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Economic Cooperation

Policy Practice and Technology Applications - Experiences on Low Carbon Emission Operations in Chinese Taipei

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Produced by

Author
Lee Hwang
Email: leehwang@topology.com.tw

Organization
Topology Research Institute
11F., No.2, Sec. 2, Nanjing E. Rd., Zhongshan Dist., Taipei City 104, Taiwan
Tel: +886-2-2571-0111
Fax: +886-2-2571-0212

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

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Executive summary

In addressing the energy challenges, APEC leaders have made commitment in regional green growth in 2011, Honolulu meeting. Through the improvement of energy efficiency, rationalized use of fossil fuels, low-emissions development, APEC economies are striving to reduce the energy intensity by 45% by 2035. In response, Chinese Taipei has voluntarily determined its national target to increase the energy efficiency by 2% annually and achieve 50% of improvement by 2025. Meanwhile, National Energy Conservation and Carbon Emission Reduction Master Plan is conducted to carry out sectorial actions in the transformation to a low-carbon emission society which has successfully brought steady decline in the energy intensity of industries in Chinese Taipei.

The project aims to cultivate the energy conservation culture in APEC community. Through introducing Chinese Taipei's policy and technology practices, conducting field verification in Thailand to examine the effectiveness to other economies and lastly, gathering knowledge and ideas from international experts, the project is expected to deliver feasible policy suggestion and industrial application models as the reference for APEC economies to implement low carbon emission operations.

In this report, key policy features have been found to promote low carbon emission society in Chinese Taipei which include, (1) the integration of top-down policy scheme and bottom-up action plans; (2) field verification at identified focal point and (3) appropriate use of a combination of policy instruments. On the other hand, the successful model of industrial application is also developed which combines (1) the technology innovation to reduce the energy intensity of industries; (2) the introduction of international energy management standard to sustain the energy conservation, and (3) the promotion policy to further enhance the effect.

Furthermore, as energy conservation culture is formed, the demand and opportunities for green technology and product are expected to grow and hence facilitate more exchange and strengthen the connectivity within APEC community.

Chapter 1 APEC Region's Energy Outlook

On the whole, APEC accounts for 60% of world's energy consumption and it is projected to grow by 53% in 2035 compared to 2005. As 80% of energy demand is met by fossil fuel, the region's carbon dioxide emission, which is considered as the main cause of climate change, is expected to increase by 46% in 2035. Meanwhile, the region will continue facing the threat of depleted oil as projected in APEC Energy Demand and Supply Outlook published by energy working group (EWG) in 2013. Considering the region's energy security and sustainable growth, improving energy efficiency has been identified as a cost-effective measure which can be attained in a shorter timescale (APEC leaders' meeting in Sydney, 2007). In addressing the challenges, the APEC leaders' meeting in Honolulu, 2011, called for working towards reducing energy intensity by 45% by 2035.

1.1 Background study: APEC Energy Working Group (EWG)

To achieve the target, projects in exploring technology and policy opportunities are conducted throughout APEC economies among which EWG plays a key player in fostering the actions. EWG was established in 1990 to maximize the contribution of energy sectors in region's economic and social welfare. It consists of 4 expert groups, Clean Fossil Energy, Energy Data & Analysis, Energy Efficiency and Conservation and New & Renewable Energy Technologies taking initiatives including Energy Security, Energy Smart Communities, Sustainable Development and Task Forces, Energy Trade and Investment, and Biofuels. The structure of this voluntary partnership is shown in

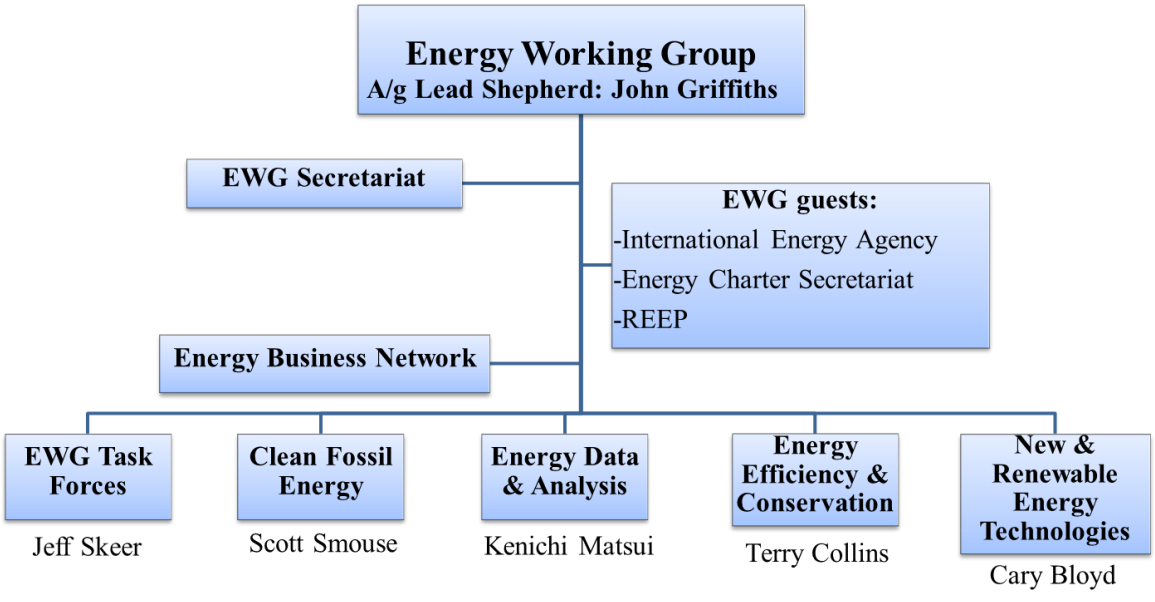

Figure 1.1 APEC Energy Working Group Organizational Structure

Figure 1.1.

1.2 Energy Security Initiative (ESI)

The Energy Security Initiative (ESI) was first endorsed in 2001. It consists of multiple measures in addressing region's short term energy supply disruption and long term energy challenges to which energy efficiency considered as a critical solution. The Energy Efficiency program under ESI is implemented through the following mechanisms,

- APEC Energy Peer Review Mechanism (APEC/PREE)
  In March, 2008, EWG members endorsed PREE in Peru. It aims to share information, policies and measures in improving energy efficiency, explore the best strategy in formulating action plan, monitor the progress and thus provides the recommendations to APEC economies in achieving their goal. It involves two activities: 1) to compile/concise AEPC member's energy policies; and 2) to review the policies by member economies which volunteer for APEC/PREE.
- Pledge and Review Program
  The voluntary program allows APEC members to share the information on energy initiatives. Two meetings are held annually. In the first meeting, APEC members would submit economy-specific energy efficiency project. While in the second meeting, the members would submit the report on a common topic.
- APEC Energy Standards Information System (APEC ESIS)
  It provides a comprehensive platform (website) which enables governments and stakeholders to share information on testing, minimum energy performance and labeling standards for equipment traded within APEC region.
- EWG Expert Group on Energy Efficiency and Conservation (EGEEC)
  It promotes energy conservation and the application of energy-efficiency practices and technologies throughout APEC region.
- Recently completed and ongoing projects
  A wide range of projects in promoting energy efficiency are carried out throughout APEC regions. The recent projects have been focusing on the following topics, the best practice in application, the harmonization of standards and exploring policy and technology opportunities.

1.3 Energy for Sustainable Development Initiative

In 2007, a Type 2 Partnership Submission, "Energy for Sustainable Development:

Fostering Regional Energy in APEC, 2007-2010" was submitted by EWG. It emphasizes the importance of environmental issues while addressing energy security by achieving the following objectives:

- Strengthening energy security and reliability
- Promoting clean and efficient technologies,
- Reducing environmental impact of energy production, use and mineral extraction
- Harnessing all expertise available to the EWG to give effect to the above objectives.

1.4 Energy Smart Communities Initiative (ESCI)

On the other hand, the Energy Smart Communities Initiative (ESCI) translates the policies into sectorial implementation aiming to foster green growth, sustainable development and long-term job creation. It was launched by US President Obama and Japanese Prime Minister Kan in November, 2010. It comprises of four pillars. Each has its own Action Network with coordinator to define and mobilize the activities and participants to contribute substances. The projects under these four pillars and the participant economies are shown in Table 1.1. From Table 1.1, it is shown that US and Chinese Taipei play the most active role participating all the projects under four pillars. On the other hand, the republic of Korea engages more in the project of Smart Grid serving as one of the coordinators. Meanwhile, the project of Smart Buildings attracts the most economies whereas the project of Smart Jobs and Consumers has less participants.

Table 1.1 ESCI Action Network: the project and participants

Pillar	**Category**	**Coordinator**	**Participant**
Smart Transport	Energy-efficient urban transport	US	Australia, Canada, Indonesia, Singapore, Chinese Taipei and US
	Energy-efficient freight transport	US	Australia, Canada, Indonesia, Chinese Taipei and US
	Electromobility	Canada	Australia, Canada, Hong Kong, China , Indonesia, Japan, Malaysia, Singapore, Chinese Taipei, US
	Electric Vehicle Demonstrations	Japan and US	Canada, Indonesia, Japan, Malaysia, The Philippines, Chinese Taipei, US
Smart Buildings	Low Energy Buildings Network		Australia, Brunei Darussalam, Canada, Hong Kong, China , Indonesia, Japan, Malaysia, Russia, Singapore, Chinese Taipei, Thailand, US

	Materials Testing and Rating Centers	Thailand	Australia, China, Indonesia, Japan, Republic of Korea, Malaysia, Mexico, Russia, Singapore, Chinese Taipei, Thailand, US
	Cool Roof Demonstrations	US	Australia, China, Indonesia, Japan, Republic of Korea, Malaysia, Russia, Singapore, Chinese Taipei, US
	Low Energy Window Demonstrations	US	Indonesia, Malaysia, Singapore, Chinese Taipei, US
Smart Grid	Interoperability Survey and Roadmap	US	Australia, Indonesia, Japan, Republic of Korea, The Philippines, Russia, Singapore, Chinese Taipei, Thailand, US
	Smart Grid Test Bed Network	Republic of Korea	Australia, Indonesia, Republic of Korea, The Philippines, Russia, Singapore, Chinese Taipei, Thailand, US
Smart Jobs and Consumers	Energy Efficiency Training Curricula	US	Canada, Hong Kong, China , Indonesia, Russia, Singapore, Chinese Taipei, Thailand, US
	Energy Efficiency School Curricula	US	Hong Kong, China , Indonesia, Japan, Russia, Chinese Taipei, US
	Sister Schools Program	Japan and US	Indonesia, Japan, The Philippines, Russia, Chinese Taipei, US

- Smart Transport

  It investigates clean and efficient ways of moving people and goods by reducing the travel time, cost, energy consumption and carbon dioxide emission from urban commuting and freight transport. The Action Network includes Energy Efficient Urban and Energy Efficient Freight Transport Network, Electromobility Survey and Roadmap and Electric Vehicle Demonstrations.
- Smart Buildings

  It seeks for cost-effective measures in improving the energy efficiency of existing and new buildings which accounts for one-third of energy consumption in APEC region. The Action Network projects are proposed as Low Energy Building Network, Materials Testing and Rating Centers, Cool Roof Demonstrations and Low Energy Window Demonstrations.

- Smart Grids

  It improves the operation efficiency of power plants, facilitates more efficient electricity consumption in buildings and industry, and enables greater penetration of renewable energy by integrating various technologies and practices into the power system. The Action Network projects are carried out in two directions, Interoperability Survey and Roadmap and Smart Grid Test Bed Network.
- Smart Jobs and Consumers

  It promotes a wide range of green jobs. Meanwhile, as to create the market, it also focuses on educating the consumers to make energy-efficient choices at their home. It comprises of three types of Action Network, Energy Efficiency Training and School Curricula and Sister Schools Program.
- Cross-Cutting

  It aims to integrate the abovementioned technologies, energy-efficiency buildings, transport and power system to create low carbon model towns (LCMTs). The Action Network is established around the APEC region. The successful examples will be collected to develop best practices.

1.5 Project Structure and Summary

This project acknowledges the abovementioned trend and APEC leaders' call for actions in sharing information on energy efficiency policies and facilitating collaboration among member economies. It specifically focuses on the efforts of Chinese Taipei government. The project is composed of five pillars (Table 1.2). The

Table1.2 The structure of the project

Background study: The energy efficiency projects in APEC region	
Energy outlook in APEC region	Energy efficiency projects by Energy Working Group
How Chinese Taipei responds to the call: policies and action plans	
National Energy Conservation and Carbon Reduction Master Program	Capacity building: technology innovation and talent training
Industrial application and its outcome	
Apply the policy to the industry: Chinese Taipei Industrial Greenhouse and Energy Reduction Corps	Case study: successful experience sharing from the industry
International collaboration: introducing energy management system to Thailand	
Methodology	Outcome
Building the comprehensive policy and industrial application model for advancing energy efficiency	
Identifying successful factors in policy making and industrial application	

first part is to introduce the previous and ongoing projects of APEC EWG which is discussed in this chapter. The other four pillars are summarized as follows and will be covered in the rest of the report.

