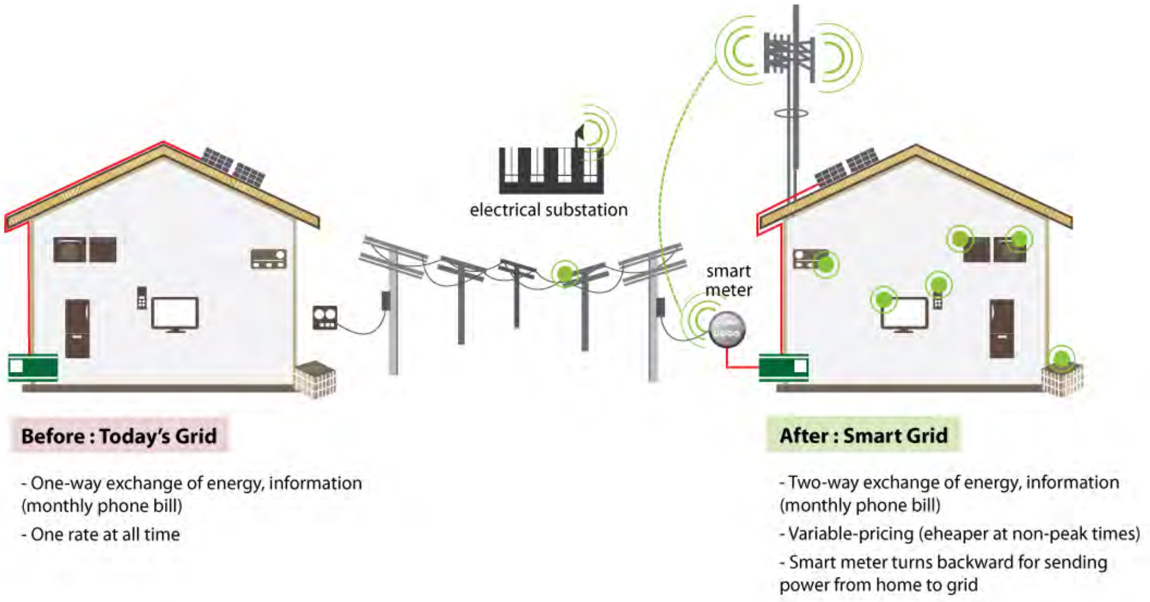


FIGURE 8-7 : Smart home concept

In order to complete the smart grid system, connecting households to Smart Grid is also recommended. There are approximately around 36,000 registered households on SAMUI Island. Up to 60% of the household which consumes most of the electrical energy in this sector would be connected to Smart Grid through Smart meters.

Smart meters provide the Smart Grid interface between consumers and energy provider. Installed in place of old, mechanical meter, these meters operate digitally, and allow for automated and complex transfers of information between household and energy provider. For instance, smart meters will deliver signals from energy provider that can help consumers cut their energy costs. Smart meters also provide utilities with greater information about how much electricity is being used throughout the island.

FIGURE 8-8 : Example of smart meter

FROM: SMART GRID METER, www.smartgridsource.com

As consumers move toward home energy generation systems, as solar rooftop system is proposed for SAMUI Island, then, the interactive capacity of the Smart Grid will become more and more important.

The Smart Grid, with its system of controls and smart meters, will help to effectively connect all these mini-power generating systems to the grid, to provide data about their operation to utilities and owners, and to know what surplus energy is feeding back into the grid versus being used on site. A potential feature of the Smart Grid will be to allow your community to use your solar array—and your neighbor's—to keep the lights on even when there is no power coming from a utility. Called "islanding," it will allow a home to grab power from "distributed resources," such as local rooftop solar, small hydropower, and wind projects, until utility workers can bring the grid back online.

8.2.4 Plug-In Electric Vehicles

FIGURE 8-9 : Plug in electric vehicle

Electric Vehicles (EVs) have been proposed for implemented on SAMUI Island as describe in Chapter 6 of this study report. In this regard, connected EVs and charging system to Smart Grid system is recommended.

The Smart Grid will have the infrastructure needed to enable the efficient use of this new generation of EVs. EVs can drastically reduce our dependence on oil, and they emit no air pollutants when running in all-electric modes. However, they do rely on power plants to charge their batteries, and conventional fossil-fueled power plants emit pollution.

Vehicle to Grid

To run an EV as cleanly as possible, it needs to be charged in the lowest peak demand period, when power *demand* is at its lowest. Smart Grid technologies will help to meet this goal by interacting with the EV to charge it at the most optimal time. But sophisticated software will assure that your EV is still fully charged and ready to go when you need it. And you'll still be able to *demand* an immediate recharge when you need it.

In the future, EVs may play an important part in balancing the energy on the grid by serving as distributed sources of stored energy, a concept called "vehicle to grid." By drawing on a multitude of batteries plugged into the Smart Grid throughout its service territory, users can potentially inject extra power into the grid during critical peak times, avoiding brownouts and rolling blackouts. EVs also have the potential to help keep isolated parts of the grid operating during blackouts. They could also help integrate variable power sources into the grid, including wind and solar power. Financial incentives may be available for EV owners that allow their batteries to be used this way.

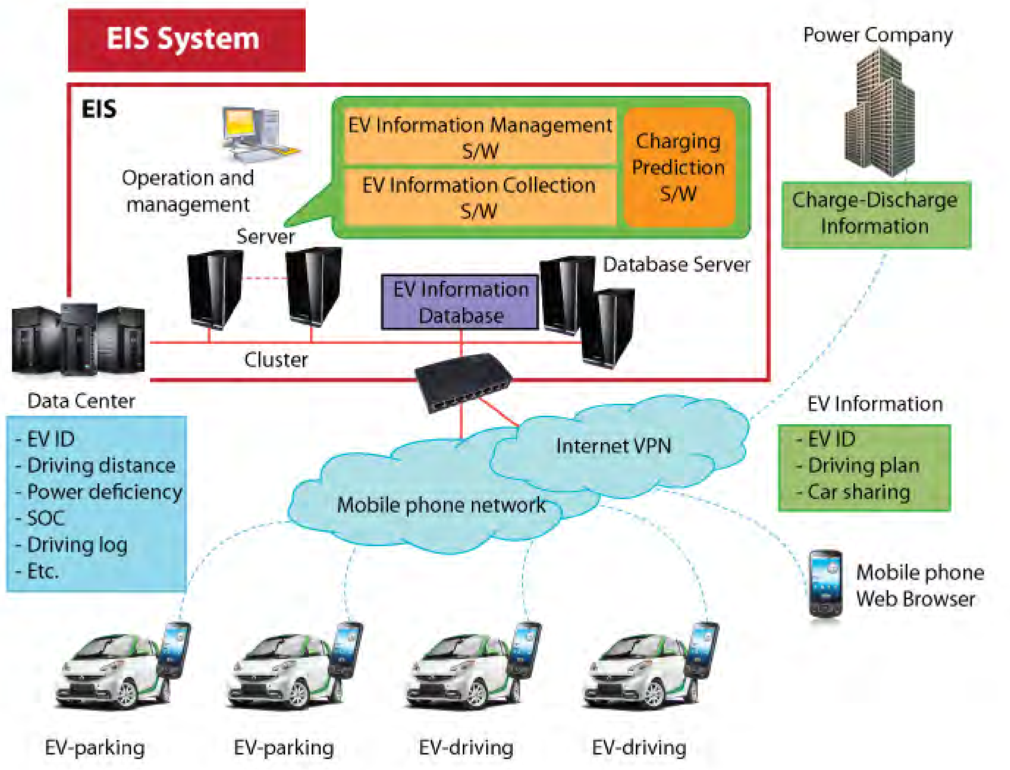


FIGURE 8-10 : Vehicle to grid concept

With the increasing market growth in EV (Electric Vehicles), comes along the increasing market need for EV charging stations. The EV charging stations usually have high power loading requirement, which poses new challenges to the grid loading demand, particularly during peak load hours.

Utilities companies need to have Smart Grid EV Solution to communicate with these charging stations to schedule for periods of reduced load or reduced electricity costs. Smart Grid EV Solution allows the utilities companies to utilize the large amount of vehicle battery power as valuable peak load demand resources. In short, Smart Grid EV solution provides intelligent communication between the grid, charging stations and vehicle electronics, with a new set of safety standards.

The benefits of Smart Grid EV Solution are as follows,

- It reduces peak load demand of electricity, thus enabling huge saving from avoiding unnecessary investment in the whole grid network, including both power generation and transmission and distribution (T&D) by utilities companies.
- Interactive and intelligent EV charging controls now available to end customers will enable them to achieve big saving in electricity expenses.
- The resulting smoothing out of electricity demand and supply will release high stress in utilities' facilities and equipment with greatly extended useful life.
- It allows utilities companies to utilize EV battery power as valuable DER (Distributed Energy Resources) to provide peak load power and power optimization resources with resulting big saving in utilities companies' capital investment.
- Reduction in Green House Gas emission.
- Improved customer satisfaction through successful Smart Grid EV charging program.
- Improvement of power quality and reduction of power outages.

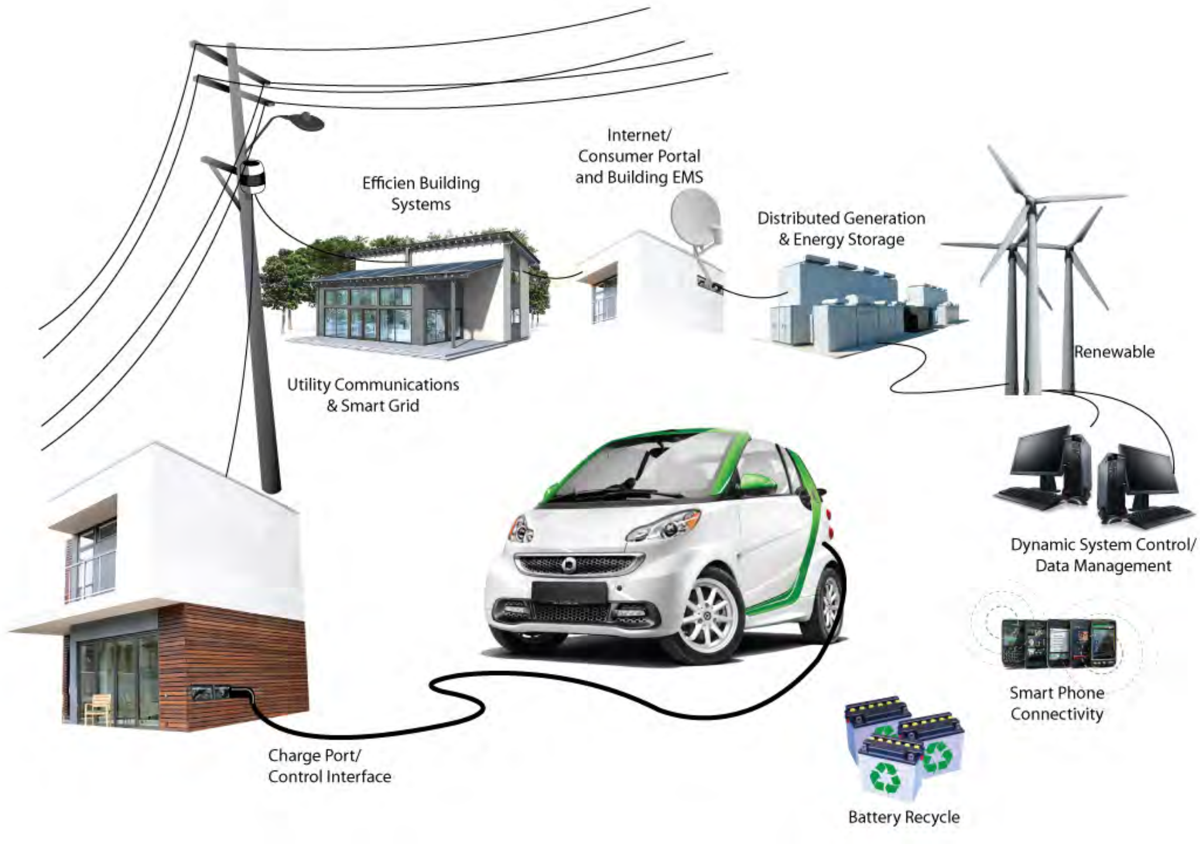


FIGURE 8-11 : Smart Grid EV Solution

8.2.5 SAMUI's Smart Grid Evolution

FIGURE 8-12 : Chaweng's Micro Grid Model

SAMUI smart grid system should be started from small area as pilot project and then expand to cover the whole island. Chaweng area is recommended to be the first area in SAMUI to implement the concept as this area consists of several type of buildings and activities such as households, hotels & resorts, department stores etc. Micro Grid concept would be introduced for Chaweng area. The solar PV roof top shall be installed on each user property and collect the power in battery to used in there property and also connected to the central battery of each community to share the power demand.

If Chaweng's micro grid is successfully implemented, Chaweng's model will be used to investigate in other area in SAMUI Island and combine to SAMUI's smart grid. Apart from the solar roof top of the micro grid, connecting of the incinerator power plant and combined cycle power plant to the smart grid to reduce the power demand and move forward for SAMUI Low Carbon Island would also be recommended.

The renewable energy as describe in chapter 9 will also be connected to Smart Grid system of the island, including the solar PV farm of 35 MW, solar PV rooftops and small hydro electricity generation.

All above shall be connected to smart grid and control the energy by centralized system in command center

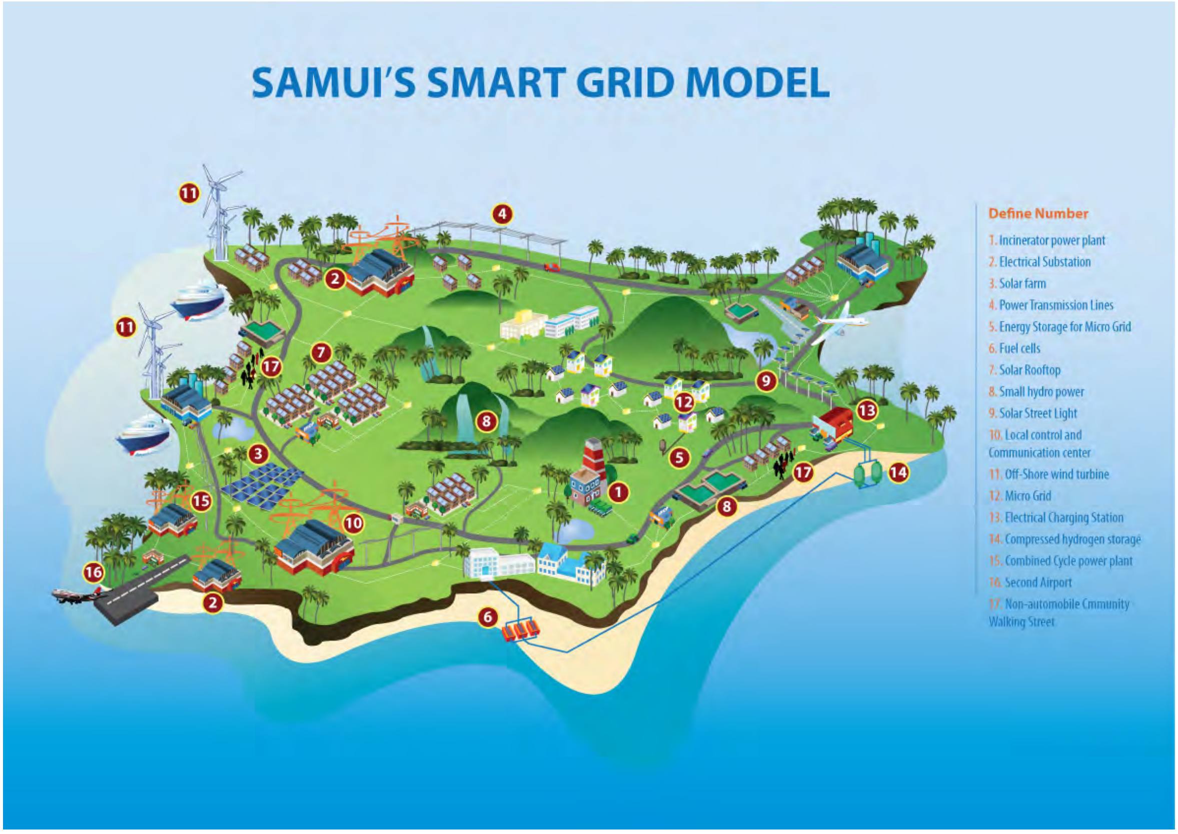
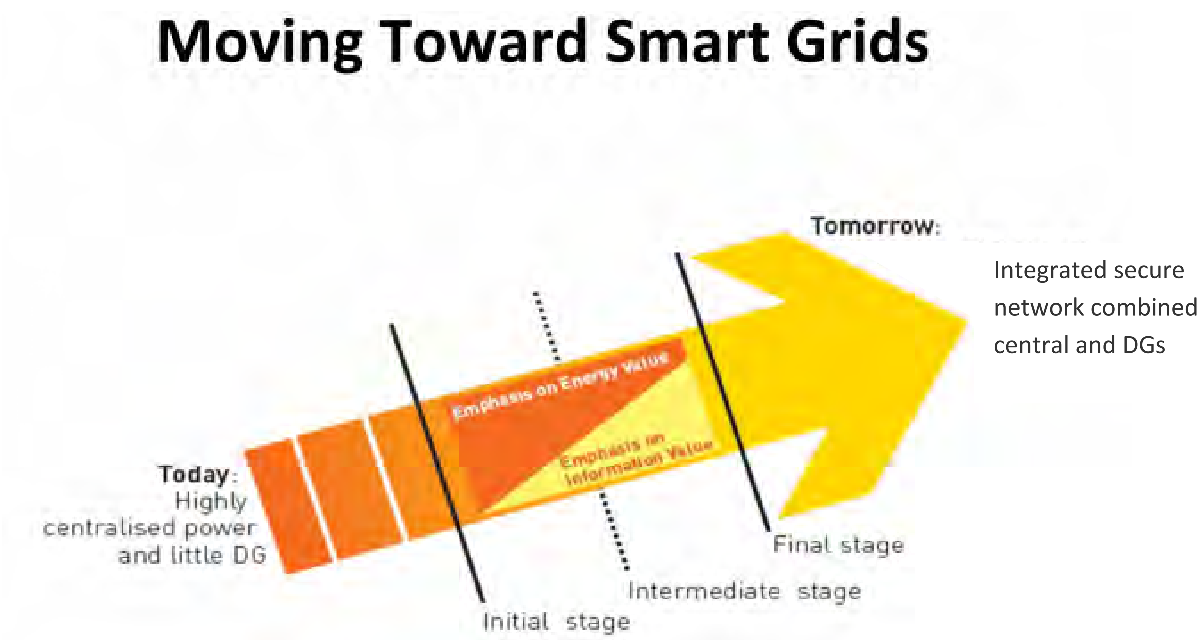
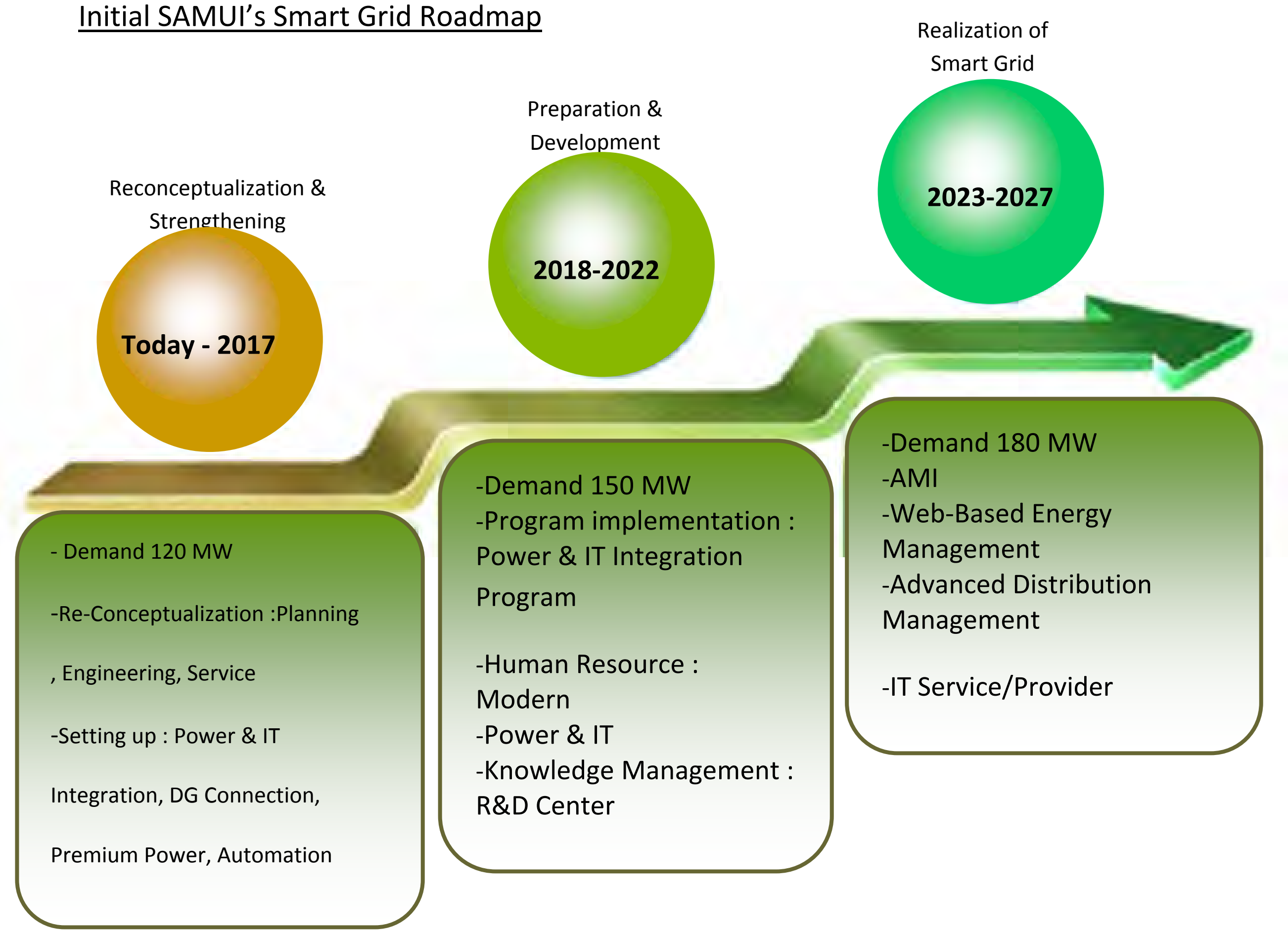


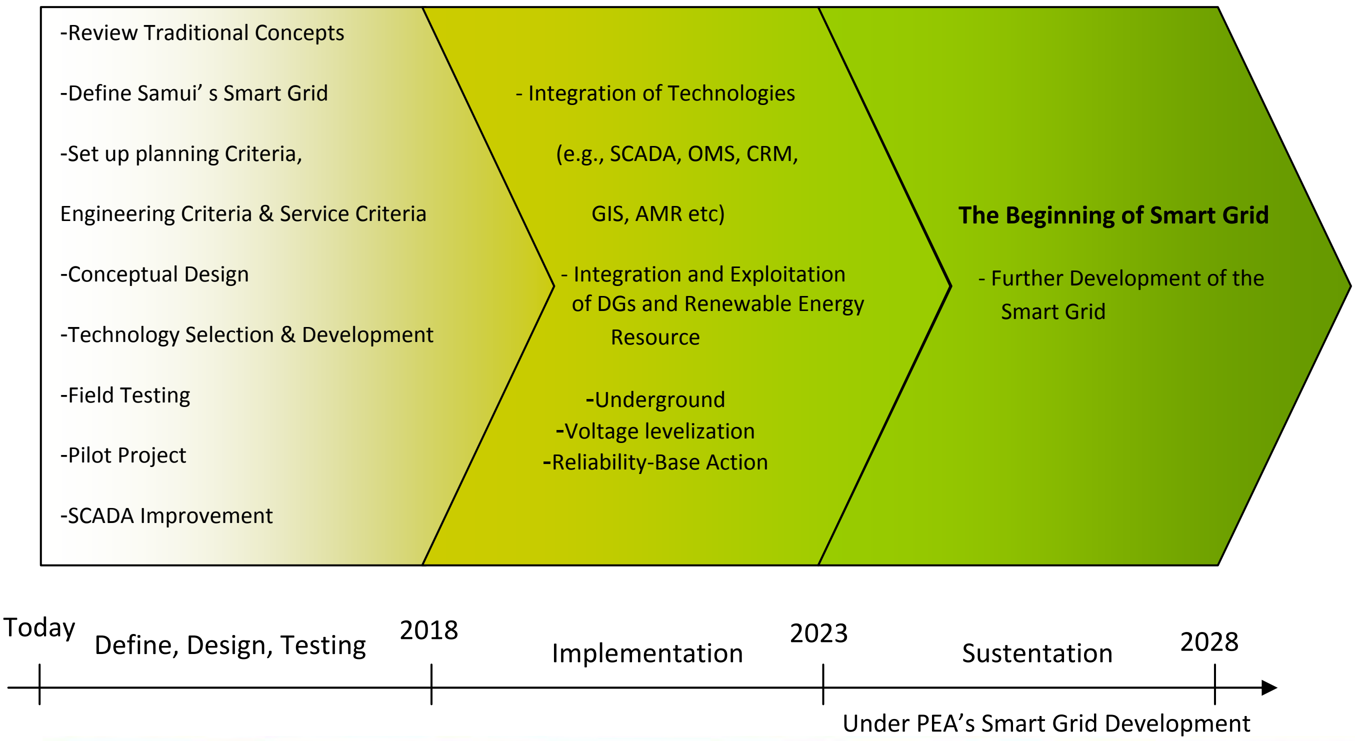
FIGURE 8-13 : SAMUI's Smart Grid Model



Initial SAMUI's Smart Grid Roadmap



Propose Timeline of Samui's Smart Grid Development



8.2.6 Implementation Cost Estimation of SMART Grid for SAMUI Island

Implementation of SMART Grid System for SAMUI Island should be divided into three phases as following;

Phase I : Infrastructures preparation and main management system for government building

Phase II : Implementation of SMART Grid system for Chaweng area

Phase III : SMART Grid system for major users of SAMUI Island

Implementation cost estimation for each phase is provided as following table:

TABLE 8-3 : Estimated implementation cost of Smart Grid for SAMUI Island

	Scope of Implementation			Cost estimation (Baht) : (USD)
	Infrastructures and No. of Government Building (site)	No. of Hotel (site)	No. of Household (site)	
Phase I	20	-	-	120,000,000 Baht (3.8 Million USD)
Phase II	-	144	13,982	227,804,800 Baht (7.3 Million USD)
Phase III	-	152	22,868	302,496,000 Baht (9.7 Million USD)
Total	20	296	36,850	650,300,800 Baht (20.8 Million USD)

Note : In phase II and III the number of hotels and households connected to SMART Grid system will be varied depend on the capacity of the system and readiness of each user. Cost estimation is based on 80% of the hotels and 60% of the households will be connected to SMART Grid system.

Reference

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3. Residential Smart Grid Solutions; Lutron Technology, www.lutron.com
4. Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey, released April 2009. (www.eia.doe.gov/emeu/cbecs/cbecs2003/lighting/lighting1.thml)
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8. DR.Surin Komfoi, King Mongkut institute of Technology Ladkrabang; Smart grid
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10. Solar fuel station for PHEV ; www.pluginbayarea.org www.foe.org
11. Ford Battery Electric Vehicle : FORD

9. Renewable Energy

9.1 Conceptualization of Low Carbon for Renewable Energy

Renewable Energy is another source of energy that can be utilized on the island. Solar energy, wind and small hydro power are the three major renewable energy sources that are recommended for SAMUI Island. Solar energy can be used to produce electricity through solar PV farm and solar PV rooftop connecting to the grid. Individual street lighting also can be able to utilize electricity from single solar panel. Installation of the cascade small hydropower technology along the rivers and canals is another renewable energy potential. Wind speed on SAMUI Island is not attractive, average of 3-4 m/s only. However, installation of appropriate type and size of wind turbine along the coastal area might have impact as the image of the Low Carbon Island.

9.1.1 Solar Energy

<u>Technologies of Solar Energy in Thailand</u>

Department of Alternative Energy Development and Efficiency has undertaken a lot of projects on solar system such as solar cells to support and make people aware of and realize how important of renewable energy such as Solar cell. Since our current dependence on fossil fuels is slowly being replaced by alternative energies. Some fuels may be completely depleted in the future, but solar energy will never be obsolete, controlled by foreign powers, or run out. From 1983 until today, many solar energy projects have been undertaken under the control of Department of Alternative Energy Development and Efficiency such as PV Power Generation System for Household Lighting (Solar Home System), PV Battery Charging Power Generation System for Non-Electrification Rural Village, PV Power Generation System for Non-Electrification Rural School, PV Power Generation System for Community Knowledge Centre, PV Power Generation System for Public Street Lighting, PV Power Generation System for Frontier Police and Military Base, PV Water Pumping System, Hybrid PV Dryer System for Agricultural Products and etc. In total the projects conducted by Department of Alternative Energy Development and Efficiency includes 1786 installations with total energy capacity of 3905.491 kW as shown in Table 9-1

TABLE 9-1 : Solar System Projects under control of Department of Alternative Energy Development and Efficiency.

System	Number of installation	kW
PV Battery Charging Power Generation System for Non-Electrification Rural Village	353	1025.5
PV Power Generation System for Non-Electrification Rural School	259	1,114.5
PV Power Generation System for Community Knowledge Centre	178	267.0
PV Power Generation System for Border Patrol School	38	100.75
PV Power Generation System for Frontier Police and Military Base	594	251.375
PV Power Generation System for Rural Clinic	83	166
PV Power Generation System for National Park Area	67	201
Smart Grid System	15	202.2
PV Power Generation System for Thai Royal Project Area	94	385.166
PV Water Pumping System for Rural Village	69	138
PV Water Pumping System for Rural Clinic	1	4
Mini Grid System for Village	5	50
Total	**1,756**	**3,905.491**

The Solar system in Thailand has been used since 1983 Government organization has been interested in and already installed PV Power Generation Systems, PV Water Pumping Systems including PV communication Systems with total capacity more than 100,691.173 kW.

TABLE 9-2 : Cumulative PV Installation in Thailand from 1983-2010

Year	Number of installation (kW)		
	off-grid	grid-connected	Total
1983-1987	30.288	120.000	150.288
1988-2535	119.033	122.100	241.133
2536-1995	1,640.248	139.360	1,779.608
1996-2001	2,570.119	319.490	2,889.609
2002	3,128.634	1,095.004	4,223.638
2003	9,070.254	1,761.036	10,831.290
2004	22,107.184	1,773.536	23,880.720
2005	28,660.284	1,863.274	30,523.558
2006	28,900.734	3,606.124	32,506.858
2007	29,336.009	4,057.084	33,393.093
2008	29,491.009	13,674.084	43,165.093
2009	29,652.009	19,556.784	49,208.793
2010	29,881.009	70,810.164	100,691.713

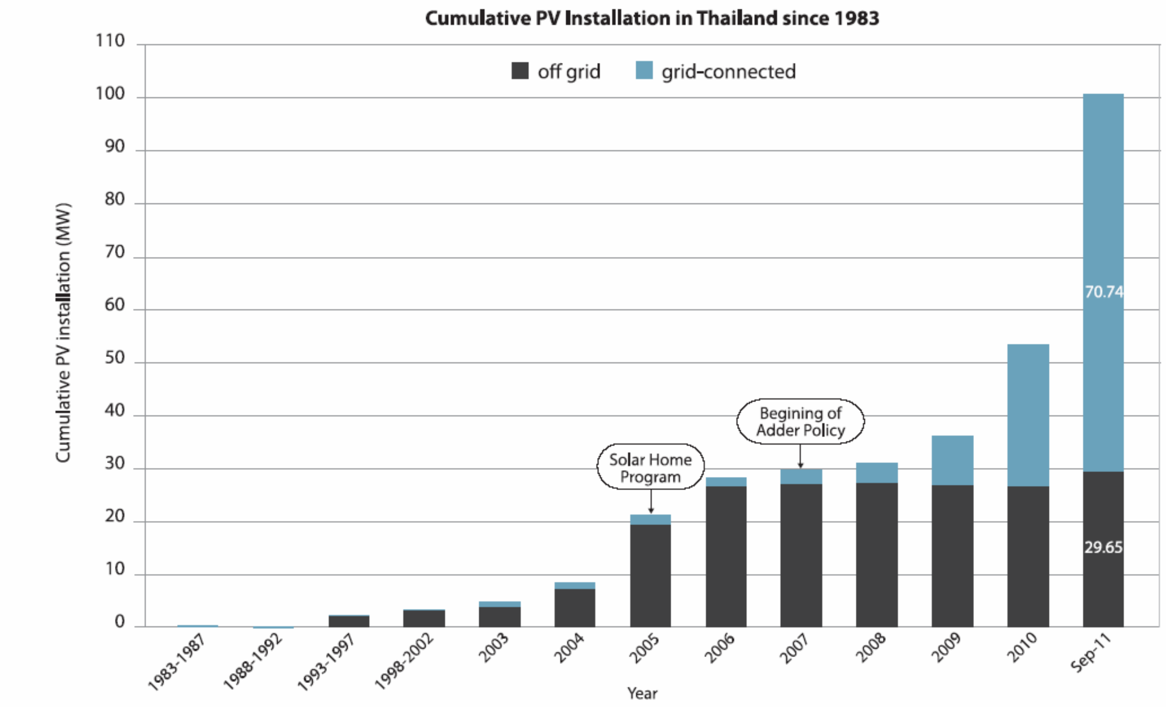


FIGURE 9-1 : Cumulative PV Installation in Thailand from 1983-2010

Source: www.dede.go.th/dede/images/stories/pdf/t_**pv**_11.pdf

TABLE 9-3 : The Technology of most popular Solar systems in Thailand

No.	Technology	Number of Installation (kW)	percent
1	PV Power Generation System	27,002.666	26.82
2	PV Battery Charging Power Generation System	1,416.042	1.41
3	PV communication System	1,142.022	1.13
4	Smart Grid System	70,810.164	70.32
5	PV Water Pumping System	320.279	0.32
	Total	100,691.173	100

Solar Energy Potential in Thailand

Thailand is located in the south eastern part of Asia, between 15° 00' North latitude and 100° 00' East longitude. The Thailand Solar Energy Map (1999) developed by DEDE and Faculty of Science at Silpakorn University, shows the distribution of solar radiation intensity at various places in the country for each month influenced by Northeast Monsoon and Southwest Monsoon. The majority of the country receives the maximum solar radiation during April and May with values ranging from 20–24 MJ/m2-day. Considering the daily solar radiation for an annual average, we found the areas with the maximum solar radiation be at the northeast partially covering Nakhon Ratchasima, Buriram, Surin, Sisaket, Roi-et, Yasothon, Ubon Ratchathani, Udon Thani and some parts of the central region at Suphanburi, Chainat, Ayutthaya, and Lopburi of which the solar radiation receiving of 19–20 MJ/m2-day as an annual average and such these areas are accounted for 14.3% of the whole country. Additionally, we found the 50.2 percent of the total area receiving an annual average of solar radiation at 18 – 19 MJ/m^2-day. The total daily solar radiation of an annual average in an overall country area has a value of 18.2 MJ/m2-day and this result indicated of the rather high potentials of Thailand solar energy.

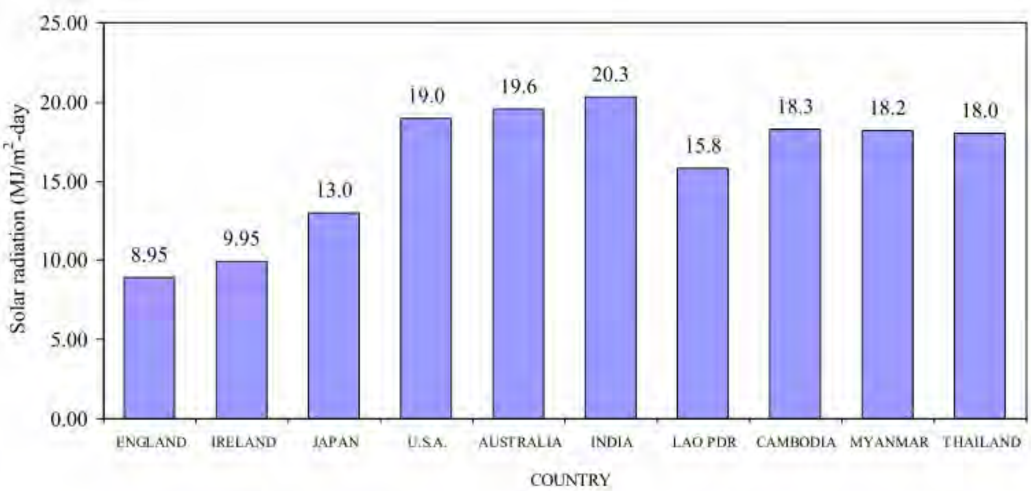
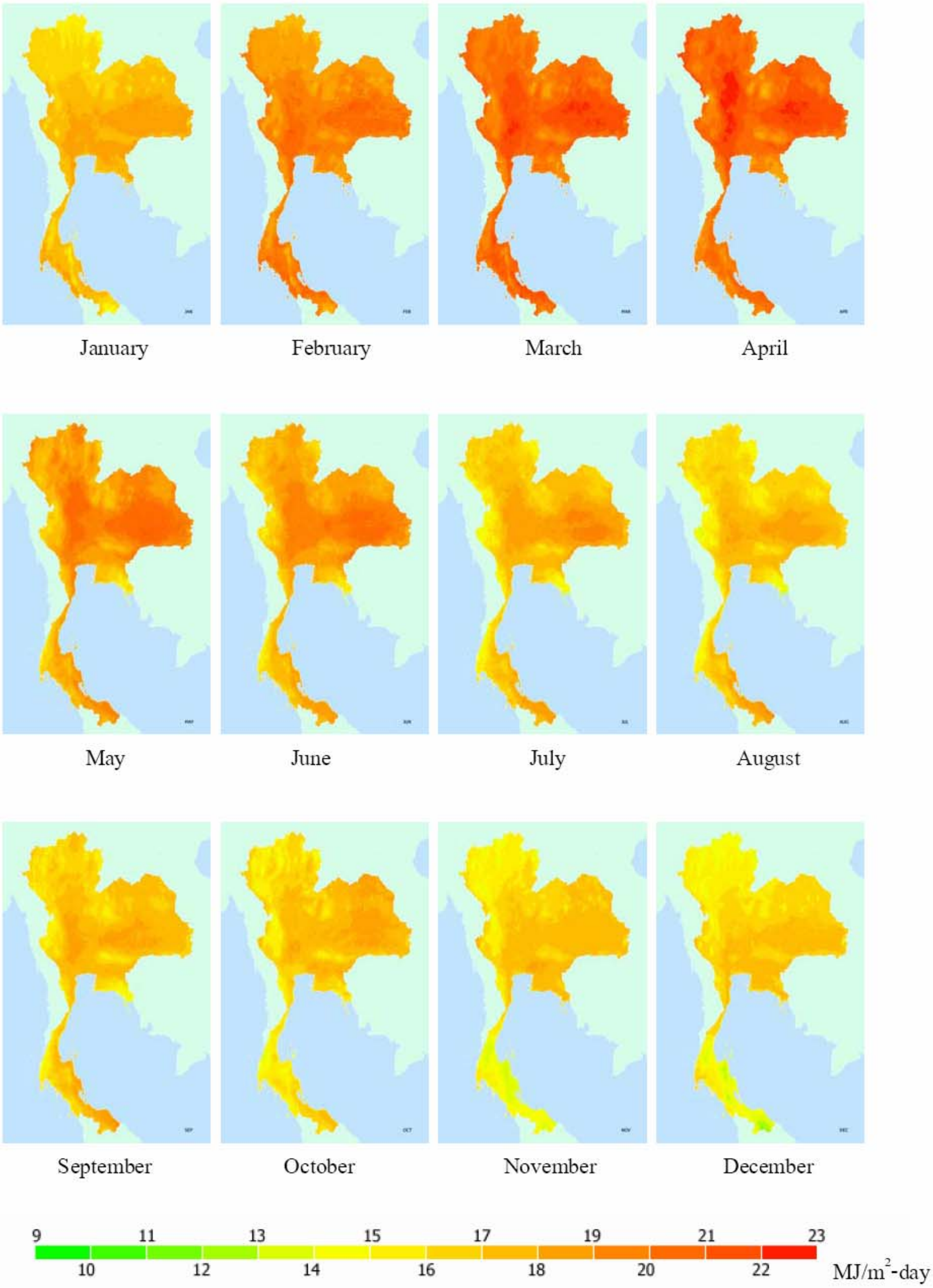
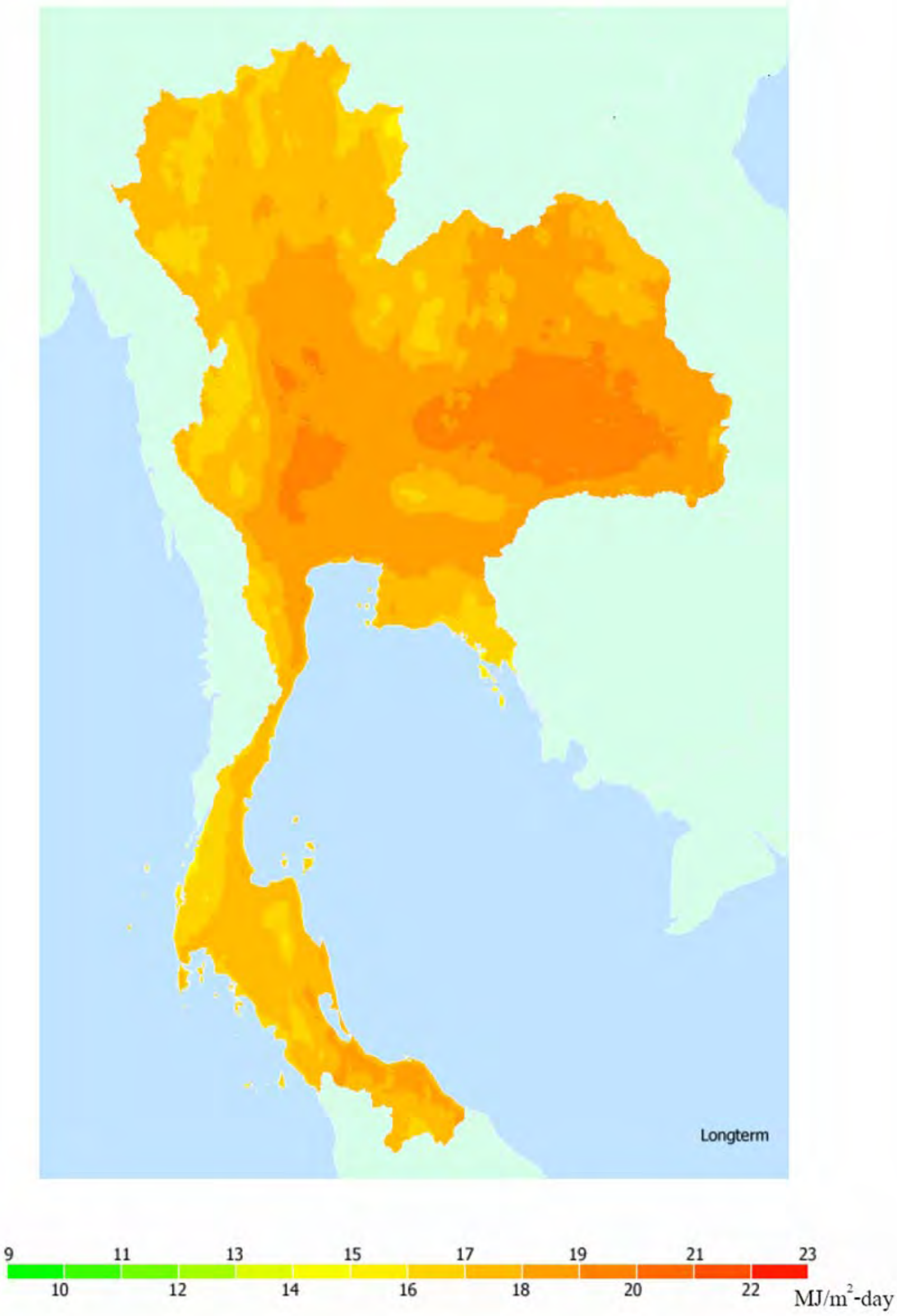


FIGURE 9-2 : Average Annual Solar radiation between Thailand and other countries



รูปที่ 3.71 แผนที่ศักยภาพพลังงานแสงอาทิตย์ของเดือนต่างๆ

FIGURE 9-3 : Solar Radiation Map Average by Month



รูปที่ 3.72 แผนที่ศักยภาพพลังงานแสงอาทิตย์เฉลี่ยตลอดปี

FIGURE 9-4 : Solar Radiation Map Annual Average

For more information, please see the Solar Energy Map Website

http://www2.dede.go.th/dede/renew/sola/map menu.html

Solar Energy Potential in SAMUI Island

SAMUI Island is located in southern part of Thailand, close to the equator line of the earth. The location is the one of the factors making SAMUI Island suitable for solar energy technologies. As Following Table 9-4 presents data collection from Weather forecast station in SAMUI Island, Ma Ret District from 2002 to 2010.

TABLE 9-4 : Solar radiator average per month (unit : MJ/m^2-day) of SAMUI Island Since 2002-2010

MONTH	THE AVERAGE OF SUN RADIATION (MJ/m^2-DAY)								
	2002	2003	2004	2005	2006	2007	2008	2009	2010
JANUARY	-	18.768	17.81	19.489	17.201	15.801	17.652	17.73	17.43
FEBRUARY	20.557	19.846	19.96	22.438	-	22.199	17.81	21.25	22.19
MARCH	22.06	21.106	21.932	22.505	22.27	21.805	21.754	22.682	21.61
APRIL	22.043	24.925	22.4	23.038	22.042	22.291	21.169	20.076	24.16
MAY	-	17.809	19.442	20.451	17.401	-	19.189	17.177	21.67
JUNE	-	19.599	18.521	18.329	19.314	-	18.209	21.416	18.81
JULY	20.207	18.406	17.116	16.863	18.219	-	18.551	16.875	17.48
AUGUST	17.378	20.545	17.719	19.586	18.217	-	20.66	19.188	18.5
SEPTEMBER	19.46	16.671	18.872	18.758	17.782	18.434	17.855	17.011	18.6
OCTOBER	18.572	19.298	16.996	15.366	17.359	13.081	16.152	18.1554	15.15
NOVEMBER	14.107	17.373	15.195	13.499	16.475	14.001	13.082	16.259	12.02
DECEMBER	14.506	15.077	17.144	10.465	15.498	16.877	15.219	16.297	14.03

FIGURE 9-5 : Solar Radiation Graph Annual Average between 2008-2010

The above data indicates that SAMUI Island has a very high potential for solar energy. Solar energy would be another way of clean energy that helps SAMUI Island to reduce carbon emissions.

Solar energy applications for SAMUI Island

Solar Farm : Connect to the Grid

Solar farm or Photovoltaic power station is a large-scale photovoltaic system designed to generate electric power from solar radiation. This system is including

1. Solar Module
2. Inverter Converter
3. System controller and Data Acquisition
4. Distribution system

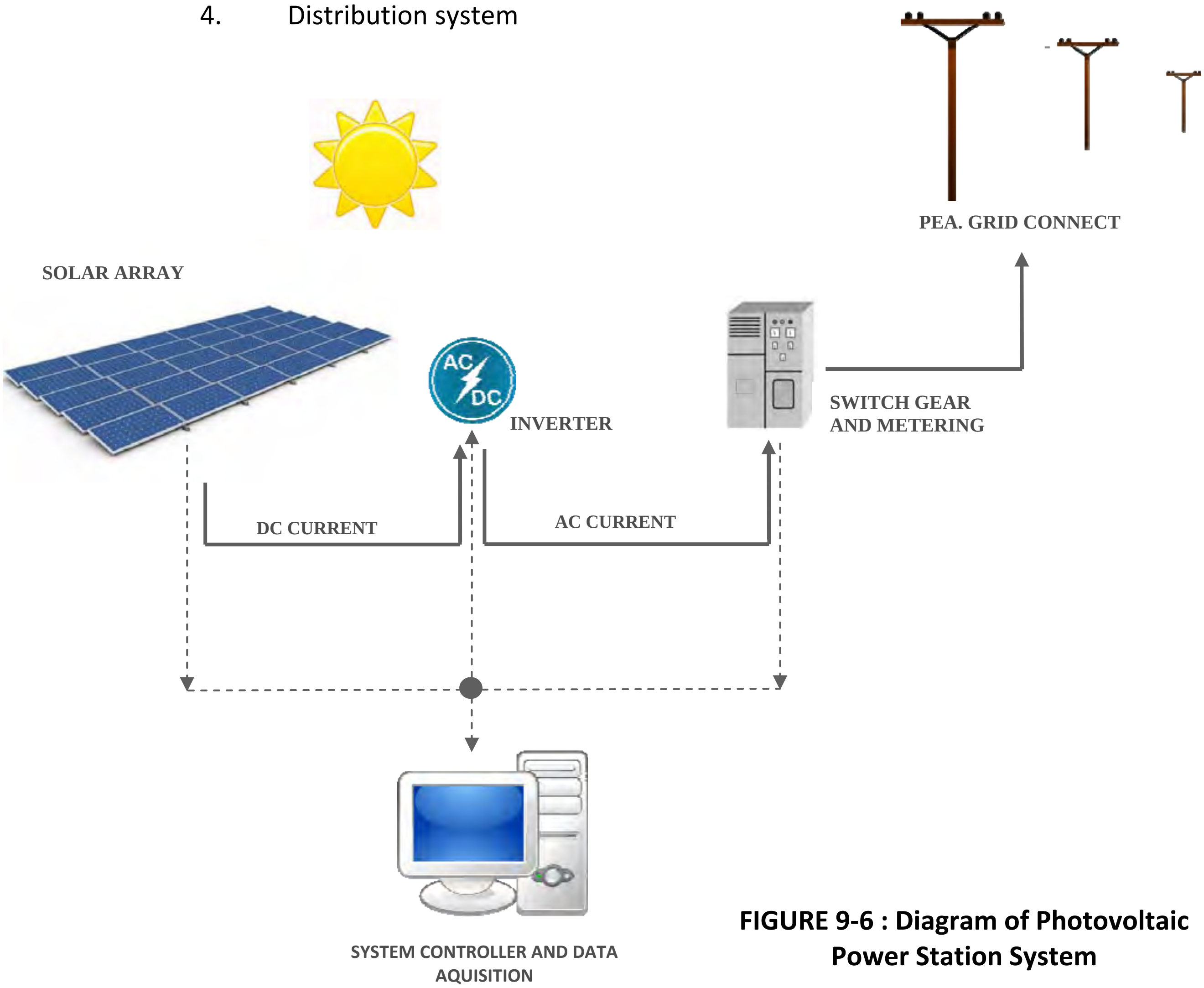


FIGURE 9-6 : Diagram of Photovoltaic Power Station System

Utilization of solar energy through the implementation of Solar PV farm is recommended for SAMUI Island. If consider the map of SAMUI Island, Taling Ngam would be the suitable place to install the Solar PV farm. A unit of Solar PV farm with 1 MW generating capapity requires 8,000 m² for solar panel installation and another 8,000 m² as spacing between panel. Thus, the total space of 16,000 m² will be required for 1 MW of solar PV farm. 35 MW of solar PV farm is recommended for SAMUI Island which will require total of 560,000 m² for installation of PV Plant. In general for Thailand, solar PV operating time is approximately 3-5 hours per day with average of 30% operating factor. According to these general operating conditions, 35 MW Solar PV farm will generate electrical energy at approximately of 52,500 kWh per day supply to the grid.

FIGURE 9-7 : Proposed area that possible to install Photovoltaic Power Station

FIGURE 9-8 : A picture of Solar Farm

Source: http://www.thaisolarfuture.com/product.php?id=12

No.	Location	Company	Module/Installation type	Capacity (MWp)	Electricity Generation (kWh/Year)	COD
1	Mae Hong Son	EGAT	Poly c-Si/ Fixed	0.504	618,000	9 Apr 2004
2	Chachoengsao	BSP	Thin film a-Si/ Fixed	1.495	2,168,000	5 Oct 2007
3	Udonthani	BSP	Thin film a-Si/ Fixed	0.282	443,000	1 Jul 2008
4	Petchaburi	BSP	Thin film a-Si/ Fixed	2.144	3,268,000	10 Feb 2009
5	Angthong	BSP	Thin film a-Si/ Fixed	1.136	1,799,000	11 Feb 2009
6	Udonthani	BSP	Thin film a-Si/ Fixed	1.563	2,451,000	2 Apr 2009
7	Nakhon Sawan	BSP	Thin film a-Si/ Fixed	0.547	865,000	1 Nov 2009
8	Nakhon Ratchasima	Solar Power	Poly c-Si/Fixed	5.940	-	30 Apr 2010
9	Lopburi	BSP	Thin film a-Si/ Fixed	2.225	3,525,000	25 May 2010
10	Ubonrachathani	EGAT	Poly c-Si/Tracking and Fixed	0.891	1,760,000	30 Dec 2010
			Thin film a-Si/Tracking and Fixed	0.121		
11	Nakhon Ratchasima	BSP	Thin film a-Si/ Fixed	1.114	1,741,000	1 Jan 2011
12	Prajuabkirikan	BSP	Thin film a-Si/ Fixed	1.949	2,972,000	1 Feb 2011
13	Sakonnakhon	Solar Power	Poly c-Si/Fixed	5.94	-	1 Feb 2011
14	Nakhon Phanom	Solar Power	Poly c-Si/Fixed	5.94	-	22 Apr 2011
15*	Ayutthaya	Bangchak	Poly c-Si/Fixed	30+8	51,831,000 + 14,408,000	Jun 2012 Mar 2012
16*	Lopburi	NED	Thin film a-Si/Fixed	73 (7 phases)	120,000,000	Phase I 22 Dec 2011

** Projects under construction*

TABLE 9-5 : Solar PV Farm in Thailand

Source: www.dede.go.th/dede/images/stories/pdf/t_**pv**_11.pdf

Solar PV rooftop

Solar PV rooftop would also be recommended to install on rooftop of houses, parking areas, gas stations, etc. Approximately of 1.3 kW (10 m^2) is recommended as a typical unit for solar rooftop installation. If the solar rooftop scheme is successfully implemented for every potential households and commercial buildings on SAMUI Island, approximately of 50 MW electricity generating capacity will be achieved. These solar PV rooftops would be able to produce electrical energy of approximately 75,000 kWh per day supply to the grid. (Calculation based on 5 operating hours per day with average of 30% operating factor)

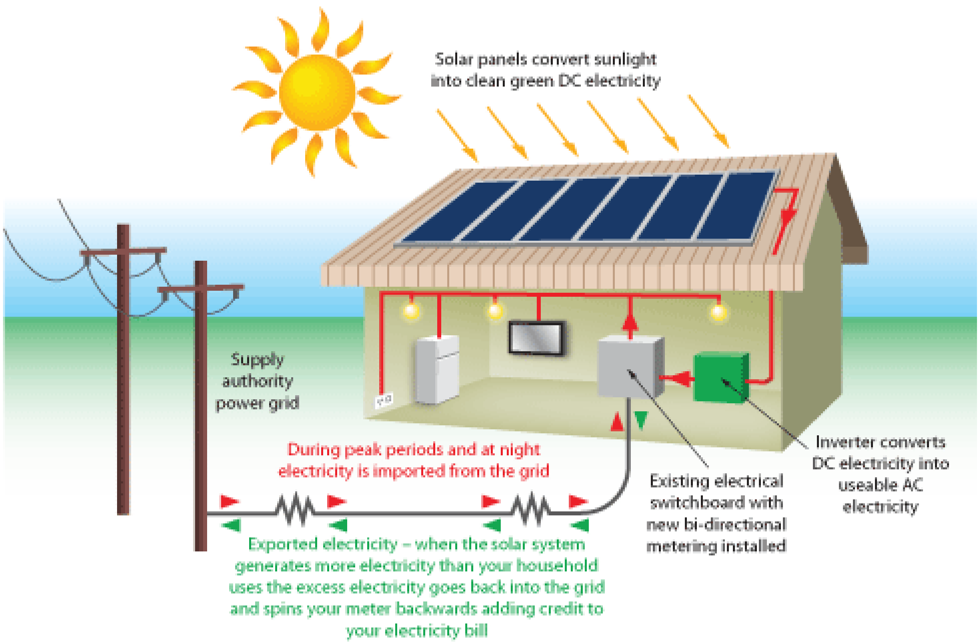


FIGURE 9-9 : Solar PV roof top connect to grid

FIGURE 9-10 : Solar PV roof top for Car Park **FIGURE 9-11 : Solar PV roof top for convenient store**

Source: http://taspower.com/services

Solar Street Lighting

Solar energy could also be implemented for street lighting system through Solar PV Street lighting pole with LED as light bulb. Battery with at least 1 day supply capacity will be required for each solar street lighting pole as backup power for the cloudy period. Solar street lighting is recommended for every street on SAMUI Island, however, as an initial stage the implementation should be located on the most density area of SAMUI Island which is Chaweng and also should be implemented on the main ring road (No.4169). The total of 4.7 km of Chaweng area and 50 km of ring road (No.4169) are recommended to utilize 130 W LED solar street lighting poles.

