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Economic Cooperation**

**Establishing Low Carbon Energy Indicators for  
Energy Strategy Study in APEC Low Carbon Town**

**FINAL REPORT**

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## Contents

<b>Foreword</b> .....	<b>5</b>
<b>1 Background</b> .....	<b>6</b>
<b>1.1 Research Review on Related Energy Indicators System</b> .....	<b>6</b>
<b>1.2 APEC Low Carbon Town Development</b> .....	<b>11</b>
<b>1.3 Implication of Low Carbon Energy Development for Developing APEC Economies</b> ..	<b>13</b>
<b>1.4 Objectives</b> .....	<b>14</b>
<b>2 The Low Carbon Energy Indicators system</b> .....	<b>14</b>
<b>2.1 Principles of Building the Low Carbon Energy Indicators System</b> .....	<b>14</b>
<b>2.2 Procedure for Indicators System Construction</b> .....	<b>15</b>
<b>2.3 Structure and Data source for The Low Carbon Energy Indicators System for APEC Low Carbon Town Development</b> .....	<b>17</b>
<b>2.3.1 Sources for Information and Data</b> .....	<b>17</b>
<b>2.3.2 Indicators System Structure</b> .....	<b>17</b>
<b>3 Case Study on Zhejiang Province, China</b> .....	<b>27</b>
<b>3.1 Explanation on Case Selection</b> .....	<b>27</b>
<b>3.2 Low Carbon Development Background in China and in Zhejiang Province</b> .....	<b>27</b>
<b>3.3 General Information of the Case</b> .....	<b>29</b>
<b>3.3.1 Social-economic Development Status</b> .....	<b>29</b>
<b>3.3.2 Energy Consumption Status</b> .....	<b>29</b>
<b>3.3.3 Resource Conditions</b> .....	<b>30</b>
<b>3.3.4 Utilization of Low Carbon Energy Resources</b> .....	<b>31</b>
<b>3.3.5 Summary</b> .....	<b>31</b>
<b>3.4 Application of the Low Carbon Energy Indicators System in Zhejiang Province</b> .....	<b>31</b>
<b>3.4.1 Indicator Data Source and Treatment</b> .....	<b>32</b>
<b>3.4.2 Indicator Data Sheet for the Zhejiang Case</b> .....	<b>36</b>
<b>3.4.3 Zhejiang Case Analysis</b> .....	<b>42</b>
<b>4 Case summary and Comparison</b> .....	<b>58</b>
<b>4.1 Zhejiang Case Summary</b> .....	<b>57</b>
<b>4.2 Thailand Case Summary</b> .....	<b>60</b>
<b>4.3 Malaysia Case Summary</b> .....	<b>61</b>
<b>4.4 Case Comparison</b> .....	<b>63</b>
<b>4.4.1 Introduction</b> .....	<b>63</b>

<b>4.4.2 Overall Carbon Emission Intensity/density.....</b>	<b>63</b>
<b>4.4.3 Structure.....</b>	<b>63</b>
<b>4.4.4 Low Carbon Energy Intensity .....</b>	<b>64</b>
<b>4.4.5 Policy Issues .....</b>	<b>64</b>
<b>Appendix 1: Expert Consultation Questionnaire for Low Carbon Energy Indicators System for APEC Energy Strategy Study in APEC Low Carbon Town .....</b>	<b>66</b>
<b>Appendix 2: List of Participating Experts at the Consultation Workshop of July 2 .....</b>	<b>72</b>
<b>Appendix 3: Project Workshop Summary.....</b>	<b>73</b>
<b>Appendix 4: Workshop Agenda .....</b>	<b>70</b>
<b>Appendix 5: Case Study Report by CEERD of Thailand .....</b>	<b>74</b>
<b>Appendix 6: Case Study Report by Malaysian Green Technology Corporation .....</b>	<b>133</b>

## Foreword

This report is the final result of the APEC – funded project *Establishing Low Carbon Energy Indicators for Energy Strategy Study in APEC Low Carbon Town (S EWG 10 I2A)*. The project has been carried out with the following objectives:

1. Establish a set of low carbon energy indicators to characterize and assess the progress of low carbon energy development of low carbon town;
2. Analyzing status and trend of low carbon energy development of selected towns by case studies, which include demonstrating status and trend, identifying potential problems and constraints, and searching for solutions.

With these objectives in mind, a literature review of selected indicators systems of the similar kind were carried out, basic features of low carbon energy development priorities in developing APEC economies were identified, and a set of low carbon energy indicators system has been set up based on these findings.

The Zhejiang Province of China has been analyzed as one case study for the establish low carbon energy indicators system, with illustrative investigation into the overall carbon emission intensity and density, the energy intensity of key energy-consuming sectors, and major low carbon policies and practices. The results have been presented in descriptions and graphs.

Finally, low carbon energy indicators case studies in Zhejiang Province of China, as well as in Malaysia and Thailand were summarized respectively, with comparison being made between them.

This final report has been jointly contributed by the Zhejiang Energy and Radiation Institute of China, Malaysian Green Technology Corporation and CEERD of Thailand. The Zhejiang Energy and Radiation Institute has been responsible for the indicators system establish and Zhejiang case study, which forms the major part of this report. The case studies of Malaysia and Thailand have been undertaken by Malaysian Green Technology Corporation and CEERD of Thailand, and the findings have been attached as APPENDIX 6 and APPENDIX 5 to this final report.

# 1 Background

## 1.1 Research Review on Related Energy Indicators System

Low carbon development has become the natural choice of all nations pursuing sustainable future. In recent years, guiding policies for low carbon development are being developed at all levels, studies and practices are being implemented.

With the concept of low carbon development getting more recognized, studies on indicators system is gaining more attention, which demonstrates importance as an effective tool of guiding the development and assessing the level or results.

Indicators system on low carbon development is still in the progress of progressing and refining. To learn from past studies we choose indicators systems for sustainable energy development or for energy efficiency as references, which are quite relevant to our topic of study, i.e. low carbon indicators systems from the low carbon energy perspective.

There are a number of indicators systems for sustainable energy development or for energy efficiency that have been developed by international organizations or renowned institutes. In the following text, the Energy Efficiency Indicators by IEA, the ODYSSEE energy efficiency database, the Energy Indicators for Sustainable Development (EISD) by IAEA, and the Low Carbon Indicator System by the Lawrence Berkeley National Laboratory.

### Energy Efficiency Indicators by IEA

International Energy Agency (IEA) has since 1997 developed a series of energy indicators to study energy-use developments and analyze factors behind changes in energy use and CO<sub>2</sub> emissions. Energy indicators (and the underlying databases) reveal key relationships between energy use, energy prices and economic activity. This insight is crucial when assessing and monitoring past and present energy policies, and for designing effective future action. This work on indicators also aims at increasing the transparency, quality, completeness and timeliness of energy-related data. With years of continuing adjustment and improvement, in 2008, IEA published the Report of *Worldwide Trends in Energy Use and Efficiency- Key Insights from IEA Indicator Analysis*, summarizing the main results and conclusions from this work of energy efficiency indicators. It shows how the new statistics and methodologies are used to identify the factors driving and restraining the demand for energy, explains why there are differences in energy intensities amongst countries, and quantifies how the introduction of best available technology can help reduce energy use.

The IEA is working on developing a common indicator template, which could be used to define a joint questionnaire on energy efficiency, similar to the existing five annual IEA energy statistics questionnaires. This improved reporting would then provide a means for developing indicators that can be tailored to the needs of both IEA and other countries.

The IEA Energy Indicators Pyramid is shown in Fig.1.

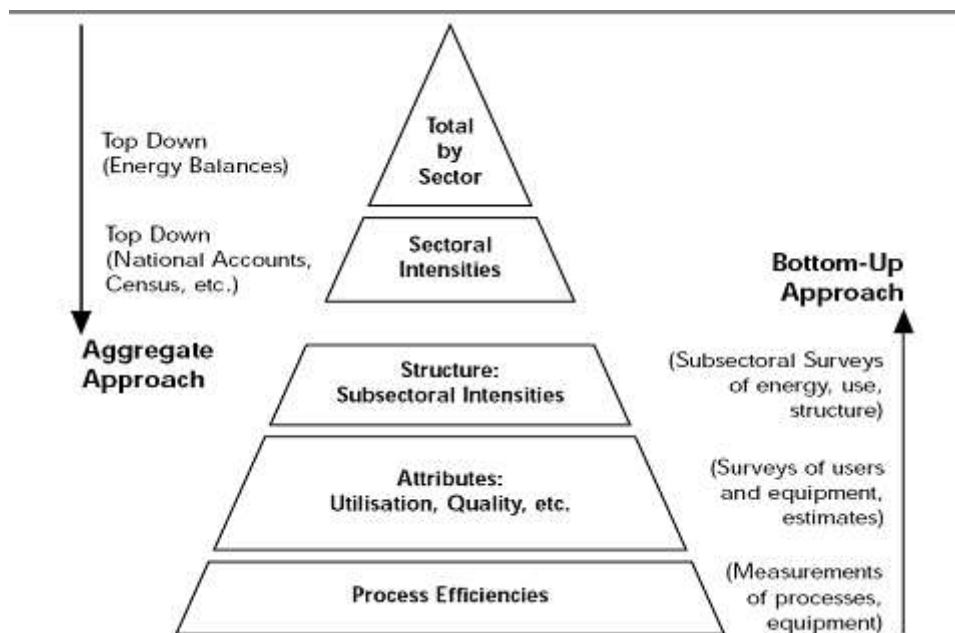


Fig.1 The IEA Energy Indicators Pyramid.

## EISD by IAEA

International Atomic Energy Agency (IAEA) , in cooperation with the International Energy Agency (IEA), the European Environmental Agency (EEA), EUROSTAT and the United Nations Department of Economic and Social Affairs (DESA) , initiated the work of devising energy indicators in the context of sustainable development in 1999 and finalized with the Energy Indicators for Sustainable Development (EISD). This indicator system has been designed to be a single set of energy indicators applicable in every country, providing information on current energy related trends in a format that aids decision making at the national level in order to help countries assess effective energy policies for action on sustainable development. The framework of the EISD indicators system is a set of 30 core indicators under three dimensions, which are social, economic and environmental, which are then further classified into 7 themes and 19 sub-themes, as shown in table 2. The EISD can be used to relate sustainable development goals and strategies to economic, environmental, or social factors, and to policy analysis and monitoring. With derivatives of basic statistical data, EISD can be used to describe the energy system situation as well as its relevance to social, economic and environmental factors. EISD can measure progress to sustainable goals, e.g. energy administrations set certain emission target, so a set of indicators are set up and monitored in progress to identify the gap toward the target, then corresponding action plans and countermeasure can be formulated to minimize the gap. EISD can also reflect impact of structure adjustment, technology progress and policy measures, with historical trends being assessed and future developments being explored. The EISD has been applied in national case studies in Brazil, Cuba, Lithuania, Mexico, Russia, Slovakia and Thailand. The flexibility of this indicator system allows the countries to adapt the EISD to their specific



energy characteristics by choosing the most suitable indicators for analysis of the status quo and best choices for future energy system and policy. For the participating countries, a spin-off benefit is that the EISD framework will be integrated into the national statistical system of participating countries, in which way energy development is becoming a more integral part of social-economic planning and also energy statistical system and information transparency have been improved.

Table 2 The list of EISD indicators by IAEA<sup>1</sup>.

<b>Social</b>		
<b>theme 1 - Equity</b>		<b>theme 2 – Health</b>
Sub-theme 1: Accessibility Sub-theme 2: Affordability Sub-theme 3: Disparities		Sub-theme 1: Safety
<b>Economic</b>		
<b>Energy use and production patterns</b>		<b>Energy security</b>
Sub-theme 1: Overall use Sub-theme 2: Overall productivity Sub-theme 3: Supply Efficiency Sub-theme 4: Production Sub-theme 5: Fuel mix Sub-theme 6: Prices		Sub-theme 1: Imports Sub-theme 2: Strategic fuel stocks
<b>Environmental</b>		
<b>Atmosphere</b>	<b>Water</b>	<b>Soil</b>
Sub-theme 1: Climate change Sub-theme 2: Air quality	Sub-theme 1: Water quality	Sub-theme 1: Soil quality Sub-theme 2: Forest Sub-theme 3: Solid Waste Generation and Management

### **ODYSSEE by EU**

Funded jointly by the SAVE program of the European Commission, of ADEME and of national funding, a monitoring tool for energy efficiency assessment called Online Database for Yearly Assessment on Energy Efficiency (ODYSSEE) has been initiated since 1992, to monitor and assess trends of energy efficiency and CO<sub>2</sub> of European countries. ODYSSEE is a detailed database covering more than 600 energy efficiency

<sup>1</sup> [http://www-pub.iaea.org/MTCD/publications/PDF/Pub1222\\_web.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/Pub1222_web.pdf).

data & indicators, for the EU-27 members plus Norway and Croatia, among which data for its 15 member states start from 1990 and those for the new member states start from 1996. All indicators in the database has been commonly defined, calculated and interpreted by the participants. Three types of indicators are included in the database, which are:

- Economic ratios, relating an energy consumption or CO<sub>2</sub> emissions to a macroeconomic variable such as energy intensities and carbon intensities;
- Technico-economic ratios, relating an energy consumption or CO<sub>2</sub> emissions to an indicator of activity measured in physical terms, such as gram of CO<sub>2</sub> per veh-km and ton oil equivalent per ton of cement;
- energy savings or CO<sub>2</sub> abatement indicators.

The ODYSSEE database can assist the participant countries in:

- definition and monitoring of the targets set at the national and international levels of energy efficiency and CO<sub>2</sub> abatement programs;
- evaluation of the energy efficiency programs that have been implemented;
- planning tool of future actions, including R&D programs;
- feeding the energy demand forecasting models and improving the quality of forecasts;
- enabling cross-country comparisons.

Based on the OYDESSEE database, the ODEX index has been developed to measure the energy efficiency progress by main sectors (industry, transport, households) and for the whole economy. The ODEX index is weighed average of sub-sectoral indices, while the sub-sectoral indices are calculated from variations of unit energy consumption measured in physical units. For example, for the industrial sector, the ODEX index calculation is based on 10 branches, and for the transportation sector, the ODEX index calculation is based on 8 modes or vehicle types.

In the European Energy Service Directive of the European Union, the energy efficiency index of ODEX is used to monitor progress of energy efficiency targets. Indicators in the ODYSSEE database are used to estimate energy savings from energy efficiency policies. Indicators from the ODYSSEE database have been frequently used in various annual reports by the European Energy Agency, such as the *Energy and Environment Report and the 4<sup>th</sup> edition of Pan-European State of Europe's Environment' Reports*.

### **China Low Carbon Indicators System by Lawrence- Berkley National Laboratory**

Macro-level indicators of low carbon development, such as energy use or CO<sub>2</sub> emissions per unit of GDP or per capita may be too aggregated to be meaningful measurements of whether a city or province is truly “low carbon”. Instead, indicators based on energy end-use sectors (industry, residential, commercial, transport, electric power) offer a better approach for defining “low carbon” and for taking action to reduce energy-related carbon emissions.

This report presents and tests a methodology for the development of a low carbon indicator system at the provincial and city level, providing initial results for an end-use low carbon indicator system, based on data available at the provincial and municipal

levels. The report begins with a discussion of macro-level indicators that are typically used for inter-city, regional, or inter-country comparisons. It then turns to a discussion of the methodology used to develop a more robust low carbon indicator for China. The report presents the results of this indicator with examples for six selected provinces and cities in China (Beijing, Shanghai, Shanxi, Shandong, Guangdong, and Hubei). The report concludes with a discussion of data issues and other problems encountered during the development of the end-use low carbon indicator, followed by recommendations for future improvement.

China Energy Group of the Lawrence Berkeley National Laboratory developed a set of low carbon indicators system for China. According to their study, considering the huge difference of industrial structures, economic development levels and climate between regions of China, macro-level indicators of low carbon development, such as energy use or CO<sub>2</sub> emissions per unit of GDP or per capita may be too aggregated to be meaningful measurements of whether a city or province is truly “low carbon”. In their opinion , indicators based on energy end-use sectors (industry, residential, commercial, transport, electric power) offer a better approach for defining “low carbon” and for taking action to reduce energy-related carbon emissions. This indicators system first identifies major end-use sectors to be: residential buildings, commercial buildings, industry, transportation, and power generation, then identifies indicators for each end-use sector. For example, for industrial sector, the indicator is defined as industrial final; for the transportation sector, the indicators is defined as s transportation final energy/capita energy per /industrial share of regional GDP. To make the indicators system more practical, it is suggested that indicator be developed at a sub-sectoral level, for example for the industry sector, the intensity of overall cement production or other industries can be given depending on data availability.

The Chinese researchers are also getting more and more interested in indicators system study for low carbon development.

The Institute of Urban Development and Environment Research of the Chinese Academy of Social Science (CASS) carried out research on in 2010. In this study, four key dimensions have been identified for low carbon development in Chinese cities as : low carbon productivity, low carbon consumption, low carbon resources and low carbon policy. Low carbon productivity includes indicators for both carbon and energy per unit of economic output, measurements consistent with existing energy-intensity targets of China and a potential national carbon-intensity target. Low carbon consumption covers per capita and per household energy consumption. Low carbon resources cover the share of low carbon energy, emissions per unit of energy production and the percentage of land covered by forest. Low carbon policy indicators review the existence of policies and plans for low carbon development, success in implementation of regulations, and public awareness levels.

On the basis of the CASS indicators system, some researcher developed their respective views on indicators system for low carbon town development. Du & Wang<sup>2</sup> put forward

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<sup>2</sup> Du Dong, Wang Ting. Comprehensive study on indicators system and development assessment

an indicators system consisting of seven key elements: low carbon building, low carbon transportation, low carbon consumption, low carbon energy, low carbon policy and low carbon technologies, among which the first four elements are the outer manifestation, while low carbon energy is the inner root for low carbon development, and low carbon policy and low carbon technology are driving forces for low carbon town development from institutional and technological aspects separately.

Other low carbon indicator system studies constructed similar system framework, which are mostly three-tier structure of target level, element level and basic indicators level. Their difference mainly lies in the connotation of the system. For example, some researchers emphasize the current low carbon development status, while some emphasize the capability for low carbon development. The elements defined in each indicator system vary, but the elements of low carbon energy supply, low carbon energy consumption can be found almost in all the studies.

There are also researches focusing on certain field. For example, Research Chen & Chu, et. al.<sup>3</sup> looked into low carbon transportation; Long, et. Al. Focused on low carbon buildings and proposed per capita CO<sub>2</sub> emission and carbon reduction efficiency during building construction to be used as indicators for low carbon energy assessment.

## **1.2 APEC Low Carbon Town Development**

The idea for transforming towns into low-carbon ones was conceived in June 2010 at the ninth APEC Energy Ministerial Meeting in Fukui, Japan, and the Energy Working Group set up a task force to develop the concept. Yujiapu, about 40 km east of Tianjin, was chosen as the first test case.

In November 2010, at the 18<sup>th</sup> APEC ECONOMIC LEADERS' MEETING Yokohama, Japan, an APEC development strategy to build low carbon society, promote low carbon policy and develop low carbon industry was officially established. At the meeting, Chinese President Hu Jintao proposed the initiative of “Strengthening cooperation on urban low carbon demonstration project, promoting energy conservation and reduction of emissions as well as strengthening cooperation on energy efficiency”. In Honolulu, 2011, APEC leaders stressed again the importance of the APEC Low Carbon Model Town.

Since then, low carbon town demonstration projects have been promoted in APEC economies.

In 2010, Tianjin Yujiapu Financial District was designated as the first low carbon model town on APEC ninth energy minister’s conference. The low carbon concept is integrated into most of its design, including optimizing functional area and energy system arrangement, improving space utilization and energy efficiency, reducing energy consumption from transportation and buildings, etc. Low carbon design has been integrated into many aspects of the town: for buildings, green eco-buildings will be

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on low carbon city development.[J].China Energy Management,2011,(08): 3-11,14.

<sup>3</sup> Chen Fei, Chu Dajian, Xu Kun. Development on low carbon transportation model in cities, problems and strategies - Case study of Shanghai, [J]. Urban Planning Forum, 2009(6).

designed and constructed, with rain water management system, energy storage central air conditioning, distributed energy supply system, energy-saving building facade, rooftops mounted with renewable energy systems or covered by vegetation; for traffic, the low carbon transportation modes of bicycles, electric motors and subways will constitute major transportation network, with buildings having access to underground facilities and the subway connecting every corner of the district; centralized heating and cooling supply improves energy efficiency, saving 30%-35% energy compared with conventional buildings. Other low carbon energy designs and technologies are also incorporated in design of this financial district, such as heat recovery from power plants, peak-valley pricing for electricity. Innovative technologies have been applied to realize intelligent low carbon management of building energy use, transportation, environment, municipal facilities and security.

Koh Samui of Thailand is the first APEC low carbon demonstration island. Located 750 km south from Bangkok, it has only around 50,000 residents but over 1 million tourists coming every year. Prosperous tourism that brings income to the island also imposes challenge on low carbon development. The Thai government has initiated actions to develop it into a low carbon island, from low carbon town planning and district energy management, promotion of renewable energies, to promoting low carbon building and transportation modes, and to ecological ways of life. Low carbon schools and low carbon hotels have been promoted by the government, eco-tourism has been encouraged to reduce wastes, and recycled use of waste has been implemented. Renewable energy utilization has been started with some off-grid PV system installed, and more renewable installations including solar PV, geothermal, tide energy, and so on will be in operation thanks to government support. As for power supply, submarine cables connect the island to the mainland, on the one hand securing power supply to the island and on the other hand can be used to export renewable power produced in the island. On the island, over 1000 large consumers pay demand charges, which is an incentive for them to manage peak demand and utilize on-site generation. Some hotels participate in the Green Leaf program that assesses their efficiency in environmental management and awards a Green Leaf Certificate ranging from 1 to 5 leaves. Passive design techniques and energy efficient solutions have been incorporated into buildings, while in traffic planning, public transportation and high-efficiency transportation modes have gained priorities.

In the effort to further promote the development of low carbon towns, indicators system that assess low carbon development level can act as effective tool to assess and guide the development in APEC economies.

Most developing economies, including China, are in the process of rapid industrialization, and urbanization can be an on-going process for decades. According to APEC report issued in 2011, *the Concept of the Low-Carbon Town in the APEC Regions*, APEC economies will foresee an average urbanization rate of 80.9% in 2050, which at year 2010 was 68%. Urbanization means increasing need for energy and hence increasing pressure of CO<sub>2</sub> emission with more population and industry in towns, along with them other negative impacts of urbanization will occur, such as traffic congestion and environmental pollution. To emphasize low carbon development not only contributes to energy need minimization and carbon emission reduction, but also can contribute to solving

accompanying problems of urbanization.

Because economic development has been major priority for developing APEC economies, and aggravated by technological and financial constraints, compared with developed economies, these member economies lag behind in low carbon development in terms of industrial structure, energy supply mix and energy consumption. Correspondingly, great potential exists in these respects. Different from low carbon development pathways of developed economies, which mainly involves setting overall and sectoral targets, and driving forward with innovative technologies and solutions, the key pathway for developing APEC economies at current stage should focus on **structural adjustment, efficiency improvement and policy promotion**.

### **1.3 Implication of Low Carbon Energy Development for Developing APEC Economies**

According to APEC definitions, *Low Carbon Town* means *towns, or cities, and villages which seek to become low carbon with a quantitative CO<sub>2</sub> emission target and a concrete low carbon developing plan, irrespective of its size, characteristics and type of development*.

In this study we choose to assess the development of low carbon town from the perspective of energy, based on the fact that energy issues are the root for low carbon development. Low carbon development, as comprehensive progress of low carbon energy, low carbon buildings, low carbon transportation, low carbon life style, and so on, covers as many sectors as it can be, but still, low carbon energy always keep the core status. Energy activities are responsible for around 90% of global CO<sub>2</sub> emission<sup>4</sup>. Therefore, low carbon energy development is the key to low carbon development, laying one major foundation for other aspect of low carbon development, like low carbon industry and low carbon town development.

Low carbon energy is differentiated from conventional high-carbon energy sources in that its utilization process emits zero or low CO<sub>2</sub> emission. In extensive terms, low carbon energy implies not only renewable energy, conventional hydro power and nuclear power, but also measure that can reduce energy consumption, as well as natural gas that is also fossil fuel but with remarkably lower CO<sub>2</sub> emission; also, economic activities that are less carbon-intensive in energy consumption are low carbon. Therefore, For the indicators system that measures low carbon energy developments, both the supply mix, industrial structure mix, and consumption efficiency should be taken into account. As we concluded in section 1.2, **structural adjustment, efficiency improvement and policy promotion** need be the main focus of developing APEC economies when developing low carbon towns, correspondingly, for the purpose of low carbon energy indicators system, the low carbon level of structure and energy consumption, as well as incentive policies that push forward low carbon energy development need be measured. Therefore, the elements of **structure** (energy supply structure & ratio of energy-intensive industry), **energy**

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<sup>4</sup> People's Republic of China Initial National Communication on Climate Change.2004.

**consumption efficiency** and **policy issues** (that drive low carbon energy development) are to be included as major targets of assessment with the indicators system.

In terms of structure, industrial ratio in total end-use energy consumption and energy supply mix will be considered. Renewable energy, conventional hydro power and nuclear power are major contributors to raise low carbon ratio in energy supply mix.

End-use energy consumption comes from three major sectors: industry, buildings and transportation, each accounting for about 1/3 in China's case. Since the energy supply factor has been covered in the element of structure, from the perspective of energy consumption, low carbon development mainly involves raising energy efficiency of the three energy-intensive sectors, i.e. Industrial energy efficiency, building energy efficiency and transportation energy efficiency. Appropriate basic indicators need be determined for these aspects.

From the policy perspective, the indicators need reflect major incentives or regulations that could play vital role in low carbon town development, including low carbon energy planning, statistics and monitoring system, etc.

## **1.4 Objectives**

In recent years, low carbon town development has been widely promoted both in APEC economies as well as in China. Many provinces and cities are claiming to promote low carbon town development. This study aims to lay scientific foundation to assess and guide development from the low carbon energy perspective, with which the endeavor is expected to go the right direction and follow the right path.

By building up the low carbon energy indicators system, analysis can be made on status and trend of key effecting factors on low carbon energy development, and it can also be used to probe into pathways for realizing low carbon energy development target.

The low carbon energy indicators system can assisting in low carbon town development, identifying potential problems and constraints and searching for solutions.

## **2 The Low Carbon Energy Indicators system**

### **2.1 Principles of Building the Low Carbon Energy Indicators System**

This study aims to build up the Low Carbon Energy Indicators system as an effective tool to assess and guide low carbon energy development for APEC low carbon town development, and to apply this indicators system to probe into cases from China, Malaysia and Thailand as case studies.

The following principles have been followed when building this indicators system:

- ① Scientific and practical. Design of the indicators should be scientific and practical, enabling comprehensive assessment of low carbon energy development and reflecting key issues from the perspective of APEC economies, while at the same time keeping simplicity of indicators and avoiding overlapping.
- ② Data availability. The study requires comparison of three cases from China, Malaysia and Thailand, which can be realized only when indicator data are available for three cases. Therefore, the indicators selected should be general enough to allow data availability within the timeframe of study.
- ③ combined use of quantitative and qualitative indicators. Other than economic, energy and emission indicators that are quantitative data, the policy aspect is also importance as a direct driving force for low carbon energy development for low carbon towns. Bearing this in mind, indicators from the energy perspective should also be included in the indicators system.

## 2.2 Procedure for Indicators System Construction

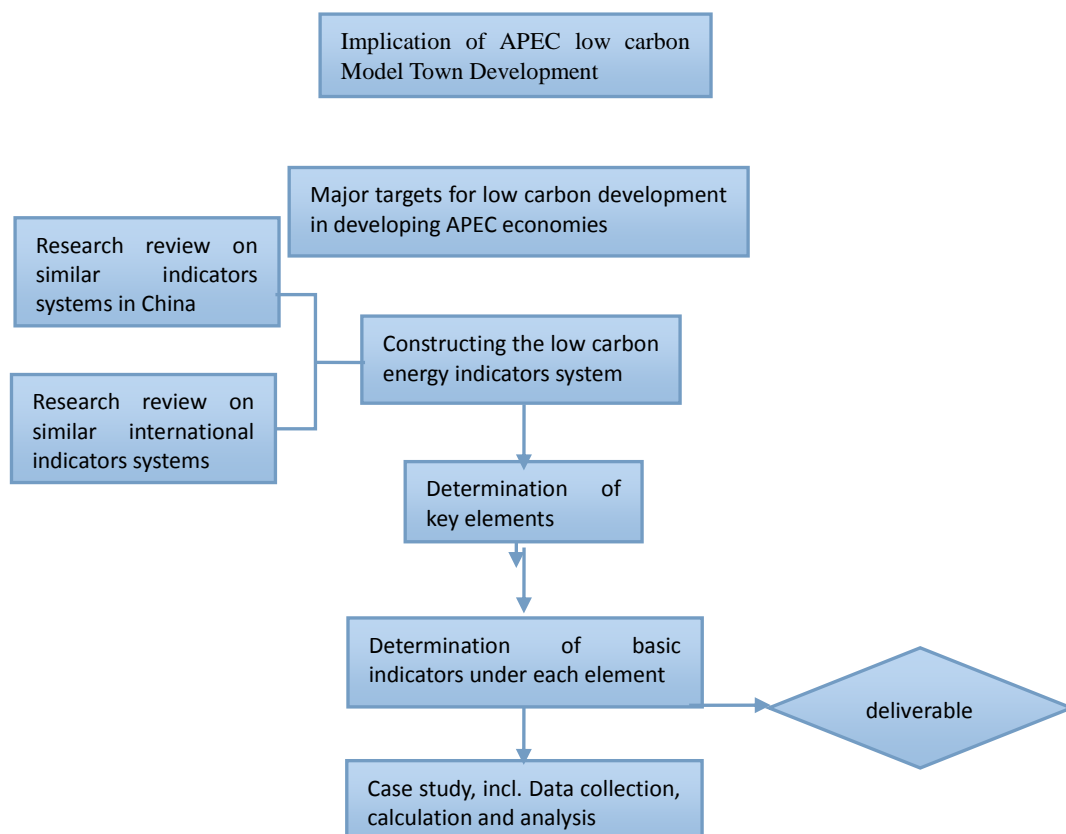




Fig.2 Construction procedure for low carbon energy indicators system for APEC low carbon town development.

Fig.2 shows the construction procedure for low carbon energy indicators system for APEC low carbon town development. In the first two months, the project team have widely reviewed related energy indicators system studies and practices made both by domestic and international organization, with several important ones of them selected to be reviewed for this project purpose. That being done, implication of APEC Low Carbon Model Town development was investigated, with key targets for low carbon town development in developing APEC economies identified. Based on the above work, a three-tier indicators system framework has been set up. A number of options of basic indicators are preliminarily decided for each tier, ready for further screening and short-listing. At this preliminary phase, these choices for basic indicators are given in abundance, for the convenience of further experts' consideration and selection.

To establish indicators system on scientific and reliable basis, comments from experienced experts could be very valuable. For this purpose, on July 2 2013, hosted by the Zhejiang Provincial Energy Administration, a Comment Solicitation Workshop was held and 11 experts ( for the list of experts please see Appendix 2) from top-notch

universities and research institutes were invited to give comments and suggestions on the “Low Carbon Energy Indicators Questionnaire”(see Appendix 1), which bears the preliminary list of basic indicators. The questionnaire was sent to them a couple of days before the Workshop for their thorough consideration.

After tentative ideas about the structure and content of the indicators system- along with general information on the project itself- were presented by ZERI, each expert raised ideas based on their years of study and practices. The discussion went on for about one and a half hours and proved to be very fruitful. Later, expert comments have been noted and summarized, and was further refined by the project team to form the final version of the Low Carbon Energy Indicator System, as is shown and illustrated in the next section.

## **2.3 Structure and Data source for The Low Carbon Energy Indicators System for APEC Low Carbon Town Development**

### **2.3.1 Sources for Information and Data**

To ensure accuracy of results, data and information are decided to be mainly based on statistical yearbooks and reports published by government authorities, with published books, reviews, papers as necessary complement.

For the case study of Zhejiang, China, main data and information sources include: *China Energy Statistical Yearbook, Zhejiang Statistical Yearbook, China Electric Power Statistical Yearbook*. When data is not available from the above sources, governmental reports, publications and related study reports or papers can be used as references.

Data source for case study of Thailand: in the consideration of CEERD of Thailand.

Data source for case study of Malaysia: in the consideration of Malaysian Green Technology Corporation.

For indicators without direct source of data, reasonable estimation would be made on the basis of solid data and justifiable assumptions, with process of estimation and assumptions illustrated in detail.

Historical data is expected to include those between 1995 ~ 2010.

### **2.3.2 Indicators System Structure**

Based on review on related studies, a three-tier structure with the target level, the element level and the basic indicator level would be applied to this indicator system, in that it can clearly demonstrate the key aspects as well as attributes to each key aspect for APEC low carbon town development from the energy viewpoint. Therefore it allows direct understanding of the whole picture, and clear exposure of problems.

The top tier is the target tier, under it are the element tier and the basic indicator tier.

Fig. 3 illustrates structure of the Low Carbon Energy Indicators System for APEC low carbon town development.

Target tier: Low Carbon Energy development level for APEC low carbon town development

Element tier: consisting of four elements, which are, overall emission, structure, energy consumption and policy issues.

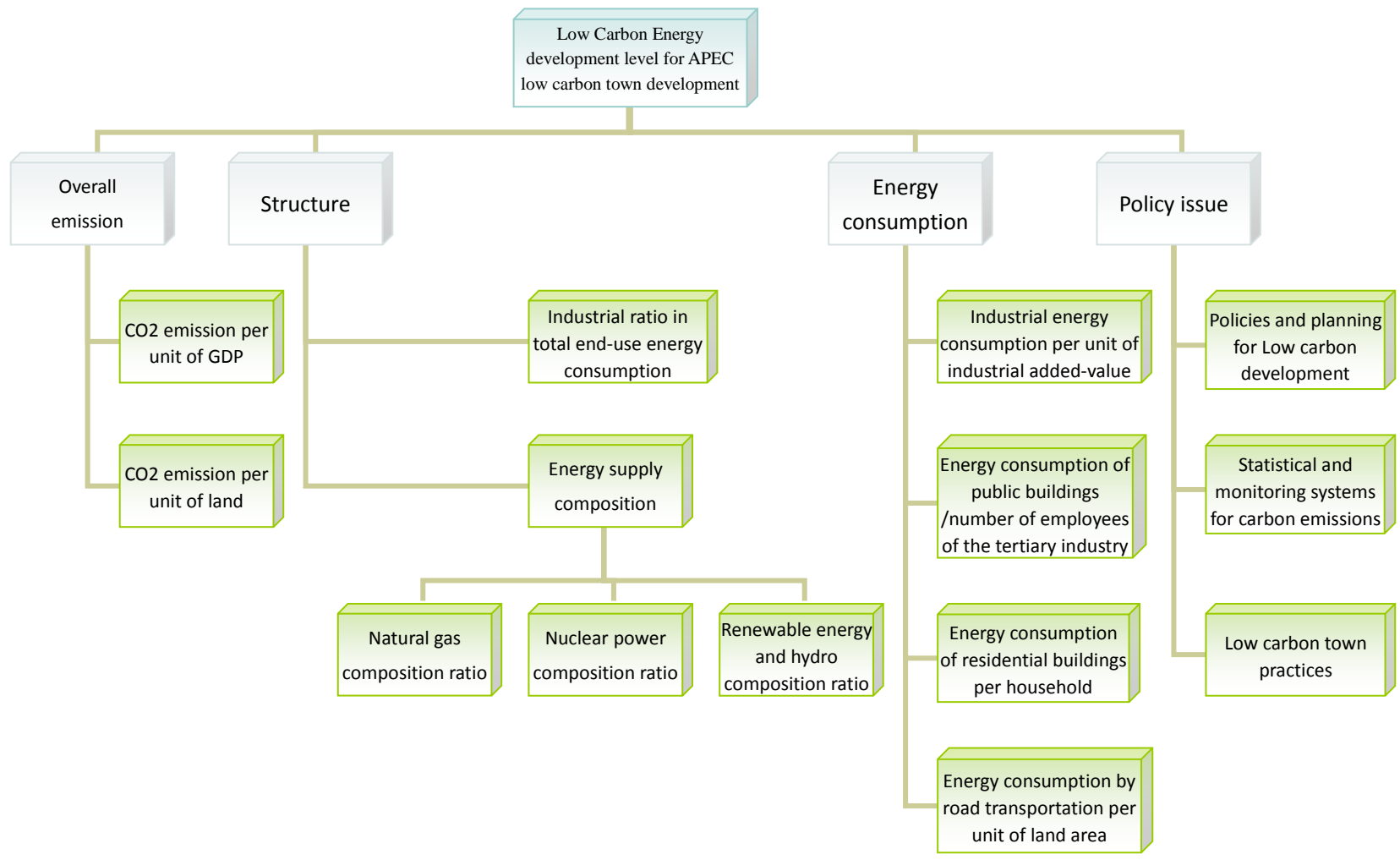


Fig. 3 The three-tier Low Carbon Energy Indicators System for APEC low carbon town development.

### **Target level**

At the target level is the comprehensive assessment of Low Carbon Energy development level.

### **Elements**

The elements tier reflects the elements that have key impact on the target of low carbon energy development.

As discussed in section 1.3, four major elements can reflect the development of low carbon energy in APEC low carbon towns, which are:

- 1 ) **Overall energy consumption or carbon emission intensity/density:** directly reflecting overall carbon emission intensity/density, which result from the other three elements.
- 2 ) **Structure:** reflecting general industrial structure and energy supply structure, especially ratio of low carbon energy in overall energy supply.
- 3 ) **Low carbon energy consumption:** reflecting energy consumption intensity of major energy-consuming sectors, i.e. industry, building and transportation.
- 4 ) **Policy measures for low carbon energy development:** reflection decision by the government to push forward the endeavor, such as dedicated low carbon development plan, whether there is carbon emission statistical and monitoring system in place, etc..

### **Basic indicators**

Basic indicators are key indicators that reflect major factors under each element at the element-tier. Most basic indicators are quantitative ones, such as those under the elements of overall energy consumption or carbon emission intensity/density, energy supply and energy consumption, which can be calculated or estimated on reasonable grounds. The indicators reflecting policy strength are qualitative ones and the way to define them is by illustration.

Table 1 Basic indicators for the Low Carbon Energy Indicators System for APEC low carbon town development

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<b>1.CO2 emission per unit of GDP (emission intensity)</b>
<b>1) CO2 emission per unit of land (emission density)</b>
<b>1) Industrial ratio in total end-use energy consumption</b>
<b>4.Energy supply composition</b>
①Natural gas composition ratio
②Nuclear power composition ratio
③Renewable energy and hydro composition ratio
<b>5.Industrial energy consumption per unit of industrial added-value</b>
<b>6.Energy consumption of public buildings /number of employees of the tertiary industry</b>
<b>7.Energy consumption of residential buildings per household</b>
<b>8.Energy consumption by road transportation per unit of land area</b>
<b>9.Policies and planning for Low carbon development</b>
<b>10.Statistical and monitoring systems for carbon emissions</b>
<b>11.Low carbon town practices</b>

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The basic indicators are shown in Table 1.

**Overall energy consumption or carbon emission intensity/density.**

This element reflects the overall energy consumption/emission intensity or density. Since in practice over 90% CO<sub>2</sub> emission comes from energy utilization and consumption activities, energy consumption intensity/density and CO<sub>2</sub> emission intensity/density indicators are very relevant so that including both of which in the indicators system can be unnecessary. For this reason, we choose the CO<sub>2</sub> emission intensity/density indicators as shown below:

1 ) **CO<sub>2</sub> emission per unit of GDP (emission intensity)** (tCO<sub>2</sub>/unit of local currency)

CO<sub>2</sub> emission intensity is the CO<sub>2</sub> emission per unit of economic output, reflecting the impact on environment per unit of economic gain.