- How Chinese Taipei responds to the call: policies and action plans
  It reviews the top down strategies, which are how the policies and strategies are made to fulfill government's targets and how these are translated into applicable actions of industry. As one of APEC members, Chinese Taipei government has been dedicated in promoting energy efficiency. In 2010, National Energy Conservation and Carbon Reduction Master Program was initiated. It aims to reduce the energy-intensity by at least 50 percent and the carbon dioxide emission from 2000 levels by 2025. In achieving the target, sectorial policies and action plans were identified and assigned to different ministry and government agencies.
- Industrial application and its outcome
  The second part introduces the bottom up strategies of how industries respond to the regulations. As industry consumes more than 50% of energy annually, it is the main target for government in promoting energy efficiency. Two small and medium enterprises of service and manufacture sector are discussed as case study. In addition to their successful outcome in implementing energy management system, the case studies are chosen for their applicable strategies that can be learned and further adapted to other SMEs.
- International collaboration: introducing energy management system to Thailand
  In exchanging the experiences and expanding Chinese Taipei's effort, the project team cooperated with Thailand partners to introduce the energy management system to Thailand textile plant. The outcome and lesson learned in the collaboration between two economies is reviewed in the report.
- Building the comprehensive policy and industrial application model for advancing energy efficiency
  The project covers an international workshop and training course in Chinese Taipei. In addition to sharing the experiences of Chinese Taipei and international experts, a survey would be conducted to investigate the opinions of participants towards energy issues and the progress of respective economy. To consolidate the findings of the projects and make it widely applicable to other economies, the successful factors of policy making and an energy management model is identified and developed.

In conclusion, energy issues are regarded as the priority of APEC economies' policy making. In addressing the challenge, improving energy efficiency is identified as a cost-effective way and becomes an important theme of APEC EWG's project. Chinese

Taipei has been an active player in these projects and dedicated in improving energy efficiency by introducing policy and action plans. By reviewing Chinese Taipei's effort and further cooperating with member economies, a policy and industrial application model for improving energy conservation and efficiency will be established for generic application throughout APEC economies in this report.

Chapter 2 Policy and action of Chinese Taipei to achieve low carbon society

In respond to the growing concern of climate change and depleted fossil fuel, energy conservation and carbon reduction has become the priority in international policy making. In Copenhagen Accord released in UNFCCC/COP15, Annex 1 parties are required to set their quantified emission reduction goal while the Non-Annex 1 parties are to establish their National Appropriate Mitigation Actions (NAMAs). Although Chinese Taipei has not been included in the regulation, it has been dedicated in addressing the challenges and set voluntary reduction goal as achieving 2000 level of emission by 2025 which is to be met by solutions such as raising the energy efficiency. Hence, the government of Chinese Taipei has determined to raise the energy efficiency by 2% annually and at least 50% by 2025 by technology breakthrough and supplementary measures.

2.1 Policy: National Energy Conservation and Carbon Emission Reduction Master Plan

To achieve the target, National Energy Conservation and Carbon Emission Reduction Master Program was initiated in 2010. The implementation is mainly conducted by Energy Conservation and Carbon Reduction Promotion Council which organizational structure is shown in Figure 3.1. The council is led by the Vice Premiere of Executive Yuan serving as the chairmen while the Secretary-General and Ministers without Portfolio as the vice chairmen. It covers topics in interior, foreign affairs, transportation,

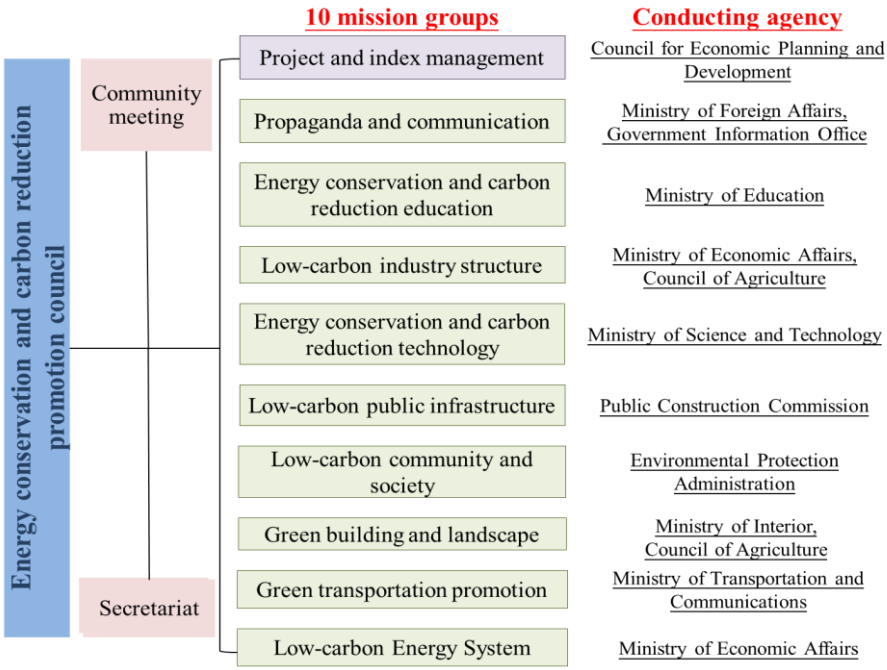

Figure 2.1 The organizational structure of energy conservation and carbon reduction promotion council

education, environmental protection, finance, technology and agriculture which are distributed to 10 mission groups shown in Figure 2.1 and assigned to respective government agencies.

The objectives of the council are to:

1. Design and build the national energy conservation and carbon reduction vision, target and plan.
2. Review and audit the energy conservation and carbon reduction strategies and the implementation performance of each conducting agencies
3. Mediate and integrate the energy conservation and carbon reduction issues across different sectors
4. Other related affairs

Each mission group is responsible for corresponding projects under National Energy Conservation and Carbon Reduction Master Program which includes 10 benchmark projects and 35 sub-projects.

1. Consolidate the legislation system

   The project is conducted by Environmental Protection Administration, Ministry of Finance and Economic Affairs. It investigates the appropriate policy tools and administrative regulations so as to develop the capability and economic incentives for industry and the public to fulfill energy conservation and carbon reduction. The project aims to establish Greenhouse Gas Reduction Act, Sustainable Energy Policy, the Renewable Energy Act and its amendment covering the regulations such as GHG Emission Permits, GHG Emission Performance Standards and Cap and Trade Scheme.

2. Transform to the low-carbon energy system

   The project involves Environmental Protection Administration, the Ministry of Finance and Economic Affairs. It aims to curtail depletion of natural resources and the impact on the environment by developing low-pollution, safe, sufficient, and sustainable energy system and advancing the reasonable growth of energy demand. It includes 4 sub-projects:

   I. Promote the new-era of renewable energy

      It focuses on solar, biomass and wind power with complementary sources such as geothermal, hydro and oceanic energy.

II. Reduce the carbon dioxide emission of electricity generation

In addition to raising the generation efficiency of coal-fired power plants, it promotes the proper development and consumption of natural gas.

III. Promote the development of smart grid

In addition to the steady buildup of the infrastructure, the project plans and prepares the services of smart grid and smart power supply.

IV. Promote and evaluate the reasonable utilization of nuclear power plants

The safety audit for the 4th nuclear power plants in fuel filling and activation is conducted. Additionally, the project reviews and issues the renewal of the nuclear power plants licenses.

3. Build the low-carbon community and society

The project is directed by Environmental Protection Administration. It promotes the low-carbon city demonstration plan which is comprised of low-carbon communities with renewable energy life circle. In addition, Penghu and Kinmen are designated as low-carbon islands while Green and Liuqiu Island are low-carbon tourism islands. Lastly, it focuses on altering citizen's lifestyle by creating green consumption trend and promoting public actions in energy conservation and carbon reduction.

4. Establish the low-carbon industry structure

The objective of the project is to increase the added value of unit carbon emission, decrease the carbon emission intensity and strengthen the green energy industrial development. The sub-projects include:

I. Promote the energy conservation and carbon reduction of the industry

It is fulfilled through promoting the voluntary emission reduction of the industry, the integration of energy and resources in the industrial zone, examining the energy efficiency and conservation of the boilers, investigating the energy consumption of heavy users, promoting and instructing the emission reduction of the industry. In achieving the abovementioned goal, Chinese Taipei Industrial Greenhouse and Energy Reduction Corps is formed to provide the technical services to the industry.

II. Conduct the Strategic Environmental Impact Assessment of energy intensive industries

In the current stage, the project targets at iron and steel and petrochemical

industries.

III. Promote the Rise of Green Energy Industry project

The project is implemented by the Ministry of Economic Affairs. It prioritizes and emphasizes the development of solar cell, LED and wind, biomass and hydrogen energy and lastly, the electric vehicles.

IV. Promote the energy conservation and carbon reduction of agriculture

5. Construct the green transportation network

The project is organized by the Ministry of Transportation and Communication. It aims to reduce the emission from transportation sector by building convenient and smart transportation system, promoting the use of low-carbon fuel and curtailing the growth of vehicle demand and use. These are achieved by the following sub-projects:

I. Develop green and seamless expressway transportation.

The project is to build low-carbon transportation network through integrated public transportation system and eastern biking route demonstration project.

II. Promote the green public railway transportation network

The railway system will be complete through finalizing the high speed railway scheme, improving traditional railway system and integrating the transportation connecting urban area and the airport.

III. Establish the smart expressway services

The project is to implement the integrated management of highway system, Electronic Toll Collection and smart transportation control.

IV. Create the human-oriented urban transportation environment based on green vehicle including the development and improvement of pedestrian and biking environment.

V. Improve the efficiency standard of private vehicles

6. Create the green environment and popularize green buildings

The project is carried out by the Ministry of Interior and Council of Agriculture. It’s directed to upgrade the new/old buildings towards green buildings so as to create the energy conservation and carbon reduction living environment. On the other hand, it strives to conserve forest as carbon storage sinks. The sub-projects include

the following four:

I. Advance new green buildings and the use of green materials

It is carried out by promoting green building certificates and labels, increasing the energy efficiency of buildings, regulating the energy conservation technical design of buildings, encourage the design, improvement and demonstration of green buildings by private sectors.

II. Promote smart green buildings

III. Advocate the labeling mechanisms of building's energy conservation

IV. Promote afforestation

7. Expand the capacity of energy conservation and carbon reduction

The project is conducted by the Ministry of Science and Technology. It emphasizes the development and innovation of new, renewable and low-carbon energy technology s so as to increase the international competitiveness of Chinese Taipei. It can be categorized as two sub-projects:

I. Promote National Energy Project

The energy technology focused in Chinese Taipei includes solar, wind, biomass, oceanic, hydrogen, nuclear, geothermal energy and its storage technology. Additionally, the project incorporates the energy technologies into carbon capture and storage, refrigerating and air-conditioning engineering, transportation, industrial energy conservation, lighting appliances, afforestation and smart grid so as to realize energy conservation and carbon reduction synergy. Lastly, as nuclear is currently considered as the zero-emission source of electricity generation, the project will proceed in increasing its safety and quality techniques.

II. Cultivate the interdisciplinary talents in energy technology through energy conservation and carbon reduction education plan

8. Promote public construction in energy conservation and carbon emission reduction manner

The project can be broken down into 3 sub-projects:

I. Develop the regulation and mechanism of sustainable and low-carbon public construction

It investigates the energy saving techniques and materials of construction, regulate the principles and references of energy conservation and carbon emission reduction design, amend the current regulations and lastly, expand the budget of green energy in public construction projects.

II. Promote the overall life cycle assessment and quality management of public construction

It is implemented through strengthening the audit system of planning and design on its energy conservation and carbon emission reduction effect, fulfilling the planning in construction stage and developing mechanism in maintaining and management.

III. Strengthen the government procurement procedure and regulate the interior energy conservation and carbon reduction mechanism

The project amends the current Government Procurement Act and investigates the mechanisms for private sectors in replacing high-efficiency appliances for the government.

9. Enhance the energy conservation and carbon emission reduction education

The project is conducted by the Ministry of Education which involves in the following sub-projects:

I. Apply the energy conservation and carbon emission reduction plan to the schools and organizations affiliated to the Ministry of Education

The plan includes the gradual upgrade of lighting system and annual examination of electricity consumption in each organization.

II. Create sustainable campuses and the evaluation system of schools' effort in energy conservation and carbon emission reduction through "Sustainable Campus Promotion Project" and "Campus Greenhouse Gas Management Project".

III. Enhance energy conservation and carbon emission reduction education

It creates the platform which promotes "Sustainable Campus Digital Learning Curriculum" and the propaganda short films.

10. Enhance energy conservation and carbon emission education propaganda and communication

The project is mainly conducted by the Ministry of Foreign Affairs and Government

Information Office. It prioritizes the collaboration in energy conservation and carbon emission reduction of one of Chinese Taipei's diplomatic strategies. Meanwhile, it has been dedicated in raising the public's awareness so as to support the implementation of the government's policy. The sub-projects include:

I. Energy conservation and carbon emission reduction propaganda project

On the government office side, it endeavors to raise the awareness and understanding in the issue of the employees and put the energy conservation and carbon emission strategies into effect. On the industry and society side, it enhances the industry's understanding and implementation and creates the societal trend in energy conservation and carbon emission reduction.

II. Promote environmental diplomacy

As environmental issue would impact across broader, it's a common responsibility and requires international collaboration in addressing the challenges. Chinese Taipei has been striving to take part in the United Nations Framework Convention on Climate Chang and enhance the propaganda of its effort in coping with the issue.

2.2 2011: the Energy Conservation and Carbon Emission Reduction Year

In order to achieve the abovementioned target and put all the projects into effect, Chinese Taipei government set 2011 as Energy conservation and Carbon Emission Reduction Year following the action plan shown in Figure 2.2 which effect is shown in Table 2.1.