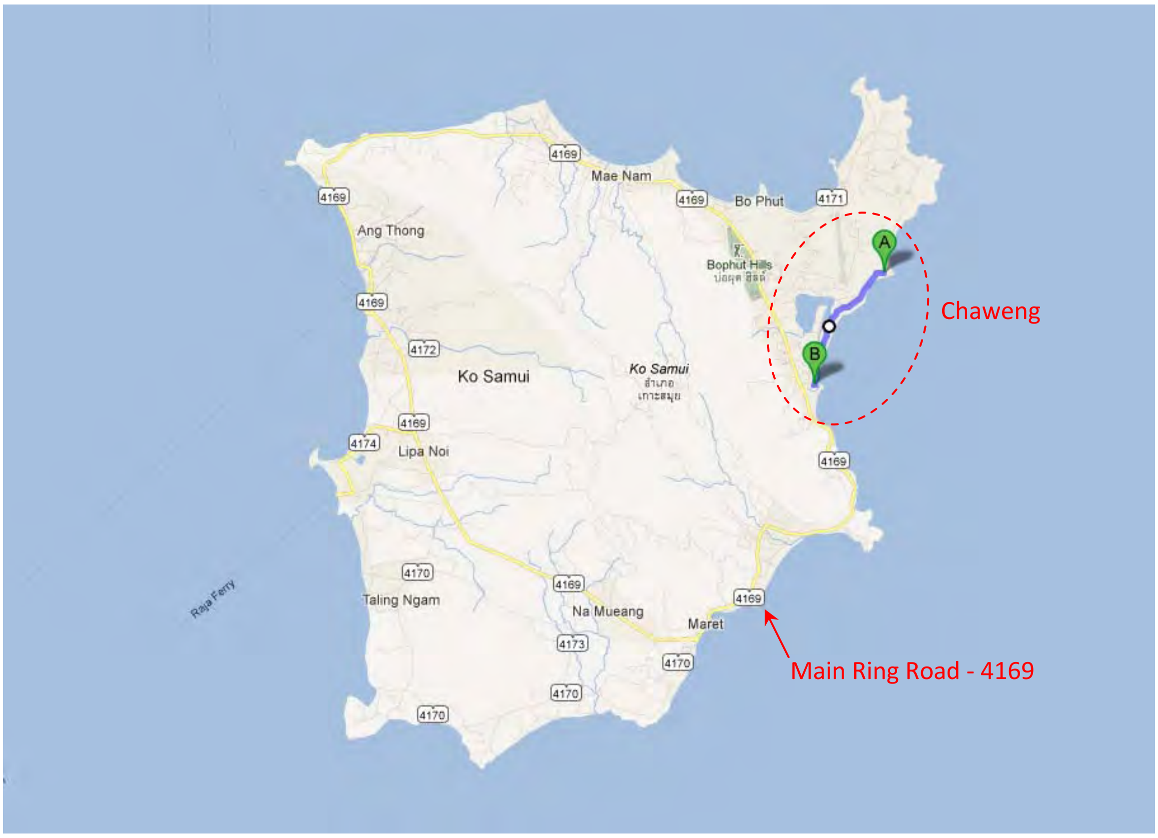


FIGURE 9-12 : Solar System for Street lighting at Chaweng and Main Ring Road No. 4169

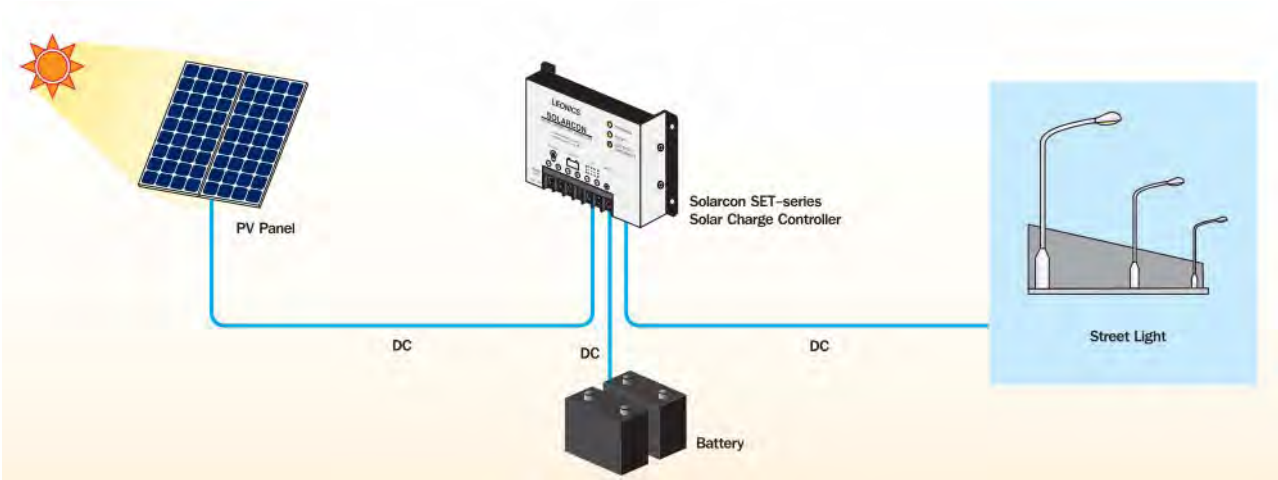


FIGURE 9-13 : Diagram for stand alone solar street light

Source: http://www.leonics.co.th/html/th/index.php

9.1.2 Wind Energy

Introduction

Wind energy production applies a technology which converts kinetic energy from wind to electrical energy. The technology consists of generating electricity by means of a wind mill which moves a turbine. A large wind farm may consist of several hundred individual wind turbines which are connected to the electric power transmission network.

Wind energy, comparing to fossil fuels, is plentiful, renewable and clean. It does not produce greenhouse gas emissions during operation and requires only little land. Wind power can be an excellent complement to a solar power system. When the sun isn't shining, the wind is usually blowing. Wind power is especially helpful in the winter to capture both the ferocious and gentle mountain winds during the times of least sunlight and highest power use. In most locations wind is not suitable as the only source of power due to instability of the wind conditions and availability. Hence, the wind energy is recommended to be integrated with other renewable energy systems such as solar energy.

Wind Energy Potential in Thailand

Thailand wind mainly occurs by the monsoon, i.e. the Southwest Monsoon in the rainy season, at the beginning of May, June, July, August and September up to the beginning of October the Northeast Monsoon in the cool season (winter) at the end of October, November, December, January up to the end of February and during March and April as transitional period.

Wind Energy Potential in SAMUI Island

The data from department of alternative energy development and efficiency ministry of energy (DEDE) indicates that SAMUI Island has wind potential at the top of mountains. SAMUI Island has WIND POWER CLASS 1.2 which average wind speed per year ~ 3.6 - 4.4 m/s but at the top of mountains have WIND POWER CLASS 3 or average wind speed per year up to 7.0 m/s

TABLE 9-6 : Average of Wind Speed per month (unit : m/s) , SAMUI Island between 2002-2009

MONTH	THE AVERAGE OF WIND SPEED (m/s)							
	2002	2003	2004	2005	2006	2007	2008	2009
JANUARY	-	4.03	4.17	4.63	3.14	-	-	4.15
FEBRUARY	-	3.97	3.65	3.62	3.74	-	-	2.85
MARCH	-	3.61	3.36	4.13	3.22	-	-	2.65
APRIL	-	2.75	2.63	3.28	2.34	-	-	2.84
MAY	-	3.29	2.99	2.89	-	-	3.04	2.82
JUNE	3.05	2.77	3.67	3.14	-	-	2.94	3.19
JULY	3.65	3.29	3.27	3.64	-	-	2.67	-
AUGUST	3.86	3.72	3.33	3.44	-	-	2.88	-
SEPTEMBER	3.9	3.16	2.36	3.28	-	-	3.85	-
OCTOBER	2.42	2.4	3.85	2.63	-	-	-	3.81
NOVEMBER	-	3.02	3.59	3.25	-	-	-	3.78
DECEMBER	3.87	4.99	4.04	3.75	-	-	-	4.75

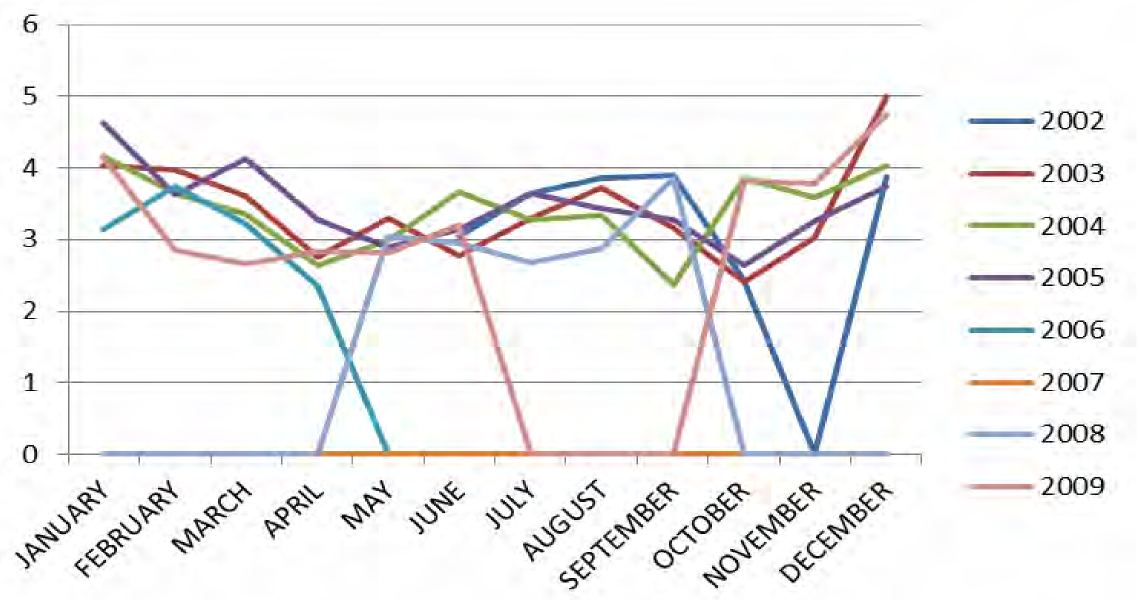


FIGURE 9-14 : Annual Average of Wind Speed per month (unit: m/s), SAMUI Island between 2002-2009

Wind energy applications for SAMUI Island

The statistic of wind energy for SAMUI indicates that average wind speed on SAMUI Island is not attractive for Installation of large size or large amount of wind turbines. However, there are some potential to install wind turbines along the coastal area of Ang Thong Road, 600 m road distance, with 20 turbines, 12 kW maximum generating capacity each. Total installed capacity is 0.240 MW.

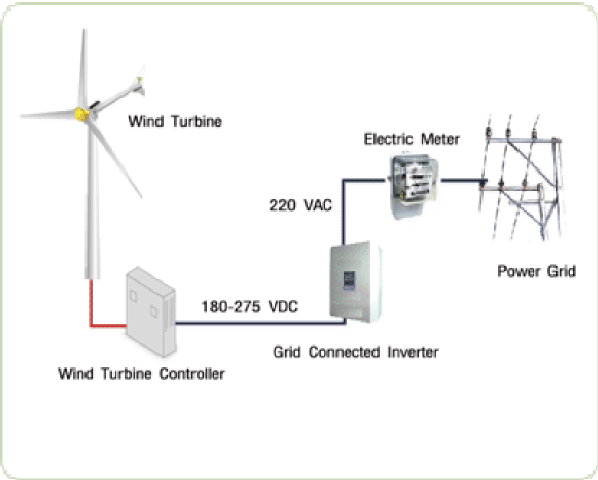


FIGURE 9-15 : Diagram for Wind turbine Grid connect

Source: http://www.prapai.co.th/

FIGURE 9-16 : Propose area for Installation of Wind turbines

Source: http://www.i-phuket.com/th/accom2.php?p=4

9.1.3 Small Hydroelectric Power Plants

Introduction

Hydroelectric power plants are the system for converting kinetic energy of water to electrical energy. Water is retained for power accumulation by constructing the dam or weir to close the water stream with height level as a potential energy and then the water flows through a pipe or penstock into water turbine or water wheel to drive the hydroelectric power generator. There are many ideas to harness the power of water. Most of them rely on the rapidly flowing water, carrying great deal of mechanical energy. The generating capacity of small hydroelectric power plants is from a few hundred kilowatts to tens of megawatts.

FIGURE 9-17 : Hin Lad Waterfall on SAMUI Island

FIGURE 9-18 : Water wheel of small hydroelectric power plants

Website: http://www.alternati ve-energy-concepts.com/hydroelectric-energy.html

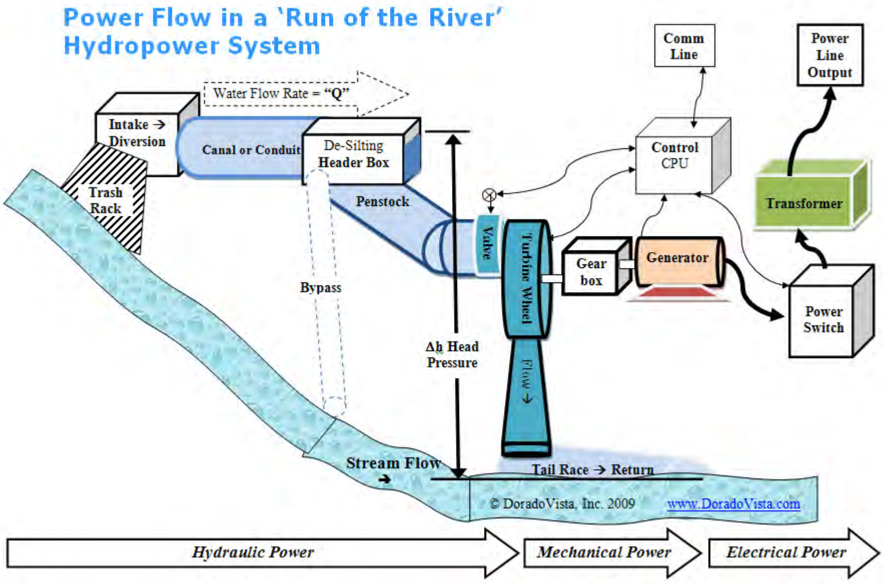


FIGURE 9-19 : Small hydroelectric power plants

Website: http://smallhydro.com/small-micro-hydro-info/

Small hydroelectric plants can be connected to conventional electrical distribution networks as a source of low-cost renewable energy. Alternatively, small hydro projects can be built in areas that are remote from national electrical distribution network. Since small hydroelectric power plants do not have elaborate civil construction works, they have a relatively low environmental impact compared to large hydroelectric plants.

<u>Components of small hydroelectric power plant</u>

The typical components of small hydroelectric power plant are illustrated in Figure 9-23.

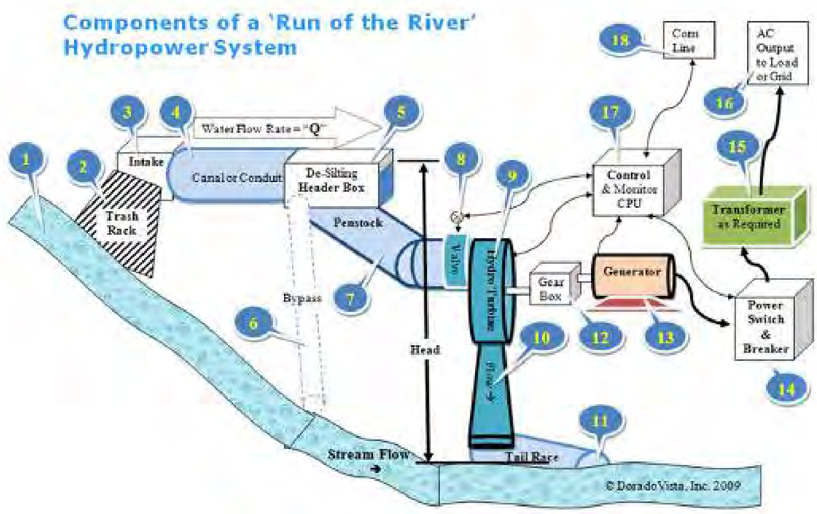


FIGURE 9-20 : Components of small hydroelectric power plant

Website: http://smallhydro.com/small-micro-hydro-info/components-of-a-small-hydropower-system/

No. 1 **Stream flowing** past intake and outlet points with sufficient flow and head to be worth hydroelectric development

No. 2 **Trash rack** or intake screen (Coanda wedge wire or bars with cleaner)

No. 3 **Intake water diversion** structure, diversion gate valve and settling basin.

No. 4 **Diversion channel**, canal, ditch or pipe at atmospheric pressure. Water flows at rate 'Q' from here to tail water

No. 5 **De-silting header box** for flow regulation into penstock where pressure builds and any water hammer can vent.

No. 6 **Bypass conduit** to allow system to clean out silt buildup and vent any excess flow.

No. 7 **Penstock**, main pressure building conduit. Must use care if head is large, 130 psi or greater. High head pressure can be dangerous.

No.8 **Inlet regulation valve** for turbine. This is the throttle for controlling power and system shutdown.

This valve regulates power into turbine to balance output from generator. Note: Turbine rpm will give right generator frequency.

No. 9 **Hydro Turbine** or Wheel depending on type of system chosen (Impulse or Reaction)

No. 10 **Draft tube** used in reaction turbine or simple atmospheric tailrace chamber

No. 11 **Tailrace**, channel for slowing and redirecting water back into stream

No. 12 **Gear Box** or Belt Drive to provide most efficient range of Turbine operation and maintain generator output at correct frequency.

No. 13 **Generator**, most common types used are either synchronous or induction depending on power application

No. 14 **Power Switch & Breaker**, Safety device to disconnect power

No. 15 **Transformer**, AC conversion of generator output voltage to transmission line or use voltage.

No. 16 **AC Output to Load or Grid,** Transmission line to point of use, voltage and current define loss based on wire gauge and distance.

No. 17 **Control and Monitor CPU**, This unit maintains power in to turbine (flow) in balance with generator power (load) and safety monitor and override controls.

No. 18 **Communication Line**, Connection to outside computer link via Web, RF, Phone or other connection. Allows remote monitor and control of complete system parameters.

From the major characteristic of water resources in Thailand, low head turbine and free flow turbine are the suitable types of small hydroelectric power plant for using in local location. Turbine for low water head up to 20 meters generally is propeller. There are several turbine forms and typical of installation for each location. The size of turbine and installation are depend on water head and required power. The selection of the turbine types will be varied depend on the location condition. The table below shows the details of each type of turbines.

TABLE 9-7 : Details of each type of turbine

Location	Type of Turbine	Head/Flow	Size	Power	Typical detail
1. Water resource with low head (Waterfall, site with weir or dam, etc.)	Bulb turbine	Head 2-18 m	Runner Diameter 0.8-0.5 m	50kW-30MW	Shaft is in horizontal or inclined 15°- 45°, use a speed-increasing gearbox, enable to install generator in horizontal or vertical
	Straflo turbine	- (No data)	- (Recommended by manufacturer)	- (No data)	Axial turbine, generator is out of inflow intake and install around turbine blades by seal lips
	The pit turbine	Head 1.5-10 m	Runner Diameter 0.4-0.5 m	50kW-8MW	A type of the bulb turbine, use generator with a speed-increasing gearbox at inflow intake
	Inclined axis axial flow turbine	Head 2-35 m Flow 3-100 m3/s	- (Recommended by manufacturer)	- (No data)	Inflow intake is inclined, outlet is inclined 45°, can use generator with or without a speed-increasing gearbox, installation and maintenance of large turbine is delicate due to shaft is inclined, so this type is suitable for not quite large system

TABLE 9-7 : Details of each type of turbine

Location	Type of Turbine	Head/Flow	Size	Power	Typical detail
	Horizontal axis S type turbine	Head 5-25 m	- (Recommended by manufacturer)	8 MW	Shaft reach out into downstream, connect the generator with or without a speed-increasing gearbox by joint at the end of shaft
	Vertical axis small Kaplan turbine with elbow draft tube	Head 2-12 m Flow 6-60 m3/s	- (Recommended by manufacturer)	- (No data)	Similar to a large Kaplan, use semi-spiral concrete casing, use generator with or without a speed-increasing gearbox, turbine installation is delicate
	Vertical axis saxo turbine	Head 10-15 m	- (Recommended by manufacturer)	12 MW	Turbine is installed upper outlet, easy to install, many suppliers have large turbine size reach to 1.8 meters diameter
2. Water resource with free flow (Canal and Stream)	Gorlov-turbine	Flow velocity 1.5 m/s	Diameter 1.5 m Length 2.5 m	1.5 kW	Suitable for free flow water resource, with 3 twist airfoils, 33% efficiency, enable to install in horizontal and vertical.

TABLE 9-7 : Details of each type of turbine

Location	Type of Turbine	Head/Flow	Size	Power	Typical detail
	Davis-Turbine	- (No data)	- (Recommended by manufacturer)	- (No data)	The principle is similar to Darrieus wind wheel, vertical axial shaft, with 4 airfoils, there are several forms, 30% efficiency
	Underwater Electric Kite (UEK)	- (No data)	- (Recommended by manufacturer)	- (No data)	Horizontal axial turbine with casing for turbine protection and flow adjustment that help to increase efficiency reach to 57%
	Kinetic hydro power	- (No data)	- (Recommended by manufacturer)	- (No data)	Similar to horizontal axial wind wheel, with 3 airfoils, high efficiency

In case of water resource is quite small, unable to provide large power or the power requirement is not much, the micro hydroelectric power plant is used instead. The principle of micro hydroelectric power plant to provide electricity is same as small hydroelectric power plant. The equipment of micro hydroelectric power plant is smaller than small hydroelectric power plant. It can provide power up to 200 kW. There are several packages of micro hydroelectric power plant for proper use in each location. The examples of installation are in pictures below.

FIGURE 9-21 : Water wheel for micro hydroelectricity power plant

Website: http://www.otherpower.com/otherpower_hydro.html

FIGURE 9-22 : Inflow side of wheel

Website: http://www.builditsolar.com/Projects/Hydro/UnderShot/WaterWheel.htm

FIGURE 9-23 : Channel for water flow to the turbines

Website: http://whatwow.org/microhydropower-for-collective-housing/11kW-micro-hydro-power-oromis-cambodia-jpg/

FIGURE 9-24 : Turbine for location with free flow

Website: http://www.smart-hydro.de/en/news/2011/details-2011/article/smart-hydro-power-stellt-im-rahmen-eines-internationalen-kolloquiums-zu-dezentraler-energieerzeugung.html

Potential of Small Hydroelectric power plants on SAMUI Island

There are a number of surface water resources in SAMUI Island. This indicates that there are possibilities to construct small hydroelectric power plants along the river or canal distributed across the island. Cascade installation of multi type small hydroelectric power is recommended to be applied around the reservoir pond, river and canal. Specific locations where appropriate, will also be identified to install small hydroelectric power. Lamai area is one of the most appropriate locations to develop a small hydroelectric power plant as there are potential canals flowing through the area. Moreover, Hin Lad waterfall is another appropriate location. Electricity from small hydroelectric power plants is capable to use for many activities in the area, such as street lighting, car park lighting, and lighting in household.

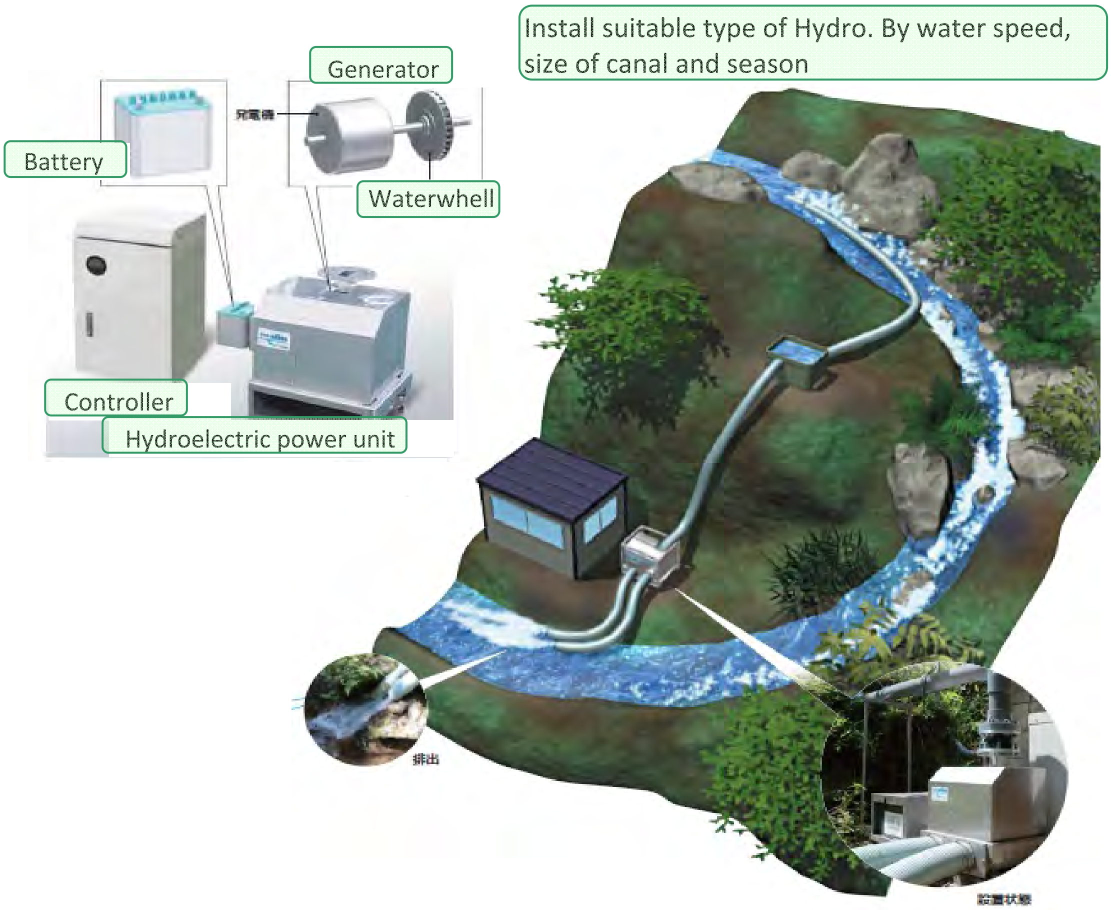


FIGURE 9-25 : Cascade installation of multi type small hydroelectric power

(One horizontal axis cross flow turbine)

Website:**http://www.sinfo-t.jp/litter/Defalt.htm**

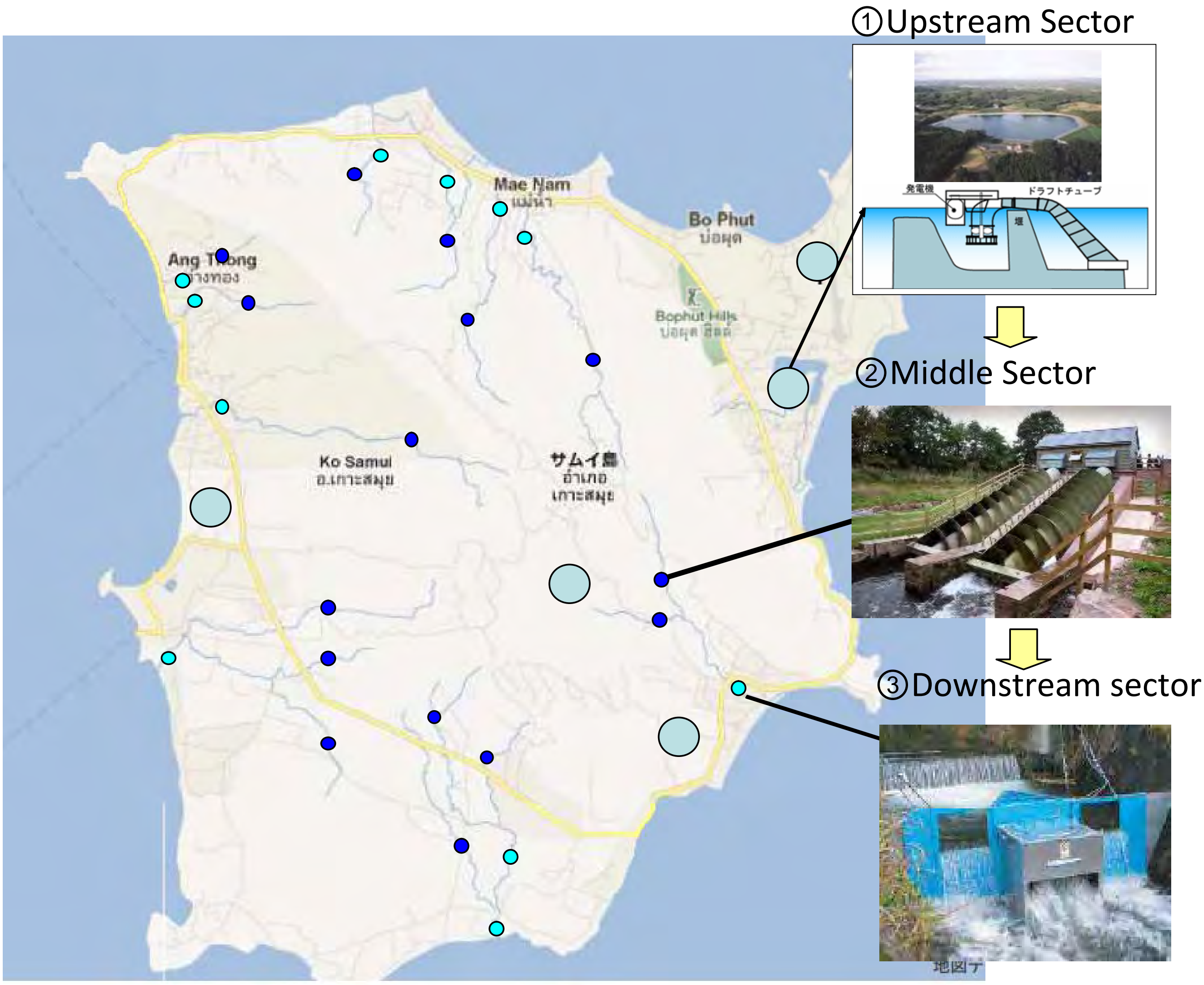


FIGURE 9-26 : Ccombinations of different types of small and micro hydroelectric power .

<u>Application of cascade installation of multi type small hydroelectric power</u>

Generally, designing reservoir pond and river with using both existing natural stream and additional artificial one will be also expected to present new type waterside scenery in SAMUI. By combining different types of hydroelectric power, the amount of power generation can be expected throughout the island about 0.69 MW.

The multi type small hydroelectric power is classified into three sectors namely, upstream, middle and downstream sectors. Potentials to install small hydroelectric power for each sector are as followings;

1) Upstream Sector:

Location	**:**	Reservoir Pond
Type of Turbine	:	Siphon turbine type
Size	:	Recommended by manufacturer
Power	:	**20kW/unit×5units = 100 kW**
Cost Investment	:	10 Million Baht

Appropriate rain water storage could be specified in order to generate electricity not only in rainy season but also in dry season

2) Middle Sector:

Location	**:**	Cannel
Type of Turbine	:	Screw turbine type
Size	:	Recommended by manufacturer
Power	:	**32kW/unit×15units = 480kW**
Cost Investment	:	48 Million Baht

High efficiency is expected at a small head of water (2-3m), even in dry season if water flow is ensured.

3) Downstream sector:

Type of Turbine	:	Vertical Axial flow type
Size	:	Recommended by manufacturer
Power	:	**10kW×11units = 110kW**
Cost Investment	:	11 Million Baht

Expected maximum efficiency in rainy season and ensure enough power generation when small water flow in dry season

Total amount of power generation: around 0.69 MW (Peak level)

Specific Application for small hydroelectric power on SAMUI Island

Apart from the application of the cascade multi type small hydroelectric power, this small hydroelectric power plant can also be installed in specific locations where there are appropriate conditions to produce electricity. Two specific locations on SAMUI Island have been identified to apply small hydroelectric power technology, Hid Lad Waterfall and Lamai area. At Hin lad Waterfall, The electricity obtained will be used around the office of Provincial Waterworks Authority such as lighting at car park, street lighting etc.

FIGURE 9-27 : Specific location for Small Hydroelectric Power plant

FIGURE 9-28 : Provincial Waterworks Authority of SAMUI Island.

At Lamai area, small hydroelectric power plant will be installed to produce electricity from the treated water that discharge from the waste water treatment plant to the new recycle water plant. The electricity obtained will be used at the new recycle water treatment plant

Type of Turbine	:	Gorlov-turbine
Flow velocity	:	1.5 m/s
Size	:	Diameter 1.5 m, Length 2.5 m.
Power	:	55 kW
Cost investment	:	5.5 Million baht

TABLE 9-8 : Conclusion of Electricity Power Generation from Renewable Energy Sources for SAMUI Island

Renewable Power Type	Installed Capacity	Energy per day	Estimated Investment (Million Baht-MB)	Input	Area required	Note
Solar PV Farm	35 MW	52.5 MWh	3,500 MB (112.9 MUSD)	Sunlight	280,000 m^2 for solar PV panel and 280,000 m^2 for space between panel	Operating factor=0.3, and 5 Operating hours per day
Solar PV Rooftop	50 MW	75 MWh	9,212.5 MB (297.1 MUSD)	Sunlight	385,000 m^2 for Solar PV 38,500 sites (10 m2/site)	Operating factor=0.3, and 5 Operating hours per day
Solar Street Light	0.676 MW	3.38 MWh	208 MB (6.7 MUSD)	Sunlight	78 km	Located on Chaweng Walking Street and along main ring road 4169
Wind Turbine	0.24 MW		50 MB (1.6 MUSD)	Wind	0.6 km	Located along Nathon Beach
Small Hydropower	0.75 MW		75 MB (2.4 MUSD)	Water	Depend on location	
TOTAL	**86.67 MW**	**130.88 MWh**	**13,045.5 MB (420.8 MUSD)**			

* Above Prices exclude installation, transportation and land cost

10. Untapped Energy Use Planning

10.1 Overview Untapped Energy Availability

Introduction

Large amount of solid waste has been generated daily on SAMUI Island. The Municipal Solid Waste (MSW) has been burnt using incinerators at the central plant. Large amount of waste heat produced by the incinerators has been rejected to the atmosphere. Heat recovery from the exhaust of the incinerators is recommended to produce electricity to be used in the incinerator plant and nearby areas. Production of electricity from biogas converted from organic waste is also recommended.

The Municipal Solid Waste (MSW) in SAMUI Island contains organic 55% of organic matter, 40% of inorganic matter and 5% other.

Energy recovery from the organic fraction of MSW can be done by various waste processing and treatment technologies. The additional benefits from waste energy recovery are.

1. The total quantity of waste can be reduced by nearly 60% to over 90%, depending upon the waste composition and the adopted technology;
2. Demand for land, which is already scarce in the island, for landfill is reduced;
3. The cost of transportation of waste to far-away landfill sites also can be reduced proportionately; and
4. Net reduction in environmental pollution.

It is, therefore, the energy recovery from wastes be also duly examined.

Basic Techniques of Energy Recovery

Energy can be recovered from the organic fraction of waste (biodegradable as well as non-biodegradable) basically through two methods as follows:

1. **Thermo-chemical conversion**: This process entails thermal de-composition of organic matter to produce either heat energy or fuel oil or gas; and
2. **Bio-chemical conversion**: This process is based on enzymatic decomposition of organic matter by microbial action to produce methane gas or alcohol.

The Thermo-chemical conversion processes are useful for wastes containing high percentage of non-biodegradable organic matter with low moisture content.
The main technological options under this category include Incineration and Pyrolysis and Gasification. The bio-chemical conversion processes, on the other hand, are preferred for wastes having high percentage of biodegradable organic matter and high moisture content, which aids microbial activities. The main technological options under this category are Anaerobic Digestion, also called to as Biomethanation.

10.1.1 Power plant based on thermo-chemical conversion technologies

The **Thermo-chemical conversion** techniques are also many chemical processes as followed:

1. Pyrolysis Process
2. Gasification Process
3. Combustion Process
4. Melting Process

Currently, there are several types of incinerator, not only a single process but also an integrated process, for example combustion technology incinerator, combined technologies between combustion and gasification, etc. It depends on know-how of manufacturer.

However, Gasification technology generate energy from waste is suitable for MSW with amount more than 100 tons/day. Nowadays, this technology is presented in term of commercial technology.

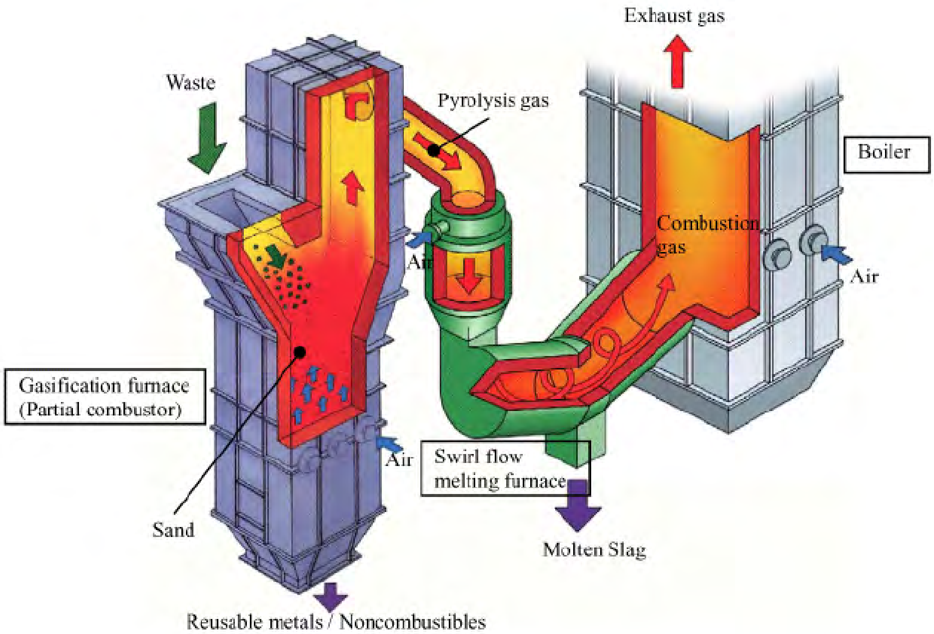


FIGURE 10-1 : Gasification technology incinerator

Unlike incineration, gasification does not produce energy from waste through direct combustion.

Waste, steam, and oxygen are fed into a gasifier where heat and pressure break apart the chemical bonds of the waste to form synthesis gas (syngas). It allows the breakdown of hydrocarbons into the gaseous mixture by carefully controlling the amount of oxygen available.

Syngas may be used directly in internal combustion engines or to make products that substitute for natural gas, chemicals, fertilizers, transportation fuels and hydrogen. Pollutants are removed from syngas before it is combusted, so that it does not produce the high levels of emissions associated with other combustion technologies.

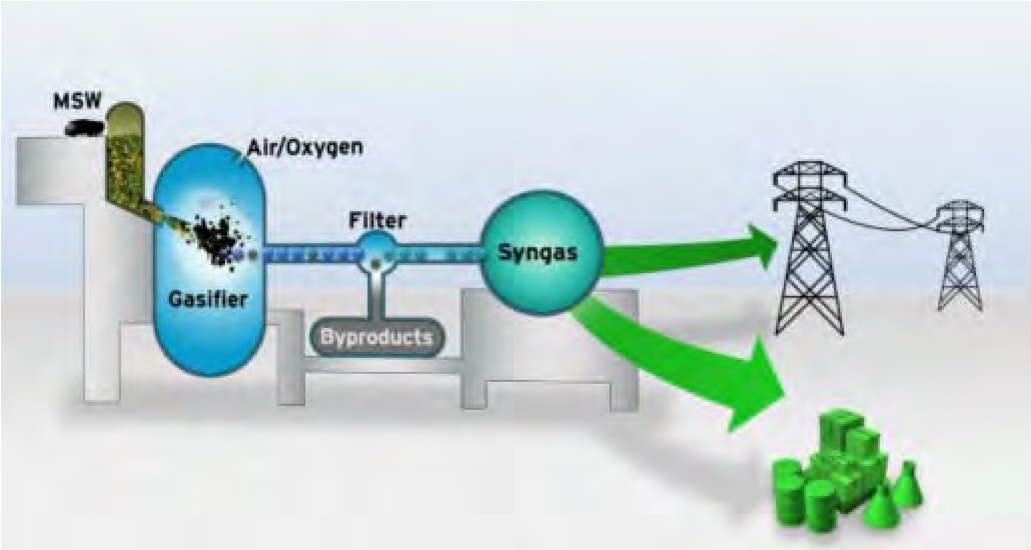


FIGURE 10-2 : Gasification Process

https://www.gasification.org/

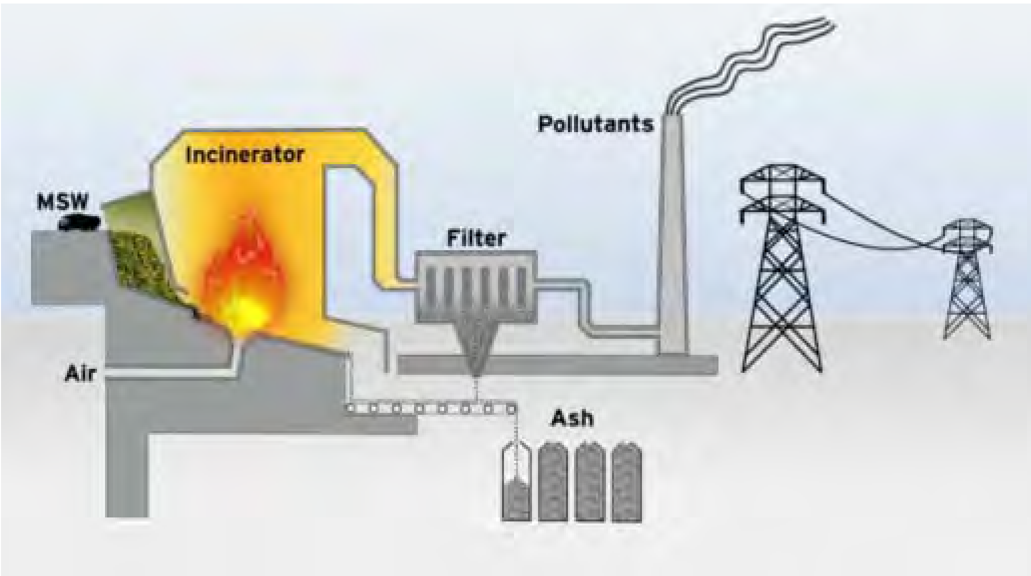


FIGURE 10-3 : The product of Gasification Process

https://www.gasification.org/

10.2 Untapped Energy Use for SAMUI Island

The solid waste quantity in SAMUI Island is growing rapidly. The waste management is required for maintained and improved SAMUI Island environment.

The analysis of waste generated portion is shown in the Figure as below:

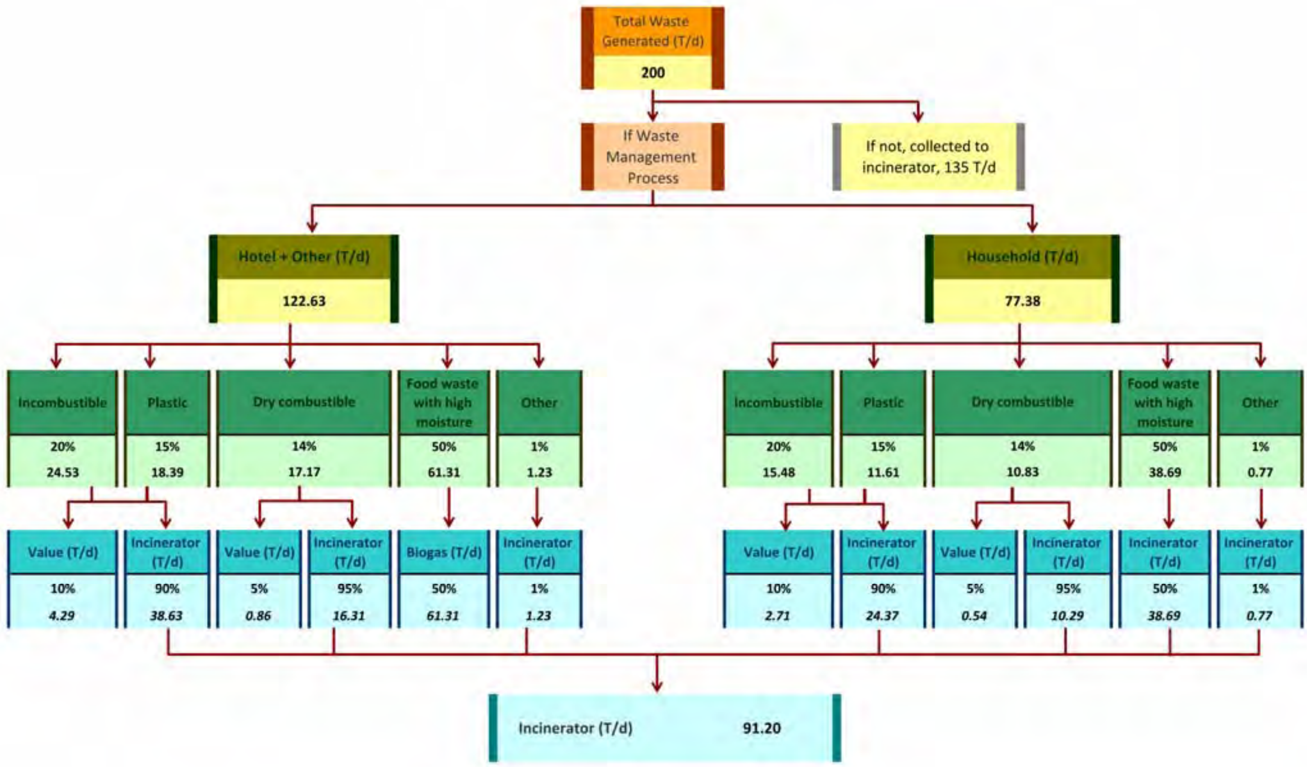


FIGURE 10-4 : The Portion of Waste generated on SAMUI Island

Currently, the solid waste has been collected by Municipality of SAMUI Island approximately 70-80% of the total solid waste generation. The amount of solid waste generated is 200 tons/day and approximately of 135 tons/day has been collected. Two scenarios of untapped energy use planning according to the waste management process are analyzed as followings.

Scenario I : Waste management process at the original site before collection to the incinerator

Scenario II : Collection of all solid waste to the incinerator

10.2.1 Scenario I : Waste Management Process at the original site before collection to the incinerator

The data of Solid Waste Composition in SAMUI Island is shown in Table 10-1.

TABLE 10-1 Solid Waste Composition in SAMUI Island

No.	Description	Percentage
1	Vegetable, wet food and fruit peel	27.35
2	Paper	10.65
3	Plastic	29.36
4	Rubber/ Leather	1.90
5	Textile	4.70
6	Wood/ Grass	5.32
7	Hazardous waste	19.12
8	Other (Glass, Metal, Stone, Ceramic)	1.60
	Total	100

Sources: Incinerator plant of SAMUI Island Municipality, 2010

The amount of waste generated in hotels and resorts on SAMUI Island which has been investigated during data collection process of this study indicates that 50% of total waste is wet waste from kitchen waste and the other 50% is dry waste.

The proper waste management process should be conducted at the original site in order to manage the amount of solid waste sending to incinerator. Solid waste management process could be performed to reduce quantity of solid waste; Recycle, Reduce, Reuse, Repair, and Reject by manual sorting. The kitchen waste of each hotel could be utilized to produce Biogas.

As indicated in Figure 10-4, (The portion of Waste generated on SAMUI Island), the proper waste management process could be able to reduce the amount of solid waste to incinerator from 135 tons/day to be approximately of 91.20 tons/day.

This amount of solid waste has been generated daily on SAMUI Island. The Municipal Solid Waste (MSW) has been burnt using incinerators at the central plant. Large amount of waste heat produced by the incinerators has been rejected to the atmosphere. Heat recovery from the exhaust of the incinerators is recommended to produce electricity to be used in the incinerator plant and nearby areas.

However, the existing incinerator has not been properly operated, currently, after major overhaul the plant is operated at around only 20-30% of its capacity. Therefore, the new incinerator plant of capacity 100 tons/day is recommended. The new plant should consist of two incinerators for reliability of operation.

The new incinerator of 100 tons/day will be able to produce electricity at 1.64 MW as following analysis.

Total waste quantity	=	100	tons
Net Calorific Value	=	1353	kcal/kg
Energy recovery potential	=	157325.58	kWh
Power generation potential	=	6555.23	kW
Conversion Efficient	=	25	%
Net power generation potential	=	1.64	MW

The details of solid waste incinerator power plant with capacity of 200 tons/day are as following:

TABLE 10-2 : Details of solid waste incinerator power plant with capacity of 200 tons/day

	Incinerator quantity 200 tons
Using area	40 rais of land (64,000 m^2) (the site area of existing incinerator plant is 23 rais (36,800 m^2).
Type of Building	- Covering plant height = 25 meters - office - and operational control room
Location	Near or far community as odorless, Smokeless and disturbed noise. There is no pollution problem for environment and community as it is the close plant. The existing site is proper location of incinerator power plant.

	Incinerator quantity 200 tons
Budget, Building, machines and equipment	450 million baht (14.5 million USD)
Implemented duration	Prepare information, construct and install machines, incinerator and machines testing and commissioning, total of 22 months.
Operational Duration	25 years, guarantee period 2 years and service after sales (throughout operational duration), guarantee revenue from electricity distribution.
Working system 4 shifts	Controlled by computer and employ total 8 employees/shift.
Cost/ton	Include water, gasoline and wage cost and others approximately 200-300 baht/ton (6.45 – 9.67 USD/ton)
Results	Waste disposal quantity 200 tons/day, generate electricity 2 MW/hr, combustion remains are soil, rocks which used to fill road and land with no pollution impact
Other income	Administration Organizations can employ staff to burn solid waste such as infected waste from hospitals, or hazardous waste from plants and combustion remains can be sold to local people to invent new products or craftsmanship.

FIGURE 10-5 : Layout of existing incinerator plant

The existing incinerator plant

The New incinerator power plant

http://www.dbdh.dk/artikel.asp?print=yes&id=464&mid=24

http://alexdalavagas.com/2011/05/07/top-ten-reasons-why-denmark-is-a-cleantech-leader

FIGURE 10-6 : The image of proposed New Incinerator Power Plant

10.2.2 Scenario II : Collection of all solid waste to the incinerator

If the waste management process has not been successfully implemented at the original site, the large amount of solid waste will be gathered in collection trucks and in stationary container. The whole solid waste will be sorting at the incinerator plant. The amount of solid waste goes to incinerator is approximately at 135 tons/day. Waste heat recovery from the incinerator to produce electricity supplied to the plant itself and nearby area is recommended. The kitchen waste could also be transformed in biogas plant to produce the electricity.

Electricity Generation from Waste Heat Recovery.

The heat rate of municipal solid waste in SAMUI Island is very low; the electricity can be produced from waste heat that recovery from the process will be at around 3 MW theoretically.

Total waste quantity	=	200	Tons
Net Calorific Value	=	1,353	kcal/kg
Energy recovery potential	=	314,651.16	kWh
Power generation potential	=	13,110.47	kW
Conversion Efficient	=	25	%
Net power generation potential	**=**	**3.28**	**MW**

Reference from: http://urbanindia.nic.in/publicinfo/swm/chap15.pdf

The electricity can be used for street lighting, household etc. in the area nearby the incineration plant.

The details of solid waste incinerator power plant with capacity of 400 tons/day are as following:

TABLE 10-3 : Details of solid waste incinerator power plant with capacity of 400 tons/day

	Incinerator quantity 400 tons
Using area	60 rais of land (96,000 m^2) (the site area of existing incinerator plant is 23 rais (36,800 m^2)
Type of Building	- Covering plant high 25 meters - office - and operational control room
Location	Near or far community as odorless, Smokeless and disturbed noise. There is no pollution problem for environment and community as it is the close plant. The existing site is proper location of incinerator power plant.

	Incinerator quantity 400 tons
Budget, Building, machines and equipment	985 million baht (31.7 million USD)
Implemented duration	Prepare information, construct and install machines, incinerator and machines testing and commissioning , total of 22 months.
Operational Duration	25 years, guarantee period 2 years and service after sales (throughout operational duration), guarantee revenue from electricity distribution.
Working system 4 shifts	Controlled by computer and employ total 8 employees/shift.
Cost/ton	Include water, gasoline and wage cost and others approximately 200-300 baht/ton (6.45-9.67 USD/ton)
Results	Waste disposal quantity 400 tons/day, generate electricity 4 MW/hr. (600,000 baht), combustion remains are soil, rocks which used to fill road and land with no pollution impact
Other income	Administration Organizations can employ staff to burn solid waste such as infected waste from hospitals, or hazardous waste from plants and combustion remains can be sold to local people to invent new products or craftsmanship.

Kitchen waste-based biogas plant

Approximately 30% MSW generated in SAMUI Island is food wastes with high moisture content. Energy content in this waste can be recovered by **Bio-chemical conversion** technique**.**

In this process, the organic fraction of MSW is segregated and fed to a closed container (biogas digester) under anaerobic conditions where the organic wastes are degraded biologically producing methane-rich biogas, effluent and sludge. The biogas production ranges from 50-150 m^3/tons of waste, depending on the waste composition. The biogas can be utilized either for cooking and heating applications, or through dual fuel or gas engines or gas and steam turbines for generating motive power or electricity. The sludge from anaerobic digestion, after stabilization, can be used as a soil conditioner, or even sold as manure depending upon its composition, which is determined mainly by the composition of the input waste.