In the context of this specific research, **the CO<sub>2</sub> emission includes those from energy consumption and utilization process only**. Therefore, its calculation is then based on assumption that the emitted CO<sub>2</sub> come from fuel combustion. The emission is then calculated fuel-based, as illustrated in 2006 IPCC Guidelines, with member economy-specific emission factors (when available) to be used in place of IPCC defaults.

In case studies of each member economy, the GDP value will be given as local currency at 2005 constant price. When making comparisons between cases, each local currency will be changed to US\$ at 2005 constant prices based on (exchange rate or PPP) method uniformly agreed by the contractor and sub-contractors.

$$\textit{CO}_2 \textit{ emission per unit of GDP} = \textit{CO}_2 \textit{ emission of the year} / \textit{GDP of the year}$$

## **2 ) CO<sub>2</sub> emission (from energy activities) per unit of land (emission density)**

( tCO<sub>2</sub>/km<sup>2</sup> )

CO<sub>2</sub> emission per unit of land measures carbon emission density of the town, reflecting the environmental impact on the town imposed by CO<sub>2</sub> emission.

The CO<sub>2</sub> emission density is measured by land area instead of per capita here, based on the consideration that for some cases, such as Thailand islands, annual visiting tourist may outnumber local residents by multiple times, and measurement per capita can lead to false data results and analysis.

$$\textit{CO}_2 \textit{ emission per unit of land} = \textit{CO}_2 \textit{ emission of the year} / \textit{land area}$$

### **Structure**

In this low carbon energy indicators system, for the element of structure, industrial structure is also taken into account as well as the energy supply structure.

### **3) Industrial ratio in total end-use energy consumption (%)**

For most developing APEC economies like China, industrializing is an on-going process and energy consumption by the comparatively energy-intensive industrial sector still consist major part in overall energy consumption. Industrial ratio in total end-use energy consumption can to some extent reflect local industrial structure, help identifying how “low carbon” its industrial structure is.

$$\textit{Industrial ratio in total end-use energy consumption} = \textit{end-use industrial}$$

*energy consumption/total end-use energy consumption*

4) **Energy supply composition ( % )**

Energy supply structure reflects ratio of low-carbon and zero-carbon energy in the energy mix, three basic indicators are included for this purpose:

① **Natural gas composition ratio ( % )**

Natural is high quality fuel compared with coal and oil for its low pollution and high utilization efficiency. At the same heat value, CO<sub>2</sub> emission from natural gas combustion is only about half of that from coal, while other pollutants, such as SO<sub>2</sub>, NO<sub>x</sub> and particulates are also significantly lower than those from coal or oil products. In the near term when renewable energy is still working its way into the mainstream energy sources, natural gas ratio in energy mix can play important role for low carbon and clean development.

$$\text{Natural gas composition ratio} = \text{natural gas supply} / \text{total primary energy supply}$$

② **Nuclear power composition ratio ( % )**

Nuclear power is one competitive low-carbon energy source. When developed in the safe way, it can make significant contribution to replacing conventional high-carbon fuels and to reducing CO<sub>2</sub> emission.

$$\text{Nuclear power composition ratio} = \text{nuclear gas supply ( converted to tce or toe based on average efficiency of local thermal power plants in that year )} / \text{total primary energy supply}$$

③ **Renewable energy and hydro composition ratio**

Renewable energy utilization is the direction of energy technology progress and may be one of the real hope to curb CO<sub>2</sub> emission growth. Renewable energy, along with conventional hydro power are clean energy sources that emit no CO<sub>2</sub>. Renewable energy technologies include mainly solar thermal utilization, solar photovoltaics, wind power, small hydro power, biomass power generation, biomass heating and geothermal energy utilization.



*Renewable energy and hydro composition ratio = energy supply from renewable energy and conventional hydro power/ total primary energy supply ,*

*Here,*

*energy supply from renewable energy and conventional hydro power= power generated from renewable energy and conventional hydro power= power ( converted to tce or toe based on average efficiency of local thermal power plants in that year ) + thermal energy supply from renewable energy*

Here,

*power generated from renewable energy = hydro power generated+ wind power generated + biomass power generated ( such as MSW incineration power plants ) + solar PV power generated ( solar PV is ignorable with the current installed capacity )*

*hermal energy supply from renewable energy = solar thermal utilization (include mainly the solar water heaters)+ heat generated from ground-source heap pumps ( GSHP is ignorable with the current installed capacity )*

### **Low carbon energy consumption**

The element of low carbon energy consumption reflects energy consumption/CO<sub>2</sub>emission intensities of major energy consuming sectors.

#### **5) Industrial energy consumption per unit of industrial added-value (tce/ unit of local currency)**

Industrial energy consumption per unit of industrial added-value reflect industrial energy consumption intensity.

*Industrial energy consumption per unit of industrial added-value =  
end-use industrial energy consumption / industrial added-value*

**6) Energy consumption of public buildings /number of employees of the tertiary industry (tce/person.year)**

The building sector is among the three major energy-consuming sectors (industry, building, transportation). Although public building is less important than residential buildings in terms of total floor area (in Zhejiang case, it is 1/4 of total building floor area), its energy use and waste can be far more significant than those of residential buildings, due to its enormous space, countless electric appliances and long period of occupancy, as well as lack of energy management. Take the Zhejiang case for example, according to survey findings, annual electricity consumption of public building varied between 37-122 kWh/m<sup>2</sup>, a lot higher than that of average residential buildings, which was around 20 kWh/m<sup>2</sup>. Among large public buildings surveyed, shopping malls and hotels had the highest figures of 122 kWh/m<sup>2</sup> and 80 kWh/m<sup>2</sup>, respectively. Considering the high energy intensity, energy consumption of public building should be taken into consideration.

Since yearly statistical data for area of public buildings is not available (at least in the Zhejiang case), the energy consumption of public buildings is divided by total number of employees in the tertiary industry is applied as a reasonable replacement to reflect the energy intensity of public buildings.

**7) Energy consumption of residential buildings per household (tce/household.year)**

Residential buildings are one ignorable energy consuming sector. It is measured here per household.

*Energy consumption of residential buildings per household = energy  
consumption of residential buildings/total number of households at the year end*

**8) Energy consumption by road transportation per unit of land area ( tCO<sub>2</sub>/m<sup>2</sup>)**

Road transportation is the major consumer of transportation fuels. According to studies<sup>5</sup>, CO<sub>2</sub> emission from road transportation in Asian economies accounted for 80%-99% of overall transportation CO<sub>2</sub> emission. For example, in 2005, this figure reached 99.9% and 99% respectively in Malaysia and Thailand. Therefore, road transportation energy consumption can be a perfect indicator to describe

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<sup>5</sup> Timilsina GR, Shrestha A. Transport Sector CO<sub>2</sub> emissions growth in Asia: Underlying factors and policy options [J]. Energy Policy, 2009, 37(11):4523-4539.

transportation energy use with enormous save of complicated work involving calculation of other transportation modes.

As mentioned before, CO<sub>2</sub> emission from road transportation in Asia economies accounted for 80%-99% of overall transportation CO<sub>2</sub> emission and this figure even reached 99.9% and 99% for Malaysia and Thailand respectively. Based on this fact, the indicator of road transportation energy consumption per unit of land area can justifiably reflect the energy intensity of transportation sector.

The reason that road transportation energy consumption is measured by land area instead of per capita is the same as illustrated in indicator 2) CO<sub>2</sub> emission per unit of land.

**Energy consumption by road transportation per unit of land area = road  
transportation energy consumption/land area of the town**

### **Policy measures for low carbon energy development**

For the low carbon energy indicators system for APEC low carbon town strategy, the following aspects are included under the “policy” element:

#### **9) Policies and planning for Low carbon development**

Government policies and plannings are the driving force and guiding engine for development of low carbon town. They have decisive impact on the progress and scale of development. For this reason this indicator is included in the indicators system, described by illustrations on the current status and trend.

#### **10) Statistical and monitoring systems for carbon emissions**

Effective CO<sub>2</sub> emission reduction relies heavily on strict carbon emission statistics and monitoring system, only in which way can practical emission be measured, emission reduction progress be confirmed, and solid grounds be laid to credit reduction activities and punish non-compliances. For this reason this indicator is included in the indicators system, described by illustrations on the current status and trend.

#### **Low carbon town practices**

The indicator of low carbon town practices measures the actual low carbon practices in all sectors for a specific town by describing whether it has taken action in this direction and what endeavors have been made.

### 3 Case Study on Zhejiang Province, China

#### 3.1 Explanation on Case Selection

Concerning the case to be selected, based on the project title, would be a *TOWN*, so the most appropriate choice is a city, or some specific urban district.

But, practical data availability makes this choice impossible.

Almost all data necessary for assessing low carbon energy development, including energy structure, energy intensity of key energy-intensive sectors, as well as data for fuel-based CO<sub>2</sub> emission calculation, need be based on systematic energy statistical information, which in China's case should be the energy balance sheets in the annual *China Energy Statistical Yearbook*. But the reality is, energy balance sheets in the Yearbook are only for provinces, the data for cities, not to mention counties or districts, are inaccessible.

This data availability issue is bigger obstacle for indicators related to renewable energy utilization, for which statistical data have been retained and publicized by different administrations and different channels, causing difficulty in data collection and incurring less data reliability.

Based on the current energy statistical system, energy data is comparatively complete at province level, with yearly energy consumption data by fuel type and by sector recorded in each year's *China Energy Statistical Yearbook*. For renewable energy data, provincial-level data can be found in *China Electric Power Yearbook* and *Energy White Paper* publicized each year by the Provincial Government.

Therefore, for the practical consideration for data availability, under current condition, the case has to be selected as a province instead of a city or a district. For this project, the case is selected as Zhejiang Province. We as researchers also hope to take this opportunity to push forward fostering of a more systematic and detailed energy statistical system, which could play vital role in laying basic data foundation for monitoring low carbon energy development here in China.

#### 3.2 Low Carbon Development Background in China and in Zhejiang Province

The Chinese Government has set concrete CO<sub>2</sub> emission reduction targets and stipulated supporting policies. In 2009, The Chinese Government made commitment to "reduce CO<sub>2</sub> emission intensity by 45% in 2020 on the basis of that of 2005". In the 12<sup>th</sup> Five-year Plan, the Chinese Government set the target of reducing CO<sub>2</sub> emission intensity by 17% between 2011 and 2015. Pushed forward by the trend of low carbon development in China, provinces and cities are vigorously pursuing low carbon demonstrations. In 2010, the *Notice on Undertaking Demonstration Work for Low carbon Provinces and Low Cities* was issued by the National Development and Reform Commission, marking the commencement of low carbon demonstration in 5 provinces and 8 cities. Another round of demonstration projects was initiated in 2012, involving more provinces and cities. The low carbon demonstration work has been

designed to probe into best practices and experiences in addressing climate change, reducing carbon emission intensity and promoting green development, while at the same time maintaining economic development and improving living standards, against the background of rapid industrialization in China. The demonstration provinces and cities were expected to develop low carbon development plans, stipulate supporting policies and incentive measures, foster emission data statistical and management system, and promote low carbon lifestyle.

According to the Chinese Government, low-carbon urban development in China is placed in the basic framework of sustainable development, emphasizing on all levels of town including production, living, transport and social, resource and sustainable development environment to achieve low carbon emission minimization. Under this concept, there are six major approaches to achieve Low Carbon Development in China, which are: industry, spatial deployment, energy, building, transport and renewable sources. In terms of energy, low carbon development requires optimization of energy structure and improvement of energy efficiency, so as to reduce overall fossil fuel consumption and hence carbon emission.

Low carbon development has gained increasingly greater attention by the Zhejiang Provincial Government. In the *Implementation Scheme for Circulated Economy Demonstration in Zhejiang Province*, low carbon development was listed as one priority. Though low carbon energy currently only account for small percentage in overall energy use, it is getting developing momentum thanks to ever-growing government support.

In 2010, the *Notice on Scheme for Addressing climate Change in Zhejiang Province* was issued by the Provincial Government. It gave detailed illustration on GHG emission and emission composition in Zhejiang Province, summarized achievement in energy saving, energy structure optimization and expansion of forestry CO<sub>2</sub> sink. It also set new targets for the above work and emphasized key sectors and incentive measures.

According to the *Notice on Scheme for Addressing climate Change in Zhejiang Province*, in 2007, the composition of green house gas sources in Zhejiang Province were: energy activities 327 million t CO<sub>2e</sub>, industrial process 48 million t CO<sub>2e</sub>, agriculture 11 million t CO<sub>2e</sub>, and municipal waste 15 million t CO<sub>2e</sub>, accounting for 81.58%, 11.97%, 2.74% and 3.74% each in overall GHG emission in Zhejiang. In 2007, CO<sub>2</sub> emission from fossil fuel combustion in Zhejiang Province accounted for 5.4% of China's total, while per capita CO<sub>2</sub> emission was 1.4 times the China average, and CO<sub>2</sub> emission per unit of GDP was 70% of China average.

With fast-growing economy and low carbon resources largely unexplored, environmental problems and energy supplies issues are getting more severe. To gradually push forward low carbon development while maintaining sustained economic development and gradual urbanization is the challenge we have to address in Zhejiang. Efforts need be made from every sector, to optimize energy structure and improve efficiency with strong support from the government.

According to the *Notice on Scheme for Addressing climate Change in Zhejiang Province*, “pushing forward structural emission reduction, saving energy, improving efficiency and expand forestry carbon sink” would be emphasized, and “adjusting economic structure, promoting economic transition, developing clean energy, optimizing energy structure, improving energy efficiency, saving energy ” would be listed as key tasks for the future.

### **3.3 General Information of the Case**

#### **3.3.1 Social-economic Development Status**

Zhejiang Province is among the most vigorously developed regions in China, with overall economic output ranking the 4<sup>th</sup> greatest of all provinces in China for recent years. The urbanization ratio in Zhejiang reached 63.2% in 2010, much higher than the 51% China average, with average income of urban residents being the second greatest in China.

There also exist problems hindering sustainable development of economy in the province: low-end industries with low added-value are highly concentrated in parts of the province, traditional manufacturing and traditional service industries are still heavily dominant in the economy; the economic development relies heavily on low-end industries, on low-cost labors and on depletion of resources and environmental cost. The transition to low carbon economy is necessary and urgent.

#### **3.3.2 Energy Consumption Status**

Energy consumption in Zhejiang Province has maintained growth for the past two decades. Between 1995 and 2010, overall energy consumption increased from 42.32 million tce to 169 million tce, with annual growth rate of 9.7%, which is lower than that of GDP, which was 12%<sup>6</sup>. Reasonable projections show that the overall energy consumption in Zhejiang will keep rising for a comparatively long period, which poses pressure on energy supply. Considering the province’s very poor fossil fuel reserve, increasing energy demand would be hard and costly to meet.

In 2010, overall energy consumption reached 169 million tce (tons of coal equivalent), with a year-on-year growth rate of 8.3%, supporting a year-on-year GDP growth rate of 11.9%. Energy consumption per unit of GDP is the 4<sup>th</sup> lowest in China. Considering the industrialization and urbanization stage Zhejiang Province is going through, energy demand in the near-to-medium term is expected to keep increasing.

Official predication<sup>7</sup> showed that in year 2020, overall energy demand for Zhejiang Province would reach 289,268 and 247 million tce respectively under three different scenarios, and in 2030 would reach 375,340 and 298 million tce, respectively. Energy

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<sup>6</sup> Calculated based on data from Zhejiang Statistical Yearbook.

<sup>7</sup> 12<sup>th</sup> Five-year and Medium-to-long Term Plan for Energy Development in Zhejiang Province.

structure optimization remains a key task in the years to come. The current heavy dependence on conventional fuels has little chance to remain unchanged, otherwise severe energy supply shortage, huge price rise and greater environmental pressure would be incurred.

In conclusion, ever pressing resource and environment stress have made the past development mode supported by heavy consumption of conventional energy source no longer sustainable. The best way out should be developing low carbon energy sources, and utilizing energy in more efficient way to support future economic development. Developing low carbon energy can help reduce energy demand and alleviate environmental pressure, creating new economic growth opportunities along with development of new technologies and new industries.

### **3.3.3 Resource Conditions**

Based on the *Notice on Scheme for Addressing climate Change in Zhejiang Province*, major characteristics and challenges for energy resource and consumption in Zhejiang could be summarized as:

- comparatively rich renewable energy and very poor fossil fuel resources. Zhejiang Province boasts of fairly rich renewable energy sources such as hydro power, wind and tidal energy. Offshore wind power potential within the 20 meter-deep submarine contour is around 83 GW, exploitable tidal energy is estimated to be 8.8 GW. Solar irradiation is around 4147-4670 MJ/m<sup>2</sup>. Fossil fuel resource reserve in Zhejiang Province is very poor, with no oil or natural gas reserve found on its land, and proven coal reserve is below 0.01% percent of China's total coal reserve.

- coal-dominant energy consumption structure. Coal consumption ratio keeps higher than 60%, oil & products accounts for about 20%. Low carbon renewable energies such as hydro power and wind power, combined with nuclear power account for only about 8% in primary energy supply. Over 95% of primary energy consumption in Zhejiang Province comes from other regions.

According to *12<sup>th</sup> Five-year and Medium-to-long Term Plan for Energy Development in Zhejiang Province* and *12<sup>th</sup> Five-year and Medium-to-long Term Plan for Renewable Energy Development in Zhejiang Province*, resource conditions for major low carbon energy in Zhejiang are as follows:

- hydro power: abundant, with exploitable hydro power resource around 8 GW, among which 6.75 GW are small hydro;

- wind power: technical potential for onshore and offshore wind power (within 50 meter-deep submarine contour) 1.3 GW and 15.15 GW, respectively;

- annual solar irradiation 1124-1368kWh/m<sup>2</sup>;

- Biomass energy: proven biomass energy reserve including 12.11 million tons of crop straw, 68.78 million tons of livestock manure, 11.95 million tons of domestic waste, 8.73 million tons of forestry waste, and 1.6 billion tons of industrial sewage water.

The overall biomass in Zhejiang that could be converted to energy each year is estimated to be 5.53 million tce in theory;

- installed capacity of nuclear power in 2010 was 3.74 GW, with annual power output of 25.7 GWh.

### **3.3.4 Utilization of Low Carbon Energy Resources**

A series of plans and incentive measures have been promulgated by the Zhejiang Provincial Government to guide and encourage utilization of low carbon energy utilization. In Zhejiang Province in 2010:

Wind power utilization: Wind power installed capacity reached 249 MW, growing 9.7% over last year. Total wind power generating was 470 GWh, growing 32.0% over last year.

Solar energy utilization: Solar PV demonstration systems that had been put into use totaled 29.6 MW, 5.7 times of that of the previous year. Installed area of solar thermal water heaters grew 5.5% over the previous year, reaching 9.2 million m<sup>2</sup>.

Waste-to-energy: Total installed capacity of incineration power plants fueled by municipal waste totaled 333 MW, generating 2.01 TWh of electricity.

Rural biomass energy: Contribution of straw and firewoods in rural energy consumption were 0.578 and 0.956 million tons of tce, respectively. Biogas projects yielded 170 million m<sup>3</sup> of biogas, which were supplies to 144 thousand rural households.

Hydro power: 19.3 TWh of electric power was generated by hydro power station of all scales. Around 80% of all hydro resources had already been utilized.

Nuclear power: 25.7 TWh of electric power was generated, accounting for 10% of overall power generated in Zhejiang.

### **3.3.5 Summary**

Zhejiang has vigorous economy and comparatively wealthy society, which has laid favorable economic ground for transition to low carbon energies; The growing energy demand is in urgent need of clean low carbon energy to meet the demand-supply balance; The province boasts of rich low carbon energy resources such as offshore wind power. All these factors can strongly justify prompt development of low carbon energies.

## **3.4 Application of the Low Carbon Energy Indicators System in Zhejiang Province**



### 3.4.1 Indicator Data Source and Treatment

#### *Note on calculation method for energy consumption*

At present, for major official energy statistical reports in China, energy equivalent value instead of energy calorific value is used for calculating energy consumption. For this reason, in this study report, overall energy consumption and end-use energy consumption values are all calculated in line with the official statistical data unless specified otherwise, by converting electricity to energy unit using energy equivalent coefficient, which is the coal consumption per unit of generated electricity at the specific year.

For the sectoral energy consumption, including industrial energy consumption, building energy consumption and transportation energy consumption, energy calorific values are also applied in the study unless specified otherwise.

One exception is the building energy intensity. Since in most related literatures, building energy intensity is characterized in energy calorific value or in electric power consumption, in the following report, building energy intensity are shown in energy calorific value in the graphs, while in the data sheet, both energy calorific value and energy equivalent values have been listed to facilitate reference and comparison.

#### **Overall carbon emission intensity/density**

##### **2 ) CO<sub>2</sub> emission per unit of GDP (emission intensity) :**

CO<sub>2</sub> emission is calculated on the basis of energy balance sheet, publicized energy statistical data and standard technical parameters.

The energy balance sheet listed in each year's *Energy Statistical Yearbook* comprise of around 20 fuel (energy) categories, among which some has very small percentage in overall consumption. To simplify calculation while not damaging reliability of results, fuel (energy) categories with minor consumptions has been neglected, including "other washed coal", "coke oven gas", "other gas", "other coking products", ,which would add to no more than 1% of total energy consumption and CO<sub>2</sub> emission.

As for the CO<sub>2</sub> emission coefficient for varies fuels, coefficients put forward in the *Guidelines for Compilation of Provincial-level GHG Inventory* that was promulgated by the National Development and Reform Commission of China were applied. For fuel types whose emission coefficient was not listed in the above document, IPCC 2006 default value would be applies.

CO<sub>2</sub> emission = (CEFi × CEi), among which:

CEF: CO<sub>2</sub> emission coefficient of fossil fuel(kg/TJ)

CE : consumption(TJ)

i : fuel type

Fig.1 CO<sub>2</sub> emission coefficient for fuels.

Fuel	Carbon content per unit of heat value ( t C/TJ )	Carbon oxidation ratio ( % )	average low calorific value ( kJ/kg , m <sup>3</sup> )	CO <sub>2</sub> emission coefficient ( t CO <sub>2</sub> /t,10 <sup>3</sup> m <sup>3</sup> )
coal	26.37	0.94	20908	1.900
cleaned coal	26.37	0.94	26344	2.394
briquettes	33.6	0.94	17562	2.034
coke	29.5	0.93	28435	2.860
Crude oil	20.1	0.98	41816	3.020
gasoline	18.9	0.98	43070	2.925
kerosene	19.5	0.98	43070	3.018
diesel oil	20.2	0.98	42652	3.096
fuel oil	21.1	0.98	41816	3.170
other petroleum products	20	0.98	43070	3.095
LPG	17.2	0.98	50179	3.101
refinery gas	18.2	0.98	46055	3.012
natural gas	15.3	0.99	38931 /m <sup>3</sup>	2.162 /10 <sup>3</sup> m <sup>3</sup>

## 2 ) CO<sub>2</sub> emission (from energy activities) per unit of land (emission density):

Calculation for CO<sub>2</sub> emission is based on the same method as illustrated above. Land area data refers to *Zhejiang Statistical Yearbook*.

### Structure

#### 1 ) Industrial ratio in total end-use energy consumption

Data refer to the *China Energy Statistical Yearbook*. One issued to be noticed is that the energy consumption of industrial sector is calculated on the basis of the energy balance sheet, in which the industrial fuel consumption actually comprises partly those for transportation. According to study by Wang<sup>8</sup>, 95% of gasoline and 35% of

<sup>8</sup> Wang Qingyi. Energy end-consumption and energy efficiency of China in 2007 [J]. Energy Saving and Environment Protection, 2009(2).

diesel consumption categorized under industrial consumption in the energy balance sheet should actually be attributed to transportation energy consumption.

## 2 ) Energy supply composition

### ① Natural gas composition ratio :

Data refers to the China Energy Statistical Yearbook under the term “total energy available for consumption.

② **Nuclear power composition ratio** : The original indicator “nuclear power ratio in overall energy consumption” is not appropriate considering part of nuclear power has been exported to other provinces. It is then adjusted to the current indicator Nuclear power composition ratio for accuracy. Data refers to *the China Electric Power Yearbook*.

③ **Ratio of renewable energy and hydro power generation** : To be consistent with the indicator for nuclear power, the **Ratio of renewable energy and hydro power generation** is applied in the study.

Hydro power includes conventional hydro and small hydro power. Wind power and waste-to-energy power are accounting for certain ratio in overall power generation, comparatively solar photovoltaic, biomass power except for waste-to-energy, and tidal power are still development in so small amount not their total weight in overall power generation can be neglected, so does this study. Data for wind power and hydro power refer to *China Electric Power Yearbook*, data for waste-to-energy power can be found in each year’s Energy White Paper issued by the Provincial Government.

### Low carbon energy consumption

#### 1) Industrial energy consumption per unit of industrial added-value:

Data source for the industrial added-value is the *Zhejiang Statistical Yearbook*.

Data source for energy consumption of the industrial sector is the *China Energy Statistical Yearbook*.

#### 2) Energy consumption of public buildings /number of employees of the tertiary industry :

Building energy consumption consists of that of residential buildings and public buildings. In the *Energy Statistical Yearbook*, energy consumption for buildings is not one separate category and need reasonable presumptions to estimate. With reference to related studies, the following calculation method has been adopted, with data based

on the *Energy Statistical Yearbook*:

Electricity consumption under “transportation, storage, postal & tel-communication services”, “wholesale, retail trade and catering services”, and “other” are summed up to represent electricity consumption in public buildings. Consumption of coal, natural and heat under the above-mentioned three categories, along with 50% of diesel consumption (assuming 50% of which used for boilers and other 50% for transportation) under “wholesale, retail trade and catering services”, and “other” are summed up to represent heat (fuel) consumption in public buildings.

**3 ) Energy consumption of residential buildings per household.** Energy consumption in residential buildings comprises of heating, cooling, lighting and cooking energy use of electric power and fuel (heat). Therefore, consumption of LNG, natural gas, other gas, coal and heat under “residential consumption” are summed up to represent heat (fuel) consumption in residential buildings. Since central heating is rare in Zhejiang Province, “heat consumption” is ignored from calculation. Electricity consumption under “residential consumption” is used to represent electric consumption in residential buildings.

**4 ) Energy consumption by road transportation per unit of land area.** CO<sub>2</sub> emission from road transportation is estimated based on consumption of major fuels, including gasoline and diesel. Wang<sup>9</sup> made data adjustment to the energy balance sheet in terms of transportation energy use. It was found in his study that aside from fuel consumed by the transportation servicing entities, part of gasoline and diesel consumption listed under other sectors should be categorized as transportation fuel use too, which include: 95% gasoline and 35% diesel used by industrial sector, construction sector and servicing sector, 100% of gasoline and 95% diesel used in residential consumption and by agriculture sector. In our research, these data finding have been applied to estimate CO<sub>2</sub> emission from the transportation sector.

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<sup>9</sup> Wang Qingyi. Energy end-consumption and energy efficiency of China in 2007 [J]. Energy Saving and Environment Protection, 2009(2).

### 3.4.2 Indicator Data Sheet for the Zhejiang Case

#### CO<sub>2</sub> emission per unit of GDP CO<sub>2</sub> (emission intensity)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO <sub>2</sub> emission (10 <sup>4</sup> t)	10200	11278	11642	11614	12031	13143	14163	15346	17062	21081	24819	28359	31965	32573	33069	34827
GDP (10 <sup>8</sup> Yuan )	4165	4865	5405	5956	6552	7273	8043	9057	10388	11895	13418	15283	17530	19300	21017	23519
CO <sub>2</sub> emission per unit of GDP (t/10 <sup>4</sup> Yuan )	2.45	2.32	2.15	1.95	1.84	1.81	1.76	1.69	1.64	1.77	1.85	1.86	1.82	1.69	1.57	1.48

#### CO<sub>2</sub> emission per unit of land area (emission density)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Land area (10 <sup>8</sup> m <sup>2</sup> )	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018
CO <sub>2</sub> emission (10 <sup>4</sup> t)	10200	11278	11642	11614	12031	13143	14163	15346	17062	21081	24819	28359	31965	32573	33069	34827
CO <sub>2</sub> emission/land area (kg/m <sup>2</sup> )	1.00	1.11	1.14	1.14	1.18	1.29	1.39	1.51	1.68	2.07	2.44	2.79	3.14	3.20	3.25	3.42

#### Ratio of industrial energy consumption in total energy consumption

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
industrial energy consumption (10 <sup>4</sup> tce)	3170	3375	3479	3540	3692	4118	4646	5231	5910	7147	8401	9570	10470	10959	11125	12028

total energy consumption (10 <sup>4</sup> tce)	4580	4853	5069	5222	5457	6560	7100	8280	9523	10825	12032	13219	14524	15117	15567	16865
Ratio of industrial energy consumption	69%	70%	69%	68%	68%	63%	65%	63%	62%	66%	70%	72%	72%	72%	71%	71%

## Energy supply structure

① ratio of Natural gas vs. Coal & oil

②ratio of nuclear power in power generation

③ratio of nuclear power and hydropower in power generation

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
total energy consumption (10 <sup>4</sup> tce), among which:	4580	4853	5069	5222	5457	6560	7100	8280	9523	10825	12032	13219	14524	15107	15567	16865
coal (10 <sup>4</sup> tce)	3022	3279	3374	3324	3410	3847	3948	4299	5191	5973	6915	8096	9303	9315	9483	9964
Oil and products (10 <sup>4</sup> tce)	957	1044	1173	1178	1322	1599	1740	1840	2121	2417	2760	2761	2824	2953	3303	3597
Natural gas (10 <sup>4</sup> tce)	0	0	0	0	0	0	0	0	0	4	22	36	70	115	254	423
Total electricity generated (100 MWh), among which:	407	448	468	539	605	697	791	889	1097	1268	1468	1777	2095	2114	2237	2557
Nuclear power (100 MWh)	22.06	22.25	20.12	11.63	7.33	20.35	24.72	56.12	149.24	219.88	226	222	230	238	240	257
Hydro power(100 MWh)	78.08	52.31	43.2	99.63	106.26	89.76	105.73	138.83	113	85.45	136	139	126	113	122	193
Renewable power, including wind and waste-to-electric power (100 MWh)	0.00	0.00	0.00	0.30	0.50	0.50	0.50	1.30	4.10	10.50	11.50	13.00	16.00	15.00	20.10	24.80

## Industrial energy consumption per unit of added-value

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Industrial added-value ( 2005 constant price ) ( 108 Yuan )	1801	2085	2362	2625	2934	3286	3648	4144	4795	5610	6345	7271	8463	9310	9859	11111
Industrial energy consumption (10 <sup>4</sup> tce)	3170	3375	3479	3540	3692	4118	4646	5231	5910	7147	8401	9570	10470	10959	11125	12028

Industrial energy consumption per unit of added-value (tce/10 <sup>4</sup> Yuan)	1.76	1.62	1.47	1.35	1.26	1.25	1.27	1.26	1.23	1.27	1.32	1.32	1.24	1.18	1.13	1.08
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### Energy consumption of public buildings /number of employees of the tertiary industry

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy consumption of public buildings (10 <sup>4</sup> tce), energy equivalent value	174	198	209	231	258	304	332	394	454	582	666	776	864	938	1040	1132
number of employees of the tertiary industry (10 <sup>4</sup> )	587	610	625	650	763	790	852	903	891	907	944	1002	1129	1156	1208	1243
Energy consumption of public buildings /number of employees of the tertiary industry (kg ce), energy calorific value	183	188	187	196	188	213	214	232	269	338	380	437	440	466	498	525
Energy consumption of public buildings /number of employees of the tertiary industry (kg ce), energy equivalent value	297	325	334	356	338	385	390	436	510	642	706	774	765	811	861	910
electricity (%)	30%	35%	38%	42%	41%	44%	46%	49%	55%	51%	49%	46%	47%	49%	49%	52%
Heat (fuel)consumption (%)	70%	65%	62%	58%	59%	56%	54%	51%	45%	49%	51%	54%	53%	51%	51%	48%
Total floor area of public buildings (10 <sup>4</sup> m <sup>2</sup> ) - estimated	-	-	-	-	-	-	-	-	-	-	-	-	27000	36743	46568	46673
Energy consumption of public buildings per unit of floor area(kg ce/m <sup>2</sup> ) -estimates, energy calorific value	-	-	-	-	-	-	-	-	-	-	-	-	16.67	13.53	11.76	12.72



### Energy consumption of residential buildings per household

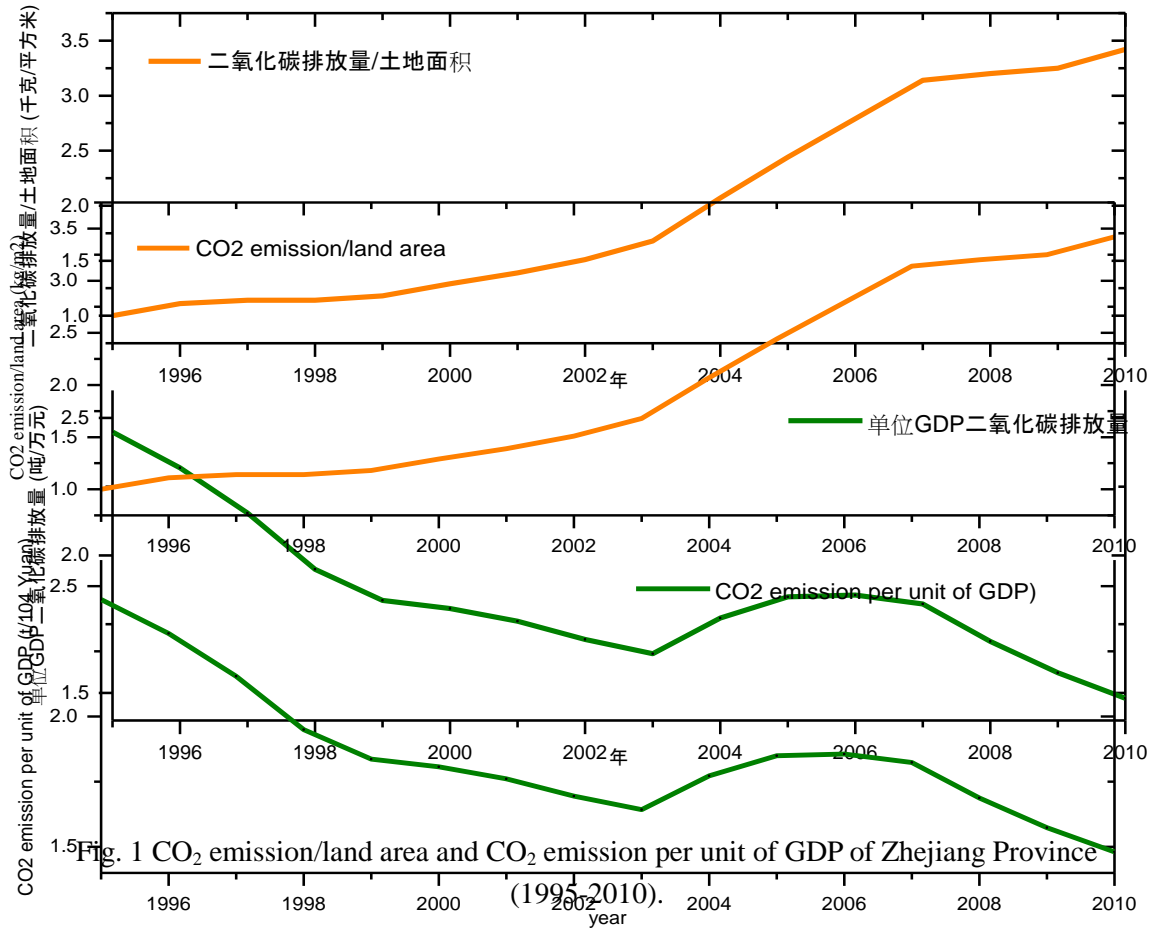
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy consumption of residential buildings (10 <sup>4</sup> tce) , energy equivalent value	237	288	534	580	594	651	701	760	857	867	1072	1173	1279	1396	1525	1657
Number of households	1340	1354	1370	1389	1410	1440	1448	1466	1486	1509	1534	1557	1579	1596	1604	1608
Energy consumption of residential buildings per household (kgce), energy calorific value	150	210	218	233	236	247	258	263	292	291	370	393	427	463	510	555
Energy consumption of residential buildings per household (kgce), energy equivalent value	177	213	390	418	421	452	484	519	577	574	699	754	810	875	951	1031
Electricity (%)	6%	29%	29%	30%	30%	34%	36%	40%	43%	40%	38%	41%	42%	43%	42%	44%
Heat (fuel) consumption (%)	94%	71%	71%	70%	70%	66%	64%	60%	57%	60%	62%	59%	58%	57%	58%	56%
Energy consumption of public buildings per unit of floor area(kg ce/m <sup>2</sup> )	2.94	4.07	4.15	3.99	3.82	3.97	4.07	4.03	4.41	4.02	4.72	4.99	4.16	4.60	4.95	5.33

### Energy consumption by road transportation per unit of land area

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy consumption by road transportation (10 <sup>4</sup> tce)	494	546	575	613	669	751	809	888	1027	1086	1341	1461	1568	1629	1672	1865
CO <sub>2</sub> emission from road transportation	1025	1134	1192	1271	1387	1555	1676	1841	2129	2252	2776	3024	3243	3366	3452	3844
Road transportation CO <sub>2</sub> emission per unit of land area (kg/m <sup>2</sup> )	0.10	0.11	0.12	0.12	0.14	0.15	0.16	0.18	0.21	0.22	0.27	0.30	0.32	0.33	0.34	0.38

### 3.4.3 Zhejiang Case Analysis

#### Overall CO<sub>2</sub> emission:



average annual growth rate of CO<sub>2</sub> emission/land area between 1995-2010 = 5.5%  
 average annual decreasing rate of CO<sub>2</sub> emission per unit of GDP between 1995-2010 = 5.9%  
 average annual growth rate of GDP between 1995-2010 = 11.8%

The graphs basically show growing trend of overall CO<sub>2</sub> emission and decreasing trend of CO<sub>2</sub> emission intensity. Zhejiang, as a fast-developing province, has seen two-digit growth rate for the past years and energy consumption grew with it in huge amounts, and so did the overall CO<sub>2</sub> emission. At the same time, energy-saving, improving efficiency, and diversification of energy structure have always been one key policy by the government in energy utilization, though not quite enough considering the energy intensity of the economy. The achievement is also remarkable, considering that the 11.8% yearly GDP growth yielded only 5.5% yearly growth rate of CO<sub>2</sub> emission, which reflected that progress has been made in energy saving, economic structure adjustment and energy structure diversification.

It is quite obvious from the graph that CO<sub>2</sub> emission is starting to growing much faster since 2001, while CO<sub>2</sub> emission per unit of GDP start to show some growing trend contrary to the previous decreasing trend around the year 2003. The major contributing

factor is thought to be the fast growing energy-intensive industrial sectors, such as the iron & steel industry and the cement industry, which has remarkably higher growth rate than the average growth rate of GDP during that period.

Statistical data shows that eight most energy intensive manufacturing industries account for around 60% of total energy consumption of the manufacturing industry, which the output accounts for around only 20% ( based on energy balance sheet of Zhejiang Province). To control the over-development of these industries has been priority for some year in China as well as in Zhejiang Province, but the result has not been optimistic. If these industries can be well controlled, CO<sub>2</sub> emission per GDP can be expected to be reduced significantly.