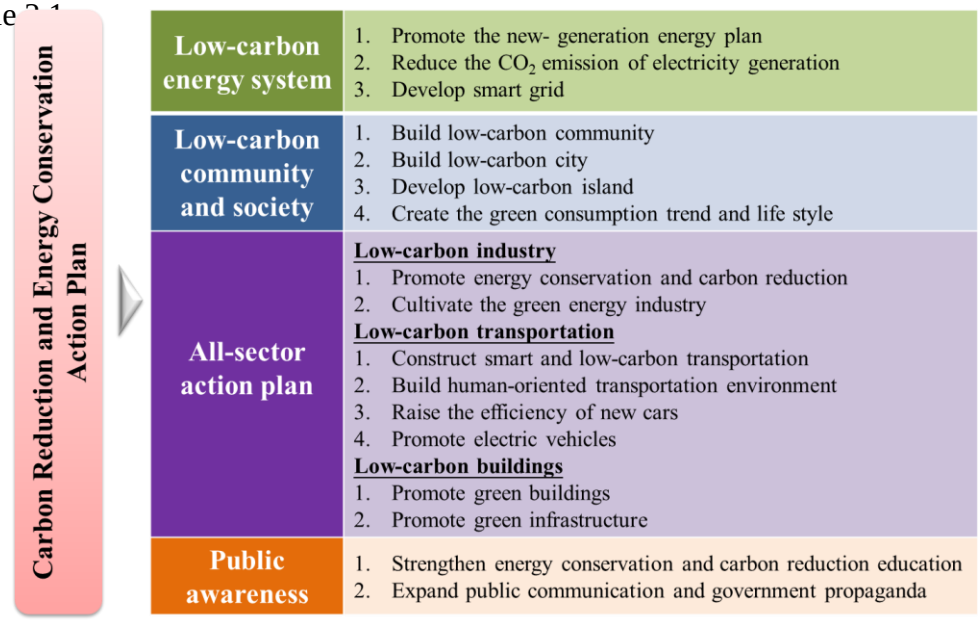

Figure 2.2 The action plan of Energy conservation and Carbon Emission Reduction Year

Table 3.1 The outcome of carbon reduction and energy conservation action plan

Title	Measures	Progress /Outcome/Target
Promote the new-generation energy plan	1. Establish the new feed-in tariff (FIT) mechanism for renewable energy. 2. Develop new FIT rate sparing renewable energy more benefits. 3. Provide subsidies for new renewable energy facilities with potential in its initial stage. 4. Exploit the opportunity for local frontier renewable energy (e.g. oceanic and geothermal). 5. Introduce small-scale generation facilities (PV panels) in the community and public buildings	1. The power generated from renewable energy reaches 33.4 MWh → CO_2 emission↓7 Mton. 2. Emission factor of electricity generation reduces 0.8kg CO_2/kWh. 3. The intensity of the household equipped with solar water heater ranks world's top 3. 4. Move on-shore wind energy forward to off-shore. 5. Upgrade biomass fuel from B1 to B2.
Reduce the CO_2 emission of electricity generation	1. Expand and renew existing power plants, Talin and Linkou from efficiency 40.7% and 37.8% to 44.5% investing 271.9 billion NTD. 2. Replace the old power plants for new, Shen-Ao and Tunghsia, investing 202.1 billion NTD (still in discussion). 3. Upgrade the existing facilities, Taichung, Hsinta and Tunghsiao, investing 7.96 billion NTD. The efficiency for steam turbine increases 0.59-0.76%, gas combined cycle (GCC) 0.38-1.4%. 4. Eliminate 31 facilities (14,515 MW).	1. Emission factor of electricity generation reduces from 0.864 and 0.929 to 0.789 kg CO_2/kWh; CO_2 emission↓9,070 thousand ton. 2. CO_2 emission↓830 thousand ton. 3. CO_2 emission↓606 thousand ton. 4. CO_2 emission↓8,440 thousand ton.

Develop smart grid	Introduce ICT into power supply system and finalize its infrastructure (High/low voltage advanced metering infrastructure, AMI)	5. ↓peak load by 650 thousand kW, power ↓9.8 billion kW, CO_2 emission↓6,200 thousand ton.
Build low-carbon community	1. Identify possible strategies and hot spots with the highest energy saving and emission reduction potential. 2. Initiate local organization. 3. Establish community index and label to encourage the public participation. 4. Promote international collaboration.	1. Established 25 low-carbon demonstration community in 2010 2. Built 2 demonstration communities in each city in 2011 3. Built 50 low-carbon demonstration communities in Chinese Taipei.
Build low-carbon city	Motivate cities' participation through competition mechanism.	1. Selected 4 cities as demonstration in 2011. 2. Finalized the construction of low-carbon cities in 2014.

Develop low-carbon island	Selected Penghu as the first demonstration site; the measures are categorized as: 1. Renewable energy: set up large-scale wind power 96 MW, solar energy building 2MW and solar water heater 1,000 households. 2. Energy conservation: Equip AMI 2,106 households, 4,000 LED street light and 21,000 energy-efficient appliances. 3. Low-carbon transportation: introduce 6,000 electric motorcycles, 61 hybrid electricity bus, full implementation of B2[1] biodiesel and E3[2] bioethanol and around-the-island biking routes. 4. Low-carbon building: 100% new public buildings and major private investment certified with greed building index and expand greenery to 330 hectares. 5. Resources recycling: reduce the water leakage from 32% to 25%, seawater supply 5,700 ton/day and achieve zero waste. 6. Low-carbon lifestyle: promote the energy education, public participation, and energy management and carbon footprint labels.	1. Achieve 55% renewable energy supply. 2. Reduce the CO_2 emission per capita by 50% compared to 2008 in 2015, from 5.4 ton to 2.1 ton/year.

Create the green consumption trend and lifestyle	1. Promote the energy efficiency labeling system of home appliances. 2. Replace the incandescent lamp and enhance the insulation of air conditioning in service sector. 3. Household electricity conservation competition: ✓ Rebate on electric bills for energy saving (current): grant discount to household that consumes less electricity than previous month. ✓ Regional household electricity conservation competition (planning): grant discount to the households that live in the region with the highest amount of energy conservation.	1. Reduced electricity consumption by 570 million kWh/ year and 360 thousand ton of CO_2. 2. Reduced electricity consumption by 2.2 billion kWh/ year and 1.4 million ton of CO_2. 3. From 2008-2010, total electricity conservation amounts to 7 billion kWh and CO_2 emission was reduced by 4.5 million tons.
Promote energy conservation and carbon emission reduction in industry	Establish Chinese Taipei Industrial Greenhouse and Energy Reduction Services Corps to direct the implementation in the industry by: 1. Providing on-site energy conservation evaluation and technical services. 2. Promoting the voluntary energy conservation in the industry. 3. Building the capacity of the industry in meeting the international standard of greenhouse gases. 4. Introducing Energy Service Company (ESCOs) to enhance energy management in the industry. 5. Providing platforms for on-line learning, technical services and information.	From 2009-2013, the Corp helped 2,243 manufacturer proving 9,478 energy saving solutions, reduced 2 million ton of CO_2 emission and cost by 9 billion NTD.

Cultivate the green energy industry	Launch Green Energy Industry Services Office to: 1. Provide information in industry, market and technology development. 2. Assist industry in solving problems in technology, investment, environment and market. 3. Investigate the barriers in the industry for improvement in government strategies.	The output value grew from 160 to 174 billion NTD: 1. The production of solar battery ranks world's top 3 and LED top 2 with annual growth rate 28%. 2. Installed 436 MW of wind power with annual generation of 1 billion kWh. 3. Introduced energy ICT technology to 150 franchises of convenience stores (Family Mart).
Construct smart and low-carbon transportation	The project is categorized into three directions: 1. Green and seamless expressway: establish mobile management system and 1,297 km of biking routes in the east. 2. Convenient public railway transportation: improve highway, urban metro and railway system. 3. Smart expressway services: implement transportation management, electronic toll collection and intelligent traffic control system.	It is estimated to reduce emission by 0.43, 1 and 1.2 million ton of CO_2 emission in 2010, 2020 and 2025.
Build human-oriented transportation environment	1. Build 120 km of urban biking routes by 2012. 2. Invest 6 billion NTD to subsidize cities and counties in improving human-oriented transportation environment.	1.1 million ton of CO_2 emission is absorbed and stored annually.

Raise the fuel efficiency of new vehicles	1. Implement energy efficiency labeling system to new vehicles in 2010. 2. Raise the minimum energy efficiency standard by 10% which eliminates 15% of vehicle models in 2011. 3. Raise the minimum energy efficiency standard by another 15% and eliminates another 15% of vehicle models.	Reduce gasoline consumption by 84 thousand kL and CO_2 emission by 220 thousand tons.
Promote electric vehicles	1. Launched electric motorcycle industry development project to encourage the market and stakeholders to build charging system. 2. Implement smart vehicle development strategy and action plan to subsidize the purchase of electric vehicles.	1. From 2009-2012, domestic electric motorcycle reached 160 thousand models reducing 13 thousand tons of CO_2 emission. 2. It is estimated be 1.5 million of electric vehicles in use reducing CO_2 emission by 2.25 million tons.
Promote green buildings	1. Promote new green buildings and the use of green materials by: ✓ Promoting green building certificates and index. ✓ Applying buildings' energy conservation design and techniques' regulation. ✓ Subsidizing the improvement of public building's energy conservation. ✓ Encouraging private buildings' energy saving design. 2. Promote building's energy conservation labeling system.	It is estimated to reduce CO_2 emission by 1.9 million tons.

Promote green public construction	1. Develop energy conservation and carbon emission reduction mechanism in public construction. 2. Promote the life cycle quality management mechanism in public construction. 3. Enhance the energy conservation and carbon emission reduction in procurement procedure and regulation.	10% of public construction investments were put into green construction.
Strengthen energy conservation and carbon reduction education	1. Replace old and inefficient appliances in schools. 2. Incorporate energy conservation and carbon emission reduction issues into current curriculum and teaching materials.	It is estimated to reduce 84 thousand tons of CO_2 emission starting from 2010.
Strengthen public communication and government propaganda	1. Introduce the energy saving competition among government administration. 2. Develop Chinese Taipei Industrial Greenhouse and Energy Reduction Services Corps to build the energy conservation capability of private sectors.	From 2007-2009, the total electricity consumption has been reduced by 150 million kWh.
Develop energy conservation and carbon emission reduction index and competition mechanism	Launched the energy conservation and carbon emission reduction performance evaluation mechanism in 2011.	It has been implemented since 2011 selecting best cities based on its performance in low-carbon lifestyle and utility conservation.

Chapter 3 Driving transformation to energy efficient industry in Chinese Taipei

To meet the target of the policy and action plan, technology innovation is required to expand the effect of energy conservation and carbon emission reduction of which development would foster the transformation towards low-carbon industry. Meanwhile, to ensure all the projects and technologies are fulfilled in the industry, expert group, Chinese Taipei Industrial Greenhouse and Energy Reduction Services Corp was formed by experts from government, industry and research sectors in 2010.

3.1 Technology innovation: the integrated effort of government, industry and research sectors

In Chinese Taipei government has set two directions for the development of technologies which involves the participation from government, industry and research sectors (Figure 3.1). It mainly focuses on freezing& air-conditioning facilities, advanced lighting, information and communication technology on energy, energy conservation techniques in buildings and industry. In promoting these technologies, Government takes the initiatives funding the technology development from research sector, setting the regulation and incentives for industry to apply the energy conserving and low-emission process and equipment.

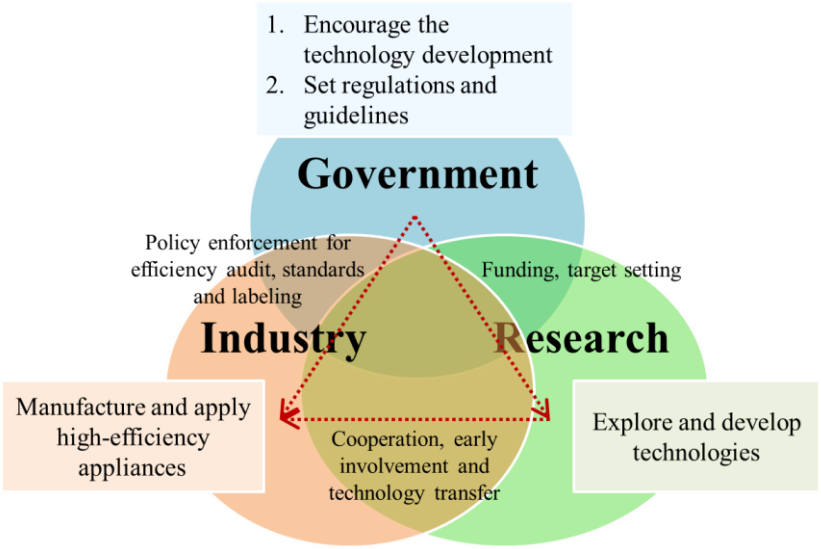

Figure 3.1 Joint efforts of government, industry and research to promote energy conservation

3.1.1Freezing and air-conditioning facilities

As located in sub-tropical area and the advancement of living standard, the electricity consumption from residential and business sectors occupies 31% of total electricity consumption among which air-conditioning contributes 40-50% in summer and 20-

30% in winter. As a result, the technology to improve the efficiency of air-conditioning system has been prioritized in 2009 national energy conference of Chinese Taipei. The strategies have been categorized into product and system efficiency management and subsidy for technology innovation.

Technology innovation

For the technology innovation, it has been focusing on three directions, high speed spinning magnetic bearing oil-free centrifugal chiller, dry separation air-conditioning system and low greenhouse gas effect refrigerant. The development follows the timetable shown in Table 3.1.