The estimation of kitchen waste is referring to total quantity of MSW 200 tons per day. The most of food waste quantities come from hotels. The expecting of kitchen waste could be presented from all hotels across the island.

Electricity productions from biogas of kitchen waste are as followings;

Total waste quantity	=	200	tons
Food waste collection from hotels	=	93	%
Food waste composition	=	30	%
Thus, food waste quantity	=	55.8	tons
Total Organic/ Volatile Solid: VS	=	50	%
Organic biodegradable fraction	=	66	%of VS
	=	18.414	tons
Typical digestion efficiency	=	60	%
Typical biogas yield: B	=	0.80	m^3/kg of VS destroyed
	=	8838.72	m^3
Calorific Value of biogas (typical)	=	5000	kcal/ m^3
Energy recovery potential	=	51387.91	kWh
Power generation potential	=	2.14	MW
Typical Conversion Efficiency	=	30	%
Net power generation potential	**=**	**642.35**	**kW**

Reference from: http://urbanindia.nic.in/publicinfo/swm/chap15.pdf

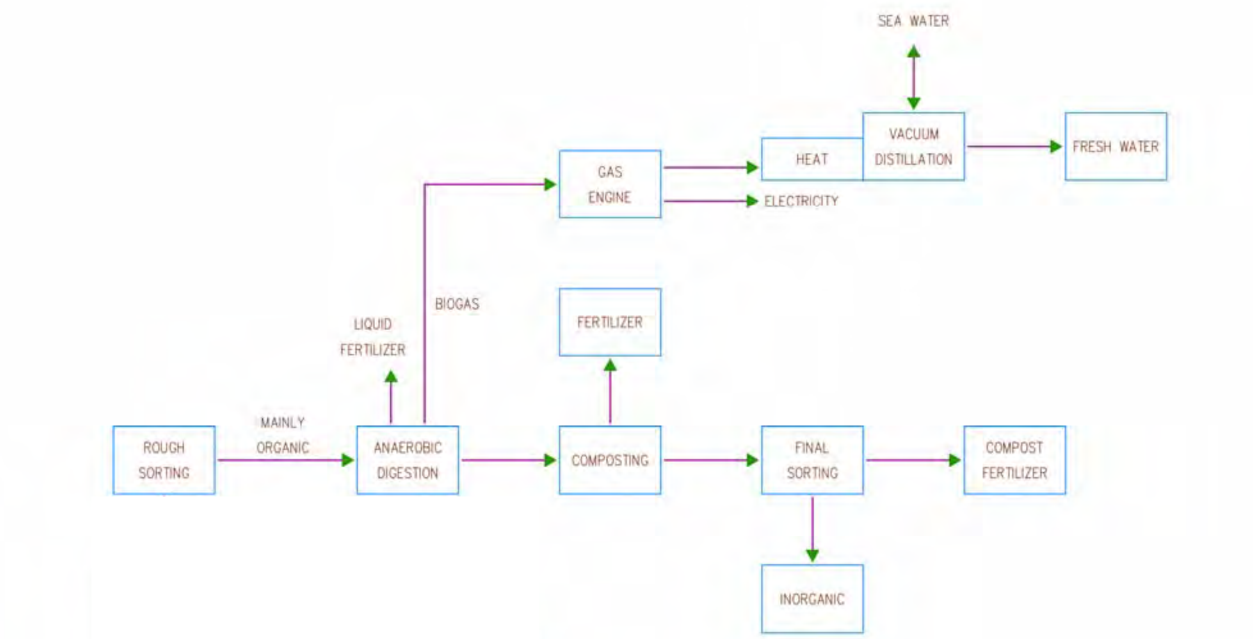


FIGURE 10-7 : The Schematic Diagram of Solid Waste Management

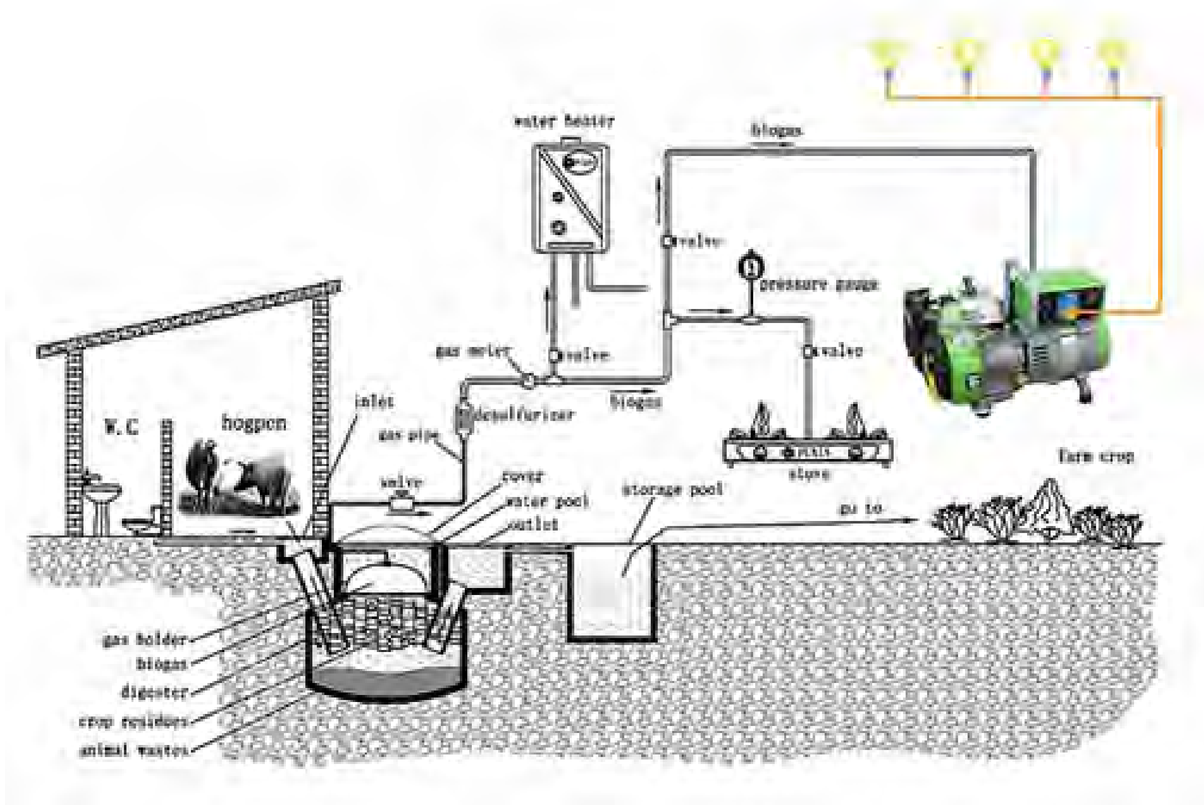


FIGURE 10-8 : Schematic of a biogas plant used for power generation.

Source: www.Greenpower.cn

The biogas plant shall be located in the incineration power plant. The amount of electricity is considerate for the staff housing in the incinerator plant.

Appropriate electric generators are available in virtually all sizes. The technology is well known and maintenance is simple. In most cases, even universally available 3-phase electric motors can be converted into generators.

The estimated price of Biogas Power Plant with capacity of 56 tons/day consists of following:

Waste to Energy			
Required area	=	4	Rai(6,400 m^2)
Investment cost	=	50	MB (1.6 MUSD)
Maintenance + operation	=	4.2	MB (0.1 MUSD)
Energy to Electricity			
Gas generator set	=	10-12	MB (0.32-0.38 MUSD)

Alternatively, biogas and organic fertilizer production centers can be set up for both energy and nutrient recovery from waste at different locations generating incomes and reducing CO_2 emissions. An example of such center is the biogas center at Kasetsart University in Bangkok (Figure 10-9). The center can be in vacant spaces at the fresh markets (Figure 10-10) because fresh market is the center of community and the main source of organic wastes. In addition, SAMUI low carbon center proposed in Chapter 12 and SAMUI municipality may help hotel and resort owners invest together to set up fertilizer and biogas production centers and use the products among themselves because hotels and resorts are also the main source of organic wastes and the main user of fertilizer and biogas.

FIGURE 10-9 : Organic fertilizer and bio-gas production center at Kasetsart University and biogas production machine

FIGURE 10-10 : Vacant spaces to set up biogas production center

TABLE 10-4 : Conclusion of Electrical Power Generation from untapped energy

Power Generation Type	Capacity	Investment	Input	Area required
Untapped Energy				
Scenario 1 : Waste management Process at the original site before collection to incinerator	1.64 MW	450 MB (14.5 MUSD)	Solid Waste 100 ton/day	27,200 m^2 (17 rais)
Scenario 2 : - Collection of all solid waste to incinerator Plant	3.28 MW	985 MB (31.7 MUSD)	Solid Waste 200 ton/day	59,200 m^2 (37 rais)
: - Kitchen waste Sorting	0.64 MW	50 MB (1.6 MUSD)	Kitchen Waste 56 ton/day	6,400 m^2 (4 rais)

11. Low Carbon Building

According to the information from The Ministry of Energy, Thailand as shown in Figure 11-1; the major electricity user on SAMUI Island is commercial building sector. Commercial building including hotels, resorts, department stores or superstores and convenient stores consume electricity for more than 70 % of total electricity consumption on SAMUI Island. Low carbon building measures are recommended for this group of electricity users. Low carbon building guideline or programme is also recommended as a tool to encourage the building owners to build or renovate their own buildings to meet with the guideline and get certification from the programme.

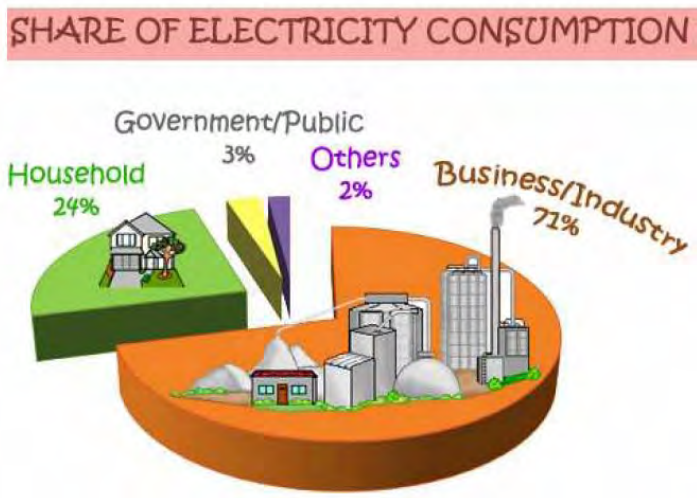


FIGURE 11-1 : Share of Electricity Consumption on SAMUI Island

11.1 Energy Consumption for Building on SAMUI Island

In general, each type of building such as hotel, resort, supermarket and residence; has typical ratio of electricity consumption as shown in Figure 11-2 to 11-4. Moreover these ratios have shown that air-conditioning system is the largest consumer in each type of building and following by laundry and refrigerator.

For SAMUI Island, a tourist attraction island, hotels and resorts are flourish industry; however almost every hotel and resort chose split type air-conditioning system which has low efficiency or about 1.2-1.4 kW/RT as their solution for cooling. Nonetheless the other buildings in SAMUI Island are houses with the same split type system and a few supermarkets using chillers.

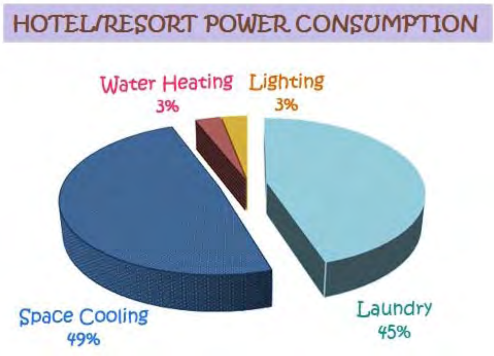


FIGURE 11-2 : Hotel and Resort Electricity Consumption Breakdown

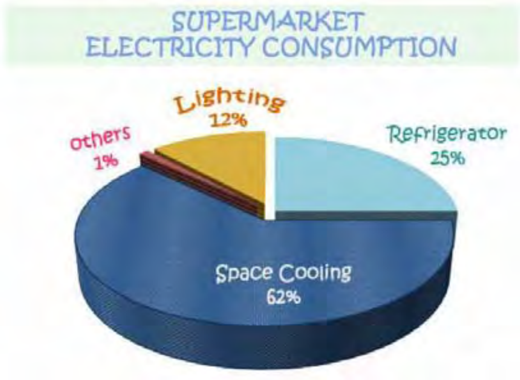


FIGURE 11-3 : Supermarket Electricity Consumption Breakdown

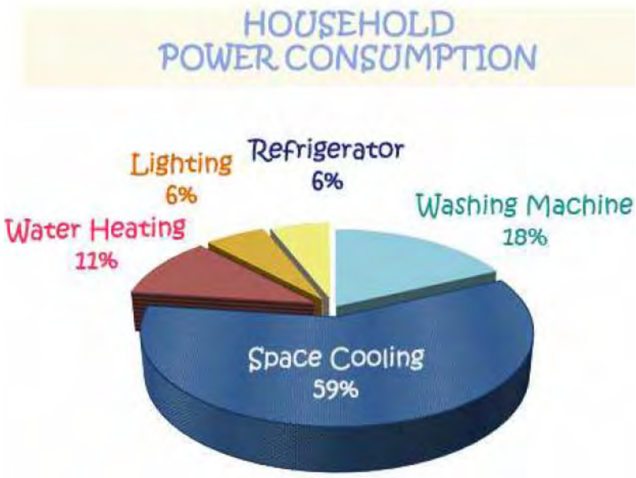


FIGURE 11-4 : Single House Electricity Consumption Breakdown

11.2 Low Carbon Building Guideline

To raise the bar of building standard, low carbon building concept shall be applied on every building development phase, from preliminary design to construction. As stated before, Low Carbon Building Achievement will be a huge impact on overall low carbon emission.

In addition, since buildings need the same accommodations which are air-conditioning, lighting, plumbing and other electrical appliances such as washing machine etc. Low Carbon Building Guideline should be grouped and classified into four major categories for building enhancement as follows;

11.2.1 Reduce heat load to/in building and minimize heat load from the planning to design stage.
11.2.2 Use the optimal efficiency of system and equipment.
11.2.3 Passive design, adaptable to local climate condition.
11.2.4 Proper operation and maintenance for system and equipment.

Low carbon building guideline or programme is recommended as a tool to encourage the building owners to build or renovate their own buildings to meet with the guideline and get certification from the programme.

TABLE 11-1 : Low Carbon Building Guidelines

Item	Measures
	Load Reduction
1	High Efficiency Building Insulation
2	Using vinyl frame instead of aluminum frame to reduce air leakage through window frame.
3	Reducing solar radiation by putting on outside shading, using high SC glass and putting on curtain or blinds.
4	Using high efficiency equipment such as minibar refrigerator not only reduces energy consumption, but also reduces heat radiation to cooling space.
5	Spot cooling for large or semi-outdoor space such as lobby area.
6	Solar hot water
7	Condensing hot air pre-heat
8	Optimum temperature for stored hot water
9	Fit aerator reduces water flow rate
10	PV street light
	Increasing Equipment Efficiency
1	Thailand Energy Label (5)
2	Using Split-type A/C inverter, VRF, Water-cooled VRF and Hybrid split type system
3	Using compact high efficiency fluorescent lamp (T5) and LED
4	Using water saving faucet
	Passive Design
1	Growing Shading Plants around buildings
2	Growing Draught-tolerant Plants around buildings
3	Light color and open pavers
4	Combining bathroom ventilation fan with lighting fixture
5	Using natural ventilation, considering wind direction
6	Using natural light by light interior color, light shelf and light tube.
7	Using natural energy such as pond water for cool down intake air and heat from A/C condensing unit

Item	Measures
8	Selecting proper lighting fixture color
9	Setting equipment shut down time when do not use
	Management
1	Proper setting temperature of equipment such as A/C, boiler, dish washer and washing machine
2	Promoting energy saving awareness and Using sign
3	Providing thinner blanket so that space temperature can be raised
4	Planning for interior furniture layout not to block air flow
	Operation and Maintenance
1	Annual equipment cleaning and check up
2	Inspect equipment insulation

11.3 Selection of Air Conditioning System

The Carbon Reduction Measures and the energy reduction percentages for Low Carbon Resort, Hotel and Government Office Models will be illustrated later in this chapter.

As stated before, more than 50% of building's electrical consumption is consumed by air conditioning system. In order to reduce the consumption, high efficiency equipment for air-conditioning system is strongly recommended. The recommendation in Table 11-1 will reduce electrical consumption for air conditioning system up to 28%, consequently the building sector's electricity consumption will be reduced at least 14%.

In addition Figure 11-5 to 11-9 clarifies the recommended system in Table 11-2

TABLE 11-2 : Recommendation of Air Conditioning System for Each Type of Buildings

Type of Building	Sub-type	Approx. Air-Conditioning Load, Tons	AC System and Heat Rejection Method	See Figure
Hotels/Resorts	Up to 100 Rooms	Up to 250	Air-cooled inverter split type[1] or VRF	11-5, 11-7
	101 - 200 Rooms	200 - 500	Hybrid split type[2], Water-cooled VRF[3] or Adsorption chiller	11-6, 11-8, 11-9
	More than 200 Rooms	More than 500	Water-cooled VRF, Adsorption chiller	11-8, 11-9
Retails	Up to 2000 m2	Up to 150	Air-cooled inverter split type or VRF	11-5, 11-7
	More than 2000 m2	More than 150	Hybrid split type, Water-cooled VRF or Adsorption chiller	11-6, 11-8, 11-9
Residential	**Apartment**			
	Up to 150 Rooms	Up to 300	Air-cooled inverter split type	11-5
	More than 150 Rooms	More than 300	Hybrid split type	11-6
	Private house	5	Air-cooled inverter split type	11-5
Government/Office	Up to 2000 m2	Up to 120	Air-cooled inverter split type or VRF	11-5, 11-7
	More than 2000 m2	More than 120	Hybrid split type, Water-cooled VRF or Adsorption chiller	11-6, 11-8, 11-9

Note:

1. Air cooled inverter split type has a better efficiency about 1 kW/RT than conventional split type which is 1.4 kW/RT.
2. Hybrid split type system has ability to use water-cooled and boost with air-cooled fan, located inside condensing unit, in case of water-cooled is not enough.
3. Water cools VRF by cooling tower.

TABLE 11-3 : Performance of Air Conditioning System

FIGURE	System	Description	Performance
11-5	Air-cooled Split Type	Inverter Type	1 kW/RT
11-6	Hybrid Split Type	Pond water-cooled Split Type with inverter	0.9 kW/RT
11-7	Air-cooled VRF	Inverter type and available for load balance and sharing	1 kW/RT
11-8	Water-cooled VRF	Cooling tower water-cooled with inverter and available for load balance and sharing	0.9 kW/RT
11-9	Adsorption chiller	Solar heat-source and cooling water-cooled and available for load balance and sharing	0.31 kW/RT

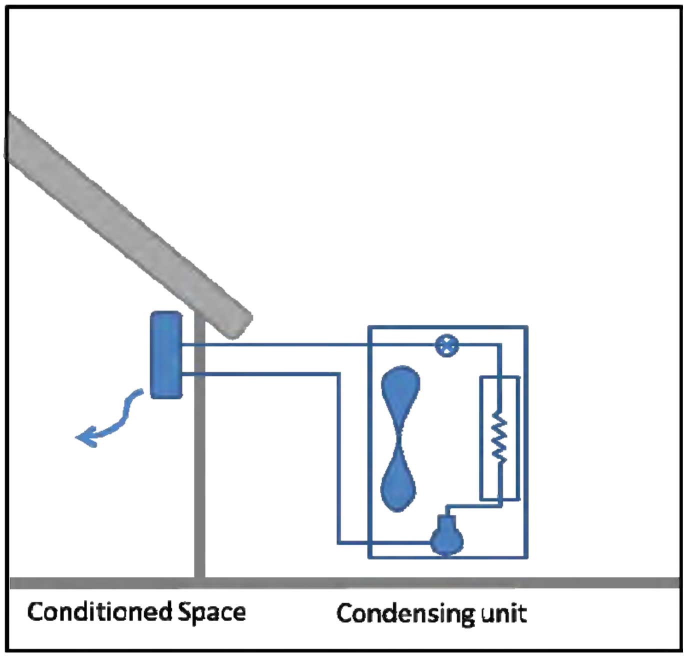


FIGURE 11-5 : Air-cooled split type system

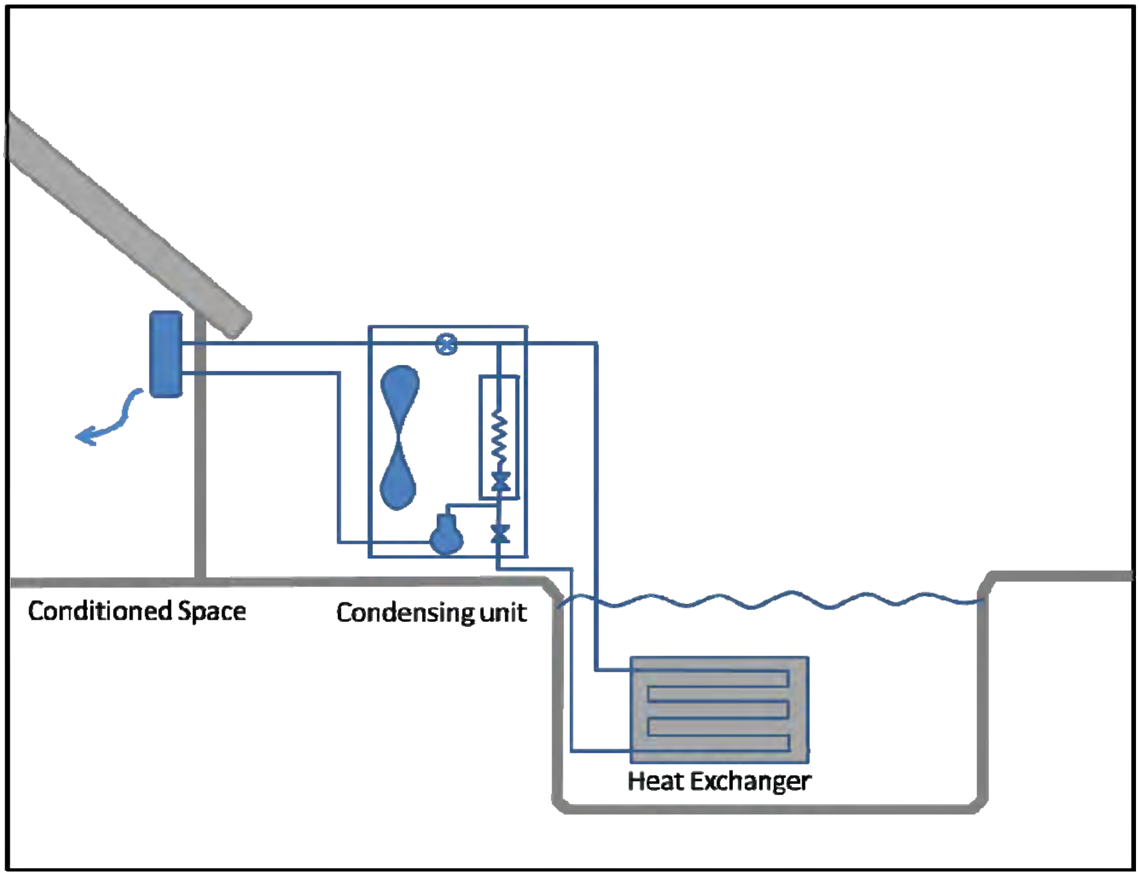


FIGURE 11-6 : Hybrid split type system

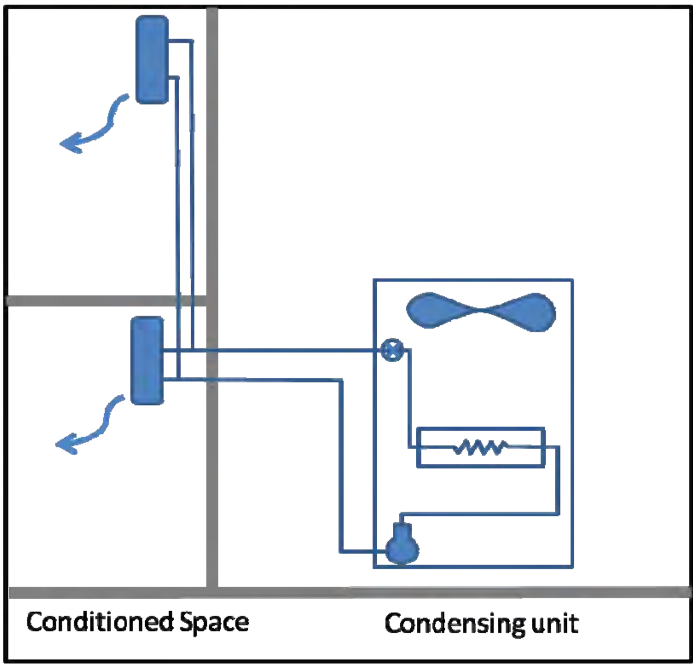


FIGURE 11-7 : Air-cooled Variable Refrigerant Flow (VRF) System

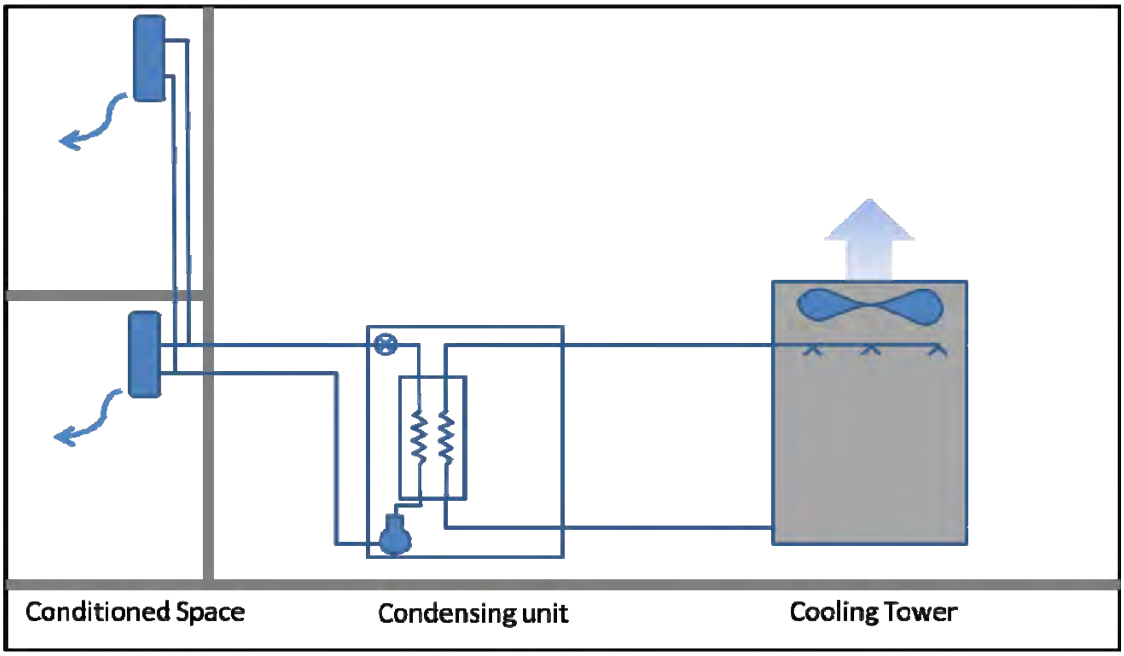


FIGURE 11-8 : Water-cooled Variable Refrigerant Flow (VRF) system

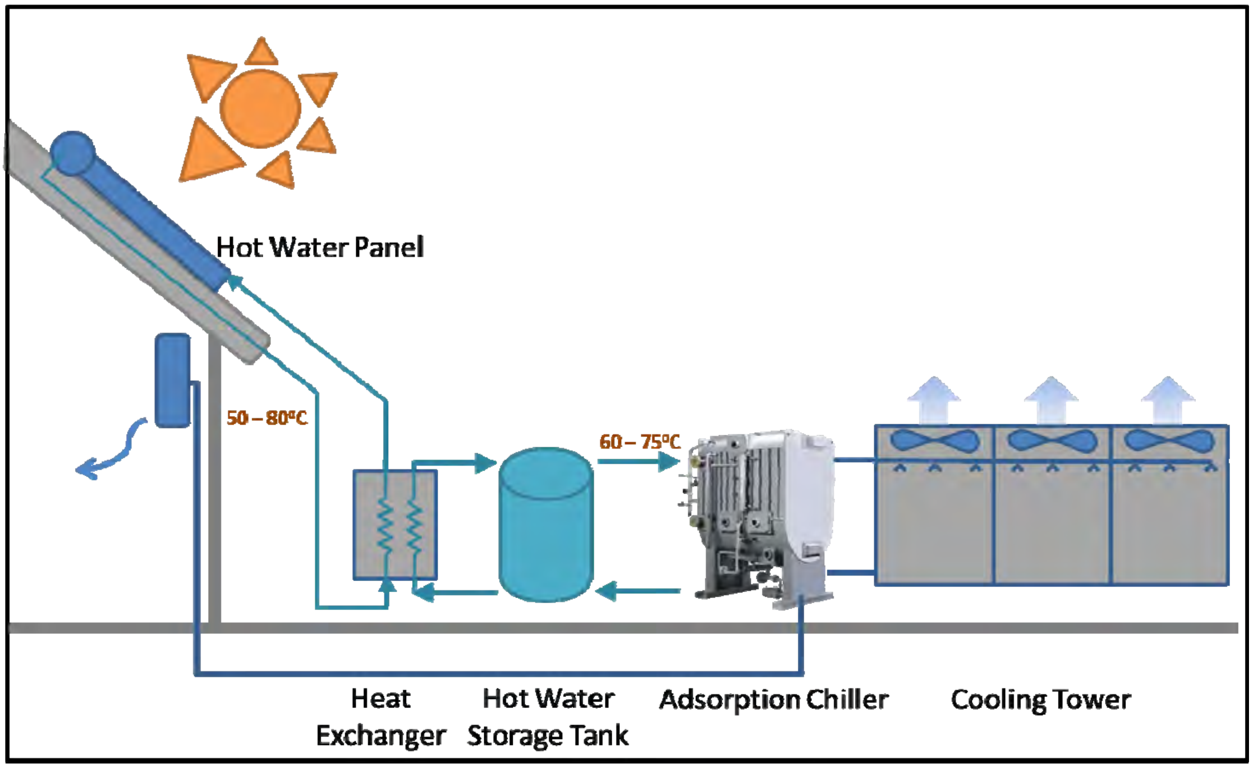


FIGURE 11-9 : Adsorption chiller system

Following is the clarification of the above recommended system, Figure 11-6 Hybrid split type system and Figure 11-9 Adsorption chiller system that we need to illustrate and stress out.

Water-cooled condenser for split type system might not sufficient enough for heat rejection because of a small compressor limiting refrigerant flow to the pond. Therefore adding a normal condensing fan backs up the system and the fan can operate in some occasion that water or its temperature is not available. However please be aware that a long piping distance also consumes energy and affects the equipment efficiency.

Adsorption chiller system has lived with humankind for a long time starting from the first refrigerator and continuing to the solar assisted air-conditioning system as stated in Chapter 7 Area Energy Planning. Though it is not well-known as household equipment, it is known as free-cooling. The heat source or equipment input is hot water from hot water panel. Hot water panel heats up water by solar heat and then transfers it to hot water storage tank. Adsorption chiller will use storage hot water as the heat source to boil its adsorbent and cools it down by cooling tower.

11.4 Low Carbon Resort Model

As a tourist attraction island, SAMUI's power is mainly consumed by hotels and resorts. In addition from the survey report dated January 5th, 2009; the small size resort up to 50 rooms or guesthouse is nearly three quarter of overall hotels and resorts on the island, see Figure 11-10 Classification of hotels by rooms.

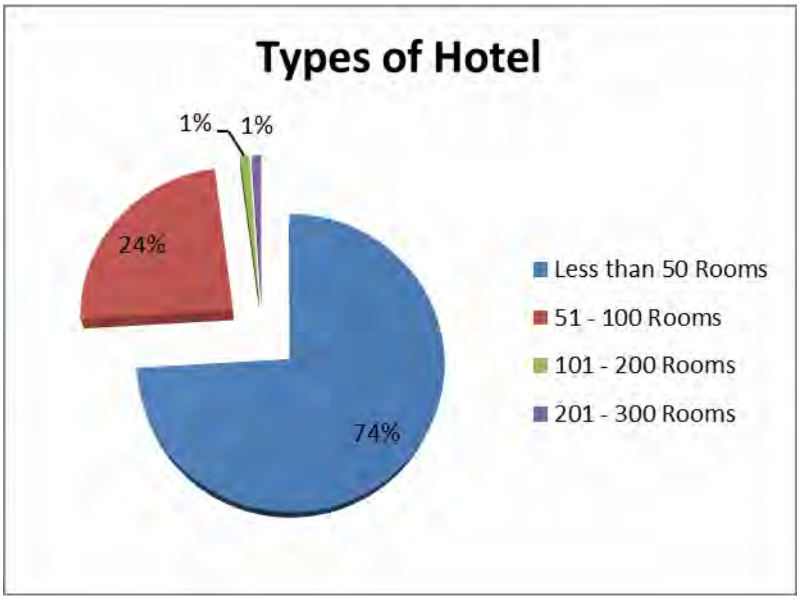


FIGURE 11-10 : Classification of hotels by rooms

In this topic, Low Carbon Resort Model is presented as a guideline and example for promoting low carbon town. Generally, SAMUI's resort is located by the sea as the Figure 11-11 SAMUI's resort master plan. There are typical 4 types of villa in the resort namely, Sea view, Private pool, Pool, and Garden villa. Normally split type air-conditioning system is commonly used because it is easy to install and maintenance but it consumes large amount of energy compare to other type of air conditioners. VRF Air Conditioning System is a good competitor for lobby building and groups of villas such as Garden villa and Pool villa because this system has load sharing capability between occupied and unoccupied spaces and consumes less energy, about 1 kW/RT. For scattered villa such as Sea view villa and Private pool villa, split type system with inverter compressor has a better efficiency than normal split type or about 1 kW/RT, however it has no chance for load sharing. Water has a better heat specific capacity than air which means it transfer heat from condenser better than air approximately 0.9 kW/RT. Pool villa and Private pool villa have a good opportunity with water-cooled condenser. Therefore water-cooled VRF is proposed for Pool villa and water-cooled split type for Private pool villa.

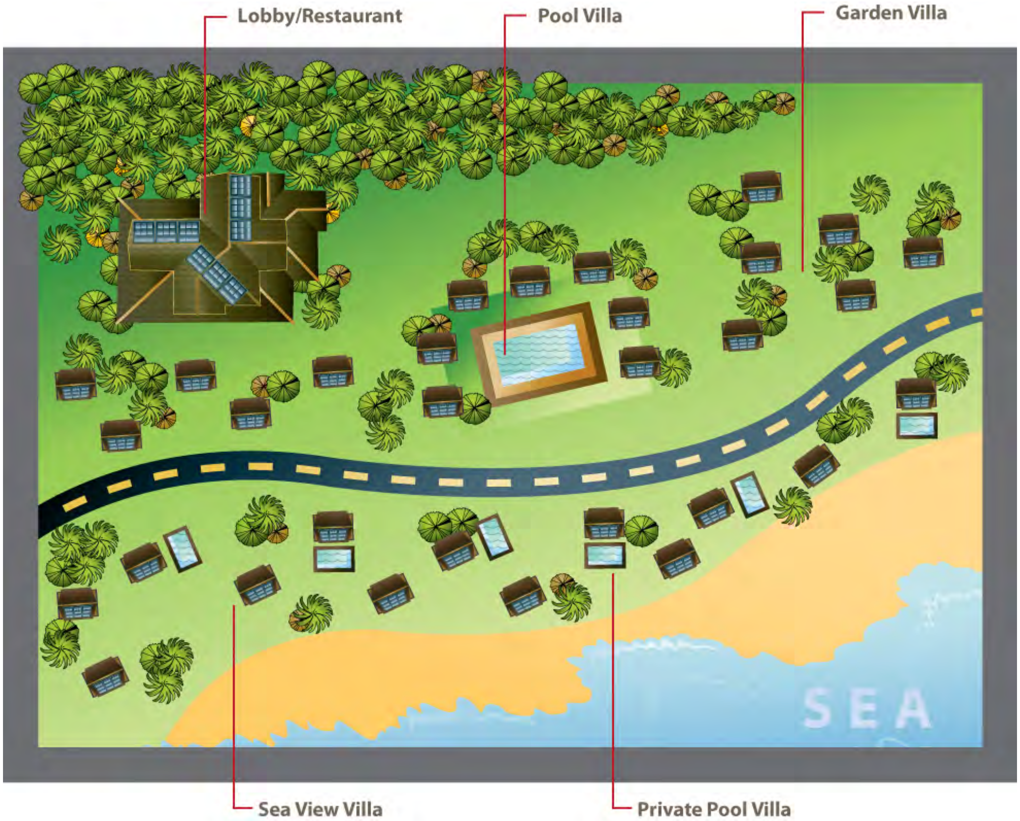


FIGURE 11-11 : SAMUI's resort master plan

Landscape impacts Low Carbon design because irrigation takes approximately 40% of resort's water consumption. Presently, SAMUI lacks of water supply since the public water supply is not able to serve this fast growing island. Local plant such as coconut trees and other drought-tolerant plants are proposed. Growing shading trees reduce heat island effect approximately 2 ^{o} C comparing with concrete paving; see Figure 11-12 Heat Island Effect Reduction. On the contrary, dark paving is not recommended. Open pavers, that water or rain can seep through, is recommended to reduce heat island effect and drain storm water.

PV (photovoltaic) for street light shall be used to reduce energy consumption and the street light cable cost and material.

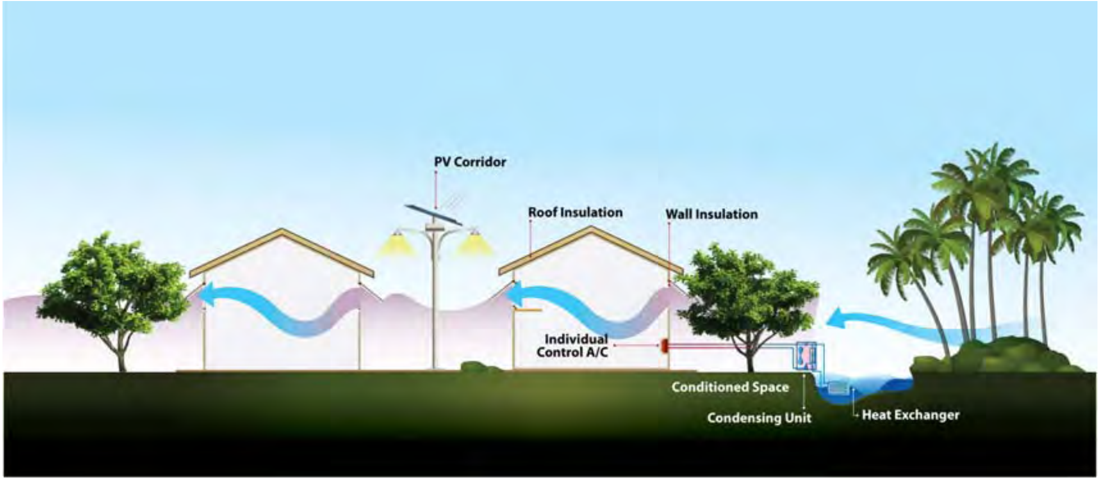


FIGURE 11-12 : Heat Island Effect Reduction (Creation of Wind Path)

Resort is similar to local house which includes 1 living room, 1 bed room and a small pantry. Besides landscaping design for external heat load reduction, building design is also important. Roof insulation is recommended to put on ceiling level instead of roof level to prevent heat installation in attic which will transfer to room space.

In case of no attic, this type of villa is preferred since a floor to floor height seems to be higher. Moreover if it is higher than 3 meters, the temperature stratification will be created, the upper level is warmer than lower level. Furthermore the upper air will also act as air insulation for living space, up to 2 meters, see Figure 11-13 Low Carbon Resort Model.

Wall insulation is also recommended. Shade, curtain or blind prevents light glare and direct sunlight or heat to room. Windows promote natural ventilation, nonetheless infiltration. Window and door sealing prevent cool air leaks from room and humid air leaks to room when conditions space.

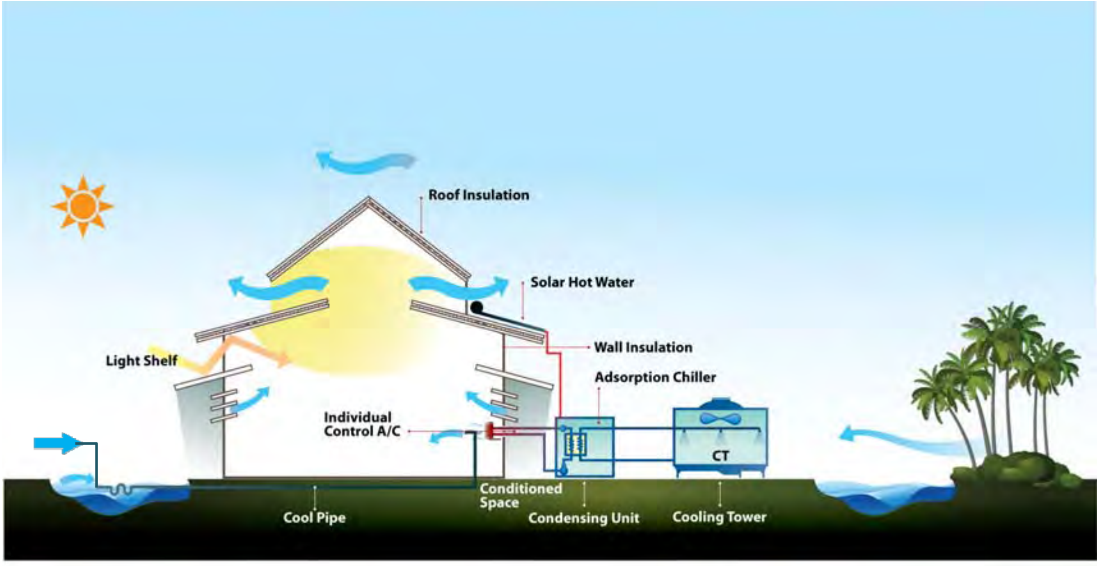


FIGURE 11-13 : Low Carbon Resort Model

Light interior color minimizes contrast or light glare between outside and inside and, on top of that, it requires less lighting since it also diffuses light. The use of natural light is values; however direct sun light is heat load. Diffused or indirect sun light can be used by light shelf or light tube as shown in Figure 11-13 Low Carbon Resort Model. Heat loss from electrical equipment transforms to heat and dissipates to space. LED light consumes less energy hence less heat will be radiated.

Indoor water saving can be achieved by utilizing high efficiency fixture such as low-flow showerhead (rain shower is not recommended) and water efficient type toilet. The interesting note is that low-flow showerheads and faucets can also reduce hot water demand or energy demand. Flush tank toilet is required less pump head than flush valve toilet.

Solar hot water is proposed since the southern part of Thailand as SAMUI Island has a good potential for solar radiation, see Figure 11-14. Hot water storage tank is required to storage hot water in day time for night use. In case of low solar radiation such as a rainy day, the electric hot water booster is needed.

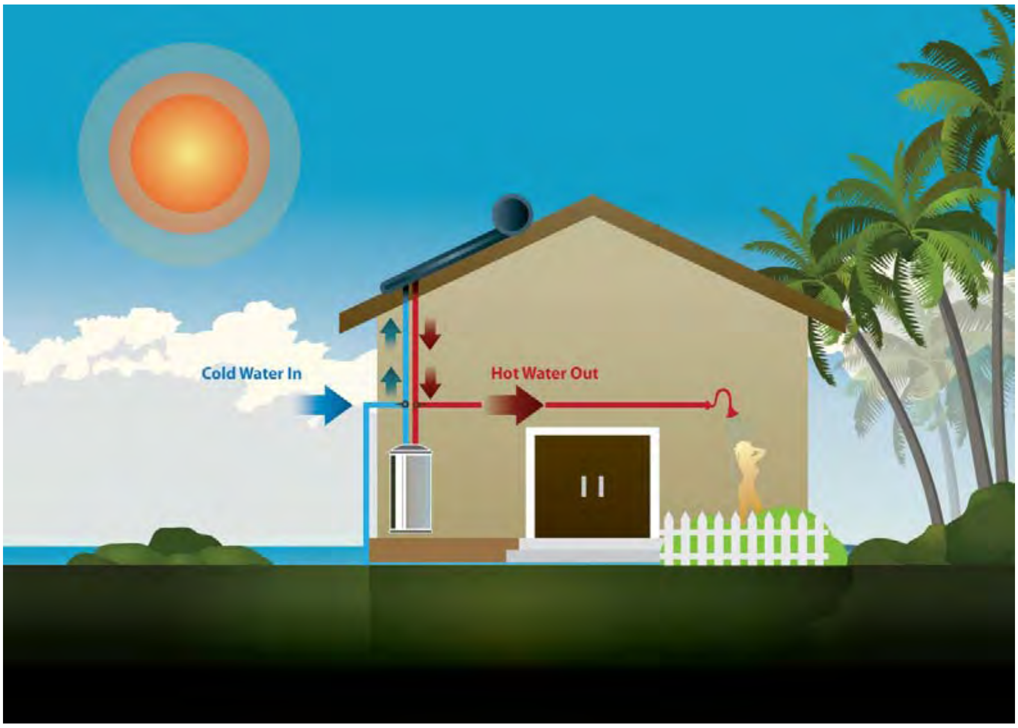


FIGURE 11-14 : Solar Hot Water

Air-conditioning system, individual control terminal unit or fan coil unit allows users to adjust temperature as needed, not too low and not too high. Moreover this system has no duct heat loss and leakage which equally to no waste energy.

Furthermore, for large area such as lobby, spot cooling is proposed. SAMUI resort's lobby is typically with very high ceiling and mostly opened to outdoor. Therefore to install duct system sometimes is impossible and waste energy. At corner, dead-end or leeward area, additional fan shall be located to increase ventilation. Figure 11-15 SAMUI resort's lobby proposed design is the example of proposed lobby hall.

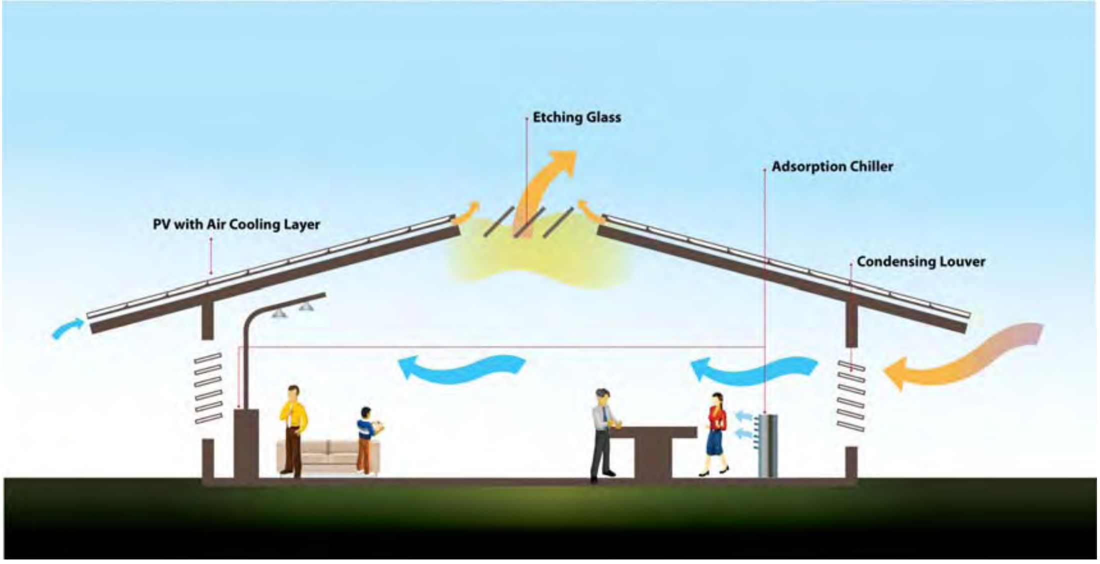


FIGURE 11-15 : SAMUI resort's lobby proposed design

The resort shall provide good indoor air quality, however not to over ventilated since it unnecessary consumes energy. The exhaust air from conditioned space is cool so air heat exchanger is provided to pre-cool fresh air, see diagram in Figure 11-16.

In addition, as shown in Figure 11-13, Cool Pipe will reduce the ambient air temperature by passing through cool pond water and then bring in cool air for fresh air intake and ventilation.

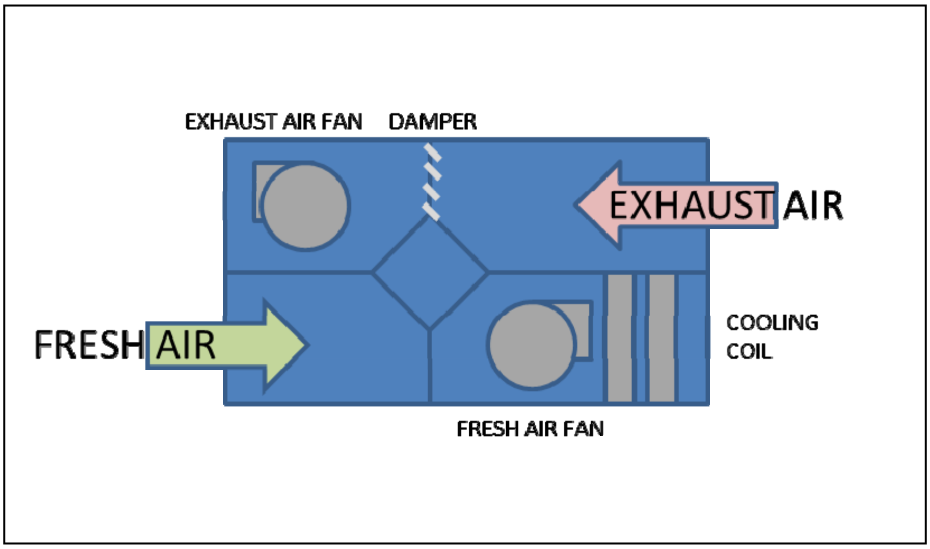


FIGURE 11-16 : Air to Air Heat Exchanger

Proper maintenance such as filter, lighting fixture and window cleaning reduces equipment's energy consumption. Low Carbon awareness should be the mandatory subject but the hardest. Signage is one of the effective measures for Carbon reduction. Put the sign such as "Turn A/C off when need natural ventilation" or "Turn the light off when you have enough light" or "Raising 1^{o}C, saving 10% energy consumption". Promote the awareness of employees also supports operation.

TABLE 11-4 : The summary of proposed design for Low Carbon Resort

	Item	BAU	Specification	Proposed Building	Specification	Cost*
1	Roof	No Insulation	U = 0.84 W/ m^2K	2 In. 24 kg/m³ Fiberglass with Al Foil	U = 0.525W/m^2K	6 USD/ m^2
2	Wall	No Insulation	U = 3.73 W/ m^2K	1 In. 24 kg/m³ Fiberglass with Al Foil	U = 1.018 W/ m^2K	6 USD/ m^2
3	Window	Clear Float 8mm Glass	U = 6.18 W/ m^2K	Low-E Glass	U = 3.40 W/m^2K	489 USD/ m^2
			SCR0.89, SCC0.04	(AF6mm+Air6mm+Heat Reflective Glass6mm)	SCR0.63, SCC0.07	-
		Clear Float 8mm Glass (with Blinds)	U = 4.88 W/ m^2K	Low-E Glass (with Blinds)	U = 2.97 W/m^2K	-
			SCR0.26, SCC0.26		SCR0.25, SCC0.21	-
		Window Area Ratio	0.7	Window Area Ratio (Lower air leakage)	0.5	-
4	Use of Natural Light	None	-	Use of Light Shelves, Light Tube	-	400 USD/tube or per 20-30 m^2
5	Lighting Fixture	T8	60 VA	LED	50 VA	0.72 USD/ m^2
6	Lighting Control	Standard ON/OFF Lighting	-	Automatic Control of Lighting Schedule	-	-
7	A/C	Conventional Split type	1.4 kW/RT	Variable Refrigerant Flow (VRF)	1 kW/RT	1,625 USD/RT
				Inverter type Split type	1 kW/RT	1,270 USD/RT
				Water cooled VRF	0.9 kW/RT	1,790 USD/RT
				Hybrid (Water cooled) Inverter type Split type	0.9 kW/RT	1,300 USD/RT
8	Fresh Air Intake	Infiltration	-	Cool Pipe	PVC or HDPE Pipe (Dia. 250 m m^2)	PVC 43 USD/m, HDPE 95 USD/m
			-	Fresh Air Box	-	10 USD/(L/s)

	Item	BAU	Specification	Proposed Building	Specification	Cost*
9	Toilet	Conventional type	6 Liter/ flush	Water saving Flush Tank	3 Liter/ flush	230 USD/set
10	Lavatory Faucet	Handle type	1 Liter/min	Low-Flow Faucet	0.4 Liter/min**	-
11	Shower Head	-	-	Low-Flow shower head	-	-
12	Water Pump	Conventional	-	Inverter type	-	
13	Landscape	-	-	Local and Shading Trees	-	-
		-	-	Light water seepage Paving such as grass block	-	10-50 USD/ m^2
14	Renewable Energy	-	-	PVs Street light	-	1,660 USD/tower or every 20 m
		-	-	Solar Hot Water	-	4,000-8,000 USD/system
		-	-	PVs roof	-	780 USD/ m^2

* Estimated Cost includes equipment and installation cost only, not includes building cost.

11.5 Low Carbon Hotel Model

The accommodations for tourists and visitors in SAMUI Island consist of two major types, resort type and hotel type. Proposed design for resort type has been highlighted in previous topic (11.4). This topic is going to propose another major type which is hotel type. The hotel type, normally, is developed in building style. The building principle of Low Carbon Hotel Model is similarly to Low Carbon Resort Model, nevertheless adding some specific measures.

The typical hotel in SAMUI is 3 stories height with restaurant, bar, main kitchen, laundry service and swimming pool. Low Carbon Hotel Model is clearly stated the proposed system, see Figure 11-17 Low Carbon Hotel Model.