### Energy Structure:

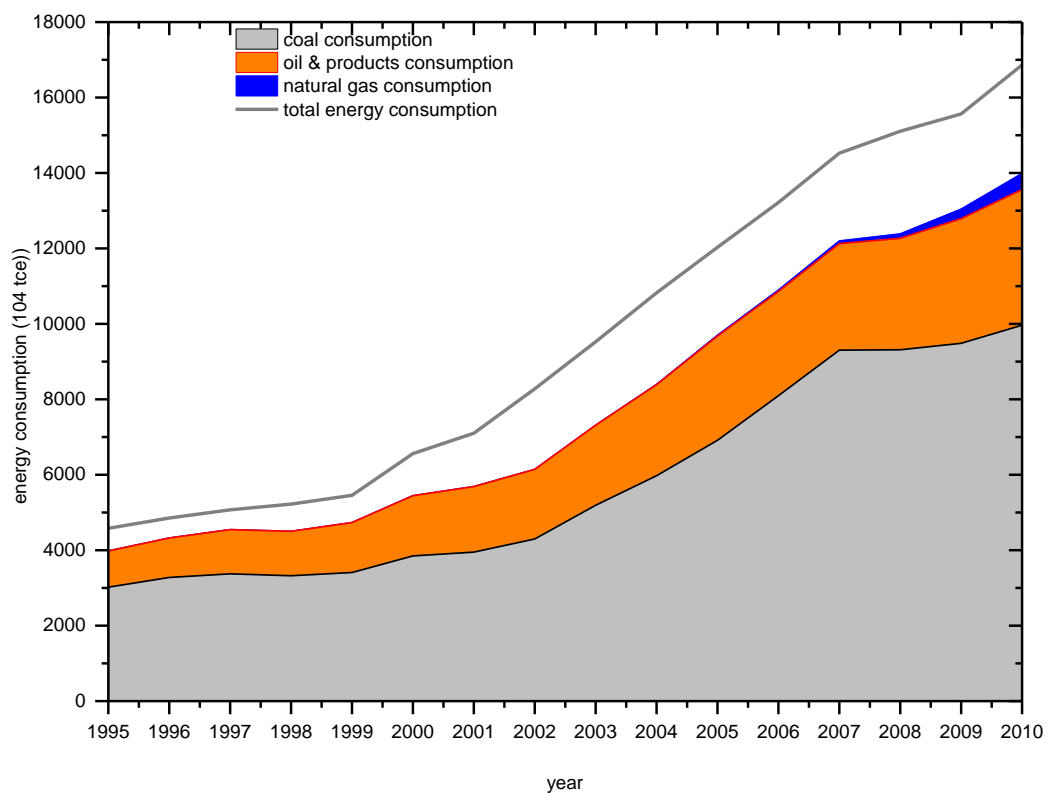


Fig. 2 Primary energy consumption structure in Zhejiang Province (1995-2010).

1995:	coal+oil&products = 86.9%
2010:	coal+oil&products = 80.4%

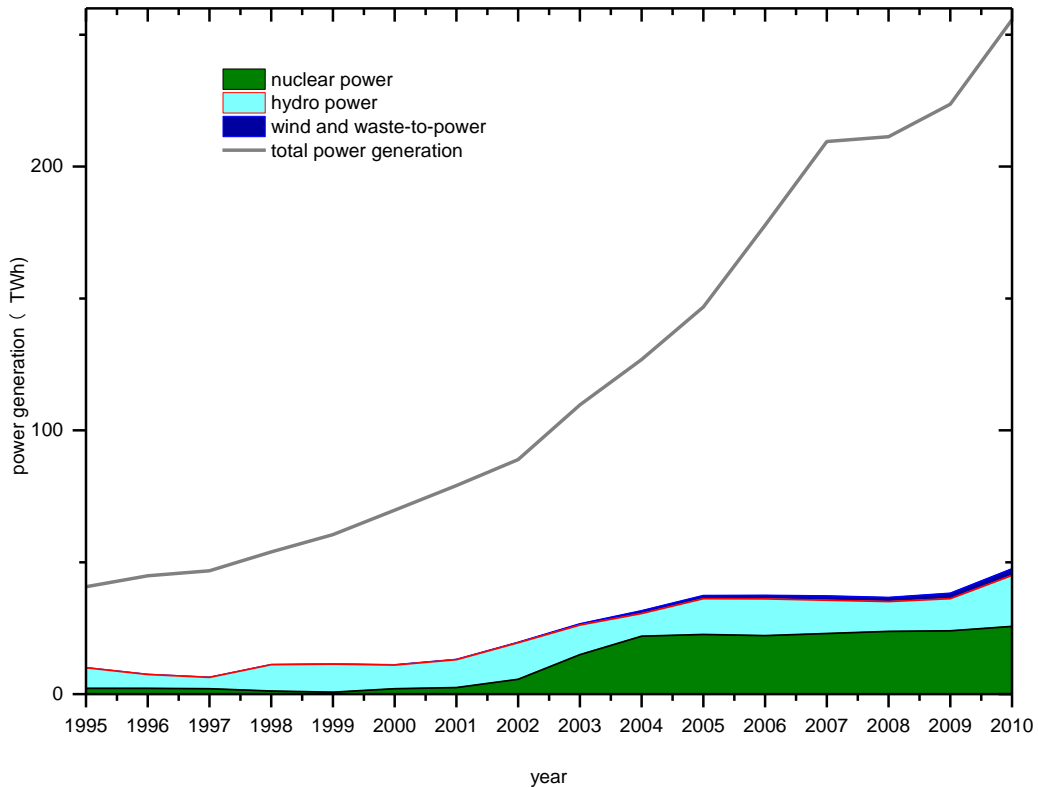


Fig. 3 Low carbon energy in Power generation structure in Zhejiang Province (1995-2010).

1995: nuclear power+hydro power+ wind and waste-to-energy = 24.6%
2010: nuclear power+hydro power+ wind and waste-to-energy= 18.6%

The coal-dominating energy structure has remained basically unchanged for the past years, owing to the energy resource condition in China. Between 1995 and 2010, the ratio of coal and oil&products combined in total primary energy consumption had seen minor decrease, reducing from 86.9% to 80.4%. The ratio of natural gas gradually grow to 2.5% in 2010 from its introduction into Zhejiang Province in 2004. Based on above figures, structure of primary energy consumption in Zhejiang has improved to some extend.

Another not so encouraging trend is that of the low carbon electric power ratio. It can be found from Fig. 3 that during the 15 years, the ratio of hydro power, nuclear power and wind power combined has not seen any growth, but decrease in power generation ratio, dropping from 24.6% to 18.6% between 1995 and 2010. This is understandable, considering the strong growth of overall energy and electricity consumption and power through the years. Low carbon energy has also developed during the 15 years, but still far from catching up the the growth rate of overall energy demand. Among these low carbon energies, hydro power once played vital part in the energy mix, but with the potential gradually explored, not much capacity is left to be explored. Nuclear power requires long construction period and its contribution needs time to manifest. Offshore wind power and tidal energy may have great potential in Zhejiang Province. In the near to medium term, low carbon energy development in Zhejiang may largely dependent on nuclear power and

natural gas; In the medium to long term, mature technologies and more commercialized market can push forward the development of renewable energies, making them mainstream energy in Zhejiang.

**Energy consumption:**

The calculation of sectoral energy consumption has been based on the energy balance sheet of Zhejiang Province. The statistical data are categorized by classes that don't include the building and transportation sectors, hence can give no distinct data for transportation energy consumption or building energy consumption. For this reason, energy consumption results for the building and transportation sectors have been calculated on the basis of reasonable presumptions, and results for transportation energy consumption comprises of those for industrial sector transportation. Given that, we think it would be inappropriate to put the transportation sector in the same graph with the industrial sector, so two graphs are given below to demonstrate the end-use energy consumption for the three major sectors.

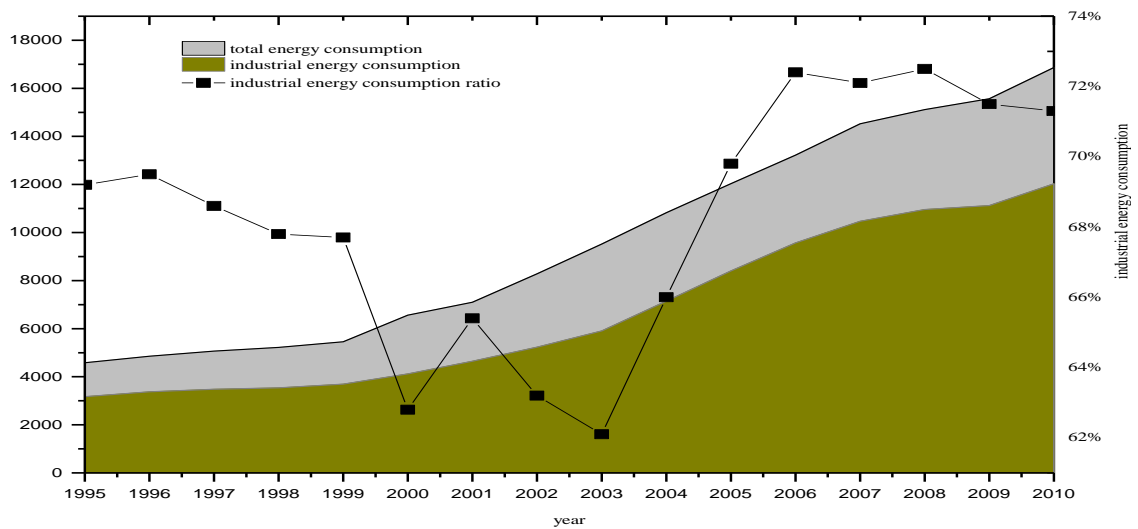


Fig.4 Industrial Energy consumption and its ratio in total end-energy consumption (1995-2010).

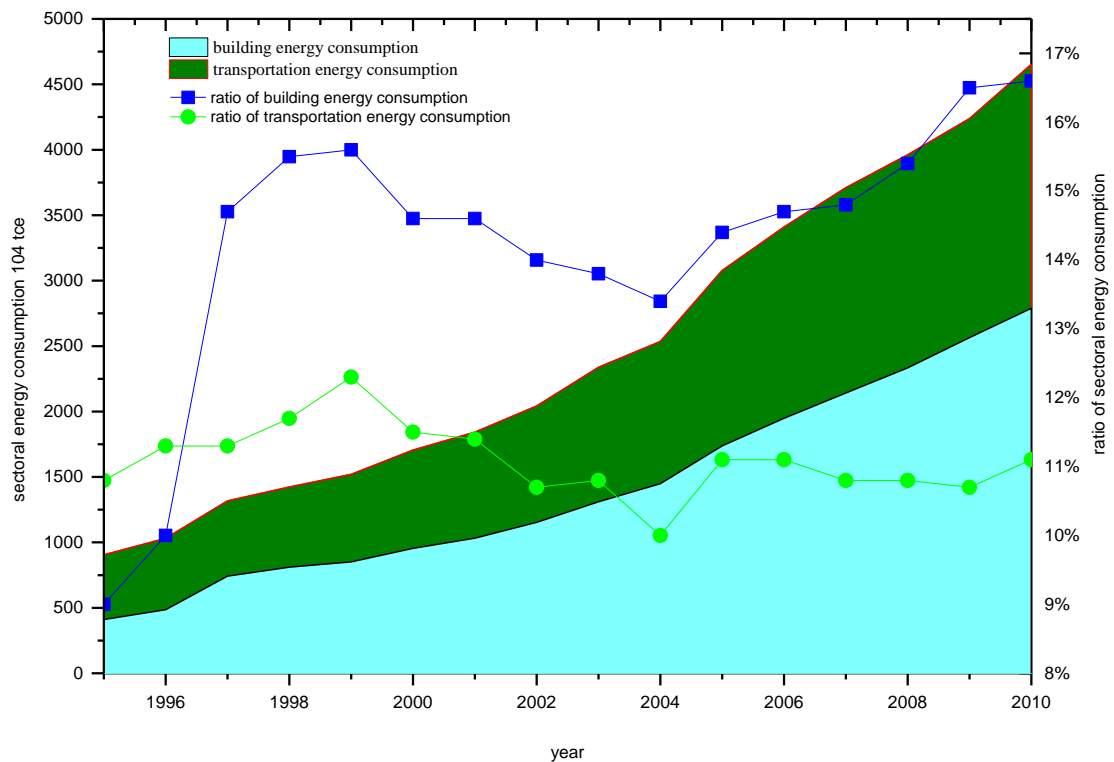


Fig. 5 Energy consumption and ratio in total end-energy consumption of building sector and transportation sector (1995-2010).

1995: ratio of industrial energy consumption= 69%, ratio of transportation energy consumption = 10.8%, ratio of building energy consumption = 9%
2010: ratio of industrial energy consumption= 71%, ratio of transportation energy consumption = 11.1%, ratio of building energy consumption = 17%

Similar to most regions in China, industrial sector is the biggest energy consuming sector in china. In 2010, tertiary industry and secondary industry accounted for 15.1% and 72.8% of total energy consumption, respectively. High energy-intensity industries, including steel industry and cement industry, still had high percentage of energy consumption.

Through the 15 years, industrial energy consumption had never dropped below 60%. The heavy ratio of industrial energy consumption in Zhejiang has seen gradual decrease between 1995-2003, thanks to efforts in energy saving and industrial structure adjustment under the guidance of the Provincial Government. But since 2003, high energy-intensity industries regained momentum and saw rapid rebound between 2003 and 2006. Only in 2007 this growing trend was overturned into slowly decrease.

During the same period (1995-2010), ratio of transportation energy consumption saw some fluctuation, but basically remained close to 10%. Ratio of building energy consumption saw significant trend of growth, jumping from 9% in 1995 to 17% in 2010. This remarkable growth underlines the importance of energy efficiency and low carbon energy utilization in buildings.

## Industrial energy intensity

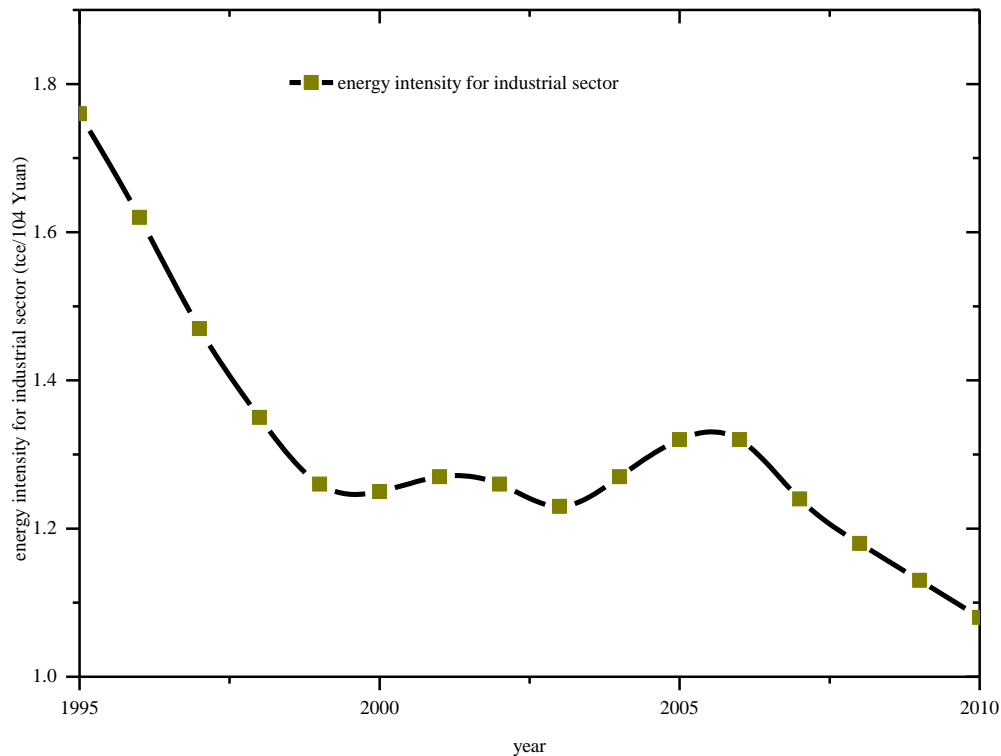


Fig.6 Energy intensity for the industrial sector of Zhejiang Province (1995-2010).

1995: energy intensity for industrial sector = 1.76%
2010: energy intensity for industrial sector = 1.08%
1995-2010: annual average decreasing rate = 4.1%

There shows three distinct periods in the curve for industrial energy intensity:

- between 1995-1999, rapid decrease. In 1994, the China Government started macro-control on economic development and Tight financial and monetary policy was implemented. In 1997, Asian Financial Crisis broke up, impacted the developing Zhejiang economy badly that only until 2000 did it pick up growth again. During this period, economic growth in Zhejiang Province had been slow, and industries with high energy intensity, such as steel, cement, chemicals and refinery had experienced little expansion. The industrial energy intensity dropped drastically during this period.
- between 2000-2006, the decreasing trend came to a halt, generally remain stable with slight sign of rebound. This is coincident with the round of vigorous economic development in Zhejiang. Industrial structure were gradually improving, with the fall of traditional labor-intensive industries and rising of electric equipment manufacturing and IT industries. During the same period, ratio of heavy industries, such as steel and cement industries, grows rapidly. In 2006, the ratio of heavy industry reached 56.2%, compared with 45.8% in 2000 (based on the Zhejiang Statistical Yearbook).
- between 2007-2010, industrial energy intensity of Zhejiang Province started to drop again, at a slower pace compared with that before 1999. During this period, economic structure had kept on improving, with average annual growth rate for hi-tech industry



output reaching over 20%, while the ratio of heavy industry only grew from 57.0% in 2007 to 59.3% in 2010. Energy saving and emission reduction was getting increasing emphasis in Zhejiang, with a series of important government regulations issued, which targeted at reducing energy consumption and emission in industries and buildings, such as the mandatory unit energy consumption cap standards for various energy-intensive industrial products. Energy efficiency and industrial structure kept improving and industrial energy intensity kept dropping as a result.

## **Buildings:**

### **General situation of building energy saving in Zhejiang Province**

According to calculation, domestic building energy between 1995-2010 kept rising strongly, with ratio of building energy consumption in overall energy consumption increased from 9% in 1995 to 17% in 2010 (energy equivalent value).

Since calculated results in this study is based on the annual energy balance sheet and based on several presumptions, they may have minor difference from the officially publicized data. To verify reliability of the estimated results, comparison has been made with other published results. The estimated building energy consumption ratio is close to the results by EIA of the United States (16%)<sup>10</sup> and the result by professor Long Weiding (20%)<sup>11</sup>, while different from the result by the Department of Construction (27.5%)<sup>12</sup>, which was based on building inventory, and the result by Building Energy Saving Center of Tsinghua University (23.1%)<sup>13</sup>.

### **Residential buildings**

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<sup>10</sup> GU Lijing, Yu Cong. Analysis on problems in energy consumption statistics[J]. China Energy,2011, (2).

<sup>11</sup> Long Weiding Ratio of building energy consumption and energy-saving targets [J]. China Energy, 2005,(10).

<sup>12</sup> Zhang Beihong, Lu Shanhou, Ni Deliang. Study on building energy consumption statistical mode and methods [J]. Construction Science, 2008,(8).

<sup>13</sup> Building Energy Research Center Tsinghua University. Annual research report on building energy saving in China. 2009 [M]. Beijing: The Construction Industry Publishing House, 2009.

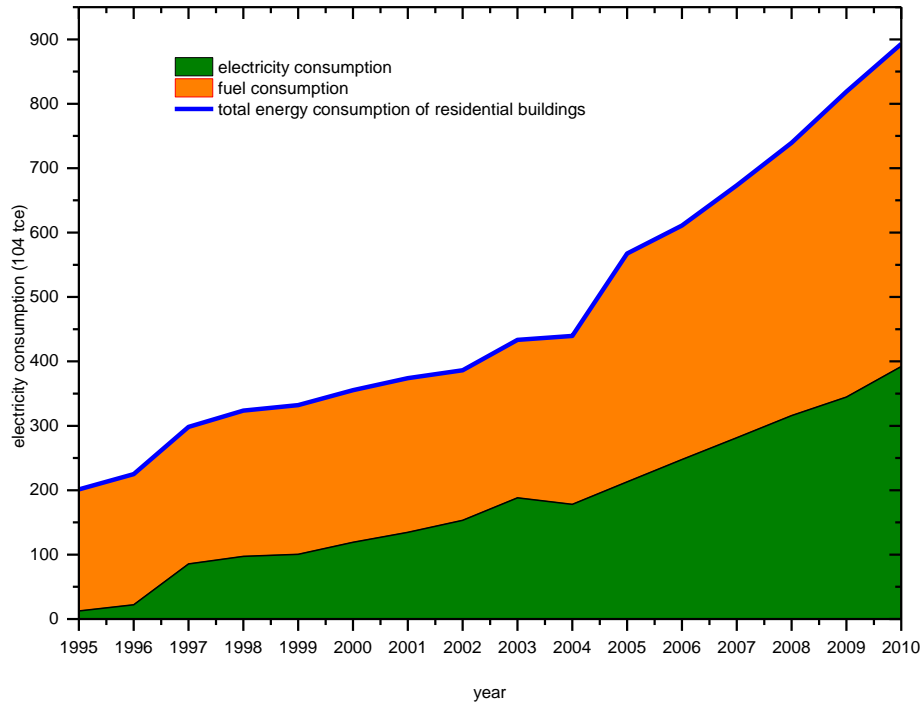


Fig. 7 Energy consumption and its composition for residential buildings in Zhejiang (1995-2010).

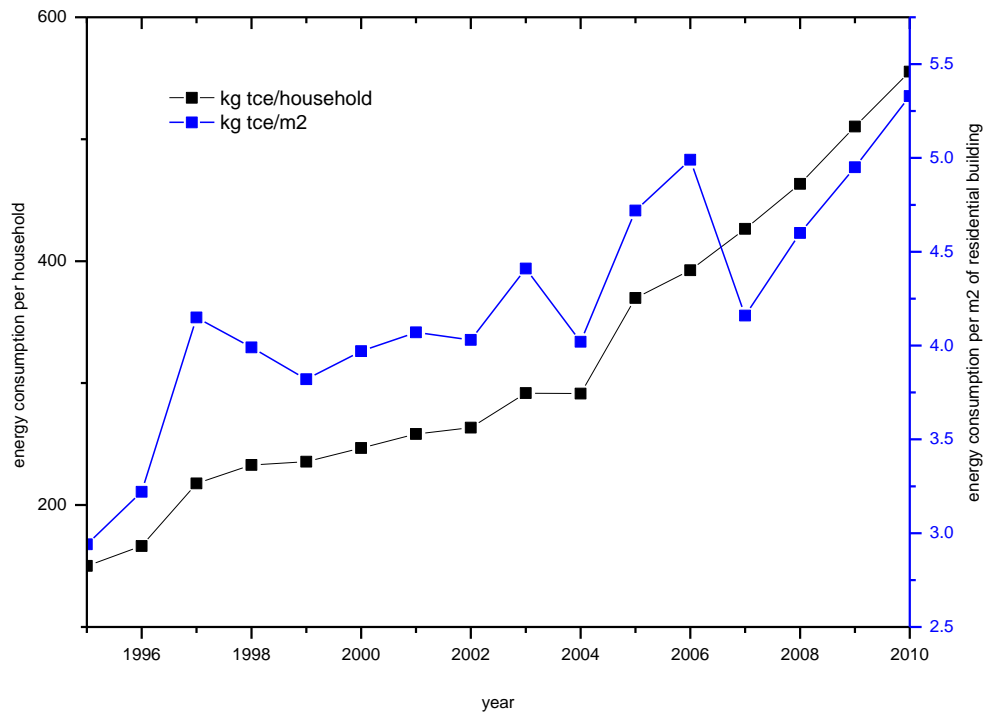


Fig. 8 Energy consumption per household and per floor area for residential buildings in Zhejiang (1995-2010).

1995-2010: Energy consumption per household increased 270%

1995-2010: Energy consumption per m<sup>2</sup> increased 81%

1995: ratio of electricity in total energy consumption = 6% (energy calorific value)

2010: ratio of electricity in total energy consumption = 44% (energy calorific value)

Between 1995 and 2010, Energy consumption for building grew very fast, with much higher growth rate than that of the industrial sector and the transportation sector. Per household building energy consumption grew 270% during the 15 years and that per unit of floor area grew 81%.

In building energy consumption, electric power consumption grew much faster than fuel (heat) consumption, with ratio of electricity being 44% compared with only 6% in 1995. Domestic electric appliances, especially those for cooling and heating purposes, are increasing become the key factor impacting building energy consumption and CO<sub>2</sub> emission, depending on their efficiency.

Between 1995 and 2010, gradual living standard improvement means increased energy demand as well as increased housing area for each resident, which bring about growing energy consumption per m<sup>2</sup> and faster growing of energy consumption per household. The big surge of 270% within 15 years can manifest at least two issues:

Firstly, residents in Zhejiang Province have experienced great living standard improvement in past years, especially in the ownership and application of electric appliances, such as air conditioners, water heaters, refrigerators. In terms of low carbon development, the efficiency of these appliances, and the possibility of replacing these electric appliances with alternatives driven by low carbon energy (e.g. substituting electric water heaters with solar water heaters) can have huge impact on low carbon building development.

Secondly, for hot-summer-cold-winter region such as Zhejiang Province, percentage of energy consumed for cooling and heating could be very high, which depends heavily on the insulating performance of the building envelope. From information we have gathered, the overall performance for buildings in Zhejiang Province in this respect is not quite optimistic, energy-saving buildings in Zhejiang Province are quite rare. As an example, data from the Construction Committee of Hangzhou Government showed that<sup>14</sup> to the end of 2006, only less than 3% of all buildings in Hangzhou are energy-saving buildings. Another study showed that<sup>15</sup> total energy consumption of buildings in urban areas of Zhejiang Province ranked the 4th highest across China, with the per m<sup>2</sup> figure ranked the 10th highest, which was the highest among hot-summer-cold-winter regions such as neighboring Jiangsu Province and Shanghai.

The curve for energy consumption per m<sup>2</sup> for residential buildings saw two drastic drops in 2004 and 2007, which may attribute mainly to the surge of house ownership due to real-estate bubble that bring up average floor area per household. Considering the fact that a lot of houses are unoccupied during the real-estate bubble, calculation based on this data may be distorted.

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<sup>14</sup> Zhejiang University City College. [http://www.zucc.edu.cn/news\\_show.php?recid=12969](http://www.zucc.edu.cn/news_show.php?recid=12969). The Issuance of energy saving development plan in Hangzhou. 2007-12-12.

<sup>15</sup> Liu Cangping, Lu Ning, Zhang Xiaojing. Urban building energy consumption and regional analysis for 2003-2007. Building Energy Saving,2009(12).

**Public buildings:**

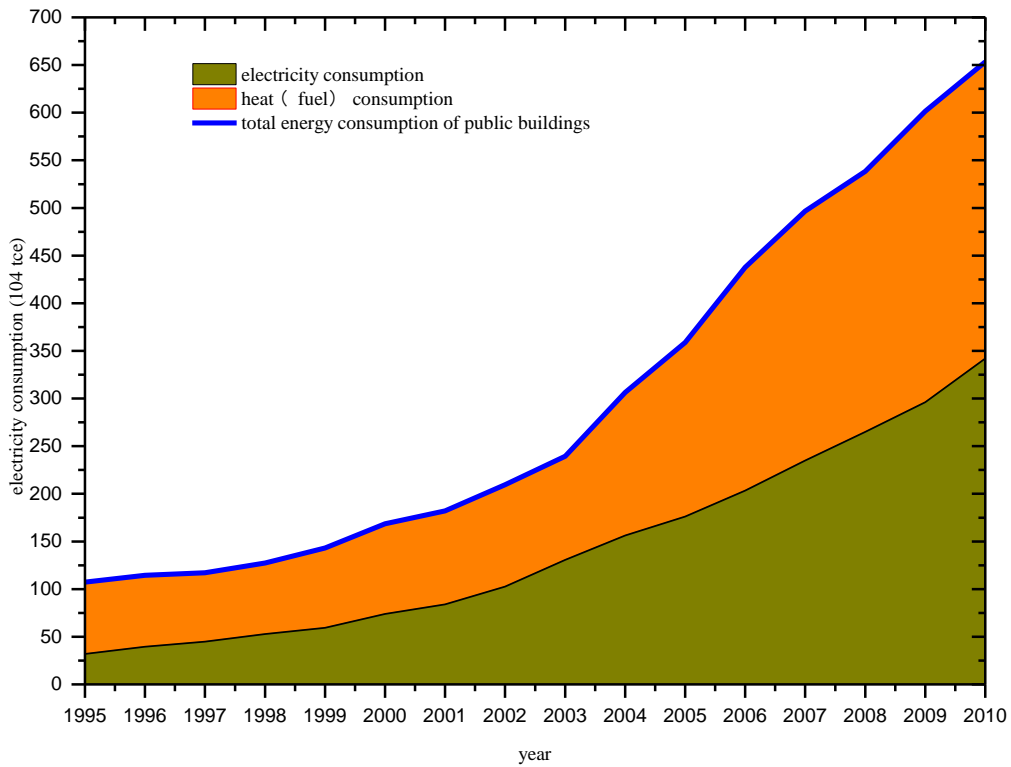


Fig. 9 Total energy consumption of public buildings and its composition in Zhejiang (2005-2010).

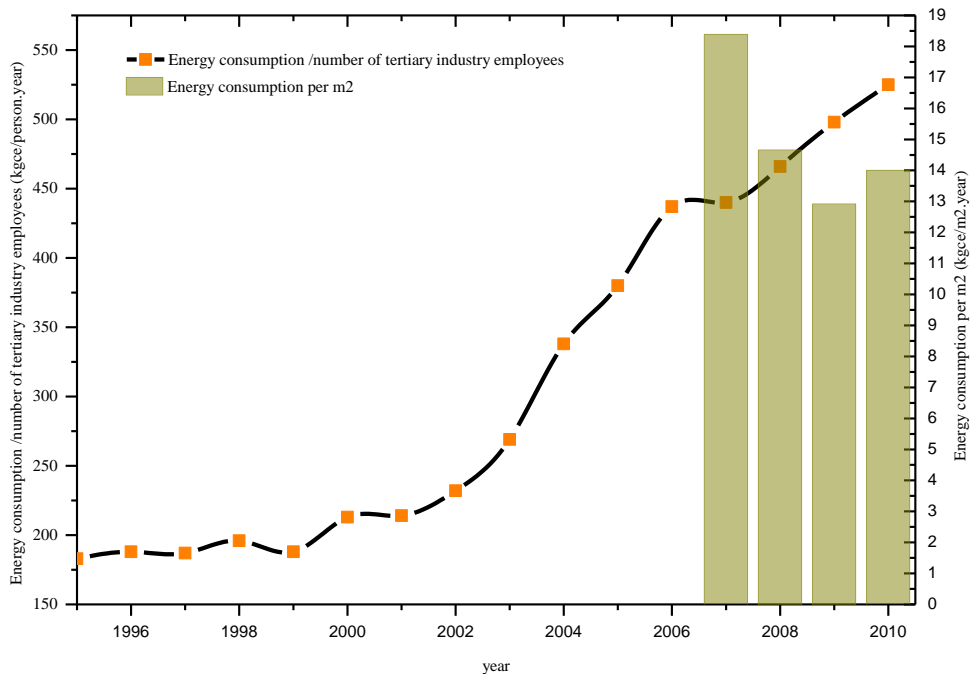


Fig.10 Energy consumption/number of tertiary industries employees and per floor area of public buildings in Zhejiang (1995-2010).

Energy consumption of public buildings have great potential in energy saving and

emission reduction, in that they generally have big space, numerous lighting and other appliances, long opening hours and low awareness for energy-saving management. Much waste as there exist, great potential there is for saving energy and reducing emission. In our study, estimation shows that on average, per m<sup>2</sup> public buildings consumed as much as 3-4 times more of energy than per m<sup>2</sup> residential building in Zhejiang. According to studies<sup>16</sup>, for all the energy consumed by public buildings (especially big shopping malls, luxury hotels and office buildings) in Zhejiang, about 50% to 60% was consumed for air conditioning and heating system, 20%-30% for lighting and another 30% just wasted through the building envelope.

The Zhejiang Provincial Department of Construction conducted energy consumption survey on government office buildings and large public buildings in 2008. The survey results showed that<sup>17</sup> around 80% of all these building are non-energy saving, while only 6.37% building survey reached the 50% energy-saving rate (based on that of buildings built in the 1980s), and an even less 2.45% reached the 65% energy-saving rate. According to the survey, annual electricity consumption for per m<sup>2</sup> of public buildings in Zhejiang was around 37-122 kWh/m<sup>2</sup>, (that figure for average hot-summer cold-winter region was estimated to be 40-60 kWh/m<sup>2</sup>). The most energy-intensive buildings were demonstrated to be shopping mall and hotels.

A survey conducted on over 300 public buildings in Zhejiang Province by Professor Li<sup>18</sup> found out that annual energy consumption in public building varied from 60 kWh/m<sup>2</sup> (office buildings) to 350 kWh/m<sup>2</sup> (shopping mall). Glass curtain walls were found on lots of public buildings, while shading and insulation measures were not general choices. found. Among buildings surveyed, 33.8% were using glass curtain walls , 53.4% were using windows with very poor insulation performance, while only 16.6% were use external shading and 24.8% considered insulation for building envelopes.

Statistical data for floor area of public building is not available through the 1995-2007 period. As a result, the published data by the Construction Department are then used for our estimation. Based on the 2007 data of 270 million m<sup>2</sup> of public building area<sup>19</sup>, it is estimated that with total electricity consumption of 19.11 TWh in 2007, per m<sup>2</sup> electricity consumption for public buildings in Zhejiang in 2007 was 70.7 kWh/m<sup>2</sup>, about 47% of overall energy consumption (in calorific value), which was 500 kgce/m<sup>2</sup>. The results from our study are basically consistent with the above-mentioned survey results and results by Professor Li, verifying the comparatively high energy intensity of public building in Zhejiang Province.

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<sup>16</sup> Explanations on provisions of the energy-saving design standard for public building of Zhejiang Province (Draf), 2007.

<sup>17</sup> Yang Yi. Building energy consumption status and construction of the energy-saving monitoring system in Zhejiang Province. China-EU International Workshop on Low Carbon Technologies 2010,2010-4-23.

<sup>18</sup> Li Yongcun, Chen Guangming, Tang Liming. Energy consumption survey and analysis on energy-saving measures for public buildings in Zhejiang Province. Energy-saving Technologies and Monitoring, 2009(10), p65-p68.

<sup>19</sup> Zhejiang Provincial Housing and Construction Department. Notice on Further Work on Building Energy-saving,2009.

According to the *China Construction Industry Yearbook*, public buildings are surpassing residential buildings in annual constructed floor area, compared with the once 1:3 ratio around 10 year ago. In this context, energy saving and CO<sub>2</sub> emission reduction in public buildings is getting increasingly important.

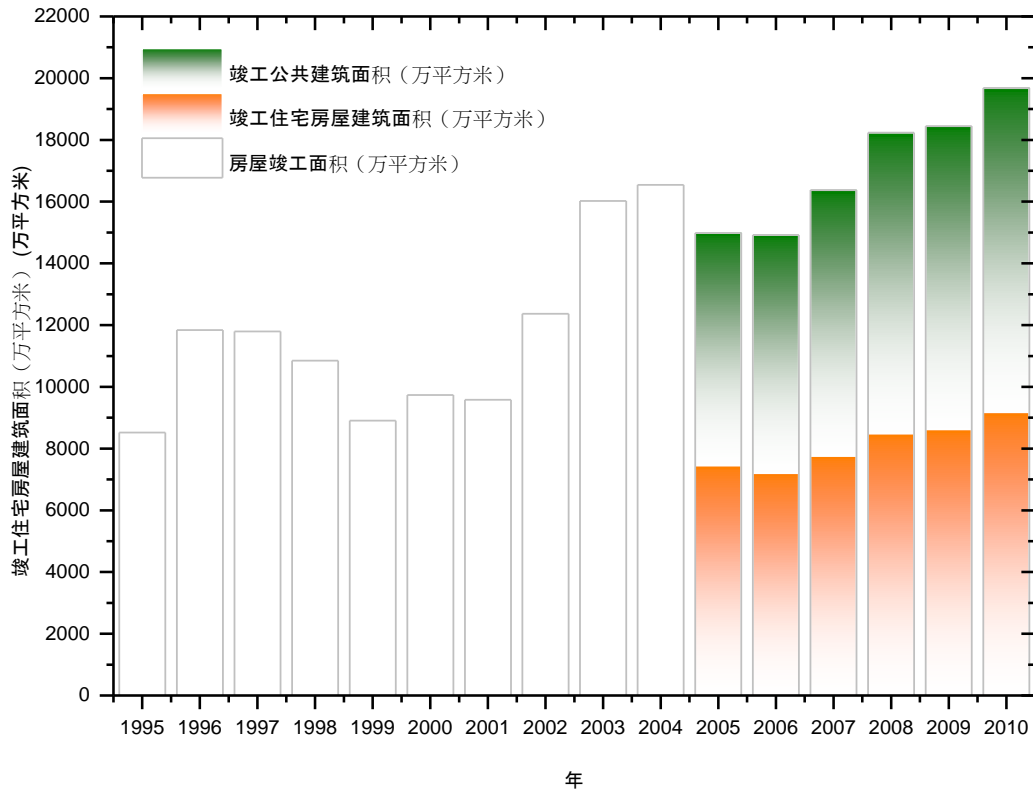


Fig. 11 Completed building area in Zhejiang (1995-2010).

before 2005: public building area : residential building area $\approx 0.37$
2005: public building area : residential building area = 1.012
2010: public building area : residential building area = 1.144

### CO<sub>2</sub> emission from road transportation:

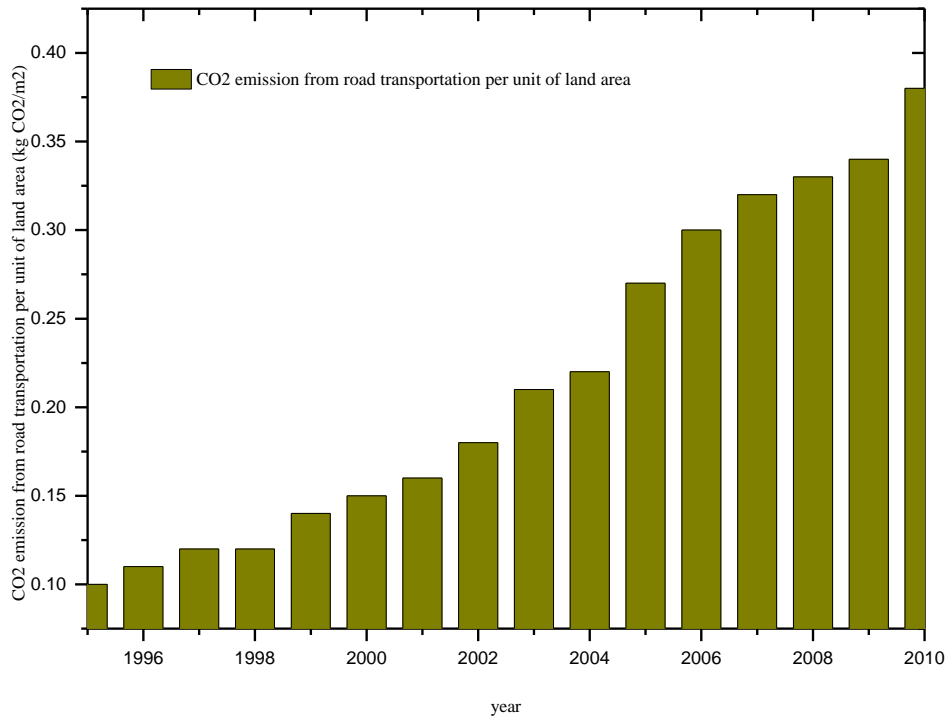


Fig.12 Road transportation CO<sub>2</sub> emission per unit of land area in Zhejiang Province (1995-2010).