Table 3.1 Technology development of air-conditioning system

Technology	Short-term (-2017)	Mid-term (-2021)	Long-term (-2025)
High speed spinning magnetic bearing oil-free centrifugal chiller	1. Develop product module, including 100-400 RT compressor, 100-800 RT chiller 2. Promote to international market 3. Target: • 100&200RT:efficiency≥93% • 300&400RT:efficiency≥94%		Develop centrifugal compressor, blower, liquid pump, air-freezing cycle application
Dry separation air-conditioning system	Analyze the energy conservation feasibility and demonstrate the system to raise the chillers' performance for 20-30%	1. Establish the design guideline for the system 2. Develop the components and equipment	Export components, equipment and system engineering to international market
The development of air-conditioner with low-greenhouse-effect refrigerant	Investigate thermal dynamic, heat transfer and compression characteristics of refrigerant	Develop specified refrigerant compressor, heat transfer and expansion equipment and components	Develop low-greenhouse-effect refrigerant air-conditioners to supply global market

Policies, promotion and application

Meanwhile, policies and regulations are made to raise consumers' awareness and cultivate the green market. The regulations and complementary criteria are introduced in three categories:

1. Regulate the Coefficient of Performance (COP) of air-conditioner and establish the methodology for measuring Integrated Part Load Value (IPLV) and its standard.
2. Establish the methodology for measuring and regulating the Cooling Seasonal Performance Factor (CSPF) of commercial air conditioner.
3. Regulate the baseline of electricity consumption of commercial air conditioner and establish the criteria in conservation encouragement.

Through the mechanism coupling technology with policies, the anticipated effect is shown in Table 3.2.

Table 3.2 The outcome of introducing efficient air-conditioning system

Measure	Energy conservation
1. DC inverted-frequency air conditioner − R&D, test facilities and capability to commercialize − CSPF standard and promotion mechanisms 2. Replace 200 thousand pieces of old air conditioners.	↓200 million kWh and 120 thousand ton of CO_2
Introduce high-efficiency chiller which combines the big-scale variable frequency control induction motor	↓450 million kWh/year
Develop high-efficiency centrifugal compressor chiller	300 million kWh/year
Develop non-ducted type air conditioners	1. ↑COP 25% 2. ↓300 million kWh/year in 2016 3. ↓1.5 billion kWh/year in 2021, ↓933.9 thousand ton of CO_2
Introduce heat recovery for air conditioners in restaurant franchises	1. ↓60% of electricity consumption 2. ↓500 million kWh/year, ↓317.9 thousand ton of CO_2 (5-year promotion, occupies 60% of market)
Develop R-134a 120RT variable-frequency chillers	↓1.7 MTOE/year (occupies 55% of the market in 2020)

3.1.2Advanced lighting system

In 2011, the total electricity consumption of lighting amounts to 26.4 billion kWh occupying 12% of national consumption. The large consumption mainly comes from: low average energy efficiency of lighting system of 50Lm/W while the mature lighting technology has achieved 70 Lm/W; high lighting power density (LPD) of 28 W/m^2 while the standard in New Zealand, Australia and Japan is 12-20 W/m^2; high illumination of 600-800 Lux which is above the actual working demand.

In addressing these issues, LED (Light-Emitting Diode) has been regarded as one of the priorities in Rising Green Industry Program in Chinese Taipei, 2012, aiming to achieve its output value as 318 billion USD in 2016.

Technology innovation

The solutions for improving the efficiency of lighting system is categorized into three parts, lighting design, lighting equipment and intelligent lighting management among which raising the energy conversion efficiency of the equipment has been the most commonly used. OLED (Organic light-emitting diode) has been another focus for its thinness, low Unified Glare Ratio (UGR), energy demand and high flexibility. The benchmark of advanced lighting system is shown in Table 3.3. The development of three technologies follows the timetable shown in Table 3.4, 3.5 and 3.6.

Table 3.3 The benchmark of advanced lighting system

Technology		International benchmark	Domestic benchmark
LED lighting	Light engine package	The efficiency of integrated light engine reaches 70%	1W integrated light engine package
	Driver	Conversion efficiency reaches 90% in 2020	Conversion efficiency reaches 92% in 2020
	Intelligent LED lighting system	In its primitive and high-cost stage	Automatic adjustment of CCT and control system
Intelligent lighting management system	System software	Digital lighting management: scheduling, modeling, scenario and illuminate	Internet control platform, lighting environment design and control technology, informatization of lighting management system
OLED lighting	OLED component	The lighting efficiency of Panasonic reaches 114 Lm/W (lighting area: 1cm × 1cm)	Lighting efficiency: 110 Lm/W
	Large area lighting	The lighting area of Lunmiotec: 12.5 cm × 12.5 cm	Lighting area: 10 cm × 10 cm
	Packaging	Water Vapor Transmission Rate (WVTR) of Vitex $<1 \times 10^{-6}$ g/m^{2}day	Water Vapor Transmission Rate (WVTR) of Vitex $<1 \times 10^{-3}$ g/m^{2}day; Oxygen Transmission Rate (OTR) $<5 \times 10^{-2}$ cc/m^{2}day

	Driver	Conversion efficiency reaches 93% in 2020	Conversion efficiency reaches 93% in 2020

Table 3.4 Development timetable of intelligent lighting management system

Technology	Short-term (-2015)	Mid-term (-2020)	Long-term (-2025)
Lighting management system	Scenario-oriented	Saving-oriented	Human-oriented
Lighting environment design	High efficiency algorithm	Environmental driven	Human-oriented & interactive

Table 3.5 Development timetable of LED lighting technology

Technology	Short-term (-2015)	Mid-term (-2020)	Long-term (-2025)
Light engine	− High integrated package − R2R surface lighting source package − Integrated driven electrical circuit − The development of process and equipment	− High reliability and c/p value technology − System efficiency 200Lm/W	− Intelligent & general design platform − The process integration of solid-state lighting and semi-conductor
Smart & value-added lighting system	− Low glare and CCT shift − Low cost and high reliability communication agreement	− Smart adjustment of lighting environment − Human-oriented	Smart and human-oriented demonstration
The construction of Solid-state lighting industry	− The ESCO model of solid-state lighting − the demonstration and promotion	50% penetration of solid-state lighting	The test and verification capability

Table 3.6 Development timetable of OLED lighting technology

Technology	Short-term (-2015)	Mid-term (-2020)	Long-term (-2025)
OLED Component	High-efficiency white light technology	The standard and application of low cost technology	Large area and low cost lighting module

OLED Application	Innovative application	Niche design application	General application

LED Street Light Demonstration and Promotion

To bolster the development of high-efficiency street lighting equipment, demonstrate and evaluate the replacement benefits of traditional ones, and boost the industry, regulations and policies are initiated. It is forbidden to equip any mercury-vapor street light from 2012 in the newly built street. The procurement of mercury-vapor street light by government administration is prohibited from 2016 aiming to eliminate the use of mercury-vapor street light from 2018.

In 2011, the Executive Yuan of Chinese Taipei initiated the Economic Revitalization Policy which incorporates the measures to install LED street lights throughout Chinese Taipei following the timetable shown in Table 3.7. The projects are estimated to save 180 million kWh reducing 112 thousand tons of CO emission annually and bring 3.69 billion NTD production value.

Table 3.7 The timetable of promoting LED street lighting

Project	Duration	Target	Scale (replaced units)	Budget (NTD)
Expanding the installation	2012	5 municipalities & 11 cities	210,000	1.69 billion
Energy saving demonstration	2012	Suburban and island district	21,000	270 million
Demonstration city	2012-2014	Keelung, Hsinchu and Chiayi cities	53,000	588 million

The Promotion of LED indoor lighting

Concerning to the indoor lighting, the Bureau of Energy conducted the LED Promotion Project procuring 500 thousand units of LED bulbs. Through the high requirement of the project, it aims to unify the specification, advance the quality and thus strengthen the global competitiveness of the industry.

By replacing 9W LED with 60W incandescent bulb, it can reduce 85% of electricity consumption saving 94 kWh annually. If the promotion target is achieved, it is estimated to reduce 47 million kWh. Assuming that 15 W compact fluorescent bulb is replaced by 9W LED, the energy saving would achieve 40%, that is, one unit can save

11 kWh annually which amounts to 5.5 million kWh saving if the promotion target is achieved.

The Promotion of LED Lighting Application

The Bureau of Energy launched LED Traffic Light System Demonstration Project in 2013 to innovate and expand the application of LED product. Replacing the traditional projection light for LED component brings advantages of low energy demand, long lifetime and saves electricity for up to 90%.

3.1.3Energy Information and Communication Technology

Energy Information and Communication Technologies (EICT) covers a variety of application and technologies which monitor analyze and optimize the operation to increase the system's energy efficiency. Chinese Taipei has played a dominant role in global ICT market of which the production value exceeds 4 trillion NTD. Nevertheless, the development of EICT, especially on the power system, has been relatively slow as the domestic business mainly focuses on electricity meter and distribution equipment lacking the experiences of system development.

As a result of rising energy cost and the urgency of reducing CO_2, the development of smart grid has been the focus of the industry. By incorporating ICT into power system, it can achieve the management on the demand side and integrate the distributed energy. Meanwhile, the demand side management opens new opportunities for business

In the power system, the system information of supply and demand is very important which makes the application of ICT necessary. The application of ICT on the electricity system can serve different purpose in electricity generation, distribution and supply

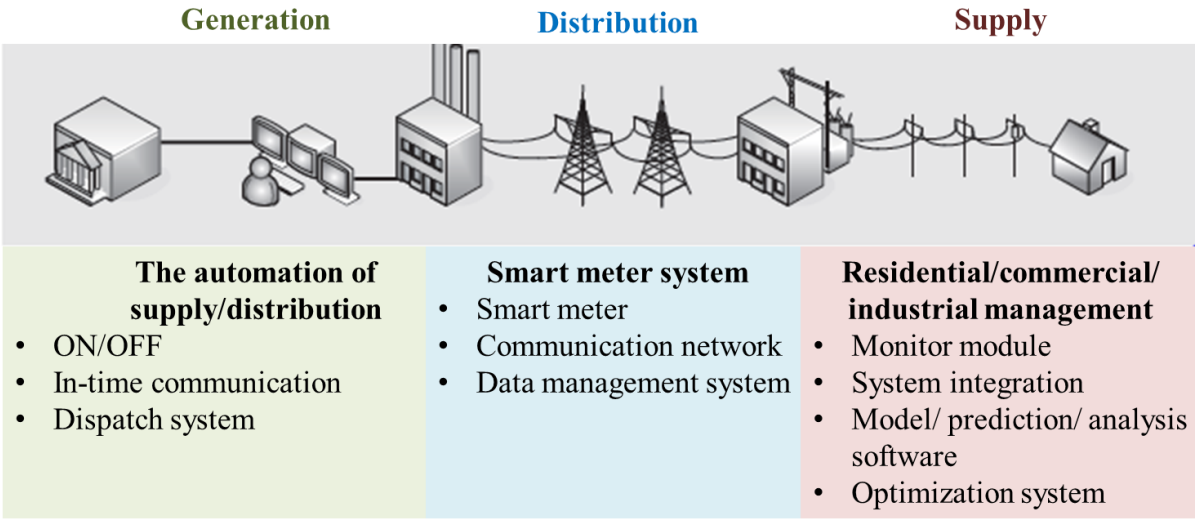

Figure 3.2 The application of ICT on power system

(Figure 3.2). It can be categorized into the automation of supply/ distribution, smart meter and energy management system. By introducing the energy management system to the end-users, it is estimated to reduce 5-15% of energy consumption. On the other hand, by using the smart meter to connect supply and demand side, it can optimize the dispatch and distribution, integrate distributed energy, reduce the impact of intermittent renewable energy, suppress the peak load and thus reduce the cost and emission of supply side. Considering the industrial development, the market is expected to grow to 26 billion NTD and 60 billion NTD in 2020.

Nevertheless, the technology and application experiences of domestic manufacturer still need upgrade and improvement. Meanwhile, the driving force from the mature market hasn't been fully shown. Therefore, the government has been taken aggressive measures in accelerating the maturity of market and the upgrade of industry.

1. Promote flexible pricing for electricity for energy saving incentives

The low electricity price has been an obstacle for energy saving services and the introduction of renewable energy. The promotion of flexible pricing which fluctuate with time and season would increase wiliness of the consumers to reduce their energy consumption and hence the total electricity consumption. On the other hand, it can reduce the peak demand reducing the difficulty and cost of grid dispatch. To sum up, flexible pricing can help incorporate the energy management system and foster the growth of ICT application.

2. Establish the standard of energy management

The electricity system is so complicated that requires the integration of various interfaces. Meanwhile, accustomed interfaces are necessary for the distribution and consumption side to integrate and operate. Concurrently, the international standards which are commonly accepted in the power system include IEC-61850 for Substation Automation System (SAS), IEC-62056 and ANSI C12.22 for smart meters, Open ADR and SEP2.0 for demand response, IEC-61968 and IEC-61970 for energy ICT.

The unified standard plays a critical role in expanding the application of energy management system and the integration of power system. It would start from the interface for end-user management which includes home and residential appliances. In addition, the generic database model to connect different interfaces, the integration interface for electricity facilities, the interface for connecting the soft and hardware of smart meter are also crucial for the future development of energy ICT technology and market.

3. Develop technologies and successful experiences based on end-user energy management system and expand to electricity dispatch system

The end-user energy management system opens wider opportunities for domestic industry to explore than traditional electricity system market. Although the industrial/building automation system and technology are mainly controlled by foreign suppliers, the application side should adapt to the local need and which requires the involvement of local system integrator and gives local industry more opportunities to enter the market. The capacity to develop energy ICT of Chinese Taipei has grown abundantly which includes the development of sensor, control and communication components and software for analysis and evaluation. Consequently, it's better to expand from end-user application to system dispatch with moderate introduction of foreign technology to speed the domestic development.

4. Cultivate large-scale system integrator by conducting demonstration projects

The energy supply is closely related to the people's livelihood and the prosperity of industry. Additionally, the development and verification of new technology requires the support of the authority so as to access the demonstration site for field experiences. Therefore, the legislation and regulation of the government is needed for power system owner to open its field for industries to do the verification as the basis for wide application and entering the international market.