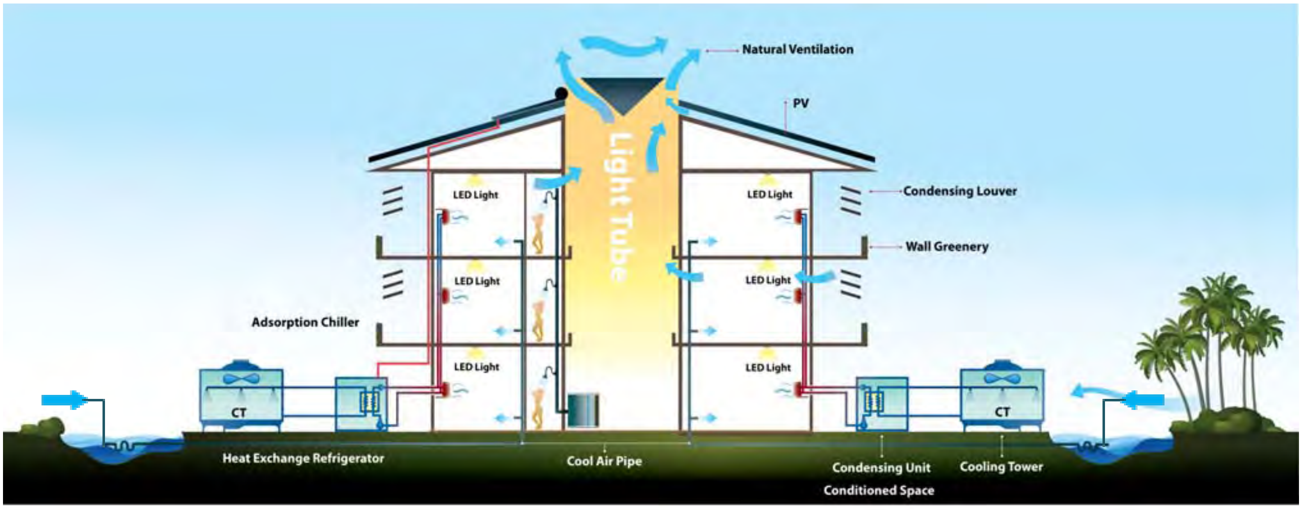


FIGURE 11-17 : Low Carbon Hotel Model

Since hotel is a group of rooms and requires the large cooling capacity, VRF system is suitable. For 50-100 rooms capacity, air-cooled VRF is proposed because the cost feasibility. However for hotel with over 100 rooms' capacity, water-cooled VRF is recommended.

Landscaping of Low Carbon Resort Model is also effective for hotel.

Despite installation of insulation material on roof and wall, green roof or PV (photovoltaic) roof are promoted. Green roof is a good building insulation and also reduce heat island effect. Intake air temperature for fresh air unit, located on the roof is lower. PV is a shade for building's roof and also generates electrical power for the building.

Besides minimizing window to wall ratio, the building design to minimize wall area also reduces building heat load. For example open court hotel has a larger wall area than normal square building because it almost double external wall for its open court. More wall area is more heat and humidity transferred.

The entrance location should not face wind direction since the large infiltration through door is hardly control. Slide door is preferred and frameless door is not applicable for outdoor application because it cannot protect the building from rain and other infiltration. Door map should be provided to prevent sand or dirt to the building that wastes housekeeping power.

Window light and light shelf might not be able to go through large building. Therefore light tube supporting by LED has more room here. Motion sensor might be provided in some public area such as corridor.

Central hot water system has load sharing capability and efficient. Furthermore, from users' side, the central system has a constant temperature and since it has a storage tank and circulated pump, users can get immediately satisfy hot water temperature. Heat Pump is also proposed as hot water generating system for the low carbon hotel model. Heat pump draws heat from air to water. Consequently it also produces cool air. This cool air can cool down the area nearby such as hotel lobby or mechanical area.

Elevation tank should be installed. Water supply pump therefore operates at constant design efficiency and provide stable water flow rate to users. Consequently shower temperature is controlled.

Natural ventilation is prompted as much as possible. On the other hand fresh air unit is needed for conditioned space. In large conditioned space such as restaurant and meeting hall, central air-conditioning with variable air volume (VAV) is recommended.

In a nut shell, Low Carbon Resort Model and Hotel will reduce overall energy consumption of SAMUI (the percentage of reduction is shown in Building energy simulation chapter). Principally the proposed system can be achieved by building design and orientation which is no cost impact. For other equipment installed to achieve Low Carbon Resort and Hotel will be turned in maintenance and operating cost which are definitely lower than conventional design. The users or occupants will gain a better indoor air quality and healthy building.

TABLE 11-5 : Low Carbon Building measures

Item	Measures
	Load Reduction
1	High Efficiency Building Insulation
2	Preventing air leakage through door and window. For example the use of vinyl frame and automatic sliding door.
3	Reducing solar radiation by minimizing window area, putting on outside shading, using high SC glass and putting on curtain or blinds.
4	Bio-façade reduces heat mass pass through building envelop.
5	Using high efficiency equipment not only reduces energy consumption, but also reduces heat radiation to cooling space.
6	Spot cooling for large or semi-outdoor space.
7	Heat Pump Hot Water
8	Condensing hot air pre-heat
9	Optimum temperature for stored hot water
10	Fit aerator reduces water flow rate
11	Spot lighting in some area such as working desk.
12	Lighting control by luminance sensor
	Increasing Equipment Efficiency
1	Thailand Energy Label (5)
2	Using Water-Cooled VRF
3	Using compact high efficiency fluorescent lamp (T5) and LED
4	Using water saving faucet
	Passive Design
1	Using Building Automation System, if needed, for monitoring and

Item	Measures
	controlling equipment
2	Growing Shading Plants around buildings
3	Combining bathroom ventilation fan with lighting fixture
4	Using natural ventilation, considering wind direction
5	Using natural light by light interior color, light shelf and light tube.
6	Using natural energy such as pond water for cool down intake air and heat from A/C condensing unit
7	Selecting proper lighting fixture color
8	Setting equipment shut down time when do not use
	Management
1	Proper setting temperature of equipment such as A/C, boiler, dish washer and washing machine
2	Promoting energy saving awareness and Using sign
3	Providing thinner blanket so that space temperature can be raised
4	Organizing occupied room (group of occupied space for cooling load reduction)
5	Planning for interior furniture layout not to block air flow
6	Individual control and adjustment for A/C system
7	Full load operation for dish washer & washing machine
	Operation and Maintenance
1	Annual equipment cleaning and check up
2	Inspect equipment insulation

TABLE 11-6 : The summary of proposed design for Low Carbon Hotel

	Item	BAU	Specification	Proposed Building	Specification	Cost*
1	Roof	No Insulation	U = 0.84 W/ m^2K	2 In. 24 kg/m^3 Fiberglass with Al Foil	U = 0.525W/m^2K	6 USD/ m^2
2	Wall	No Insulation	U = 3.73 W/ m^2K	1 In. 24 kg/m^3 Fiberglass with Al Foil	U = 1.018W/m^2K	6 USD/ m^2
3	Window	Clear Float 8mm Glass	U = 6.18 W/ m^2K	Low-E Glass	U = 3.40W/m^2K	489 USD/ m^2
			SCR 0.89, SCC 0.04	(AF6mm+Air6mm+Heat Reflective Glass 6 mm)	SCR0.63, SCC0.07	-
		Clear Float 8mm Glass (with Blinds)	U = 4.88 W/ m^2K	Low-E Glass (with Blinds)	U = 2.97W/m^2K	-
			SCR 0.26, SCC 0.26		SCR0.25, SCC0.21	-
		Window Area Ratio	0.7	Window Area Ratio	0.5	-
4	Door	Swinging Door	-	Automatic Slide Door (Lower air leakage)	-	1,560 USD/Set
5	Use of Natural Light	None	-	Use of Light Shelves, Light Tube	-	400 USD/tube or per 20-30 m^2
6	Lighting Fixture	T8	60 VA	LED	50 VA	0.72 USD/ m^2
7	Lighting Control	Standard ON/OFF Lighting	-	Automatic Control of Lighting Schedule	-	-
8	A/C	Conventional Split type	1.4 kW/RT	Variable Refrigerant Flow (VRF)	1 kW/RT	1,625 USD/RT
				Water cooled VRF	0.9 kW/RT	1,790 USD/RT
9	Fresh Air Intake	Infiltration	-	Cool Pipe	PVC or HDPE Pipe (Dia. 250 m m^2)	PVC 43 USD/m, HDPE 95 USD/m
			-	Fresh Air Box	-	10 USD/(L/s)
10	Toilet	Conventional type	6 Liter/ flush	Water saving Flush Tank	3 Liter/ flush	230 USD/set

	Item	BAU	Specification	Proposed Building	Specification	Cost*
11	Lavatory Faucet	Handle type	1 Liter/min	Low-Flow Faucet	0.4 Liter/min**	-
12	Shower Head	-	-	Low-Flow shower head	-	-
13	Water Pump	Conventional	-	Inverter type	-	
14	Hot Water	Electric	-	Heat Pump	-	-
15	Landscape	-	-	Local and Shading Trees	-	-
		-	-	Light water seepage Paving such as grass block	-	10-50 USD/ m^2
16	Renewable Energy	-	-	PVs Street light	-	1,660 USD/tower or every 20 m
		-	-	PVs roof	-	780 USD/ m^2
17	Building Control	Human Oriented	-	Building Automation System	-	-

* Estimated Cost includes equipment and installation cost only, not includes building cost

11.6 Low Carbon Government Building

In order to promote the low carbon building on SAMUI Island, government building should be the first target to be implemented as demonstration building. Therefore, in this topic, I, we will take the initiative and provide the role model for Low Carbon Government Building.

One existing government office on SAMUI is chosen; see Figure 11-18 SAMUI District Office. This building presents the typical government office in SAMUI which is 2 stories height (approximately 3 m. per floor) with gable roof. Wall to window ratio is roughly 0.8. The normal brick/concrete wall is widely used for exterior wall. The windows are single glazing with aluminum frame horizontal slider. The swinging doors are stile and rail type with single glazing and aluminum frame. The conventional split type air conditioning system and fluorescent light are used.

FIGURE 11-18 : SAMUI District Office

Since we have chosen the classic government building to be renovated, we would like to keep the classical design of the main architecture and synchronizes Low Carbon Design. The passive design is taken the important role here. Roof and Wall insulation are the priority since there can reduce approximately 50 % (2 inches insulation, R factor 1.429 W/m^{2}K) of heat load transfer to the building when compare with no insulation installed. Insulation does not mean only fiberglass insulation, but also green roof or wall, see Figure 11-19 Bio-façade wall. Theses gardens, both horizontal and vertical, create low temperature surfaces and shading area for the building. We still support operable window type since we want to encourage natural ventilation use if there is any opportunity. However the fiberglass or vinyl frame has a lower air leakage or infiltration and better Heat Transfer value, see Figure 11-20 Proposed Double Glazing and Fiberglass Window. In addition, the double glazing is used to prevent solar radiation and heat conduction into the building. The swinging door brings a mass infiltration through one opening and sometimes it usually opens all the time. Therefore automatic slide door is proposed.

FIGURE 11-19 : SAMUI District Office with Bio-façade Wall

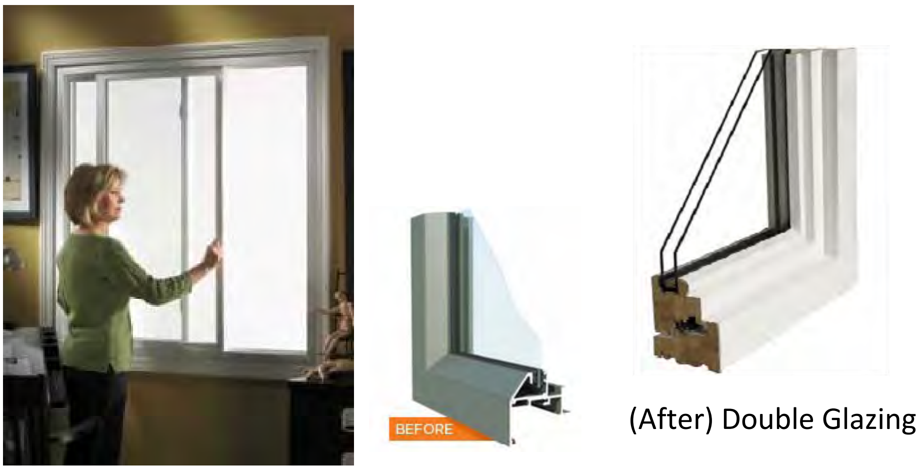


FIGURE 11-20 : Proposed Double Glazing and Fiberglass Window

Additionally we would like to build up natural light use. The direct sun light brings heat, so to induce natural light we put light shelves, light tubes, prismatic sheeting or glass blocks to transform it to be diffused sun light or only light. Nonetheless the area ratio of natural light use should not more than 10% of wall area at upper level to prevent glare and heat. The natural right uses are shown in Figure 11-21 to 11-23. Furthermore a solid internal wall blocks all the light that we induce. The partitions should be a glass partition at least at the upper level to allow natural lighting in the internal space as shown in Figure 11-24. The light interior color such as wall and ceiling also promote light diffusion.

FIGURE 11-21 : Glass Blocks and Prismatic Sheeting for Natural Light Uses

FIGURE 11-22 : Light Shelf for Natural Light Uses

FIGURE 11-23 : Light Tube for Natural Light Uses

FIGURE 11-24 : Interior Design for Natural Light Uses

The inverter type air-conditioning system such as VRF (Variable Refrigerant Flow) will take the conventional system's place. The low energy consumption fixture type such as T5 is supported by Ministry of Energy and will be used. Water efficient type toilet and slow-self closing faucet are used to reduce water consumption.

Landscaping affects human comfort. Hardscape such as concrete paving radiates heat to the building and surrounding area. Shading trees can bring down the temperature approximately 2-3^{o}C. The grass block as shown in Figure 11-25, is proposed to replace the concrete paving car park and front yard. This type of paving allows water seepage and reduces heat island effect that causes from concrete floor or hardscape. Therefore the surrounding temperature will be lowered.

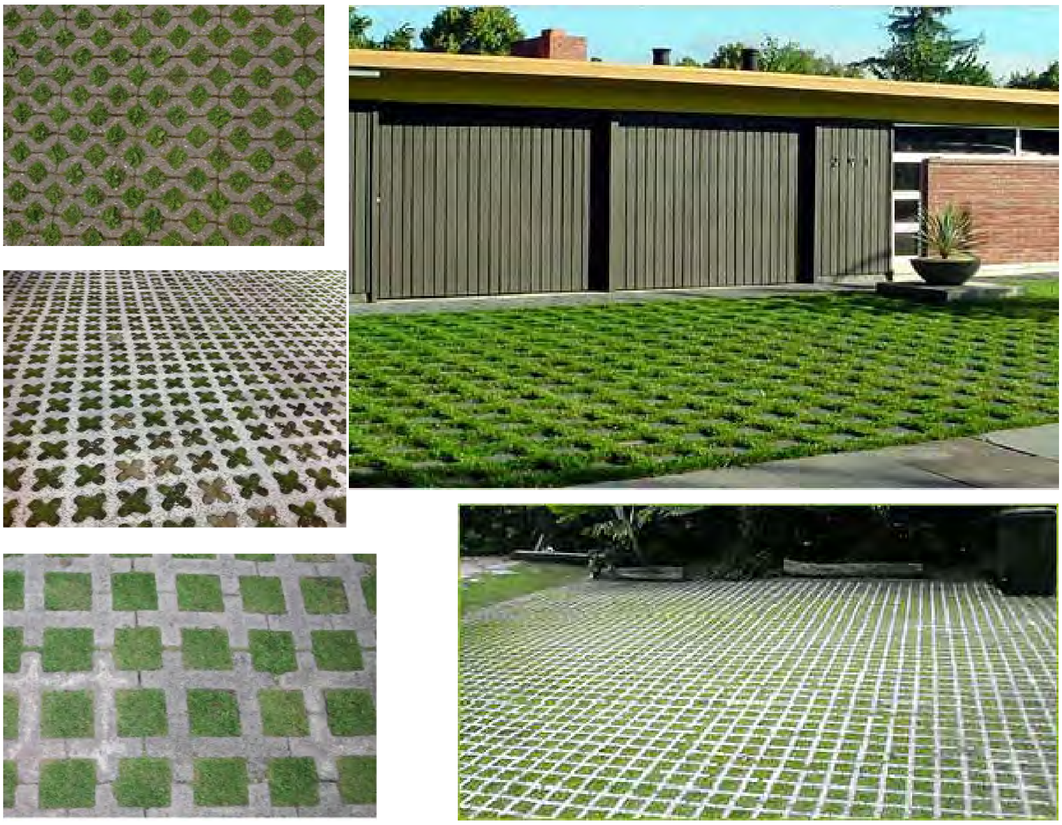


FIGURE 11-25 : Green Paving (Grass Block)

The proposed design for Low Carbon Government Office is summarized in Table 11-7.

TABLE 11-7 : The summary of proposed design for Low Carbon Government Building

	Item	Existing Building	Specification	Proposed Building	Specification	% Saving	Cost***
1	Roof	No insulation	U = 1.54 W/m2K	2 In. 24 kg/m^3 Fiberglass with Al Foil	U = 0.49 W/ m^2K	73%*	6 USD/ m^2
2	Wall	No insulation	U = 3.00 W/m2K	2 In. 24 kg/m^3 Fiberglass with Al Foil	U = 0.57 W/ m^2K	83%*	6 USD/ m^2
3	Window	Single Glazing with aluminum slide frame	U = 6.98 W/m2K	Double Glazing with fiberglass slide frame	U = 2.00 W/ m^2K	54%*	489 USD/ m^2
		(3 mm clear float glass)	SC = 0.916	(6 mm blue green reflective, 13 mm air space and 3 mm clear low-e double glazing)	SC = 0.420		-
4	Door	Swinging Door (Mass cool air loses with one opening)		Automatic Slide Door (Lower air leakage)	-	Can't measure	1,560 USD/Set
5	Use of Natural Light	None		Prismatic Sheet	-	Can't measure	-
				Glass Block	-	Can't measure	195 USD/ m^2
				Light Shelves	-	Can't measure	(Depends on design)
				Light Tube	14 inches tube	Can't measure	400 USD/tube or per 20-30 m^2
6	Lighting Fixture	T8	60 VA	T5	50 VA	30%	0.46 USD/ m^2
7	A/C	Conventional Split type System	1.4 kW/RT	Variable Refrigerant Flow	1 kW/RT	28%	1,630 USD/RT
8	Toilet	Conventional type	6 Liter/ flush	Water saving type	3 Liter/ flush	50%	230 USD/set
9	Lavatory Faucet	Handle type	1 Liter/min	Slow-self closing	0.4 Liter/min**	60%	-
#	Landscape	Concrete paving car park		Grass block car park		Can't measure	10-50 USD/ m^2

Note: * Comparison between heat load through this section
** Based on 1 cycle of self-closing faucet
*** Estimated Cost includes equipment and installation only, not includes building cost

11.7 Prediction for Potential CO_2 Emission Reduction Level by Building Use Types Using Various Low Carbon Measures

11.7.1 Setting Conditions for Calculation to Determine BAU

An annual energy consumption simulation was performed by setting the building's scale, staff density, operation hours, and installed equipment to grasp quantitatively the CO_2 reduction effect from low carbon methodologies. Table 11-8 and 11-9 are the condition set for a model building (BAU). Model conditions for other usage such as guest room building, hall (lobby) building, office building, and residence were also set.

Specifications for the typical Hotels

(Guest room building, Lobby or Hall building, Office building, Residences, etc)
From the survey report dated January 5, 2009; 75% of hotels in SAMUI Island has less than 50 guestrooms and another 25% has up to 100 guestrooms. Therefore our assumption is based on the middle points at 25 rooms hotel and 75 rooms hotel. Moreover the circulation area and support facility are approximately 50% of sale area.

TABLE 11-8 : Specifications for the Model Building (Typical 25 rooms resort**)**

Building Type	Typical 25 rooms resort in SAMUI	Image of Model Building
Total area	1,875 m^2	
Height	4 m	
Floors	1 Floor	
Underground Floor	0 Floors	
Typical Room area	50 m^2	
Passageway area	375 m^2	
Hotel Facility (Restaurant, lobby, pool)	250 m^2	
Structure	RC and Wood	
(Floor Height)	4 m (Ceiling 3 m)	

TABLE 11-9 : Specifications for the Model Building (Typical 75 rooms hotel)

Building Type	Typical 75 rooms hotel in SAMUI	Image of Model Building
Total area	3,300 m^2	
Height	12 m	
Floors	3 Floors	
Underground Floor	0 Floors	
Typical Room area	30 m^2	
Typical Floor area	900 m^2	
Passageway area	150 m^2/floor (corridor)	
Hotel Facility (Restaurant, lobby, pool,laundry,kitchen, and other back of house)	600 m^2	
(Floor Height)	4 m (Ceiling 3 m)	

Note: Since resort style or villa type as shown in the picture has the walkway with garden, the passageway is approximately 30% (20% walkway+10% grass or other turf). For hotel which is 2-3 stories building, the passageway/floor is only for walkway, typically 20%.

75 rooms hotel is a medium size hotel with facility such as Main kitchen, Laundry service, chiller plant, central hot water plant.

Window area ratio

Window area /wall per floor＝ 0.7.

Exterior wall and roof structure

Table 11-10 shows the wall structure and Table 11-11 shows the roof structure.

TABLE 11-10 : Wall structure

Material Details	Thickness (mm)	Conductivity , k (W/mK)	Resistance , R (m^2K/W)	Total R (m^2K/W)	U (W/m^2K)
Outside Air Film	-	-	0.044		
Sand cement plaster	20	0.72	0.028		
Concrete block	70	1.442	0.049		
Sand cement plaster	20	0.72	0.028		
Inside Air Film	-	-	0.120	**0.268**	**3.730**

TABLE 11-11 : Roof structure

Material Details	Thickness (mm)	Conductivity , k (W/mK)	Resistance , R (m^2K/W)	Total R (m^2K/W)	U (W/m^2K)
Outside Air Film	-	-	0.055		
Concrete slab	300	1.442	0.208		
24 kg/m^3 Fiberglass with Al Foil	25	0.035	0.714		
Gypsum board	10	0.191	0.052		
Inside Air Film	-	-	0.162	**1.192**	**0.839**

Overall heat transmission coefficient

Exterior wall: 3.73 $W/m^2 \cdot K$, as shown in table above

Roof : 0.839 $W/m^2 \cdot K$, as shown in table above

Glass : Clear Float 8mm Glass, specification: 6.18 $W/m^2 \cdot K$, SCR 0.89, SCC 0.04

Glass with blind : specification: 4.88 $W/m^2 \cdot K$, SCR 0.26, SCC 0.26

Construction floor plan for a typical floor

Figure 11-26 and 11-27 shows the typical floor plan for resort and hotel.

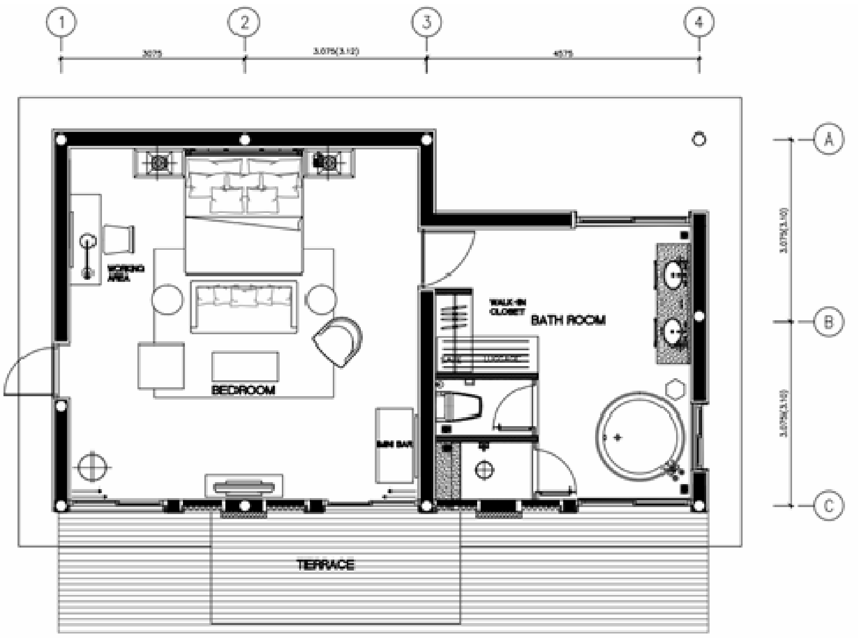


FIGURE 11-26 : Typical Room Floor Plan for Resort

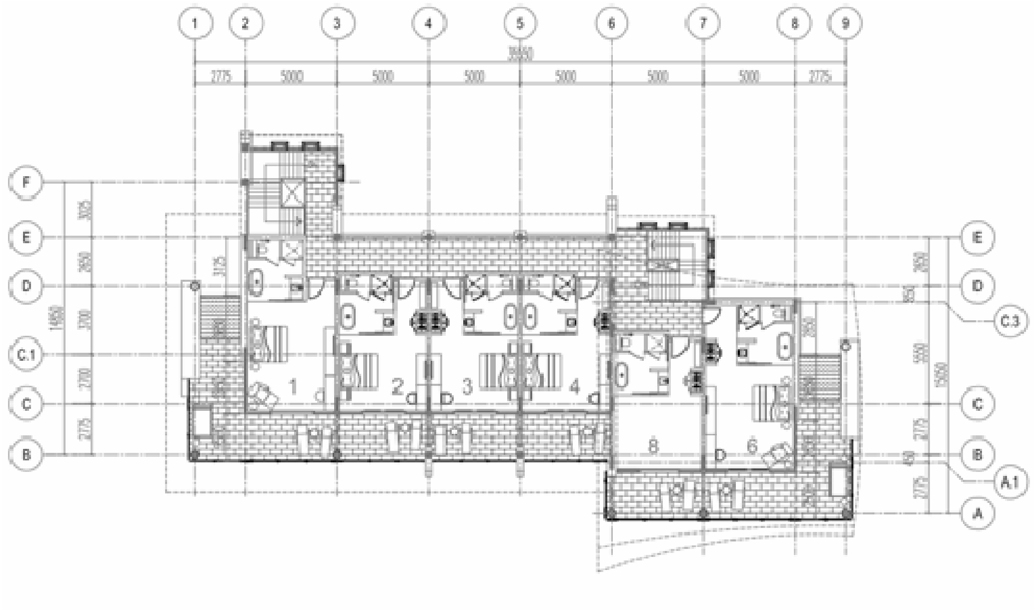


FIGURE 11-27 : Typical Room Floor Plan for Hotel

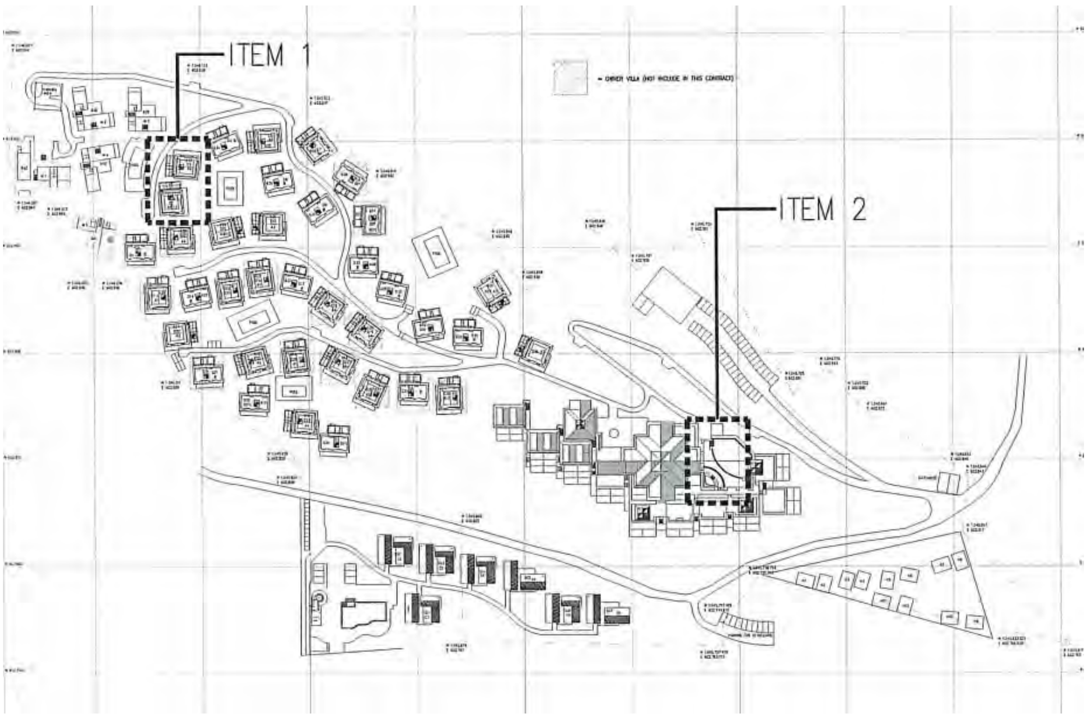


FIGURE 11-28 : Resort Site plan

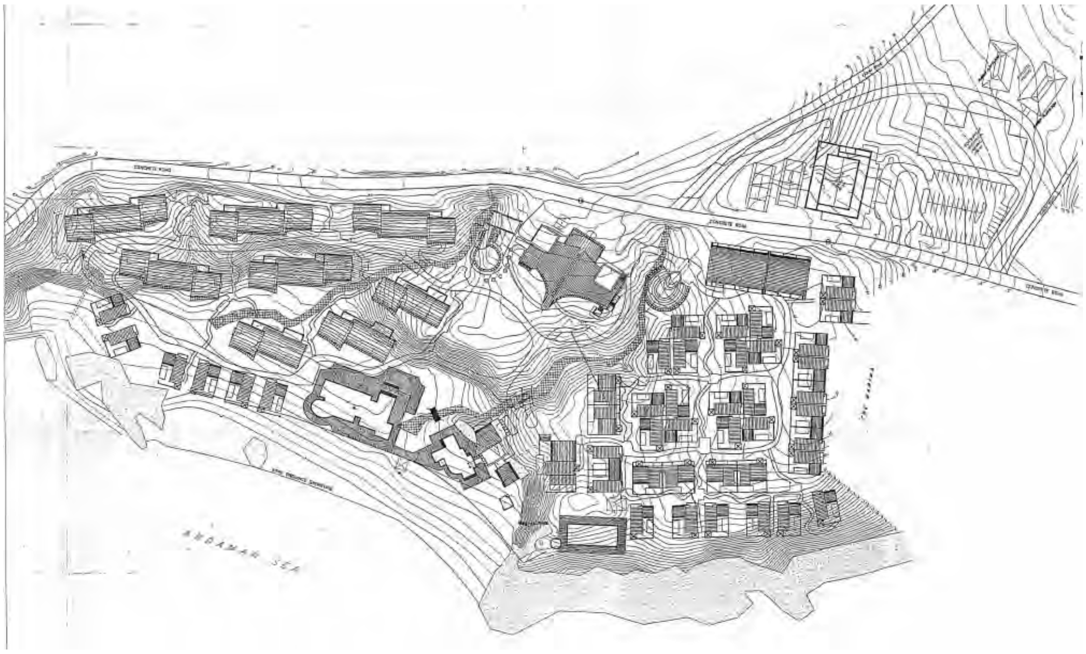


FIGURE 11-29 : Hotel Site plan

Annual Schedule of each Building type

Guestroom building is a 24 hours operation since there is no control on guests. Load demand schedule is shown below. In addition, Hot and humid climate of SAMUI Island makes it impossible for non-cooling season.

Figure 11-30 shows the Lighting Load Demand Schedule and Figure 11-31 shows the Air-conditioning Load Demand Schedule.

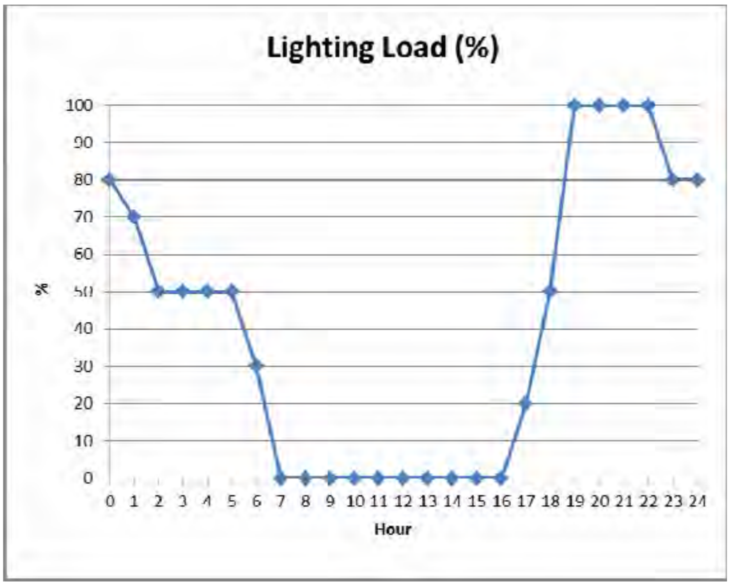


FIGURE 11-30 : Lighting Load Demand Schedule

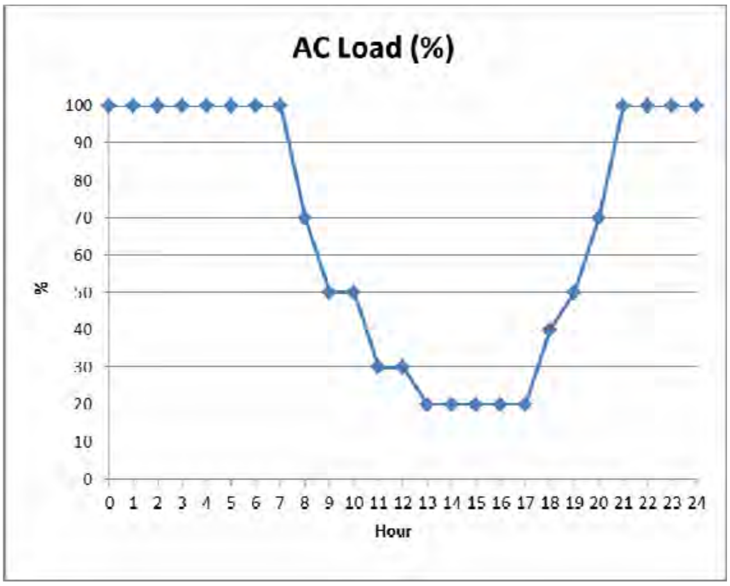


FIGURE 11-31 : Air-conditioning Load Demand Schedule

TABLE 11-12 Design conditions for air-conditioning, ventilation, etc

Floor Use	Temp. [°C]	Relative Humidity [% RH]	Persons [Person]	Lighting [W/m^2]	Equipment [W/m^2]	Fresh Air [m^3/h/person]
Guest room	24	50	2/room	16	10	30

* Heat load from human body: Sensible heat + Latent heat = 102 W/m^2/person (seated at rest)

HVAC and plumbing system of BAU

Heat source type and specification is Air-cooled split type COP 2.52

Air conditioning type for resort and hotel is 'Air-cooled split type'. Air supply temperature: 13^{o}C.

Simulation tool

FACES 4.37.0 (Japan)

11.7.2 Results from simulation of BAU

Electricity consumption for Hotel in SAMUI is estimated around 181,027,000 [kWh/year], total rooms around 16,000 rooms with approx. floor area 750,000 [m^2] (estimated from room numbers). Therefore, electricity consumption per unit area is 241 [kWh/(m^2・year)].

Coefficient value of Primary energy consumption in SAMUI is not clear. If it is 9,970 [MJ/kWh], Primary energy consumption is 2,400 [MJ/(m^2・year)].
Energy consumption of BAU model is set to equal above.

Figure 11-32 shows the breakdown of CO_2 emission for the model under BAU. Annual CO_2 emission per floor area is about **137 CO_2-kg/(m^2·year)** for BAU without any carbon reduction measures.

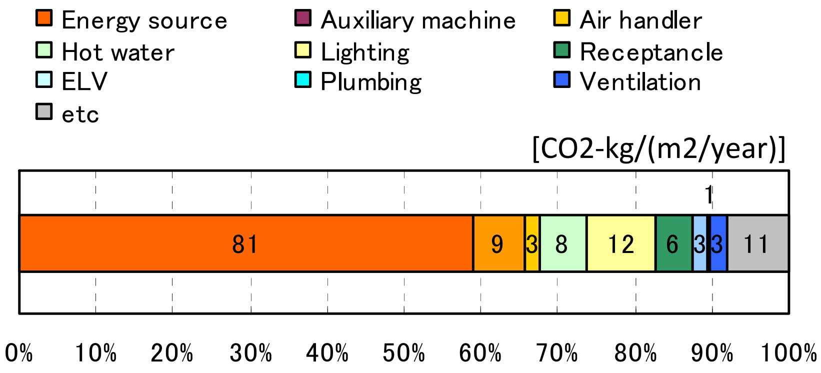


FIGURE 11-32 : CO_2 Emission for BAU

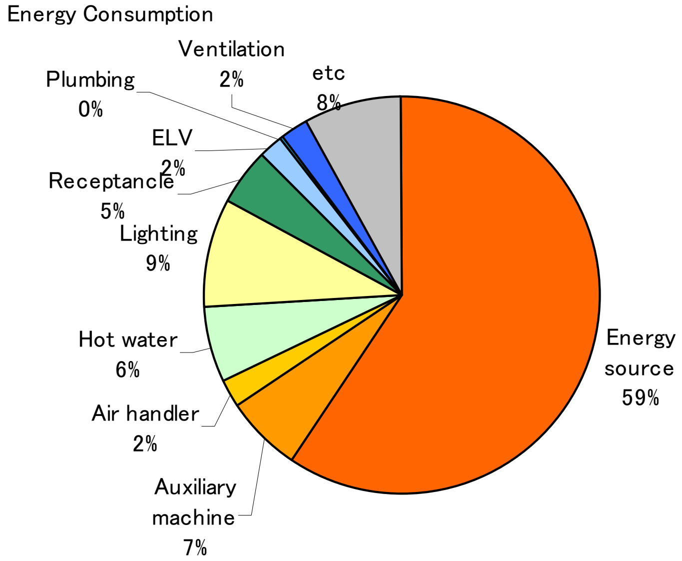


FIGURE 11-33 : Primary Energy Annual Consumption Constituent Ratio of BAU

11.7.3 Prediction of CO2 Reduction Effects of Low Carbon Measures

Low energy Measure in building

Table 11- 13 shows Low energy measure in building for calculation model.

TABLE 11-13 : Low energy measure in building for calculation model

No.	Business as usual (BAU)	Energy-saving case by 2020
	Load Reduction measures	
1	Window area ratio 0.7	0.5
2	Heat transmission coefficient of Wall 3.730 W/(m² ・K)	See Note 1 1.018 W/(m² ・K)
3	Heat transmission Coefficient of Roof 0.839 W/(m² ・K)	See Note 2 0.525 W/(m² ・K)
4	Clear Float Glass type 6.18W/(m² ・K) SCR 0.89, SCC 0.04	Low-E Glass type: AF6mm+Air6mm +heat reflective glass6mm 3.4 W/(m² ・K), SCR0.63, SCC0.07 -With blind 2.97 W/(m² ・K), SCR0.25, SCC0.21
5	Room temp. : 24 ^{o}C	27 ^{o}C
	Natural Energy Use	
6	Non Natural ventilation	Outdoor air cooling
7	Non Day light use	Daylight use
8	Non installing	Solar hot water
9	Non	Pond cooling Water-cooled variable Refrigerant Flow (VRF) System
	High Efficiency & Technology	
10	Air-cooled Split type 1.4 kW/RT (COP 2.52)	Split type with inverter compressor. 1kW/RT (COP3.52)
11	Non installing	Fresh air box to exchange heat between exhaust air and intake air
12	Fluorescent lamp	LED
13	Standard ventilation	CO_2 control
14	Standard Elevator	VVVF control
15	Standard ON/OFF of lighting	Lighting control by human sensor
16	Standard ON/OFF of lighting	Automatic control of lighting schedule
17	Non installing	Controlling of initial illumination correction
18	Standard type	Water saving sanitary fixture
19	Standard	INV control on water supply pump
20	Operation by human oriented	Support by BEMS

Note: 1. Heat transmission coefficient of wall

Material Details	Thickness	Conductivity , k	Resistance , R	Total R	U
	(mm)	(W/mK)	(m^2K/W)	(m^2K/W)	(W/m^2K)
Outside Air Film	-	-	0.044		
Sand cement plaster	20	0.72	0.028		
Concrete block	70	1.442	0.049		
24 kg/m³ Fiberglass with Al Foil	25	0.035	0.715		
Sand cement plaster	20	0.72	0.028		
Inside Air Film	-	-	0.120	0.983	1.018

Note 2: Heat transmission coefficient of roof

Material Details	Thickness	Conductivity , k	Resistance , R	Total R	U
	(mm)	(W/mK)	(m^2K/W)	(m^2K/W)	(W/m^2K)
Outside Air Film	-	-	0.055		
Concrete slab	300	1.442	0.208		
24 kg/m³ Fiberglass with Al Foil	50	0.035	1.429		
Gypsum board	10	0.191	0.052		
Inside Air Film	-	-	0.162	1.906	0.525

Results from simulation of Low Carbon Measures

CO_2 reduction effects with more than one low carbon measure are to be assessed to validate the feasibility of CO_2 reduction target for buildings of 30% reduction by 2020.

The effects of low carbon measures were determined for the model hotel. Figure 11-34 shows CO_2 reduction effects from the measures adopted.

It was revealed that about 33% of CO_2 reduction from BAU was to be achievable with all measures combinations in the figure.

Water-cooled type HVAC system is adopted because pond cooling is one of available measures in SAMUI. Although CO_2 emission is increase because of pump electricity.

The accomplishment of the CO_2 reduction target is expected through low carbon measures based on the results when buildings are planned, designed, constructed, used and renovated.

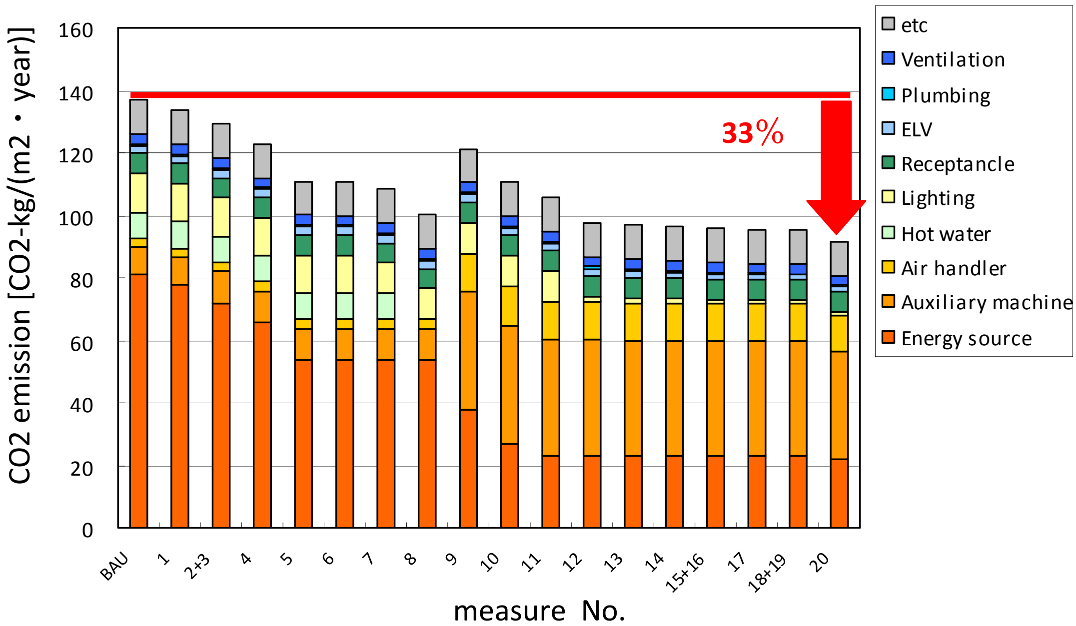


FIGURE 11-34 : CO_2 Reduction Effects of Low Carbon Measures

11.8 Carbon Emission Reduction for Low Carbon Building

Energy Effectiveness

Present Electricity Consumption in SAMUI (BAU) 241 [kWh/(m^2・year)]

Proposed Design Electricity Consumption (33% saving) 161.47 [kWh/(m^2・year)]

The proposed low carbon building is recommended by concerning about owner's worthiness and interest. Therefore this concept is recommended for hotels and resorts in SAMUI Island especially for the medium to large scale hotel (50 rooms or above) and every resort. For the small size hotels, selectable measures should be carefully considered according to the conditions of each type and size of the hotels. From the survey information dated January 5, 2009; estimating 180,000 m^2 of resorts and 270,000 m^2 of hotels potentially applied the concept.

The government office has a good potential and possibility for low carbon building application since the government can fully support and boost up the low carbon building concept. There are approximately 30,000 m^2 of major offices located around the island.

Cost Effectiveness of Low Carbon Building Measures

Government Building:

The estimated investment cost for the proposed design is 94.73 USD/m^2.

*Based on adding 2 inches insulation for roof and wall, changing lighting fixture, A/C system and toilet as shown in proposed design for Low Carbon Government Building Model

Resort:

The estimated investment cost for the proposed design is 271.15 USD/m^2.

*Based on proposed design for Low Carbon Resort Model

Hotel:

The estimated investment cost for the proposed design is 296.06 USD/m^2.

*Based on proposed design for Low Carbon Hotel Model

Recommendation on the implementation of low carbon building measures

Low carbon building concept is recommended to implement with all major government offices on SAMUI Island. Voluntary scheme with incentive mechanism should be introduced to encourage the hotels and resorts to build or renovate their places to meet with low carbon guidelines. If 30% of the hotels and resorts participate in the scheme by Y2020 and another 30% by Y2030 the amount of CO_2 emission reduction would then be expected as indicated in Table 11 – 14.

TABLE 11- 14 : Estimated amount of CO_2 emission reduction and investment cost

Type of Building	Estimated total area (m^2)	Estimated implemented area (m^2)			Estimated CO_2 emission reduction (ton CO_2/year)			Cost per m^2 (USD)	Total (USD)
		Y2020	Y2030	Total	Y2020	Y2030	Total		
Government	30,000	30,000	-	30,000	1,357	-	1,357	94.73	2,841,900
Resort	300,000	90,000	90,000	180,000	4,072	4,072	8,144	271.15	48,807,000
Hotel	450,000	135,000	135,000	270,000	6,108	6,108	12,216	296.06	79,936,200
Total							21,717		131,585,100

Note : CO_2 emission reduction rate for low carbon building = 33% of conventional building (241 x 33% = 79.53 kWh/m^2/year or 45.25 CO_2 –kg/m^2/year) – refer to the result from energy simulation program -

12. Eco-Lifestyle

12.1 Overview of SAMUI's Conventional and Eco-Lifestyles

Lifestyle of people in SAMUI is one of the most important factors for the successful implementation of low carbon town development project at SAMUI Island. People in SAMUI include not only SAMUI citizen but also tourists and business providers. If there is no behavioral change among all stakeholders, there will be no one using the technologies and measures for carbon reduction previously proposed "*in practice*". Hence, eco-lifestyle is a very crucial bottom-up or people-driven measure (demand side) to reduce CO_2 emissions as well as other negative environmental impacts. The technology-driven approaches lead to "**sustainable production**" while the people-driven approaches lead to "**sustainable consumption**". Both approaches are required to actually achieve sustainable and low carbon SAMUI. As shown in Chapter 2 and 3, conventional lifestyle of people in SAMUI with the existing trends in energy, material and water consumption will definitely increase carbon emissions as well as other pollutions from waste and wastewater production. Furthermore, in SAMUI the current electricity facilities will be critically in short of supplies and the current waste and wastewater management is ineffective resulting in environmental problems.

Towards low carbon society in SAMUI, environmental awareness of SAMUI citizen, business providers and tourists shall be increased and eco-lifestyle (people living their lives with sustainable manners) shall be promoted. This chapter describes the concept of eco-lifestyle and proposes measures and targets for different eco-lifestyle index.

12.2 Conceptualization of Eco-Lifestyle

12.2.1 Eco-Lifestyle

Eco-lifestyle is defined as "*sustainable and responsible lifestyle which aims at reducing negative impacts, or increasing positive benefits from living our lives on the environment, society and economy*" (adapted from TEATA et al., 2010). The framework for eco-lifestyle with responsibility and sustainability is illustrated in Figure 12-1.

To make the eco-lifestyle concept being effectively applied, the core business of SAMUI – "TOURISM" need to be taken into account. The important aspects are needs of the tourists shown in Figure 12-2 whereas Figure 12-3 illustrates three legs of certification programmes for sustainable and ecotourism. As a result, the additional factors of "**quality**", "**health, hygiene, safety**", "**accessability**" and "**acceptable prices for value offered**" should be considered at the same time. Nevertheless, these factors are mentioned here as notation because tourism business generally needs to include those additional factors by nature. The focus in this chapter is on the sustainablility aspect.

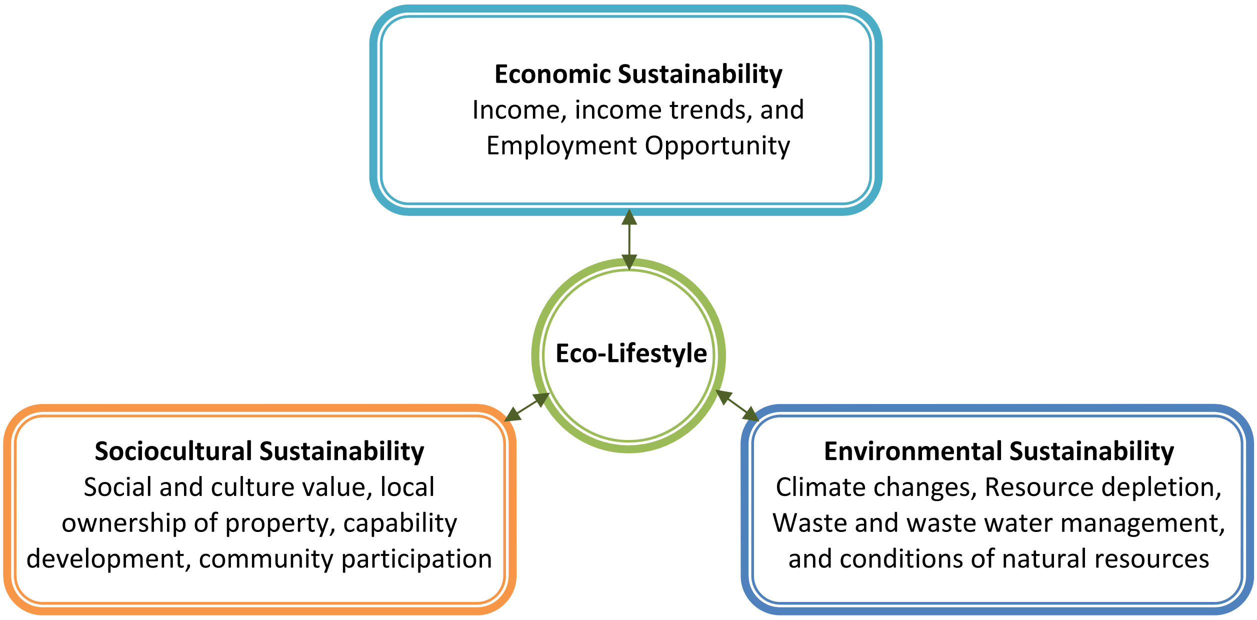


FIGURE 12-1 : Orginal framework for Eco-Lifestyle
(Modified from sustainable eco-tourism in Jitpakdee and Thapa, 2012)

FIGURE 12-2 : Needs of the tourist
(CESD, 2006)

FIGURE 12-3 : Three legs of certification programmes (Toth, 2002 as cited in CESD, 2006)

In order to set up measures and targets for eco-lifetyle, eco-lifestyle indexes are identified as shown in Table 12-1. The indexes primarily focus on environmental sustainability. To the less extent economic and sociocultural indexes are included as well. Afterwards, the interconnection of eco-lifestyle concept, indexes, measures and targets is drawn as illustrated in Figure 12-4.

TABLE 12-1 : Eco-Lifestyle Indexes

No.	Eco-Lifestyle Index	Unit
1	CO_2 emission	% Reduction
2	Total energy consumption (Electricity and heat)	% Reduction
3	Fuel consumption	% Reduction
4	Water consumption	% Reduction
5	Material consumption (Other materials excl. fuels and water)	% Reduction
6	Waste generation	% Reduction
7	Reusing rate	% of Total waste generation
8	Recycling rate	% of Total waste generation
9	Repairing rate	% of Total waste generation
10	Cost savings	% (Only from selected measures; e.g., energy-fuel-material consumption reduction)
11	Employment opportunity from eco-services, eco-hotels and eco-activities	Number of workers
12	Social and cultural value	Number of eco-services and eco-activities which provide a program (or tour) for visitors to gain social and cultural value from local communities in SAMUI Island
13	Community participation	Number of SAMUI Citizens involving in eco-services, eco-hotels and eco-activities

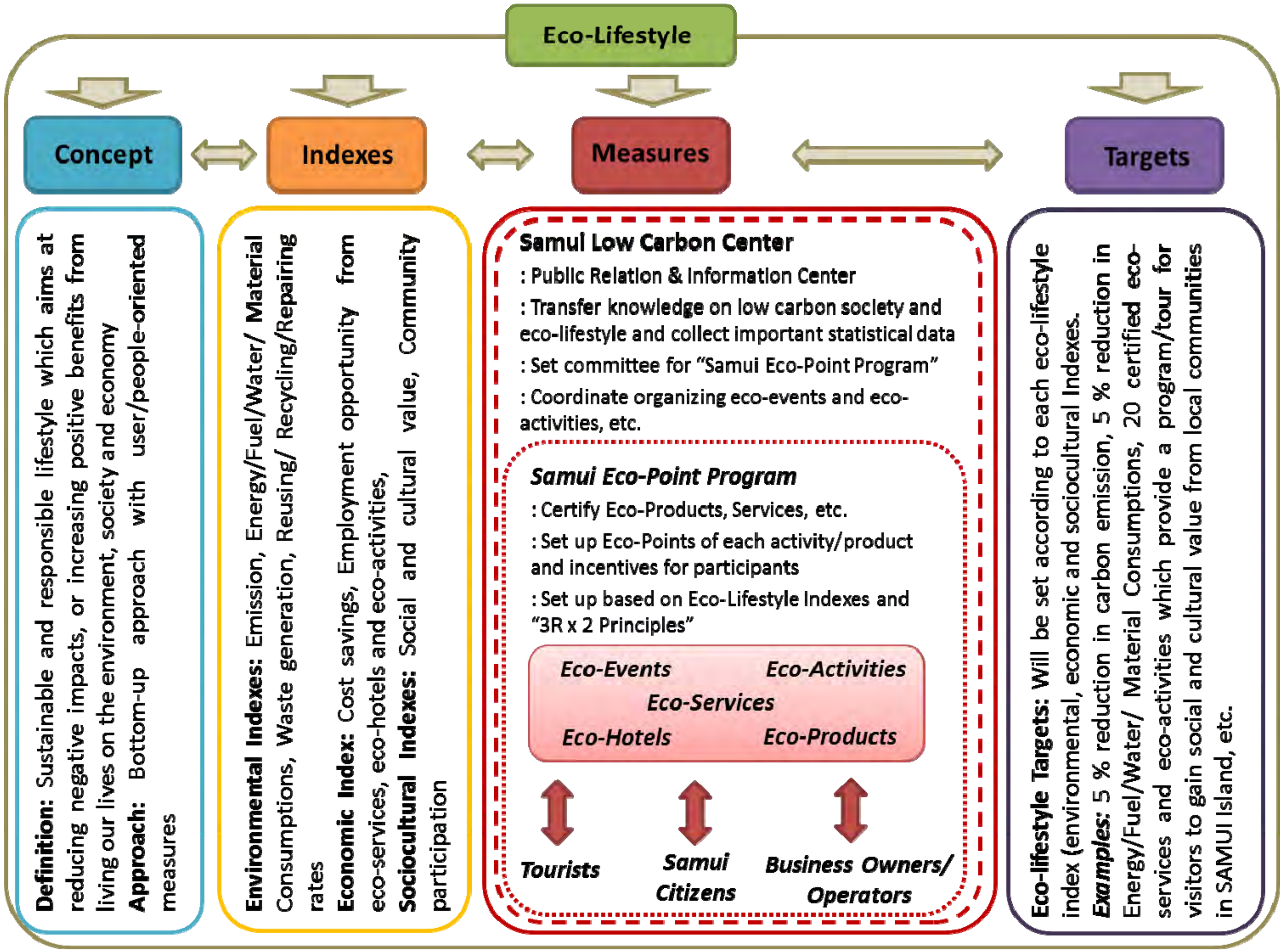


FIGURE 12-4 : Interconnection of eco-lifestyle concept, indexes, measures and targets

12.2.2 Low Carbon Lifestyle

Low carbon is the core environmental issue in this study. Low carbon lifestyle is a part of eco-lifestyle. The specific eco-lifestyle index towards low carbon SAMUI Island is the % reduction in $C0_2$ emissions.