1995-2010: average annual growth rate of CO<sub>2</sub> emission of road transportation/land area = 10.5%

Between 1995-2010, Energy consumption of road transportation has grown 275% between 1995-2010 ,up 10.5% year-on-year. During the same period, number of domestic vehicles increased 22 times, from 0.478 million to 11.43 million (estimated on the basis of Zhejiang Statistical Yearbook), attributing mainly to the surge of private cars. Private cars are gradually taking the place of public transportation as one major way of commuting and traveling, with significantly less efficiency and much higher CO<sub>2</sub> emission intensity. As mobile polluting sources, the surge of private cars has caused growing untreated pollution, aside from increasing demand for oil and growing CO<sub>2</sub> emission. Although Fig. 5 shows that the proportion of road transportation energy consumption had hardly increased between 1995 and 2010, the absolute amount has increased in huge amount. Considering the about negative impacts of current road transportation mode, low carbon transportation should be strongly promoted.

Road transportation sector can have great carbon emission reduction potential, with efforts from the following aspects:

- develop public transportation systems, such as building urban rail transportation system, setting dedicated bus lanes, setting up public transportation transition hubs and promoting non-motorized transportation, in order to guide urban resident to travel in low carbon way. At present, Hangzhou and Ningbo, the two biggest cities in Zhejiang Province have

recently started subway operation and more lines are under design or under construction, which are expected to largely facilitate traveling of urban residents.

- push forward wider use of low carbon fuels in vehicles, especially natural gas-fueled vehicles, hybrid vehicles and electric vehicles. The Zhejiang Provincial Government has stipulated development plan<sup>20</sup> for this: buses and taxis will be major carriers for natural gas-fueled vehicles development, with the target to be:

- in 2015, natural gas-fueled vehicles will account for 30% and 60% in buses and taxis respectively;

- in 2020, natural gas-fueled vehicles will account for 60% and 75% in buses and taxis respectively;

With respect to new energy vehicles, the Zhejiang Provincial Government issued Implementation Opinions on Accelerating Energy-saving and New Energy Application in Vehicles, according to which, new energy vehicles will be promoted in public service sectors, company/government cars, taxis and in commercial car rental business.

### **Policies and plans for low carbon energy development**

In recent years, in the context of low carbon development trend globally and in China, low carbon development, especially low carbon energy, has been paid unprecedented attention and can be found on a series of important government publications, support incentive policies and a series of related development plans have been promulgated.

In 2009, the *Implementation Scheme for Circulated Economy Demonstration in Zhejiang Province* was issued by the Provincial Government, in which low carbon energy structure, low carbon industry development and low carbon technology improvement were listed as priorities.

In 2010, the *Scheme for Addressing climate Change in Zhejiang Province* was issued by the Provincial Government. It gave detailed illustration on GHG emission and emission composition in Zhejiang Province, summarized achievement in energy saving, energy structure optimization and expansion of forestry CO<sub>2</sub> sink. It also set new targets for the above work and emphasized key sectors and incentive measures.

In recent years, major development plans related to low carbon energy development promulgated by the Provincial Government include:

#### **- 12<sup>th</sup> Five-year and Medium-to-long Term Plan for Energy Development in Zhejiang Province**

In this plan, the practical resource conditions, development backgrounds and trends were introduced, general targets and objectives, as well as project arrangements, and securing measures for energy development during the 12<sup>th</sup> five-year period and in the medium-to-long term were illustrated.

#### **- 12<sup>th</sup> Five-year and Medium-to-long Term Plan for Renewable Energy Development in**

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<sup>20</sup> Zhejiang Provincial Development and Reform Commission. Development Plan for Natural Gas Refueling Stations in Zhejiang (2011-2020).



## ***Zhejiang Province***

In this plan, the generation situation of renewable energy development in Zhejiang Province was explained and targets and securing measures for renewable energy development during the 12<sup>th</sup> five-year period and in the medium-to-long term were illustrated.

### ***- Development Plan for Natural Gas Station for Refueling Vehicles in Zhejiang Province***

In this plan, background situation for natural gas-fueled vehicles was explained and future development path and target were illustrated, and arrangement of gas stations and securing mechanisms were presented.

### **Statistical and monitoring systems for carbon emissions**

To materialize carbon emission targets, statistical and monitoring system on key energy-consuming (carbon-intensive) sectors is necessary to guarantee real and effective carbon emission reduction.

In late 2011, the State Council of China issued the *Work Plan for Green House Gas Control during the 12<sup>th</sup> Five-year Period*, in which it was emphasized that during the 12<sup>th</sup> Five-year period, statistical and verifying system should be built up in faster pace. In the *Specialized Science & Technology Development Plan for Addressing Climate Change in China during the 12<sup>th</sup> Five-year Period* issued by the Ministry of Science and Technology in 2012, a technical system for CO<sub>2</sub> emission statistics and monitoring was also raised as an important job to be accomplished.

At present, the CO<sub>2</sub> emission statistical and monitoring system is still at the design stage. The government concerned government administrations are working to build up CO<sub>2</sub> emission statistical and monitoring system of China, so as to realize “measurable, reportable and verifiable” CO<sub>2</sub> emission control and improve overall capability of the China government to address climate change. It is estimated that it would still take some time to be completed.

### **Low carbon town practices:**

A bunch of cities and communities have already engaged enthusiastically in developing low carbons. Hangzhou, Ningbo and Wenzhou has been decided as pilot cities for low carbon town development around China.

### **Low carbon town - Hangzhou**

Hangzhou is capital city of Zhejiang Province with it economy dominant by servicing industry and light industry. It has made efforts in low carbon town development, especially in low carbon transportation system development since it started low carbon town demonstration in 2010.

Low carbon transportation system in Hangzhou has been developed from all aspects, from

subway lines, bus rapid transit system , convenient bus routes, to aqua-buses (boats functioning as buses) and free bicycles for rent. As expected by the government, that a transit-oriented public transportation system will be built up with convenient transit between subways, buses, taxis, aqua-buses and rented bicycles at transit centers. Hangzhou is also among the first bunch of pilot cities for promotion of new energy vehicles (the “ten cities, a thousand new energy vehicles” program). Until the end of 2010, seven electric vehicle charging stations have already been built up in Hangzhou.

In terms of low carbon buildings, the Hangzhou Municipal Governments initiated the “million-roof power generation program”, installing solar PV panel on rooftops of large public buildings. Until now, pilot projects have been initiated on the subway station, east Train Station hub, Aoti Expo Center, and the New Energy College of Hangzhou Normal University.

### **Low carbon town -Ningbo**

Ningbo is the heavy industry center of Zhejiang Province. In 2013, the *Implementation Plan for Pilot Low Carbon Town Development in Ningbo* was issued, in which optimizing energy structure and improving energy efficiency were emphasized as key tasks.

According to the Implementation Plan, natural gas consumption would account higher ratio in overall energy supply, supported by wide coverage natural gas pipelines for all its urban areas. Coal consumption would be restricted in certain regions and non-fossil energy utilization would be encouraged including: to intensify wind power development, encourage solar PV utilization, undertake rooftop PV projects and implement demonstration of distributed PV projects. It was expected that by the end of 2015, total PV installed capacity would reach 40 MW in Ningbo.

Industrial sector was paid great attention in energy saving and CO<sub>2</sub> emission reduction, in that Ningbo is an industrial city. Industrial sector energy saving would be further strengthened in Ningbo, with more intensive monitoring on key energy-consuming plants and projects.

In the respects of low carbon development of building and transportation sector, the Implementation Plan required gradual improvement of building energy efficiency to fulfill the target of 20% building areas heated (cooled) by advanced heat pump air conditioning system by the end of 2020; low carbon logistics and low carbon public transportation system would be developed and public bicycle renting network would be established to fabricate low carbon transportation system.

### **Low carbon town - Wenzhou**

According to the *Implementation Plan for Pilot Low Carbon Town Development in Ningbo* issued by the Wenzhou Municipal Government, low carbon town development would be pushed forward in the following aspects in Wenzhou:

- non-fossil energies would be developed as priority and electric power industrial

development would be optimized. Energy efficiency improvement, solar PV and natural gas utilization would be promoted to foster a low carbon energy town.

- fabricate low carbon transportation system with the network of light rail, buses, taxis, public bicycles and aqua-buses, push forward demonstration and promotion of new energy vehicles, building up non-motorized urban transportation system and encourage low carbon travel.

- With expansion of green low carbon building, promoted utilization of renewable energy in newly-built building and energy-saving renovations in existing buildings, some key urban communities would be selected to promote low carbon building technologies and implement low carbon renovations.

#### **Low carbon community - Xiacheng District of Hangzhou City**

In 2010, the Xiacheng District of Hangzhou initiated low carbon community program , with the plan to foster 11 low carbon communities within the district from every aspect of life from everyday lifestyle, behaviors to surrounding environment. With the working mechanism of “government as the driving force, community as the subject of liability, co-working by all administration and participation by all walk of life”, In this program, low carbon knowledge and information have been introduced to families, low carbon living manuals have been distributed from home to home, low carbon lifestyle has been promoted to people living in the communities. The communities have been acting as effective media to convey low carbon lifestyle to families and to promote energy saving and emission reduction for the whole society.

In the low carbon communities, low carbon knowledge are quite familiar to families and good energy-saving behaviors and the habit of recycling are getting more and more common. The communities also organized installation of low carbon facilities, such as solar water heaters, peak-valley electricity meters and energy-efficient lightbulbs.

## **4 Case summary and Comparison**

### **4.1 Zhejiang Case Summary**

Zhejiang Province of China has been chosen for the case study due to data availability reasons. The Characteristic of social-economic and energy situation can be summarized as: robust economy, comparatively high average income, huge energy demand, poor fossil fuel resource reservation and good potential for low carbon energy development.

Zhejiang Province has seen strong economic development for decades, with overall economic output ranking the 4<sup>th</sup> greatest of all provinces in China for recent years. The urbanization ratio in Zhejiang reached 63.2% in 2010, much higher than the 51% China average, with average income of urban residents being the second greatest in China.

To support the fast economic development, energy consumption in Zhejiang Province has maintained growth with economy. Between 1995 and 2010, overall energy consumption increased from 42.32 million tce to 169 million tce, with annual growth rate of 9.7%,

which is lower than that of GDP, which was 12%<sup>21</sup>. Reasonable projections show that the overall energy consumption in Zhejiang will keep rising for a comparatively long period, which poses pressure on energy supply. Considering the province's very poor fossil fuel reserve, increasing energy demand would be hard and costly to meet.

High dependence on coal is projected to sustain for the short to medium term, incurring pressing resource and environment stress. The best way out should be low carbon energy development, in the way of utilizing energy in more efficient way to support future economic development, as well as adding more low carbon energy sources into the energy mix, especially offshore wind energy followed by solar energy, biomass energy, ocean energy and nuclear power.

The case study results show basically growing trend of overall CO<sub>2</sub> emission and decreasing trend of CO<sub>2</sub> emission intensity through the years, with average annual growth rate of CO<sub>2</sub> emission between 1995-2010 being 5.5%, average annual decreasing rate of CO<sub>2</sub> emission per unit of GDP being 5.9%, and average annual growth rate of GDP being 11.8%. Though overall emission is still on the growing trend, its intensity growth has been declining, indicating the Province is heading towards low carbon development path.

Case study results show that low carbon energy ratio energy structure of Zhejiang province has seen certain decline instead of any obvious progress, with low carbon energy ratio in total energy mix dropped from 24.6% in 1995 to 18.6% in 2010, which indicates that fast growing energy demand has been met mainly by growing fossil fuel supply, and on the other hand indicates that the above-mentioned reduction of CO<sub>2</sub> emission intensity has been largely attributed to energy efficiency improvement.

The case's low carbon energy development status has been further probed into by analysis into the energy intensity of each key energy consuming sector, namely the industrial sector, the building sector and the transportation sector. The industrial sector is dominant in energy consumption, consuming around 70% of total energy consumption. This ratio has hardly changed during the 16 years between 1995-2010, though declining trend was found between 1999 and 2002, it went back increasing largely due to the fast development of heavy industries such as the steel and cement industries. The building sector and the transportation sector have been big contributors to energy consumption too, basically growing in similar trend with industrial energy consumption.

In terms of energy intensity for these three key sectors, a good sign is for the heavily energy-consuming industrial sector, energy intensity shows distinct trend of reduction. Between 1995 and 2010, industrial energy consumption per GDP dropped 4.1% year-on-year on average, demonstrating that energy-efficiency improvement and structural optimization have been achieved to some extent.

The energy intensity for the building sector, indicated by energy consumption per m<sup>2</sup> and per employee at the tertiary industry for residential and public buildings respectively, has seen steady growth, instead. Public buildings and residential buildings energy intensities grew 187% and 81%, respectively between 1995 and 2010. This can be partly explained by great improvement of living standards through the years, but still unnecessary

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<sup>21</sup> Calculated based on data from Zhejiang Statistical Yearbook.

consumption is expected to be huge due to poor insulation and other energy-saving measures.

Indicator results show that transportation sector is not inspiring also. Due to the fast increase of private cars and more frequent, longer-distance travel pattern of people, as well as poor fuel efficiency of vehicles, road transportation CO<sub>2</sub> emission per land area, which has been selected to indicate transportation energy intensity, has seen steady growth during the years, with annual growth rate being 10.5%. To overturn this trend would need development of vehicles driven by clean energies, as well as promotion of public transportation.

The policy-related indicators demonstrate that the policy framework and general targets have been set up for low carbon energy development, and government at all levels have shown enthusiasm in pilot low carbon practices. The weak points are systematic implementation arrangement for the targets, which requires the scientific statistical and monitoring system, potential analysis by sector, concrete goals, strict execution of regulations, as well as supporting incentive and punishing mechanisms.

Based on the findings, the low carbon energy development in Zhejiang Province has shown signs of advance in policy framework as well in some aspects such as industrial energy intensity and overall CO<sub>2</sub> emission intensity, but still, it has a long way to go, especially in terms of further development of low carbon energy sources and reduction of energy intensities of major energy-consuming sectors, and policy preparations are key to realize the low carbon development targets.

## **4.2 Thailand Case Summary**

Thailand is highly dependent on energy imports, which accounted for 46% of the total primary energy supply (TPES) in 2009. Imports accounted for 72% of oil demand and 28% of gas demand the same year (IEA, 2011). Oil was mainly imported from the Middle East via tanker, while gas was imported from Myanmar via pipeline.

Conservative assumptions suggest that Thailand will need to continue to increase imports of oil and gas from neighboring economies. Also, because of the economy's faster than expected growth in demand for natural gas, and the limited scope of its reserves, Thailand is actively seeking new gas resources. It is also seeking to improve security of energy supply by diversifying its power generation fuel mix, through increased use of renewable resources, particularly solar, wind, hydro and biomass.

Thailand has good potential for generating electricity from renewable energy (RE). Assessments from Thailand's Ministry of Energy estimated that about 57.3 GW of RE capacity may be available, mostly from solar, biomass and wind energy. As of 2012, only 2786 MW of RE capacity had been installed in Thailand, of which 70% was fuelled by biomass.

Climate change has been recognized as a threat to the nation and has been integrated into the formulation of several national plans and policies. Both the public and private sectors have been actively involved in reducing GHG emission, and a series of measures and

actions have been implemented in each sector to achieve this.

Developing RE and promoting energy conservation and efficiency are the primary ways to mitigate GHG emissions. Green consumption and production, as well as green lifestyle, have also been addressed but are yet to mature. The other area that has not clearly emerged yet is stakeholder involvement and engagement for tackling climate change. Even though Thailand has made significant progress toward green and low-carbon development, more needs to be done. Overall, Thailand has to focus on implementing no-regret policies to ensure the decoupling of the economy and the environment, while starting to look further at implementing least-cost policies. Short-term policies should immediately address the issue of rapidly increasing GHG emissions, and long-term policies should address fundamental changes towards a green and low-carbon society.

In the short term, Thailand needs to increase the implementation of its current promising policies on RE, energy efficiency, and other green policies. Additionally, incentive policies should be introduced using economic instruments through the market system

New policy initiatives concerning GHG emissions reduction, such as green buildings and homes, and green islands and cities, should be further developed, and suitable concepts and models should be developed to fit the Thai context. The basic information and knowledge on climate change should be developed and utilized to advance new policy initiatives.

For long-term policies, the foundation of the society needs to be addressed, especially in the public sector. Fundamental changes are needed in terms of environmental awareness and behavior, and these issues should be addressed by integrating both environmental knowledge and awareness into the educational system and facilitating environmentally friendly behavior.

### **4.3 Malaysia Case Summary**

The Low Carbon City Framework (LCCF) was developed by the Ministry of Energy Green Technology and Water (MEGTW) in collaboration with the Malaysian Green Technology Corporation (GreenTech Malaysia) to facilitate the development of Low Carbon Cities in Malaysia. LCCF is a performance based system comprising of four (4) elements namely, Urban Environment, Urban Infrastructure, Urban Transportation, and Building.

Within the four elements, there are altogether fourteen (14) criteria and thirty five (35) sub criteria. Currently, pilot implementation is being carried out to undertake the application of the LCCF at various development projects that are different and vary in developmental needs.

Each pilot implementation envisage several target outcomes that can be used to improve or enhance the environmental sustainability of a locality and to serve as a model to other projects of similar nature. The target outcomes are to produce carbon emissions baseline with specific figures and calculation methodologies. The exercise enables formulation of strategies and recommendations, and establish carbon emissions reduction target.

The pilot implementation is carried out at Putrajaya, Cyberjaya, and Hang Tuah Jaya. Seven focus areas comprising of Planning, Urban Design & Building, Integrating Nature Into The Urban Fabric, Energy Usage, Water Usage, Transportation and Mobility, Solid Waste Management, and City Administration and Management were addressed under the Putrajaya Green City 2025 initiative resulting in the following key targets being established: -

- To reduce CO<sub>2</sub> emission intensity by 60%;
- To reduce peak temperature by 2 degree Celsius; and
- To reduce the final disposal of solid waste and CO<sub>2</sub> emission per waste generation by 50%.

For LCCF, the efforts in Putrajaya include strategic actions in developing best practises, increasing awareness, reducing landfill requirement and promoting research for advanced carbon emission reduction activities.

Cyberjaya is located next to Putrajaya and has a total land area of 28.16km<sup>2</sup>. It's population is 47,961 (2010) and population density is about 1,703/km<sup>2</sup>. Based on the calculations and projections, the baseline Total Carbon Emissions for Cyberjaya for 2011 is 1,401,350 tCO<sub>2</sub>/year with a projected value of 1,109,205 tCO<sub>2</sub>/year, resulting in a reduction of 21%. The business-as-usual scenario leads to a staggering increase of 128% CO<sub>2</sub> emission or 3,200,909 tCO<sub>2</sub>/year.

Hang Tuah Jaya Municipal Council has an area of 35,733 acre and is located in the middle of Melaka State. The township within Hang Tuah Jaya Municipal Council has a population of about 114,732 people or consists of 19 percent (%) of total 602, 867 population of Melaka.

The boundaries selected for the implementation of LCCF is an area size of almost 2,000 acres comprising of various parks, complexes, and buildings. Hang Tuah Jaya Municipal Council undertook a city based approach consisting 5 sub-criteria for the application of LCCF's selected criteria, which are Urban Environment Road And Parking, Green Open Space, Number Of Trees, Operational Energy Emissions and Operational Water Emissions. The current carbon emission calculation stands at -36 mil tCO<sub>2</sub>, without the finalised figures for the energy and water emissions. It is projected that a potential emission reduction of between 10-29% equivalent to two diamond rating is achievable within the next 1-2 years.

The pilot implementation has produced encouraging outcomes resulting in the LCCF also currently being implemented at several other localities, namely Miri, Universiti Teknologi Malaysia, University Malaya, Petaling Jaya, with several other locations in the pipeline to begin implementation throughout 2014.

The experiences gained in developing the LCCF and carrying out the pilot implementation has provided key learning points towards the suitable indicators in determining the level of green activities in a township or development area. As LCCF is a performance based system it is very data intensive and difficulties in data collection can

be a limiting factor. However, this has provided further opportunities to improve the carbon calculator to ensure a more diverse sphere of application of LCCF can be achieved.

The four elements, Urban Environment, Urban Infrastructure, Urban Transportation, and Building together with the fourteen (14) criteria and thirty five (35) sub criteria provides a comprehensive coverage of factors that altogether contribute towards reducing the carbon emission of the entire city or developmental area. Through the pilot projects, it has been demonstrated that these elements can be considered as key indicators for low carbon cities.

## **4.4 Case Comparison**

### **4.4.1 Introduction**

The case study comparison is made between Zhejiang Province of China), Thailand, and Malaysia. The comparison has been made based on 2010 data for Zhejiang and Thailand, while for Malaysia it's 2011 data based on their report. All prices have been converted to 2005 constant price in US\$ based on data results from case studies by each economy.

In terms of basic information for the year 2010: Zhejiang Province has a population of 54 million on its 101,800 km<sup>2</sup> of land, Thailand has a population of 67 million on its 513,116 km<sup>2</sup> of land, while Malaysia has a population of 28 million on its 330,000 km<sup>2</sup> of land. Among the three cases, Zhejiang Province is remarkable densely populated, around 5 times that of Thailand and 6 times that of Malaysia. As a middle-income economy, Malaysia has the highest per capita GDP among the three cases, around 1.3 times that of Zhejiang Province of China and 1.9 times that of Thailand.

### **4.4.2 Overall Carbon Emission Intensity/density**

In Zhejiang Province of China, CO<sub>2</sub> emission per land area and per unit of GDP were 3.42kg/m<sup>2</sup> and 13.3 t/10000US\$, respectively. Compared with that, Thailand: 0.429 kg/m<sup>2</sup> and 10.4 t/10000US\$, Malaysia: 0.580 kg/m<sup>2</sup> and 10.2 t/10000US\$<sup>22</sup>. The above results show that the most densely populated Zhejiang Province of China faced the highest pressure of carbon emission density, almost 6 times those of Thailand or Malaysia. But if compared in per capita emission, the three cases were more or less on the same level. The Zhejiang case also had the highest carbon emission density, largely due to its high ratio of energy-intensive heavy industries in economic structure.

### **4.4.3 Structure**

The industrial ratio of total energy consumption was 71% in Zhejiang, 36.4% in Thailand and 27.8% in Malaysia. The remarkably high ratio of Zhejiang and the low ratio Malaysia are very different, but this huge difference seems have little impact on the overall carbon emission intensity, in which figure these two cases are not so widely apart. The reason why the energy-intensive industrial sector seems irrelevant for overall CO<sub>2</sub>

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<sup>22</sup> All currencies have been changed into US\$ at constant price of 2005 with the presumption that 1 US\$= 8.2 Chinese Yuan =40 Thai Baht = 3.8 Malaysia RM



emission intensity still needs further investigation, one preliminary presumption is that the higher consumption of energy due to tropical climate.

In terms of low energy mix, Malaysia and Thailand demonstrate far healthy energy structure. Due to resource privileges, Both Malaysia and Thailand had big portion of natural gas in their energy mix. Thailand had 34% of natural gas and 19% of renewable energy and hydro in its overall primary energy supply, while Malaysia had 39% of natural gas and 7% of renewable energy and hydro. Compared to these two economies, Zhejiang Province of China had very limited clean energy supply, with natural gas and renewable and hydro all below 5% in primary energy supply, which is a formidable constraint for low carbon development.

#### **4.4.4 Low Carbon Energy Intensity**

Industrial energy intensity for Zhejiang Province of China was 6.2 toe/10000 US\$ in 2010. As comparison, the figures for Thailand and Malaysia were 2.89 toe/10000 US\$ and 4.92 toe/10000 US\$, respectively

Energy consumption of residential buildings per household for Zhejiang, Malaysia and Thailand were close, being 0.388 kgoe, 0.433 kgoe and 0.51kgoe, respectively. In Thailand and Malaysia, the energy consumption consisted dominantly of electric power, while in Zhejiang case, only around half of the energy consumption was electric power.

In terms of energy consumption of public buildings /number of employees of the tertiary industry, the figures were 0.64 kgoe and 0.36 kgoe for Zhejiang and Thailand respectively (no data from the Malaysian case). The tropical climate of Thailand may need cooling for public buildings most of the year, while for public building in Zhejiang, the cooling and heating season altogether accounted for around half the year. But still, this indicator in the Zhejiang case was still higher than that of Thailand, indicating that energy intensity of public buildings in the Zhejiang Case could have big potential for reduction.

As for the transportation sector, road transportation energy consumption per land area for Zhejiang, Thailand and Malaysia were 128.2 toe/km<sup>2</sup>, 37.44 toe/km<sup>2</sup> and 10.2 toe/km<sup>2</sup>, respectively. The high road transportation energy consumed per unit of land of the Zhejiang Case, similar to the indicator of overall CO<sub>2</sub> emission density as mentioned before, was many times higher than those of Thailand and Malaysia. This high density demonstrated that the environmental pressure from the transportation sector of Zhejiang was very high.

#### **4.4.5 Policy Issues**

For all the three cases, general low carbon energy policies have been developed, with targets set at national levels, but concrete implementation plan and more detailed goals by sector are yet to be formulated to actually decoupling economic development and environmental impacts. For all three cases, pilot low carbon town demonstrations have been initiated, but basically at the early stage of development.

For Zhejiang Province of China, policy framework and general targets have been set up for low carbon energy development, and government at all levels have shown enthusiasm in pilot low carbon practices. The weak points are systematic implementation

arrangement for the targets, which requires the scientific statistical and monitoring system, potential analysis by sector, concrete goals, strict execution of regulations, as well as supporting incentive and punishing mechanisms.

Thailand has recognized climate change as a big potential threat to the nation and has been integrated into the formulation of several national plans and policies. Both the public and private sectors have been actively involved in reducing GHG emission, and a series of measures and actions have been implemented. Even though Thailand has made significant progress toward green and low-carbon development, more needs to be done. Overall, Thailand has to focus on implementing no-regret policies to ensure the decoupling of the economy and the environment, while starting to looking further at implementing least-cost policies. Short-term policies should immediately address the issue of rapidly increasing GHG emissions, and long-term policies should address fundamental changes towards a green and low-carbon society.

Similar to the Zhejiang Province of China and Thailand, Malaysia has promulgated regulations and development plans to encourage the development of low carbon energy resources and promotion of energy efficiency. The development of low carbon towns in Malaysia is still quite new where it requires an active promotion and uses of green technologies and sustainable method in the development and operation of a city.

## **Appendix 1: Expert Consultation Questionnaire for Low Carbon Energy Indicators System for APEC Energy Strategy Study in APEC Low Carbon Town**

### **Explanation on consultation**

The proposed Low Carbon Energy Indicators System is a three-tier system. The top tier is the target tier, which is low carbon energy development level for low carbon town development. Under the top tier is the element tier, consisting of four elements, which are, overall emission, structure, energy consumption and policy issues. Basic indicators at the third tier need be determined based on the preliminary list as shown in the table below for further screening and short-listing. For the convenience of your consideration and selection, an abundance of possible basic indicators are given for your selection, some of which could be redundant or overlapping, please choose the most appropriate one and please give reasons for your choice.

You are expected to:

- tick “yes” or “no” for your opinion on each indicator;
- Other than your suggestion of “yes” or “no”, other suggestions on the indicator are welcome, such as replacing it with another more appropriate indicator, or suggestion on the data source or data treatment;
- if you have suggestions on new indicators under certain element, please fill it in the “your suggestion for new indicator” and give your reasons;
- if you have any suggestion on the indicators system framework, please put in in “other suggestions” behind the table.



### Expert Consultation Questionnaire

Key element	Basic indicator	Your choice	Note	Reason & Other suggestions
<b>Overall energy consumption or carbon emission intensity/density</b>	Energy consumption per unit of GDP	<input type="checkbox"/> yes <input type="checkbox"/> no	Calculated at constant price of 2005 (or another year appropriate)	
	Energy consumption per capita	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Electricity consumption per capita			
	CO <sub>2</sub> emission per unit of energy consumption	<input type="checkbox"/> yes <input type="checkbox"/> no		
	CO <sub>2</sub> emission per capita	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Elastic coefficient of CO <sub>2</sub> emission	<input type="checkbox"/> yes <input type="checkbox"/> no	Annual growth rate of CO <sub>2</sub> emission/annual growth rate of GDP	
	Progress to the carbon emission reduction target	<input type="checkbox"/> yes <input type="checkbox"/> no		
	New indicator -----			
<b>Structure</b>	Total primary energy supply	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Composition ratio of natural gas in total energy supply	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Composition ratio of non fossil-fuel in total energy supply	<input type="checkbox"/> yes <input type="checkbox"/> no	Including nuclear power, renewable energy and conventional hydro power	

	Ratio of renewable energy in total primary energy supply	<input type="checkbox"/> yes <input type="checkbox"/> no	Including wind power, hydro power, solar heating, and biomass heating and power generation	
	waste-to-energy ratio	<input type="checkbox"/> yes <input type="checkbox"/> no	Ratio of waste that is put into energy use, such as waste incineration	
	Your suggestion for new indicator			
	Your suggestion for new indicator			
<b>Energy consumption</b>	Energy consumption per unit of industrial added-value	<input type="checkbox"/> yes <input type="checkbox"/> no	Calculated at constant price of 2005 (or another year appropriate)	
	Energy consumption per unit of industrial added-value for major energy consuming industries	<input type="checkbox"/> yes <input type="checkbox"/> no	Industrials sectors that consumes over 5% of overall industrial energy consumption (excluding power generation sector)	
	Energy consumption of public buildings per m <sup>2</sup> (or, per capita)	<input type="checkbox"/> yes <input type="checkbox"/> no	Including fuel or heat consumption for heating, cooling as well as electric power consumption	
	Energy consumption of Residential buildings per m <sup>2</sup> (or, per capita)	<input type="checkbox"/> yes <input type="checkbox"/> no	Including fuel or heat consumption for heating, cooling and cooking as well as electric power consumption	
	Public transportation share in overall transportation	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Bus owned by every 10000 people	<input type="checkbox"/> yes <input type="checkbox"/> no		
	private car owned per capita	<input type="checkbox"/> yes <input type="checkbox"/> no		

	Share of clean vehicles	<input type="checkbox"/> yes <input type="checkbox"/> no	Including LNG-, CNG-fueled vehicles and electric vehicles	
	Your suggestion for new indicator			
	-----			
<b>Policy</b>	setting CO <sub>2</sub> emission reduction target or issuing action plans addressing climate change (descriptive indicator)	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Existence of regional CO <sub>2</sub> emission inventory (descriptive indicator)	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Government plannings that promote low carbon energy development (descriptive indicator)	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Statistical and monitoring systems for CO <sub>2</sub> emissions (descriptive indicator)	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Existence of CO <sub>2</sub> emissions verification mechanism for industries (descriptive indicator)	<input type="checkbox"/> yes <input type="checkbox"/> no		
	Development of low carbon towns and communities			
	Your suggestion for new indicator			
	-----			

Other suggestions:

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## Appendix 2: List of Participating Experts at the Consultation Workshop of July 2

### List of Participating Experts at the Consultation Workshop of July 2

Name	Organization	Position
CHEN Hong	Energy Division of the Zhejiang Provincial Statistic Bureau	Division chief
WU Hongmei	Zhejiang Provincial Research Institute for Economic Development Planning	Chief engineer
Wang Yunpeng	Zhejiang Provincial Energy Surveillance Agency	Chief
BAO Jianqiang	Zhejiang University of Technology	Professor
XU Yanchun	Zhejiang Provincial Research Institute of Information Science	Senior research fellow
DAI Yiqiong	Environmental Science Research and Design Institute of Zhejiang Province	professor
WANG Lihong	College of Environment and Resources, Zhejiang University	Associate professor
PAN Yi	Zhejiang Provincial Energy Association	Senior research fellow
SONG Hongfang	Statistics and Analysis Division, Department of Development Strategy of Zhejiang Provincial Electric Power Company	Division chief
YUAN Chen	Economic Projection Department of Ningbo Information Center	Deputy director
ZHANG Zhibin	College of Economics, Zhejiang University	Associate professor

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### Appendix 3: Project Workshop Summary

The Workshop of Establishing Low Carbon Energy Indicators for APEC Low Carbon Town was held at Shangri-La Hotel Hangzhou, China on 24-25 October 2013.

This workshop was a set activity by the APEC project *Establishing Low Carbon Energy Indicators for Energy Strategy Study in APEC Low Carbon Town (S EWG 10 12A)*, aiming at the following objectives:

1. providing a platform for Chinese and experts and government officials from other APEC economies to share information and practices on LCMT development.
2. disseminating project results of the “EWG 10 2012A Establishing Low Carbon Energy Indicators for energy strategy study in APEC Low Carbon Town”.
3. identifying potential opportunities for further cooperation.

Mr. Chen Haitao, Deputy Director of the Zhejiang Provincial Energy Bureau announced opening of this workshop. The workshop session had been held with presentations contributed by experts and government officials concerning topics related to low carbon development in APEC economies. Major topics on the workshop included:



1. APEC low carbon town development demonstration status and prospect.
2. introduction to the APEC low energy indicators system established by the project and its case study application in Zhejiang Province of China.
3. low carbon development demonstration practices in certain cities of APEC economies.
4. carbon mitigation cost analysis and carbon footprint management.

There were around 50 participants presented at the workshop, coming from China and from other APEC economies including Canada, Hongkong, Mexico and Thailand. On the second day of the workshop, participants went for site visit to two demonstration projects in Zhejiang Province, one of which was an agricultural waste-to-resource and large-scale biogas power generation project by Kaiqi Energy, and the other was the biomass power generation project by

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Hengxin Power Company.

The workshop has been wrapped out successfully with active exchange of ideas. The workshop materials has been compiled and printed out as an result.

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## Appendix 4: Workshop Agenda



### International Workshop on Establishing Low Carbon Energy Indicators for APEC Low Carbon Town

## Agenda

#### **Supported by**

The Asian and Pacific Economy Cooperation Organization

#### **Organized by**

Zhejiang Provincial Development and Reform Committee

Zhejiang Provincial Energy Bureau

#### **Co-organized by**

Zhejiang Energy and Radiation Institute

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24-25 October, 2013  
Hangzhou, China

**Oct. 24, 2013**

**8:30 - 9:00 Registration**

**9:00 -9:30 Welcome remarks**

*Hosted by Mr. Chen Haitao, Deputy Director of the Zhejaing Provincial Energy Bureau*

*Ms. Yang yang, International Cooperation Department, National Energy Administration*

*Mr. Carlos Guerrero-Perrez, Secretariat of Environment of the State of Aguascalientes, Mexico*

**9:30-12:00 Keynote speeches**

*Hosted by Mr. Chen Haitao, Deputy Director of the Zhejaing Provincial Energy Bureau*

**APEC Low carbon town demonstration in China: development and prospect**

*Dr. Ma Linwei, Deputy Director of the Tsinghua-BP Clean Energy research and education centre*

**Indicators of Sustainability in Mexico: Results for Metropolitan Area of Aguascalientes**

*Mr. Carlos Guerrero-Perrez, Secretariat of Environment of the State of Aguascalientes, Mexico*

**The prospect for low carbon energy in terms of carbon emission**

*Prof. Wu Hongmei, Environment and Resources Division, Zhejiang Provincial Development and Reform Commission*

**The direct cost of reducing carbon output of renewables**

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*Dr. Jon ykawy, Head of Global Research, Clean Technologies and Materials Analyst, Byron*

*Capital Markets*

**Assessment study on low carbon energy development in Zhejiang Province**

*Prof. Bao Jianqiang, Director of the College of Politics and Public Manageme, Zhejiang University of Technology*

**12:00-13:30 Lunch**

**13:30 -15:00 workshop session**

*Hosted by Ms. Huang Dongfeng, Research Fellow, Zhejaing Energy and Radiation Institute*

**Carbon Footprint Management for Sustainable Low Carbon Living**

*Michael K.H. LEUNG , Associate Dean and Associate Professor Director, Ability R&D Energy Research Centre School of Energy and Environment City University of Hong Kong*

**Indicators System for APEC Low Carbon Town Development**

*Mr. Guo Zhiqiang CECEP Consulting Co., Ltd*

**Low Carbon Energy Indicators for Energy Strategy Study in APEC Low Carbon Town**

*He Sizheng, Associate Research Fellow, Zhejiang Energy and Radiation Institute*

**Case Study on low carbon demonstration town of Thailand**

*Mr.Anek Nakabutara, Chairman of the Local Development Foundation*

**15:00-15:15 Tea Break**

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**15:15-16:45 Demonstrations and Practices**

**APEC Low Carbon Town Demonstration Project at Tianjin Yunjiapu**

*Mr. Yanghaisong, Division Chief of Tianjin Innovative Finance Academy & Design of Low Carbon*

**Low Carbon Town Practice in Hangzhou City**

*Mr. Jiang Xiaojun, Deputy Director of the Hangzhou Development and Reform Commission*

**Longyou , a national-level green energy demonstration county**

*Mr. Liu Genhong, County Governor*

**16:45-17:00 Conclusion**

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**Oct. 25, 2013**

**8:00-17:30 site visit to Longyou County of Zhejiang Province, a national-level green energy demonstration county**

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## Appendix 5: Case Study Report by CEERD of Thailand

### Disclaimer:

*This document has been prepared by the Centre for Energy Environment Resources Development (CEERD) at the request of The Asia-Pacific Economic Cooperation Secretariat (APEC Secretariat). The contents of this document are the sole responsibility of the Centre for Energy Environment Resources Development (CEERD) and can under no circumstances be regarded as reflecting the position of the Asia-Pacific Economic Cooperation Secretariat (APEC Secretariat).*

## TABLE OF CONTENT

<b>FOREWORD</b> .....	<b>81</b>
<b>LIST OF TABLES</b> .....	<b>82</b>
<b>LIST OF FIGURES</b> .....	<b>82</b>
<b>LIST OF UNITS</b> .....	<b>84</b>
<b>LIST OF ACRONYMS</b> .....	<b>84</b>
<b>LIST OF INSTITUTIONS</b> .....	<b>84</b>
<b>EXECUTIVE SUMMARY</b> .....	<b>85</b>
<b>1. Introduction / Background</b> .....	<b>90</b>
<b>2. General Country Overview</b> .....	<b>91</b>
<b>2.1 Thailand's Alternative Energy Development Plan</b> .....	<b>91</b>
<b>2.2 State of the Energy Sector in Thailand</b> .....	<b>93</b>
<b>2.3 Renewable Energies and Energy Efficiency</b> .....	<b>94</b>
<b>2.4 Energy Demand/Supply and CO<sub>2</sub> Emission Projections</b> .....	<b>96</b>
<b>3. Policy and Planning for Low carbon Development / Statistics and Monitoring</b> .....	<b>100</b>
<b>3.1 Policy and Planning</b> .....	<b>100</b>
<b>3.2 Statistics and Monitoring of CO<sub>2</sub></b> .....	<b>101</b>
<b>4. Low Carbon Development Initiatives in Thailand</b> .....	<b>105</b>
<b>4.1 Vision, Missions, Objectives and Targets of the Eleventh Plan (2012-2016)</b> .....	<b>106</b>
<b>4.2 Development Strategies</b> .....	<b>107</b>



---

<b>5. Low Carbon Model Town Project</b> .....	<b>109</b>
5.1 Samui Island.....	109
5.2 Muang Klang.....	110
<b>6. Low carbon Indicators</b> .....	<b>112</b>
6.1 Thailand.....	112
6.2 Samui Island.....	120
<b>7. Conclusions</b> .....	<b>122</b>
 <b>INTERNET LINKS</b> .....	 <b>124</b>
<b>REFERENCES</b> .....	<b>126</b>

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## FOREWORD

With an increasing urbanization in the APEC region in recent years, energy consumption and therefore CO<sub>2</sub> emissions have grown at a fast pace, especially in Asian countries such as China, Indonesia, Chinese Taipei, Thailand and Malaysia. In recent years, policies that promote low carbon development have therefore been developed designed and are now being implemented.