Technology innovation

The energy ICT is an integrated application technology. Therefore the key of its development does not depend on single technology breakthrough but on the system design. Based on the mature development of ICT, the domestic development focuses on smart meter system aiming to energy the grid management system by microgrid system. The technology development can be categorized into grid management, industrial and residential and commercial energy management.

1. Grid management

Smart meter system is to provide stable and reliable mutual communication. The key lies in compatibility, communication stability and information safety. Firstly, the compatibility would follow the international smart meter application standard which is IEC-62056 in Europe and ANSI C12.2 in the US. As for the stability, the internet protocols needs to adapt to the changing environment reaching 99.9% data acquisition rate. Lastly, as the meter communication internet will be widely distributed within the electricity supply region, the current internet block and protection would no longer be

effective making the encryption and key exchange algorithm very critical in assuring the safety of data and power system operation. The following Table_ shows the Chinese Taipei's roadmap of developing grid management.

2. Industrial energy management

The energy consumption from industry occupies the world's 50%. Unlike other industries, the productivity of the system cannot be interfered by the energy saving measures. As all the sub-processes are closely interrelated, it is important to understand the characteristics of process to maximize its energy saving outcome without decreasing the productivity. On the other hand, it consumes large amount of coal, gas and oil aside from electricity. Hence optimizing the operation of facilities that transformed the energy sources (e.g. Boilers) is important. This has made it possible to integrate the energy supply of the factory or the industrial park so as to increase the overall energy efficiency. Table 3.8 shows the roadmap of Chinese Taipei to promote industrial energy management.

Table 3.8 The roadmap for developing grid management

	Short term (-2015)	**Mid-term (-2020)**	**Long-term (-2025)**
Smart meter	1. Compatible communication protocols 2. Communication reliability 3. The internet safety of smart meter 4. Smart communication chip	1. Information system 2. Data analysis application module 3. Internet safety system (FIPS 140-2)	1. Value added application of data 2. Equipping solutions 3. Integrated application of energy management system
Grid integrated dispatch	1. Prediction of regional power load 2. Prediction of renewable energy supply 3. Solutions for demand dispatch 4. Dispatch management of renewable energy	1. Solutions for integrated operation of energy storage 2. Microgrid system on island district	Dynamic integrated microgrid system

Table 3.9 The roadmap for developing industrial energy management

	Short term (-2015)	Mid-term (-2020)	Long-term (-2025)
Smart energy sensor & transmission	1. Soft and hardware sensor system 2. Wireless transmission in for industrial environment	1. Near end primary data processing 2. Information safety	1. Value added application of data 2. Equipping solutions 3. Integrated application of energy management system
Industrial energy analysis & balance control	1. Prediction of regional power load 2. Prediction of renewable energy supply 3. Solutions for demand dispatch 4. Dispatch management of renewable energy	1. Modularity in energy saving technology 2. Cross-system energy saving technology integration 3. Factory energy management system	Regional energy integration
Energy supply & demand control	1. Energy flow and loss technology 2. Energy demand and load prediction	Smart dynamic balance technology	Integrate new solutions for energy conservation and emission reduction
Energy monitor & management	1. Open communication interface 2. Energy visualization	Smart energy conservation monitoring software	Cloud platform for industrial energy management

3. Residential and commercial energy management

The energy consumption from residential and commercial sectors occupies 40% of total electricity consumption in Chinese Taipei. Generally speaking, households' energy conservation potential is 10-15 %. Meanwhile, it is easier to introduce energy management system in residential and commercial sectors and to adapt to the demand response measures which mainly focus on air-conditioners and lightings. The roadmap to develop these technologies is shown in Table 3.10.

Table 3.10 The roadmap for developing commercial and residential energy management

	Short term (-2015)	Mid-term (-2020)	Long-term (-2025)
Environmental sensing	1. Human activity and energy use sensor 2. Energy harvesting	Integrated energy monitor and analysis	Low/zero energy demand transmitter and sensor
Demand response	1. Smart appliances energy information interface 2. Demand response mechanism and safety	1. Regional demand response dispatch 2. Joint contract capacity management	Dynamic demand management
Economization of energy management	1. Energy demand and load projection 2. Energy system model	Smart dynamic balance	integrated energy saving solutions for demand and supply side
Interactive energy management	1. Non-intrusive energy use analysis 2. Interactive energy saving control	Rational energy conservation algorithm control	Deductive energy conservation control

3.1.4Energy Efficiency Standard and Index

Setting the Minimum Energy Performance Standard, MEPS, has become the primary tool for developed countries to promote energy efficiency management. Concurrently, Chinese Taipei has launched MEPS on 17 categories, voluntary Energy Conservation Labels for 45 categories and mandatory Energy Efficiency Ranking Labeling on 9 categories which include air conditioners, refrigerators, cars, motorcycles, dehumidifiers, incandescent bulb, gas hobs, gas water heater and electric water heater. In total, there are 27,170 products mandatorily or voluntarily indicating their energy performance for consumers to consider energy efficiency while purchasing. The comparison of three systems is shown in Table 3.11.

Table 3.11 The introduction of different energy efficiency labeling systems

	MEPS	**Energy Efficiency**	**Energy Conservation**

		Ranking Labeling	Labels
Type	Mandatory	Mandatory	Voluntary
Purpose	Prohibit the import/ sale of low energy efficiency / high energy consumption products.	Provide enough information for consumers' reference	Encourage the industry to research and manufacture high efficiency product
Enforcement	Set by the Bureau of Energy and regulated by Bureau of Standards, Metrology and Inspection (BSMI)	Incorporated into Chinese National Standard (CNS) and regulated by BSMI	Voluntarily applied by the manufacturer
Target product	17 categories	9 categories	45 categories
Criteria	Eliminates the products with the bottom 15-30% energy efficiency	Rank the products' energy efficiency by the market distribution and MEPS	Based on the product with the top 20-30% energy efficiency

Up to 2013, the total products applied for Energy Conservation Labels amount to 7,674 models which reduced energy consumption to 150 thousand tons of oil equivalent. On the other hand, there are 18,163 models of home appliances verified with Energy Efficiency Ranking Labeling among which the air conditioner has the highest occupation, 7,988 models. These have been proven to be effective in replacing inefficient product with efficient one on the market.

3.1.5Industrial energy conservation

The industry consumes up to 50% of Chinese Taipei energy and has been made the main target of energy conservation and carbon emission reduction. Concurrently, the primary measure from the government is energy audit so as to establish the energy consumption benchmark for the domestic industry. In addition, the regional energy integration has been another focal point to not only reduce the overall energy demand but cultivate the growth of related equipment, engineering and design industries. In addition to the ICT application on the energy management introduced in 4.1.3, this section focuses on the improvement of the dry air compressor, high efficiency motor, thermoelectric module and waste heat recycling to generate electricity.

1. Dry air compressor

Dry air compression has been one of the four primary power sources in factories. To

decrease the humidity of air as to meet the manufacture criteria, traditionally, factories use Dual Tower Heatless Desiccant Air Dryers to absorb the humidity and regenerate the absorbents with the air compressor. However, the high resistance, 2,000mAq, of the absorbent bed and vertical flow of compressed air may fracture the absorbent particle increasing the dust content. Consequently, the generated compressed air is often released and thus reduces the energy efficiency making it the priority of industrial energy conservation in developed countries.

The solutions developed in Chinese Taipei focuses on absorbents and dehumidifier. By inventing the metal base as the high pressure dehumidifier component, it induces the horizontal flow of compressed air and decreases the heat loss and resistance for about 80% eliminating the fracture of absorbents and hence makes the compressed air reusable. The target has been set to conserve the electricity for up to 30%.

The current domestic industry, the average electricity consumption for Dual Tower Heatless Desiccant Air Dryers is 3.4-8.4kW/cmm. The loss of regenerative compressed air rates 30.6%-52%. On the other hand, the electricity consumption for Dual Tower Heating Desiccant Air Dryers is 1.51-2.12 kW/cmm while the loss rate of regenerative compressed air is 9.1%-13.1% reducing the electricity consumption for about 75%.

2. Thermoelectric module

Thermoelectric module utilizes waste heat from manufacture process and generates electricity. The performance of thermoelectric materials dominates the overall heat recycling rate where ZT value represents the conversion rate of thermoelectric materials. As ZT value gets higher, the conversion rate of the materials gets better. ZT value would vary with different temperature, that is, each thermoelectric material has its own optimal temperature range categorizing it into low (25-300℃), mid (300-600℃) and high-temperature (600℃↑) types. As the average temperature for domestic industry lies below 400℃, the low and mid-temperature type of material has been the focus of development in Chinese Taipei following Table 3.12.

Bi_2Te_3 has been the most suitable thermoelectric material for recycling the waste heat under 200 ℃ where the ZT value achieves more than 1.5 and the conversion efficiency improves from 3% to 10%. However, its performance reduces at temperature 200-400 ℃ where the PbTe, Silicide and Zn_4Sb_3 proves to have better performance. As the temperature increase, the stability and low heat transfer rate gets more important. Complex thermoelectric alloy has been widely used to reduce the heat transfer and increase the ZT value to more than 1.2.

Table 3.12 Domestic development of Solid Thermoelectric materials

Temperature	Material	Development	Target
Low temperature (25-300℃)	Bi_2Te_3 Alloy	− Single-crystal growth − Nano-structure high energy ball milling − Chemical synthesis of thermoelectric powder − P type BiSbTe material: ZT_{max}=1.57(80℃) − N type BiSbTe material: ZT_{max}=1-1.1(100℃) − Efficiency of thermoelectric module: 3-6%	ZT > 1.5 Energy conversion efficiency > 10%
Mid temperature (300-600℃)	PbTe Alloy GeTe Alloy BaGe Alloy Silicide Alloy Zn_4Sb_3 Alloy Clathrate compound	− Complex thermoelectric alloy − Alloy smelting and refining − High energy ball milling and hot embossing − ZT > 1.2	ZT > 1.5

3. Mid and Low-Temperature Waste Heat Recycling

Domestic development focuses on Organic Heat Rankine Cycle (ORC) with capacity below 500kW in Chinese Taipei. Considering its capacity, heat transfer and economic efficiency, the development are conducted in two directions, one is s screw-expander ORC for capacity under 200 kW and another is turbine ORC for capacity over 200 kW. The prior is commonly used in low-speed rotation (3,600 rpm/3,000rpm) providing generation capacity for 10-200 kW under wind flow rate 100-1,500 m^3/hr. The latter is usually used for high speed rotation (>10,000 rpm) which increases the thermodynamic performance of ORC and reduces the size of turbine for more flexible design.

3.1.6 Residential and commercial energy conservation

The energy consumption from residential and commercial sectors occupies 21-23% of domestic energy consumption. Its energy conservation is conducted in two directions which are the improvement of energy consumption facilities, system integration design

and control and energy conservation at consumption stage. The prior has been introduced in the previous session, and the following would focus on building energy conservation technology developed in Chinese Taipei.

Considering the energy demand of residential and commercial sector is projected to grow, progressive measures and policies are needed to conserve the consumption. The target is to achieve the wide implementation of near Net-zero Energy Building, (nNZEB) which accommodates the demand response capability under the introduction of distributed energy. In meeting the target, research and development is required to (1) the simulation of building energy consumption and the code/standard for building performance; (2) the control of building energy management network and the development of demand response technology and lastly, (3) the development of key energy conservation materials for buildings.

The simulation of building energy consumption and the code/standard for building performance

In developing the simulation of building energy consumption and the code/standard for building performance, three directions are identified which include the energy simulation technology, the promotion of green buildings and building energy analysis and energy conservation service platform. The simulation models have been widely used to understand the energy consumption of the buildings and provide the best operation parameters for energy conservation and residence's comfort. Nowadays, Chinese Taipei thrives to develop domestic and customized building energy model which investigates various materials and categories of buildings and thus provides the reference model for future buildings. Meanwhile, through conducting mathematical analysis in domestic buildings, the feasibility and difficulty of adopting international model in localizing data can be revealed. These would serve an essential basis for developing Chinese Taipei localized database for buildings.

In promoting green buildings, the trend has shifted from maximizing the efficiency of single facility into smart design management, cloud computing, storage analysis, system integration and customized services and information thanks to the development of ICT. BIM (Building Information Model) has been a popular application of abovementioned approaches. It utilizes traditional 3D model to perform systematic management of building in evaluating its socio-economic, energy conservation and carbon reduction impact. The model provides important information for government and industry. Chinese Taipei is concurrently incorporating 4D simulation into BIM to integrate database of meteorological, facility, building design, green building, and smart building code in providing a platform to predict the impact of government's policy and

industry’s business plan.

The control of building energy management network and the development of demand response technology

The technology and market of energy management network has been directed toward incorporating ICT into systematic and smart control for smart sensing and equipment energy management to reduce the power waste. However, most of the control technologies can’t be adjusted in response to the demand. Additionally, the interface of each equipment hasn’t be standardized and thus inhibits system integration analysis, feedback control and better efficiency improvement. Meanwhile, the components of current power system which include generation, storage and consumption lack the communication and compatibility with one another. The abovementioned features play important roles in accommodating distributive energy in the power system and the energy management of buildings.