12.3 Measures and Targets

The development of eco-lifestyle measures is different from one of the low carbon measures in the previous chapters. For eco-lifestyle, they are stakeholder-driven measures (bottom-up approach). Other low carbon measures are technology-driven and primarily based on top-down approach. The key stakeholders in SAMUI Island include visitors, SAMUI citizens and business operators/owners. In this section, the eco-lifestyle measures and targets for eco-lifestyle indexes for the key stakeholders are presented.

12.3.1 SAMUI Eco-Logo

To visualise ecolifestyle of visitors, SAMUI citizens and business operators/owners in SAMUI Island, the SAMUI eco-logo should be designed. The common and effective approach for obtaining the logo while promoting eco-lifestyle and low carbon measures is to set up competition for designing the SAMUI eco-logo.

The examples of ecolabels for tourism certificaton programmes in Thailand, Europe, and the US are shown in Table 12-2.

TABLE 12-2 : Different ecolabels for different products/businesses

No.	Eco-label	Name & Type of Business	Operator	Criteria Emphasis	Other description	Reference
Thailand						
1		**Green Label** *Type of Business:* Products	Thailand Environmental Institute (TEI)	Conservation of resource, reduction of pollution and waste management in production process until disposal.	*Launch Date:* August 1994 *Number of Participants:* 507 Models 25 Products Category and 75 Companies *Evaluation Method:* Third-party certification *Certification Fee:* 1,000 Baht for an application fee and after approved the applicant have to pay 5,000 Baht for a license. The contract time period for 2 years or until the criteria is re-evaluated. *Levels of Certification:* 1 level The green label is given after ensuring that the application is completed and met all criteria and also passes the investigation of criteria fulfillment.	http://www.tei.or.th/greenlabel/ * Number of participants as of 31 July 2011
2		**Green Leaf*** *Type of Business:* Hotels	Green Leaf Foundation (jointly established by Tourism Authority of Thailand, Thai Hotels Association; United Nations Environment Program, Demand Side Management Office of Electricity Generating Authority of Thailand (EGAT), Association for the Development of	Reduce environmental Impacts (Also aim to improve efficiency in saving energy, water and other resources)	*Launch Date:* At the end of 1997 *Number of Participants:* 669 hotels (in 2012) *Evaluation Method:* Self-assessment with third-party audit *Levels of Certification:* 5 levels The certification considers policy and standards of environmental practice; waste management; efficiently use of energy and water, purchasing, in-door air quality, air pollution, noise pollution, quality of water, storage and	http://www.greenleafthai.org/en/ * Green Leaf Standard for ASEAN

No.	Eco-label	Name & Type of Business	Operator	Criteria Emphasis	Other description	Reference
			Environmental Quality, Metropolitan Water works Authority		management of fuel, gas, and toxic waste, Impact on eco-system, cooperation with community and local organizations	
3		**Carbon Reduction Label** *Type of Business:* Products and services (Domestic market)	Thailand Greenhouse Gas Management Organization (Public organization; TGO), Thailand Business Council for Sustainable Development (TBCSD), and TEI	Reduction of greenhouse gas emissions (Considering only production processes)	*Launch Date:* 2008 *Number of Participants*:* 159 products (from 41 companies) *Evaluation Method:* Third-party certification *Certification Fee:* 100,000 THB/product for 3 years; renewal every three year *Levels of Certification:* 5 levels depend on the percentage of GHG emission reduction	http://thaicarbonlabel.tgo.or.th/carbonlabel/; http://www.tei.or.th/carbonreductionlabel/age.html ;http://www.tei.or.th/publications/2011-download/2011-carbonlabel.pdf * Number of participants as of April 2012
4		**Carbon Footprint Label** *Type of Business:* Products	TGO	Greenhouse gas emissions as unit of CO_2 equivalent	*Launch Date:* 9 April 2010 *Number of Participants:* 506 products (from 124 companies) *Evaluation Method:* Third-party certification *Certification Fee:* 8,500 THB/product *Levels of Certification:* The value of GHG emissions will be documented on the label. This label has 2 years period.	http://thaicarbonlabel.tgo.or.th/carbonfootprint/ * Number of participants as of August 2012

No.	Eco-label	Name & Type of Business	Operator	Criteria Emphasis	Other description	Reference
5	 *	**Energy Label No.5** *Type of Business:* Products	Electricity Generating Authority of Thailand (EGAT)	Reduction of Energy consumption	*Launch Date:* 20 September 1993 *Number of Participants:* There are 2 main participants; Habitat session (11 type of products implemented between year 1994-2010) and Business session/ Industrial session *Evaluation Method:* Third-party certification; Approved by EGAT *Levels of Certification:* 1 level For Energy label, there are specific Minimum Energy Performance Standard of products for each appliance.	http://labelno5.egat.co.th/index.php?lang=en * The indicators for different products are not the same
6		**Crown Standard** *Type of Business:* Thai CDM Projects	TGO	Greenhouse gas emissions	*Launch Date:* 2009 *Number of Participants:* 24 projects *Evaluation Method:* Third-party certification *Levels of Certification:* 1 level This standard has approach score for projects. 1. Score of Environmental category must approach "B" level 2. Score of Social category; There are 3 items to approach - Item 1 has to equal to or higher than 1 - Item 2 has to equal to or higher than 1 - Item 3 has to equal to or higher than 2 *Additional information:* The projects which had been approved and given Letter of Approvals (LoAs) before 1st December 2009 can apply	http://www.tgo.or.th/english/index.php?option=com_content&view=category&id=42&Itemid=13 * Number of participants as of 7th February 2012

No.	Eco-label	Name & Type of Business	Operator	Criteria Emphasis	Other description	Reference
					without any fee. This standard has contract period for 3 years.	
7		**CoolMode** *Type of Business:* Textile products	Thailand Greenhouse Gas Management Organization (TGO), Thailand Textile Institute (THTI)	Safety, quality, durability, and heat ventilation that help to decrease GHGs emissions from use of air-conditioning	*Launch Date:* June 2009 *Number of Participants:* 6 companies with 18 types of textile products. *Evaluation Method:* Third-party certification *Certification Fee:* 1) Application form: 500 THB 2) Examination fee: 10,000 THB/fabric structure 3) Administrative fee for using CoolMode label: 15,000 THB per fabric structure for 2 yrs & 5,000 THB per each additional fabric structure for 2 yrs. *Levels of Certification:* 1 level	http://thaicarbonlabel.tgo.or.th/coolmode/ * Number of participants as of 1st January 2012
Global						
8		**Green Globe** *Type of Business:* Variety of entities in travel and tourism sector	EC3 Global	Economic, environmental , and social sustainability	*Launch Date:* Established 1994 *Evaluation Method:* Third-party certification *Levels of Certification:* Platinum, gold, silver, bronze - benchmarked	Poser (2009); www.ec3global.com/products-programs/green-globe/Default.aspx

No.	Eco-label	Name & Type of Business	Operator	Criteria Emphasis	Other description	Reference
9		**STEP** (Sustainable Tourism Eco-Certification Program) *Type of Business:* Tour operators, accommodations, attractions, transportation service providers	Sustainable Travel International	Economic, environmental , and social sustainability	*Launch Date:* Feb 2007 *Number of Participants*:* 10, approx. *Evaluation Method:* Self-evaluation; Third-party certification for highest level *Certification Fee:* Based on annual gross revenue for overall annual operations; range $200-$2500 *Levels of Certification:* Level of certification denoted by 1 to 5 stars	Poser (2009) * Number of participants as of April 2009
Europe						
10		**EU Ecolabel** *Type of Business:* Products and services	EU Ecolabelling Board and European commission	Environmental sustainability	*Launch Date:* 1992 *Number of Participants:* There are 16 product categories with more than 17,000 EU Ecolabel products in the market* *Evaluation Method:* Third-party certification *Certification Fee:* There are 3 types of application fee. 1. Micro-enterprises: One-off application fee (€) = 200-350; Annual fee (€) = Max.350 2. SMEs and firms from developing countries: One-off application fee (€) = 200-600; Annual fee (€) = Max.750 3. All other companies: One-off application fee (€) = 200-1200; Annual fee (€) = Max.1500	http://ec.europa.eu/environment/ecolabel/ * Number of participants as of July 2012

No.	Eco-label	Name & Type of Business	Operator	Criteria Emphasis	Other description	Reference
					Levels of Certification: 1 level and there is EU Ecolabel Communication Award for the best practice of Ecolabel license holders.	
US						
11		**Travel Green Wisconsin** *Type of Business:* A variety of tourism businesses & organizations in WI	WI Dept. of Tourism and WI Environmental Initiative (Government –non-profit partnership)	Economic, environmental , and social sustainability	*Launch Date:* 2007 *Number of Participants*:* 208; 85 of those are lodging *Evaluation Method:* Self-evaluation *Certification Fee:* Based on FTEs; range $75-$950; yearly *Levels of Certification:* Sliding scale of "greenness"	Poser (2009) * Number of participants as of April 2009 FTEs = Full Time Equivalent Employees
12		**Virginia Green** *Type of Business:* Lodging, restaurants, convention centers, conference centers, travel & partner organizations, etc.	VA Tourism Corp., VA Hospitality & Tourism Assoc., & VA Dept. of Environmental Quality	Reduce environmental impacts	*Launch Date:* September 2006 *Number of Participants*:* ~ 413 total; 250 of those are lodging *Evaluation Method:* Self-evaluation *Certification Fee:* Free *Levels of Certification:* 1 level	Poser (2009) * Number of participants as of April 2009
13		**Florida Green Lodging** *Type of Business:* Lodging	FL Department of Environmental Protection	Reduce environmental impacts	*Launch Date:* 2004 *Number of Participants*:* 419 certified; 390 applicants *Evaluation Method:* Second-party certification *Certification Fee:* Free *Levels of Certification:* 3 levels noted by 1, 2 or 3 palm trees	Poser (2009) * Number of participants as of April 2009

12.3.2 SAMUI Low Carbon Center

SAMUI low carbon center – the public relation center of “Low Carbon Model Town Phase II project in SAMUI Island” should be found to fullfill various purposes as follows.

- Encourage and facilitate all stakeholders to engage low carbon activities initiated by this project by addressing the environmental, social and economic benefits from the involvement
- Gather, transfer and exchange knowledge and experiences on climate change mitigation and adaptation, and low carbon actions/businesses/communities
- Collect statistical data including all controlled parameters for low carbon and sustainable society listed in Chapter 3
- Set committee for “SAMUI Eco-Point Program”

The diagram visualising all components of SAMUI Low Carbon Center is shown in Figure 12-5. SAMUI Low Carbon Center can also work as the center for community environmental conservation network as proposed in Chapter 5. The recommended location of SAMUI Low Carbon Center is illustrated in Figure 5-8 of Chapter 5.

Towards effective public relations, the “7c’s of communication” from Scott et al. (1971) is applied as follows.

- ***Credibility:*** To build the credibility by communicating and transferring knowledge of low carbon society and eco-lifestyle with sufficient scientific background and cooperation with relevant experts in the field.
- ***Context:*** A communication program must align with the existing businesses and the culture of SAMUI Communities. If there are contradictory, the rationale should be clearly explained to the public.
- ***Content:*** The center should clearly communicate the role and responsibility of each stakeholder including tourists, SAMUI citizens,business owners/operators in eco-lifestyle aswell as the benefits they would gain from participation.
- ***Clarity:*** The message should be simple & easily understandable. All information should be communicated to the public with non-technical documents.
- ***Continuity and Consistency:*** The center should communicate to the public continuously (e.g., via monthly newsletters). In order to make everyone understand, it requires repetition of communications.
- ***Channels:*** At the beginning, the center should identify and use the channels which have been established, applied and respect prior to creating new channels of communications which may be harder to gain attention.
- ***Capability of audience:*** The center should design communication program specifically for each type of recipients. Since capability of different audience

is not the same, the ways to communicate must be adjusted according the targeted audience.

In general, channels or options for public relations are publicity, newsletters, leaflets, direct mail, posters, flyers, stickers, events, internet sites, competitions, lobbying, community meetings/ announcements, open days, annual reports, videp/photography, sponsoerships and exhibitions, etc.

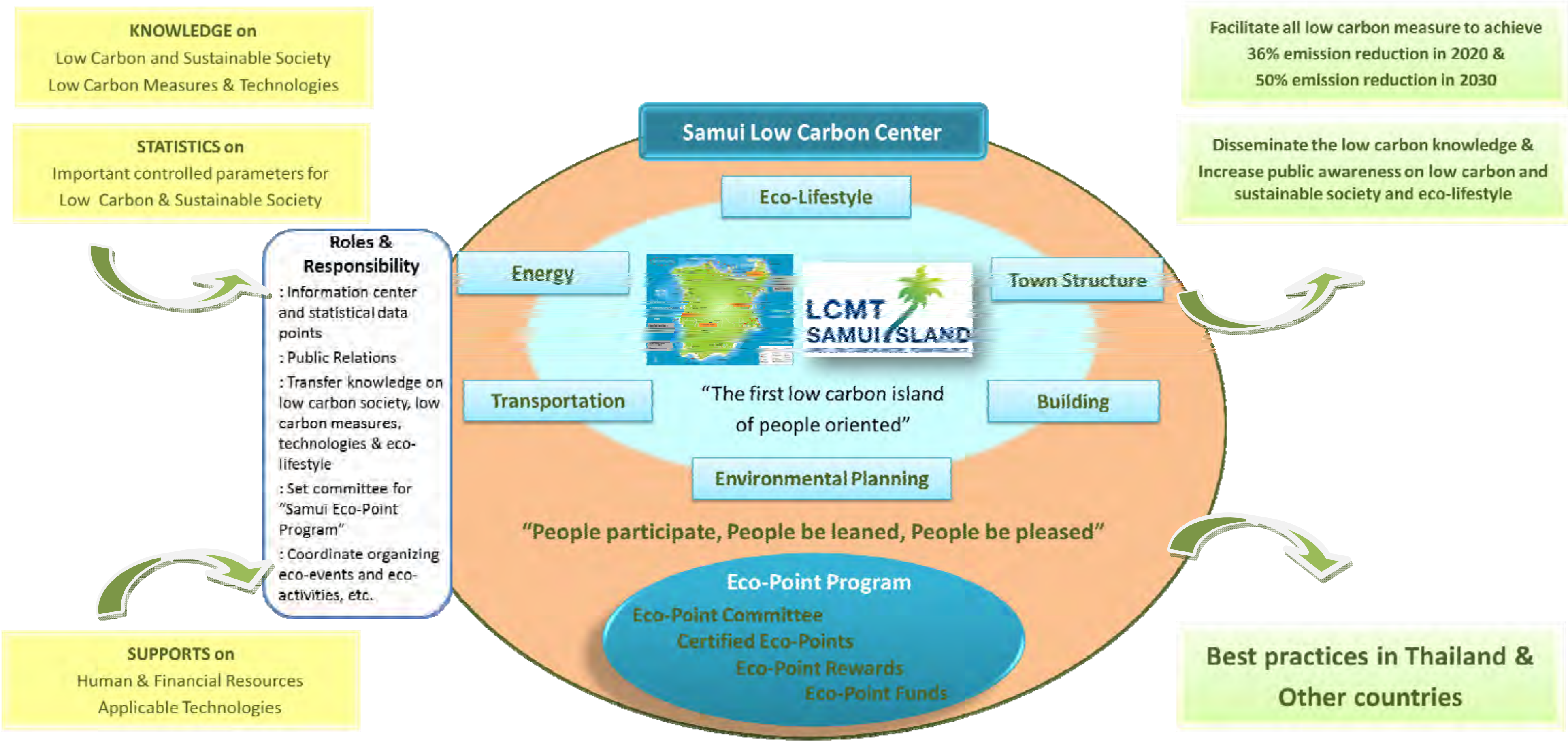


FIGURE 12-5 : Visualisation of SAMUI Low Carbon Center

12.3.3 Eco-Point Programme

Eco-point program which was originally developed and implemented by Japanese Government since 2009 for green home appliances can be applied to promote eco-lifestyle measures by giving points to those who purchase eco-products, stay in eco-hotels and pay for eco-services, and/or involve in eco-activities. In order to certify all eco-measures with eco-points, the SAMUI low carbon center should be responsible for setting up eco-point program committee. Moreover, the common components of certification programmes from Honey (2008) in Table 12-3 are also taken into consideration in the development of framework for eco-point program.

TABLE 12-3 : Common components of certification programs from Honey (2008)

No.	Common components of certification programs in the travel and tourism industry
1	***Voluntary enrolment:*** The certification programs are voluntary (i.e., businesses can decide whether to join the program). The benefits for business sector are that the certification can i. provide technical assistance, ii. facilitate adaptation of cost-saving measures, iii. bring market distinction, and iv. ward off government regulation and consumer boycott
2	***Logo:*** The logo, seal or brand given by certification programs could help businesses to be recognizable to consumers. Most permit the logo to be used only after certification is achieved and for a specified period of time before another audit is required. Many certification programs give logos for different levels of achievement potentially encouraging continual improvement by the business
3	***Standards and criteria:*** The standard is a document approved by authorized organization prescribing set of rules, conditions or requirement. The criteria (and indicators) are the specific measurements against which a business is being judged. All certification programs require that businesses be assessed by measuring their level of compliance with prescribed criteria that either comply with or go beyond government regulations. As described above, the criteria can be viewed as a three legged stool of safety, quality and service, and sustainability (see **Figure 12-3**).
4	***Assessment and auditing:*** All certification programs award logos based on some kind of assessment or audit. This can be first-party, by the company itself, typically by completing a written questionnaire; second party, i.e. by an industry association; or third-party, by an independent organization, usually multiple-stakeholder, that is not connected with either the company seeking certification or the body that grants certification and issues the logo. Auditing can be done by a review of the written materials submitted by the business or on-site. Third-party assessment and on-site auditing is considered the most rigorous and credible because it avoids any conflict of interest (Conroy, 2007).

No.	Common components of certification programs in the travel and tourism industry
5	***Membership and fees:*** While many 'green' certification programs are initially financed with start-up funds from governments, NGOs, international financial institutions or foundations, the long-run aim is to make them self-supporting. This can come, at least in part, through charging an enrolment fee to those businesses seeking certification. However, this is likely to be insufficient beyond the start-up phase, and therefore on-going sources of additional funding are necessary to enable certification programs to be effective.

The overall framework for eco-point program is illustrated in Figure 12-6

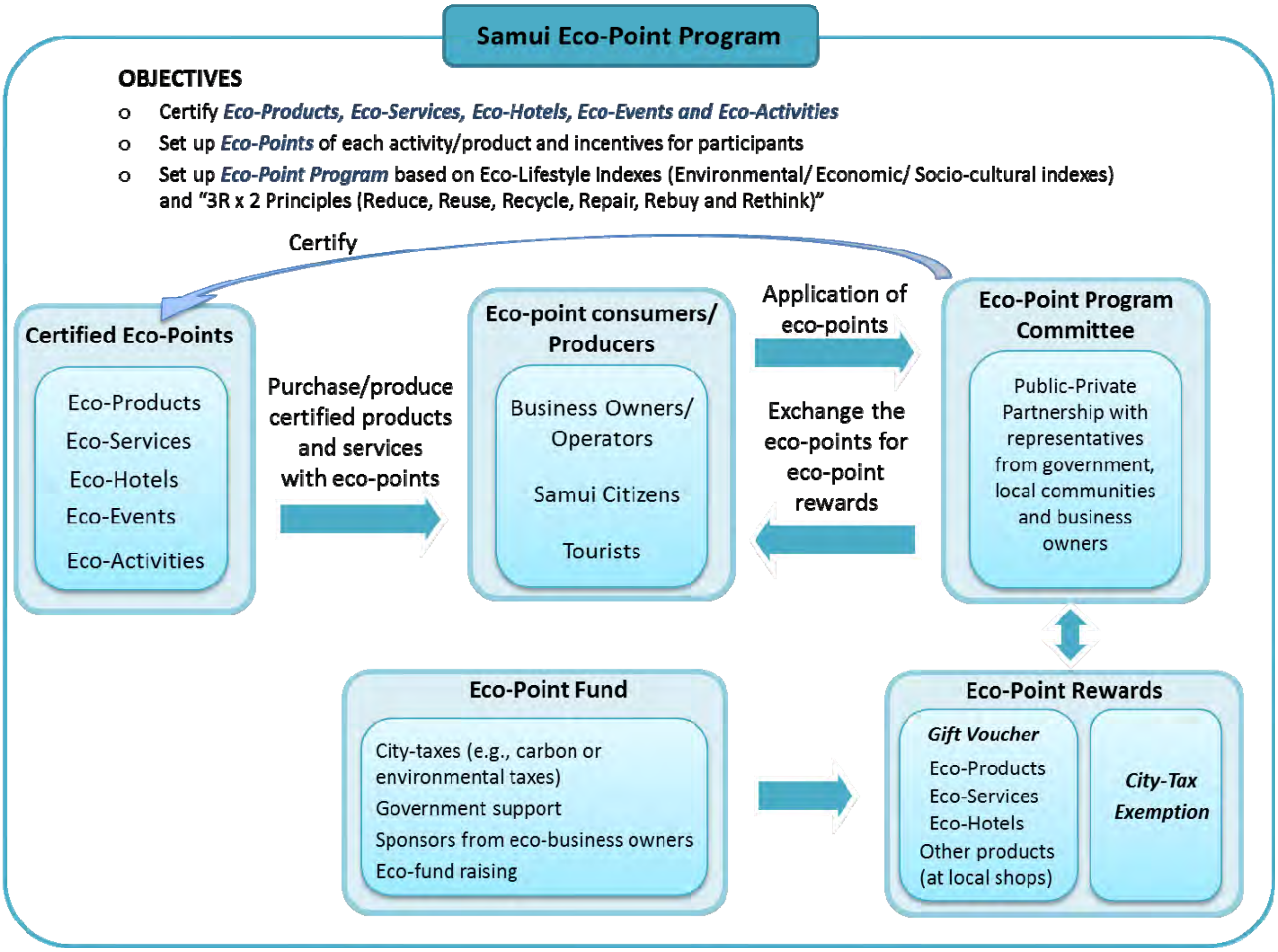
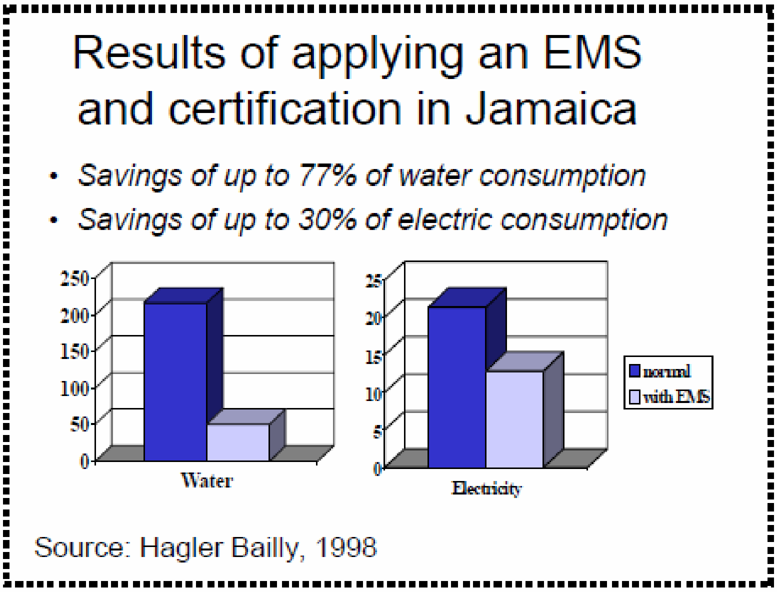


FIGURE 12-6 : Overall framework for eco-point program (Modified from Hosaka, 2010)

This eco-point program is voluntary basis and the logo will be the SAMUI's eco-logo described in the former section. For standards and criteria, it can be set-up based on the eco-lifestyle indexes in Table 12-1. Examples of standards and criterias for exisitng certification programs in Thailand are documented in Annex 13. The eco-point program committee will be responsible for the assessment and auditing. The membership and fees can be added to the eco-point rewards which will be obtained from eco-businesses and city taxes. The eco-points can be exchanged for specific eco-services and eco-products (as gift voucher) and/or city tax exemption funded by government, city taxes, the eco-business partners and public. City taxes can be set up by SAMUI municipality to charge high carbon emitters and environmental polluters. The eco-business partners can benefits by increase in their revenues due to their eco-services.

Overall incentives of eco-point program are shown in Table 12-4

TABLE 12-4 : Benefits certification via the eco-point program (taken from the benefits from certification for sustainable tourism and ecotourism in CESD, 2006)

No.	Benefits from certification via eco-point program
1	**Benefits from certification for eco-businesses** o Improve themselves e.g., to teach the businesses the elements of sustainability in their operations and to focus their attention on the required changes. A better-operating business tends to be more efficient and to attract more clients o To potentially reduce operating costs. In tourism, it has been shown to dramatically reduce the costs of water, electricity, and fossil fuels, without reducing the quality of service, as shown in the graph below  o To obtain technical assistance and financing for businesses to implement new technologies – the business is educated about these technologies, while donors and financial institutions are more likely to offer low-cost financing

No.	Benefits from certification via eco-point program
	o To provide a marketing advantage to certified businesses, as consumers learn to recognize credible certification brands
2	**Benefits from certification for consumers** o Provides tourists with environmentally and socially responsible choices – it helps consumers to know which businesses are truly socially and environmentally responsible and to make choices on this basis. As certification programs become better known, this may produce tangible benefits in a business's reputation and popularity o Increases public awareness of responsible business practices o Alert tourists to the environmental and social issues in an area, allowing them to act more respectfully or contribute to solutions o Potentially offer better quality service
3	**Benefits from certification for governments** o Helps governments protect their market niches as ecotourism or sustainable tourism destinations, especially when the credibility of the destination is threatened by green-washing o Certification raises industry standards in health, safety, environment, and social stability o It lowers the regulatory costs of environmental protection o By requiring economic benefits to communities, certification can help reduce poverty, especially in rural areas
4	**Benefits for the environment and local communities** Certification requires the businesses o To protect the environment and to be economically sustainable o To offer services with high quality o To respect local culture and provide real economic and social benefits for it

12.3.4 Encouraging "3 Rs X 2" Principles

One of the important measures for eco-lifestyle is to encourage "3Rs X 2" Principles. Conventional 3Rs include reduce, reuse and recycle. Recently, other Rs have been introduced as the forth "R" to increase the sustainable consumption and waste management. The other Rs are repair (sometimes called recover), rebuy and rethink. The decsription of "3Rs X 2" Principles are briefly described in Table 12-5 The "3Rs X 2" Principles are applied in eco-activities as later shown.

TABLE 12-5 : “3 Rs X 2” Principles

3Rs X 2	Description
REDUCE	REDUCE the waste generation and the use of energy, fuels, water, other materials and natural resources Reduce the amount of waste that we produce each day by using less or eliminating waste at source through better planning and design. Reduction is the first choice in reducing the waste stream
REUSE	REUSE products/materials Instead of buying disposable items, try to purchase and use items that can be reused to eliminate unnecessary trash
RECYCLE	RECYCLE wasted products/materials The process of taking a product at the end of its useful life and using it to make another product or to re-manufacturing into its original. Another way of recycling is to purchase a product that uses recycled materials. Many materials like wood, concrete, gypsum/plasterboard, metal, plastic and paper/cardboard are easily recycled.
REPAIR	REPAIR or recover malfunctioned products
REBUY	REBUY the recycled and repaired products/materials
RETHINK	RETHINK your world – consider how to consume and live our life more sustainably by reducing the consumption, and reusing, recycling, repairing and rebuying products/materials.

12.3.5 Eco-Activities for Tourists, Local Communities and Business Operators/Owners

Eco-activities are identified based on the “3Rs X 2” Principles. The activities are for different stakeholeders - business owners, local communities and tourists. Business owners are main manufacturing/service provider which use considerable amount of resources and generate the large amount amount of waste so it is very important for business owners to find the ways to develop and improve their activities not to destroy the environment. Local communities and tourists need to be educated on the issue of environmental and impact of their activities including their purchasing decisions and consumption patterns.

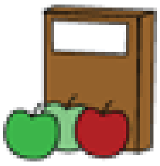
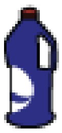
The list of activities, case studies in Thailand and recommendations for SAMUI are as following.

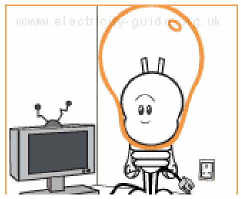
1. “REDUCE” activities

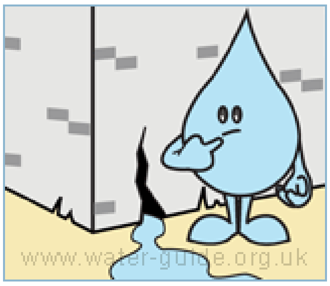
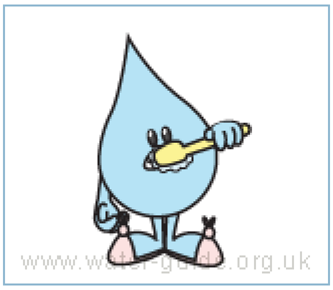
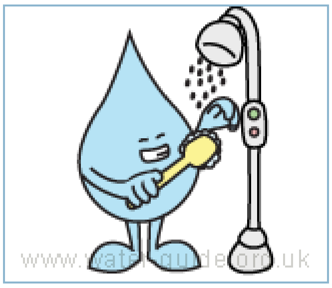
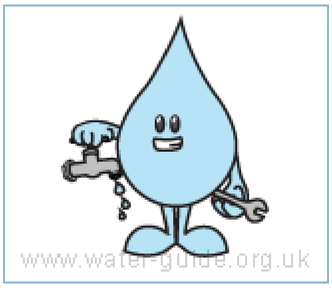
To reduce consumption of water, energy, fuels, other materials and natural resources is the first thing to do to help the environment. All stakeholders such as business owners, local communities and tourists should have awareness and responsibility in their activities which affecting the environment. They should design their activities to use less of all material. Examples of "REDUCE" activities are listed in Table 12-6 whereas case studies in Thailand are presented in BOX 12-1 to 12-2.

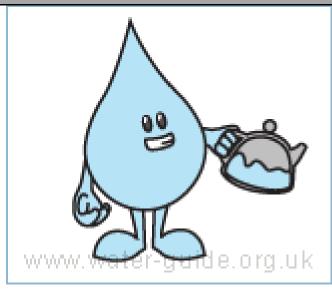
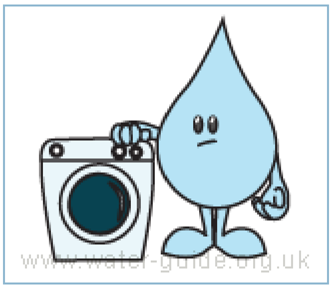
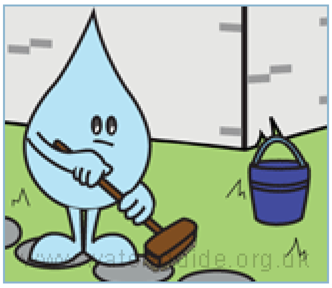
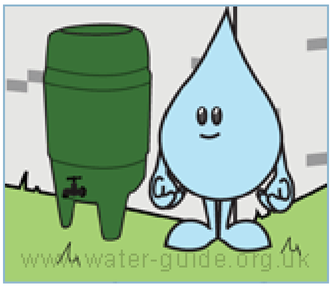
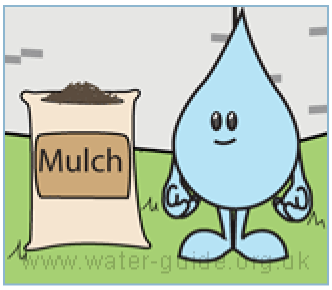
It should be mentioned that in many cases REUSE, RECYCLING and REPAIR activities can also be interpreted as REDUCE activities because the activities lead to reduction of waste generation and energy consumption. Nevertheless, in practice only eco-points should be given to one category (e.g., reduce or reuse or recycling, ect.) and not to be double-counted.

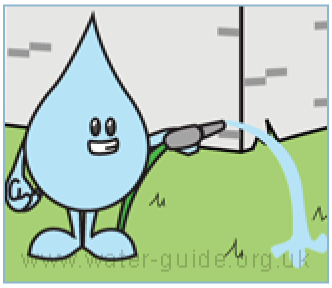
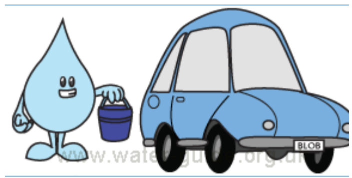
TABLE 12-6 : Examples of "REDUCE"activities.

No.	Eco-Activities
1	*Waste generation* • Buy in bulks or concentrates to reduce the material needed for packaging and can save money. • Use the reusable packaging • Reduce use of single use and disposable products where possible and choose alternatives which can be used again. For example, instead of buying bottled water on the run, take a bottle with you from home or buy rechargeable batteries. • Choose products with refillable containers. • Refuse plastic bags when you don't need them. Keep re-usable bags handy and take them to the shops. You can also use boxes or your own shopping trolley bag on wheels. • Save on plastic wraps and freezer bags in kitchen by using re-usable containers as much as possible. • Plan your meals to use items before they go out of date. Compost your food scraps or use them in a worm farm. • When building or renovating, build only what you need and think carefully about your design. Good design can make existing space more usable or comfortable. Choose durable materials and finishes as they should last longer. •  Buy only what you need: Reduce unnecessary waste by avoiding those pointless purchases. Items that rarely get used can be borrowed or shared with others. •  Buy all-purpose household cleaner: Instead of buying many different ones for each cleaning role.

No.	Eco-Activities
	 • Reduce paper waste by cancelling unwanted mail • Buy non-toxic products whenever possible: Many toxic products such as motor oil and pesticides cannot be reused. • Use all of toxic product, such as furniture polish, so there is no hazardous material left in the container when it is discarded. • Find safer alternatives to hazardous household products: You can even make your own household cleaners using products such as baking soda and vinegar. Olive oil with lemon juice is a good alternative to furniture polish and using scented candles are a good alternative to air fresheners
2	*Use of energy*  • Don’t leave electrical appliances on standby. • Install compact fluorescent light bulbs (CFLs) when your older incandescent bulbs burn out. • Using Fluorescent which can reduces use of energy and improves light quality • Adjust the air condition to 25°C (or) higher, use a fan instead of an air-conditioner or try natural air sometimes. • Install window film to lower heating and cooling loads and reduce glare in guestroom. • Install a solar system used for water heating or electricity. • Produce electricity by solar and wind power • Plant the trees around the building, 1 tree could provide cooling capacity same as air-conditioner 12,000 BTU. • Don't use electrical appliances for things you can easily do by hand, such as opening cans. • Turn off the lights, TV, or other electrical appliances when you are out of a room. • Try to hold off turning on lights during the late afternoon until it is necessary.
3	*Use of fuels* • Travel on weekdays to avoid congestion and to reduce fuel consumption. • Provide bicycles, information of public transport and walking maps for tourist • Take a walk, ride a bicycle, row a boat or use local public transportation. • Engine oil can be recycled at civic amenity sites. • Inflate your tires well. This preserves the life of the tires and saves gas, which ultimately saves money. • Find the quickest route. To avoid getting lost and to not use more gas than necessary look up where you are going before you leave.

No.	Eco-Activities	
	• Clear out your car; extra weight decreases gas mileage. • Avoid high speeds. Above 60 mph, gas mileage drops rapidly	
4	*Use of water*	
	Water saving tips in Home • Check for home for leaks, hidden water leaks can be wasting water without you even being aware of it. A good way to check for leaks is, if your property is metered, then read your water meter and do not use any water for a couple of hours and go back to check that the meter reads exactly the same. If it does not, there is a leak.	
	• Turn off tap while cleaning your teeth, shaving or washing your face. You can waste up to 9 litres a minute by just letting the water pour down the sink.	
	• Take a short shower rather than a bath could save you up to 400 litres a week. If you do have baths, just half fill them.	
	• Fix any dripping tap, you can waste 90 litres a week which will cost a lot more than what might just be the price of a new washer.	
	• Don't overfill the kettle when making a cup of tea. Only fill and boil what you need, this will save you	

No.	Eco-Activities	
	money on your energy costs too.	
	• Only use the washing machine and the dishwasher when you can put on a full load. It wastes both water and energy to run only a half full machine.	
	Water saving tips in Garden • Use a broom and bucket of water for washing down the patio rather than a steady flow of water from the hose.	
	• Install a water butt in the garden to collect the rain water. This will mean you always have water to use for watering the garden without the need to use fresh water from the hose.	
	• Using mulch on the garden with help the soil retains water so will mean you won't have to water the garden as often.	

No.	Eco-Activities	
	• Don't overuse hoses or sprinklers in hot weather. A sprinkler can use as much water in an hour as a family of four will use in a day. Your lawn only really needs watering once a week and it is better to water in the morning when the temperature is lower and evaporation is less. Research your plants, some actually thrive in drier conditions and will not benefit from over watering.	
	• Use a sponge and bucket of water to clean your car or if you use the hose, ensure you use a shut off nozzle so the water is not constantly running.	
5	*Use of other materials and natural resources*	

Source: http://www.livinggreener.gov.au/waste/recycling/reduce-reuse-recycle
http://www.recycling-guide.org.uk/reduce.html
http://ehs.columbia.edu/ReduceReuseRecycle.html
http://www.savewithces.com/365in2008.html
http://www.electricity-guide.org.uk/tips-home.html
http://www.water-guide.org.uk/

BOX 12-1 : Case Study in Thailand No.1 - "REDUCE" activities.

In Thailand, Best Care International (Thailand) Company Ltd. (2010) has organized a Zero Waste to Multi use program and Community Learning Center to teach people how to make an organic fertilizers and cleaning products, using organic waste, such as wood, leaves, branches and trash (FIGURE 12-7). This program is established in SAMUI Island to **reduce the amount of household trash** in the communities, **reduce the use of chemical for cleaning products** and provide alternative income. To encourage public participate, BCI provide a toolkit samples and lectures to introduce products to the communities.

FIGURE 12-7 : Making of Organic Fertilizer
Source: Best Care International (Thailand) Co., Ltd. 2010

BOX 12-2 : Case Study in Thailand No.2 - "REDUCE" activities.

To reduce use of plastic bag, since 2010, Tesco Lotus has launched the campaign "**Green Bag Green Point**" in order to encourage customers for using their own shopping bags by giving Clubcard Green Points (FIGURE 12-8). This campaign is aimed to help customers reduce greenhouse gas (GHG) emissions which cause Global Warming by reducing the plastic bags usage. According to Tesco Lotus' if we reduce 2% of plastic bags usage in each year, we decrease greenhouse gas (GHG) emissions about 1,980 tons per year and will reduces carbon dioxide emissions by 50% within 2020. (Kaewprom, 2010).

In order to actively advertise, Tesco Lotus has set up fun activities and hires celebrities to promote the campaign, as well as trains their staffs to first ask customers if they actually need plastic bags, setting up **express lane** and special equipment at checkouts to facilitate the use of cloth bags, and offering more rewards to customers who use cloth bags. (Kaewprom, 2010)

FIGURE 12-8: "Green Bag Green Point" campaign poster and use of club card
Source: TescoLotus.com as cited in Kaewprom, 2010 (left) and http://www.thairath. co.th /column/eco/market/104996

To coincide with the launch, **in reducing chemicals in the environment,** Tesco Lotus is offering extra Green Points on **green products** including light bulbs, garbage bags, liquid paper, lever files, copy paper, **mosquito repellent spray and toilet cleaner**. (The Nation, 2010) Additionally, the company will open its first Green Store or Zero-Carbon Store in Southeast Asia at Bang Phra store in Chonburi by installing technology to **reduce energy**. The company also plans to increase the number of green products available at its store and shops in the plaza and send its technical team to help farmers who supply produce to develop **products that are chemical-free** and at lower cost, as well as cooperation from suppliers to implement greener transport and delivery systems. (BMEM Expo Asia, 2012).

2. "REUSE" activities

"REUSE" activities are listed in Table 12-7 whereas case study in Thailand is presented in BOX 12-3.

TABLE 12-7 : Examples of "REUSE" activities.

Eco-Activities
1. Bring your own reusable bags – no need for plastic bags. 2. Choose reusable products 3. Use small plastic bags to wrap wet and smelly rubbish or to pick up after your pet. 4. If you are building or renovating, consider using reused materials such as second-handed furniture—you can save money and add character at the same time. 5. See whether your trash could be treasure for someone else. For example, if your food scraps are going in the bin, there might be a gardener or someone with chickens who wants your organic waste. 6. Donate the items that not use – clothes, furniture, dishes, books, magazines, sport equipments, etc. 7. Washed takeaway containers make good stackable containers for frozen food. 8. Paper and Envelopes: Can be used as scrap paper for making notes. 9. Jars and Pots: Can be used as small containers to store odds and ends. 10. Carrier bags and twist ties. Carrier bags can be reused in the shops or as bin bags around the house. Paper bags make useful wrapping paper and twist ties can be used to secure loose items together, such as computer wires. 11. Newspaper, cardboard and bubble wrap Make useful packing material when moving house or to store items. 12. Reduce paper waste by cancelling unwanted deliveries, or read news online as opposed to buying newspapers. 13. Put a 'no junk mail please' sign on your letter box to reduce unwanted deliveries. 14. Scrap paper can be used to make notes and sketches. Don't forget to recycle it when you no longer need it. 15. Old clothes can be made into other textile items such as cushion covers or teapot cosies. 16. Donate Old Clothes and Books Other people can reuse your unwanted clothes and books when you donate them to charity shops. 17. Old Electrical Equipment: Donate old electrical equipment to schools or community centers so that others can reuse them. 18. Car-boot Sale Have a car-boot sale and get rid of some unwanted items. Other people may find a use for them, plus it gives you the opportunity to earn some extra cash. 19. Rechargeable Batteries Rechargeable batteries can be reused many times before they need throwing away, opposed to regular batteries that create unnecessary waste. 20. Build a Compost Bin You can reuse many waste items, such as eggshells and old tea bags, using a compost bin. This waste then degrades and turns into compost that can be used to help your garden grow. 21. Grass Cycling After mowing your lawn, instead of throwing the grass cuttings away, leave them in your garden. The nutrients from the cuttings go back into the soil and act as a fertilizer. 22. Reuse glass whenever possible. Jars can be used as small containers and bottles can be used as vases.

Source:
http://www.livinggreener.gov.au/waste/recycling/reduce-reuse-recycle
http://www.recycling-guide.org.uk/reuse.html

BOX 12-3 : Case Study in Thailand No.3 - "REUSE" activities.

Reuse program is also found outstanding in Thailand. In 1944, Supermarket for the poor (**Figure 12-9**) was found by Suankaew Foundation (2011). It is a large flea market offers a variety of donated products, including clothes, electronics, refurbished computers, books, furniture and food for sale at discounted price. Donations of any of these goods are accepted and pickup services are available for large-sized donations. In the refurbishing program, used or broken computers are sorted through by volunteers. Those which function are sold, while others are taken apart with usable spare parts resold separately. Refurbished computers are also use to educate children who live at the temple, to learn computer skills. This becomes a "free" training process for amateur technicians and allows people to exchange their labor for goods. The foundation will provide them with vouchers to exchange for what they need at the supermarket. (Amanda Suutari, n.d. as cited in the Eco Tipping Point Project, 2012)

FIGURE 12-9 : Supermarket for the poor
Source: Suankaew Foundation (2011)

3. “RECYCLE” activities

“RECYCLE” activities are listed in Table 12-8 whereas case studies are presented in BOX 12-4 to 12-6.

TABLE 12-8 : Examples of “RECYCLE” activities.

Eco-Activities
1. Promote the recycling centers to everyone via different methods 2. Bring recyclable products (e.g. food packaging as boxes, beverage bottles and cans, and steel soup, vegetable, and fruit cans)) to recycling centers in the local areas 3. Provide a recycle basket in a guestroom. 4. Provide recycle bins in public area such as kitchen room, garden, poolside and lobby. 5. Buy products that use recycled materials or are recyclable. This way can help to keep useful materials and metals out of landfill. 6. Do not use packaging that cannot be recycled such as chocolate wrappers made from Metallic plastic film which cannot recycled 7. Cardboard, Newspaper and Bubble Wrap: Can be used as packing materials. Packaging products, such as foil and egg cartons, can be used for art projects in schools and nurseries. 8. *Used cooking oil:* Can be recycled to produce biodiesel 9. *Used wood:* Can be used in woodcrafts for making small garden objects such as bird tables. Alternatively it could be used as firewood. 10. Old tires can be given to your local petrol station where they will be recycled. Or you could make a tire-swing by tying a strong rope around a tire and attaching it to a tree. 11. *Avoiding buying hazardous material:* It is difficult to recycle products that contain hazardous waste. Try to find safer alternatives to household cleaners and buy non-toxic products whenever possible. 12. *Provide Recycle bins:* Make sure you have a recycle bin in your home. Keep it in an obvious place so you won’t forget to use it. Your local council should be able to provide you with a recycle bin that can be used for materials such as glass, paper, aluminium and plastic. 13. *Composting:* Composting is a process where waste degrades into compost, which can then be used in your garden to help it grow. It is an excellent way to recycle garden and kitchen waste such as plant trimmings and leftover food. 14. *Grass cycling:* Grass cycling is an excellent way of recycling grass cuttings after mowing the lawn. Simply leave the cuttings on the ground instead of throwing them away, they will turn into nutrients and act as a fertilizer in the soil. 15. Rechargeable batteries are the most environmentally friendly option as can last for up to several hundred charging cycles resulting in less waste being produced. 16. Deposit glass at your nearest recycling bank by throwing them into the appropriate container. 17. Buy recycled paper whenever possible.

Source: http://www.livinggreener.gov.au/waste/recycling/reduce-reuse-recycle
http://www.recycling-guide.org.uk/reduce.html

BOX 12-4 : Case Study in Thailand No.4 - "RECYCLE" activities.

Successful **recycling program** in Thailand, is found in the Siam City Concrete Co.,Ltd. (SCCO) who produces "INSEE Concrete" products. All staffs there have to bring wet and dry trash from homes to exchange for eggs on every Thursday. The company also provides 4 bins for 4 types of separated trash in each division. It then takes the trash to fertilization and recycling process. Nowadays, there is no any trash for sanitary landfill (Sukumanont, 2012).

FIGURE 12-10: Sample of Plastic Bags Recycle bin
Source: plasticbagrecycling.org (2007)

BOX 12-5 : Case Study in Thailand No.5 - "RECYCLE" activities.

In the housing community context, successful **recycling program** is found at eco-village, Ban Sathaporn, the housing community in Pathumthani province, Thailand. The program includes a waste center where many large recycling containers are located for dwellers' convenience in dropping off recyclable wastes (Panthasen, et al., 2012). Figure 12-11 shows example of such recycling containers.

FIGURE 12-11 : Recycling containers at Ban Sathaporn

BOX 12-6 : Case Study in Thailand No.7 - “RECYCLE” activities.

Successful program for **recycling waste cooking oil to produce biodiesel** in Thailand is found by Bangchak Petroleum Company Ltd. The company has installed a biodiesel unit at the refinery with a capacity of 20,000-liter/day, running on either crude palm oil or used cooking oil, the latter of which is being used as the main raw material. For this purpose, the company has opened units to buy used vegetable oils for the production of biodiesel at more than 20 petrol stations of the Company in Bangkok, its adjacent province and Suphan Buri. The project has also purchased the used vegetable oils from various markets in Bangkok in a bid to supply raw material for the biodiesel-production unit. Various organizations, such as Central World, Zen at Central World, Ramathibodi Hospital, Fort Suranari Hopital, Phra Khanong Police Station and Queen Siritkit National Convention Center are also incorporated into the program (Bangchak Petroleum PLC, 2009).

In Smaller scale, Kasetsart University in Bangkok and Don Ping Dad Village in Phetchaburi province are the outstanding cases where the system was set up to collect **used cooking oil**, from their members, as feedstock for biodiesel production processed in their production center (Panthasen, 2012 and Puntasen, et al., 2012). In addition, Ban Sathaporn, a middle-income housing community in Pathumthani province, is an interesting case; where its dwellers sell their used cooking oil to their neighbor, then the neighbor send the used cooking oil to be processed into biodiesel outside community (Panthasen, et al., 2012).

4. “REPAIR” activities

While the first 3Rs – Reduce, Reuse, Recycle - consist of varied activities, the R as “Repair” is very simple. In practice, this R is only to repair malfunctioned products and to reuse them instead of buying new items.

5. “REBUY” activities

Similar to the R – Repair, rebuy activities are not complicated. The main activity is to buy the reused, recycled or repaired products from the previous Rs activities as well as to buy other environmental friendly products.

6. “RETHINK” activities

The last R as “Rethink” is simple in theory but difficult and most important in practice. It is to rethink before taking any actions (e.g., take a bath, eat, breath, travel, buy, sleep, etc.) with concerns on the environment and society. In fact, Rethink is the most important successful factor for “Eco-lifestyle”. Prior to behavioral changes, it starts with “rethinking”. Other examples include:

1. To plan the travel route and to combine errands into one trip instead of making many small trips.
2. To consider “sufficient consumption” to reduce resource consumption such as eating food sufficiently, not extravagantly

7. Other eco-activities

TABLE 12-9 : Other eco-activities.

No.	Eco-Activities
1	Choose renewable energy for their vehicles
2	Choose an environmental friendly accommodation facility (e.g., Eco-hotels)
3	Take action. If a recycling program does not exist in specific areas in SAMUI Island, take action to start one (e.g., by forming a “green team” to coordinate, implement, and manage the recycling program)
4	Choose fresh and local products instead of packaged food.
5	Consult the outside consultant to evaluate the system to replacing new system or finding the opportunities to reduce the costs in initial investment and operating system.

8. Additional recommendations for SAMUI

Apart from all activities recommended earlier, additional recommendations as examples for eco-activities applying the 3Rsx2 principles are given in BOX 12-7 to BOX 12-12. All activities and centers can be coordinated by SAMUI Low Carbon Center in cooperation with SAMUI municipality.

BOX 12-7 : Recommendation No.1 - “REDUCE” activities.

“Reduce plastic bags” by a discount or point collecting program for reusable bags in cooperation with the eco-point program & an express lane for reusable bags at the checkout counter.

Tesco Lotus in SAMUI Island has the campaign “Green Bag Green Point”, but it was found that the new cashier did not know about the campaign. Also, there is no clear signage to show campaign available. Therefore, this campaign should be re-promoted to make it known by both employees and customers. In addition, this campaign should be duplicated to Big C and other convenience stores such as Seven-eleven and Family Mart. The program can be integrated into the SAMUI eco-point program.

Furthermore, Big C and Tesco Lotus in SAMUI Island have a lot of checkout counters. There are often unused counters and spared cashiers. As an express lane for reusable bags is new, municipality may ask the stores to provide one lane in each store as the pilot activity at the beginning. It is possible because these stores have already had some environmental promotion programs in place.

BOX 12-8 : Recommendation No.2 - "REUSE" activities.

"Shopping bags (cloth, plastic, paper)" Similar to what have been done in the USA, recycling bins, provided by municipality, to receive used but clean bags for everyone who can grasp to reuse can be placed at the entrances of Tesco Lotus (Figure 12-12), Big C, and other convenience stores such as Seven-eleven and Family Mart. The bins also can be placed at the hotel lobby. Moreover, a small bin for the same purpose can be placed in each hotel guest room as normally tourists buy stuffs, put in plastic bags and throw the bag away in the guest room.

FIGURE 12-12 : Entrance of Tesco Lotus in SAMUI Island

BOX 12-9 : Recommendation No.3 - "REUSE" activities.

"Clothes" Containers to receive used but clean clothes Municipality should provide containers or huge baskets to receive used but clean clothes, as donation, to be delivered to store/ markets that sell used clothes, and foundations, in the same manner as Suankaew Foundation. These containers can be also placed at the entrances of Tesco Lotus and Big C. The containers, moreover, can be placed at the hotel lobby and near the check in counter at the airport, similar to donation boxes (Figure 12-13). Moreover, a small basket for the same purpose can be placed in each hotel guest room as sometimes tourists would not like to bring old clothes back to their homes.

FIGURE 12-13 : Donation boxes at the hotel lobby and SAMUI Island Airport

BOX 12-10 : Recommendation No.4 - "REUSE" activities.

"Clothes" Used clothes store/ markets/ foundations There are many used clothes stores near or in the fresh markets (Figure 12-14). Also, there are many foundations and temples in SAMUI Island such as Dipabhāvan Meditation Center (Figure 12-15) and SAMUI Rescue Foundation (Figure 12-16). So, all of donated clothes have the places for people to access for used clothes. SAMUI Low Carcon Center can link all existing centers as well as **open addition stores in Tesco Lotus and Big C to sell used clothes** from donation cheaply and takes the profits for eco-point funds.

FIGURE 12-14 : Used clothes store in SAMUI Island

FIGURE 12-15 : Dipabhāvan Meditation Center
Source: http://www.dipabhavan.org and http://dipabhavan.weebly.com/

FIGURE 12-16 : SAMUI Rescue Foundation
Source: http://www.facebook.com

BOX 12-11 : Recommendation No.5 - "RECYCLE" activities.

"Non-organic materials (plastic, can, paper, glass)" Drop-off Recycling Center Complete recycling system was found in SAMUI Island. From the main source that is local hotels, employees keep the trash separated and sell for their benefits. There are recyclable-material collectors, under the control of municipality, driving 3–wheel bikes to deliver the materials to the recyclable-material vendors (Figure 12-17). Moreover, it was found that there are two major vendors in Bophut sub-district and and one in Namuang sub-district who buy used materials for recycling. The one in Bophut, named Wongpanich, have franchised branches all over Thailand. They get to schools, hospitals, and other places to buy recyclable-materials and process the separation at their factory (Figure 12-18). Eco-point program can support these centers by using eco-point funds or link the centers to SAMUI Low Carbon Center.

FIGURE 12-17 : Municipality's material collectors, and recycling factory in SAMUI Island

FIGURE 12-18 : recycling process in Wongpanich factory

Source: http://www.wongpanit.com/wpnnew/abountme.php

BOX 12-12 : Recommendation No.6 - “RECYCLE” activities.

“Organic materials (vegetable, fruit)” Containers to receive organic materials Nowadays, there are a lot of organic wastes in many places, a large quantity was observed in fresh markets. These wastes are mixed in one container (Figure 12-19). So, SAMUI municipality and/or SAMUI Low Carbon Center should provide containers to receive only organic materials to be delivered to organic fertilizer and bio-gas production center (as proposed in **Chapter 10**). In the same time, the eco-point funds can be used to hire staffs and to buy organic materials from vendors in the markets, restaurant, food shops, and households. Later, the fertilizer and biogas can be sold to farmers, restaurant, and food shops at cheap price to make moderate economic gains in return

FIGURE 12-19 : Existing waste containers

12.3.6 Eco-Events

In order to support eco-activities, eco-events can be arranged by the SAMUI Island's Municipality, SAMUI Low Carbon Center or other stakeholders. The eco-events are listed below.