While the low carbon development concept is now being more widely recognized, studies on indicators systems are also gaining more attention. These indicators systems are in fact an essential tool for guiding the development and assessing results.

The development of APEC “Low-Carbon Town (LCT)” is a pathway to achieve CO<sub>2</sub> emissions reductions coupled with comprehensive measures to achieve sustainable development. In order to achieve such goals, it is vital to shift from conventional energies to low carbon energies.

Due to the lack of data availability for Samui Island, the low carbon energy indicators calculated in this report were for the whole Kingdom of Thailand. Alternatively, this will serve as a quantitative tool to monitor the progress toward the targets and to evaluate the effect of low carbon energy strategy and measures.

## LIST OF TABLES

TABLE 1: THAILAND BASIC ECONOMIC AND ENERGY INDICATORS .....	86
TABLE 2: ALTERNATIVE ENERGY DEVELOPMENT PLAN BENEFITS (2012-2021).....	87
TABLE 3: CONSUMPTION, PRODUCTION AND IMPORT OF PRIMARY COMMERCIAL ENERGY.....	88
TABLE 4: FINAL ENERGY CONSUMPTION 2012 .....	89
TABLE 5: PERFORMANCE ON ALTERNATIVE AND RENEWABLE ENERGY POLICY – 2012 .....	90
TABLE 6: ANALYSIS OF REASONS FOR CHANGE IN BAU CO <sub>2</sub> EMISSIONS FROM FUEL COMBUSTION.....	94
TABLE 7: CO <sub>2</sub> EMISSION FROM ENERGY CONSUMPTION BY SECTOR .....	97
TABLE 8: THAILAND’S SUSTAINABLE DEVELOPMENT INDICATORS .....	100
TABLE 9: CO <sub>2</sub> EMISSION PER UNIT OF GDP.....	107
TABLE 10: CO <sub>2</sub> EMISSION PER UNIT OF LAND.....	118
TABLE 11: INDUSTRIAL SECTOR EC IN FINAL ENERGY CONSUMPTION .....	109
TABLE 12: NATURAL GAS SUPPLY IN TOTAL PRIMARY ENERGY SUPPLY .....	110
TABLE 13: RENEWABLE ENERGY AND HYDRO SUPPLY IN TOTAL PRIMARY ENERGY SUPPLY.....	111
TABLE 14: INDUSTRIAL SECTOR EC PER UNIT OF INDUSTRIAL ADDED-VALUE .....	112
TABLE 15: PUBLIC BUILDINGS EC PER NUMBER OF EMPLOYEES OF THE TERTIARY INDUSTRY.....	112
TABLE 16: RESIDENTIAL BUILDINGS EC PER HOUSEHOLD .....	113
TABLE 17: ROAD TRANSPORTATION EC PER UNIT OF LAND AREA.....	114
TABLE 18: CO <sub>2</sub> EMISSION PER UNIT OF LAND IN SAMUI - 2010 .....	115
TABLE 19: RESIDENTIAL BUILDINGS EC PER HOUSEHOLD IN SAMUI - 2010.....	115
TABLE 20: ADDITIONAL DATA OF SURATTHANI PROVINCE.....	115

### Tables in “ Macroeconomic And Energy Data Summary”

TABLE 1: MACROECONOMIC DATA – THAILAND - 1995 – 2010 .....	127
TABLE 2: PRIMARY ENERGY SUPPLY – THAILAND - 1995 – 2010 .....	129
TABLE 3: FINAL ENERGY CONSUMPTION – THAILAND - 1995 – 2010 .....	130
TABLE 4: ELECTRICITY CONSUMPTION & RELATED CO <sub>2</sub> EMISSIONS IN SAMUI ISLAND (2000 – 2012).....	131
TABLE 5: FUEL CONSUMPTION & RELATED CO <sub>2</sub> EMISSION IN SAMUI ISLAND (2010).....	131

## LIST OF FIGURES

FIGURE 1: ALTERNATIVE ENERGY DEVELOPMENT PLAN (2012-2021).....	87
FIGURE 2: ALTERNATIVE AND RENEWABLE ENERGY SHARES OF THAILAND FINAL ENERGY CONSUMPTION, 2012.....	91
FIGURE 3: BAU FINAL ENERGY DEMAND .....	92
FIGURE 4: BAU PRIMARY ENERGY SUPPLY.....	92
FIGURE 5: BAU CO <sub>2</sub> EMISSIONS BY SECTOR.....	93
FIGURE 6: CO <sub>2</sub> EMISSIONS BY ENERGY TYPE.....	97

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FIGURE 7: CO <sub>2</sub> EMISSION PER UNIT OF GDP - INDEX .....	108
FIGURE 8: CO <sub>2</sub> EMISSION PER UNIT OF LAND .....	108
FIGURE 9: INDUSTRIAL SECTOR EC IN TOTAL ENERGY CONSUMPTION .....	109
FIGURE 10: NATURAL GAS SUPPLY IN TOTAL PRIMARY ENERGY SUPPLY.....	110
FIGURE 11: RENEWABLE ENERGY AND HYDRO SUPPLY IN TOTAL PRIMARY ENERGY SUPPLY .....	111
FIGURE 12: INDUSTRIAL SECTOR EC PER UNIT OF INDUSTRIAL ADDED-VALUE - INDEX .....	112
FIGURE 13: PUBLIC BUILDINGS EC PER NUMBER OF EMPLOYEES OF THE TERTIARY INDUSTRY - INDEX.....	113
FIGURE 14: RESIDENTIAL BUILDINGS EC PER HOUSEHOLD - INDEX .....	114
FIGURE 15: ROAD TRANSPORTATION EC PER UNIT OF LAND AREA.....	115

## LIST OF UNITS

<b>GW</b>	Gigawatt	<b>MW</b>	Megawatt
<b>Kgoe</b>	Kilogram oe	<b>oe</b>	Oil equivalent
<b>Ktoe</b>	1000 toe	<b>Sq. m</b>	Square meters
<b>kW</b>	Kilowatt	<b>Sq, Km</b>	Square kilometre
<b>kWh</b>	Kilowatt hour	<b>tCO<sub>2</sub></b>	Ton of CO <sub>2</sub>
<b>KBD</b>	Thousand Barrels per day	<b>toe</b>	Ton of oil equivalent
<b>Mtoe</b>	1000 Ktoe		

## LIST OF ACRONYMS

<b>AEDP</b>	Renewable & Alternative Energy Development plan	<b>FEC</b>	Final Energy Consumption
<b>BAU</b>	Business As Usual	<b>GDP</b>	Gross Domestic Product
<b>CH<sub>4</sub></b>	Methane	<b>GHG</b>	Greenhouse Gas
<b>CDM</b>	Clean Development Mechanism	<b>LED</b>	Light-emitting diode
<b>CNG</b>	Compressed Natural Gas	<b>LNG</b>	Liquefied Natural Gas
<b>CO<sub>2</sub></b>	Carbon Dioxide	<b>LCMT</b>	Low-Carbon Model Town
<b>EC</b>	Energy Consumption	<b>MSW</b>	Municipal Solid Waste
<b>EE</b>	Energy Efficiency	<b>RE</b>	Renewable Energy
<b>EEDP</b>	Energy Efficiency Development Plan	<b>SPPs</b>	Small Power Producers
<b>EIA</b>	Environmental Impact Assessment	<b>TPES</b>	Total Primary Energy Supply
<b>ENCON</b>	Energy Conservation and Promotion	<b>VSPP</b>	Very Small Power Producers
<b>ESCO</b>	Energy Service Company		

## LIST OF INSTITUTIONS

<b>ADB</b>	Asian Development Bank	<b>EPPO</b>	Energy Policy and Planning Office
<b>ADBI</b>	Asian Development Bank Institute	<b>IEA</b>	International Energy Agency
<b>APEC</b>	Asia-Pacific Economic Cooperation	<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>ASEAN</b>	Association of Southeast Asian Nations	<b>NEPC</b>	National Energy Policy Council
<b>CEERD</b>	Centre for Energy Environment Resources Development	<b>NESDB</b>	National Economic and Social Development Board
<b>DEDE</b>	Department of Alternative Energy Development and Efficiency	<b>NSO</b>	National Statistical Office of Thailand
<b>DOPA</b>	Department Of Provincial Administration	<b>ONEP</b>	Office of Natural Resources and Environmental Policy Planning
<b>EGAT</b>	Electricity Generating Authority of Thailand	<b>TEI</b>	Thailand Environment Institute

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## EXECUTIVE SUMMARY

### Introduction / Background

Thailand has made significant progresses toward green and low-carbon development; however, there is a need to further address the issue. The country has to focus on the implementation of no-regret policies to ensure the decoupling of economic growth, while starting to look further at implementing least-cost policies. There should be short-term policies to immediately address a rapid increase of greenhouse gas (GHG) emissions and long-term policies to address fundamental changes towards a green and low-carbon society

### General Country Overview

Thailand is highly dependent on energy imports, which accounted for 46% of the total primary energy supply (TPES) in 2009. Imports accounted for 72% of oil demand and 28% of gas demand the same year (IEA, 2011). Oil was mainly imported from the Middle East via tanker, while gas was imported from Myanmar via pipeline.

Conservative assumptions suggest that Thailand will need to continue to increase imports of oil and gas from neighboring economies. Also, because of the economy's faster than expected growth in demand for natural gas, and the limited scope of its reserves, Thailand is actively seeking new gas resources. It is also seeking to improve security of energy supply by diversifying its power generation fuel mix, through increased use of renewable resources, particularly solar, wind, hydro and biomass.

Thailand has good potential for generating electricity from renewable energy (RE). Assessments from Thailand's Ministry of Energy estimated that about 57.3 GW of RE capacity may be available, mostly from solar, biomass and wind energy. As of 2012, only 2786 MW of RE capacity had been installed in Thailand, of which 70% was fuelled by biomass.

### Policy and Planning for Low carbon Development

Thailand's energy policy seeks to build an energy self-sufficient society; achieve a balance between food and energy security; build a knowledge-based society; promote Thailand's role in the international arena; and enhance economic links with other economies in the region to facilitate harmonious cooperation in energy and other sectors.

In order to tap into the RE potential, the Renewable and Alternative Energy Development Plan 2012–2021 (AEDP) sets a framework for Thailand to increase the share of renewable and alternative energy to 25% of total energy consumption by 2021. The plan states the Thai government will encourage the use of indigenous resources including renewable and alternative energy (particularly for power and

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heat generation), and supports the use of transport biofuels such as ethanol-blended gasoline (gasohol) and biodiesel. The plan also strongly promotes community-scale alternative energy use, by encouraging the production and use of RE at a local level, through appropriate incentives for farmers. It also rigorously and continuously promotes research and development of all forms of RE.

Furthermore, Thailand has adopted a 20-year Energy Efficiency Development Plan 2011–2030 (EEDP). This plan sets a target of 25% reduction in the economy’s energy intensity by 2030, compared to 2005 levels. In 2011, the EEDP targets were revised to meet the new target declared by APEC Leaders at the APEC Summit 2011. Thailand now aims to achieve a 25% reduction of energy intensity by 2030, compared with 2010 levels. The focus for energy efficiency measures is on transport and industry sectors. Implementation of the EEDP will result in cumulative final energy savings of about 289 000 ktoe by 2030 (or an average of 14 500 ktoe per year), and avoided CO<sub>2</sub> emission of 976 million tons (EPPO, 2011).

#### Low Carbon Development Initiatives in Thailand

In Thailand there are no specific low-carbon green development indicators. However, the indicators are defined under the broad development indicators—the sustainable development indicators. These indicators are formulated by the Office of National Economic and Social Development Board (NESDB) and Thailand Environment Institute (TEI), and economic, social, and environmental dimensions were taken into account. From the set of indicators, key issues for achieving green and low-carbon development are included, such as energy consumption, RE, research and development, forest conservation, resource efficiency, and GHG emissions.

Furthermore, the Eleventh National Economic and Social Development Plan (2012-2016) also sets development strategies, one of which is to shift the development paradigm and steer the country toward an environmentally sustainable, low-carbon economy and society. In order to achieve this strategy the 11<sup>th</sup> Plan prescribes a set of guideline ranging from the restructuring of production sectors toward an environmentally sound low-carbon economy to modifying consumption behavior to facilitate the transition to a low carbon and environmentally stable society.

#### Low Carbon Model Town Project

The APEC Low-Carbon Model Town (LCMT) Project, under The Energy Smart Communities Initiative (ESCI) seeks to promote low-carbon technologies in city planning in order to manage rapidly growing energy consumption and GHG emissions in urban areas of the APEC region. There are currently 2 towns in Thailand, which have been proposed as LCMT: Samui Island and Muang Klang. The Samui Island LCMT Project has already been accepted and under implementation while the Muang Klang LCMT has been submitted and is still under review.

#### Low carbon Indicators

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The APEC project (*Establishing Low Carbon Energy Indicators for Energy Strategy Study in APEC Low Carbon Town*) carried out by the Zhejiang Energy and Radiation Institute, has build up a Low Carbon Energy Indicators system as an effective tool to assess and guide low carbon energy development for APEC Low Carbon Town Development. In the case of this report, indicators were calculated and used to probe the case of the whole Kingdom of Thailand since there was not enough available data to calculated indicators for Samui Island. It has been found that:

- Thailand's Overall CO<sub>2</sub> emissions have increased by 60.1% between 1995 and 2010 and closely follow the growth pattern of the GDP during the same period. As a consequence, CO<sub>2</sub> emission Intensity (per unit of economic output) increased by 5.3% during the same period implying that CO<sub>2</sub> emissions and GDP growth are still closely coupled.

- Thailand's Industrial Sector Energy Consumption (EC) increased by 59.4% between 1995 and 2010. Its share in the FEC remained overall constant with a slight increase of 3.8% during the same period.

- Between 1995 and 2010, Natural Gas has steadily increased its share in the Total Primary Energy Supply (TPES), reaching 34% share in 2010. This represents a 116.5% increase since 1996. Natural Gas now plays a major role in the energy mix of the country.

- Renewable Energy Supply (including Hydro and Biofuels) increased by an overall of 51.8% between 1996 and 2010 while its share in the TPES remained stable at an average of 18.9%, but with a slight increase in the last years of the studied period. Significant efforts have been done in the past and are being made by the Thai Government to increase the share of Renewable Energy in the energy supply.

- The Industrial Sector Energy Consumption (EC) has increased by 59.4% between 1995 and 2010, following closely the Industrial added value growth. The industrial sector has been progressively consuming less energy per unit of added value. However, further analysis and data is needed to determine whether the decrease of the Industrial Energy Intensity is due to Energy Efficiency improvement.

- While Public Buildings EC has increased at an average of 5.7% per year between 1995 and 2010, the numbers of employees in the tertiary sector has increased by 67% during the same period. Figures seem to indicate that more energy is being consumed per employee in the Public Building sector and that energy efficiency measures certainly need to be promoted and achieved in this sector.

- Residential Buildings EC increased by 59.7% between 1995 and 2010, following closely the number of Households growth. Consequently, the residential buildings EC per household only increased by 8.3% during the same period. This shows that the



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EC of the Residential Sector has not changed much in the period of study; however, since 2007, the Household Sector seems to be showing a clear pattern of increasing EC, due most probably to an increased use of electrical appliances.

- EC by road transportation increased by 29.6% between 1995 and 2010. However, the EC growth rate seems to be decelerating since 2004. Perhaps the introduction of Gasohol, Biodiesel and other Biofuels since 2005/2006 has contributed to slowing down CO<sub>2</sub> emissions in the road transportation sector.

### Conclusions

Climate change has been recognized as a threat to the nation and has been integrated into the formulation of several national plans and policies. Both the public and private sectors have been actively involved in reducing GHG emissions, and a series of measures and actions have been implemented in each sector to achieve this.

Developing RE and promoting energy conservation and efficiency are the primary ways to mitigate GHG emissions. Green consumption and production, as well as green lifestyle, have also been addressed but are yet to mature. The other area that has not clearly emerged yet is stakeholder involvement and engagement for tackling climate change. Even though Thailand has made significant progress toward green and low-carbon development, more needs to be done. Overall, Thailand has to focus on implementing no-regret policies to ensure the decoupling of the economy and the environment, while starting to looking further at implementing least-cost policies. Short-term policies should immediately address the issue of rapidly increasing GHG emissions, and long-term policies should address fundamental changes towards a green and low-carbon society.

In the short term, Thailand needs to increase the implementation of its current promising policies on RE, energy efficiency, and other green policies. Additionally, incentive policies should be introduced using economic instruments through the market system

For agricultural activities, policies around GHG emission reduction have not yet taken shape. The key consideration is changing current agricultural practices to be environmentally friendly by changing farmer behavior and introducing new technologies and materials.

New policy initiatives concerning GHG emissions reduction, such as green buildings and homes, and green islands and cities, should be further developed, and suitable concepts and models should be developed to fit the Thai context. The basic information and knowledge on climate change should be developed and utilized to advance new policy initiatives.

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For long-term policies, the foundation of the society needs to be addressed, especially in the public sector. Fundamental changes are needed in terms of environmental awareness and behavior, and these issues should be addressed by integrating both environmental knowledge and awareness into the educational system and facilitating environmentally friendly behavior.

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## 1. Introduction / Background<sup>23</sup>

In Thailand climate change has been integrated into the formulation of several national plans and policies. Even though Thailand is not obligated to reduce GHG emissions, it voluntarily takes numerous actions to mitigate emissions. Both the public and private sector have been actively involved in reducing GHG emissions, with a series of measures and actions implemented in each sector.

The development of Renewable Energy (RE) and the promotion of energy conservation and efficiency are the primary means to mitigate GHG emissions in Thailand. With the establishment of the Energy Conservation Program in 1995, a viable movement for energy conservation and efficiency and RE had begun. Over the years, progress in RE and energy efficiency has been made. Recently, the 15-Year Renewable Energy Development Plan and the 20-Year Energy Conservation Plan comprised several innovative measures and incentive mechanisms to further advance the development of energy efficiency and RE. Regardless of government policies and measures, the private sector has also taken part in GHG emissions mitigation by implementing a number of activities to reduce carbon sources (e.g., improved production processes and resource efficiency) and to create carbon sinks (e.g., reforestation and mangrove plantations).

Thailand has made significant progresses toward green and low-carbon development; however, there is a need to further address the issue. The country has to focus on the implementation of no-regret policies to ensure the decoupling of economic growth, while starting to look further at implementing least-cost policies. There should be short-term policies to immediately address a rapid increase of GHG emissions and long-term policies to address fundamental changes towards a green and low-carbon society.

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<sup>23</sup> ADBI Working Paper Series: Development Trajectory, Emission Profile, and Policy Actions: Thailand (2012)

## 2. General Country Overview

Thailand is located in Southeast Asia and has a land area of 513,116 Sq. Km. The country is divided into 76 provinces, which are gathered into 5 regions (North, Northeast, East, Central and South).

Geographically Thailand can be classified into four natural regions. Northern Thailand is dominated by forested mountain ranges divided by four fertile river valleys. Central Thailand is mainly composed of the Chao Praya basin, where the major part of the population and industry as well as the majority of agricultural production is based. The North-East is sparsely vegetated and largely infertile. The southern peninsula is dominated by dense tropical forests. The climate is essentially tropical with a wet, warm south-west monsoon from May to September and a drier, cooler monsoon from November to March. Temperatures vary from 20 to 37°C.

Thailand's GDP was valued at Baht 8,500 billion in 2011 (constant 2005 prices) while the population in 2011 was estimated at about 67,6 million. Final energy consumption in 2011 was 1.1 toe per person while electricity consumption was 2,202 kWh per person.

TABLE 1: THAILAND BASIC ECONOMIC AND ENERGY INDICATORS

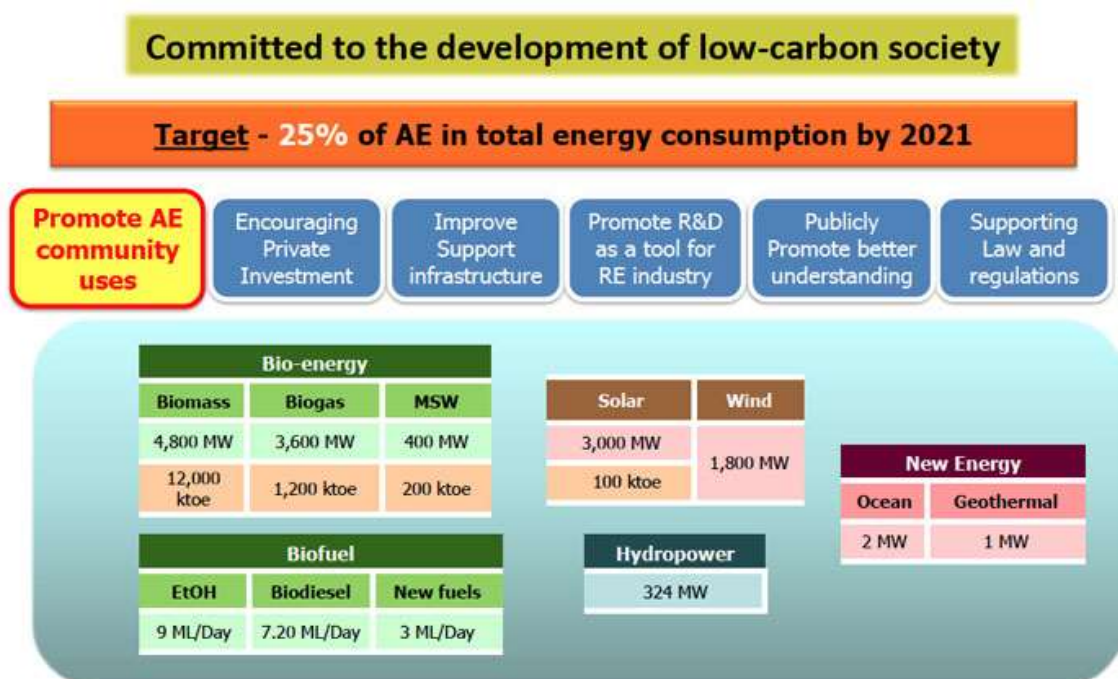
	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>GDP (billion Baht - 2005 prices)</b>	5,579	5,663	5,791	6,048	6,427	6,805	7,092	7,465	7,918	8,021	7,969	8,482
<b>Population (millions)</b>	59.4	62.2	62.8	63.4	64	64.5	65.1	65.6	66	66.5	66.9	67.3
<b>CO<sub>2</sub> Emissions/GDP (Ton CO<sub>2</sub>/m. baht GDP)</b>	24.68	26.62	26.50	27.03	26.75	27.53	27.14	25.87	25.31	25.33	26.12	25.98
<b>Energy consumption per capita (toe/person)</b>	0.76	0.77	0.78	0.83	0.88	0.95	0.96	0.955	0.99	1.00	1.02	1.08
<b>Electricity consumption (kWh/person)</b>	1,191	1,407	1,477	1,577	1,668	1,784	1,862	1,950	2,015	2,038	2,020	2,218

SOURCE: NESDB, EPPO, DEDE (2012)

### 2.1 Thailand's Alternative Energy Development Plan

A 10-year Renewable and Alternative Energy Development Plan (2012 – 2021) (AEDP) was approved by the Cabinet on 30 December 2011. The AEDP replaced the Renewable Development Energy Plan (2008 to 2022) (REDP). The AEDP establishes more aggressive objectives, with RE consumption targeted at 25% of total energy consumption by 2021 (the REDP target was 20.3%). This amounts to approximately 13.9 GW from alternative energy sources, as shown in the following Figure 1:

FIGURE 1: ALTERNATIVE ENERGY DEVELOPMENT PLAN (2012-2021)



SOURCE: DR. TWARATH SUTABUTR - DEPUTY DIRECTOR-GENERAL DEDE (SEPTEMBER 2013)

The benefits expected from the implementation of the AEDP between 2012 and 2021 are shown on following Table 2.

TABLE 2: ALTERNATIVE ENERGY DEVELOPMENT PLAN BENEFITS (2012-2021)

13,927 MW of Electricity
13,500 Ktoe of heat
19.2 Million liters/day of biofuels
Share of Alternative Energy in final consumption is 24,634 Ktoe

SOURCE: ENERGY IN THAILAND: FACTS AND FIGURES 2012 - DEDE

## 2.2 State of the Energy Sector in Thailand

The National Economic and Social Development Board (NESDB) estimated Thailand's GDP growth rate in 2011, at 0.1%. During the first three quarters, the GDP growth rate was 3.2%; despite the impact of the Japanese earthquake and tsunami incidents in March 2011, the economy was able to be recover in the 3rd quarter. At the end of the 3rd quarter and throughout the 4th quarter of the year, Thailand was faced to a sever flood situation which heavily impacted the manufacturing sector, agricultural and industrial sectors, as well as the he tourist industry. These factors greatly affected the overall energy demand of the country, which can be summarized as follows:

TABLE 3: CONSUMPTION, PRODUCTION AND IMPORT OF PRIMARY COMMERCIAL ENERGY  
UNIT : KBD (CRUDE OIL EQUIVALENT)

	2010	2011	2010				2011			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
<b>Consumption</b>	1,783	1,845	1,780	1,807	1,765	1,780	1,868	1,890	1,858	1,763
<b>Production</b>	989	1,018	979	1,002	987	990	1,051	1,012	1,034	977
<b>Import (Net)</b>	1,001	1,017	991	1,082	916	1,015	1,040	1,097	1,031	903
<b>Import/Consumption (%)</b>	56	55	56	60	52	57	56	58	55	51
<b>Growth Rate (%)</b>										
<b>Consumption</b>	7.2	3.5	10.4	6.7	6.9	5.2	5.0	4.6	5.3	1.0
<b>Production</b>	10.6	2.9	10.0	11.2	12.4	8.6	7.4	1.0	4.8	-1.3
<b>Import (Net)</b>	8.5	1.6	11.0	13.4	-2.7	12.7	5.0	1.4	12.6	-11.0
<b>GDP (%)</b>	7.8	0.1	12.0	9.2	6.6	3.8	3.2	2.7	3.7	-9.0

SOURCE: ENERGY STATISTICS OF THAILAND – EPPO (2012)

The total primary energy consumption in 2011 increased by 3.5% from that in 2010, being at a level of 1,845 thousand barrels per day (KBD) of crude oil equivalent. Natural gas accounted for the largest share of the consumption, i.e. 44%, accounting for an increase of 3.3%. Oil consumption was the second largest, holding a share of 37%, or an increase of 3.8%. The consumption of imported coal decreased by 3.4%, but lignite increased by 13.9%. As for hydropower and imported electricity, the demand sharply rose by 48.5% due to increased generation by hydropower plants as well as additional power purchase from Lao PDR. Import of 615 MW of electricity from Nam Ngum 2 project in Lao PDR commenced in March 2011 to compensate natural gas supply shortage during the end of June to early August 2011, caused by leakage of the natural gas transmission pipeline in the Gulf of Thailand. Furthermore, around year-end, there was plentiful supply of water in domestic dam reservoirs

resulting from the occurrence of five storms altogether passing by the country. In addition, Thailand first imported liquefied natural gas (LNG) in May 2011.

In 2012 Thailand's final energy consumption increased by 3.9% from 2011 whereas final alternative energy consumption has grown by 7.6% and energy intensity decreased by 2.4%.

TABLE 4: FINAL ENERGY CONSUMPTION 2012

UNIT: KTOE

Final Energy Consumption	Agriculture	Industry*	Residential	Commercial	Transportation	Total
Coal & its Products	-	5,794	-	-	-	<b>5,794</b>
Petroleum products	3,765	4,070	2,161	1,195	23,996	<b>35,187</b>
Natural Gas	-	2,884	-	2	2,228	<b>5,114</b>
Electricity*	25	7,742	2,735	4,102	6	<b>14,610</b>
Renewable Energy	-	4,882	-	4	-	<b>4,886</b>
Tradition Renewable Energy	-	1,538	6,187	-	-	<b>7,725</b>
Total	3,790	26,910	11,083	5,303	26,230	<b>73,316</b>
Total %	5.2%	36.7%	15.1%	7.2%	35.8%	100.0%

\*Including off grid power generation. / \*\*Including mining, manufacturing and construction

SOURCE: ENERGY STATISTICS OF THAILAND – EPPO (2012)

Out of the 35,187 Ktoe petroleum products, 94.4% were fossil fuels while 3.6% biofuels. Also, out of the 14,610 Ktoe consumed by the electricity generation sector, 81.1% were fossil fuels, 7.8% renewable energies, 6.1% imported hydro power and the remaining 5% from large hydro power.

### 2.3 Renewable Energies and Energy Efficiency

Primary actions and pledges concerning GHG emissions reduction are associated with RE and energy efficiency. The plan to promote RE and energy efficiency became tangible with the establishment of the Energy Conservation (ENCON) Program in 1995. Progress toward RE and energy efficiency is driven by the 10-year Alternative Energy Development Plan (AEDP) and 20-year Energy Conservation Plan.

The ENCON Program is the master plan that lays down the framework for developing RE and improving energy efficiency in Thailand. Since the establishment of the ENCON program in 1995, the program has been revised regularly taking into consideration the recent changes in the energy sector as well as socio-economic conditions in the country. Phase 3 of the Energy Conservation Program has recently been completed, while Phase 4 (2012 - 2016) was approved by the ENCON Fund Committee on 1 March 2012. Phase 3 of the ENCON Program focused on three main

areas:

1. **Renewable/alternative energy utilization** aimed to increase the share of renewable/alternative energy in 2011 to 15.6% of the final energy demand, supplanting about 10,961 ktoe of commercial energy use. The promotion of RE utilization focused on activities such as the promotion of biofuels and RE utilization for power and heat generation, policy studies, technology research and public awareness campaigns to create correct understanding of RE use.
2. **Energy Efficiency Improvement** targeted to increase energy efficiency and hence reduce commercial energy consumption by 10.8%, equivalent to 7,820 ktoe, by 2011. The program involved research and development and support to bring about efficient use of energy in the industrial, transportation as well as household sectors.
3. **Strategic Management Program** focused on policy research and studies to provide recommendations for decision-making pertaining to the improvement of the Renewable Energy Development Program or the Energy Efficiency Improvement Program. The program also supported monitoring and management of the overall ENCON fund to ensure efficient and effective implementation of the ENCON Program.

The Phase 4 (2012 - 2016) of the ENCON Program focuses on the transport industry and other sectors similar to Phase 3. It aims to support projects under the ENCON Act, technical research and development and demonstration and initiation of projects. The total implementation budget for phase 4 is 7.000 million baht per year of which 50% is to be used for energy efficiency improvement program.

In 2011, the Cabinet approved the resolution of the Nation Energy Policy Council (NEPC) calling for the Alternative Energy Development Plan (AEDP 2012 - 2021) and also the 20-Year Energy Efficiency Development Plan 2011 – 2030 (EEDP - 2011 - 2030). The EEDP is complementary to the ENCON program for promoting energy efficiency. The EEDP is targeting on 25% reduction of energy intensity of the country within 20 years (2011 - 2030), resulting in the decrease of power demand projection on account of energy saving programs and energy efficiency promotions.

The following Table 5 and Figure 2 show the Alternative and Renewable Energy shares of Thailand Final Energy Consumption in 2012.

TABLE 5: PERFORMANCE ON ALTERNATIVE AND RENEWABLE ENERGY POLICY - 2012

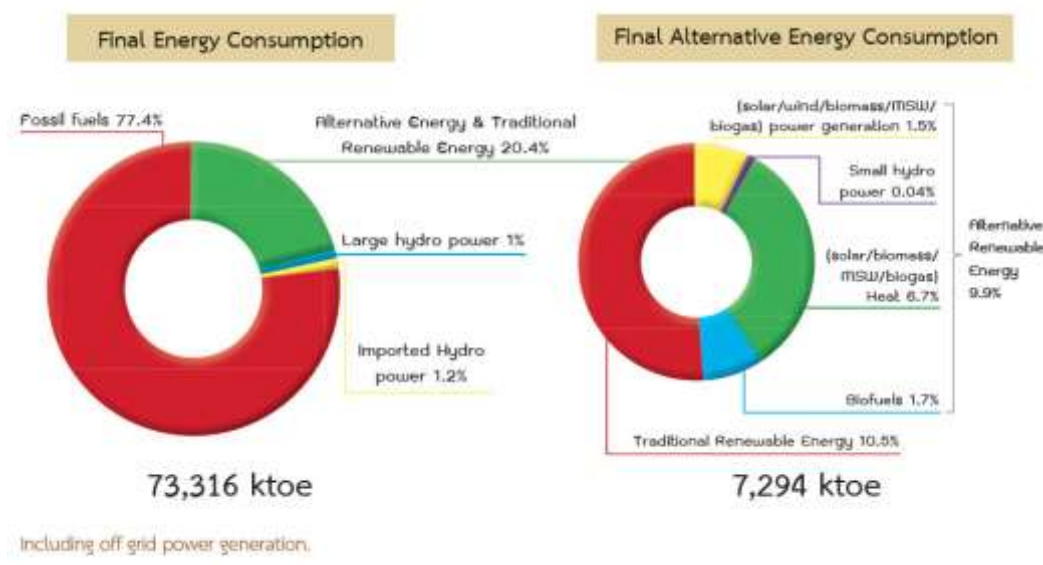
Types of Energy	unit	Target 2021	As of 2012
<b>Electricity</b>	<b>MW</b>	<b>13,927</b>	<b>2,786</b>
	ktoe		<b>1,138</b>
Solar	MW	3,000	376.72



Wind	MW	1,800	111.73
Small Hydro Power	MW	324	101.75
Biomass	MW	4,800	1,959.95
Biogas	MW	3600	193.4
MSW	MW	400	42.72
New Energy	MW	3	-
<b>Heat</b>	<b>ktoe</b>	<b>13,500</b>	<b>4,886</b>
Solar	ktoe	100	4
Biomass	ktoe	12,000	4,346
Biogas	ktoe	1,200	458
MSW	ktoe	200	78
<b>Biofuels</b>	<b>million litre/day</b>	<b>19.2</b>	<b>3.5</b>
	<b>ktoe</b>		<b>1,270</b>
Ethanol	million litre/day	9	1.4
Biodiesel	million litre/day	7.2	2.7
New Fuels	million litre/day	3	-
<b>%AE</b>		<b>25%</b>	<b>9.90%</b>

SOURCE: ENERGY IN THAILAND: FACTS AND FIGURES 2012 - DEDE

FIGURE 2: ALTERNATIVE AND RENEWABLE ENERGY SHARES OF THAILAND FINAL ENERGY CONSUMPTION, 2012



SOURCE: ENERGY IN THAILAND: FACTS AND FIGURES 2012 - DEDE

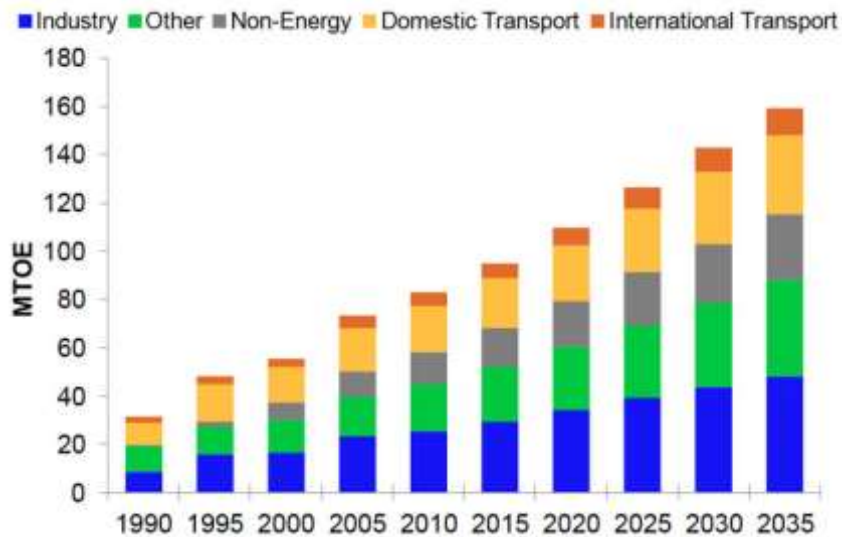
## 2.4 Energy Demand/Supply and CO<sub>2</sub> Emission Projections<sup>24</sup>

Final energy demand is expected to grow under business-as-usual (BAU) assumptions at an average annual rate of 2.6% over the outlook period (a 92% growth in total). In 2035, industry and non-energy use together will account for 48% of the total final

<sup>24</sup> APEC Energy Demand and Supply Outlook – 2013 (5th Edition)

energy demand, while transport will account for 27% and ‘other’ sector demand for 25%, as shown in Figure 3. More than half of the final energy demand will come from oil. Natural gas demand will be the most rapidly growing energy source, at an annual average rate of 4.4% per year from 2010 to 2035.

FIGURE 3: BAU FINAL ENERGY DEMAND

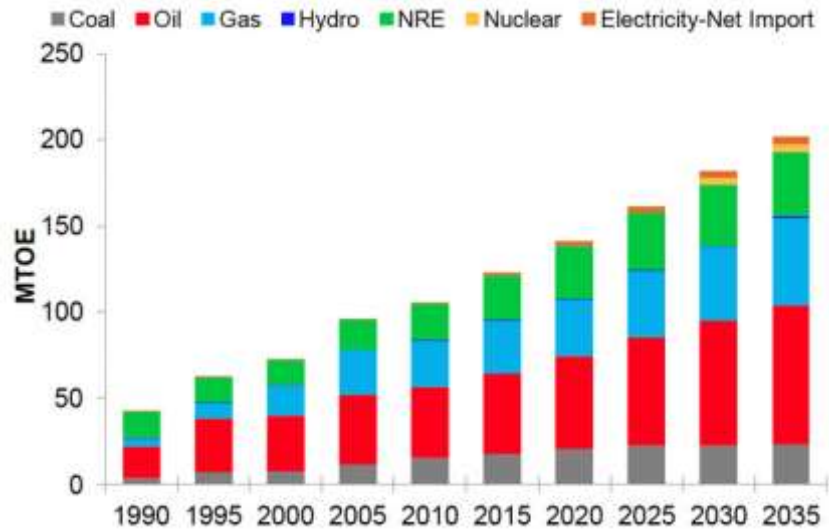


SOURCE: APEC ENERGY DEMAND AND SUPPLY OUTLOOK – 2013 (5TH EDITION)

Thailand’s final energy intensity is expected to decrease by over 25% between 2010 and 2030, and over 35% between 2005 and 2035. This should meet the economy’s own target of 25% energy intensity reduction by 2030, compared to 2010 levels, as set in the Energy Efficiency Development Plan (EEDP).

Under BAU, Thailand’s total primary energy supply is projected to grow at an annual average of 2.6% over the outlook period. Figure 4 below shows that oil and gas will dominate the mix, and in 2035 will account for over 65% of total primary energy supply. New Renewable Energy sources are expected to grow by 77% over the period, and will account for 19% of the 2035 total. In this BAU projection, Thailand will likely introduce nuclear energy into the primary energy fuel mix from 2027 onwards. However, there is still much uncertainty about the future of nuclear in Thailand.