3.2 Promotion and application：ESCOs and Chinese Taipei Industrial Greenhouse Gas and Energy Consumption Reduction Corps

In response to the target of Sustainable Energy Policy Framework, to increase the added value and decrease the energy intensity of industry by 30% in 2025, ESCOs and Chinese Taipei Industrial Greenhouse Gas and Energy Consumption Reduction Corps serve as two major tools to build the capacity of the industry. The Greenhouse Gas and Energy Consumption Reduction Corps are established to provide the counsel and assistant in the analysis of energy consumption facilities and GHGs Registry and Offset Scheme. On the other hand, Energy Service Company (ESCO) is to assist clients with latest energy conservation technology and knowledge in satisfying their energy demand and conservation objectives. It provides services include the energy trade, supply and management, efficiency improvement, maintenance and counsel. By integrating the guideline counsel provided by Industrial Greenhouse Gas and Energy Consumption Reduction Corps and technical assistance by ESCOs, it is expected to accelerate and expand the effect of energy conservation technology.

3.2.1Energy Service Company (ESCO)

Nowadays, the focal development of ESCOs is Energy Savings Performance Contracts (ESPC) which helps clients in applying loans to reduce the cost barriers of introducing energy services. As end users applied ESPC, the loans of energy saving projects can be paid by the benefits earned by less energy consumption as shown in Figure 3.3. Additionally, ESPC can be coupled with Emission Trading. Hence the user can not only benefit from energy saving but the trade of emission cut.

In addition to financial instrument, ESCO requires interdisciplinary and integrated application technology. Meanwhile, training program is needed to cultivate ESCO specialists in International Performance Measurement and Verification Protocol, IPMVP) for the growing demand of the industry. To validate the development of

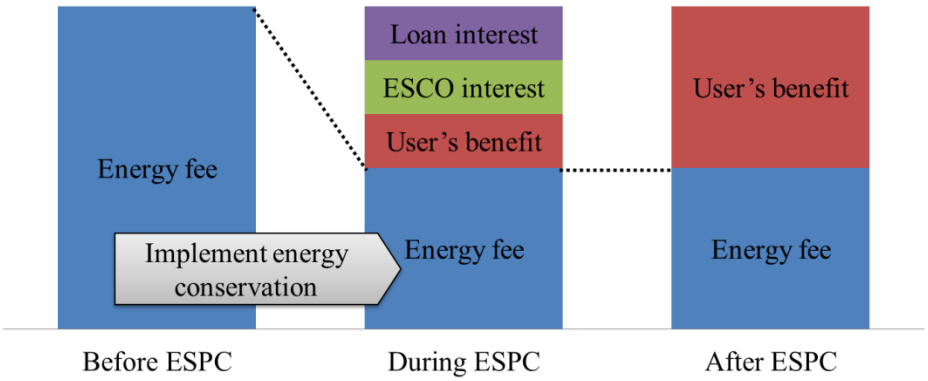

Figure 3.3 How ESCP compensates energy service fee

financial tools, technology and training program necessary for ESCO development, policy plays an important role to provide subsidy and demonstration to encourage the involvement across different sectors. As shown in Figure 3.13, roadmap has been set in developing demonstration & subsidy, industrial financing system, the verification of energy conservation performance, training program and international cooperation.

Table 3.13 Roadmap in supporting the growth of ESCO

Technology	Short-term (-2015)	Mid-term (-2020)	Long-term (-2025)
Demonstration and subsidy	Apply in public sector to develop successful business model	Expand to private sector with the introduction of energy tax	
Industrial financing system	Enlarge the scale of ESPC financing system and develop ESCO industry preferential loans and development fund		
Verification of energy conservation performance	Develop M&V (Measurement and Verification) process and document	Incorporate IPMVP (International Performance Measurement and Verification Protocol) into energy audit guideline	Promote licensing qualification program
Training program	Prepare M&V seed lecturers	Incorporate into energy management training program	Develop database of experts in performance verification

International cooperation	Encourage the participation in international ESCO activities and develop cooperation network	Introduce international best practices and products and connect with domestic industry

From 2005 to 2011, the productivity of ESCO has grown from 370million to 6.65 billion among which 90% coming from SMEs. ESCOs in Chinese Taipei mainly provide energy conservation solutions and the replacement high energy-consuming facilities. From 2004 to 2013, the demonstration and promotion project of energy performance provision has subsidized 423 million NTD, annually saved energy for 20,295kLOE, carbon dioxide emission for 51,326 tones and 274 million NTD.

In addition domestic promotion, ESCOs in Chinese Taipei thrives to incorporate themselves with international standard, ISO 50001. Table 3.14 compares two systems. Generally speaking, ISO 50001 aims to integrate the technology and management so as to effectively perform the energy management. It emphasizes more on the development of institution and management while ESCOs on technology, fund, measurement and verification. As a result, combining the two has become the future trend of ESCO's development.

Table 3.14 The comparison of ISO 50001 and Chinese Taipei ESCO

Category	Item	ISO50001	Chinese Taipei ESCO
Institutional and Technological	**Contract**	No	Yes, after setting the baseline
	Performance provision	No	Yes
	Continuous improvement	Yes	Contract base
	Management level	Highest	Based on M&V regulation
	Technological risk	Mid to high	Low
	Objective	Fulfill energy management	Cost and energy conservation
	Intention	Voluntary	Voluntary
	Scope	Whole company	Contract base
	Maintenance	No	Contract base
Financial	**Risk**	High	Low
	Capital source	Company	Multiple channels (government's loan, subsidy, etc.)
	Investment efficiency	Required	Required

	evaluation		
Training	**Technicians**	Less	More
	Managers	Less	More
	Guideline inquiry	Standard verification companies	ESCO committee

3.2.2 Chinese Taipei Industrial Greenhouse Gas and Energy Consumption Reduction Corps

To achieve the government's target to reduce the industrial carbon emission intensity by 30% in 2025, Chinese Taipei Industrial Greenhouse Gas and Energy Consumption Reduction Corps serves as another measure to gather domestic experts' capacity in counseling industries to assess their process energy consumption and apply for emission registry program. The corps builds the bottom-up consensus process by engaging government agencies, scientists, industry associations, and community organizations to help businesses. It comprises of 6 groups, 15 service team and 500 experts based on different industries including manufacture, SMEs, energy, commercial, school and green buildings. Based on the energy characteristics of each industry, 15 groups provide different solutions among which manufacture and SMEs industries have the highest energy saving potential and contribute 78% conservation outcome. Therefore, the following discussion would focus on these two sectors. The service provided by the corps is shown in Figure 3.15. Generally, it starts with a plant visit to understand the need and business owner's intention, followed by technical assistance which usually combines baseline setting, problems identification, equipment examination, conservation potential evaluation, energy conservation solutions and implementation assistance. On the other hand, energy saving assessment tools is developed and promoted to cultivate the self-assessment capability of industries aiming to achieve their independence in practicing energy conservation without assistance from the corps. Lastly, the energy saved can be registered, verified and converted into credits which can be used as future emission allowance. In 2013, the corps assisted 2,129 plants in introducing energy conservation and carbon reduction technologies, providing 7,700 efficiency improvement solutions, reducing over 0.6 KLOE energy consumption, 1.6

Figure 3.15 Services provided by Chinese Taipei Industrial Greenhouse Gas and Energy Consumption Reduction Corps

Process \ Target industry	Emission-intensive	Traditional	SMEs
	Tasks	**Description**	
Counsel	Develop domestic energy saving solutions	Validate the conservation performance	
Technical assistance	Demonstrate registry and verification project	Focus on industries with high conservation potential and additionality	
	Promote collaborative conservation		
Reduction potential assessment	Promote energy saving assessment tools	Provide the industries with self –assessment capability	
	Follow up and check	Follow up the application outcome and performance	
Implementation	Assist energy efficiency improvement techniques	Focus on industry with capacity higher than 500 kW	
	Provide energy assessment for SMEs	Provide general guidelines for wide application	
Registry and verification	Other technical counsel and services	Tailor solutions for specific industry	

million ton of CO_2 emission and NTD 8.7 billion energy cost.

3.3 Best practices

The chapter focuses on the SMEs and manufactures in Chinese Taipei as they've shown the greatest energy conservation potential. Two case studies from each sector would be introduced to elaborate how energy conservation trend is led by major manufacturers, promoted by the government and spread to the SMEs.

In Chinese Taipei, SMEs account for around 98 percent of all businesses which aligns with the trend in APEC region; however, SMEs - whose collective energy consumption and environmental impact are immense - are often lack resources (by nature) to adopt energy-efficiency technologies and boost their operational efficiency. On the other hand, the major manufacture who often leads the transformation of the industry has shown great ambition and potential in energy conservation. Both major manufacturers and SMEs in Chinese Taipei rely largely on the export business. As green supply chain has become global trend, it is necessary for the two industries to adapt greener energy conservation strategies in response to the requirement of international clients.

Manufacturer and SMEs service groups are developed under Chinese Taipei Industrial Greenhouse Gas and Energy Consumption Reduction Corps to assist the transformation to the greener industry. Two service groups provide tailored energy conservation strategies which are categorized into three levels and can be selected based on the budget of business owners (shown in Table 3.16).

Table 3.16 Energy saving solutions for Manufacturers and SMEs

	Level A (ROI = 0-1 year)	Level B (ROI = 1-2 years)	Level C (ROI = 2-3 years)
Manufacturers	• Rationalize the contract capacity • Turn off the heater of make-up air unit (MAU) • Recycle and reuse the heat from waste water • ↓ the oxygen content of exhaust air from boilers • ↓ the discharge pressure of air compressor	• Replace the old air compressor • Add frequency conversion control in motors • Recycle waste heat from melting pots • Apply rich-air combustion in the heating boiler • Recycle the condensed water in boilers	• Recycle heat from the economizer of boilers • Add heat pump system • Apply high-efficiency lighting • Apply high-efficiency motors
SMEs	• Rationalize the contract capacity • Apply time of use (TOU) pricing • ↑power factor (PF) • Repair the leakage of air pipe • ↑the isolation of facilities and ↓the steam leakage	• Condense and recycle the discharged air • Upgrade the cooling tower • Replace the old air compressor • Recycle the condensed water in boilers	• Replace boilers with heat pump • Apply high-efficiency motors • Add frequency conversion control in motors • Apply high-efficiency lighting

3.3.1 The energy retrofit in Chinese Taipei Semiconductor Manufacturing Company

Chinese Taipei Semiconductor Manufacturing Company (TSMC) ranks the third in global market position in 2014 which generates USD 59.7 billion in 2013. Being one of the world leading manufacturers, it has been pursuing greener and more energy

efficient process since 2006 to prepare for the requirement of green supply chain. Its energy retrofits are carried out in two directions; one is develop innovative energy conservation measures in the process and facilities and another is introducing the energy management system to understand the whole-plant energy consumption.

Developing innovative energy conservation measures

1. Energy efficient clean room

TSMC has thrived to improve the energy efficiency of clean room by using FOUP (Front Opening Unified Pod) to transfer wafers. Compared to the previous process which consumes additional energy to maintain the class-100 ballroom, using FOUP consumes less energy by only using the necessary energy to create class-100 micro environment in class-10,000 ballroom. Therefore, auxiliary energy consumption is reduced by only creating the clean space that is needed.

2. Central air conditioning

Chiller consumes 10-20% of total cleanroom energy use. TSMC has pinpointed it as the energy conservation hotspot and applied two measures which are introducing dual temperature chiller system and reducing the backup units, to increase its energy efficiency. The central chiller is generally designed to produce chilled water at the lowest temperature requirement for the entire facility. This is normally at 4–6°C. This coldest temperature is typically only needed in specific clean rooms to control humidity. In addition, most of the chilled water produced is used for general cooling and conditioning of non-clean room space. By introducing dual temperature chiller which provides chilled water at different temperature based on the requirement, one for colder water to provide dehumidification in the cleanroom and another to generate warmer water for process cooling and air-conditioning. As a result, the chiller's load can be minimized reducing almost 10 million kW annually. On the other hand, reducing the backup unit has been one of the criteria in green building awards. TSMC also recognizes its importance. By reducing backup unit, TSMC saved USD 650 thousand in the initial setup cost and subsequent operation cost by eliminating idle load.

3. Chiller heat recovery system

Generally, the semiconductor foundry produces enormous exhaust air which is costly to dispose. TSMC has developed a system to recover the exhaust air from the main manufacture to the secondary area. Recycling the exhaust air reduces the use of external air and hence the energy used for cooling and drying which is amounted for 3 million kW annually.

TSMC's practice on energy management

Traditionally, cross-fab comparison is used to manage the utility and its energy consumption in the semiconductor foundry. However, the data it provides was too complicated and doesn't apply to continuous management. Therefore, TSMC has implemented Mr. Energy, an energy information management system, which complies with ISO 50001. By integrating all the energy consumption data of utilities, Mr. Energy can provide the analysis of energy use profile, energy efficiency, energy regression and prediction model, real-time management and alert function. In other words, it not only provides simplified and comprehensive data of energy use but a tool for management and future planning.

TSMC has gained the certification of ISO 50001, which is the international guidance of energy management. To assure its continuous energy consumption improvement and management, multiple measures are taken followed the roadmap shown in Table 3.17.

To sum up, the energy management carried out by TSMC follows understanding the energy consumption, integrating and analyzing the data, designing and performing the energy saving measures. As a result, TSMC has saved 127 million kW annually and reduces the electricity use of manufacturing one wafer from 16.78 to 9.1 kWh/waferout-8EQlayers (46% reduction) in one year.