1. Zero Emission Day

Objective	To encourage people to consume less fossil energy by shutting down non-essential fossil fuel-powered equipment and vehicles for a day
Type	International event
Description	"Zero Emission Day" is the annual Global 24 hour Moratorium on the Combustion of Fossil Fuels on September 21.
Source	http://zeday.org/

2. Car Free Day

Objective	To encourage people to reduce transportation by private cars and to support mass transportation, walking and bicycling.
Type	International, national and local event
Description	World car free day has been promoted on September 22 since 2000. In Thailand, there have been Thailand car free days since 2003 whereas Bangkok car free day was initiated in 2007.
Source	http://www.worldcarfree.net/wcfd/, http://www.bangkokcarfreeday.com/, http://www.pcd.go.th/info_serv/air_carfree.html

3. Clean Up the World Weekend

Objective	This activity focuses public attention to concern about environment and also contributes the world to get cleaner and healthier.
Type	International event
Description	Clean up the world weekend are held on 3rd. weekend in September of each year. This activity helps to improve the environment such as cleaning parks or beaches, planting trees and raising or educating environmental awareness.

Source http://www.cleanuptheworld.org/en/Activities/clean-up-the-world-weekend.html, http://www.cleanuptheworld.org/en/Activities/theme-2012.html

4. Earth Week and Earth Day

Objective To promote awareness and appreciate in environmental and sustainable living. In addition, to encourage people to recycle and conserve energy in this earth week.

Type International, national event

Description "Earth week" usually promote from April 16th. To Earth day, April 22nd. In this week, people are going to recycle and conserve energy by purchasing items with less packaging, Adopt a chemical free lifestyle, using sustainable, renewable and clean energy, plant a new tree for every book you read, etc. Furthermore, this activity will encourage people to design initiative activity to help and protect the environment.

Source http://earthday2012.com/tag/green-week/

5. Bike Week (Bicycle Week)

Objective To support bicycling community and to reduce fuel consumption and emissions from transportation

Type International, National and Local Event

Description "Bike Week" is an annual event that promotes citizens to help the environment and exercise by cycling. For example; In USA Bike week is during the first or second week of May, in Europe Bike week is during third week of June.

Source http://en.wikipedia.org/wiki/Bike_Week_(Bicycle_Week)
http://www.goinggreentoday.com/blog/7-ways-that-bicycling-can-save-the-environment/

6. SAMUI Clean Beaches Week

Objective Initiative SAMUI citizens and tourists in awareness of environmental.

Type Local event

Description Provide a week to promote SAMUI citizens and tourists to playing a role in help and keep their beaches open and clean.

Source -

7. National Recycling week (NRW)

Objective To bring a national focus to recycling, minimizing waste and managing material resources.

Type National event

Description "National Recycling week" is an annual event which promote during second or third week in November. This activity focuses on encouraging students to learn environmental benefits of recycling, increasing the recycling in businesses and workplaces, promoting reuse and recycling initiatives and improving knowledge of recycling. So during the National Recycling Week, it is a time to reduce, reuse and recycle waste at home and at work.

Source http://recyclingweek.planetark.org/about/

8. National Water Week

Objective Improving community awareness of water issues in Australia.

Type National event

Description This event is an annual awareness event which commencing on the 3rd. Sunday of October. Providing the water-related activities and educating knowledge of water resources.

Source http://www.awa.asn.au/nationalwaterweek/

9. National tree day and School tree day

Objective Contributing citizens to do something which are environmental benefits and to let citizens reconnect with nature. This event provides for inspiring, educating and recruiting citizens to care for their environmental and create future generations who concern about environmental.

Type National and local event

Description National Tree Day and School Tree Day are tree-planting event in Australia to plant native trees, shrub and grasses.

Source http://treeday.planetark.org/about/

12.3.7 Other Eco-Measures

Other eco-measures are eco-services, eco-products and eco-hotels. The difference among eco-services, eco-activities and eco-events is the main players. Service providers (e.g. businesses owners/operators) will provide eco-services for customers whereas eco-activities are user-self driven (e.g. tourists do or initiate the eco-activities by themselves). For eco-events, they combine selected eco-services and eco-activities with different themes and targets. For eco-products and eco-hotels, it requires eco-certification system which is set up by eco-point program and committee. The certification of eco-hotels can be integrated with another category – low carbon building.

Table 12-10 provides examples of eco-products and eco-hotels in Thailand. The full list of certifed eco-products and eco-hotels based on existing eco-labelling certification programs in Thailand is documted in Annex 14.

TABLE 12-10 : Examples of eco-products and eco-hotels in Thailand

Certificate	Example of certified products/hotels	Reference
1. Green Label	Liquid Paper	http://market.mthai.com/product/1389153
	Washing Powder	http://www.measwatch.org/news/3563
	Chevrolet car	http://www.bangkokbiznews.com/2008/11/10/news_310362.php For more information: http://www.tei.or.th/greenlabel/
2. Green Leaf	2.1 AMARI PALM REEF KOH SAMUI	http://www.greenleafthai.org/en/
	2.2 BAN SABAI SUNSET BEACH RESORT & SPA	
	2.3 BANANA FAN SEA RESORT	
	2.4 BHUNDHARI SPA RESORT & VILLAS SAMUI| A CENTARA RESORT	
	2.5 CENTARA GRAND BEACH RESORT SAMUI	

Certificate	Example of certified products/hotels	Reference
3. Carbon Reduction Label	3.1 Oil	http://www.measwatch.org/news/3563
	3.3 Doikham Product	http://www.snc.lib.su.ac.th/snclibblog/?p=11363
	3.4 Chaokoh coconut Milk	http://measwatch.org/news/503
4. Carbon Footprint Label	4.1 Jasmine rice	http://www.manager.co.th/Science/ViewNews.aspx?NewsID=9520000158737&TabID=3&
	4.2 Select tuna (in can)	
5. CoolMode	5.1 Selected clothes from ID Knitting Company Co., Ltd.	http://www.thaitextile.org/lab/content.php?id=ARC0120410153256
	5.2 Selected textile products from Satin Textiles Co., Ltd.	http://www.thaitextile.org/lab/content.php?id=ARC0120410143313

12.3.8 Targets for Eco-Lifestyle Measures

Eco-lifestyle measures include SAMUI eco-logo, SAMUI low carbon center, eco-point program, eco-activities, eco-events, eco-products, eco-services, eco-hotels. Many measures are interconnected. It is not possible to set up the separate targets for each measure. As a result, carbon emission target is set up for implementation of all eco-lifestyle measures as 5% in 2020 and 2030. The eco-lifestyle measures are set according to the previously identified eco-lifestyle indexes. The list of the targets are documented in Table 12-11.

TABLE 12-11 : Targets for Eco-Lifestyle Measures

Eco-Lifestyle Index	Targets for eco-lifestyle measures
Main Target	
Carbon Emission (*% Reduction*)	2.5% Reduction from BAU in 2020 and 2030
Sub-Targets	
1. Total energy consumption (*Electricity and heat; % Reduction*)	10% from BAU in 2020 and 2030
2. Fuel consumption (*% Reduction*)	10% from BAU in 2020 and 2030

Eco-Lifestyle Index	Targets for eco-lifestyle measures
3. Water consumption (*% Reduction*)	10% from BAU in 2020 and 2030
4. Material consumption (*Other materials excl. fuels and water; % Reduction*)	15% from BAU in 2020 and 2030
5. Waste generation (*% Reduction*)	15% from BAU in 2020 and 2030
6. Reusing rate (*% of Total waste generation*)	15% from BAU in 2020 and 2030
7. Recycling rate (*% of Total waste generation*)	15% from BAU in 2020 and 2030
8. Repairing rate (*% of Total waste generation*)	15% from BAU in 2020 and 2030
9. Cost savings *(Only from selected measures e.g., energy-fuel-material consumption reduction; %*)	10% from BAU in 2020 and 2030
10. Employment opportunity from eco-lifestyle measures (Number of workers)	3,000 Workers in 2020 and 5,000 Workers in 2030
11. Social and cultural value (*Number of eco-services and eco-activities which provide a program/tour for visitors to gain social and cultural value from local communities in SAMUI Island*)	50 Eco-services & 50 Eco-activities in 2020 and 100 Eco-services & 100 Eco-activities in 2030 ***Note:*** Only eco-services & eco-activities to increase social and cultural value & awareness of local communities in SAMUI Island
12. Community participation (*Number of SAMUI Citizens involving in eco-services, eco-hotels and eco-activities*)	20,000 SAMUI Citizen in 2020 and 40,000 SAMUI Citizen in 2030

Similarly, Japanese government also set up the target of 6% for CO_2 emission reduction by implementing six actions as illustrated in Figure 12-20.

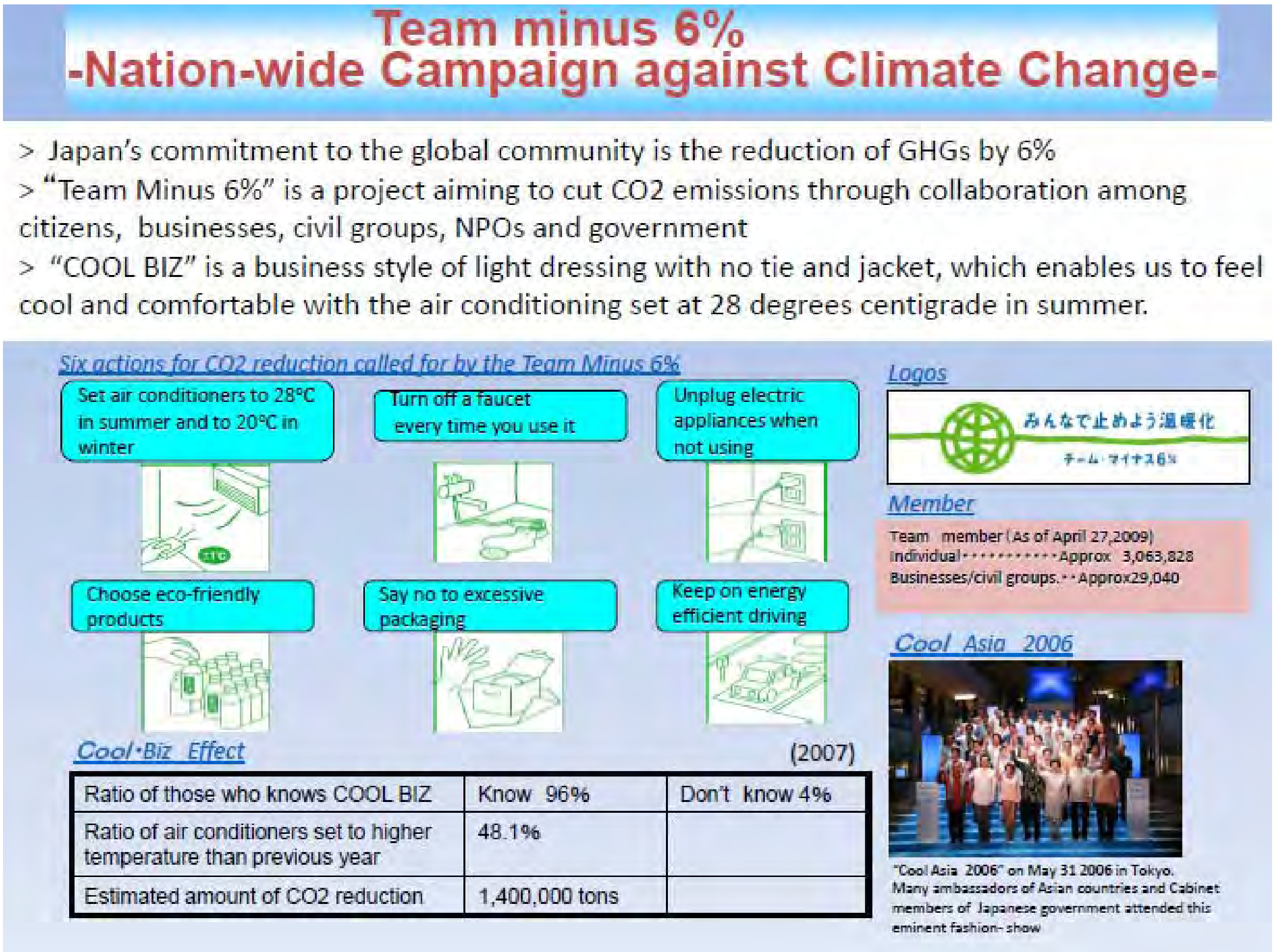


FIGURE 12-20 :Japanese Campaign Against Climate Change – "Team minus 6%" (Obtanied from Kutsukake, 2009)

Additionally, there are potentials to generate incomes from eco-products, eco-services and eco-hotels. General characteristics of tourists in SAMUI and expected tourist participation in the eco-point program are presented in Table 12-12. Based on the approximated values, income generation from eco-products/eco-hotels/eco-services consumed by tourists – the main driver for SAMUI economy - can be estimated as 1,600,000,000 THB/year from 2012 to 2020 and 2,200,000,000 THB/year from 2020 to 2030.

TABLE 12-12 : General characteristics and expected participation in the eco-point program

No.	Parameters	Approximated values
1	Numbers of tourist	10,000 person/day*
2	Share of tourist participation	50% of tourists in 2020 and 2030**
3	Tourist Expenses	3,000 THB/day
4	Eco-point gain/day/person (for 100% participation)	7 points***/day
5	% Participation in Eco-point program	50% participation

* Only an approximated value for this feasibility study. The value is estimated according to the average numbers of tourists and the average length of stay in SAMUI.
** The share of tourist participation is gradually increased from 0% in 2012 to 50% in 2020 and remained the same (as 50%) until 2030.
*** Eco-points gained from eco-products/services/hotels = 5 points (70% from total) whereas another 30% are from eco-activities (25%) and eco-events (5%)

12.4 Carbon Reduction Impact and Low Carbon Costs of Measures

Carbon emission target is set up for implementation of all eco-lifestyle measures as 5% in 2020 and 2030 as described in section 12.3.8. The low carbon costs of eco-lifestyle measures are listed in Table 12-13

TABLE 12-13 : Eco-Lifestyle Indexes

No.	Eco-Lifestyle Measures	Cost Estimation
1	SAMUI Eco-Logo Advertisement Awards for the winner Operating costs (Include only human resources[1]; 1 person – 1 month) ***Total***	 75,000 THB (for the 1st year and 100,000 for other years) 10,000 THB 15,000 THB ***100,000 THB/year[2]***

No.	Eco-Lifestyle Measures	Cost Estimation
2	SAMUI Low Carbon Center 2.1 Infrastructure establishment (building construction) 2.2 Operating costs (Include only human resources[1]; 5 persons/year) ***Total***	Costs for infrastructure establishment is estimated in CHAPTER 5 15,000x5x12 = 900,000 THB/year ***900,000 THB/year***
3	Eco-Point Program 3.1 Infrastructure establishment (building construction) and Operating costs (Human resources) 3.2 Costs for eco-funds ***Targets***: 29 million eco-points by 2020 (3.7 million eco-points/year) and 95 million eco-points by 2050 (5.3 million Eco-points/year). Eco-point distribution of each measure is: Eco-products (30%) Eco-services (10%) Eco-hotels (30%) Eco-activities (25%) Eco-events (5%) 3.3 Costs for organizing eco-activities, eco-events 3.4 Costs for certifying eco-products, eco-services, eco-hotels ***Total***	No cost (Use the same facilities and human resources in SAMUI Low Carbon Center; In addition, there is no payment for eco-point program committee because it will be voluntarily based) 37,000,000 THB/year (from 2013 to 2020), 65,000,000 THB/year (from 2020 to 2030) Eco-funds are estimated from eco-point awards of 10 THB per 1 eco-point. The initial funds supported by government are required to start up the program. Afterwards, the eco-funds should be obtained from various measures such as city-tax, sponsor from eco-business owners and eco-fund raising. In the long run, this program should be self-sufficient. No cost (Use the same facilities and human resources in SAMUI Low Carbon Center) No initial cost (use the existing certification systems in Thailand: Green label, Green leaf, etc.) ***37,000,000 THB/year[3] (from 2013 to 2020),*** ***65,000,000 THB/year[3] (from 2020 to 2030)***

[1] Using new salary rate for governmental organizations (15,000 THB/month for Bachelor Degree)

[2] Costs for eco-logo for the 1st year include advertisement, awards for the winner and operating costs. For other years, costs include only for advertisement and operating costs will be under SAMUI loa carbon center.

[3] Average values. The value of 37,000,000 THB THB/year is an average of costs from 2012 to 2030 (start from 0 THB in 2012, when no eco-point is redeemed, to 65,000,000 THB in 2020). From 2020 to 2030, the costs keep constant at the rate of 65,000,000 THB/year.

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Annex 13 Examples of standards and criterias for certification programs in Thailand

1. Green Label

Thai Green Label Scheme was initiated by the Thailand Business Council for Sustainable Development (TBCSD), chaired by Mr. Anand Panyarachun in October 1993 as a TBCSD council project. It was formally launched in August 1994 by Thailand Environment Institute (TEI) in association with the Ministry of Industry.
The Green Label is an environmental certification awarded to specific products that are shown to have minimum detrimental impact on the environment in comparison with other products serving the same function.

The Thai Green Label Scheme applies to products and services, not including foods, drinks, and pharmaceuticals. Products or services which meet the Thai Green Label criteria can carry the Thai Green Label. Participation in the scheme is voluntary.

The symbol signifies environmental conservation. The flora (the leaves) and fauna (the bird) depicted are the living wonders of the world. In the myriad of links with our earth, our hopes for future generations (the smiling face) grow from life respecting nature.

Objectives

The scheme is developed to promote the concept of resource conservation, pollution reduction, and waste management. The purposes of awarding the green label are:

- To provide reliable information and guide customers in their choice of products.
- To create an opportunity for consumers to make an environmentally conscious decision, thus creating market incentives for manufacturers to develop and supply more environmentally sound products.
- To reduce environmental impacts which may occur during manufacturing, utilization, consumption and disposal of products.

International Cooperation

The Thai Green Label Scheme implemented by TEI has signed bilateral mutual recognition agreements (MRA) with six Eco Labelling Programs in six countries, including the Environment Development Foundation (EDF) of Chinese Taipei in 2003, Japan Environment Association (JEA) in 2003, Korea Environmental Industry and Technology Institute (KEITI) in 2003, The New Zealand Eco Labelling Trust (NZET) in 2004, Good Environmental Choice Australia (GECA) in 2005 and China Environment United Certification Center Co. Ltd (CEC) in 2007. All recognition agreements in six countries cover: (1) recognition on the laboratory testing, (2) product certification operation system including on-site audit recognition and (3) specific requirements of the criteria. The Scheme also conducted and participated an international cooperation among four countries, including Chinese Taipei, Korea and Japan for Common Core Criteria development in 2002 (paints and Toner cartridge) and 2003 (television, dvd/vcd player and multifunction device). In 2008, the Scheme exercised the MRA with EDF and AELA, respectively, by assisting the afore-mentioned programs to perform on-site assessments in three cases. The Scheme recognize s this MRA mechanism as an international environmental management tool which is capable of synergizing various Eco labelling programs/actions in order to expand the global market for green products and provide a wider range of environment and resource conservation . All the MRAs are publicly available from the Scheme.

The Thai Green Label Board

The Thai Green Label Board takes all major decisions regarding the green label. The Board is intended to be neutral and objective. It consists of the following members who were appointed by the Minister of the Ministry of Industry in August 1994:

- Permanent Secretary of the Ministry of Industry (Chairman)
- Permanent Secretary of the ministry of Science, Technology and Environment (Deputy Chairman)
- President of the TEI
- Secretary General of the Thai Industrial Standards Institute (TISI)
- Representative of the Federation of Thai Industries (FTI)
- Representative of the Board of Trade of Thailand
- Representative of the Press Association
- Representative of the Environmental Engineering Association of Thailand
- Representative of the Office of Consumer Protection
- Representative of the Public Relations Confederation of Thailand
- Representative of the marketing Association of Thailand
- Representative of the TBCSD

Tasks of the Board are as follows:

- To decide on the basic strategies of the green label scheme
- To select product groups for consideration for a green label
- To decide on the criteria for a product group
- To decide on the structures and level of the fees for the green label
- To decide on supporting activities

The Board is supported by the secretariat (TEI and TISI) which organizes meeting and prepares material to be discussed by the Board.

The Technical Subcommittee

The technical subcommittee, with participation from TEI and TISI, develops proposals for green labels including product criteria, test methods (if necessary), and other requirements for applicants. A new subcommittee is established for each selected product category and consists of experts from institutes, industry, and environmental groups and others if appropriate and available. Together with the proposals, the technical subcommittee reports on the environmental significance and the impacts of the product group and estimates the market share of the product group. Product criteria will be reviewed after a period of two years.

Procedure for the Development of the Product Criteria

. General public presents proposals to the secretariat
. Secretariat submits proposals to the Board
. Board decides on the product categories
. Board sets up a technical subcommittee to work on the criteria
. Secretariat submits final proposal to the Board
. Board decides on the criteria
. Announcement of the decision of the Board to the public

Criteria Development

The green label criteria have been developed under the guidance of the following principles:

- An environmental assessment of the product using life cycle consideration, taking into account all aspects of environmental protection, including the efficient use to row materials and focusing on opportunities to achieve significant reductions in detrimental environmental impacts.
- Solving specific issues of high political priority, e.g. reduction of waste production, and minimization of energy and water consumption.
- Capability to meet proposed criteria with reasonable process modification and/or improvement.
- Possession of appropriate test methods.

Award of the Green Label

1. Producers/distributors apply for the green label to TEI
2. TEI examines the application to ensure that it is completed and all criteria are met
3. TEI delivers the application to TISI for further investigation of criteria fulfillment
4. TEI registers the application and awards the green label by granting a contract
5. Producer/distributor is entitled to use the green label

Licensing

Upon approval of the application, a contract for the use of the Thai Green Label will be drawn up between TEI and the applicant. The applicant right to use the Green Label is conditional upon its fulfillment of the terms or the contract, which will be valid for a maximum period of two years, or until the criteria for green label status are re-evaluated.

Fees

An application fee of 1,000 Baht is charged to all applicants. Upon approval of the product, applicants must pay a user fee of 5,000 Baht for license to use the label throughout the contract term. Al payments are made to TEI.

2. Green Leaf

Source: http://www.greenleafthai.org/en/green_found/

The Green Leaf Foundation was officially founded and registered on the 17th of March 1998. It was the day that members of the Board of Environmental Promotion of Tourism Activities or BEPTA were pleased and proud of their hard work and vision in developing both the quality of the environment and the tourism industry at the same time.

The green leaf foundation was jointly established by the 6 organizations with the same determination and responsibility, with support fund sponsorship from various local and international organizations. They have organized several training seminars on environmental educational, environmental standards, and energy efficiency since 1999.Their main objective is

British Embassy
he Asia Foundation
United State-Asia Environmental Partnership
National Energy Policy Office
Department of Environmental
Quality Promotion
Faculty of Environment and Resources
ıdies
Mahidol University
Tridhod Three-Generation School Village
Dusit Group
Hilton International Bangkok at Park Nai Lert
May Fair Inn Company Limited
Thai International Airways Company Limited
and other leading hotels in Thailand are their sponsors for several of activities.

The visionary organizations are composed of :

1. Tourism Authority of Thailand
2. Thai Hotels Association
3. United Nations Environment Program
4. Demand Side Management Office of Electricity Generating Authority of Thailand

5. Association for the Development of Environmental Quality, and
6. Metropolitan Water works Authority.

Green Leaf Program for hotels under the Green Leaf Foundation is the first step in the development of environmental quality for the tourism industry. Various activities will be organized by the Foundation in the future, according to its future development and objectives. Once the foundation has sufficient capacity to move on.

The Green Leaf Programs are organized by BEPTA, which has completed environmental practical checklists for hotels for the environmental assessment and to be audited by the BEPTA's appointed Audit team. The assessment will be graded with the standard score to measure hotel's each operation's efficiency in environmental management. The results of the assessment will be compared with the reference standard score of the hotels .Audited hotels to promote environmental awareness in tourism industry, highest level of resource efficiency of environmental protection will be awarded with Green Leaf Certificate ranging from 1 to 5 leaves, 5 denoting the most practiced hotel in environmental management.

The Green Leaf Foundation has confidence in the efforts of hotel owners, operators, and their business partners in working collaboratively towards the betterment in managing the environmentally quality for the prosperity and sustainability of the industry and the country.

Objectives of Green Leaf foundation

1. Promote knowledge and support studies and research in the creation of a good understanding of environmental conservation.
2. Assist owners and operators in the tourism industry to develop environmental quality standard in their work place.
3. Develop standards of environmental practices for tourism and tourism-related business in responding to consumer's requirement.

Green Leaf Programs

Green Leaf Programs was initiated at the end of 1997. Its prime objective is to help hotels improve their efficiency in saving energy, water and other resources. It focuses on facilitating the efficient use of energy and natural resources under the theme **"Save Money, Save Environment."**

Prior to that, a network existed under an executive committee which began working in 1994 by conducting activities to boost awareness and knowledge about efficiently operating tourism businesses in ways that help preserve a quality environment, appreciate the value of energy and natural resources, and have minimum impact on the environment.

Hotels and tourism-related operators, government organizations, educational institutions and other private organizations were invited and encouraged to join the Green Hotel Fair

& Seminar which were organized five times in Pattaya, Phuket, Bangkok, Chiang Mai and Khon Kaen.

The TAT supported the programme by conducting 11 Green Mobile between 1995 - 1997 in Su-ngai Kolok, Hat Yai, SAMUI Island, Krabi, Cha-am, Rayong, Chiang Rai, Ubon Ratchathani, Mukdaharn, Phitsanulok and Nakhon Ratchasima.

After the successful **"Green Hotels Fair & Seminars"**, attended by more than 1,000 hotels nationwide, a certification program called Green Leaf was created to institutionalise environmental best-practices for all hotels, as well as to promote the efforts of those who already contribute to the protection of environment via efficient management of energy, environmental and natural resources.

This was also designed to help lower operational costs and pass those cost-savings on to the customers, too. Indeed, the program also encouraged participatory activities by customers in saving energy and natural resources saving.

Green Leaf Standard

Standard of Green Leaf Hotels
A process of auditing environmental standard of hotel has consisted of 3 steps as follows:

1. Screening Process
   consists of 13 questions concerning with certain rules, regulation, or legislation in regarding to environmental restriction.

2. Qualifying Process or Questionnaires
   contains questions regarding to proper environmental activities in hotels.

3. Grading Process or Questionnaires
   a self environmental audit in operational process of hotel which divides into 11 sections, as follows.
   Section 1: Policy and Standards of Environmental Practice
   Section 2: Waste Management
   Section 3: Efficiently Use of Energy and Water
   Section 4: Purchasing
   Section 5: In-door Air quality
   Section 6: Air Pollution
   Section 7: Noise Pollution
   Section 8: Quality of Water
   Section 9: Storage and Management of fuel, gas, and toxic waste
   Section 10: Impact on Eco-system
   Section 11: Cooperation with Community and Local Organizations

The following process will be taken place during the Grading Process.

1. Any hotel will have 30 days after receiving the Grading Questionnaires to complete and send back to the Green Leaf foundation. The attachments requested are documents, pictures, or any data supporting the answers.
2. Once the answered questionnaire is sent back, the Foundation will forward it to the Audit team to screen and audit the hotels.
3. The hotels will be contacted in 48 hours before the audit team visit the hotels for auditing.
4. Scores will be calculated from questionnaires and results of audit which will be compared to the Standard score derived from 20 reference hotels.
5. The ranking will be set to identify 1-5 green leaf hotels.

The First Standard scores for Green Leaf Hotel to be qualified :

Less than 45.34 per cent	The hotel will receive	1 Leaf certificate
From 45.34-55.89 per cent	The hotel will receive	2 Leaf certificate
From 55.90-66.44 per cent	The hotel will receive	3 Leaf certificate
From 66.45-77.99 per cent	The hotel will receive	4 Leaf certificate
More than 77.99 per cent	The hotel will receive	6 Leaf certificate

The Second Standard scores for Green Leaf Hotel to be qualified :

Less than 52 per cent	The hotel will receive	1 Leaf certificate
From 52-56.8 per cent	The hotel will receive	2 Leaf certificate
From 56.90-61.7 per cent	The hotel will receive	3 Leaf certificate
From 61.8-66.5 per cent	The hotel will receive	4 Leaf certificate
More than 66.5 per cent	The hotel will receive	5 Leaf certificate

Green Leaf Foundation has successfully established Environmental Standards and management, which is very well accepted by the hotel operators. It is a good indication showing that the hotel operators consider the environmental practices and developmental responsibilities seriously.

Green Leaf Program is a part of Green Leaf Foundation’s activities which transforms an environmental vision into practices by 79 hotels in 2003 which have received green Leaf Certificate. The happenings will help encourage other hotels to continue to upgrade the environmental standards, which leads to sustainability.

Annex 14 List of eco-products and eco-hotels based on existing eco-labelling certification program in Thailand

1. Green Label

Total certified products for Green Label (Updated in 31 July 2011) are 507 Models 25 Products Category and 75 Companies. The full list of all certified products is published and publicly available in:

Office of Green Label Secretariat, TEI (2011), List of Thai Green Label Products. Update 31 July 2011. [online] Also available at:

http://www.tei.or.th/greenlabel/eng%20pdf/2011-07-Name-GL-eng.pdf

2. Green Leaf

There are 669 Green Hotels that certified by Green Leaf, the information provide at http://www.greenleafthai.org/th/green_hotel/

3. Carbon Reduction Label

There are 159 products from 41 companies that certified by Carbon Reduction Label (Last update 25th April 2012).

Source: http://thaicarbonlabel.tgo.or.th/carbonlabel/index.php?page=2#

4. Carbon Footprint Label

There are 506 products from 124 companies that certified by Carbon Footprint Label (Last update 17th August 2012).

Source: http://thaicarbonlabel.tgo.or.th/carbonfootprint/index.php?page=2

13. Environment Planning

SAMUI Island is facing with several environmental issues due to rapidly growth in the number of visitors. In this regard, environmental issues including water supply management, waste water management and solid waste management are recommended.

13.1 Water Supply System

13.1.1 Overview of Water Supply System in SAMUI Island

SAMUI Island is considered as one of the Continental Islands which is located in the Gulf of Thailand, where there are also 25 other smaller land masses located nearby. The Island itself is the largest and inevitably most prosperous which covers approximately 227 km^2

of land. There is a large mountainous area located right in the middle of island. The altitude varies from 100 meters to 635 meters and the summit of that mountain is located at Taay Kwai, where it is 635 m. above sea level. Around 53.77% of these mountainous areas are covered by mixed deciduous forests or coconut trees, which acts as an instigator for a number of important water sources such as the Lipa Yai River, the Mae Nam River, the Ta Jine River and the Na Muang River.

Like the rest of Thailand, SAMUI Island has only two seasons: the summer and the monsoon season. The summer usually starts from February and lasts until April. During this period, the rain is scarce and temperature tends to rise unambiguously. However, the wind is calm and the sea water is crystal clear, making it the perfect time for tourism. The monsoon season starts from around May to January. From May to October, there is a tropical storm coming in from the south-eastern part of the Andaman Sea. From November to January, the monsoon sweeps in from the Chinese Sea, through the north-eastern part of Thailand. As a result, there is a lot of rain throughout the year.

The average annual amount of rainwater is 1,945.9 millimeters. Approximately 59.9% of the rain is estimated to come between January and October, while the total number of rainy days has been averaged to 158.5 days/year, (the data was taken from the meteorological department between 1971 and 2000).

The rainwater in SAMUI Island typically forms a stream or a river which flows down from the mountains located at the center of the island. The main watercourses on SAMUI Island are located at:

- Lipa Yai:

  Lipa Yai originates from the center of the island and provides the source of water for Hin Lad waterfall. The river flows through various hills and valleys, which covers around 9.4 km^2 of land. Thus, this would mean that approximately 9.0 million m^3 of rainwater is gathered per year within the area.

- Lipa Noi:

  The main source of water is the same as that of the Lipa Yai River, but it branches out and flows into the sea via Baan Lipa Noi.

- Skej:

  Skej originates in the hills of Taay Kwai and the river flows into the sea after passing Krajud reservoir. The whole area covers 4.7 km^2 of land and the average amount of rainwater collected here is 4.62 million m^3 per year.

- Ta Lamai:

  Ta Lamai originates from Kow Yai and Kow Plu, where the two streams meet and integrate into a river which flows into the gulf in Lamai. The whole area covers 4.5 km^2 of land and the average amount of rainwater collected here is 4.46 million m^3 per year.

- Baang Namjued:

  Baang Namjued originates from Kow Plu where it flows out into the sea around Baan Hua Thanon. The whole area covers 1.2 km^2 of land and the average amount of rainwater collected is 0.9 million m^3 per year.

- Ta Ret:

  Ta Ret originates from Kow Yai and flows out around the province of Maret.

- Seeya:

  Seeya originates from Kow Yai again and flows out into the sea near the Na Muang province.

- Jarakae:

  This area covers 5.0 km^2 of land and the average amount of rainwater collected is 4.87 million m^3 per year.

- Mae Nam:

  This area covers 8.3 km^2 of land and the average amount of rainwater collected is 7.48 million m^3 per year.

  Apart from these natural sources of water, there are other means of water storage (i.e. dams and water reservoirs) constructed mainly for agricultural use. They are located at:

- Hin Lad:

  Rain water from Lipa Yai where there are water pipes connected to and from the Krajud reservoir. The average amount of rainwater collected here is 8.0 million m^3 per year.

- Na Muang:

  Located in front of the Na Muang waterfall, where it distributes water to the farming areas on the west side of the Ta Seaw River. The average amount of rainwater collected is 1.3 million
  m^3 per year.

- Mae Nam:

  Gathers water from the Mae Nam River, which is then used for agricultural purposes. The average amount of rainwater collected here is 2.4 million m^3 per year.

- Ta Sok:

  This located around Kow Plu, which covers around 3.0 km2 of land and the average amount of rainwater collected here is 2.3 million m^3 per year.

- Bang Namjued:

  Gathers water from the Bang Namjued river. The average amount of rainwater collected here is 0.9 million m^3 per year.

- Wang Sow Tong:

  This is located at the Ma Ret province on the Ma Ret river. The average amount of rainwater collected here is 2.4 million m^3 per year.

- Wang Hid Lad:

  This was constructed near the river at Mae Nam market. The average amount of rainwater collected here is 2.0 million m^3 per year.

- Pung Pae:

  This was constructed at the Pung Pae River in Baan Tung Kyow for agricultural purposes. The average amount of rainwater collected here is 0.8 million m^3 per year.

Some of the water flows from the mountain is collected in a large water storage which is called by locals as ‘Pru’ or commonly known as a reservoir. This can either be created naturally or man-made, each of them has itsown advantages and disadvantages. The reservoirs which have the most influence on the water supply system on SAMUI Island are:

- The Chaweng Reservoir

This reservoir is located in the northeastern part of the island. It is the largest natural reservoir on the Island with the total area of approximately 450 rais. It is 2–3 meters deep and has the storage capacity of approximately 1.6 million m^3. The catchment area is around 7 km^2 and the average amount of rainwater collected is 6.0 million m^3 per year. However, due to the increase in population and construction works, the water cannot flow in the sub terrain–through and along the ground like in the past; so the only source of water that replenishes the reservoir is the rainwater.

FIGURE 13-1 : Chaweng Reservoir

- The Na Muang Reservoir

This reservoir is located on a flat terrain in the southeastern part of the Island where mountains surrounding the area. The total area is about 300 rais but the actual usable area is 250 rais. The reservoir has around 5–6 meters deep with the original capacity of 480,000 cubic meters, but after the water drought in 2002, there were short- term plans (from 2003–2004) to develop and increase its capacity. Nowadays, the Na Muang Reservoir has a capacity of 800,000 m^3 and it is also the most important source of water storage on SAMUI Island.

FIGURE 13-2 : Na Muang Reservoir

- The Krajud Reservoir

This reservoir is located in the western part of the Island. It covers 42 rais of land with the depth of approximately 5 – 6 meters. It used to have a capacity of 250,000 m3, but like the Na Muang Reservoir, it was included in the short-term plan as issued after the water drought in 2002. Presently, the Krajud Reservoir can store up to 350,000 cubic meters of water, it also acts as a main source of water supply for the treatment plant located at the Hid Lad waterfall. There are some difficulties due to its location. For instance, as the reservoir is located near the sea and the seawater tends to penetrate through the reservoir and contaminates the fresh water. To solve this problem, plastic sheets were laid down at the bottom of the reservoir.

FIGURE 13-3 : Krajud Reservoir

Apart from the surface water that flowing above ground, there are also sub-terrain water sources on SAMUI Island. These sources are divided into three types as follows:

- Granitic Aquifers:

  This type of source is made out of granite and diorite and can be found in the central part to the eastern side of the Island. There is actually very little depth in these bowels and cracks can be found on the surface of the rocks at approximately 10 gallons/minute, while some spots rise to 20 gallons/minute.

- Chao Phraya Aquifers:

  This type of source is mainly found in areas consisting of residues on the banks of rivers which are flat and smooth. These areas are common on the beaches in the northern, southern and western parts of the island. Normally, these aquifers are water sources which forms around a pond and usually have a depth of approximately 30 meters. The amount of water gathered here is 100 – 150 gallons/minute. The purity of the water is excellent.

- Metamorphic Aquifers:

  This type of source can be found in small areas on southwestern part of the island. This type of aquifers is very shallow and therefore it could not contain much water.

The water sources in SAMUI Island are still insufficient. The best method for the water supply system is to distribute clean water to residential or commercial areas located near the sources.

Water Treatment Plant

There are two water treatment methods to produce clean water on SAMUI Island:

- Conventional WTP:

  This is a standard method that allows the raw water to coagulate and then all residues and other excesses are filtered out. The purified water is collected and distributed into the water supply system.

- Reverse Osmosis (RO) Plant:

  Sea water is converted into clean, usable water through various processes and procedures.

There are five water treatment plants to produce clean water on SAMUI Island:

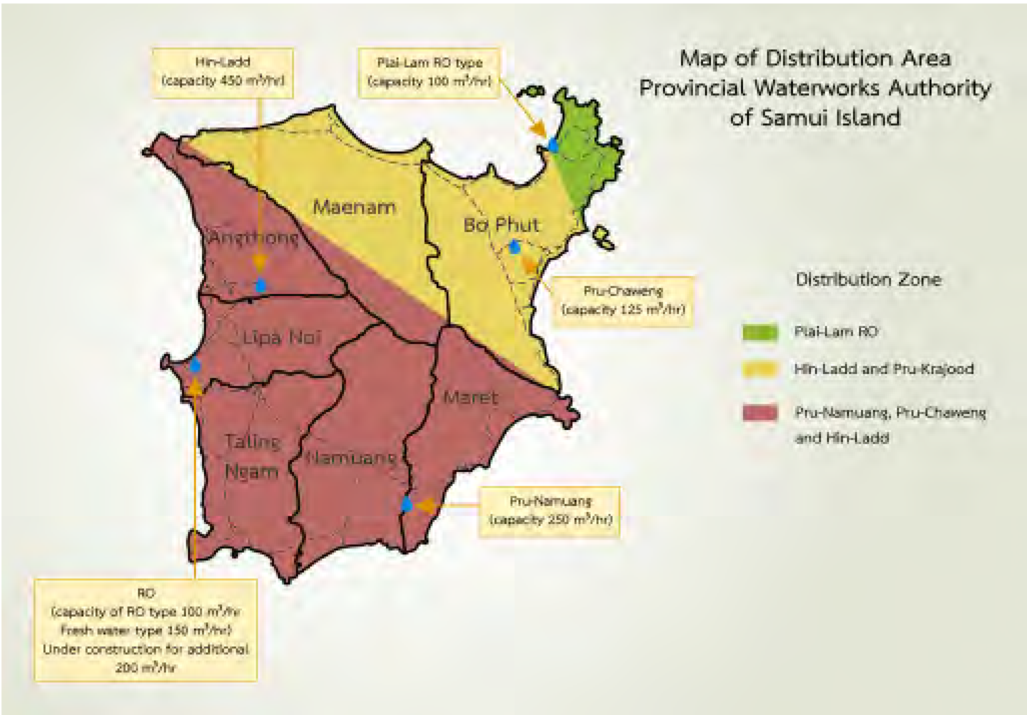


FIGURE 13-4 : Map of Distribution Area

- Hid Lad Waterfall:

  Located next to the waterfall where the Provincial Waterworks Authority (PWA) of SAMUI Island is also situated. This water treatment plant uses the conventional method. In the past, this treatment plant had capacity of 250 m^3/hour or 6,000 m^3/day. After budgets were given to the development of the water supply of the whole island, the Hid Lad Treatment Plant has the capacity of 450 m^3 /hour or 10,800 m^3/day.

- Na Muang Reservoir:

  This plant is located next to the Na Muang reservoir. It has the capacity of 250 m^3/hour or 6,000 m^3/day of clean water, also by conventional process.

- R.O. Plant:

  Due to the lack of water sources, especially in the heavily populated areas such as the Chaweng beach, the PWA has brought in a private water supply management company called ‘East Waters Co. Ltd’ to construct a treatment plant using the R.O process in Bo Phut district.

  This involves bringing in seawater and filtering it through a fine membrane which sifts out the salt. The rate of production is presently at 2,400 m^3/day. This treatment process is important to prevent any knock-on effects it may have on the tourism industry and to improve the water supply system on the Island.

- Mobile Plant Unit:

  In 2004, the Public Works Authority arranged to bring a mobile plant unit to the Chaweng Reservoir with the production rate of 125 m^3/hour or 2,880 m^3/day. This was mainly to make the public gain confidence that the water supply shortage was not serious. However due to the uncertain of the locals about the purity of the water at the Chaweng Reservoir, the Public Works Authority issued a decree to permit the use of this source only in emergencies.

- R.O. Plant at Lipa Noi:

  This plant is located around Lipa Noi. At the beginning, it had the capacity of 100 m^3/hour of clean water. However, after completing the plant enlargement in 2013; it will have the capacity of 200 cubic meters per hour or 4,800 cubic meters per day of clean water.

13.1.2 Water Consumption Planning

To continuously develop SAMUI Island as the premium vacation destination for travelers from all over the world, it is essential that there should be enough water supplies with high quality for the public. Nowadays, the reverse osmosis (R.O.) plant are operated and maintenance by the private supplier. The Provincial Waterworks Authority (PWA) purchases the water with a regular rate of 2.7 baht/ m^3 for surface water usage and 11.1 baht/ m^3 for seawater usage. However, there was an extreme shortage of clean water and the locals have to purchase the water from the other private suppliers for over 50 Baht/ m^3 . The regular rate charged by Provincial Waterworks Authority (PWA) was only at 10–35 Baht/ m^3.

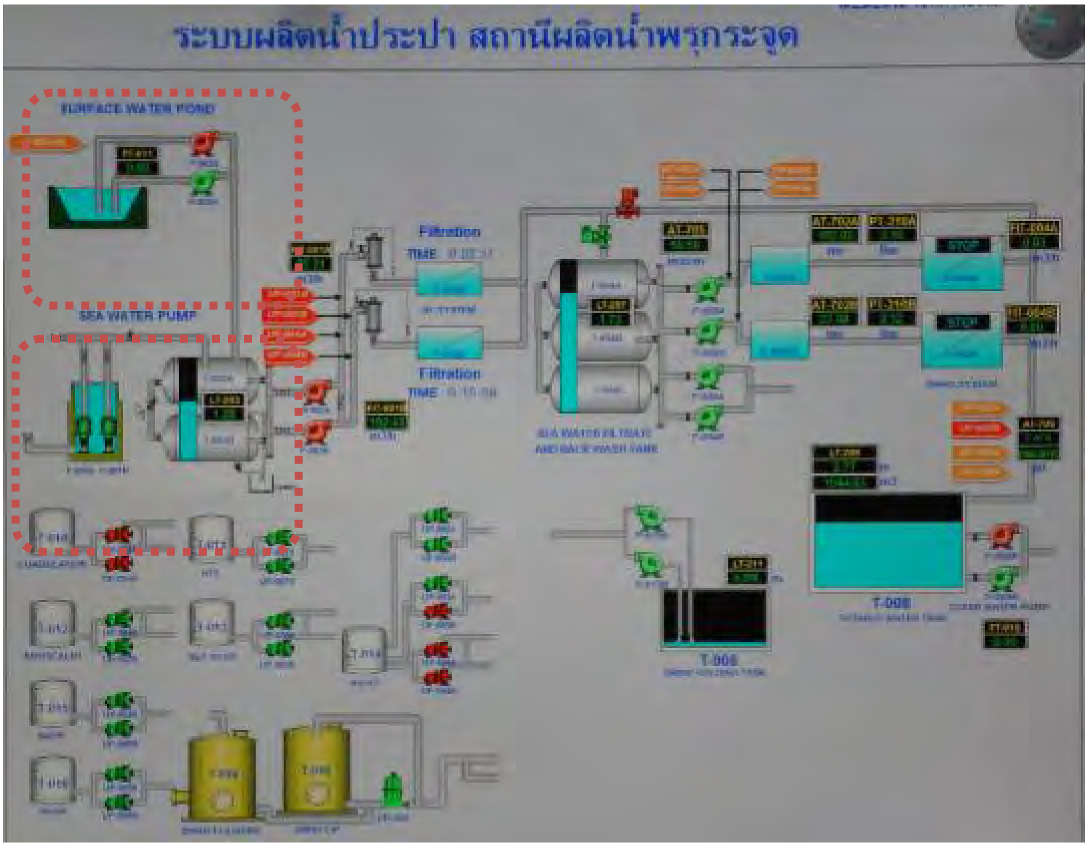


FIGURE 13-5 : Water Treatment Plant Process at Krajud.

This has an adverse impact on all businesses on the Island, which prompts the government to take action and improve the overall water supply system. Currently, the water system development on the Island is supported by the government such as increases in the capacity or production rate of the reservoirs and the installation of the reverse osmosis (R.O.) plant which does not require water storage space. This contributes to the overall advancement of SAMUI Island.

Over 10 years ago, the average amount of tourists visiting the Island each year is around 600,000 compare to more than 1,000,000 tourists throughout the year in the present. This is an extremely rapid growth rate, and the tourism industry has taken this opportunity to expand their business and offer more promotions and tours. The business growth was even better at the beginning of 2005 after the tsunami hits the west coast of Thailand along the Andaman Sea. The disaster prompts investors to come and set up their businesses in SAMUI Island, which result in the very high-prices of the land and properties around the Island.

To accommodate this rapid growth, it requires the improvement of the water supply system. Furthermore the public must be encouraged to realize the value of water and to use it efficiently. Since SAMUI Island is located in the Gulf of Thailand, it receives plenty of rainfall throughout the year, mostly from May to January. As a result, there are plenty of raw water falls into the reservoir but there is not enough storage space to hold the rain water. Moreover, water in the reservoir has been contaminated naturally or by the locals, so it cannot be used to produce clean water supply. The peak season, which is in summer period, could use the reserve water up rapidly if there are long intervals of scarcity of rain.

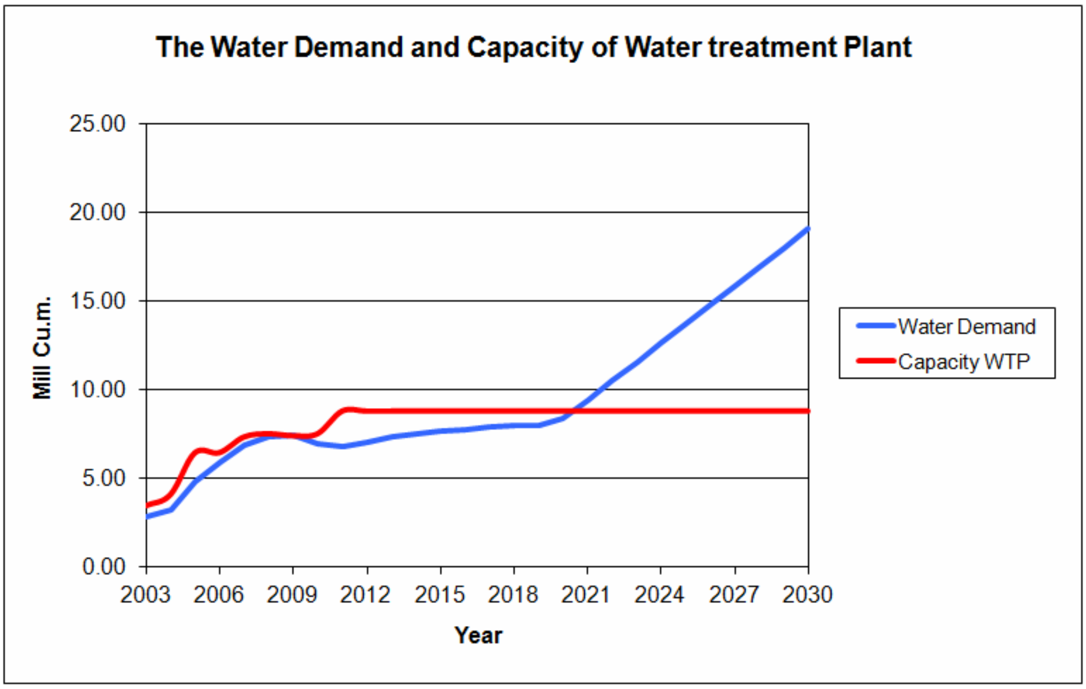


FIGURE 13-6 : The Water Demand and Capacity of Water Treatment Plant.

From the Figure above, the capacity of Water Treatment Plant can be efficiency reserved until 2020.

Therefore, the future improvement plan of the water supply system on SAMUI Island involves investigation on the possibilities of an increase in the capacity of raw water and improvement of the water supply system and its production rate. Currently, the water supply pipes have a water loss of 25%, which is actually below the national average. However, this is still considered to be a substantial waste of resources and there should be plans to develop more efficient and better quality pipes. This involves endorsing the locals and various businesses to have their own water supply storage in case of a water shortage. This may involve construction of water tanks or containers to collect the rain water directly. As mentioned earlier, SAMUI Island has plenty of rain but most of the water just precipitates and flow back into sea due to the lack of storage facilities. If every household has their own storage of water supply, then it would be beneficial to the overall development of the island.

<u>Recommendations for Drinking Water Process in SAMUI Island</u>

SAMUI Island is one of the most beautiful tourist island in Thailand. There are many hotels for service the tourist. The Hotel rooms often feature drinking water bottles instead of drinking water plant. In generally, the bottle water is carried from the main land. The estimating of drinking water for all hotels is around 1,000 cubic meters per month. (See Annex 2: Estimating Drinking Water Demand for Hotel on SAMUI Island).

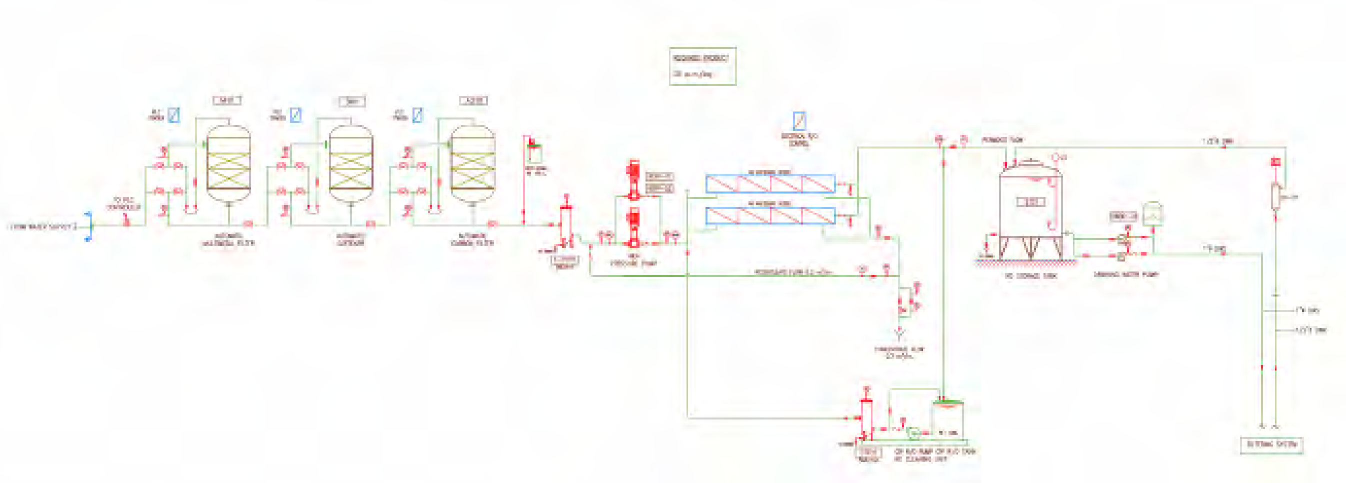


FIGURE 13-7 : Drinking water process diagram

FIGURE 13-8 : The location of Drinking water Plant

The cost of drinking water plant consists of the following:

1.	The cost of building (6 x 12 m^2) is approximately:	1.5	million THB.
2.	The cost of Drinking water process equipment (35 m^3/day) is approximately:	2.5	million THB.
3.	The cost of filtering system is approximately:	0.8	million THB.
	TOTAL:	4.8	million THB

Recommendations for Reclaimed Water

Since agricultural area in SAMUI Island has 102,598 rais. The use of water for irrigation is around 50,000 m^3/month. (See Annex 2: Estimating Drinking Water Demand for Hotel on SAMUI Island). Therefore, the potable water can be reduced by using reclaimed water.

The water quality used for irrigation is essential for the yield and quantity of crops, maintenance of soil productivity, and protection of the environment. For example, the physical and mechanical properties of the soil, ex. soil structure (stability of aggregates) and permeability are very sensitive to the type of exchangeable ions present in irrigation water.

The proper water treatment plant for irrigation should be located at the discharge point of a wastewater treatment plant.

After sewer collection pipeline system has been done, the first recycle water treatment plant should be installed at Lamai Wastewater treatment plant.