FIGURE 4: BAU PRIMARY ENERGY SUPPLY

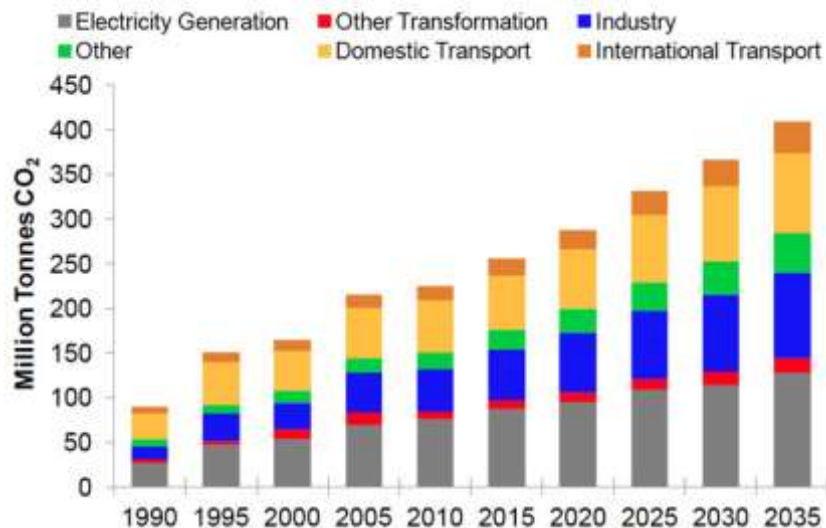


SOURCE: APEC ENERGY DEMAND AND SUPPLY OUTLOOK – 2013 (5TH EDITION)

Over the outlook period Thailand is expected to remain highly dependent on energy imports, particularly for oil. Oil imports are expected to grow at an average annual rate of 3.4%, to 80 Mtoe in 2035. This is to meet the projected demand for oil, especially in the domestic transport and non-energy sectors over the outlook period. Increasing demand for natural gas, especially for electricity generation, and Thailand’s limited gas production will require the economy to increase its gas imports almost four-fold from 7.5 Mtoe in 2009 to 27 Mtoe in 2035. Coal imports are expected to grow at an annual average of 2.3% from 2010 to 2035, mostly serving the industrial sector and electricity generation.

Consequently, Thailand’s level of CO<sub>2</sub> emissions in a BAU scenario is expected to increase, across all sectors, as shown in Figure 5 below. The average annual rate of increase for the whole economy is 2.4%. Electricity generation, industry and domestic transport will be the main contributors.

FIGURE 5: BAU CO<sub>2</sub> EMISSIONS BY SECTOR



SOURCE: APEC ENERGY DEMAND AND SUPPLY OUTLOOK – 2013 (5TH EDITION)

The decomposition analysis in Table 6 shows Thailand’s growth in GDP drives the total change in CO<sub>2</sub> emissions, offset by reductions in CO<sub>2</sub> intensity of energy (fuel switching) and energy intensity of GDP (energy efficiency and industry structure).

TABLE 6: ANALYSIS OF REASONS FOR CHANGE IN BAU CO<sub>2</sub> EMISSIONS FROM FUEL COMBUSTION

	(Average Annual Percent Change)				
	1990-2005	2005-2010	2005-2030	2005-2035	2010-2035
Change in CO <sub>2</sub> Intensity of Energy	0.4%	-1.0%	-0.4%	-0.4%	-0.2%
Change in Energy Intensity of GDP	0.9%	-1.6%	-1.5%	-1.6%	-1.5%
Change in GDP	4.7%	3.6%	4.1%	4.1%	4.3%
Total Change	6.1%	0.9%	2.1%	2.2%	2.4%

SOURCE: APEC ENERGY DEMAND AND SUPPLY OUTLOOK – 2013 (5TH EDITION)

Under business-as-usual assumptions, Thailand’s final energy demand will double within the next 25 years, and with its limited resources, the economy will likely remain a net energy importer to meet its increasing energy demands. The BAU scenario also indicates Thailand’s high dependency on fossil fuels will likely result in the further increase of CO<sub>2</sub> emissions and environmental pollution.

To improve energy security and alleviate the climate change problem, the economy is actively pursuing initiatives in biofuels and natural gas for vehicles, and nuclear and RE in the power sector, as well as diversifying its imported energy resources. The economy already has a 20-year Energy Efficiency Development Plan 2011–2030 in place—this should accelerate energy efficiency and conservation measures in the economy, with the result of reducing energy intensity by 25% from 2010 to 2030.

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### 3. Policy and Planning for Low carbon Development / Statistics and Monitoring

#### 3.1 Policy and Planning

Thailand's energy policy aims at implementing sustainable energy management, so the economy has sufficient energy to meet its needs. Currently, it is based on these five strategies:

- Energy security
- Promoting the use of indigenous energy resources including renewable and alternative energy
- Monitoring energy prices and ensuring prices are at competitive levels and appropriate for the wider economic and investment situation
- Effectively promoting energy conservation and efficiency
- Supporting energy development domestically and internationally while simultaneously protecting the environment

Thailand's energy policy also seeks to build an energy self-sufficient society; achieve a balance between food and energy security; build a knowledge-based society; promote Thailand's role in the international arena; and enhance economic links with other economies in the region to facilitate harmonious cooperation in energy and other sectors.

To improve energy security, Thailand's government has adopted a range of comprehensive measures covering the oil, gas and electricity sectors. The policy development includes comprehensive and careful study of nuclear energy as another option for increasing the stability of the economy's future electricity supply. According to the original Power Development Plan 2010 (PDP 2010), the Electricity Generating Authority of Thailand (EGAT) has estimated that nuclear power could contribute up to 10% of the economy's total electricity generation from 2023. However, public acceptance of nuclear energy is a major challenge in Thailand, and an effective communication strategy will be needed to reduce the public's fear of nuclear power and increase recognition of the benefits it would offer to the community. The latest version of the PDP 2010 (Version #3) released in June 2012 reflects this sentiment, and limits the share of nuclear to less than 5% of total generation capacity.

The same revision of PDP 2010 stipulates that Thailand's reserve margin should not be less than 15% of peak power demand and reduces the allowable share for foreign power purchase from neighboring countries from 25% to 15% of total generating capacity.

The Renewable and Alternative Energy Development Plan (2012–2021) sets a framework for Thailand to increase the share of renewable and alternative energy to

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25% of total energy consumption by 2021. The plan states that the Thai government will encourage the use of indigenous resources including renewable and alternative energy (particularly for power and heat generation), and supports the use of transport biofuels such as ethanol-blended gasoline (gasohol) and biodiesel. The plan also strongly promotes community-scale alternative energy use, by encouraging the production and use of RE at a local level, through appropriate incentives for farmers. It also rigorously and continuously promotes research and development of all forms of RE.

Thailand has also adopted a 20-year Energy Efficiency Development Plan 2011–2030 (EEDP). This plan sets a target of 25% reduction in the economy's energy intensity by 2030, compared to 2005 levels. In 2011, the EEDP targets were revised to meet the new target declared by APEC Leaders at the APEC Summit 2011. Thailand now aims to achieve a 25% reduction of energy intensity by 2030, compared with 2010 levels. The focus for energy efficiency measures is on transport and industry sectors. If the energy conservation measures can be successfully implemented, energy elasticity (the percentage change in energy consumption to achieve a 1% change in the economy's GDP) will be reduced from an average of 0.98 in the past 20 years to 0.7 in the next 20 years. Implementation of the EEDP could result in cumulative final energy savings of about 289 000 ktoe by 2030 (or an average of 14 500 ktoe per year), and avoided CO<sub>2</sub> emission of 976 million tons (EPPO, 2011).

### 3.2 Statistics and Monitoring of CO<sub>2</sub>

The Energy Policy and Planning Office (EPPO) acts as the coordinating and central implementing agency involving both directly and indirectly various government agencies, state enterprises and the private sector. It is responsible for the formulation of national energy policies, energy management and development plans. Among its responsibilities, EPPO is in charge of providing energy statistics.

EPPO calculates the amount of CO<sub>2</sub> emissions based on the energy use in Thailand. It is calculated from the amount of energy consumption and the CO<sub>2</sub> emission factor by fuel type, with reference to the estimation methodologies and CO<sub>2</sub> emission factors prescribed in the 2006 Guidelines of the Intergovernmental Panel on Climate Change (IPCC), using the following calculation formula:

$$\text{CO}_2 \text{ Emission} = \Sigma(\text{EFFuel} \times \text{FCFuel})$$

Where:

CO<sub>2</sub> Emission means the amount of CO<sub>2</sub> emission from energy consumption

EFFuel (Emission Factor) means the CO<sub>2</sub> emission coefficient of each fuel type

FCFuel (Fuel Consumption) means the amount of utilization of each fuel type

The scope of the above-mentioned CO<sub>2</sub> emission calculation covers energy consumption in four major economic sectors, namely: power generation, transportation, industry and other economic sectors (covering the residential, agricultural and commercial sectors). As for the fuel types used in the calculation, they are divided into three types, namely: petroleum products (calculated from consumption of gasoline, diesel, fuel oil, LPG, jet petroleum and kerosene), natural gas and coal/lignite. Certain types of fuel are not included in the calculation, i.e. bunker oil for international ocean liners, jet petroleum for international flights, and renewable fuels, such as biomass, biogas, ethanol, biodiesel and hydropower, to be in line with the exceptions to the calculation and to avoid the possibilities of double counting prescribed by the IPCC.

The following Table 7 shows the CO<sub>2</sub> emission from energy consumption by sector in Thailand:

TABLE 7: CO<sub>2</sub> EMISSION FROM ENERGY CONSUMPTION BY SECTOR

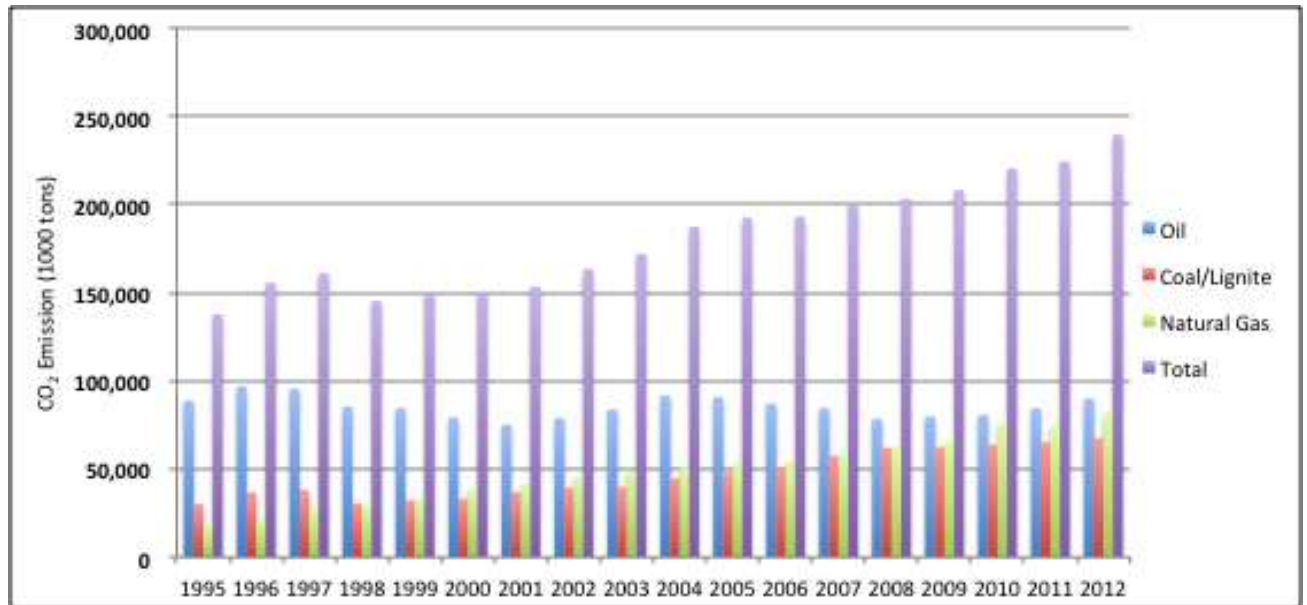
UNIT: 1,000 TONS

	Power Generation	Transport	Industry	Other	Total	Growth Rate
1995	49,014.06	48,210.82	31,030.68	9,436.11	137,691.67	12.06
1996	56,887.38	52,710.65	35,211.04	10,744.09	155,553.15	12.97
1997	61,241.88	55,235.11	33,717.82	10,862.73	161,057.54	3.54
1998	57,973.97	46,741.34	27,745.59	12,884.44	145,345.34	(9.76)
1999	59,658.57	46,892.62	29,454.96	13,773.95	149,780.10	3.05
2000	62,405.28	45,559.69	29,266.93	13,494.84	150,726.74	0.63
2001	62,748.58	46,536.65	30,338.02	13,838.97	153,462.22	1.81
2002	65,265.27	49,245.40	34,351.98	14,609.10	163,471.75	6.52
2003	67,884.03	53,002.59	35,478.44	15,590.93	171,956.00	5.19
2004	74,098.52	56,546.03	40,320.51	16,370.73	187,335.79	8.94
2005	76,893.12	57,520.14	42,599.19	15,473.96	192,486.41	2.75
2006	81,028.45	54,831.18	41,056.60	16,219.54	193,135.78	0.34
2007	84,080.42	55,571.15	43,769.83	17,017.47	200,438.86	3.78
2008	85,159.55	52,538.01	48,059.51	17,437.74	203,194.80	1.37
2009	83,231.42	56,379.96	50,684.69	17,905.96	208,202.02	2.46
2010	89,965.05	57,587.14	54,172.94	18,657.74	220,382.87	5.85
2011	87,816.07	59,215.34	57,477.07	19,873.34	224,381.81	1.81
2012	95,928.69	63,145.53	58,587.51	21,927.24	239,588.96	6.78

SOURCE: ENERGY STATISTICS OF THAILAND - EPPO (2013)

FIGURE 6: CO<sub>2</sub> EMISSIONS BY ENERGY TYPE





Source: Energy Statistics of Thailand - EPPO (2013)

While CO<sub>2</sub> emission statistics are calculated by EPPO, monitoring of CO<sub>2</sub> emissions is in the hands of the Office of Natural Resources and Environmental Policy and Planning (ONEP) under the Ministry of Natural Resources and Environment. ONEP develops and proposes the natural resources and environmental enhancement and conservation management plan and policy. The office uses the Environmental Impact Assessment (EIA) report process to implement, coordinate and monitor development projects. This aims at strengthening the national economy, promoting sustainable development and enhancing quality of life. Details are listed below:

- Develop natural resources and environment conservation and administrative management plans;
- Coordinate and develop natural resources and environment management plans in compliance with the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992) and other related laws. This includes coordinating practical implementation;
- Study, analyze, coordinate and develop measures for the proclamation of environmentally sound natural resources and environment protection areas;
- Monitor, inspect and measure performance through policy, plans and measures and prepare the environmental quality situation report;
- Analyze the environmental impacts which may be arisen from government or private projects which have potential to damage environmental quality;
- Administrate the environment fund efficiently to support natural resources and environment management policy and plans at all levels;
- Propose recommendations for policy and guideline development on land management, land possession planning, land preservation and development for public allocation and public land preservation and prohibition;



- 
- Cooperate with foreign countries and international organizations in the implementation of natural resources and environment conservation and administrative management policies and plans; and
  - Perform other functions, as required by law, observing the authority and duty of the Office of the Natural Resources and Environment Policy and Planning or as designated by the Ministry or the Cabinet.

#### 4. Low Carbon Development Initiatives in Thailand

In Thailand there are no specific low-carbon green development indicators. However, the indicators are defined under the broad development indicators—the sustainable development indicators. These indicators are formulated by the Office of National Economic and Social Development Board (NESDB) and Thailand Environment Institute (TEI), and economic, social, and environmental dimensions were taken into account. Table 8 summarizes the 39 indicators.

TABLE 8: THAILAND’S SUSTAINABLE DEVELOPMENT INDICATORS

Objectives	Indicators
<b>Economic Dimension</b>	
<i>Quality</i>	1. Total factor productivity of each sector
	2. Ratio of energy consumption to GDP
	3. Renewable energy utilization
	4. Waste reutilization and recycling
	5. Organizations having environmental management system and products having green label
<i>Stability</i>	6. Unemployment rate
	7. Current account per GDP
	8. Short-term external debt per national reserve
	9. Public debt per GDP
<i>Equality</i>	10. Gini coefficient
	11. Poverty incidence
	12. Gap between the highest and the lowest income quintile
<b>Social Dimension</b>	
<i>Human development and adjustment to a knowledge-based society</i>	1. Average year of education
	2. Test score from four major subjects
	3. Percent of investment in research and development per GDP
<i>Quality of life and life security</i>	4. Life expectancy at birth
	5. Percent of people with major illnesses
	6. Percent of people with access to tap water
	7. Percent of losses (life and assets) from fires and floods
<i>Community development and cultural immunity</i>	8. Ratio of crime and drug cases to total population
	9. A number of activities for supporting, conserving, and disseminating arts and culture
<i>Equity and participation</i>	10. Human rights violations by the government
	11. Ratio of female to male members in local government
	12. Corruption
	13. Ratio of communities having community development plans to total communities
<b>Environmental Dimension</b>	
Conservation	1. Percent of forest area
	2. Percent of mangrove compared to the past
	3. Economic marine animals being captured per hour

	4. Marine fauna (in the protected areas) for endangered species
	5. Ratio of usable surface water quantity to the total quantity of surface water, and ratio of groundwater used to total groundwater quantity
Good environmental quality	6. Ratio of water resources meeting minimum acceptable quality standards to total water resources
	7. Infertile land
	8. Air quality in main cities exceeding the standards
	9. Ratio of treated hazardous waste
	10. Chemicals used in agriculture
	11. Proportion of green areas in cities
Participation and resource allocation	12. A number of networks for conserving natural resources and environment
	13. Quantity of GHG emissions
	14. Quantity of ozone-depleting substances

SOURCE: ADBI WORKING PAPER SERIES: DEVELOPMENT TRAJECTORY, EMISSION PROFILE, AND POLICY ACTIONS: THAILAND (2012)

From the set of indicators, key issues for achieving green and low-carbon development are included, such as energy consumption, RE, research and development, forest conservation, resource efficiency, and GHG emissions.

#### 4.1 Vision, Missions, Objectives and Targets of the Eleventh Plan (2012-2016)

The Eleventh National Economic and Social Development Plan (2012-2016) is an indicative medium-term strategic plan aimed at achieving the vision of the year 2027 which was set out by all parties in Thai society, that is: ***“Thai people are proud of their national identity, in particular hospitality. They also follow the path of Sufficiency Economy with democratic values and good governance. Quality public services are provided throughout the country. Thai people live in a caring and sharing society in a safe and sound environment. Production process is environmentally friendly, and food and energy resources are secure. The economy is based on self-reliance and increasing linkages and competitiveness on the global market. Thailand actively contributes to the regional and world communities with dignity.”***

To achieve its vision, the 11<sup>th</sup> Plan sets several missions. Among those missions, Thailand aims at enhancing the efficiency of production and services based on local wisdom, knowledge, innovation and creativity by developing food and energy security, reforming the structure of the economy and consumption to be environmentally friendly, and strengthening relations with neighboring countries in the region for economic and social benefits. Securing natural resource and environmental base by supporting community participation and improving resilience to cushion impacts from climate change and disasters is also part of the Thailand’s missions. Such missions are supported by setting the following objectives:

- To develop efficient and sustainable economy by upgrading production and services based on technology, innovation and creativity with effective regional linkages, improving food and energy security, upgrading eco-friendly production and consumption toward a low-carbon-society
- To preserve natural resources and environment to be sufficient for maintaining the ecology and a secure foundation of development

The main target is to make sure that environmental quality is improved to meet international standards, that reduction of green house gas emission is more efficient, and finally that forest areas have been expanded for a more balanced ecological system. Key indicators such as quality of water and air, the proportion of conservation forest areas to total land area, and ratio of green house gas emissions per capita to GDP will be used to quantify the objective and targets set by the 11<sup>th</sup> Plan.

## 4.2 Development Strategies

The Eleventh National Economic and Social Development Plan (2012-2016) also sets development strategies, one of which is to shift the development paradigm and steer the country toward an environmentally sustainable, low-carbon economy and society. In order to achieve this strategy the 11<sup>th</sup> Plan prescribes a set of guideline:

- **Restructure production sectors toward an environmentally sound low-carbon economy:** Upgrade industries that have emitted high levels of greenhouse gases toward environmentally safe technology by providing low-interest loans and tax incentives; Revise of industrial promotion policies; accelerate domestic mitigation mechanisms that foster sustainable development; Encourage coexistence of industries with communities through eco-industrial towns where most wastes can be recycled and raw materials managed systematically; Encourage sustainable agriculture to support the ecosystem; Businesses with high potential and services with low environmental impact should be expanded; Create market opportunities for environmentally beneficial products and services
- **Increase energy efficiency in the transport sector to reduce GHG emissions:** Encourage people to alter their traveling patterns and freight shipments by using transportation systems that use less energy per unit than road transport. Public transportation networks should be developed to reduce energy use in order to attain greater efficiency throughout the country; Support the use of vehicles that use clean or RE such as natural gas and biofuel; Poor driving behavior and excessive speed should be curtailed to reduce fuel consumption.

- 
- **Develop environmentally friendly cities with emphasis on integrated urban planning having cultural, social and ecological aspects:** Develop compact urban designs where areas are used creatively, with emphasis on the expansion of green spaces and increased energy efficiency; Utilize tax support and other incentives to redirect technology and materials toward RE; Supervise intensive land use both inside and beyond cities and establish measures to curb urban sprawl; Manage an integrated urban environment by using innovative technology for wastewater and solid waste management, using the 3R principles (reduce, reuse, and recycle).
  - **Modify consumption behavior to facilitate the transition to a low carbon and environmentally stable society:** Encourage people from all sectors to be responsible for their ecosystems by applying the Philosophy to their way of life in order that Thailand becomes a model of an environmentally sustainable society; Undertake a campaign to change attitudes to create an understanding of the value of sustainable consumption as the norm in the society; Publicize information and transfer knowledge to people about the environment and sustainable consumption so as to enhance their ability to choose environmentally desirable products and services; Strengthen consumer protection mechanisms and support networks, media, advertising and public relations to redirect society toward sustainable consumption.

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## 5. Low Carbon Model Town Project

Low Carbon Model Town (LCMT) 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.

The APEC Low-Carbon Model Town (LCMT) Project seeks to promote low-carbon technologies in city planning in order to manage rapidly growing energy consumption and GHG emissions in urban areas of the APEC region. The key objectives of the project are;

- To develop “The Concept of the Low-Carbon Town in the APEC Region”, which is intended to be a guidebook to the principles and implementation of low-carbon design;
- To assist in the implementation of the concepts in selected towns by providing feasibility studies and policy reviews of these planned urban development projects;
- To share best practices and real-world experiences of low-carbon design with planners and policymakers throughout the APEC

### 5.1 Samui Island

The Samui Green Island Project aims to reduce CO<sub>2</sub> emissions as well as reduce and reuse solid waste and treated wastewater for non-sanitary purposes. The project has developed a comprehensive strategy to meet these goals that includes reducing CO<sub>2</sub> emissions in the transportation and building (both residential and commercial) sectors through public awareness campaigns, planning and engineering techniques, and advances in technology.

It was estimated during a previous feasibility study (2006) that energy supply/demand side management alone could avoid the release of more than 80,000 CO<sub>2</sub> per year. However, that target must be re-evaluated in light of current trends, such as increased private transportation, and the construction of additional tourist facilities.

New estimates for potential CO<sub>2</sub> reduction have been estimated at 20 – 30 % in the year 2030 (over 2010) for a savings of between 120,000 – 180,000 tones CO<sub>2</sub> per year. Potential projects for CO<sub>2</sub> reduction are:

- reduction in energy use in homes and commercial buildings

- 
- reduction from fuel switching either to bio-diesel or Compressed Natural Gas (CNG) in ferry transportation
  - reduction from the implementation of public transport, including EV buses
  - reduction from the implementation of district cooling
  - reduction from the implementation of RE, along with recovery of waste heat
  - reduction from the introduction of LED street lighting
  - reduction from the reduced amount in landfill and methane (CH<sub>4</sub>) fermentation

In addition to reducing CO<sub>2</sub> emissions, the plan for the Samui Green Island Project to be a “Clean and Green Development” calls for sorting solid waste to avoid sending it to the landfill, reusing treated wasted water for non-sanitary purposes, and promoting the development of open, green spaces in an effort to attract tourist activity. Furthermore, the introduction of sidewalks and bicycle lanes along the beach will increase the island’s attractiveness to tourists, while improving quality of life for the island’s residents.

## 5.2 Muang Klang

The Muang Klang Low Carbon Town project, an initiative of the municipal mayor, Somchai Chariyacharoen, has launched a comprehensive program including solid waste reduction, water and air quality improvement programs, implementation of natural gas vehicles, and overall quality of life improvement programs.

By 2020, Muang Klang aims to be a green, sustainable and low carbon city with low levels of waste, high energy efficiency and sustainable levels of consumption. Muang Klang also aims to be a learning center for Low Carbon Cities for other local governments within Thailand as well as the Greater Mekong region.

To achieve Muang Klang’s vision of becoming a sustainable low-carbon city, the knowledge of municipal officers and community leaders on low carbon city development needs to be strengthened rapidly. In parallel, continuous efforts need to be invested to raise the awareness of the public, particularly women and youth groups. The ASEAN ESC Model Cities program will support targeted training activities building on the municipality’s existing efforts in low carbon development and urban agriculture.

Specific goals have been set for the Muang Klang project as follows:

- Increase the sustainable green area by 20 sq.m. per capita by 2015 and 30 sq.m. per capita by 2020
- Decrease waste generation to less than 1 kg per capita
- Increase the pre-landfill waste sorting capacity by at least 20%

- 
- Increase food production from utilizing locally produced compost by 10% and intensify the campaign for urban agriculture



## 6. Low carbon Indicators

The APEC project (*Establishing Low Carbon Energy Indicators for Energy Strategy Study in APEC Low Carbon Town*) carried out by the Zhejiang Energy and Radiation Institute, has build up a Low Carbon Energy Indicators system as an effective tool to assess and guide low carbon energy development for APEC Low Carbon Town Development. In the case of this report, this indicator system was used to probe the case of Thailand.

Indicators where initially calculated for the whole territory of Thailand. When available, the indicators were also calculated for Samui Island (see 6.2). The Indicators that were used are the following:

- CO<sub>2</sub> emission per unit of GDP (emission intensity) (Ton CO<sub>2</sub>/Million Baht)
- CO<sub>2</sub> emission per unit of land (emission density) (Ton CO<sub>2</sub>/Sq. Km)
- Industrial ratio in total end-use energy consumption (%)
- Natural gas ratio in total primary energy supply (%)
- Renewable energy and hydro composition ratio (%)
- Industrial EC per unit of industrial added-value (Kgoe/1000 Baht)
- Public buildings EC per number of employees of the tertiary industry (Kgoe/Employee)
- Residential buildings EC per household (Kgoe/household)
- Road transportation EC per unit of land area (Kgoe/Sq. Km)

### 6.1 Thailand

The following indicators have been calculated for Thailand. When available, historical data is given between 1995-2010:

#### CO<sub>2</sub> emission per unit of GDP (emission intensity)

TABLE 9: CO<sub>2</sub> EMISSION<sup>25</sup> PER UNIT OF GDP (UNIT: TON CO<sub>2</sub>/MILLION BAHT)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>CO<sub>2</sub> Emission / GDP In Constant prices 2005</b>	24.7	26.3	27.8	27.7	27.7	26.6	26.5	27.0	26.8	27.5	27.1	25.9	25.3	25.3	26.1	26.0

SOURCE: CALCULATED BY CEERD (2013) FROM NESDB AND EPPO STATISTICS (1995 - 2010)

<sup>25</sup> Notes: 1 - CO<sub>2</sub> emission factors reference from IPCC 2006

2 - Emission estimation excluded bunker oil for oversea, jet oil for international flight and renewable energy

FIGURE 7: CO<sub>2</sub> EMISSION PER UNIT OF GDP - INDEX



SOURCE: CALCULATED BY CEERD (2013) FROM NESDB AND EPPO STATISTICS (1995 - 2010)

Overall CO<sub>2</sub> emissions have increased by 60.1% between 1995 and 2010 and closely follow the growth pattern of the GDP in the same period. As a consequence, CO<sub>2</sub> emission Intensity (per unit of economic output) increased by 5.3% during the same period. This implies that CO<sub>2</sub> emissions and GDP growth are still closely coupled as shown in Figure 7.

**CO<sub>2</sub> emission per unit of land (emission density)**

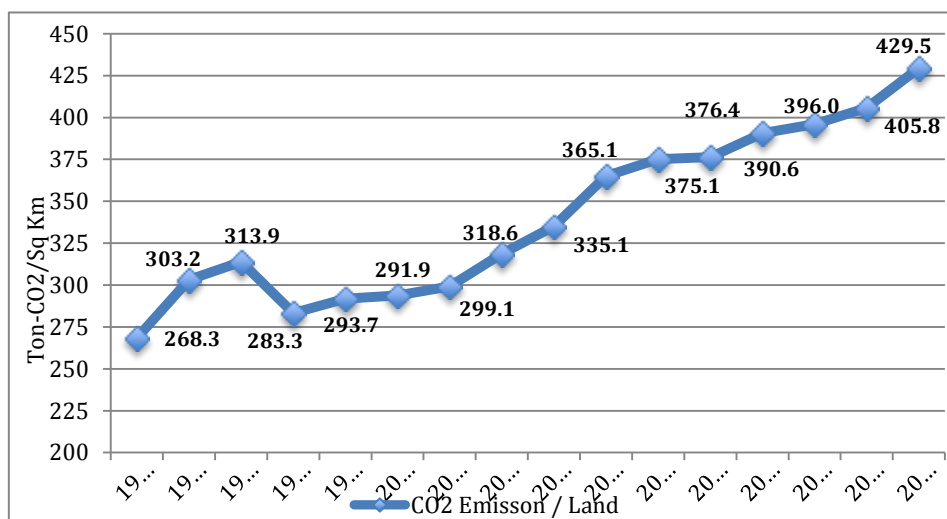
TABLE 10: CO<sub>2</sub> EMISSION<sup>26</sup> PER UNIT OF LAND (UNIT: TONS CO<sub>2</sub>/SQ KM)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>CO<sub>2</sub> Emission / Land</b>	268.3	303.2	313.9	283.3	291.9	293.7	299.1	318.6	335.1	365.1	375.1	376.4	390.6	396.0	405.8	429.5

SOURCE: CALCULATED BY CEERD (2013) FROM NSO AND EPPO STATISTICS (1995 - 2010)

FIGURE 8: CO<sub>2</sub> EMISSION PER UNIT OF LAND

<sup>26</sup> See footnote 3



SOURCE: CALCULATED BY CEERD (2013) FROM NSO AND EPPO STATISTICS (1995 - 2010)

Overall CO<sub>2</sub> emissions in Thailand increased by over 60.1% between 1995 and 2010 with a slight decreased in 1997, consequence of the Asian economic crisis. The country land area size being constant, CO<sub>2</sub> emission per unit of land has increased at the same rate than the overall CO<sub>2</sub> emission of the country, as shown in Figure 8.

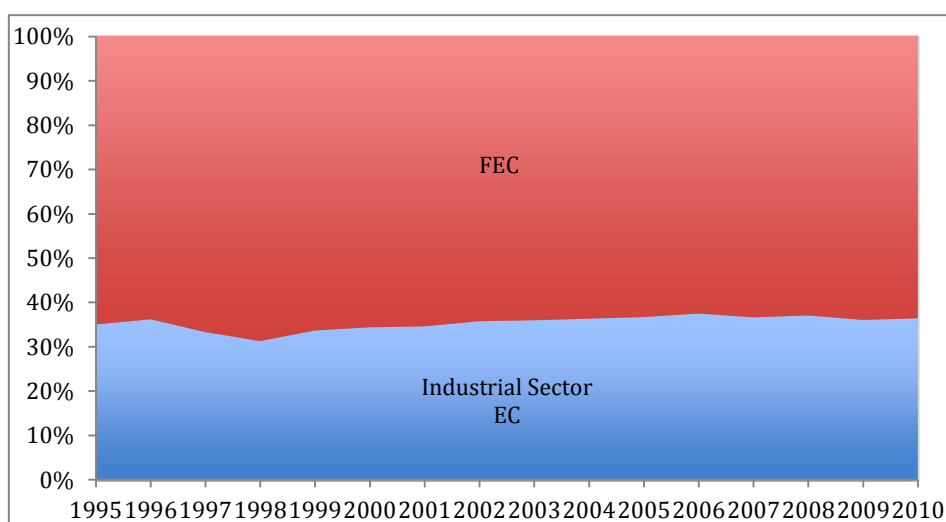
**Industrial ratio in total end-use energy consumption**

TABLE 11: INDUSTRIAL SECTOR EC IN FINAL ENERGY CONSUMPTION (UNIT: %)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Industrial Sector EC / FEC</b>	35.1	36.2	33.3	31.3	33.7	34.4	34.6	35.7	36.0	36.3	36.7	37.5	36.7	37.1	36.1	36.4

SOURCE: CALCULATED BY CEERD (2013) FROM DEDE STATISTICS (1995 - 2010)

FIGURE 9: INDUSTRIAL SECTOR EC IN TOTAL ENERGY CONSUMPTION



SOURCE: CALCULATED BY CEERD (2013) FROM DEDE STATISTICS (1995 - 2010)

On one hand, Thailand's Final Energy Consumption (FEC) has increased by 53.6% between 1995 and 2010, and on the other hand, the Industrial Sector Energy Consumption (EC) increased by 59.4% during the same period. As a consequence, its share in the FEC remained overall constant with a slight increase of 3.8% during the same period, as shown in Figure 9.

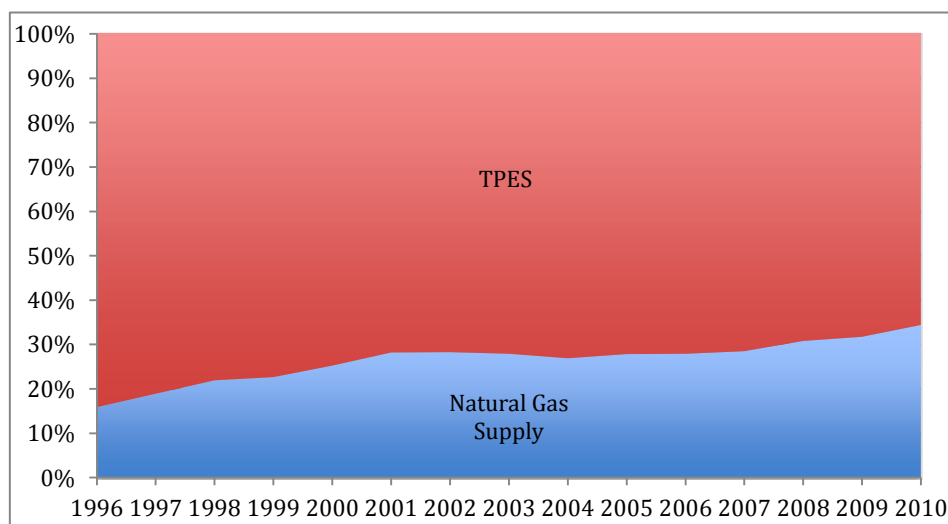
**Natural Gas ratio in total primary energy supply**

TABLE 12: NATURAL GAS SUPPLY IN TOTAL PRIMARY ENERGY SUPPLY (UNIT: %)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Natural Gas supply / TPES</b>	n/a	15.9	18.9	22.0	22.7	25.3	28.2	28.3	27.9	26.9	27.8	28.0	28.5	30.8	31.7	34.4

SOURCE: CALCULATED BY CEERD (2013) FROM DEDE STATISTICS (1995 - 2010)

FIGURE 10: NATURAL GAS SUPPLY IN TOTAL PRIMARY ENERGY SUPPLY



SOURCE: CALCULATED BY CEERD (2013) FROM DEDE STATISTICS (1995 - 2010)

The discovery of domestic natural gas reserves in the 1970's was considered to be the major factor in the increase of natural gas share in the Thai power industry. Natural Gas has had a major impact in the energy structure of the country. In terms of natural gas utilization, the power sector consumes approximately 70% of the total supply, followed by the industrial and transportation sectors respectively<sup>27</sup>. Between

<sup>27</sup> A Study On Fuel Options For Power Generation In Thailand, Weerin Wangjiraniran and Bundhit

1995 and 2010, natural gas has steadily increased its share in the Total Primary Energy Supply (TPES), reaching 34% share in 2010. This represents a 116.5% increase since 1996, as shown in Figure 10.

**Renewable energy and hydro composition ratio**

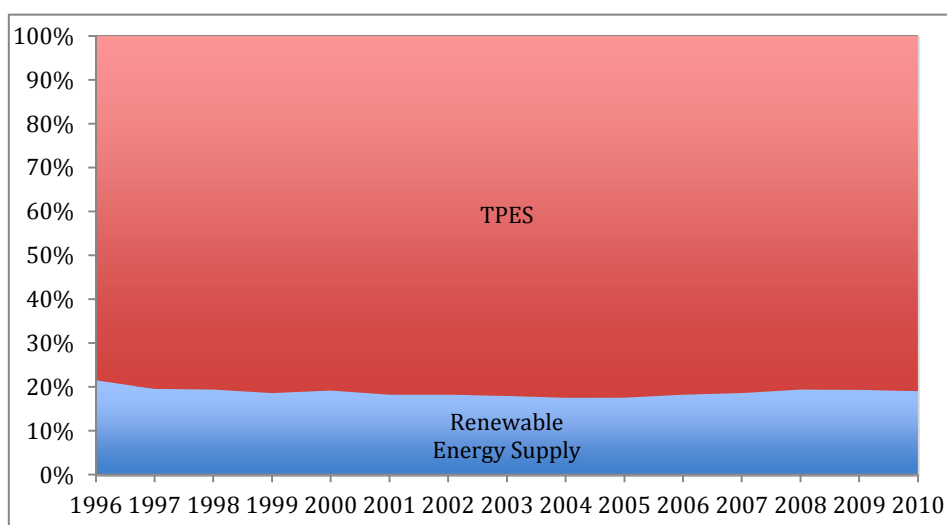
TABLE 13: RENEWABLE ENERGY AND HYDRO SUPPLY IN TOTAL PRIMARY ENERGY SUPPLY (UNIT: %)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Renewable and Hydro / TPES</b>	n/a	21.6	19.6	19.4	18.6	19.2	18.2	18.3	18.0	17.6	17.7	18.3	18.6	19.4	19.4	19.1

SOURCE: CALCULATED BY CEERD (2013) FROM DEDE STATISTICS (1995 - 2010)

(SEE NEXT PAGE)

FIGURE 11: RENEWABLE ENERGY AND HYDRO SUPPLY IN TOTAL PRIMARY ENERGY SUPPLY



SOURCE: CALCULATED BY CEERD (2013) FROM DEDE STATISTICS (1995 - 2010)

Renewable Energy Supply (including Hydro and Biofuels) increased by an overall of 51.8% between 1996 and 2010 while its share in the TPES remained stable at an average of 18.9%, but with a slight increase in the last years of the period, as shown in Figure 11. Significant efforts have been done in the past and are being made by the Thai Government to increase the share of Renewable Energy in the energy supply. The introduction of Biofuels since 2006 partly reflects those efforts.