Table 3.17 TSMC continuous energy management strategies

Status	**Measures**	
Maturity	Continuous promotion and management	
	Mini-environment energy saving design	Hot air recovery from VOC treatment
	CDA power saving by ASC control system	Improvement of MAU cold discharged air temperature setting
	Dual temperature chiller system	Energy saving mode of elevator and escalator
	Main chiller unit with one time variable water flow system	Optimization of cooling tower operation
	Optimization of MAU temperature discharged air	Energy saving mode of dryer
	Exhaust air recovery	Installation of water conservation equipment
	High efficiency lighting and smart parking lot design	Recycle and reuse of water packaging materials

	Efficiency improvement of VOC treatment	
Innovation	Innovative breakthrough and steady implementation	
	UPS energy saving system	Electrical transportation
	e-Tag smart parking lot	Automatic transmission system
	Installation of solar panel and renewable energy	Eliminating idle utilities
Brilliance	Brilliant management to initiate new future	
	ISO 50001	Green building promotion
	Mr. Energy management platform	best practice exchange of energy conservation
	Energy conservation volunteer programs	

3.3.2 The energy conservation practice of Sunnytex dyeing and finishing company

The textile industry has been one of the focal industries in Chinese Taipei among which the dyeing and finishing sector has played an important role in global supply chain. To meet the increased demand and requirement of international clients, domestic industries are facing the challenge of upgrading the facilities and green supply chain. Therefore, the dyeing and finishing industry has been a major target of Chinese Taipei Industrial Greenhouse Gas and Energy Consumption Reduction Corps

Sunnytex is a dyeing and finishing plant with 1,300 employees. It has gained the certification of Bluedesign, which identified eco and environmental friendly, healthy and safe textile product. It has participated in the government's energy conservation and carbon emission reduction project since 2011 and started to develop company's 50001 energy management system in 2013.

To understand its energy consumption profile, the company has set up its own energy consumption inventory. It reveals that the operation process amounts for the largest energy use followed by waste water treatment. The energy used by operation process can be further broken down into individual facility among which the shaping machine ranks the highest. With the information, the hotspot for energy conservation is identified and therefore developed optimized strategies.

Based on the analysis, 8 measures are carried out in recent 3 years which includes the exhaust heat recycling of shaping and desizing machine, the district energy integration,

the replacement of 20 Hp compressor and 3 rapid dyeing machine, high efficiency lighting, the repair and enhancement of steam pipe isolation, check and amendment of the steam trap. From 2011-2013, the outcome of energy conservation is shown in Table 3.18.

Table 3.18 Annual energy conservation (2011-2013)

Year	**Energy saving (KLOE)**	**CO_2 reduction (ton)**	**Saved energy bill (thousand NTD)**	**Energy saving rate (%)**
2011	351	1,256	1,995	2.92
2012	840	2,990	4,479	8.45
2013	2,087	7,937	18,588	18.84
Average	1,093	4,061	8,354	10.07

Chapter 4 Expanding the effort：On-site energy management project in Thailand

In addition to developing the domestic low-carbon industry, Chinese Taipei acknowledges the growing need of energy conservation globally and is dedicated in promoting its successful model to other economics. In this project, field verifications of Chinese Taipei energy conservation are carried out in Thailand SMEs.

In 2012, the total energy consumption (shown in Figure 4.1) of Thailand is amounted to 852,655 GWh among which 48% comes from petroleum (48%), followed by natural gas (20%) and renewables (17%). Based on Figure 4.2, the highest energy consumption lies in industrial sector (37%), followed by transportation (15%) and agriculture (5%). Nowadays, the government of Thailand has dedicated in reducing the energy intensity of domestic intensity setting the goal as Figure 4.3.

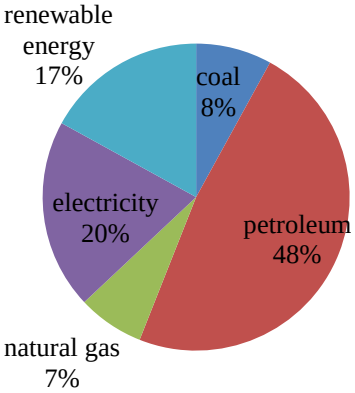

Figure 4.1 Energy source distributions in Thailand

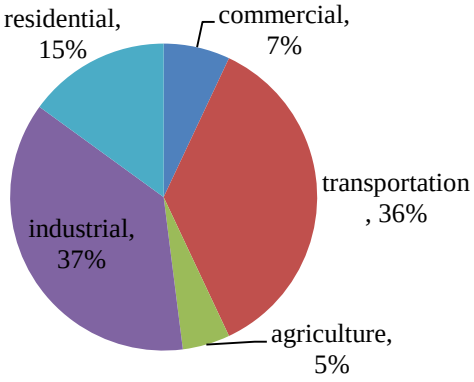

Figure 4.2 Energy end-use profile in Thailand

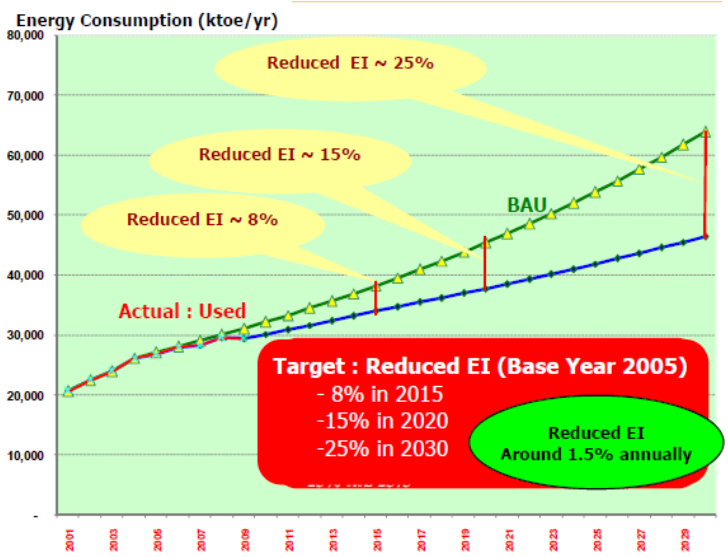

Figure 4.3 Thailand's energy intensity improvement target

As a result, the filed verification targeted at the textile and garment plants in the

industrial sector which occupies 17% of Thailand GDP and 3% of industrial emission. Thailand has been the principal suppliers of either global textiles or apparel products since 2005. In addressing the national target to reduce the industrial energy intensity and meet the requirement of global green supply chain, it is inevitable for it to improve its energy efficiency.

4.1 Methodology

The first step is to understand the energy consumption of the plants through field survey. The information is collected following the categories in Figure 4.4. With the information, the energy model of the plant can be developed to simulate the energy consumption throughout a year. Secondly, the hotspots for energy conservation can be identified and hence the optimized use of energy and retrofit strategies can be generated. As the energy retrofits are implemented, the plant can commence the introduction of ISO 50001, to involve the commitment of both workers and management level to assure the sustained energy conservation. Lastly, to save the human resources and ensure steady energy conservation, introducing control system such as iBEMS to allow the facilities to work automatically at its optimized efficiency.

4.2 Outcome

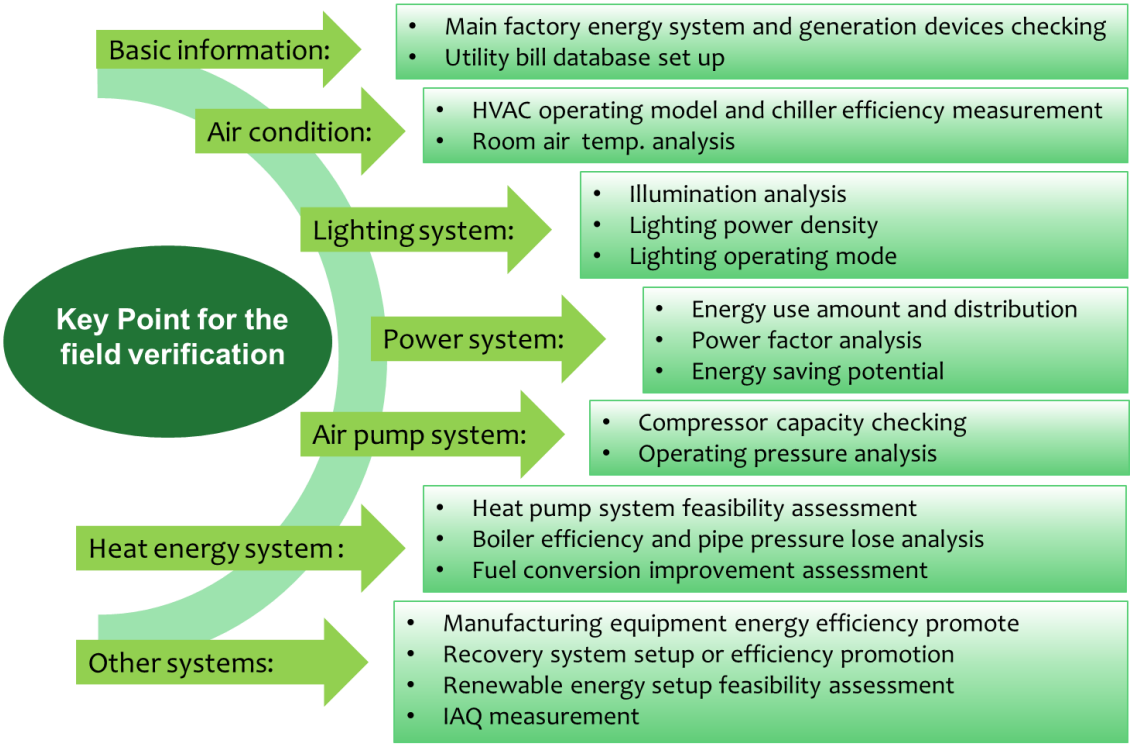

Figure 4.4 Key data for field verification

The project team has carried out field verifications in two textile and gourmet factories,

Les Enphant and Suratanapat Textile LTD, in Thailand reducing energy consumption by 10% (considering the whole factory) and 78% (considering one process) (shown in Table_).

Le Enphant

Le Enphant is a garment factory where the electricity consumption amounts to 217,093 kWh. With the basic information shown in Table 4.1, the annual electricity consumption can be simulated as Figure 4.5 and further distributed into lighting, equipment and cooling shown in Figure 4.6.

Table 4.1 Simulation condition

Simulation condition			
Total floor area (m^2)		1,023	
Window-wall ratio (%)		23.8	
Window U-factor (W/M^2-K, single-pane)		2.72	
Cooling set point (℃)		25	
LPD (Lighting Power Densitity)		**EPD (Equipment Power Density)**	
Position	**Value (W/m^2)**	**Position**	**Value (W/m^2)**
3F Office	10.76	3F Office	10.76
2F Factory	17.5	2F Sewing machine, steam boiler	56
1F back Factory	17.5	1F back Factory	35
1F front restaurant	12	1F front restaurant	18

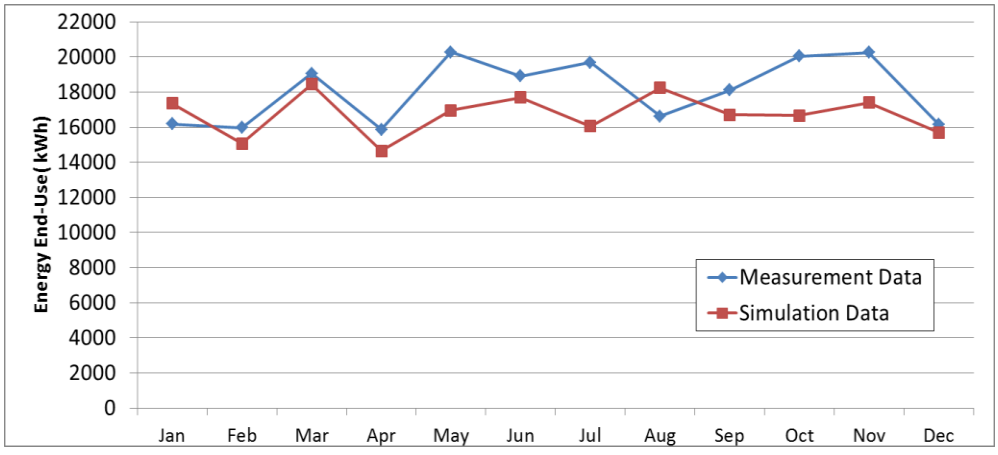

Figure 4.5 Simulated annual energy consumption

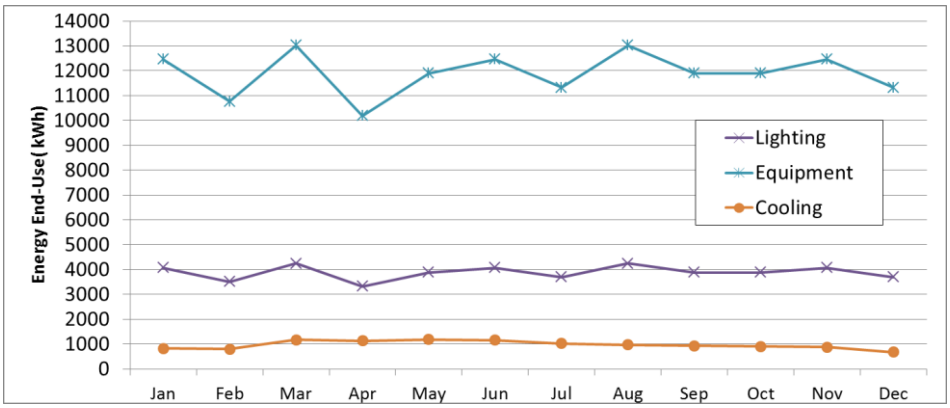

Figure 4.6 Simulated annual energy distribution

After analyze the energy consumption in the factor, the hotspot for energy saving can be identified. In this case, the manufacture equipment consumes 73% of energy, followed by lighting (22%). Considering the budget and feasibility, the suggested energy retrofits are shown in Table 4.2. As a result, the factory has installed high-efficiency lighting and steam boiler and the outcome is shown in Table 4.3.