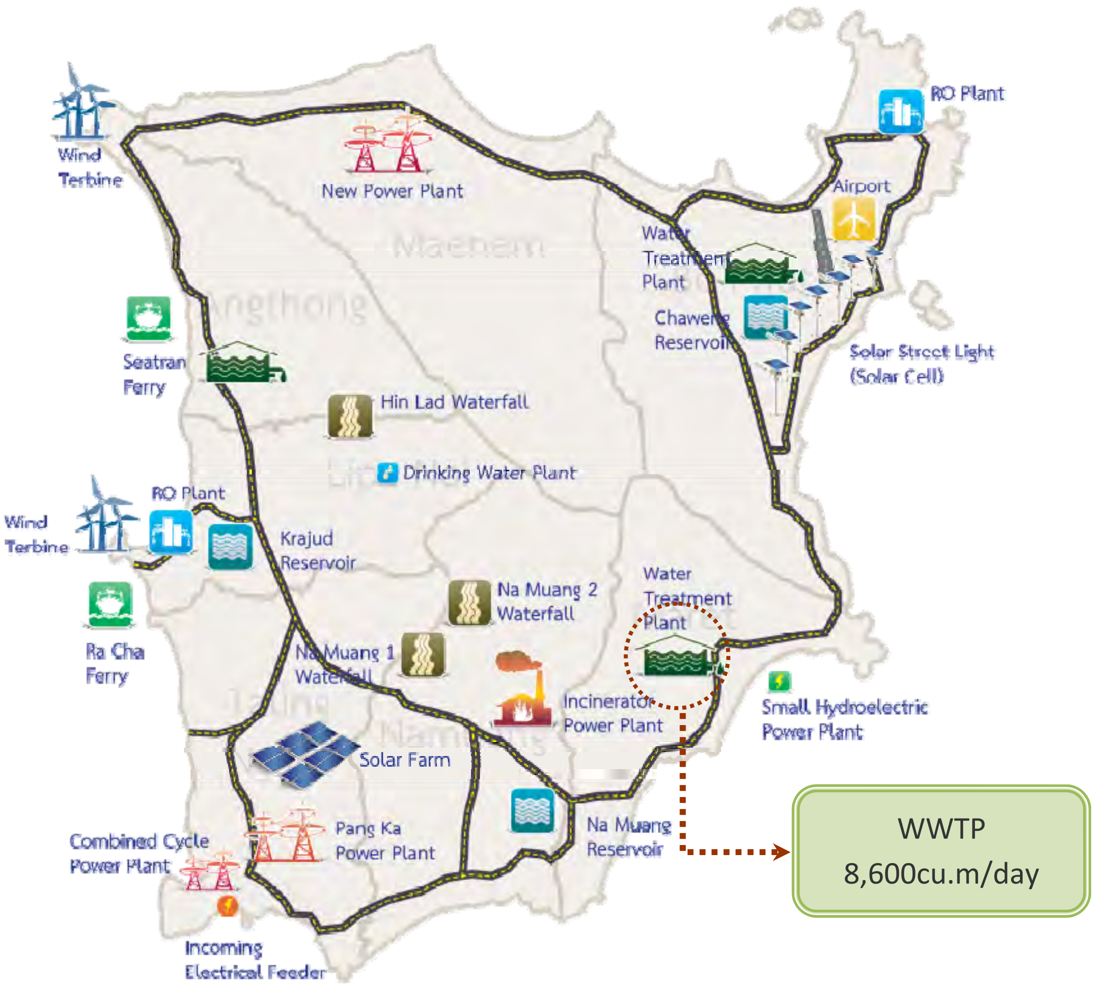
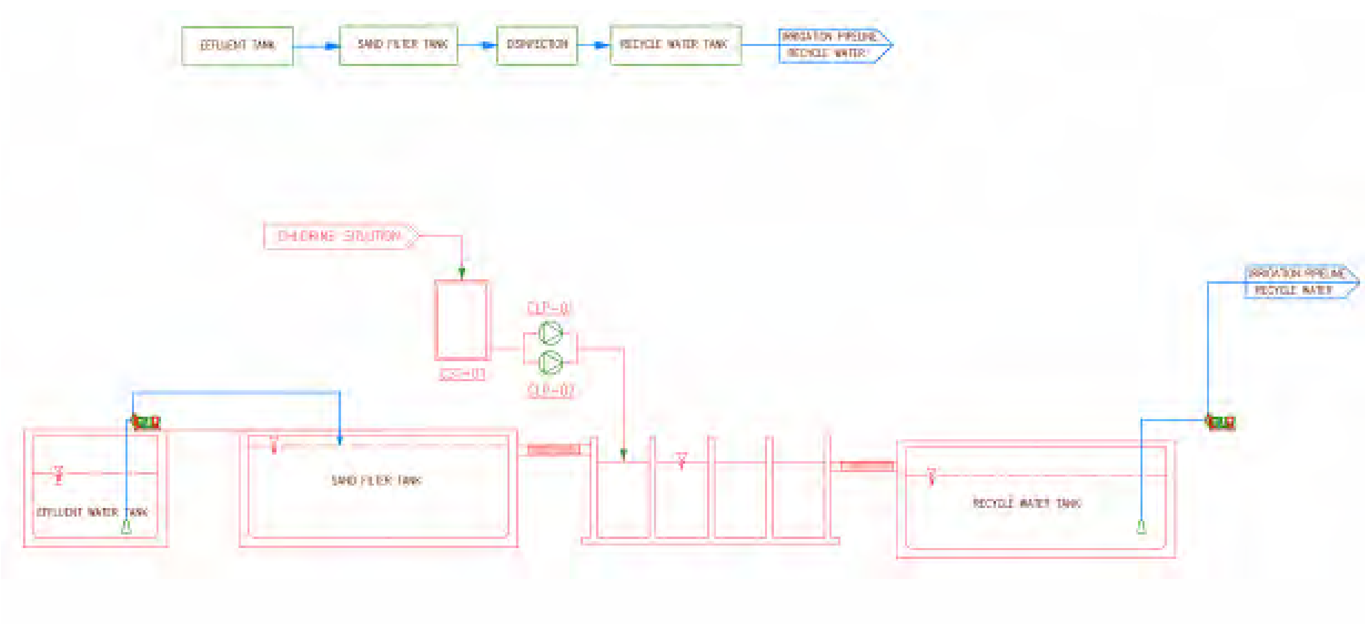
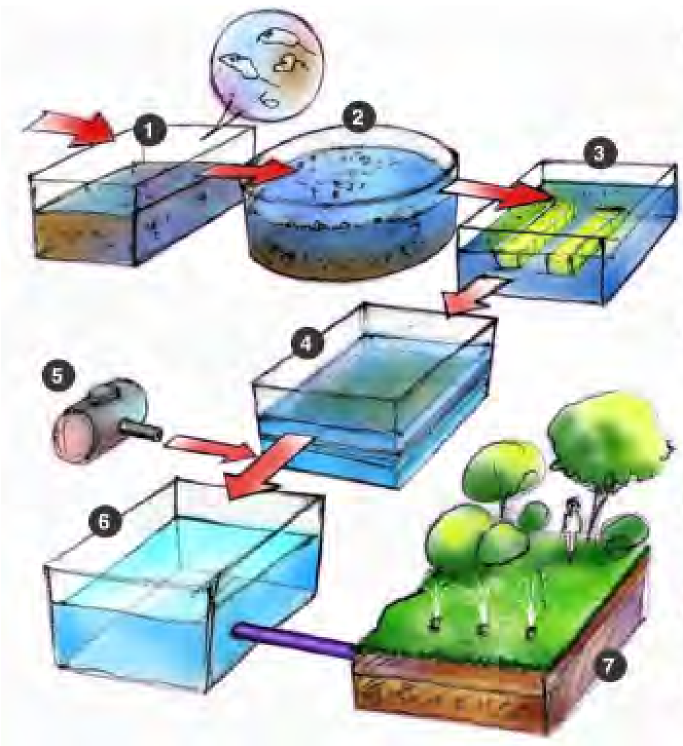


FIGURE 13-9 : The location of Water Treatment Plant for reclaimed water.





1. Wastewater that has already undergone primary settling enters activated sludge basins where beneficial bacteria feed on suspended organic particles.
2. Secondary clarifiers remove 96 percent of the remaining particles through settling and mechanical separation.
3. The secondary water is now disinfected with ultraviolet light.
4. A portion of disinfected water is diverted to our Recycling Plant where it passes through a sand and anthracite filter, similar to those used for purifying drinking water. This filter further removes residual particles and improves clarity— almost to drinking water standards.
5. The filtered water is disinfected again using a chlorine bleach solution as an added safety factor, and the "recycled water" is ready for distribution.
6. The recycled water is stored in a covered seven million gallon reservoir.
7. Recycled water can then be pumped to customers in the community for irrigation purposes.

FIGURE 13-10 : Flow Diagram for Recycled Water Treatment Process System

Reference from http://www.centralsan.org/documents/Recycled_Water_Process.pdf

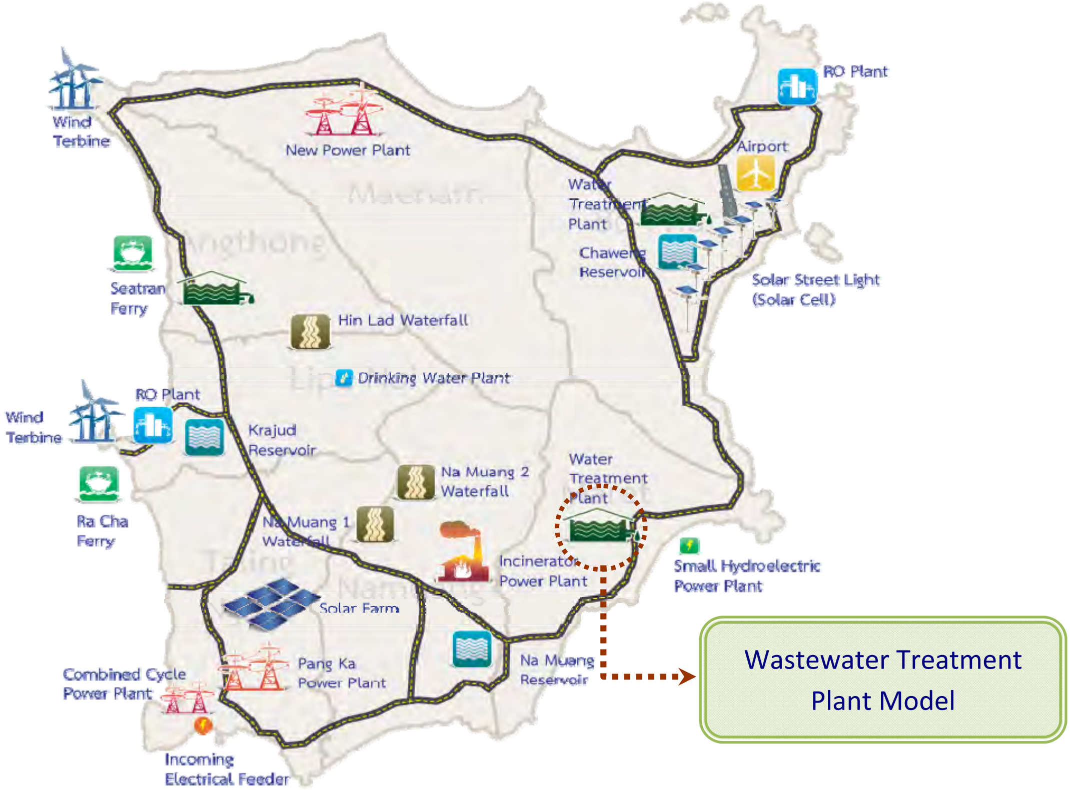


FIGURE 13-11 : Existing wastewater discharge point

Source : http://modelbuilders.net/blog/bid/

: http://www.greentank.co.nz/GreenBuilding

FIGURE 13-12 : Recycle Water Treatment Plant Model

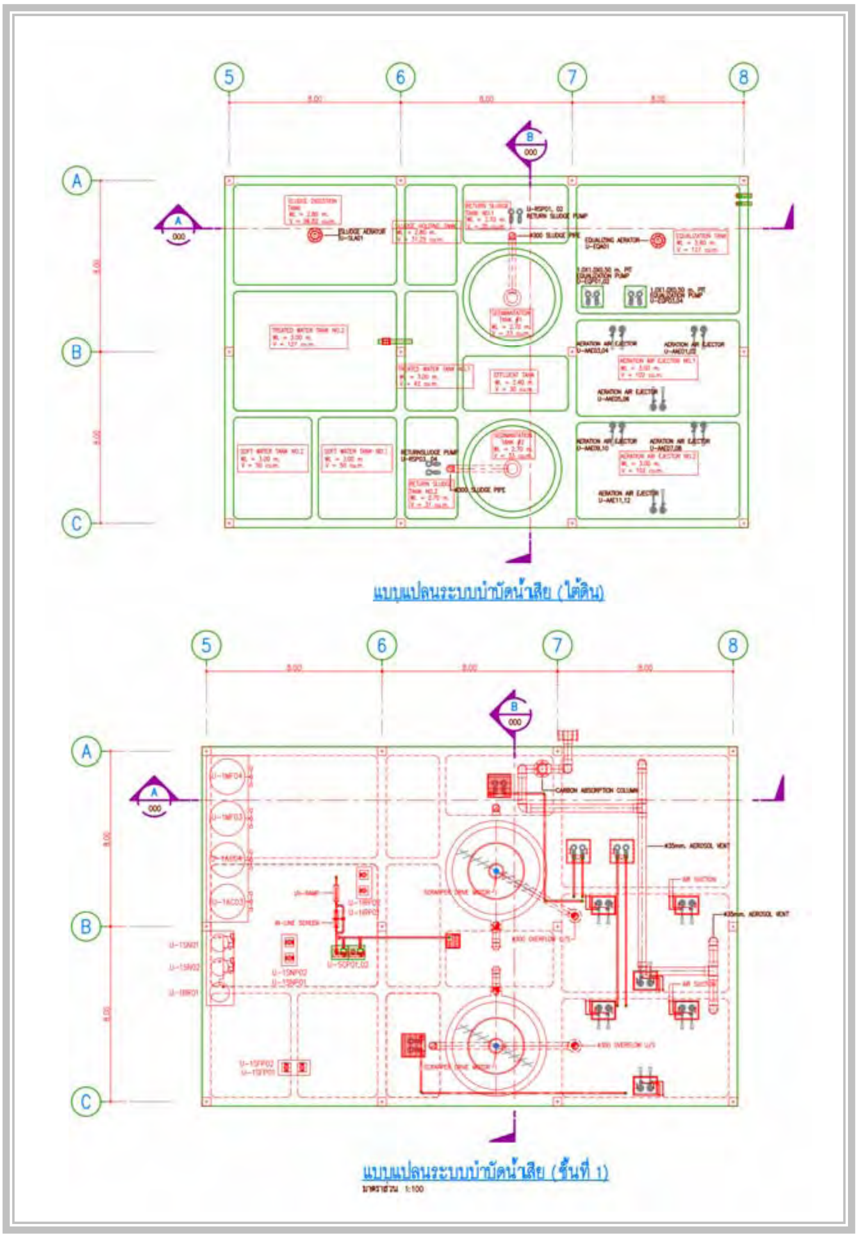


FIGURE 13-13 : Recycle Water Treatment Plant Layout

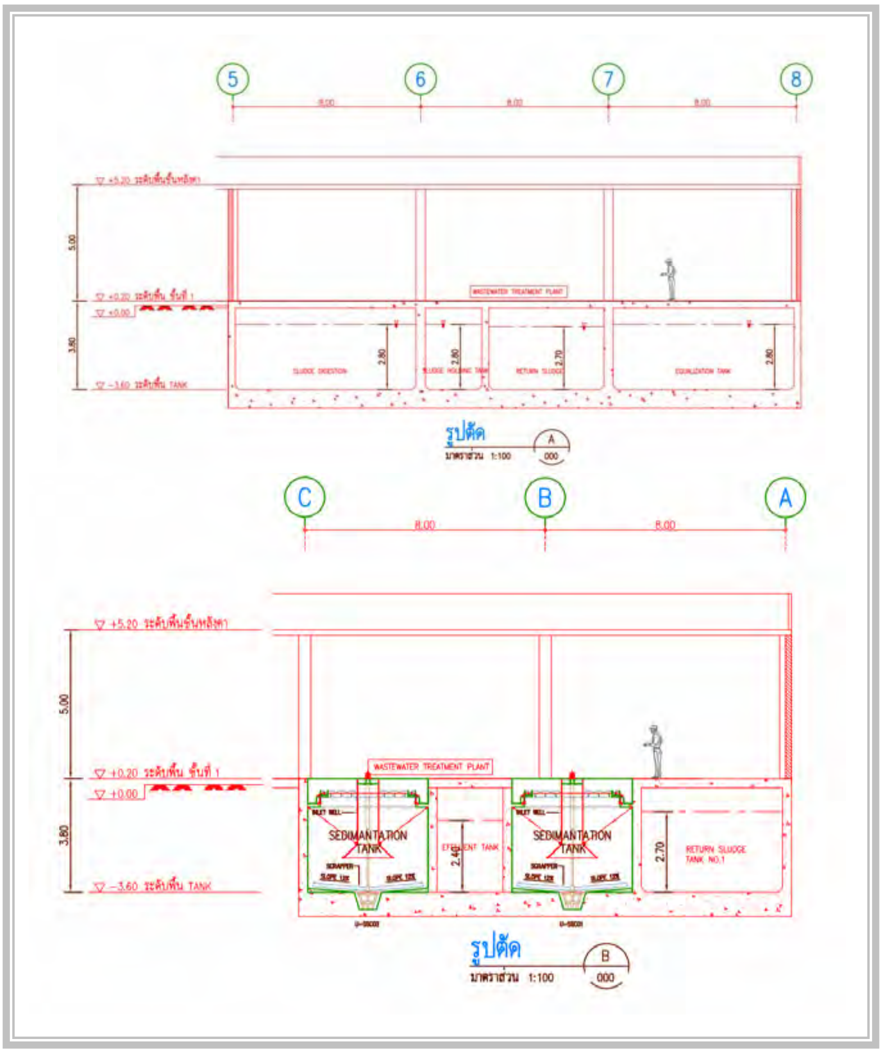


FIGURE 13-14 : Recycle Water Treatment Plant Section

<u>Recommendations for the Development of Various Reservoirs on SAMUI Island</u>

The lack of water storage facilities on SAMUI Island is considered to be the most apparent problem with the water supply system. There have been methods and procedures to solve. This problem and one of them is the installation of a reverse osmosis (RO) plant, which use sea water as a water source. By improving the quality of the water supply system, there will be an inevitably increase in the operating cost. Even though the government is supporting this project, they are not correlating with the reality of the condition of the Island that has more than enough of raw water supply. It would make more sense if the cost of production of clean water and maintenance would be a lot more economical. In this regard the development of various reservoirs on SAMUI Island are recommended as followings

1. The Development of the Krajud reservoir

This reservoir is situated on the western part of the Island around Baan Lipa Noi district. It covers 42 rais of land with the depth of approximately 5 – 6 meters. A short-term development plan, which issued after the water drought, was to expand the reservoirs on SAMUI Island. When this expansion was completed in 2004, the capacity of the Krajud reservoir is increased to 350,000 m^3.This reservoir also acts as the water source for the Hid Lad water treatment plant. If there is a shortage of supply at the Hid Lad waterfall plant, then the raw water would be drawn from the reservoir using PE pipes with the diameter of 315 millimeters.

There are still some lands available surrounding the Krajud reservoir that could be used for the expansion of the reservoir. By comparing the expansion cost of this area to other areas on the Island, it is much lower and also suitable for expansion at Krajud reservoir. However, this reservoir is located near the sea and there have been problems when the seawater manages to seep through and contaminate the water source in the past. This will obviously decrease the quality of the water supply overall.

To overcome this difficulty in the future, the Action Team must consider the seawater prevention method. One of the possible solutions is the insertion of a layer of plastic linings on the bedrocks at the bottom of the reservoir.

Surrounding the reservoir is still an additional 55 rais of land which the reservoir can be expanded. If it can be deepen the average depth to 5.80 meters, then the capacity of the additional section would be 450,000 m^3. Perceptibly, the water source can be transferred to the Hid Lad waterfall treatment plant and used for the production of clean water supply.

The cost of expanding the Krajud reservoir consists of the following:

1.	The cost of land is approximately	30 million THB.
2.	The cost of the PE plastic linings is approximately	32 million THB.
3.	The cost of construction is approximately	15 million THB.
	TOTAL:	77 million THB.

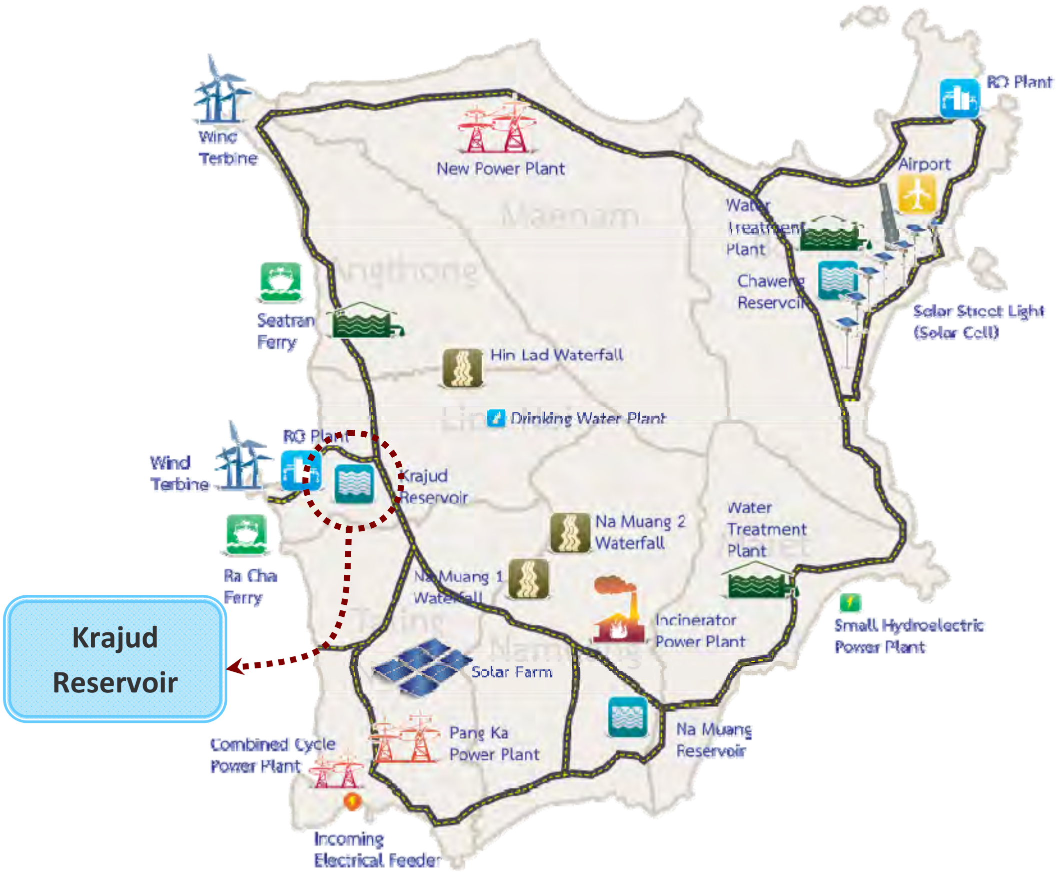


FIGURE 13-15 : Recommended expansion area for Krajud Reservoir

<u>The Advantages of Expanding the Krajud Reservoir</u>

1. The Krajud reservoir is already a source of water supply for the Hid Lad waterfall treatment plant. Therefore, there is no need to construct an extra plant to accommodate this expansion.
2. The cost of land around the reservoir is considered economical compared to the other areas on the Island, which could reduce the overhead cost considerably.
3. The reservoir is located near the Provincial Waterworks Authority (PWA) which is situated at the Hid Lad waterfall. This is convenient for the officials to keep track of any progress being made.
4. This reservoir can be used as a retaining pond to collect the rain water and prevent any flooding that may occur on the western part of the Island.

2. The Development of the Na Muang reservoir

This reservoir is situated on the southeastern part of the Island and the area covers 260 rais, with its depth approximately of 5 – 6 meters. A short-term development plan, which issued after the water drought, was to expand the reservoirs on SAMUI Island. When this expansion was completed in 2004, the capacity of the Na Muang reservoir is increased to 800,000 m^3. This reservoir acts as a source for the Na Muang treatment plant and it is also the largest fully functioning reservoir presently.

Its geographical terrain of the reservoir is completely flat, however there are mountainous areas engulfing the place, as a result the reservoir tends to flood when it rains heavily. Due to this nature, this reservoir is suitable for raw water collection on the southeastern part of SAMUI Island.

Furthermore, the vicinity surrounding the reservoir consists of flat, unused terrain which would be most appropriate for expansion. Since few removal works to be done, the cost of construction will be kept at minimum. The cost of land around Na Muang is considered to be rather high, but that is still inexpensive when compared to other areas such as the Chaweng and Lamai beaches.

Since the Na Muang reservoir is located reasonably far from the sea, there is no need for the incorporation of plastic tiles to prevent sea water coming through. Presently, there is a further 250 rais available for expansion and if the depth of the reservoir can be deepen to around 5.80 meters, there will be 2,320,000 m^3 of storage capacity available.

The cost of expanding the Na Muang reservoir consists of the following:

1. The cost of land is approximately:	150	million THB.
2. The cost of construction is approximately:	60	million THB.
TOTAL:	210	million THB.

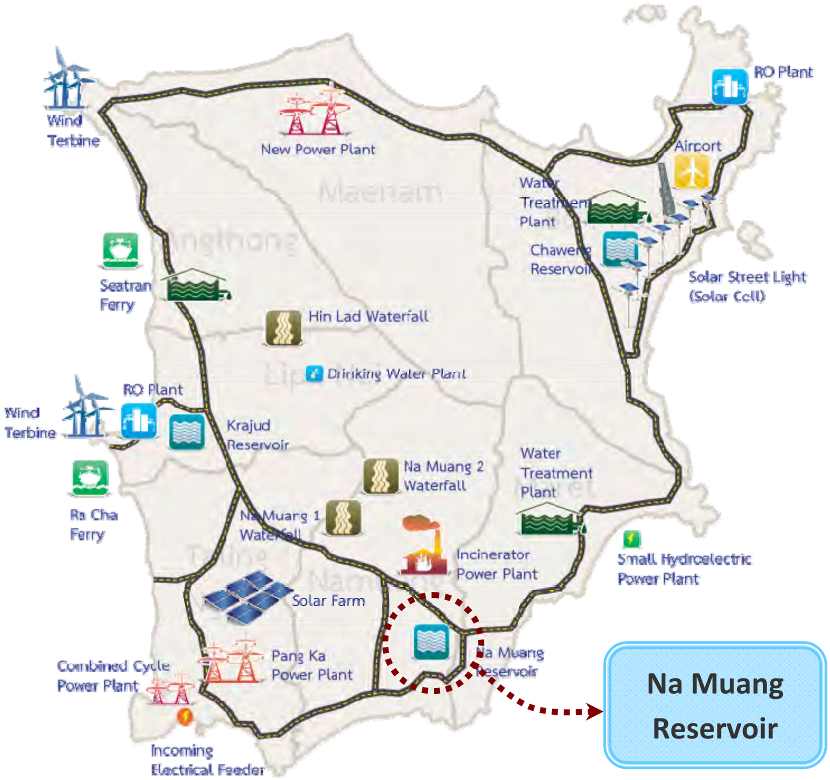


FIGURE 13-16 : Recommended expansion area for Na Muang Reservoir

The Advantages of Expanding the Na Muang Reservoir

1. The Na Muang reservoir is already a source of water supply for the Na Muang water treatment plant. Therefore, there is no need to construct an extra plant to accommodate the expansion.
2. The cost of land around the reservoir is considered economical compared to the other areas on the Island, which could reduce the overhead cost considerably.
3. It is the focal point for rain water collection on the southeastern part of SAMUI Island.
4. There is a small chance that the reservoir will be contaminated by the daily activities of the nearby small community.

3. The Development of the Chaweng reservoir

This reservoir is situated on the northeastern part of the Island. It is the largest reservoir on the Island with the total area of 370 rais, with its depth approximately 2 – 3 meters, giving a total capacity of 1,600,000 m^3. At present, the eastern side of the reservoir is next to the Chaweng beach, where it is the most heavily populated area on the Island. On the west side, however, there are quite a few mountainous areas which the reservoir can receive plenty of the natural water resources. In spite of this benefit, the water cannot flow into the reservoir due to the formation of various buildings and housings. Furthermore, the communities around the Chaweng area have released untreated wastewater into the reservoir, which makes it unsuitable for the use of water supply production. Even if the wastewater treatment plant which has been constructed in 2005 is available, the actual procedure has not been put into action. Not only that, there is no wastewater treatment plant built around the Lam Din district and therefore the water is not suitable for the use of water supply production.

The development of the Chaweng reservoir will involve:

(1) Open up the obstructed passageway for the water to flow efficiently from the mountains. This will require the full cooperation of the local community, which can be obtained either through comprehension or though government laws and warrants.
(2) Construct a wastewater system for the Lam Din district which will combine the wastewater from the area to the treatment plant that already exists.
(3) Decrease the level of contamination of the water in the reservoir after the expansion so that the purity of the water is suitable for the use of production of clean water. In the future, this area will be developed into a commercialized area, which will make the source unsuitable for the treatment process. Therefore, only 20% or 320,000 m^3 of water will be used from the Chaweng reservoir as reserved water.

Apart from using the Chaweng reservoir as a reserved water source, it can also be used for further storage as the landscape is very flat and would be able to collect plenty of rain during the monsoon season. For example, a flooding incident occurred all over the Island and especially on the Chaweng beach area at the end of 2005. The passage for the water to flow into the reservoir around the Island has been blocked and together with the continuous torrential rain, the reservoir could not be able to store all of this excess water. So, part of the plan in developing the Chaweng reservoir is to utilize this factor to prevent any flooding in the future.

The cost of developing the Chaweng reservoir consists of the following:

1. The development cost of demolish the obstruction is approximately: 8 million THB.
2. The construction cost for the wastewater collection system is approximately: 12 million THB.

TOTAL: 20 million THB.

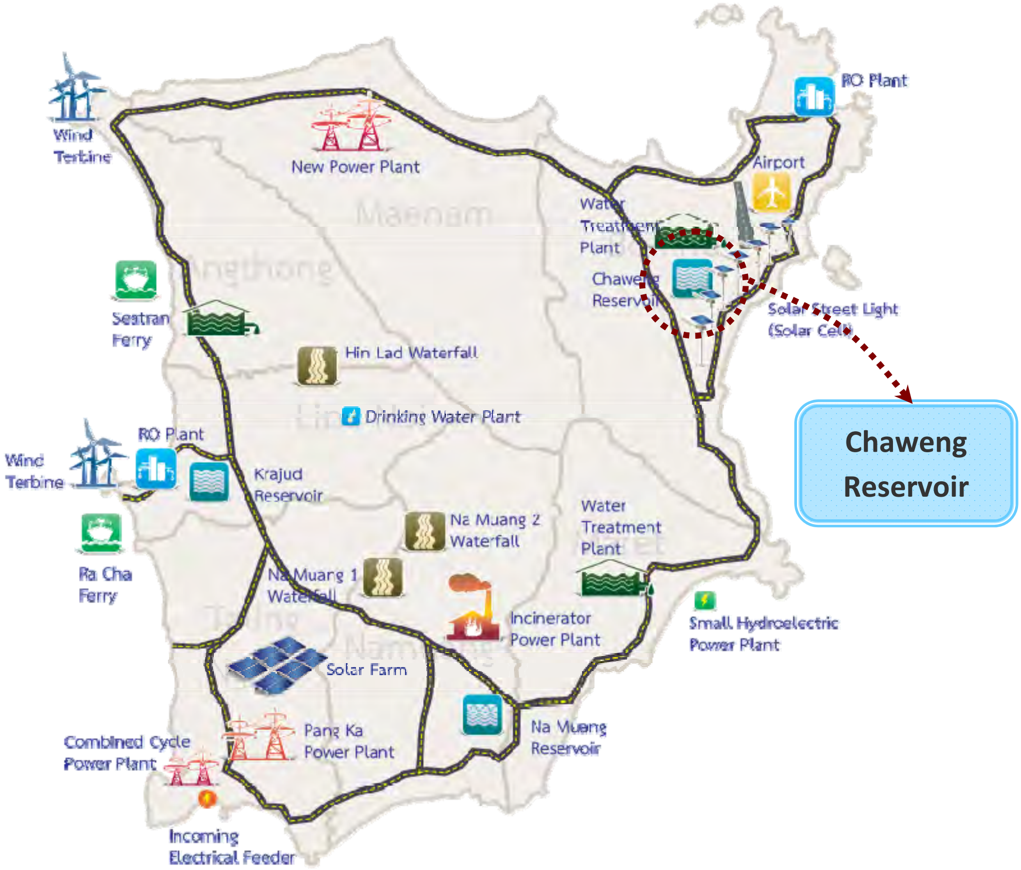


FIGURE 13-17 : Location of Chaweng Reservoir

The Advantages of Developing the Chaweng Reservoir

(1) The Chaweng reservoir is the largest natural reservoir and would not require any further construction plans. This would significantly decrease the initial cost due to no additional land required.

(2) The Chaweng district is the most populated area on SAMUI Island and would have the highest demand of water supply. Therefore, it would be very convenient if the reservoir which located right next to the community is operated and the production of water supply can be distributed with the minimum amount of water loss. There is also already a mobile water treatment plant with the production capacity of 120 m^3/hour located on site which is currently unused. If the purity of the water in the Chaweng reservoir can be enhanced and is approved by the public, then this treatment plant can be operated straight away.

(3) The Chaweng reservoir acts as a water duct for the mountains on the eastern side of SAMUI Island

4. The Development of the Bang Rak reservoir

The development of this reservoir is part of a mid-term plan issued by the PWA to solve the water drought incident. It is situated on the northeastern part of the Island cover the area of 200 rais around Bang Rak district, which is very close to the SAMUI Island Airport.

However, only 74 rais can be registered as public property since the rest of the land has been used by the locals for commercial or residential purposes. In order to carry out the project successfully, all of the 200 rais must be obtained for the reservoir to have the total capacity of 500,000 cubic meters. Similar to Krajud reservoir, it is located close to sea and would require the installation of the PE plastic linings at the bottom of the reservoir to prevent the sea water contaminating the source.

Moreover, it was discovered that there is no passageway for the water to flow into the reservoir. As a result, this would require appropriate pipe works for the raw water to flow efficiently into the reservoir from the surrounding mountains.

The cost of developing the Bang Rak reservoir consists of the following:

1.	The cost of digging a reservoir with the capacity of 500,000 $m^3$is approximately:	30	million baht
2	The cost of the PE plastic linings is approximately:	40	million baht
3	The cost of construction for laying the water pipes leading into the reservoir is approximately:	10	million baht
	TOTAL:	80	million THB.

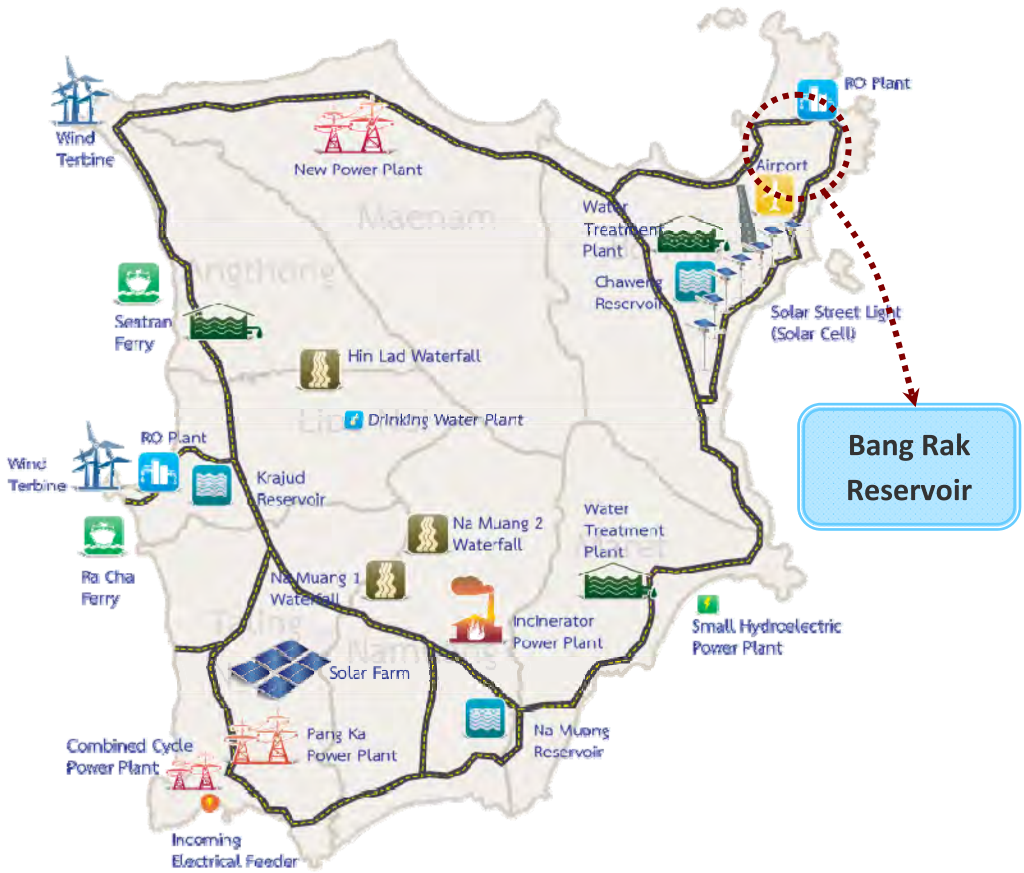


FIGURE 13-18 : Location of Bang Rak Reservoir

The Advantages of Developing the Bang Rak Reservoir

(1) The Bang Rak reservoir is located near a populated area which has a high demand for water supply.

(2) The land which the reservoir situated is publicly owned, so it would be most suitable to make use of the available land.

5. The Development of the Lipa Yai Dam

The investigation into the construction of the Lipa Yai dam has been ongoing since 1987. It was first initiated by the previous Ministry of Energy but was put on hold since the project was situated in a preserved rainforest area (at watershed area proximity, 1A). According to the laws of Thailand, the preserved rainforest area cannot have any man-made structures. The project was reintroduced in 1997 as the dam for a reserve water supply facility, which would also be available for the production of clean water supply if required, especially in the summer season.

The project to build a dam at Lipa Yai will be located where the river between Lipa Yai and Praeng Nun meets, which is approximately 5 kilometers in land from the ring road. The area is around 9.4 km^2 and the average amount of water coming into the impoundment is approximately 9,030,000 m^3/year. The height of the dam will be 21.50 meters above sea level and 390 meters wide, with the capacity of 950,000 m^3 over the surface area of 71 rais. This will also be used as a source for the water treatment plant at Hid Lad.

However, the construction of a dam will have environmental impact on the purity of the raw water supply. For example, the amount of residue in the raw water would decrease while the level of minerals in the water source would increase. At present, the project is still being considered by the Commissioners of the Planning and Environmental Board, whose approval is required to proceed with the project.

The initial cost of constructing the Lipa Yai dam would be approximately 230 million THB, (taken from the PWA).

FIGURE 13-19 Location of Lipa Yai Dam

The Advantages of Constructing the Lipa Yai Dam

1. It would be a large water storage facility for the Hid Lad waterfall treatment plant.
2. The Lipa Yai and Praeng Nun rivers would offer a generous amount of water flowing into the dam throughout the year.
3. The dam can be used as an excellent barrier containing the water to prevent any flooding which may occur on the western part of the island.

Recommendation for Water Supply System Development

Clean Water Supply Production Methods

The system which will be used for the production of clean water supply depends mostly on the quality and the nature of the raw water. If the reservoir development plans could be successfully completed for the short and long term, there will be more than enough good quality water available. The recommended treatment process is the conventional method as it has passed various quality control tests and also the most widely used treatment method in the country.

This conventional system also requires low initial cost and it is very economical to maintain. As a result, this system is the most suitable treatment process in Thailand. However, if the development plans are hindered for any reasons, it would be most likely that there would not be enough water storage capacity to meet the water demand of the population on SAMUI Island. If this is the case, the solution would be to use seawater which is essentially unlimited. The treatment of seawater can be done using the reverse osmosis (R.O.) system, which is currently being utilized on SAMUI Island. However, this process is extremely expensive to operate and should only be used when needed.

13.1.3 Overview Wastewater Situation in SAMUI Island

SAMUI Island produced approximately 7,056 m^3 of wastewater per day. Most of the wastewater came from the eight most heavily populated areas on the Island, i.e. Nathon, Mae Nam-Bo Phut, Chaweng, Lamai, Hua Thanon, Na Muang, Taling Ngam, and Lipa Noi, and also hotels and bungalows.

In the past, the wastewater system was available only in residential or commercial areas, markets and other tourist attractions. There were wastewater ducts and pipelines to collect the wastes, and flowed into the reservoir for treatment before being released into rivers and then the sea. However, some accommodation services and restaurants released wastewater straight into rivers without treatment.

It can be clearly seen that while number of tourists visiting SAMUI Island is increasing, the environment problem are also amplifying. However, there have not been enough measures to solve these problems. Although the Government has prioritized these issues for a number of years and has given appropriate funding, the problems still persist. In 1992, a project, to improve the wastewater system in residential areas or beaches, was announced but the process had been delayed and was finally submitted on 8 September 2005. Since then, there still has not been much improvement on the wastewater system.

FIGURE 13-20 : Chaweng Beach

In 1993, the Public Works Department had carried out an examination on the suitability of wastewater collection system and wastewater treatment processes. One of the solutions was to construct wastewater treatment plants in the four areas in which populations are most likely to increase the fastest, these are:

- Nathon
- Mae Nam-Bo Phut
- Chaweng
- Lamai-Hua Thanon

However, only three out of the four plants have been completed, the unfinished one was at Mae Nam-Bo Phut. The three Central Water Treatment Plants on SAMUI island are currently located at:

- Nathon (2,400 m^3/day)
- Chaweng (6,000 m^3/day)

- Lamai (8,600 m^3/day)

Each of these treatment plants has been designed to accommodate the growth and development of the Island for the next 20 years.

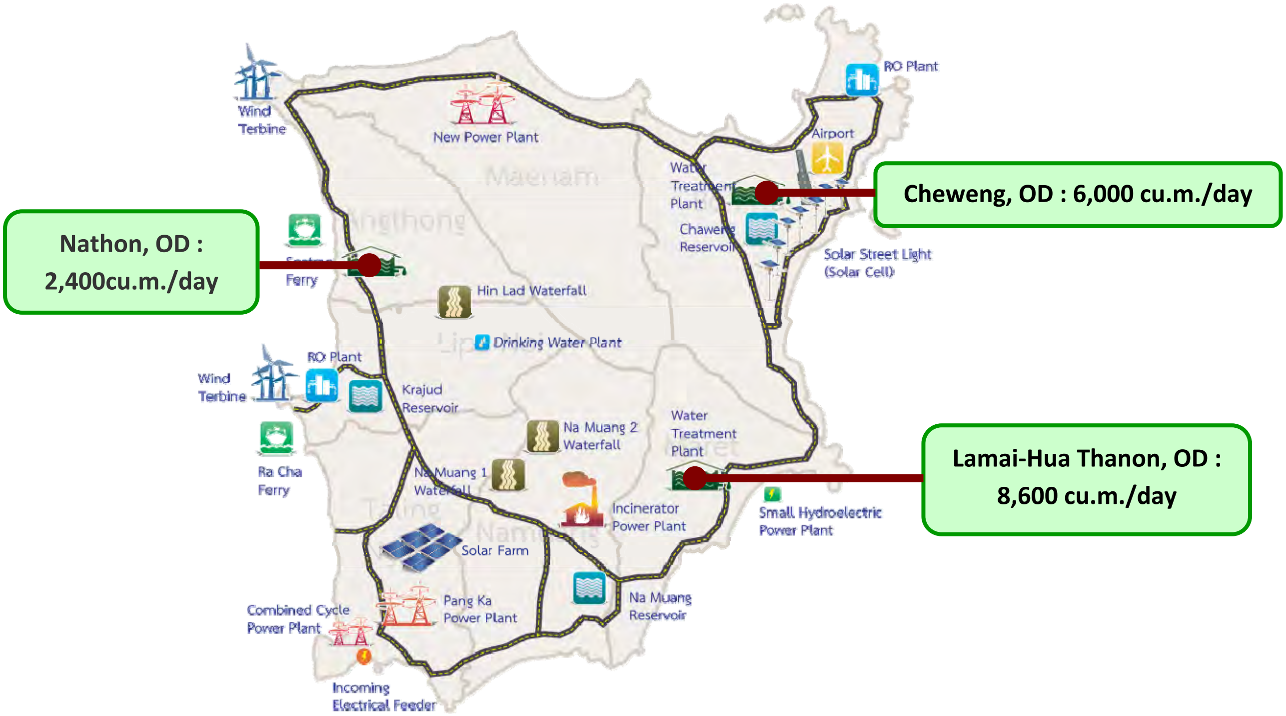


FIGURE 13-21 : Map of Wastewater Treatment Plant Location

<u>The Wastewater Treatment Plant at Nathon</u>

This treatment plant is located on the west side of the Island, about 200 meters from the 4169 Road and the Klong Jorake. Its area is about 4 rais which also act as a basin to collect the wastewater from the Nathon area. There are a few number of government owned buildings around the area, including the sheriff's Office, police station, the post office and the tourism office. The main pier for boats traveling from the mainland is also located in the vicinity.

The wastewater system used in Nathon is a combined sewer system, which collects both the wastewater and the rain water into the treatment plant. Its total length is 4,505 meters, which includes a water pump station, 3 interceptors and pipes running from the Klong Jorake along the 4169 Road, into the treatment plant. There is also another line runs from the Win Hotel that is parallel to the beach, through the pier and the Sheriff’s Conference Room to the treatment plant.

The Nathon Wastewater Treatment Plant has a capacity of 2,400 m^3/day. The operated system is an Oxidation Ditch type, the BOD5 value which is used to design a 110 milligrams/ liter, system consists of:

- A screen chamber
- An aerated grit chamber
- 2 units of the oxidation ditch type aeration tank
- 2 units of the sedimentation tank
- A sand drying bed
- A chlorination tank

Eight jet aerators were used to create a mixing in the aeration tank. When the system was first operated, only half of the full capacity- one set of aeration tank and the sedimentation tank-was used. Currently, the system has been put on hold since the Municipality Authority is finding the private organization to take responsibility and operate this system.

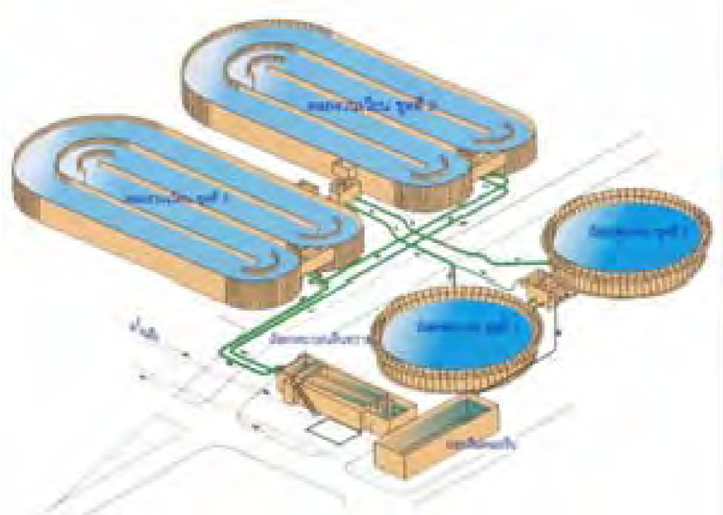


FIGURE 13-22 : Nathon Wastewater treatment plant

<u>The Wastewater Treatment Plant at Lamai – Hua Thanon</u>

Lamai is also another popular holiday destination for many tourists who visit SAMUI Island. It is located on the southeastern part of the Island and the beaches(the Lamai and the Hin Ta-Hin Yaay) there prove to be the main attractions, Therefore, Lamai has become the second largest community on the island next to Chaweng, and similarly tends to be enlarged rapidly.

The wastewater system used in the Lamai– Hua Thanon region is also a combined sewer system, which collects both the wastewater and the rain water into the treatment plant. Its total length is 9,226 meters, with 2 water pump stations, 5 interceptors and pipes running on both sides of the 4169 Road right to the Junction. There is also another line runs parallel to the Lamai beach and the Klong

Lamai road.

The Lamai – Hua Thanon Wastewater Treatment Plant has a capacity of 8,600 m^3/day and is the largest plant currently available on SAMUI Island. It is an empty land of 5 rais, located right next to the Lamai River, which is approximately 800 meters from the 4169 Ring Road. The treatment system was the Oxidation Ditch type, the same as the one used in the Nathon Treatment Plant, and the BOD5 value is also similar. This plant has not been operated since the Municipality Authority is finding the private organization to take responsibility and operate this system.

FIGURE 13-23 : Lamai - Hau Thanon Wastewater treatment plant

The Wastewater Treatment Plant at Chaweng

As mentioned earlier, Chaweng is the most popular and most populated area on SAMUI Island because of its long, beautiful stretches of beach, clear water and sunny. Especially after the tsunami tragedy in 2003, tourists are piling into the east side of the mainland and there has been a sharp increase in the number of visitors each year. Although there are hotels all over the Chaweng beach at present, the demand still increases leading to more clean water and the amount of wastewater generated. In addition, the increase in the number of hotels would mean more jobs available and more accommodation needed for employees. Eventually, more villages and communities would increase in and around the Chaweng area.

The wastewater system used in Chaweng is also a combined sewer system, which collects both the wastewater and the rainwater into the treatment plant. Its total length is 4,017 meters, with a water pump station and pipes running along the Had Chaweng–Cheang Mon road, right from the Wat Swarng Arom to the south entrance of the beach. It acts as a wastewater channel for all hotels, houses, restaurants and other commercial areas along the Chaweng beach.

The Chaweng Wastewater Treatment Plant has a capacity of 6,000m^3/day. It is located on the southeastern of the Chaweng reservoir. Next to the reservoir it is an empty land of approximately 4 rais. The treatment system was the same type using in the Nathon and Lamai Treatment Plants, the oxidation ditch type. This plant has not been in operation. Moreover, some parts of the equipment, such as the water pump and the valve on the control panel, were damaged by major flooding in the year 2005.

FIGURE 13-24 : Chaweng Wastewater treatment plant

The Water Treatment Process on Other Areas

For most of the populated regions such as Chaweng, Mae Nam, Lipa Noi, etc., there tends to be a wastewater system installed for domestic use. The laws of Thailand stated that the amount of wastewater must be congruent with the size of the building. For those in the rural areas who have not been provided with the central treatment plant system, the most common solution is to use cement pipes and to construct a little basin for trapping wastewater and then leaving it to dissolve into rivers and the sea.

13.1.4 Wastewater Consumption Planning

The construction process issued by the Public Works Department to improve the wastewater management system involves 3 heavily populated areas: Nathon, Lamai–Hua Thanon and Chaweng. The construction was completed in 2005, hence the overall wastewater management system was expected to be improved.

However, the wastewater treatment plant and its water pipe system constructed do not cover the whole island. The most particular concern was Mae Nam–Bo Phut area, which was included in the original plan but finally left unconstructed.

The prediction for the amount of wastewater on the Island for the planning process in the future development of the wastewater system has been taken from the Public Works Department. In 1993, they divided the Island into seven different sub-district and grouped them into two categories: heavily populated areas (Chaweng, Lamai–Hua Thanon, Nathon and Mae Nam–Bo Phut) and rural areas (Lipa Noi, TalingNgam and Na Muang).

When comparing various factors concerning the suitability of the treatment process, it was found that heavily populated sub-districts should use the central treatment plant with the oxidation ditch system, the BOD value should not exceed 110 milligrams/liter, and the collection system should be the combined sewer. In rural areas, an onsite treatment plant system should be used. This involves the application of an anaerobic filter tank together with the use of cement pipes, which can be commonly found.

From this investigation, the amount of wastewater for the next 20 years can be predicted as the Figure below:

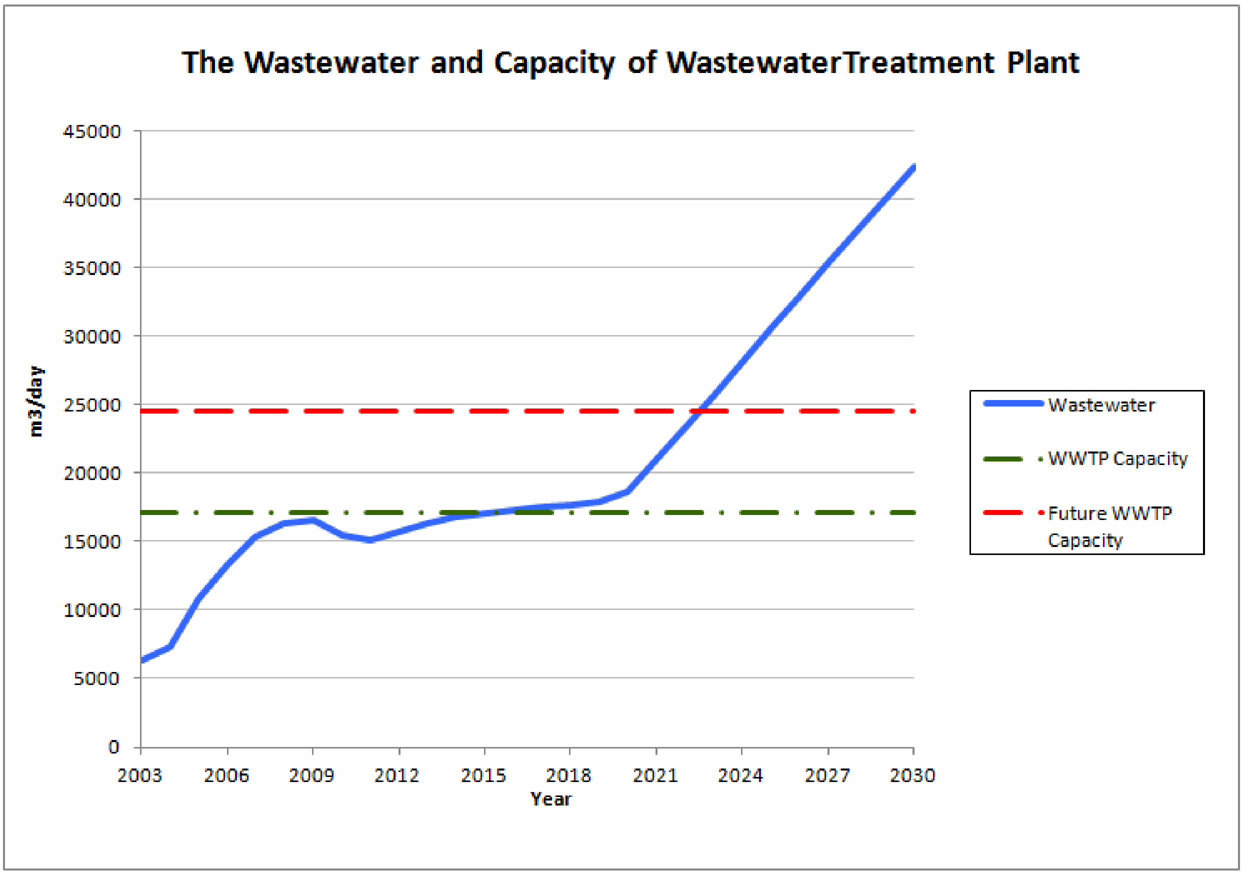


FIGURE 13-25 : The Wastewater and Capacity of Wastewater Treatment Plant

However, SAMUI Island City Municipality has planned to construction the new wastewater treatment plant around 5,000 cubic meters per days in the future.

The Action Team has taken each individual district and analyzes them separately, since these areas vary in size and the growth rates are also different. SAMUI Island is rather big and each community is located separately from the others. Hence each community should have its own wastewater treatment plant.

Recommendation for Wastewater Management

Short-term Plan

- Since the wastewater treatment plant has not been in operation. The system should be repaired, such as the water pump and the valve on the control panel.
- Encourage Mangrove wetlands as the wastewater treatment plant.

- Apply advanced service charges for the production of clean water. The fee depends on the amount of wastewater than one generates.
- Offer incentives to the public in order to reduce the level of wastewater produced.
- Apply strict control over the amount of wastewater released from each households and commercial buildings.

Long-term Plan

- Encourage sewage collection pipeline for all area connect to the central wastewater plants, as presently, it is difficult to collect the wastewater from households and commercial buildings across the island.
- Encourage the recycled water as irrigation. The recycled water pipeline should be serviced in agricultural area in phase I in 10 year's time.
- The Municipality Authority has a plan to construction the new Wastewater Treatment Plant 2,500 m^3/day in Bo Phut, 2,500 m^3/day in Mae Nam and 2,500 m^3/day in Hua Thanon. These are potential if the sewage collection system is completed.