**Industrial energy consumption per unit of industrial added-value**

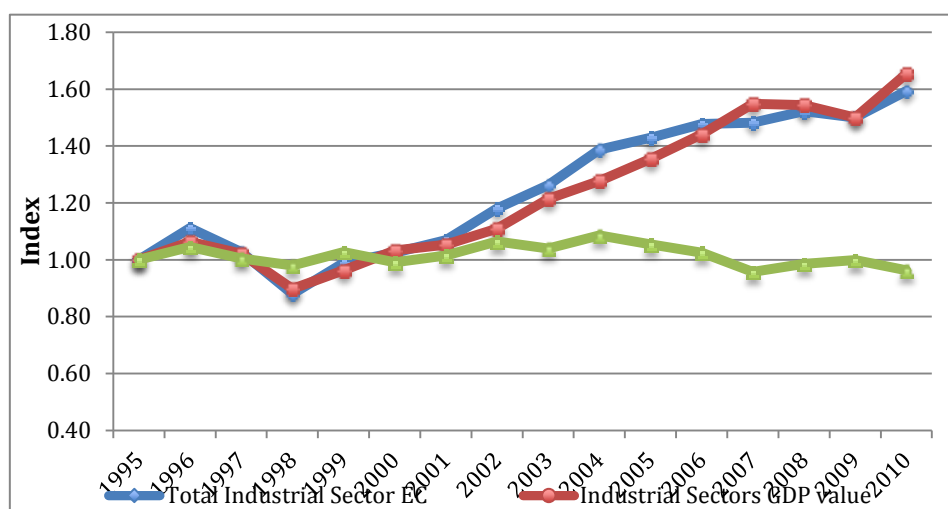
Euaarporn, Energy Research Institute, Chulalongkorn University (July 2010)

TABLE 14: INDUSTRIAL SECTOR EC PER UNIT OF INDUSTRIAL ADDED-VALUE (UNIT: KGOE/1000 BAHT)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Industrial Sector EC / unit of industrial added-value</b>	7.50	7.84	7.54	7.35	7.71	7.44	7.61	7.98	7.80	8.15	7.91	7.69	7.18	7.40	7.50	7.23

SOURCE: THAILAND ENERGY STATISTICS – DEDE (1995 - 2010)

FIGURE 12: INDUSTRIAL SECTOR EC PER UNIT OF INDUSTRIAL ADDED-VALUE - INDEX



SOURCE: THAILAND ENERGY STATISTICS – DEDE (1995 - 2010)

The Industrial Sector EC has increased by 59.4% between 1995 and 2010, following closely the Industrial added value growth. As a consequence, the industrial energy intensity (energy consumption per unit of industrial added-value) has slightly decreased by 3.7% within the same period. This shows that the industrial sector has been progressively consuming less energy per unit of added value, as shown in Figure 12. However, further analysis need to be done to determine if the decrease of the Industrial Energy Intensity is due to Energy Efficiency improvement.

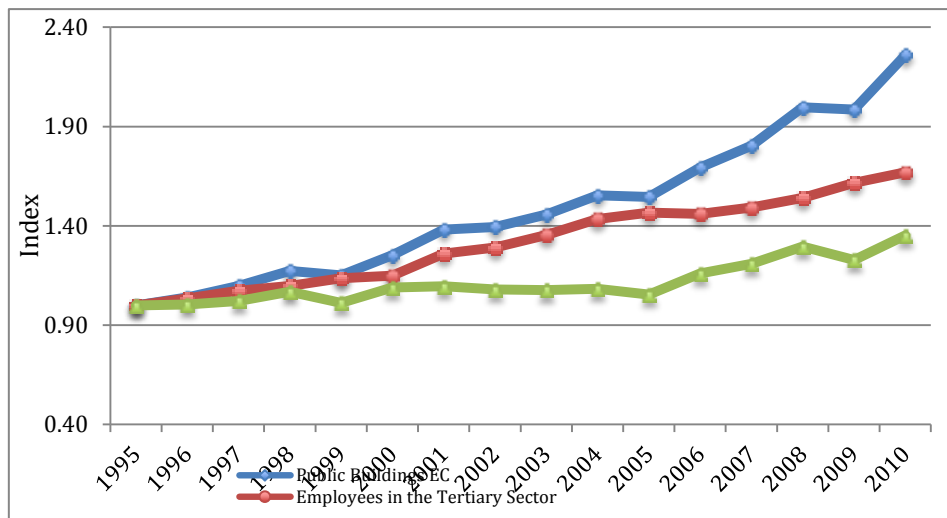
**Energy Consumption of public buildings / number of employees of the tertiary industry**

TABLE 15: PUBLIC BUILDINGS EC PER NUMBER OF EMPLOYEES OF THE TERTIARY INDUSTRY (UNIT: KGOE/EMPLOYEE)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Public Buildings EC / Employees</b>	0.27	0.27	0.27	0.28	0.27	0.29	0.29	0.29	0.29	0.29	0.28	0.31	0.32	0.35	0.33	0.36

SOURCE: CALCULATED BY CEERD (2013) FROM NSO AND DEDE STATISTICS (1995 - 2010)

FIGURE 13: PUBLIC BUILDINGS EC PER NUMBER OF EMPLOYEES OF THE TERTIARY INDUSTRY - INDEX



SOURCE: CALCULATED BY CEERD (2013) FROM NSO AND DEDE STATISTICS (1995 - 2010)

Public Buildings EC has increased at an average of 5.7% per year or a total of 125.9% between 1995 and 2010. The numbers of employees in the tertiary sector has increased by 67% during the same period, consequently affecting the EC in public buildings per employee, as shown in Figure 13. This seems to indicate that more energy is being consumed per employee in the Public Building sector (probably due to increased use of air conditioning) and that energy efficiency measures certainly need to be promoted and achieved in this sector.

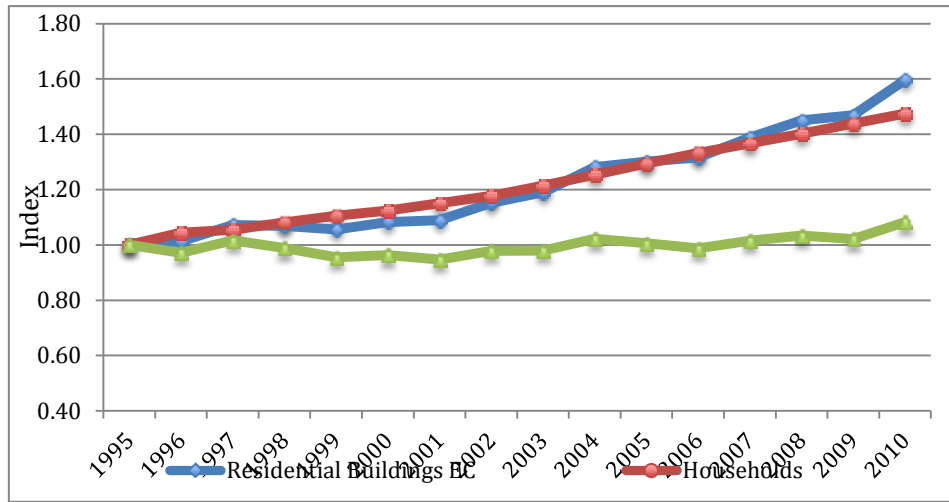
**Energy Consumption of residential buildings per household**

TABLE 16: RESIDENTIAL BUILDINGS EC PER HOUSEHOLD (UNIT: KGOE/HOUSEHOLD)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Res. Bld. EC / Household</b>	0.47	0.45	0.47	0.46	0.45	0.45	0.44	0.46	0.46	0.48	0.47	0.46	0.47	0.48	0.48	0.51

SOURCE: CALCULATED BY CEERD (2013) FROM DOPA AND DEDE STATISTICS (1995 - 2010)

FIGURE 14: RESIDENTIAL BUILDINGS EC PER HOUSEHOLD - INDEX



SOURCE: CALCULATED BY CEERD (2013) FROM DOPA AND DEDE STATISTICS (1995 - 2010)

Residential Buildings EC increased by 59.7% between 1995 and 2010, following closely the number of Households growth. Consequently, the residential buildings EC per household only increased by 8.3% during the same period, as shown in Figure 14. This shows that the EC of the Residential Sector has not changed much in the period of study; however, since 2007, the Household Sector seems to be showing a clear pattern of increasing EC, due most probably to an increased use of electrical appliances, and more particularly of air conditioning. Further detailed studies should be done to ascertain the reasons of this increased EC in Thai Households since 2007.

**Energy Consumption by road transportation per unit of land area**

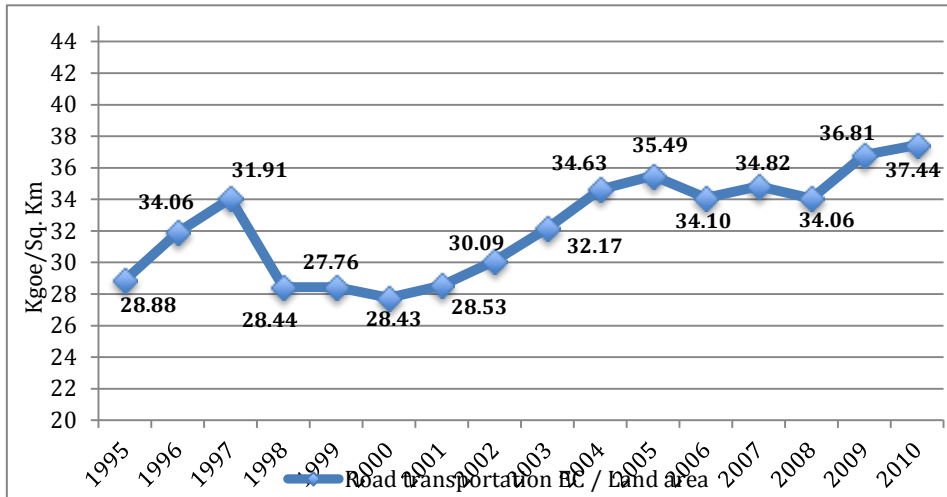
TABLE 17: ROAD TRANSPORTATION EC PER UNIT OF LAND AREA (UNIT: KGOE/SQ. KM)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Road Trans. EC / Land</b>	28.8	31.9	34.0	28.44	28.4	27.7	28.5	30.0	32.1	34.6	35.4	34.1	34.8	34.0	36.8	37.4
	8	1	6		3	6	3	9	7	3	9	0	2	6	1	4

SOURCE: CALCULATED BY CEERD (2013) FROM NSO AND DEDE STATISTICS (1995 - 2010)



FIGURE 15: ROAD TRANSPORTATION EC PER UNIT OF LAND AREA



SOURCE: CALCULATED BY CEERD (2013) FROM NSO AND DEDE STATISTICS (1995 - 2010)

EC by road transportation increased by 29.6% between 1995 and 2010. However, the EC growth rate seems to be decelerating since 2004, and it would be interesting to analyse more in details if the introduction of Gasohol, Biodiesel and other Biofuels since 2005/2006 has contributed to slowing down CO<sub>2</sub> emissions in the road transportation sector.

## 6.2 Samui Island

**Total CO<sub>2</sub> emission per unit of land (emission density) = CO<sub>2</sub> emission of the year/land area**

TABLE 18: CO<sub>2</sub> EMISSION PER UNIT OF LAND IN SAMUI - 2010

Item	2010
CO <sub>2</sub> Emission from Electricity consumption (tCO <sub>2</sub> )	256,835 (72%)
CO <sub>2</sub> Emission from Fuel consumption (tCO <sub>2</sub> )	101,388 (28%)
Land area (Sq. Km)	228
Total CO <sub>2</sub> Emission per unit of land (tCO <sub>2</sub> /Sq. Km)	<b>1,571</b>

SOURCE: APEC LOW CARBON MODEL TOWN PROJECT – FEASIBILITY STUDY FOR SAMUI ISLAND, NOVEMBER 2012

**Energy consumption of residential buildings per household**

TABLE 19: RESIDENTIAL BUILDINGS EC PER HOUSEHOLD IN SAMUI - 2010

UNIT: KWH/HOUSEHOLD

Item	2010
Energy Consumption (kWh)	104,940,637
Households	38,952
Energy consumption of residential buildings per household kWh/Household	<b>2,694</b>

SOURCE: APEC LOW CARBON MODEL TOWN PROJECT – FEASIBILITY STUDY FOR SAMUI ISLAND, NOVEMBER 2012

**The following data is for the whole province of Suratthani of which Samui Island is a part**

TABLE 20: ADDITIONAL DATA OF SURATTHANI PROVINCE

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Energy Consumption by Residential Buildings (Ktoe)</b>	57	57	52	60	67	67	75	49	51	56
<b>CO<sub>2</sub> Emission (tCO<sub>2</sub>)</b>	1,821	9,196	7,997	9,137	5,548	5,967	1,967	4,939	6,263	8,167

SOURCE: THAI ENERGY DATA ([HTTP://WWW.THAIENERGYDATA.IN.TH/OUTPUT\\_LASTUSE.PHP](http://www.thaienergydata.in.th/output_lastuse.php))

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## 7. Conclusions<sup>28</sup>

Climate change has been recognized as a threat to the nation and has been integrated into the formulation of several national plans and policies. Both the public and private sectors have been actively involved in reducing GHG emissions, and a series of measures and actions have been implemented in each sector to achieve this.

Developing RE and promoting energy conservation and efficiency are the primary ways to mitigate GHG emissions. Green consumption and production, as well as green lifestyle, have also been addressed but are yet to mature. The other area that has not clearly emerged yet is stakeholder involvement and engagement for tackling climate change. Even though Thailand has made significant progress toward green and low-carbon development, more needs to be done. Overall, Thailand has to focus on implementing no-regret policies to ensure the decoupling of the economy and the environment, while starting to look further at implementing least-cost policies. Short-term policies should immediately address the issue of rapidly increasing GHG emissions, and long-term policies should address fundamental changes towards a green and low-carbon society.

In the short term, Thailand needs to increase the implementation of its current promising policies on RE, energy efficiency, and other green policies, such as Small Power Producers (SPPs) and Very Small Power Producers (VSPPs), Revolving Fund, and Energy Service Company (ESCO) Fund. Additionally, incentives policies should be introduced using economic instruments through the market system. Policies regarding greenhouse gas emission reduction should allow the participation of the private sector, because the private sector has the abilities and is efficient in making environmental advancements. At the same time, the bodies of knowledge concerning new issues, such as green building and homes, need to be developed.

It is essential for Thailand to emphasize technology transfer regarding green and clean technologies, and regional and bilateral cooperation for developing technologies, so that the technologies can be deployed quickly and at low cost. Nevertheless, Research and Development into green and clean technologies, especially commercialized energy efficiency and RE technologies, should be prioritized as it is still low in Thailand. The focus of policies on technologies should concentrate not only on Research and Development but also on generating the demand for such technologies.

For agricultural activities, policies around greenhouse gas emission reduction have not yet taken shape. The key consideration is changing current agricultural practices to be environmentally friendly by changing farmer behavior and introducing new technologies and materials.

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<sup>28</sup> ADBI Working Paper Series: Development Trajectory, Emission Profile, and Policy Actions: Thailand (2012)

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New policy initiatives concerning GHG emissions reduction, such as green buildings and homes, and green islands and cities, should be further developed, and suitable concepts and models should be developed to fit the Thai context. The basic information and knowledge on climate change should be developed and utilized to advance new policy initiatives.

For long-term policies, the foundation of the society needs to be addressed, especially in the public sector. Fundamental changes are needed in terms of environmental awareness and behavior, and these issues should be addressed by integrating both environmental knowledge and awareness into the educational system and facilitating environmentally friendly behavior.

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## INTERNET LINKS

### Energy, Renewables & Energy Conservation

Ministry of Energy, Thailand	<a href="http://www.energy.go.th">www.energy.go.th</a>
Energy Policy and Planning Office	<a href="http://www.eppo.go.th">www.eppo.go.th</a>
Department of Mineral Fuels	<a href="http://www.dmf.go.th/index.php?ln=en">www.dmf.go.th/index.php?ln=en</a>
Electricity Generating Authority of Thailand	<a href="http://www.egat.co.th">www.egat.co.th</a>
Department of Alternative Energy Development and Energy Efficiency (DEDE)	<a href="http://www.dede.go.th">www.dede.go.th</a>
The Joint Graduate School of Energy and Environment (JGSEE )	<a href="http://www.jgsee.kmutt.ac.th/jgsee1/index2.php">www.jgsee.kmutt.ac.th/jgsee1/index2.php</a>
Thai Energy Resources	<a href="http://www.thaienergy.org">www.thaienergy.org</a>
Thai Energy Database (Ministry of Energy)	<a href="http://www.thaienergydata.in.th">www.thaienergydata.in.th</a>
The Energy Conservation Center of Thailand (ECCT)	<a href="http://www.ecct-th.org">www.ecct-th.org</a>
Energy Saving Consultation Center (ESCC)	<a href="http://www.esccctcc.com">www.esccctcc.com</a>
Japan External Trade Organization (JETRO)	<a href="http://www.jetro.go.jp/thailand/e_activity/energylaw.html">www.jetro.go.jp/thailand/e_activity/energylaw.html</a>
International Institute for Sustainable Development	<a href="http://www.iisd.org">www.iisd.org</a>
GIZ	<a href="http://www.giz.de/en">www.giz.de/en</a>
Thai German International Cooperation	<a href="http://www.thai-german-cooperation.info">www.thai-german-cooperation.info</a>
United Nations Development Programme	<a href="http://www.snap-undp.org/default.aspx">www.snap-undp.org/default.aspx</a>
Energy Smart Communities Initiatives (ESCI)	<a href="http://www.esci-ksp.org">www.esci-ksp.org</a>
Asia-Pacific Economic Cooperation Energy Working Group (APEC – EWG)	<a href="http://www.ewg.apec.org">www.ewg.apec.org</a>
International Energy Agency (IEA)	<a href="http://www.iea.org">www.iea.org</a>

### Environment

Thailand Greenhouse Gas Management Organization (Public Organization)	<a href="http://www.tgo.or.th">www.tgo.or.th</a>
Ministry of Natural Resources and Environment	<a href="http://www.monre.go.th">www.monre.go.th</a>
Pollution Control Department	<a href="http://www.pcd.go.th/index.cfm">www.pcd.go.th/index.cfm</a>
Office of Natural Resources and Environmental Policy and Planning (ONEP)	<a href="http://www.onep.go.th">www.onep.go.th</a>
Thailand Environment Institute (TEI)	<a href="http://www.tei.or.th">www.tei.or.th</a>
Energy for Environment Foundation	<a href="http://www.efe.or.th">www.efe.or.th</a>
Thailand Business Council for Sustainable Development	<a href="http://www.tei.or.th/tbcSD/index.html">www.tei.or.th/tbcSD/index.html</a>
Palang Thai	<a href="http://www.palangthai.org/en/home">www.palangthai.org/en/home</a>

### General Statistical Data

National Statistical Office of Thailand (NSO)	<a href="http://web.nso.go.th">http://web.nso.go.th</a>
Department of Provincial Administration	<a href="http://www.dopa.go.th">www.dopa.go.th</a>
National Economic and Social Development Board	<a href="http://eng.nesdb.go.th">http://eng.nesdb.go.th</a>
Asian Development Bank Institute	<a href="http://www.adbi.org">www.adbi.org</a>
Bank of Thailand	<a href="http://www.bot.or.th/English">www.bot.or.th/English</a>

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Thailand Energy and Environment Network (TEENET)  
Thai Energy News

[www.eppo.go.th/encon/teenet/member\\_eng.html](http://www.eppo.go.th/encon/teenet/member_eng.html)  
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## MACROECONOMIC AND ENERGY DATA SUMMARY

TABLE 1: MACROECONOMIC DATA – THAILAND - 1995 - 2010

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GDP at Current Market Price <u>Unit: Millions of Baht</u> Source: NESDB	4,186,212	4,611,041	4,732,610	4,626,447	4,637,079	4,922,731	5,133,502	5,450,643	5,917,369	6,489,476	7,092,893	7,844,939	8,525,197	9,080,466	9,041,551	10,104,821
Implicit Price Deflator <u>Source: UN</u>	0.75	0.78	0.82	0.88	0.86	0.87	0.89	0.90	0.92	0.95	1.00	1.05	1.08	1.13	1.13	1.19
GDP at 2005 Constant Prices <u>Unit: Millions of Baht</u>	5,579,455	5,904,173	5,803,616	5,249,373	5,400,912	5,663,035	5,791,833	6,048,107	6,427,659	6,805,712	7,092,893	7,465,697	7,918,385	8,021,778	7,969,946	8,482,576
Total Employees in the Tertiary Sector (Unit: 1000 Employees)	9,334	9,658	10,024	10,248	10,603	10,724	11,772	12,047	12,640	13,388	13,697	13,626	13,934	14,388	15,085	15,585

<u>Source:</u> NSO																
Households <u>Source:</u> DOPA	14,697,085	15,341,204	15,495,755	15,888,639	16,248,890	16,516,322	16,910,473	17,309,344	17,853,423	18,432,937	19,016,784	19,582,845	20,089,221	20,608,269	21,143,975	21,681,635
CO <sub>2</sub> Emissions <u>Unit:</u> Unit: 1,000 Tons <u>Source:</u> EPPO	137,692	155,553	161,058	145,345	149,780	150,727	153,462	163,472	171,956	187,336	192,486	193,136	200,439	203,195	208,202	220,383
Thailand Land Area <u>Unit:</u> Sq. Km <u>Source:</u> NSO	513,116															
Energy Consumption of Road Transportation <u>Unit:</u> Ktoe <u>Source:</u> DEDE	14,818	16,371	17,475	14,593	14,588	14,244	14,638	15,442	16,509	17,767	18,209	17,499	17,868	17,478	18,886	19,211

SOURCE: COMPILED BY CEERD

TABLE 2: PRIMARY ENERGY SUPPLY – THAILAND - 1995 – 2010 (UNIT: KTOE)

Energy Sources	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Modern Energy	52,567	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New & Renewable Energy	-	13,937	12,865	12,283	12,723	13,201	13,031	13,821	14,818	16,050	16,679	-	-	-	-	-
Renewable Energy	20,240	-	-	-	-	-	-	-	-	-	-	17,058	18,227	19,330	19,578	21,182
Commercial Energy	-	58,498	61,230	57,416	60,839	63,683	67,276	72,033	77,673	84,143	86,303	87,532	90,071	91,242	93,189	101,733
Biofuel	-	-	-	-	-	-	-	-	-	-	-	96	190	602	798	820
Other Energy	-	0	0	0	0	0	0	0	0	302	320	255	292	267	304	566
<b>Total</b>	<b>72,807</b>	<b>72,435</b>	<b>74,095</b>	<b>69,699</b>	<b>73,562</b>	<b>76,884</b>	<b>80,307</b>	<b>85,854</b>	<b>92,491</b>	<b>100,495</b>	<b>103,302</b>	<b>104,941</b>	<b>108,780</b>	<b>111,441</b>	<b>113,869</b>	<b>124,301</b>

SOURCE: THAILAND ENERGY STATISTICS – DEDE (1995 - 2010)

TABLE 3: FINAL ENERGY CONSUMPTION – THAILAND - 1995 – 2010 (UNIT: KTOE)

Final Energy Consumption	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture	1,581	1,786	1,493	1,880	2,160	2,161	2,847	3,032	3,308	3,520	3,207	3,312	3,448	3,446	3,477	3,499
Mining	104	114	118	94	139	85	93	106	115	131	125	130	131	121	110	123
Manufacturing	15,664	17,398	16,659	14,326	16,058	16,741	16,922	18,679	19,988	21,961	22,643	23,442	23,536	24,195	23,798	25,281
Construction	273	315	369	265	237	149	128	149	152	171	152	139	114	105	152	167
Residential	9,353	9,543	10,092	10,253	10,114	10,551	7,483	7,909	8,173	8,801	8,933	9,034	9,533	9,958	10,089	10,963
Commercial							3,437	3,468	3,626	3,866	3,846	4,215	4,489	4,968	4,940	5,620
Transportation	18,754	20,094	21,399	18,856	18,991	18,652	18,632	19,636	20,927	22,812	23,491	22,985	23,615	23,097	24,132	24,594
<b>Total</b>	<b>45,729</b>	<b>49,250</b>	<b>50,130</b>	<b>45,674</b>	<b>47,699</b>	<b>48,339</b>	<b>49,542</b>	<b>52,979</b>	<b>56,289</b>	<b>61,262</b>	<b>62,397</b>	<b>63,257</b>	<b>64,866</b>	<b>65,890</b>	<b>66,698</b>	<b>70,247</b>
<b>Note:</b>	From 1995 to 2000, Residential and Commercial sectors were reported as one.															

SOURCE: THAILAND ENERGY STATISTICS – DEDE (1995 - 2010)



TABLE 4: ELECTRICITY CONSUMPTION & RELATED CO<sub>2</sub> EMISSIONS IN SAMUI ISLAND (2000 – 2012)

	Peak Demand (MW)												Estimated	Actual	Load Factor (%)	Estimated Electricity (kWh)	Actual Electricity (kWh)	Emission Factor (tCO <sub>2</sub> /MWh)	Emissions (tCO <sub>2</sub> /yr)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Peak Load (MW)	Peak Load (MW)					
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		28.40	59.06%	146,927,163		0.569	83,602
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		31.34	59.06%	162,137,228		0.569	92,256
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		37.07	59.06%	191,781,335		0.569	109,124
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		40.57	59.06%	209,888,556		0.569	119,427
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		55.47	59.06%	286,973,582		0.569	163,288
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		61.22	59.06%	316,721,159		0.569	180,214
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		72.20	59.06%	373,526,097		0.569	212,536
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		81.40	59.06%	421,122,220		0.569	239,619
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		88.40	59.06%	457,336,662		0.569	260,225
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		92.30	59.06%	477,513,279		0.569	271,705
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	94.60	94.60	59.06%	451,378,952	451,378,952	0.569	256,835
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	95.60	95.60	59.06%	458,149,636	454,044,767	0.569	260,687
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	97.80	97.80	59.06%	481,057,118		0.569	273,722

SOURCE: BRIGHT MANAGEMENT CONSULTING COMPANY LIMITED - 2013

TABLE 5: FUEL CONSUMPTION & RELATED CO<sub>2</sub> EMISSION IN SAMUI ISLAND (2010)

Fuel Consumption (Liters/yr)				Total Fuel		Emission Factor (tCO <sub>2</sub> /liter)				Emissions (tCO <sub>2</sub> /year)				Total					
Gasohol	Gasohol	E20	Diesel	Gasoline	Gasoline	Consumpti	Gasohol	Gasohol	E20	Diesel	Gasoline	Gasoline	Gasohol	Gasohol	E20	Diesel	Gasoline	Gasoline	Emissi
91	95			91	95	on	91	95			91	95	91	95			91	95	on

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2010	2,208,250	6,711,620	450,045	20,448,760	11,790,595	18,250	41,627,520	0.0022	0.0022	0.0022	0.0027	0.0022	0.0022	4,817	14,642	982	55,186	25,722	40	101,388

SOURCE: SOURCE: BRIGHT MANAGEMENT CONSULTING COMPANY LIMITED - 2013

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## **Appendix 6: Case Study Report by Malaysian Green Technology Corporation**

### **Disclaimer:**

*This document has been prepared by the Malaysian Green Technology Corporation at the request of The Asia-Pacific Economic Cooperation Secretariat (APEC Secretariat). The contents of this document are the sole responsibility of the Malaysian Green Technology Corporation and can under no circumstances be regarded as reflecting the position of the Asia-Pacific Economic Cooperation Secretariat (APEC Secretariat).*

## **Contents**

<b>1. Background .....</b>	<b>139</b>
<b>2. Introduction .....</b>	<b>140</b>
<b>3. Energy Overview .....</b>	<b>142</b>
<b>4. Energy Policy, Legislation and Regulations .....</b>	<b>144</b>
<b>5. Green Technology Policy .....</b>	<b>146</b>
<b>6. Low Carbon Initiatives .....</b>	<b>148</b>
<b>6.1. Low Carbon Indicators .....</b>	<b>149</b>
6.1.1. CO <sub>2</sub> emission per unit of GDP (emission intensity) .....	149
6.1.2. CO <sub>2</sub> emission per unit of land (emission density).....	149
6.1.3. Industrial ratio in total end-use energy consumption (end-use industrial energy consumption/total end-use energy consumption) .....	149
6.1.4. Energy supply composition .....	150
6.1.5. Energy consumption of residential buildings per household .....	150
6.1.6. Energy consumption by road transportation per unit of land area.....	151
6.1.7. Policies and planning for low carbon development .....	151
<b>7. Low Carbon City Framework (LCCF) .....</b>	<b>153</b>
<b>8. Low Carbon Model Town Project.....</b>	<b>158</b>
<b>8.1. Putrajaya .....</b>	<b>158</b>
<b>8.2. Cyberjaya.....</b>	<b>160</b>
<b>8.3. Hang Tuah Jaya.....</b>	<b>162</b>
<b>9. Conclusion - The Way Forward .....</b>	<b>166</b>

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## **Background**

In December 2009, YAB Prime Minister Dato' Sri Mohd Najib bin Tun Abdul Razak announced a conditional voluntary target of 40% reduction in CO<sub>2</sub> intensity of Malaysian GDP by 2020. This is based on the realisation that Malaysia's emission is significantly higher compared to other countries of similar economic standing, and it is expected to increase in proportion to the overall growth of the economy. The Malaysian population currently stands at 28.7 million (*July 2011, Department Of Statistic Malaysia, 2012*), with 72% urbanization rate (2010, [www.cia.gov/library](http://www.cia.gov/library)). According to World Bank Data the current urban population in 2011 is 19 million.

Based on 2009 data, the CO<sub>2</sub> emissions is 148 million tonnes (*International Energy Statistics, 2011*) which translates to 7.1 Mton CO<sub>2</sub> per capita, by far exceeding the average Asia Pacific CO<sub>2</sub> emission of 2.6 Mton CO<sub>2</sub> per capita (*World Resource Institute*).

Given the magnitude of the situation, therein lies a great opportunity to develop and execute a robust low-carbon growth plan that is in line with Malaysia's economic aspirations of developing a High Income Society. Green townships and low carbon cities only provide a strong and sustainable platform for technological and economic growth, but also provide the opportunity to place Malaysia to be among the global leaders green technology.

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## **Introduction**

The Low Carbon City Framework (LCCF) is a system developed by the Ministry of Energy Green Technology and Water (MEGTW) in collaboration with the Malaysian Green Technology Corporation (GreenTech Malaysia) to facilitate the development of Low Carbon Cities in Malaysia. The framework will assist local authorities, township developers, and designers in formulating appropriate strategies that will reduce the levels of carbon through identified criteria. It will also help the users assess their current baseline and provide them with insights on how carbon emissions levels can be reduced.

LCCF is not a rating system but is a performance based system comprising of four (4) elements namely: -

- Urban Environment;
- Urban Infrastructure;
- Urban Transportation; and
- Building.

Within the four elements, there are altogether fourteen (14) criteria and thirty five (35) sub criteria. One of the key initiative within LCCF is the development of effective training modules and conducting training sessions for the potential users of the LCCF. Three (3) types of modules have been designed namely the LCCF Advance Level Training, Training the Trainers and Training the Assessor. LCCF is currently undergoing pilot implementation at several localities to ensure its applicability and effectiveness in encouraging green township development.

The key objective of the pilot implementation is to undertake the application of the LCCF at various development projects that are different and vary in developmental needs. This is a preliminary step undertaken to establish: -

- “test-bed” conditions for the LCCF at various localities with different setting and developmental needs;
- baseline level of carbon emissions by using the LCCF;
- applicability of the carbon calculator at various settings and localities, and potential for improvement;
- understanding different needs and requirements that would lead to enhancing the LCCF further;
- strategies and recommendations for implementation based on the Framework; and
- differences in the carbon emissions levels to show reduction or abatement in carbon emissions.

Each pilot implementation envisage several target outcomes that can be used to improve or enhance the environmental sustainability of a locality and to serve as a model to other projects of similar nature. The target outcomes are as follows: -

- 
- To produce carbon emissions baseline with specific figures and calculation methodologies;
  - To propose strategies and recommendations;
  - To propose carbon emissions reduction target;
  - To conduct a SWOT analysis; and
  - To identify constraints and shortfalls encountered and lesson learnt.

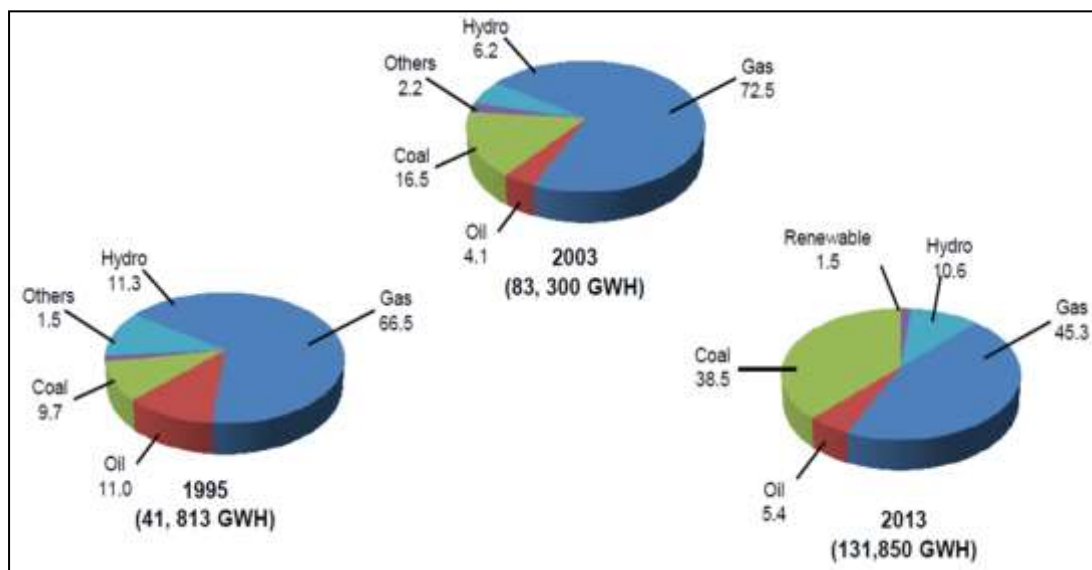
The implementation of the pilot project is to be undertaken in phases for a maximum of two (2) year upon which baseline would have been obtained together with appropriate recommendations and strategies.

## Energy Overview

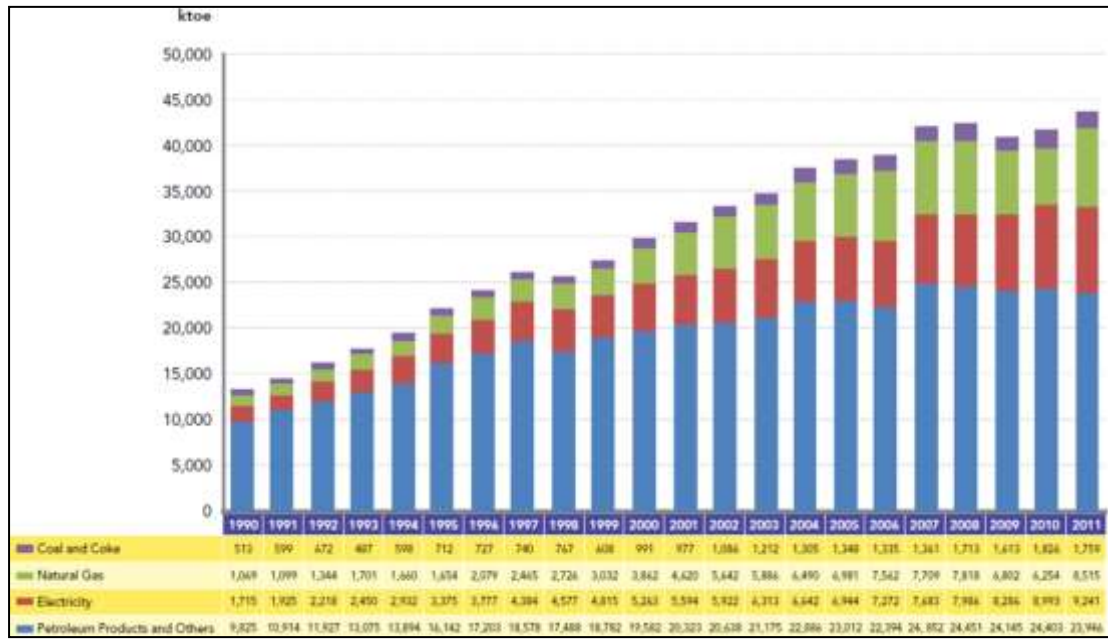
The Malaysian economy recorded a steady growth rate of 5.1 percent in 2011. Primary energy supply correspondingly recorded an increase of 3.2 percent from 76,809 ktoe in 2010 to 79,289 ktoe in 2011. Final energy demand increased by 4.8 percent, from 41,476 ktoe in 2010 to 43,455 ktoe in 2011.

The current electricity generation mix comprises of mainly gas, with increasing coal steadily over the past ten years with the increase in coal fired power plants capacity. The hydro generation is approaching its maximum potential, of course this is not include the mini hydro. The composition of renewables in the generation mix is still very small; though a lot of effort is currently being put in place to increase the percentage.

As a comparison, the changes in electricity generation mix since 1995 is depicted in the following diagram. The changes are mainly dictated by new policies put in place and also changes in the prices of gas and coal, which prompted the planting up of a more balanced generation capacity.



The Final Energy Demand, based on the type of fuel is given in the graph below. The transport sector was still the main consumer of energy with a share of 39.3 percent, followed by the industrial sector at 27.8 percent (*National Energy Balance 2011*).





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# **Energy Policy, Legislation and Regulations**

Several policies, legislation and regulations are currently in place to steer the national energy agenda. These policies were developed over the past 40 years to cater for the changes that has occurred in the country as well as external factors that required intervention from the policymakers.

## **Petroleum Development Act 1974**

This Act provided for exploration and exploitation of petroleum whether onshore or offshore by a Corporation in which will be vested the entire ownership in and the exclusive rights, powers, liberties and privileges in respect of the said petroleum, and to control the carrying on of downstream activities and development relating to petroleum and its products. This Act provided for the establishment of Petronas, the national oil company.

## **National Petroleum Policy 1975**

This policy was formulated in the Third Malaysia Plan (1976-1980) with the objective of encouraging efficient utilization of the resource for industrial development, as well ensuring that the nation exercises majority control in the management and operation of the industry.

## **National Energy Policy 1979**

This policy provides broad guidelines on long term energy objectives and strategies to ensure efficient, secure and environmentally sustainable supplies of energy. The energy sector in Malaysia is governed by this key policy.

## **National Depletion Policy 1980**

This policy was implemented to safeguard the exploitation of natural oil reserves as a result of the rapid increase in the production of crude oil.

## **Four Fuel Diversification Policy 1981**

Over-dependence on oil became an issue at the time, and this policy was developed to ensure reliability and security of the energy supply by focusing on four primary energy resources: oil, gas, hydropower and coal.

## **Fifth Fuel Policy 2000**

The fifth fuel, which is renewable energy was introduced into the energy supply mix, coupled with emphasis on energy efficiency to address issues related to Malaysia potentially becoming a net energy importer.

## **National Renewable Energy Policy and Action Plan 2009**

Further emphasis was put on renewable energy through this policy and action plan, with the aim of enhancing the utilisation of indigenous renewable energy (RE) resources to contribute towards national electricity supply security and sustainable socioeconomic development.

---

**National Green Technology Policy 2009**

This policy focusses on green technology as an economic engine while also tackling the problems of destruction of the environment and natural resources, increasing health levels and the quality of life; and conserve the ecosystem and reducing costs to the government in overcoming the negative effects from development.

**National Policy on Climate Change 2009**

This policy aims to ensure climate-resilient development to fulfil national aspirations for sustainability. It integrates climate change considerations at the planning level by addressing environmentally sensitive areas, conducting strategic environmental assessment, and developing economic evaluation ecological services.

**Renewable Energy Act 2011 & Sustainable Energy Development Authority Act 2011**

These Acts provide for the establishment and implementation of a special tariff system, Feed-in-Tariff to catalyse the generation of renewable energy and the establishment of the Sustainable Energy Development Authority of Malaysia, to provide for its functions and powers and for related matters.

---

# **Green Technology Policy**

Malaysian Green Technology Policy was launched in July 2009 and specifies five (5) strategic thrusts namely Institutional Frameworks, Conducive Environment, Human Capital Development, Research and Development and Promotion and Awareness as the critical agenda to realize Green Technology development approach. As such, the reshuffle of cabinet in April 2009 has strengthened the Institutional Framework focusing on Green Technology through the structuring of Ministry Of Energy, Green Technology and Water (KeTTHA). In Malaysia, Green Technology is defined as the development and application of products, equipment, and systems used to conserve the natural environment and resources, which minimizes and reduces the negative impact of human activities.

The National Green Technology Policy Objectives are as follows: -

- Minimise energy consumption growth while enhancing economic development;
- Facilitate GT industry growth and contributions to national economy;
- Increase national capability & capacity for GT innovation and enhance Malaysia's competitiveness;
- Ensure sustainable development and conserve environment; and
- Enhance public education and awareness for widespread use.

The Short-Term Goals of the Green Technology Policy leading to the year 2015 are: -

- Increase public awareness and commitment for Green Technology adoption and application through advocacy programmes;
- Widespread availability and recognition of Green Technology through development of standards, rating and labelling programmes;
- Increase FDIs and DDIs in Green Technology;
- Expansion of local research, development and innovation; and
- Focus on energy, buildings, water & waste, transport sectors.

The Mid-Term Goals of the Green Technology Policy as Malaysia approaches the year 2020 are: -

- Green Technology becomes the preferred choice in procurement;
- Increase in Green Technology's local market share and contribution to regional markets;
- Increased production of local Green Technology products;
- Increase of Green Technology RDICs by industry and MNCs;
- SMEs and SMIs ventures in global Green Technology markets;
- Green Technology expands to include most economic sectors.

The Long-Term Goals of the Green Technology Policy gearing towards the year 2025 and beyond are: -

- Inculcation of Green Technology in Malaysian culture;
- Reduce overall resource consumption via widespread adoption of Green Technology while sustaining national economic growth;
- Significantly reduce national energy consumption;

- 
- Improve Malaysia's ranking in environmental ratings;
  - Position Malaysia as a major producer of Green Technology in global market;
  - Expand international collaborations between local RIs and Green Technology industries.

The impact of Green Technology adoptions and deployment is measured through four key indicators, namely: -

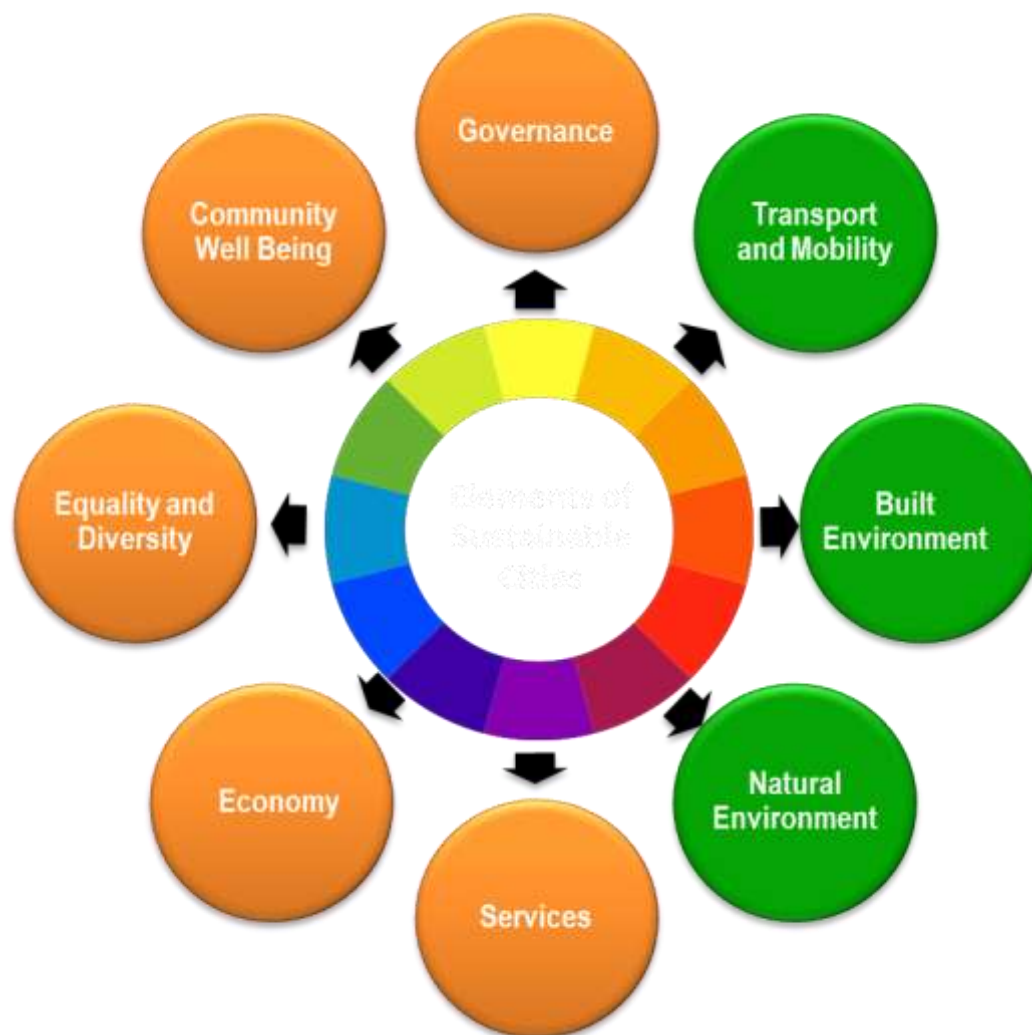
- Environment – determined through reduction of carbon emission;
- Economy – increase in GNI/GDP and investments;
- Social – creation of green jobs and increase in high income jobs and knowledge workers;
- Energy – reduction of fossil-fuelled power and increase in renewable power.

---

## Low Carbon Initiatives

The development of Low Carbon Cities in Malaysia is still quite new where it requires an active promotion and uses of green technologies and sustainable method in the development and operation of a city.

The framework and planning is depicted in the diagram below, and the main enabler is the involvement of all key stakeholders, from government, private sector, research and higher education, as well as the general population.



Government as policymakers need to develop framework and policies that ensures strong governance. The policies must also support low carbon efforts in the transport and mobility sector, built environment and the natural environment. The private sector is encourage to take the leading role in advancing the industry and markets to ensure sustainability of the low carbon efforts. Through innovation by the research and higher education institution, the private sector can capitalise on the higher value add activities, products, and services, thus propelling the low

carbon economy towards greater wealth creation. Communities can support the efforts and ensure equality, diversity, and well being is constantly kept in check.

## Low Carbon Indicators

Based on the low carbon indicators developed by ZERI, the numbers for Malaysia has been worked out based on several key published figures, namely the National Energy Balance 2011, Annual Gross Domestic Product Publication 2005-2012, and US Energy Information Administration.

### CO<sub>2</sub> emission per unit of GDP (emission intensity)

Malaysia GDP at 2005 prices (RM million)	711,351
Population ('000 people)	28,964
CO <sub>2</sub> Emissions for the consumption of Energy	191.444 million tons of CO <sub>2</sub>
GDP at 2005 prices per capita (RM Million)	24,560
CO <sub>2</sub> Emissions for the consumption of energy per capita	6.609 tons of CO <sub>2</sub>
Emission intensity	269.0 tons of CO <sub>2</sub> / GDP at 2005 prices (RM Million)

Source : National Energy Balance 2011 and US Energy Information Administration

### CO<sub>2</sub> emission per unit of land (emission density)

Total Carbon Dioxide Emissions from the Consumption of Energy (Millions Metric Tons) 2011	191.444 million Mt of CO <sub>2</sub>
Land area	329, 961.22 km <sup>2</sup>
CO <sub>2</sub> emission per unit of land	0.00058 million tons CO <sub>2</sub> / km <sup>2</sup>

Source: US Energy Information Administration (EIA),

<http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8&cid=MY,&syid=2007&eyid=2011&unit=MMTCD>

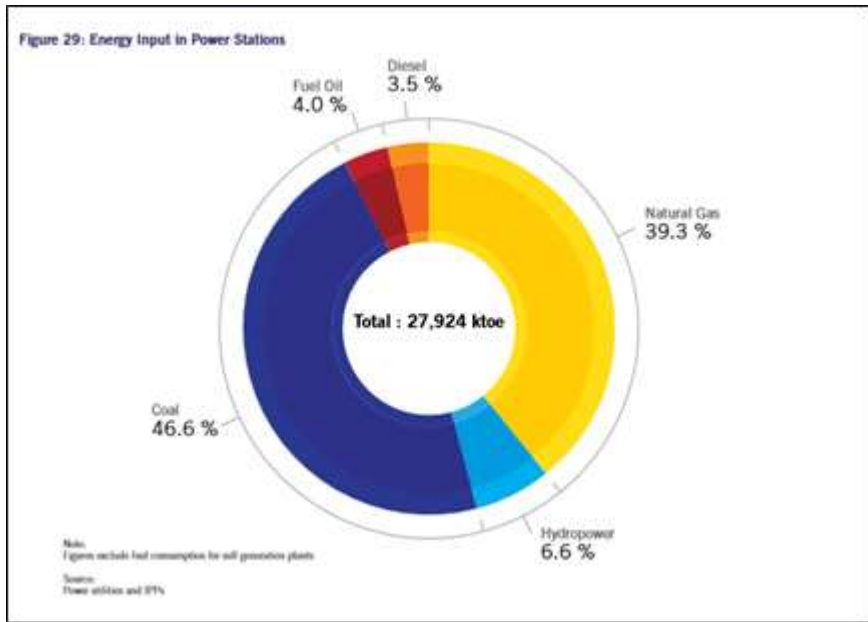
### Industrial ratio in total end-use energy consumption (end-use industrial energy consumption/total end-use energy consumption)

Final Use for Industry	12,100 ktoe
Total Final Use	43,455 ktoe

Industrial ratio in total end-use energy consumption	0.28 or 27.84%
--	----------------

**Energy supply composition**

Natural gas composition ratio	39.3%
Nuclear power composition ratio	none
Renewable energy and hydro composition ratio	6.6%



Source: National Energy Balance 2011, Suruhanjaya Tenaga

Industrial energy consumption per unit of industrial added-value

Final Energy Use for Industrial, 2011	12,100 ktoe
Industry value add	RM 326 bil
Industry energy consumption per unit of industrial value add	37.1 ktoe/RM bil GDP

Source : Annual Gross Domestic Product Publication 2005-2012

**Energy consumption of residential buildings per household**

Total Households in Malaysia for 2010	6,396,174
Final Energy Use for residential 2010	2,655 ktoe
Energy Consumption of Residential Building	0.000415 ktoe/household

per Households	
----------------	--

Source: National Energy Balance 2011, Suruhanjaya Tenaga

### Energy consumption by road transportation per unit of land area

Final Energy Use for Transport, 2011	4,441 ktoe
Assuming 74% in road consumption, Final Energy Use for Transport, 2011	3,365.25 ktoe

Source: National Energy Balance 2011, Suruhanjaya Tenaga

### Policies and planning for low carbon development

#### National Policy on Climate Change, under Natural Resources and Environment Ministry (NRE)

The National Policy on Climate Change helps to ensure climate-resilient development to fulfill national aspirations for sustainable development. Five principles underpin the ten strategic thrusts to set the national direction in responding to the challenges of climate change.

- Development on Sustainable Path
- Conservation of Environment and Natural Resources
- Coordinated Implementation
- Effective Participation
- Common but Differentiated Responsibilities and Respective Capabilities

The National Policy on Climate Change will facilitate the integration of climate change considerations into planning and implementation of development programmes and decision-making processes; to foster sustainable economic and human development; as well as environmental conservation. It complements existing policies and takes cognisance of international conventions on global concerns. National responses on climate change in all sectors will be directed towards the following strategic thrusts.

The Key Actions KA4-ST2 will focus to identify and recommend options towards low carbon economy for the following sectors:

- Energy security;
- Industries;
- Transportation;
- Public infrastructure;
- Waste management;
- Human settlements;
- Forestry; and



- 
- Agriculture

While the Key Actions KA10-ST3 will focus on to establish a greenhouse gas (GHG) emissions reporting framework for industries with linkage to the Statistic Department to ensure a sustainable and quality assured reporting process.

### **A Roadmap of Carbon Intensity Reduction in Malaysia, under NRE**

This report presents a detailed analysis of mitigation options and potential in each of the sector till 2030 and evaluates the feasibility of achieving the voluntary 40% emission intensity of GDP reduction target through an integrated framework. It also lays out a roadmap for each of the key sectors in terms of suggestions for the short, medium and long term, based on the analysis. The report also includes the technology needs assessment and low carbon economy approaches to climate change mitigation and adaption.

### **National GHG Inventory and National Communication**

National GHG Inventory is a National Study on GHG Inventory from the Energy, Industrial Processes, Agriculture, Waste and Forestry sector. A greenhouse gas inventory is an accounting of greenhouse gases (GHGs) emitted or removed from the atmosphere over a period time.

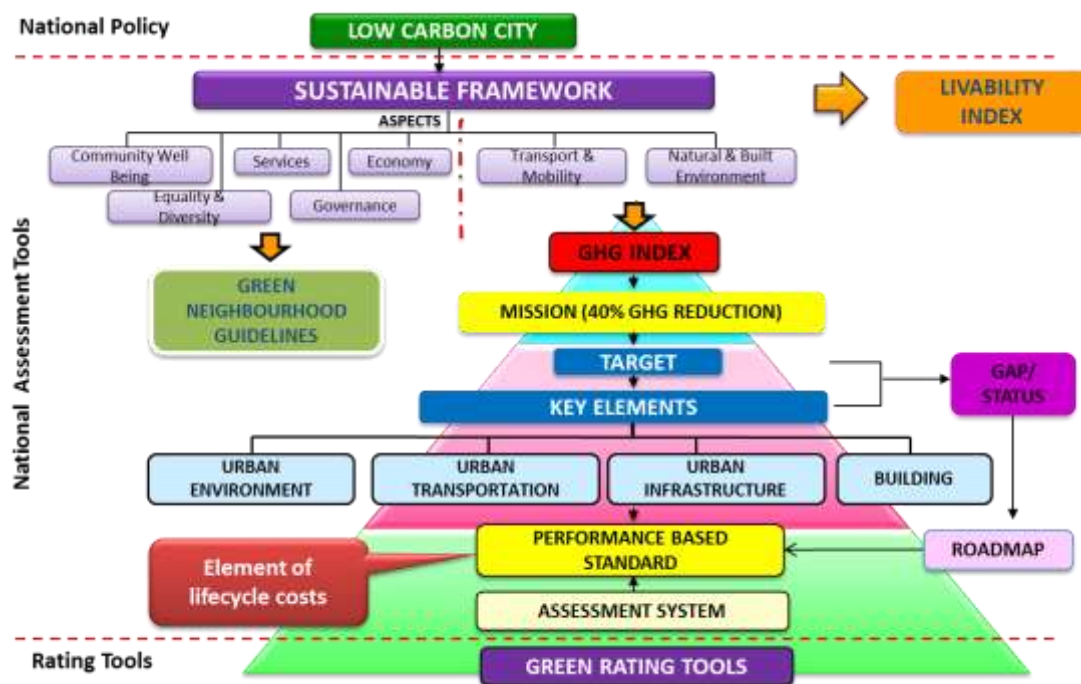
The inventory is used to:

- Identify the largest sources of GHG emissions within a location
- Understand emission trends
- Quantify the benefits of activities that reduce emissions
- Establish a basis for developing an action plan
- Track progress in reducing emissions
- Set goals and targets for future reductions.

Malaysia submitted its Initial National Communication (base year 1994) and Second Communication (base year 2000) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2000 and 2011 respectively. Submission is required in accordance to Article 12 of the Convention.

# Low Carbon City Framework (LCCF)

The Low Carbon Cities Framework & Assessment System (LCCF) is a national framework and assessment system developed by GreenTech Malaysia to guide and assist stakeholders such as developers, local councils, town planners, non-governmental organizations (NGO's) and the public to lower the levels of carbon emission in cities towards achieving sustainable urban developments. The framework was launched in 2010 and is currently undergoing pilot implementation at several localities. The framework is implemented by formulating baseline studies via data collection, carrying out stakeholders consultation, and developing the action plan or roadmap.



LCCF focusses on four (4) key areas namely, Urban Environment, Urban Transportation, Urban Infrastructure, and Buildings.

## Urban Environment

The criterias and indicators under Urban Environment area are: -

### UE 1 : Site Selection

- 1-1: Development within defined urban footprint
- 1-2: Infill development within existing urban footprint
- 1-3: Development within transit nodes and corridor
- 1-4: Brownfield and Grey field redevelopment

---

1-5: Hilly slope development

UE 2 : Urban Form

2-1: Mixed-use development

2-2: Compact development

2-3: Road and parking

2-4: Comprehensive pedestrian network

2-5: Comprehensive cycling network

2-6: Urban Heat Island (UHI) effects

UE 3 : Urban Greenery And Environmental Quality

3-1: Preserve natural ecology, water body and bio-diversity

3-2: Green open space

3-3: Number of trees

**Urban Transportation**

The criterias and indicators under Urban Transportation area are: -

UT 1 : Shift of Transport Mode

1-1: Single Occupancy Vehicle (SOV) dependency

UT 2 : Green Transport Infrastructure

2-1: Public transportation

2-2: Walking and cycling

UT 3 : Clean Vehicles

3-1: Low carbon public transportation

3-2: Low carbon private transportation

UT 4 : Traffic Management

4-1: Vehicle speed management

4-2: Traffic Congestion and traffic flows management

**Urban Infrastructure**

The criterias and indicators under Urban Infrastructure area are: -

UI 1 : Infrastructure Provision

1-1: Land take for infrastructure and utility services

1-2: Earthworks management

1-3: Urban storm water management and flood

Mitigation

---

## UI 2 : Waste

2-1: Construction and industrial waste management

2-2: Household solid waste management

## UI 3 : Energy

3-1: Energy optimization

3-2: Renewable Energy

3-3: Site wide district cooling system

## UI 4 : Water Management

4-1: Efficient Water Management

## **Building**

The criterias and indicators under Building area are: -

### B1 : Low Carbon Buildings

1-1: Operational energy emissions

1-2: Operational water consumption

1-3: Emission abatement through retrofitting

1-4: Building orientation

### B2 : Community Building

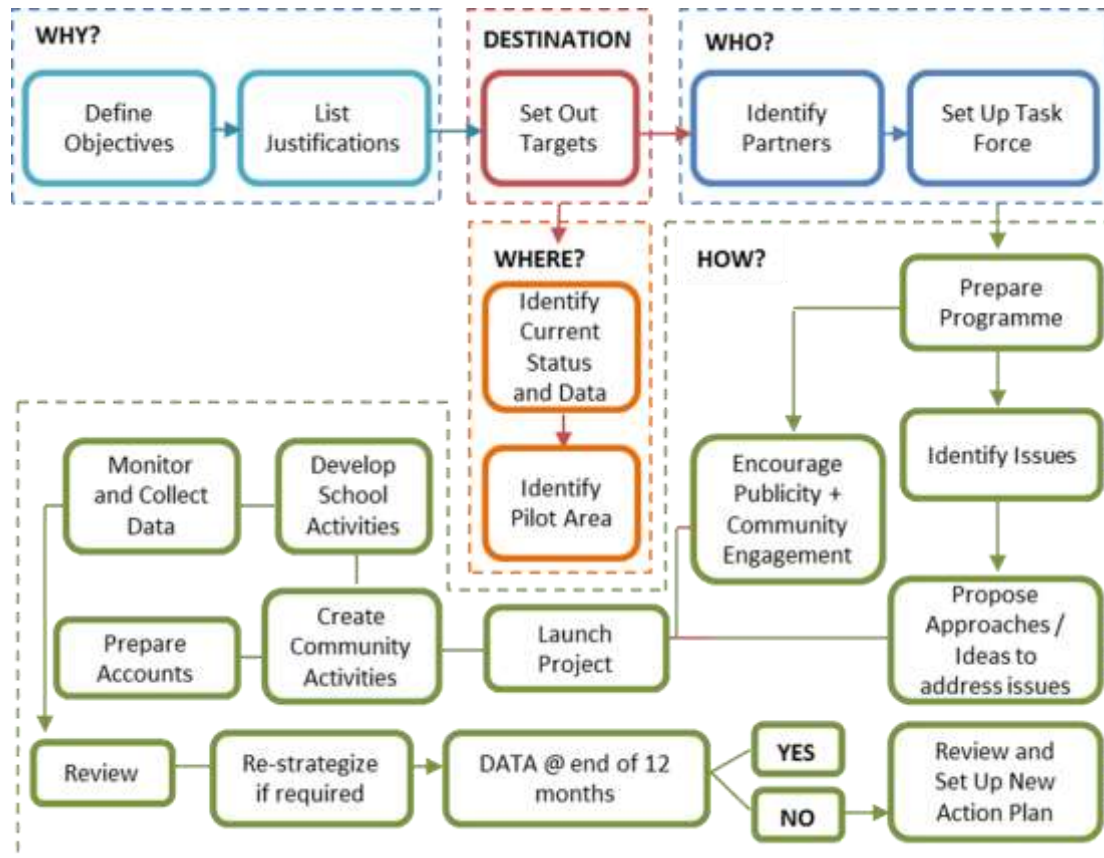
2-1: Shared facilities and utilities within  
Building

LCCF can be implemented through a One-System Approach or a City-based Approach depending on the objective and capacity. One system approach enables implementers to realize benefits of integration by planning, designing and managing the whole urban system, while a city based approach encourages a development process that consider their specific circumstances including ecology

The boundaries and elements of development for assessment of carbon emissions are first identified to establish elements contributing to carbon emissions in the development. This allows deeper appreciation and understanding of which elements contribute most to the development's carbon emissions. The selection or prioritization of elements for measurement looks into the source of emissions. The baseline information on current emission level is then established.

For non-availability of data other appropriate benchmarks or baselines for elements can be adopted provided that the assumptions used in the development of the adopted baseline are fully understood. Based on the baselines, achievable and measurable targets can be set for reduction of emissions. It is also necessary to identify the gaps between current emission status and targets to arrive at the emission reduction measures.

A roadmap or strategic action plan for the development based on local requirements and prioritization for achieving low carbon development can then be formulated to ensure all efforts towards reducing emission reduction have clear actions and targets to be achieved. A template for the roadmap is shown below.



LCCF uses a diamond rating system, where at 100% carbon reduction level, the achievement is five (5) diamond rating. This provides a progressive and sustainable method for implementers of LCCF to continue reducing their emission levels, while gradually increasing the number of elements and indicators that is tackled within the LCCF framework.



Carbon Reduction Level	Level of Achievement
100%	Carbon Neutral
70-99%	Best Practice 5 (BP5) ♦♦♦♦♦
50-69%	Best Practice 4 (BP4) ♦♦♦♦
30-49%	Best Practice 3 (BP3) ♦♦♦
10-29%	Best Practice 2 (BP2) ♦♦
1-9%	Best Practice 1 (BP1) ♦

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# **Low Carbon Model Town Project**

## **Putrajaya**

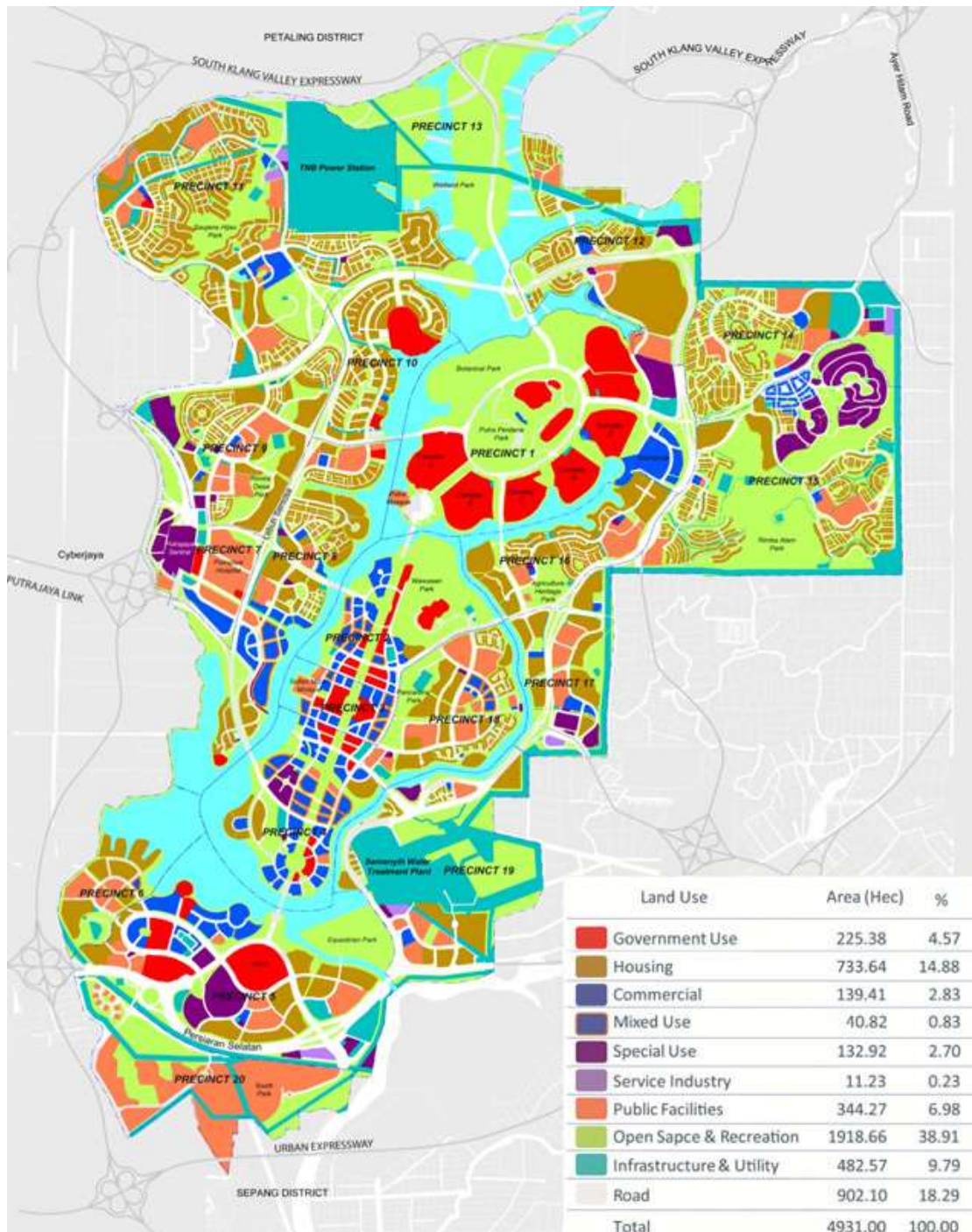
Putrajaya is the administrative capital of Malaysia and is located 25 km south of Kuala Lumpur. It is a planned city that was conceived to reduce the congestion of Kuala Lumpur, which is still the commercial and financial center. The overall objectives of the low carbon model project at Putrajaya are: -

- To evaluate the current status of Putrajaya in terms of green initiatives and green culture towards achieving Low Carbon City status;
- To identify appropriate policies, actions and programmes in both Putrajaya towards achieving low carbon development and Low Carbon City status;
- To obtain a baseline of current carbon emissions and future CO<sub>2</sub> reduction scenario for Putrajaya by using LCCF; and
- To prepare comprehensive “Action Plan” containing certain Key Performance Indicator (KPI) and monitoring system in order to promote the actions towards achieving Low Carbon City in Putrajaya.

From the city administrator’s perspective, the green city of Putrajaya aims:

- To minimise negative environmental impacts and degradation;
- To encourage human interaction back with nature; and
- To reduce the carbon emission from human activities.





Seven focus areas comprising of Planning, Urban Design & Building, Integrating Nature Into The Urban Fabric, Energy Usage, Water Usage, Transportation and Mobility, Solid Waste Management, and City Administration and Management were addressed under the Putrajaya Green City 2025 initiative resulting in the following key targets being established: -

- To reduce CO<sub>2</sub> emission intensity by 60%;
- To reduce peak temperature by 2 degree Celsius; and
- To reduce the final disposal of solid waste and CO<sub>2</sub> emission per waste generation by 50%.



---

The overall plan for Putrajaya based on LCCF can be summarized as follows:-

#### **Building and Energy**

- ✓ Formulation of a mechanism for low carbon city and implementation of pilot projects.
- ✓ Improvement by expansion of best practice and integrated management.
- ✓ Improvement by retrofit with large investment.

#### **Urban Transport**

- ✓ People become aware of public transport.
- ✓ People increasingly begin to use public transport.
- ✓ People almost stop using private vehicles.

#### **Waste and Water**

- ✓ Implement pilot projects in model areas.
- ✓ Diffuse systems developed within the model areas into other areas.
- ✓ Reduce landfill amount by facility investment.

#### **Urban Environment**

- ✓ Review results of existing programmes, and plan R&D.
- ✓ Promote R&D for an advanced activities.
- ✓ Implement the outcomes of R&D.

The Japan Research Institute (JRI) collaborated closely with KeTTHA and GreenTech Malaysia with respect to the research and knowledge sharing that contributes to the achievement of the project's objectives. The other Japanese private organizations in the consortium, which are also related to NEDO, shared their expertise and experience in the field of Low Carbon City development.

## **Cyberjaya**

Cyberjaya is located next to Putrajaya and has a total land area of 28.16km<sup>2</sup>. It's population is 47,961 (2010) and population density is about 1,703/km<sup>2</sup>. For Cyberjaya objectives of the LCCF Baseline Study research are: -

- To identify the sub-criteria (based on LCCF) which are applicable for Cyberjaya;
- To identify the carbon emission baseline of Cyberjaya for 2011;
- To forecast the carbon emission level for 2020 based on Business-as-Usual (BaU) model and Low Carbon Strategies (LCS); and
- To recommend low carbon strategies that may help in reducing carbon emission level of Cyberjaya.



*Bus shelters with solar photovoltaic (Cyberview Sdn. Bhd.)*

The following Low Carbon Strategies 2020 for Cyberjaya have been defined as follows: -

#### **Urban Environment**

- ✓ Hill slope development – replanting trees with high carbon sequestration vegetation;
- ✓ Road and parking should not exceed 20% of total area of development in Cyberjaya. In this case the roads and parking area are less than 20% as allocated by the Cyberjaya Master Plan;
- ✓ Green open space is minimum at 10% of the total development or greater;
- ✓ Water bodies are conserved for carbon sequestration;
- ✓ Indigenous trees of high carbon sequestration including bamboos are planted;
- ✓ Expansion of greeneries through green roofs and grid paving etc;

#### **Urban Transportation**

- ✓ Awareness campaigns of the carbon impact of transport as a result of usage of Single Occupancy Vehicle (SOV);
- ✓ Incentives for the reductions of SOV;
- ✓ Penalties due to the usage of SOV;

#### **Urban Infrastructure**

- ✓ Promote awareness campaigns to achieve zero waste to landfills;
- ✓ Generate energy out of organic (green) waste;

#### **Buildings**

- ✓ Ensure all buildings use DCS cooling;
- ✓ Design energy efficiency measures conforming to benchmarks and common carbon metrics to provide trajectories to 40% carbon reduction in 2020 and beyond;
- ✓ Build retrofits for existing buildings to meet energy efficiency benchmarks and climate goal trajectories;
- ✓ Design buildings conforming to the Common Carbon Metrics (CCM) for carbon reduction in 2020 and beyond;

- 
- ✓ Use of renewable energy to reduce carbon emissions; and
  - ✓ Conserve water and therefore resulting in energy savings in water processing and distribution.

Based on the calculations and projections, the baseline Total Carbon Emissions for 2011 is 1,401,350 tCO<sub>2</sub>/year with a projected value of 1,109,205 tCO<sub>2</sub>/year, resulting in a reduction of 21%. The business-as-usual scenario leads to a staggering increase of 128% CO<sub>2</sub> emission or 3,200,909 tCO<sub>2</sub>/year.

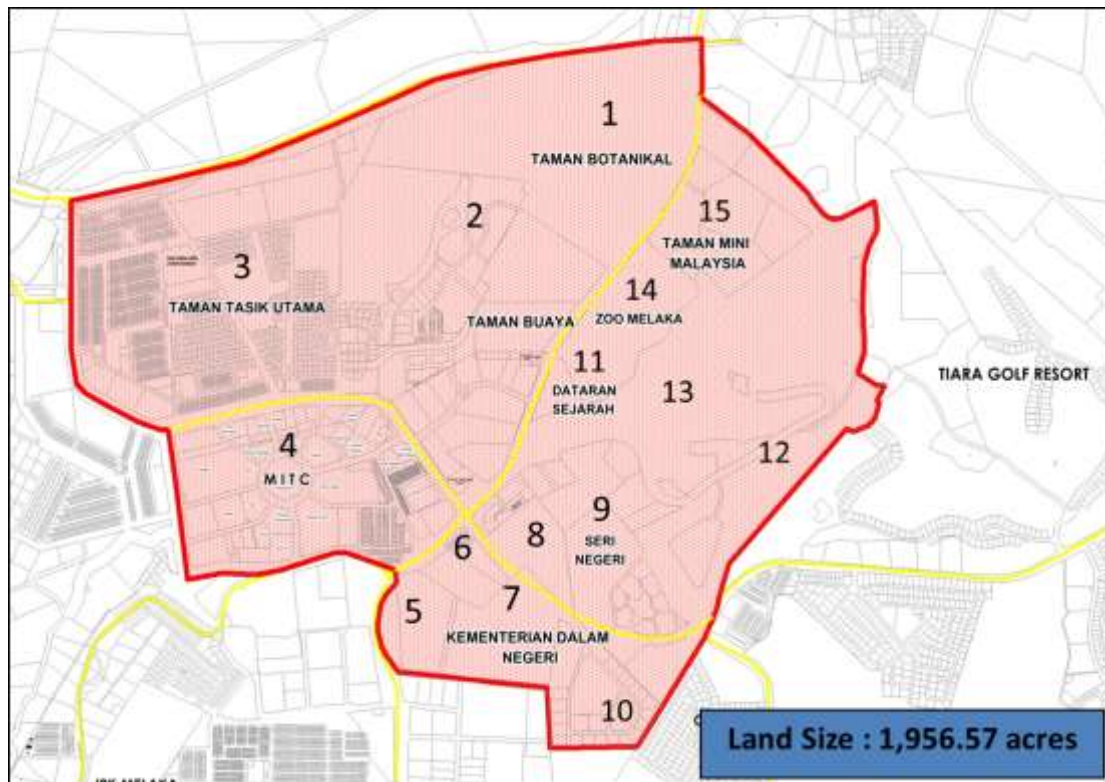
## Hang Tuah Jaya

Hang Tuah Jaya Municipal Council has an area of 35,733 acre and is located in the middle of Melaka State. The township within Hang Tuah Jaya Municipal Council has a population of about 114,732 people or consists of 19 percent (%) of total 602, 867 population of Melaka.

The key objective of the project at Hang Tuah Jaya was to study the current inventory of activities of the Hang Tuah Jaya (HTJ) municipality and the potential impact where LCCF assessment is applied. The carbon emission baseline of the development can then be determined. Most importantly LCCF pilot project at Hang Tuah Jaya was aimed at testing the applicability of LCCF to an existing city development.

The boundaries selected for the implementation of LCCF is an area size of almost 2,000 acres comprising of the following: -

- Taman Botanikal
- Taman Tema Air Wonderland Melaka
- Taman Tasik Utama
- MITC
- Dusun Dato Murad
- Kota Cemerlang
- Kompleks KDN
- Taman Seribu Bunga
- Seri Negeri
- Seri Bendahara
- Dataran Sejarah
- Ayer Keroh Country Club (AKCC)
- Tasik Ayer Keroh
- Zoo Melaka
- Taman Mini Malaysia



Hang Tuah Jaya Municipal Council undertook a city based approach consisting 5 sub-criteria for the application of LCCF's selected criteria.

No.	Criteria	Sub-Criteria	Calculator Involved
1.	Urban Environment	Road And Parking (UE 2-3)	Landuse/ Embodied Carbon
2.		Green Open Space (UE 3-2)	Landuse/ Embodied Carbon
3.		Number Of Trees (UE 3-3)	Landscape
4.	Building	Operational Energy Emissions (B 1-1)	Energy
5.		Operational Water Emissions (B 1-2)	Water

A data collection exercise was carried out throughout the areas identified. The exercise is still currently in progress, particularly the data on energy and water is still being finalised. The

preliminary results are shown in the table below: -

Element of Carbon Emissions	Details	Baseline CO2 Sequestration OR CO2 emissions tCO2/year
Landuse (Road and Parking) (Green Open Space)	Soil Carbon	22.84
	Carbon Sequestration (losses) from trees	1,237,056.84
Landscape (Number Of Trees)	Soil Carbon Storage	-584,844.13
	Carbon Sequestration Trees (within open space)	-37,575,428.95
	Carbon Sequestration Trees (not within open space)	-30,000.00
Embodied Carbon (Road And Parking) (Green Open Space)	Buildings	5,304.91
	Other Infrastructure	248.21
Energy		To be determined
Water		To be determined
<b>TOTAL</b>		<b>-36,947,640.28</b>

The negative value is expected to be positive when the figures for energy and water becomes available. Nevertheless, initial projection and comparison with BAU reveals that there is a potential emission reduction of between 10-29% (Two diamond rating). A strategic action plan is also developed outlining the following: -

#### Short term action

- To embark on energy and water saving program to achieve 10% savings (at no additional cost);
- To ensure all air conditioning system in buildings are set to 24°C;
- To implement rainwater harvesting for water usage in landscaping, toilets, and general cleaning; and
- To embark on daylighting projects for buildings.

#### Long term action

- Tree planting program, encourage local species with high carbon absorption properties eg bamboo, eucalyptus;
- Encourage solar photovoltaic installation on building;
- Encourage energy efficient fittings and appliances (LED/ T5 lights, laptop computers, inverter aircond); and
- Ensure open green spaces at the minimum of 10% of total development area.

Hang Tuah Jaya Municipal Council has defined a few constraints in carrying the LCCF exercise. The constraints are:-

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- Difficulties in data collection due to the limitation of manpower. Existing manpower are designated to run the existing core business of the Council. Since LCCF is a whole new additional task to be added to the Council, it will require more manpower to undertake the tasks;
  - Limited data availability where there is a strong possibility of insufficient or non-existence of data required for the LCCF.

These issues have been taken into account and will be addressed in the next review of the LCCF framework.

The implementation of LCCF in MPHTJ is in line with MPHTJ's vision of Melaka Green Technology City State and Low Carbon City. The active participation and commitment from all parties ranging from internal and external stakeholders and the community in greening MPHTJ will be a strong component in making the implementation of LCCF a success.

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## **Conclusion - The Way Forward**

The Low Carbon City Framework is a government initiative that requires strong collaboration and cooperation from all quarters both from the public and private. The success of the LCCF depends very much on the availability of data and the strong commitment from stakeholders in identifying, collecting, analyzing and reporting the data.

The LCCF is a very dynamic system that can be applied at different localities with varying developmental needs. Since the LCCF is a performance based system it emphasizes on continuous carbon abatement through mitigating strategies. The strategies recommended from the baseline findings will help developments and local council not only set realistic targets but offers suggestion on how to achieve those targets.

Challenges in implementing LCCF includes lack of fiscal incentives during earlier phase of implementation and lack of manpower and financial resources. These issues can be addressed through increasing acceptance and awareness of the stakeholders and eventually bring LCCF into the mainstream of current development mechanism.

In summary, LCCF enables cities to compare their Business As Usual (BAU) scenario and compare them with if they were to implement low carbon strategies. LCCF is able to guide, gauge and monitor how much reduction in carbon emission can be achieved by using low carbon strategies defined.

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## **References**

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2. International Energy Statistics, 2011
3. Annual Gross Domestic Product Publication 2005-2012
4. Low Carbon Cities Framework Publication
5. Putrajaya Green City 2025 Publication