13.1.5 Overview of Solid Waste Situation in SAMUI Island

Approximately 135 ton/day of municipal solid waste were collected and disposed of by the SAMUI Island City Municipality. At present, The Municipality of SAMUI Island is growing rapidly and the amount of solid waste produced is expected to be double in the next 20 years. The collection and disposal of this increasing waste stream is a very difficult and expensive problem it requires careful planning so that the current level of sanitation is to be maintained and improved.

Solid waste quantities and characteristics

1. Background

   Determination of the quantities and characteristics of solid waste in SAMUI Island City Municipality, as well as their specific distributions by municipality, set the stage of solid waste management planning. The tonnage generated and their densities in various types of equipment, as they are handled along the path from point source to ultimate point of disposal, provide the basis for determining the capacities of the collection fleet, transfer facilities, disposal sites and treatment works.

The waste characteristics provide the basis for determining such issues as the extent to which compaction could be conducted in collection trucks and in stationary containers. Materials recovery could be performed through either mechanized or manual sorting; while waste reduction could be accomplished through either incineration or biodegradation. In this regard, biodegradation could take place naturally in a landfill or via the mechanized enhancement in a composting facility or in a biogas plant.

As an urban area develops economically, the quantities of solid waste produced through consumer activities, trade, services and tourism industry increases in parallel. The waste quantity generated per capita is highest in the urban zones, where the amount of commercial and tourist activity is highest. This was considered relatively to the number of residents in those areas though. On the contrary, the wastes generated per capita are lowest in the rural residential zones, particularly those of low income levels and comparatively low consumption patterns. SAMUI is a rapidly growing area, every district of which has a unique blend of residential, commercial, tourist, institutional and other activities- all of which generate solid waste. The following sections of this report present available data on waste quantities and characteristics forecast the future trends and develop projections upon which the solid waste management alternatives are to be based.

2. Waste quantities

2.1 Current solid waste generation and disposal rates. The estimation of the solid waste amount generated in SAMUI Island City Municipality area is very difficult to conduct because of the amount of scavenging and recycling that occurs between the points of waste generation and the disposal sites. In addition, there is little reliable information is available regarding the quantity of material removed from the waste stream by separation at source or recycling at homes and commercial establishments.

Wastes or material separated at source by especially from the scavenging and recycling right after the wastes are put out for collection. The garbage collection crews will sort through the waste at the curb or on the trucks and then separate paper, plastics, metals and other salvageable items for sale to small scale recycling businesses which are located along the truck routes or near the disposal sites.

Nowadays, approximately 80 percent of generated solid waste is collected daily and then transferred for disposal at the solid waste incineration plant.

The incineration plants have not been in operation, the quantities of solid waste in landfill are increasing significantly.

13.1.6 Resource Consumption Planning

The existing waste composition is:

40% incombustible and plastic
25% dry combustible
30% food waste with high moisture
5% other

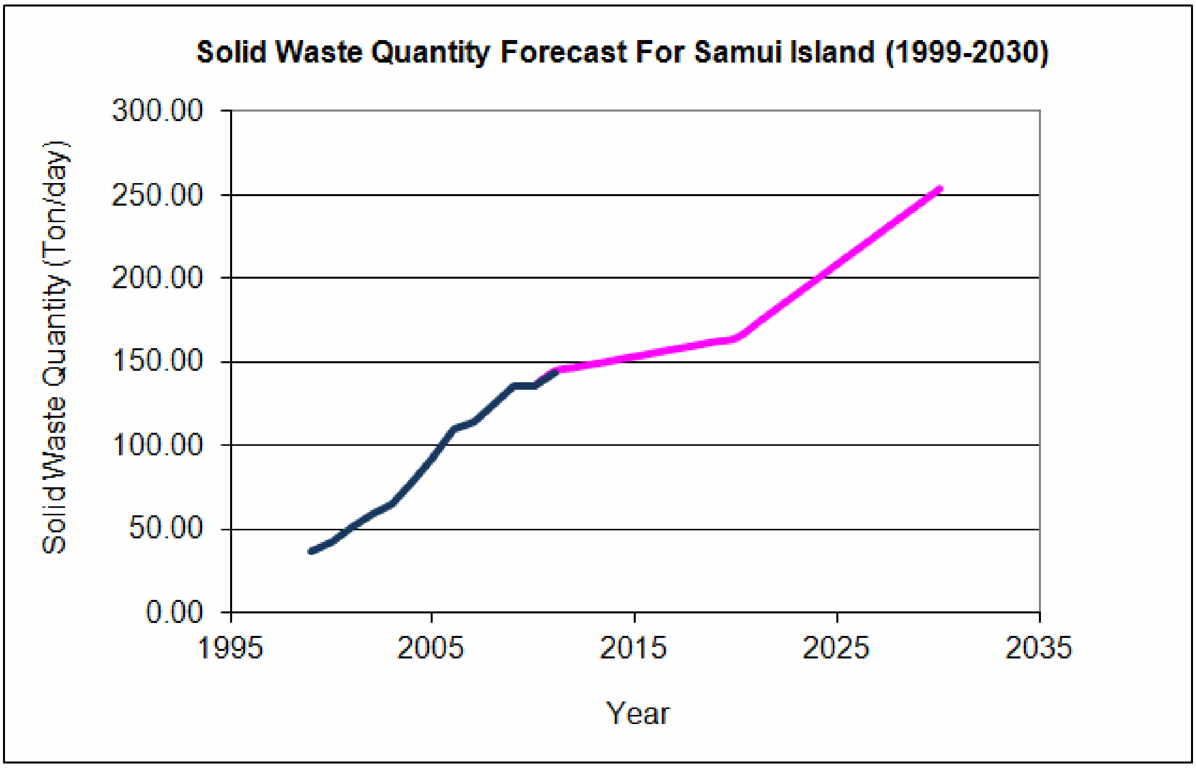


FIGURE 13-26 : Solid Waste Quantity Forecast For SAMUI Island (1999-2030)

<u>Recommendation for solid waste in SAMUI Island</u>

1. Installation of the new 2 incinerators, capacity 200 ton/day per incineraor in 3 year's time (Cost estimate 985 MB per each). Use high efficiency technology and suitable for the characteristic of solid waste in Thailand. For exemple, the gasification incinerator.
2. Sorting system, the sorting system is recommended to be mechanical with rotating screens and conveyor belts, this is to minimize manual handling, thus reducing health hazards for people engaged with the sorting.
3. Encourage RDF from the combustible fraction of the MSW, to substitute fossil fuel for electricity.
4. Encourage Combined Heat and Power Generation from Municipal Solid Waste
5. Encourage Zero waste practices both upstream (including reducing consumption, product redesign, clean industrial production and processes, reducing packaging waste, encouraging refillable containers, and toxics use reduction) and downstream (including reuse, composting, recycling, and materials recovery)

6. Sorting of the hazardous waste, they are substances or materials which are not used or cannot be used, which contain or are contaminated with combustible substances, corrosive substances, highly active substances, explosives, toxic substances, soluble substances, radio-active substances, and/or disease producing organisms which are produced by various industrial, community, agricultural activities.

The management of hazardous waste shall be processed by the major laws involving which are:

- Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992);
- Factory Act B.E. 2535;
- Hazardous Substance Act B.E. 2535;
- Factory Act B.E. 2535;
- Public Health Act B.E. 2535.

14. Low Carbon Cost and Benefit Analysis

14.1 Overall analysis of low carbon effects

1) Examination of Commercial Sector

a) Calculation method of CO_2 Reduction for Commercial Sector

The CO_2 reduction calculation for commercial sector on SAMUI Island is developed using existing operating conditions in 2010. Since hotels and resorts are the major energy users in commercial sector. Therefore; it is first prioritized and focused for low carbon reduction study. The typical building design of hotels and resorts including government buildings is used for BAU calculation for energy consumption and carbon emission.

When BAU of represented types commercial buildings – hotels and resorts, and government buildings, are simulated, appropriate carbon reduction measures are applied. The energy demand of buildings is from cooling and heating, lighting, plumbing and others. In order to achieve the low carbon buildings, following areas are well investigated.

- *Reduce heat load to/in building and minimize heat load from the planning to design stage.*
- *Use the optimal efficiency of system and equipment.*
- *Passive design, adaptable to local climate condition.*
- *Proper operation and maintenance for system and equipment.*

The demand side management is as well effective as supply side management. In addition to the adaptation of above mentioned measures to individual commercial buildings, area energy planning is of interest to be analyzed to see the carbon reduction effect.

The hierarchal approach for carbon emission reduction analysis is employed. This approach helps to see all the effect orderly once each measure is applied.

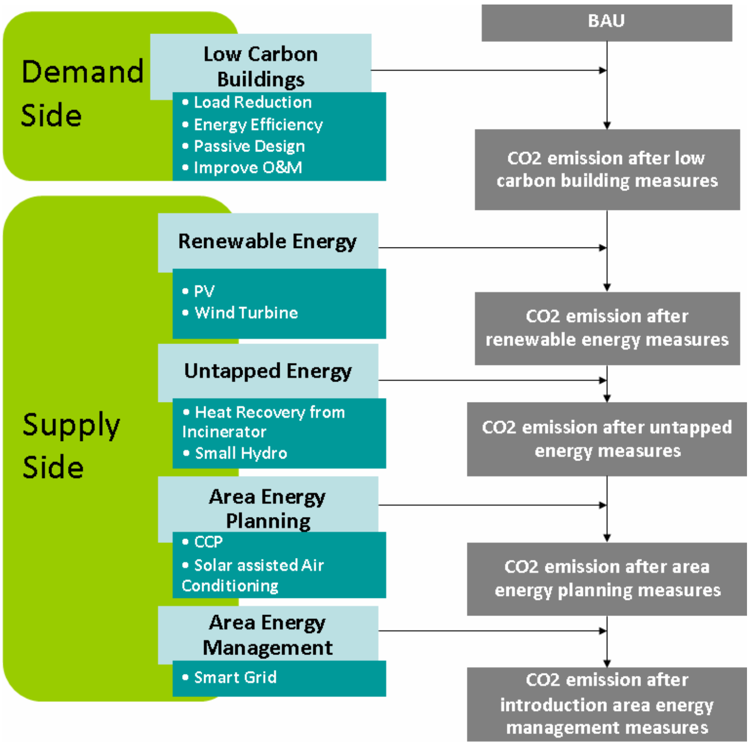


FIGURE 14-1 : Hierarchal Approach

b) Result from the analysis of low carbon effects

The result of carbon emission reduction from applying the hierarchal approach to commercial sector is from the integration of all measures **including demand side management and supply side management.** However, the supply side management either contributes to commercial, residential as well as agriculture and industries and it is not possible to distinguish the effect of carbon reduction from supply side management, therefore, it shall assume all the carbon contribute same share of energy consumed by each sector as shown in Figure 14-2

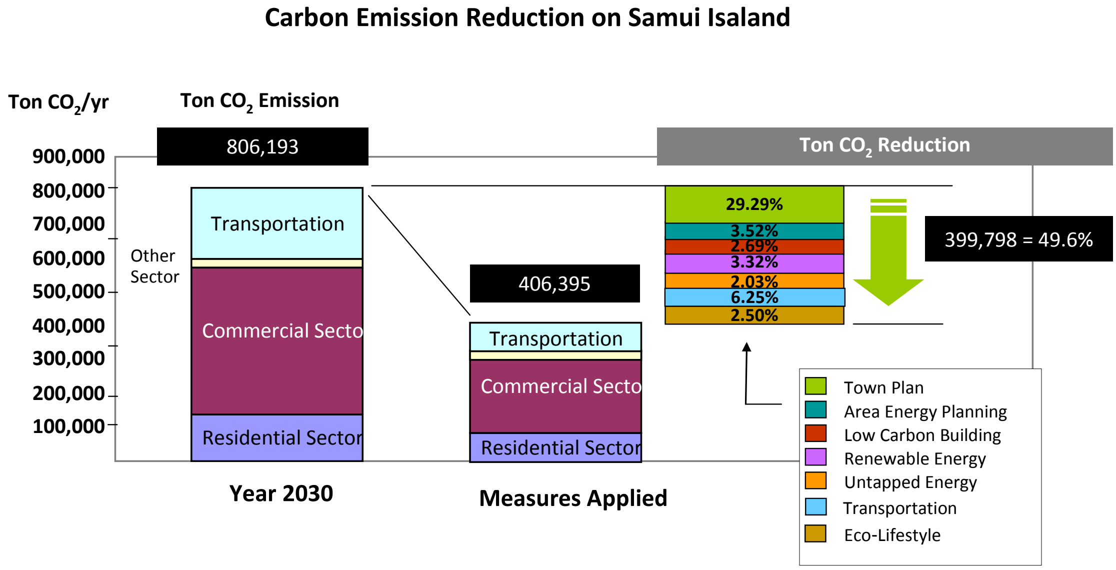


FIGURE 14-2 : Carbon Emission Reduction of commercial and residential sector when considering demand and supply side management

In addition to the overall consideration by hierarchal approach as shown in Figure 14-2, energy demand for low carbon buildings has also taken into consideration. Simulation tool is used for calculation of energy consumption for BAU in year 2030. The energy demand calculation, when applying low carbon building measures, has resulted in reduction of energy consumption at least 33% or equivalent to carbon reduction of 45.2 kg $CO_2/m^2/yr$ as shown in Table 14-1 and Figure 14-3.

TABLE 14-1 : Energy consumption for Commercial Building and Government Buildings

Type of Building	Estimated total area (m^2)	Estimated implemented area (m^2)			Energy Consumption (kWh/yr)
		Y2020	Y2030	Total	@ 241 (kWh/(m^2/year)
Government	30,000	30,000	-	30,000	7,230,000.00
Resort	300,000	90,000	90,000	180,000	43,380,000.00
Hotel	450,000	135,000	135,000	270,000	65,070,000.00
Total	780,000	255,000	225,000	480,000	115,680,000

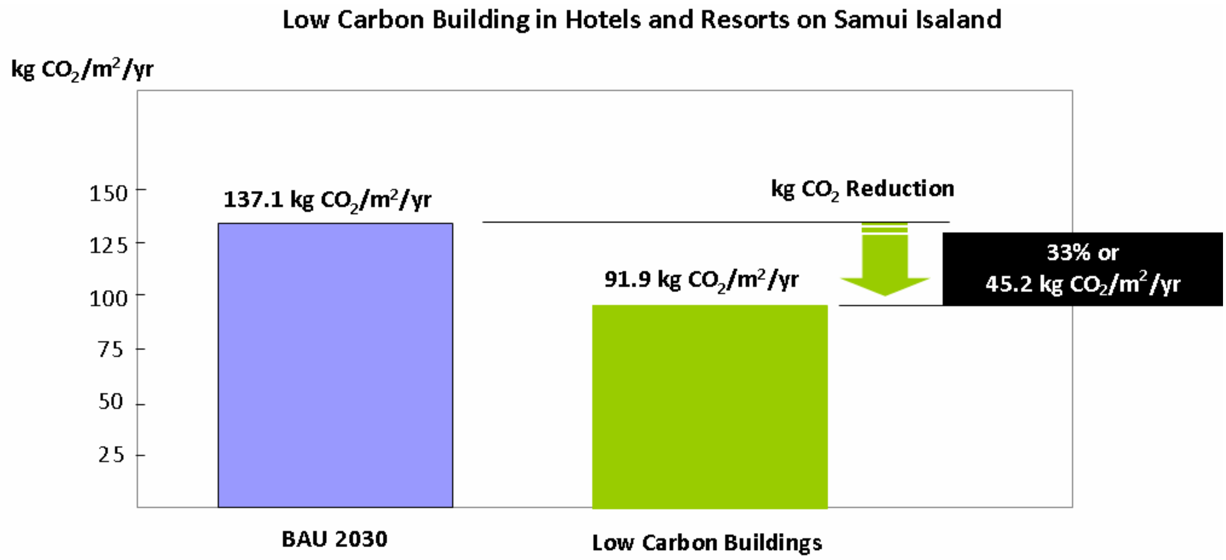


FIGURE 14-3 : Carbon Reduction of commercial sector when considering only low carbon buildings for medium to large hotels and resorts

2) Examination of Transportation

a) Calculation method of CO_2 Reduction for Sector

Based on current situation on SAMUI's transportation system, there shall have two approaches to successfully increasing efficiency of transportation system

1. Policy-supported measures
Public Transportation promotion policy

2. New Technology-supported measures
Introduction of EVs to SAMUI

The carbon reduction effects from two measures can work independently and dependently. The policy from government or local administration will be supporting the implementation of low carbon emission long term strategies for future growth rate of tourists.

The policy will promote and encourage use of low emitted vehicles as well as raising public awareness in shifting to use public transportation such as EV bus when moving from the entrance of

SAMUI to the destination, or EV cars, and EV bikes for shorting traveling or sightseeing.

Based on the conversion of fuel-based vehicle to EV cars, the future number of low carbon vehicle can be forecasted in 2030 as shown in Table 14-2

TABLE 14-2 : Conversion to Low Carbon Vehicles

Unit: Vehicle unit

	Personal Vehicle			Public transportation Vehicle		
	Car	Motorcycle	Taxi	Big Bus	Van	Mini Bus
Total	37,300	44,300	1,000	100	300	400
Coverage	10%	30%	30%	10%	10%	10%
No. of EV	3,730	13,290	300	10	30	40

b) Result from the analysis of low carbon effects

The result of carbon reduction from applying public transportation policy and introduction of EV into the market is highly dependent on subsidized programs and penetration rate of EV.

The demonstration project will encourage the use of EV technology at the beginning and when technology is fully commercialized where cost of EV is considerably reduced. The high diffusion rate of EV on SAMUI will be large and considerable amount of CO_2 reduction as be achieved.

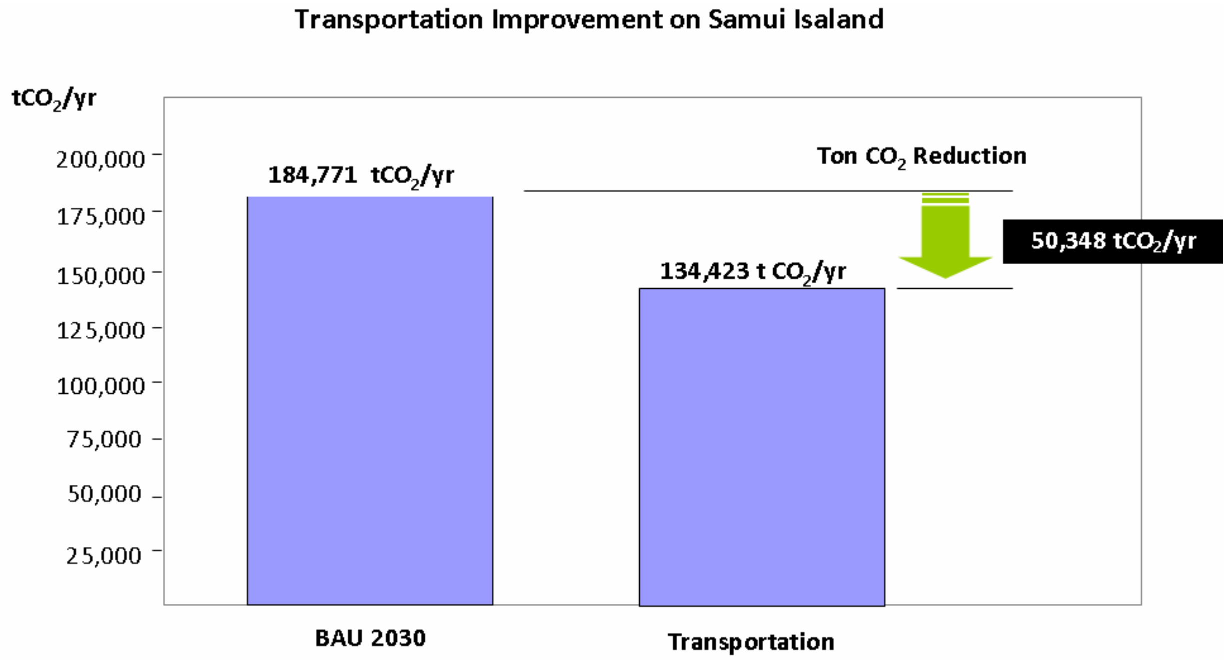


FIGURE 14-4 : Carbon Reduction from Transportation Improvement

14.2 Examination of Cost Performance

1) Overall Cost Calculation

The overall investment cost and cost of each measure is shown in Table 14-3

TABLE 14-3 : The initial investment for each Measure

Item. No.	Categories	Generated Power (kW)	Investment Cost (Mil. USD)	Life Span (yrs)	Annual Cost (Mil. USD)[1)]
1	C1 : Town Structure Planning	-	20.14	20.00	1.01
2	C2 : Transportation	-	126.45	7.00	18.06
3	C3 : Area Energy Planning	45,000.00	64.52	20.00	3.23
4	C4 : Area Energy Management	-	20.98	10.00	-
5	C5 : Renewable Energy	85,916.00	418.40	20.00	20.92
6	C6 : Untapped Energy	4,670	35.81	15.00	2.39
7	C7 : Low Carbon Building	-	131.59	15.00	8.77
8	C8 : Eco-Life Style	-	23.86	18.00	0.68
9	C9 : Environment [2)]	-	-	-	-
Total			**841.74**		**55.06**

Remark :

[1)] Exchange rate 1 USD = 31 THB

[2)] No evaluation of direct emission reduction

The annual cost is obtained by dividing the investment cost by life span of the equipment or project life time. As be seen from Table 14-3, the annual cost of renewable energy measures are most expensive (20.92 Mil. USD per year) based on the current technology price in the market, however, the cost is anticipated to be lower when the market is growing and production of equipment is higher. The second highest annual cost investment is from transportation which is 18.06 Mil. USD per year due to the requirements of infrastructure.

2) Low Carbon Building Cost

The cost of implementing of low carbon building is calculated for different type of buildings. Table 14-4 indicates the investment cost per square meter.

TABLE 14-4 : Investment cost of Low carbon Buildings

Type of Building	Estimated CO_2 emission reduction	Cost per m^2 (USD)	Total (USD)
Government	1,357	94.73	2,841,900
Resort	8,144	271.15	48,807,000
Hotel	12,216	296.06	79,936,200
Total	21,717		131,585,100

With different types of hotels and resorts for low carbon building measures, the present electricity consumption for BAU is 241 kWh/m^2/year and when the applying low carbon measures the electricity consumption is reduced to 161.47 kWh/m^2/year which is equivalent to 33% energy reduction. The cost of improvement comparison for different type of buildings is shown in Figure 14-5

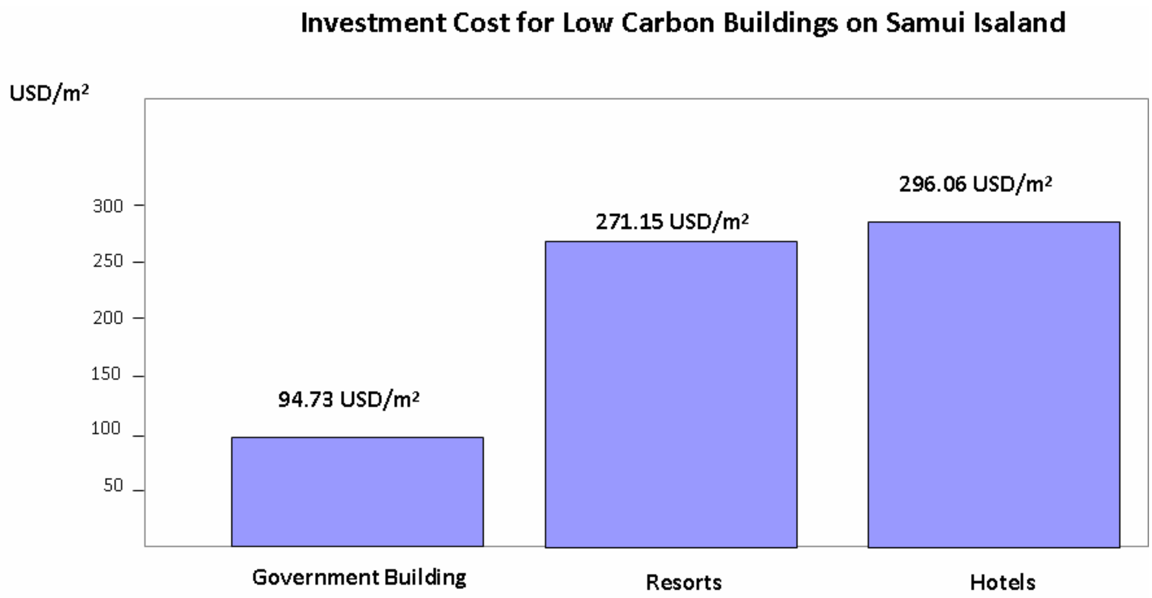


FIGURE 14-5 : Investment cost comparison for different type of buildings

3) Transportation Cost

Cost of carbon reduction measures from transportation is from

a) Infrastructure cost for public transportation promotion policy
b) Infrastructure cost for introduction of EV

Table 14-5 provides cost of infrastructure and cost of new type of buses used for public transport. Table 14-6 provides cost of infrastructure and cost of EV vehicles.

TABLE 14-5 : Cost of infrastructure for trunk bus route

Infrastructure	Amount	Cost of unit	Cost (million Baht)
Improvement of trunk road	50km	3,500 Bath/m	175
Constructing bus stops	30 bus stops	300,000Bath/unit	9
Introducing new bus*1)	12 units	25million Baht/unit	300
Total			**259**

Infrastructure	Amount	Cost of unit	Cost (million Baht)
Quick charging station	10 units	6,200,000 Baht/unit	62
Total			62

TABLE 14-6 : Cost of infrastructure and cost of EVs

EV	Amount	Price of unit	Cost per unit**2)	Cost (million Baht)
Personal car	3,730	1.0million Baht/unit	0.5million Baht/unit	1,865
Bike	13,290	0.2million Baht/unit	0.1million Baht/unit	1,329
Taxi	300	1.0million Baht/unit	1.0million Baht/unit	300
Van	30	1.5million Baht/unit	1.5million Baht/unit	45
Mini bus*1)	40		1.5million Baht/unit	60
Total				3,599

*1) Bus type: Hybrid coupled bus

**2) 50% subsidy is proposed for personal vehicle and 100% subsidy is proposed for public vehicle

14.3 Effective Low Carbon Cost for Investment

Carbon reduction cost is mainly dependent on the existing system and cost of technology to be implemented including lifetime of equipment. To be practical and effective, the cost of technology and carbon reduction cost shall not be too expensive. However, some measures require to be subsidized from the government or policy to drive it to low carbon society.

Table 14-7 indicates the overall investment cost and carbon reduction cost per 1 ton of reduced carbon dioxide.

TABLE 14-7 : Overall Carbon Emission Reduction

Item. No.	Categories	Carbon Emissions Reduction (ton CO_2/yr)		Life Cycle Carbon Emissions Reduction (ton CO_2)	% Reduction		Total Life Cycle Cost Savings	Marginal Cost*	Life Cycle Carbon Unit Cost (USD/ton CO_2)
		2020	2030		compared with 2020	compared with 2030	(USD)	(USD)	
1	C1 : Town Structure Planning	86,795.00	236,096.04	4,714,540.40	17.04%	29.29%	-	20,143,555.58	4.27
2	C2 : Transportation	-	50,348.00	352,436.00	-	6.25%	-209,435,483.87	-82,983,870.97	-235.46
3	C3 : Area Energy Planning	28,390.82	28,390.82	567,816.48	5.58%	3.52%	-112,668,387.10	-48,152,258.06	-84.80
4	C4 : Area Energy Management **	-	-	-	-	-	-	-	-
5	C5 : Renewable Energy	26,765.20	26,765.20	535,303.93	5.26%	3.32%	-106,217,119.35	312,186,106.45	583.19
6	C6 : Untapped Energy	16,326.02	16,326.02	244,890.32	3.21%	2.03%	-48,592,103.23	-12,785,651.61	-52.21
7	C7 : Low Carbon Building	11,537.00	21,717.00	325,755.00	2.27%	2.69%	-64,650,193.55	66,934,906.45	205.48
8	C8 : Eco-Life Style	12,730.73	20,154.82	223,146.89	2.50%	2.50%	-	12,219,898.04	54.76
9	C9 : Environment ***	-	-	-	-	-	-	-	-
Total		**182,544.77**	**399,797.90**	**6,963,889.02**	**35.85%**	**49.59%**	**-541,563,287.10**	**267,562,685.88**	**-**
Averaged									**38.42**

Remark :

* Marginal Cost = Investment + Total Life Cycle Cost Savings; Negative sign indicate **energy savings and cost savings**

** Carbon emission is calculated within renewable and untapped energy

*** No evaluation of direct emission reduction

Depending on the implementation period, the total carbon emission during the equipment life span is calculated. The carbon emission reduction target is distinctively divided into mid-term and long term as 2020 and 2030 respectively.

When compared the investment cost and carbon reduction thought life-cycle of measures implemented, it is found that the marginal abatement cost per ton of carbon dioxide reduction for Transportation is the cheapest cost which is -235.46 USD/ton CO_2. The minus sign indicates the fuel cost savings of measure. Therefore, Transportation is the most effective measure of reducing carbon emission.

The second cheapest carbon reduction cost is from Area Energy Planning is the cheapest cost which is -84.80 USD/ton CO_2. The third order of reduction costs are from Untapped Energy which the carbon reduction cost is -52.21 USD/ton CO_2.

In addition to lowest cost for carbon reduction of Transportation, Area Energy Planning and Untapped Energy, Town planning is also attractive since it will increase attractiveness for tourists to visit SAMUI resulting in higher revenue for people and investors while Eco-lifestyle is suitable for tourism business like SAMUI. This eco-lifestyle will involve shift of tourists' behaviors and directly impact to other carbon reduction measures. The cost of carbon reduction will be continually decreased when more tourists have gained more perception in living and traveling with low impact to environment. However, at the beginning, incentive scheme and contribution from all stakeholders shall be considered.

The other carbon reduction cost such as Low carbon buildings and Renewable Energy measures are considerably high which mostly relates to high technology investment, therefore, special financial tools like subsidy, tax incentives, or other schemes are required to compensate those investment cost.

14.4 Cost Performance Benchmark

Cost performance of carbon reduction from each measure will be compared in order that the mitigation action can be properly managed and of importance for policy maker to decide which measures are economically and environmentally attractive.

When compared carbon cost performance, there can be consideration of investment with or without savings included per ton of carbon reduction.

Figure 14-6a and Figure 14-6b illustrate the comparison of carbon reduction cost where Figure 14-6a shows the only cost of investment compared with amount of carbon reduction though its life cycle while Figure 14-6b shows the cost of investment plus cost savings i.e. electricity and fuel savings, compared with amount of carbon reduction thought its life cycle.

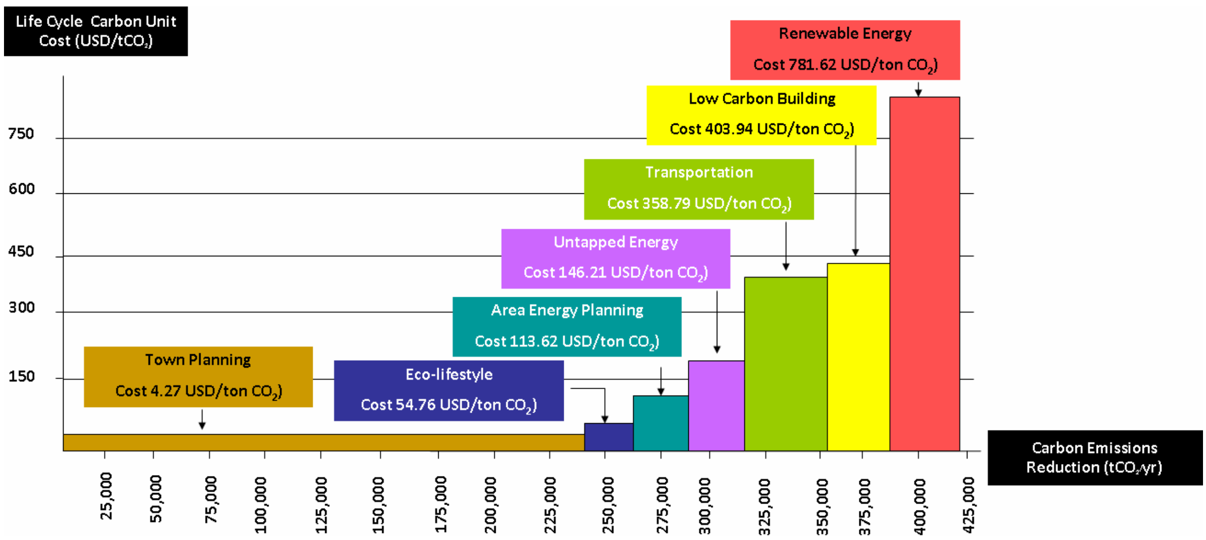


FIGURE 14-6a : Carbon Emission Reduction Cost Performance (without cost savings included)

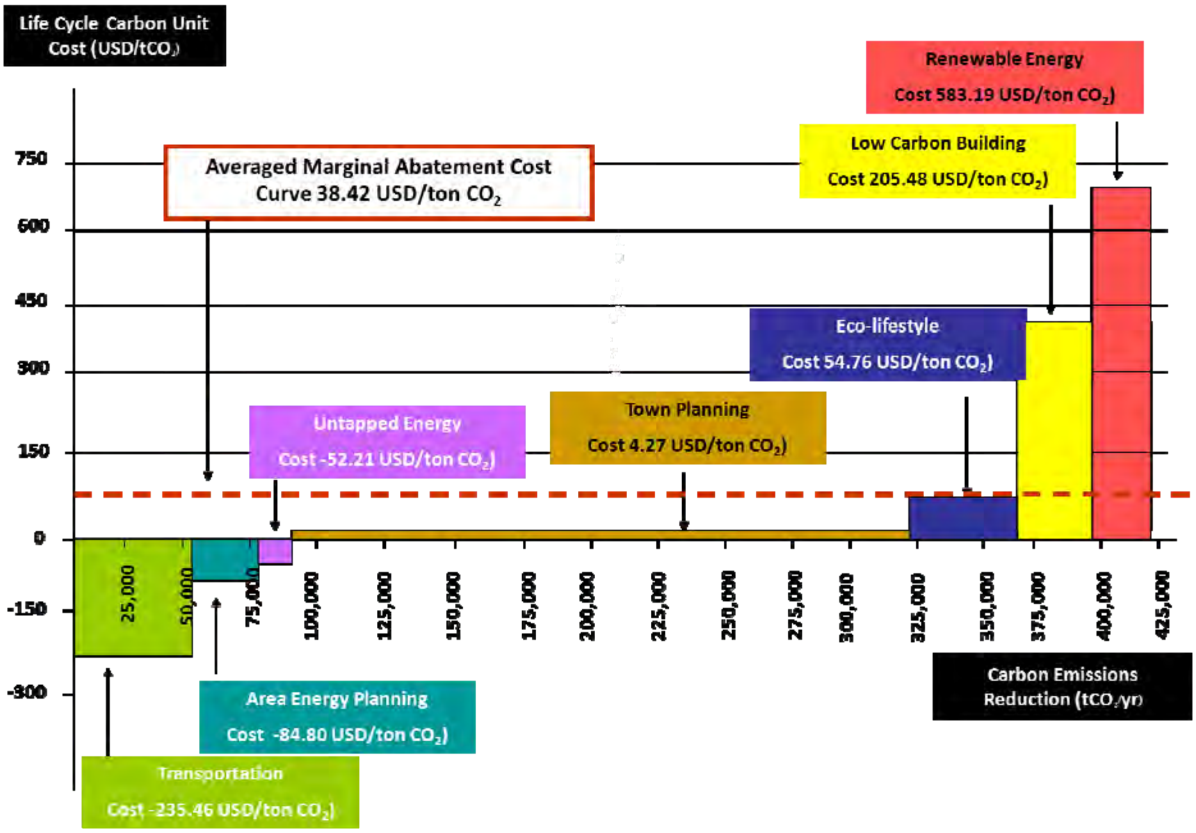


FIGURE 14-6b : Carbon Emission Reduction Cost Performance (with cost savings included)

From the Figure 14-6a where the carbon cost calculation based on only investment cost, the carbon reduction cost of renewable energy is the highest. This is not surprised especially when PV measures is considered.

When considering carbon cost performance in Figure 14-6b, the carbon reduction cost of each measure ranges from -235.46 USD/ton CO_2 to 583.19 USD/ton CO_2 and the averaged carbon reduction cost is 38.42 USD/ton CO_2. The higher carbon reduction cost implies high investment of technology or low energy savings. It is impractical for investors or owners to invest such high cost. However, financial tools or subsidy programs shall be launched or supported by the government to encourage to implement potential measures.

1) Carbon Performance Cost for Town Planning

Table 14-8 shows carbon performance cost of Town Planning for each measure. There are carbon absorption measures and carbon emission measures.

TABLE 14-8 : Carbon Performance Cost for Town Planning

Categories		Description	Investment Cost (Mil. USD)	Life Cycle Carbon Emissions Reduction (ton CO_2)*	Total Life Cycle Cost Savings (USD)	Marginal Cost (USD)	Life Cycle Carbon Unit Cost (USD/ton CO_2)
1) Forest	1	Protection of the Existing Trees	0.02	(70,140)	-	20,645.16	0.29
	2	Reforestation	0.01	(50,120)	-	14,193.55	0.28
2) Orchards	1	Protection of the Existing Trees	0.04	(1,860,000)	-	36,451.61	0.02
	2	Replacement with Economic Plant Holding Higher CO2 Absorption Rate	1.64	(2,700,000)	-	1,635,483.87	0.61
3) Urban Plant Areas	1	Development of Comfortable and Greenery Walk Pass and Street	0.45	(7,460)	-	449,354.84	60.24
	2	Improvement of Building Envelope by Using Bio-facade	0.05	(400)	-	51,935.48	129.84
	3	Adding Trees in Public Spaces and Airport Areas	0.01	(460)	-	10,548.39	22.93

Categories	Description		Investment Cost (Mil. USD)	Life Cycle Carbon Emissions Reduction (ton CO_2)*	Total Life Cycle Cost Savings (USD)	Marginal Cost (USD)	Life Cycle Carbon Unit Cost (USD/ton CO_2)
	4	Adding Trees in Resort Areas	0.04	(8,660)	-	39,032.26	4.51
	5	Adaptation toward Comfortable and Greenery Beaches	0.03	(2,040)	-	30,645.16	15.02
4) Community Node			8.39	7,880	-	8,387,096.77	1,064.35
5) Development of Walkable Areas			9.47	3,690	-	9,468,168.48	2,565.76

Remark

* ( ) means the carbon is absorbed

From the Table 14-8, the carbon reduction cost of Town Planning ranges from 0 - 2,566 USD/ton CO_2. The low cost measures (item 1 to item 3) are from planting trees in the forest while higher cost is from improving and developing greenery area in which carbon is absorbed. The most expensive measures (item 4 and 5) are from Community Node Development and Development of walkable areas. Despite the Community Node Development and Development of walkable areas are quite expensive but, in view point of tourism industry, it is very vital to improve quality of life and economy.

Figure 14-7 illustrates the total amount of carbon emission and carbon absorbed by Town Planning

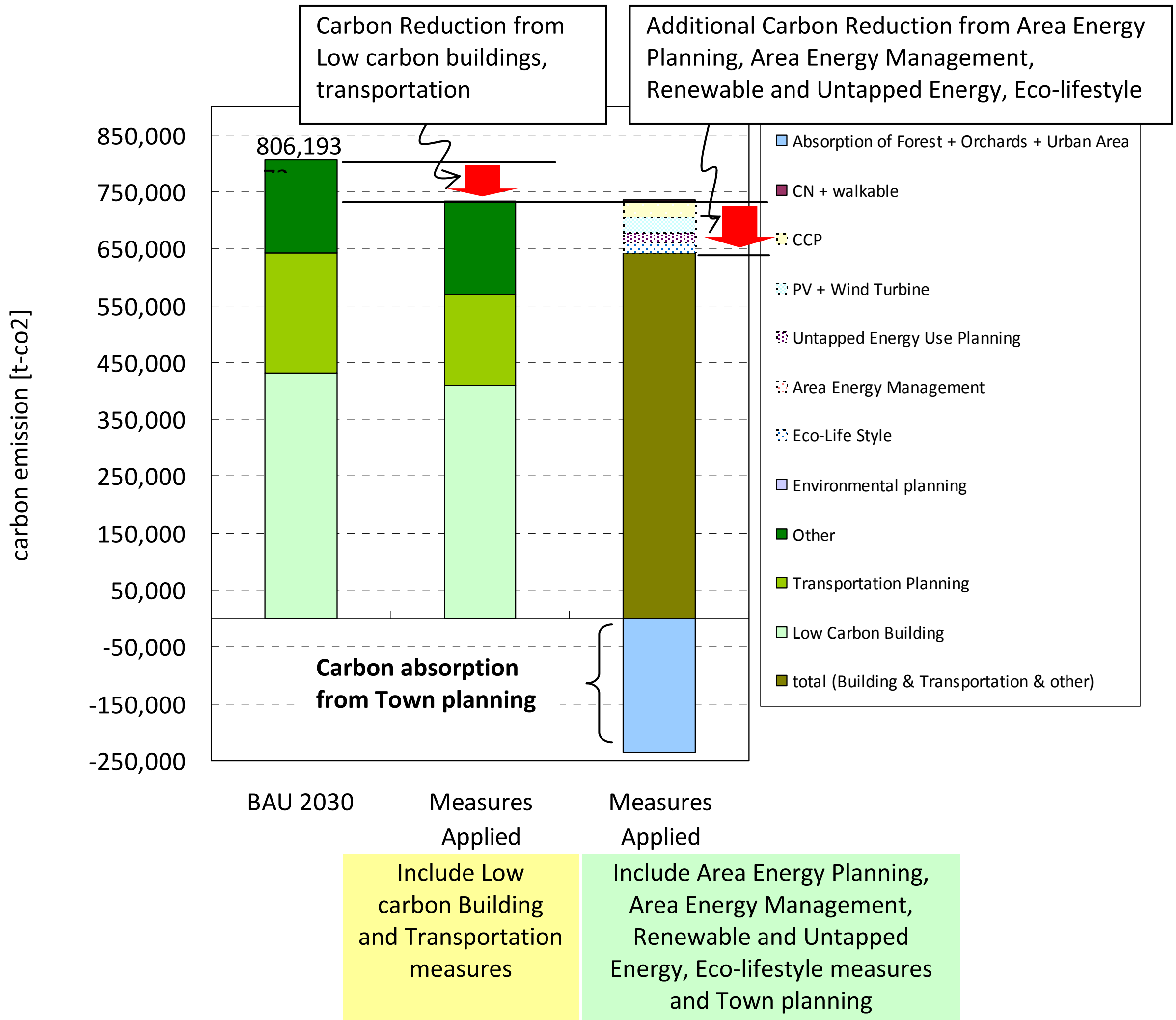


FIGURE 14-7 : Carbon emission and absorption

2) Carbon Performance Cost for Transportation

Table 14-9 shows carbon performance cost for Transportation category.

Table 14-9 : Carbon Performance Cost for Transportation

Description		Investment Cost (Mil. USD)	Total Life Cycle Cost Savings (USD)	Marginal Cost (USD)	Life Cycle Carbon Unit Cost (USD/ton CO_2)
1	Transportation	126.45	-209,435,483.87	-82,983,870.97	-235.46

From the Table 14-9**,** the carbon reduction cost of Transportation is -235.46 USD/ton CO_2. The cost is from infrastructure preparation and EV cars. Since the investment cost is very high, therefore, the government shall subsidize the project developers via several financial instruments such as.

1. Low Interest Loan (Soft Loan)
2. Low Import Tax for EV Cars

3) Carbon Performance Cost for Renewable and Untapped Energy

Table 14-10 shows carbon performance cost of Renewable and Untapped Energy for each measure.

TABLE 14-10 : Carbon Performance Cost for Renewable and Untapped Energy

Item No.	Categories	Description		Generated Power (kW)	Investment Cost (Mil. USD)	Generated Electricity (kWh/yr)	Energy Savings (kWh/yr)	Cost Savings (USD/yr)	SPP (yrs)
1	C5 : Renewable Energy	1	PV Plant	35,000.00	112.9	19,162,500.00	19,162,500.00	-2,163,508.06	52.19
		2	Solar Rooftop	50,000.00	297.18	27,375,000.00	27,375,000.00	-3,090,725.81	96.15
		3	Solar LED Street Light	676	6.71	370,110.00	370,110.00	-41,786.61	160.57
		4	Wind Turbine	240	1.61	131,400.00	131,400.00	-14,835.48	108.72
2	C6 : Untapped Energy	1	Incinerator Power Plant	3,280.00	31.77	20,152,320.00	20,152,320.00	-2,275,261.94	13.97
		2	Kitchen Waste for Power Generation	640	1.61	3,932,160.00	3,932,160.00	-443,953.55	3.63
		3	Small Hydro						
		3.1	Hin Lad Waterfall	400	1.29	2,457,600.00	2,457,600.00	-277,470.97	4.65
		3.2	Lamai Beach	350	1.13	2,150,400.00	2,150,400.00	-242,787.10	4.65

Remark
* Negative sign indicate energy or cost savings

TABLE 14-10 : Carbon Performance Cost for Renewable and Untapped Energy (continued)

Item No.	Categories	Description		Total Life Cycle Cost Savings (USD)	Marginal Cost (USD)	Life Cycle Carbon Unit Cost (USD/ton CO_2)
1	C5 : Renewable Energy	1	PV Plant	-997,813,642.05	80,715,688.97	370.14
		2	Solar Rooftop	-1,425,448,060.07	251,195,223.87	806.33
		3	Solar LED Street Light	-15,464,222.04	6,210,831.55	1,966.14
		4	Wind Turbine	-5,490,256.35	1,435,798.18	1,280.25
2	C6 : Untapped Energy	1	Incinerator Power Plant	-842,019,808.03	4,612,264.26	26.82
		2	Kitchen Waste for Power Generation	-117,397,428.35	-2,174,110.59	-97.17
		3	Small Hydro			
		3.1	Hin Lad Waterfall	-73,373,392.72	-1,076,561.06	-76.99
		3.2	Lamai Beach	-64,201,718.63	-941,990.92	-76.99

From the Table 14-10, the carbon reduction cost of untapped energy (-77 to -98 USD/ton CO_2) is more attractive than renewable energy (370-2,000 USD/ton CO_2).

In order to reduce investment cost, project developers shall find incentive programs from Ministry of Energy (MOE) via Renewable Energy Promotion Program under ENCON Fund. The program can support the implemented project and make it more feasible in term of financial return.

4) Carbon Performance Cost for Low Carbon Buildings

Table 14-10 shows the energy consumption based on BAU 2030 calculation for each type of building. Based on calculation of energy savings for low carbon measures, the Simple Payback Period (SPP)

TABLE 14-11 : Carbon Performance cost for Low Carbon Buildings

Type of Building	Estimated total area (m^2)	Estimated implemented area (m^2)			Energy Consumption (kWh/yr)
		Y2020	Y2030	Total	@ 241 (kWh/(m^2/year)
Government	30,000	30,000	-	30,000	7,230,000.00
Resort	300,000	90,000	90,000	180,000	43,380,000.00
Hotel	450,000	135,000	135,000	270,000	65,070,000.00
Total	780,000	255,000	225,000	480,000	115,680,000.00

Type of Building	Estimated total area (m^2)	Energy Consumption	Energy Savings*	Energy Cost Savings	SPP (yrs)
		@ 161.47 (kWh/(m^2/year)	(kWh/y)	(USD/yr)	
Government	30,000	4,844,100.00	2,385,900.00	269,375.81	10.55
Resort	300,000	29,064,600.00	14,315,400.00	1,616,254.84	30.20
Hotel	450,000	43,596,900.00	21,473,100.00	2,424,382.26	32.97
Total	780,000	77,505,600.00	38,174,400.00	4,310,012.90	Avg. 30.53

*** Energy Cost = 0.097 USD/kWh**

Type of Building	Estimated total area (m^2)	Estimated CO_2 emission reduction (ton CO_2)			Cost per m^2 (USD)	Total Cost (USD)
		Y2020	Y2030	Total		
Government	30,000	1,357	-	1,357	94.73	2,841,900
Resort	300,000	4,072	4,072	8,144	271.15	48,807,000
Hotel	450,000	6,108	6,108	12,216	296.06	79,936,200
Total	780,000	11,537	10,180	21,717		131,585,100

Type of Building	Total Life Cycle Operating Cost	Marginal Cost	Life Cycle Carbon Unit Cost (USD/ton CO_2)
	(USD)	(USD)	
Government	-2,693,758.06	544,069.73	40.09
Resort	-16,162,548.39	35,020,018.39	430.01
Hotel	-24,243,822.58	59,255,727.58	485.07

From the Table 14-11, the carbon reduction cost of government building is lowest (40.09 USD/ton CO_2) while the commercial buildings like resorts and hotels have high carbon reduction cost (430-485 USD/ton CO_2). The total carbon reduction cost is from heat load reduction through roof and wall and advanced energy saving technology applied in the building.

In order to reduce investment cost, building owners shall find incentive programs which regularly issued by Ministry of Energy (MOE) via Energy Efficiency Program under ENCON Fund. The program can support the implemented project and make it more feasible in term of financial return.

Summary of Measures to be implemented

Table 14-12 shows the summary of all measures to be implemented on SAMUI Island. All proposed measures in this study are possible to be invested. However, the financial tools for some measures are highly requested in order to make appropriate carbon reduction cost. The averaged carbon reduction cost when considering all measures is 38.42 USD/ton CO_2. Although, there is no limit on carbon reduction cost, for easy comparison, the referenced marginal cost per ton CO_2 reduced in the report of McKincey is used where the carbon reduction cost of 40 Euros (~50 USD) shall be appropriate with carbon trade mechanism.

Thus the averaged carbon cost of SAMUI seems to be practical to be achieved. However, with strategically managed the implementation of all measures, central government, local government, and private sector shall work and agree with possible mechanism to resolve the obstacles.

Roles of governments shall provide or facilitate private sectors in terms of finance such as soft loan, subsidy or other financial mechanism in order that the private sector will find attractiveness for investment.

TABLE 14-12 : Special Requirements for Low Carbon Measures

Item No.	Categories	Life Cycle Carbon Emissions Reduction (ton CO_2)	Total Life Cycle Cost Savings (USD)	Marginal Cost (USD)	Life Cycle Carbon Unit Cost (USD/ton CO_2)	Requirements
1	C1 :Town Planning	4,714,540.40	-	20,143,555.58	4.27	Local government shall encourage commercial buildings to implement greenery area and also raising awareness for people and tourists to walk for short distance
2	C2 : Transportation	352,436.00	-209,435,483.87	-82,983,870.97	-235.46	Investment of Infrastructure by Governments and Subsidy from Governments
3	C3 : Area Energy Planning	567,816.48	-112,668,387.10	-48,152,258.06	-84.80	Central government shall encourage private investors to invest technology by prepare infrastructure for all sources of clean energy sources such as natural gas, biomass etc.
4	C4 : Area Energy Management	-	-	-	-	Investment of infrastructure by Governments and proper implementation scheme to convince private sector

Item No.	Categories	Life Cycle Carbon Emissions Reduction (ton CO_2)	Total Life Cycle Cost Savings (USD)	Marginal Cost (USD)	Life Cycle Carbon Unit Cost (USD/ton CO_2)	Requirements
						(demand side) to connect to the SMART Grid system
5	C5 : Renewable Energy	535,303.93	-106,217,119.35	312,186,106.45	583.19	Subsidy from central governments Example : Adder, FIT, Soft Loan, Low Import Tax Or Initiate the public private partnership (PPP) project to implement the high investment cost project such as solar PV rooftop.
6	C6 : Untapped Energy	244,890.32	-48,592,103.23	-12,785,651.61	-52.21	Subsidy from central governments Example : Adder, FIT
7	C7 : Low Carbon Building	325,755.00	-64,650,193.55	66,934,906.45	205.48	Subsidy from Governments Example : Tax Incentive, Soft Loan, Low Import Tax Implement the demonstration project for the government office on SAMUI Island

Item No.	Categories	Life Cycle Carbon Emissions Reduction (ton CO_2)	Total Life Cycle Cost Savings (USD)	Marginal Cost (USD)	Life Cycle Carbon Unit Cost (USD/ton CO_2)	Requirements
8	C8 : Eco-Life Style	223,146.89	-	12,219,898.04	54.76	Conduct details study on the Establishment of Eco-Life Style Scheme for SAMUI Island to identify responsible entity, related stakeholders, programme development procedures (Eco-point programme) etc.
9	C9 : Environment	-	-	-	-	
Total		**6,963,889.02**	**-541,563,287.10**	**267,562,685.88**	**38.42**	

14.5 Recommendation on the follow on activities for SAMUI Low Carbon Island

The results of this study indicate wide range of implementation potential of low carbon measures for SAMUI Island. The realization of the carbon emission reduction will be depended on the actual implementation of each measure. Thus, in order to enhance the implementation of SAMUI Low Carbon Island, details research, studies or actions should be considered for the following topics,

1. Project Finance of each low carbon measure

   All measures in the study are possible to invest. The financial tools for some measures are highly required in order to make appropriate carbon reduction cost. Based on the study, the averaged carbon reduction cost when considering all measures is 38.42 USD/ton CO_2. Although, there is no limit on carbon reduction cost, for comparison, the referenced marginal cost per ton where the carbon reduction cost of 40 Euros (~50 USD) shall be appropriate. Thus the averaged carbon cost of SAMUI seems to be practical to be achieved. However, with strategically manage the implementation of all measures, central government, local government, private sector shall cooperate and work together. Roles of all stakeholders and source of funding or project finance scheme should be clearly identified.

2. Establishment of Eco-Life Style Scheme for Low Carbon Island

   Lifestyle of people in SAMUI Island is one of the most important factors for the successful implementation of low carbon town development project at SUMUI Island. People in SAMUI include not only SAMUI citizen but also tourists and business providers. If there is no behavioral change among all stakeholders, there will be no one using the technologies and measures for carbon reduction previously proposed "*in practice*". Hence, eco-lifestyle is a very crucial bottom-up or people-driven measure (demand side) to reduce CO_2 emissions as well as other negative environmental impacts. The technology-driven approaches lead to "**sustainable production**" while the people-driven approaches lead to "**sustainable consumption**". Both approaches are required to actually achieve sustainable and low carbon SAMUI.

The development of Eco-Life Style measures need involvement of all stakeholders in SAMUI Island include visitors, SAMUI citizens, business operators/owners and government agencies. Eco-Life Style project development and management procedures should be carefully studied, identified and established.

3. Development of SMART Grid and Micro Grid for SAMUI Island

The development of SMART Grid and Micro Grid for SAMUI Island requires involvement of government agency (for supply side) and also from private sectors (as demand side). The details studies should be conducted to identify the suitable technology that should be connected to SMART Grid of the Island. The scheme to convince the private sectors to connect to SMART Grid should also be considered. In case of the development of Micro Grid for Chaweng' area as indicated in this study, the development of Solar PV rooftop will be very crucial part for the successful implementation as the first Micro Grid for SAMUI Island. However, as the implementation requires high investment cost, thus, the possibility to initiate the public private partnership programme should be studied and considered.

4. Development the Measurement and Verification Process

In order to monitor the implementation of the SAMUI low carbon town development Project, a number of indexes, direct and indirect indexes, have already been identified in this study. In this regard, the proper measurement and verification process indicated the responsible entity, data collection procedures, analysis methodology, etc should be clearly identified. The data or information from the Measurement and Verification Process will also be to use for raising the awareness of the related people on SAMUI 's Island through the data dissemination process.