Table 4.2 Suggested energy retrofits for Le Enphant

Item	Current situation/issues	Suggestion
Illumination	1.39 klux	Replace for 1000 lux (CNS12112) in Sewing Room
Lighting	T8-40W	Replace for T5-28W
Boiler, water tank	No insulation	• Add insulation • Add Heat Pump
Indoor air quality	No air convection (hot air accumulation in the ceiling)	Set up exhaust fan
Pump	Pump shutdown due to overheating	Replace for high temperature Heat Pump

Suratanapat Textile LTD

Table 4.3 Energy conservation by Le Enphant

	Energy saving (kWh)	Carbon emission reduction ($kgCO_2$)	Pay-back period (year)
Efficient lighting	11,404.8 (30%↓)	7,071.0	2
Steam boiler	7,477.0 (5%↓)	4,635.7	3
Total	**18,881.8 (10%↓)**	**11,706.7**	

Assumption: The emission factor of electricity = 0.62kg CO_2/kWh

Suratanapat Textile LTD is a textile factory operating on a 24-hour basis. It's an open

factory without installing any insulation on the wall and roof; therefore, the heat leakage and accumulated dust on the machine become a major issue of the current inefficient operation. The identified hotspot for energy conservation and its solution is shown in Table 4.4.

Another major issue lies on the wood steam boiler which not only uses energy

Table 4.4 Suggested energy retrofits for Suratanapat Textile LTD

Item	Current situation/issue	Suggestion
Lighting	T8-40W	Replace for T5-28W
Boiler, water tank	Inefficient Wood steam boiler Air pollution	Setup CO_2 Heating Pump and hot water recovery system
Poor Indoor air quality	No air convection, lot of hot air cotton accumulate on the air	Set up exhaust fan to increase air convection
Air Pump device	High temperature waste air exhaust to outdoor	Set up heat recovery system
Weaving machine	Using power 220V/60Hz for motor 220V/50Hz	Apply the frequency converter for suitable power supply

Table 4.5 Outcome of replacing wood steam boiler

	CO2 generation (kg)	Utility cost (NTD)
Wood	963.63	1230.6
Electricity (Heat Pump COP=3.5)	206	1395.24
Nature gas	259.3	2654.3

inefficiently but emits air pollutants and therefore creates poor working condition. The project team proposed to replace the current steam boiler with the ones fueled by electricity or natural gas which reduces CO_2 emission as shown in Table 4.5. However, as the biomass, wood, is much cheaper than electricity and natural gas in Thailand, it is impossible for the factory to compensate their cost in replacing boilers making the payback period infinite. Therefore, policy instruments such as subsidy and fines for air pollutants are required to encourage the business owner to engage in aggressive energy conservation measures.

4.3 Lesson learned and further cooperation with APEC economies

After conducting field verification in Thailand, it is found that large energy conservation lies in textile potential with simple retrofits of facilities. In addition to energy retrofits, systematic control system can be introduced to eliminate the use of human resource and automatically turn off/ on the facilities to optimize its operation efficiency. However, these cannot assure the sustained conservation which requires long-term commitment of the business owner. Therefore, energy management system such as ISO 50001 is required to involve the participation throughout the factory from high-level management to the employees.

On the other hand, from the second field verification carried out in Suratanapat Textile LTD revealed the importance of economic incentives for the industry to engage in energy conservation. Government plays an important role in revealing the external cost of energy consumption using policy instruments such as carbon tax, emission trading and etc. to convert the environmental impact into monetary term and raise the economic incentives for the industry to take action. Many countries have started applying carbon tax especially for the developed countries in European Union. Take Sweden for example, it starts to implement carbon tax in 1991 which starts with USD 150/ton and it has been proved to reduce CO_2 emission and raise the use of bioenergy which currently occupies 50% of Sweden power source. In Suratanapat Textile LTD case, if the carbon emission by using as three different fuels is converted into Swedish carbon tax, the cost of using wood, electricity and natural gas is changed as shown in Table 4.6. Incorporating the external cost makes the operation of wood steam boiler has grown much higher than the one using electricity and natural gas; hence provides the factory owner incentives to carry out the retrofit.

To extend the impact and further enhance the connectivity within APEC community, we propose not only to reach out to other economies but to other industries with innovative energy conservation technologies developed in Chinese Taipei following the roadmap shown in Figure 4.7.

Table 4.6 Outcome of replacing wood steam boiler

	CO2 (kg)	**Utility cost (NTD)**	**Utility cost with carbon tax (NTD**
Wood	963.63	1,230.6	5,567
Electricity (Heat Pump COP=3.5)	206	1,395.24	2,322
Nature gas	259.3	2,654.3	3,821

Stage 1 (Present Project)

1.1

Small-scale Textile Plant Implementation	
Measures	Energy Consumption Evaluation
	Lighting and Significant Energy Consumption Unit Replacement or Upgrade
Outcome	Energy Consumption ↓10%
Macro Impact	**228k Tons CO_2↓ (0.31%)**

1.2

Energy Management + Control System	
Measures	Air Flow, Pressure and Wind Speed Model
	Real-time Automatic Control
	Case: IBM + TAIYUAN Textile
Outcome	Energy Consumption ↓33-40 %
Macro Impact	**912k Tons CO_2↓ (1.25%)**

Stage 2 (Future Project): Expand to other Industries

Thermoelectric material and module technology	
Application	Recycle the Low-temperature (≤300˚C) Waste Heat → Electricity Generation
Case	200W Small-scale Demo-site (Thermoelectric System, China Steel)
Full application (annual)	• ↓ 110 million kWh • Recycle Waste Heat 95 G kcal • ↓140 thousand Tons CO_2

CO_2 Capture Technology with Calcium Looping Process	
Application	Capture CO_2 (Calcium Looping) → Store CO_2 (Micro Algae) → Biomass or Energy
Case study	1.9MWth Pilot Plant (Cement Industry)
Outcome	• ↓ 90% CO_2 (Conversion Rate: 15%) • ↓ Cost : 28→26 USD/ton
Applicable Industry	Iron & Steel, Petrochemical, Cement and Ceramics Industry

Figure 4.7 Technology collaboration roadmap

Chapter 5 Conclusion

The project has reviewed Chinese Taipeiese energy conservation policies, technologies, best practices and further expands its effort through field verification in Thailand SMEs. Lastly, international workshop and training course were held in Chinese Taipei in gathering knowledge and experiences from international experts across different sector. As a result, policy suggestions and industrial application model for low carbon emission operation are generated.

5.1 Policy suggestion

1. Establish top-down sectorial action plan

In Chinese Taipei, the main guideline for low carbon emission operation is National Energy Conservation and Carbon Emission Reduction Master Plan which allocates the contribution of each sector to achieve the National emission and energy intensity reduction target. Meanwhile, sectorial action plan is carried out under the structure of master plan. It identifies the key elements towards Chinese Taipei's low carbon emission operation including energy system, community and society, cross-sector action and public awareness. These four themes are further broken down into projects of different government administration. Under the action plan, each government administration at different level and sector not only works independently to fulfill its own project but jointly across different departments in advancing the four key elements to achieve the national goal.

2. Form expert group to initiate bottom-up community and industrial actions

The action plan not only involves the government administrations but also the participation of industry and citizens. Through the promotion of expert group, Chinese Taipei Industrial Greenhouse and Energy Reduction Services Corp, and the raise of ESCOs, there are growing number of industries strive for low carbon emission operation voluntarily and hence gradually decreases the energy intensity in Chinese Taipei (shown in Figure_). On the other hand, the public participation plays an important role to form the low-carbon society. Campaigns such as low carbon community competition thrive to engage all the residence in the energy conservation. Starting from the smallest community unit, it is expected to spread the effect to the district, city and eventually form the low carbon culture throughout Chinese Taipei.

3. Identify the focal point for the integrated demonstration of low carbon policy and technology

Lastly, an integrated demonstration for low carbon society is carried out in Pen-Hu Island. The demonstration would not only examine the effect and feasibility of the national policy but produce valuable experiences and lessons for further and wider application throughout Chinese Taipei.

4. Incorporate policy instruments

In addition to action plans, policy instrument is developed to help achieve the target. It can be categorized into regulatory and economic instruments; the prior usually demands the industry to meet the requirement while the latter serves as an incentive to encourage energy conservation. In Chinese Taipei, regulatory instruments such as setting the Minimum Energy Performance Standard (MEPS) to prohibit the sale and import of inefficient appliances. As a result, the suppliers are obliged to advance the energy efficiency of their products. On the other hand, Chinese Taipei also developed economic instruments such as Energy Savings Performance Contracts (ESPC). By introducing ESPC, the loans of business owners to apply ESCO can be compensated by future energy saving. It serves as an economic incentives as to reduce the barrier of high capital cost in energy retrofits. The policy instrument would evolve and there's no single instrument to address all the current energy issues. European Union has one of the most mature energy management schemes. Table 5.1 shows some unique design of energy management schemes and instruments from Germany and Netherland which can be learned by APEC economies.

Table 5.1 Energy efficiency policy instruments of Germany and Netherland

	Energy Target	**Measures**		
		Industrial	Residential	Others
Germany (2008)	Consumption: • ↓ 20% (2020) • ↓ 50% (2050)	• Emission Trading System (ETS) • Energy efficiency network • Renewable charge/ energy tax exemption	• Building regulations (zero emission) • Subsidy schemes • Building certificate	• Eco-design/ Labeling Directives • Energy Service Market
Netherland	Consumption: ↓20% (2020)	• Voluntary agreement : ↓13% energy use • Systematic design → ↑process/chain efficiency • Renewable energy	The integration and demonstration of innovative solutions → ARUBA Smart Community	• Transportation: LPG, LNG • System optimization

* Words marked in red：new policy themes as successful models for APEC economies

5.2 Industrial application model

Industrial energy conservation has played a significant role in achieving national target

in Chinese Taipei. Although there hasn't been mandatory scheme for industries to increase their operation efficiency, the expert groups, Chinese Taipei Industrial Greenhouse and Energy Reduction Services Corp, and ESCOs have been developing and promoting localized conservation measures. The promotion scheme follows the model in Table 5.2 which provides tailored services for different industries. Furthermore, international standard such as ISO 50001 is widely promoted in Chinese Taipei to develop systematic, sustained energy management. Consequently, by coupling the technology, ISO 50001and promotion scheme by policy making, the energy conservation is enhanced as Figure 5.1.

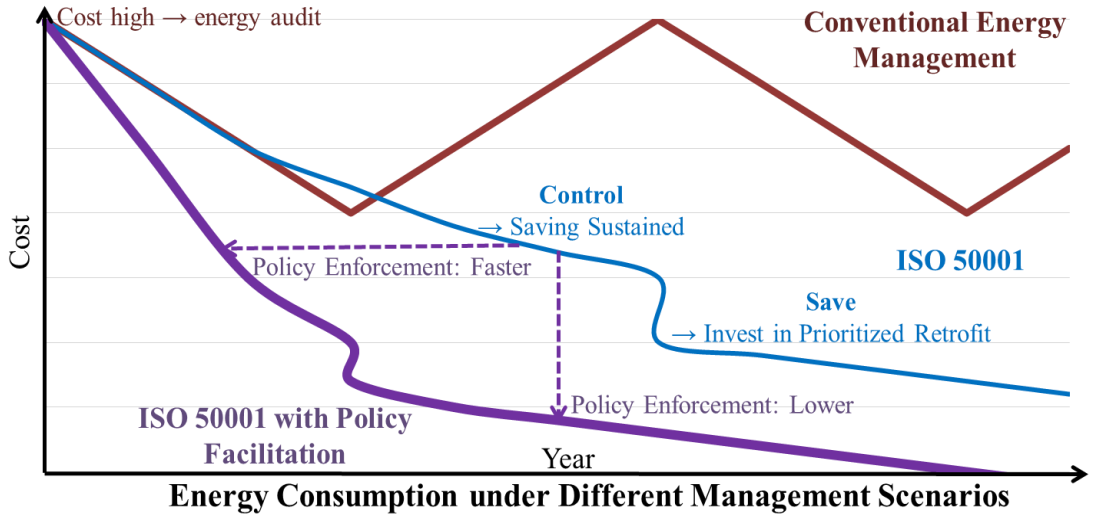

Figure 5.1 Energy conservation enhancement through the combination of technology, ISO 50001 and policy promotion

5.3 Conclusion

To sum up, the project aimed to cultivate the energy conservation culture with APEC economy through shared experience of Chinese Taipei's policy and technology in low carbon operation, established platform for idea exchanged by conducting workshop and training course, and lastly, enhanced connectivity through field verification. The energy conservation culture is expected to be cultivated through three stages which are capacity building, execution and diffusion. These are expected to be delivered through the three tasks covered in these project, policy research, field verification and workshop and training course as shown in Figure 5.4.

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Table 5.2 Chinese Taipei industrial application model

Target (contract capacity)	Requirement	Focal point				
		Demonstration	Training	Conservation counsel	Reduction inventory	
Energy sector	• GHGs reduction • Establish regulation and energy conservation counsel	***Low***	***Low***	***Low***	***High***	**Technical conservation**
Major consumer (801kW↑)	• Energy conservation and carbon emission reduction assessment • Energy audit • Establish regulation and incentives	***Medium***	***Medium***	***High***	***Medium***	**Management conservation**
Manufacturer, commercial sector, school, SMEs (501~800 kW)	• Energy conservation assessment and counsel • Establish regulation and incentives	***Medium***	***Medium***	***Medium***	***Low***	
Manufacturer, commercial sector, school, SMEs (101~500kW)	• Energy conservation assessment and counsel • Develop voluntary improvement	***High***	***High***	***Medium***	***Low***	**Awareness management**

Small business	• Raise energy conservation awareness • Voluntary energy conservation actions • Energy saving counsel	***High***	***High***	***Low***	***Low***	**Awareness management**

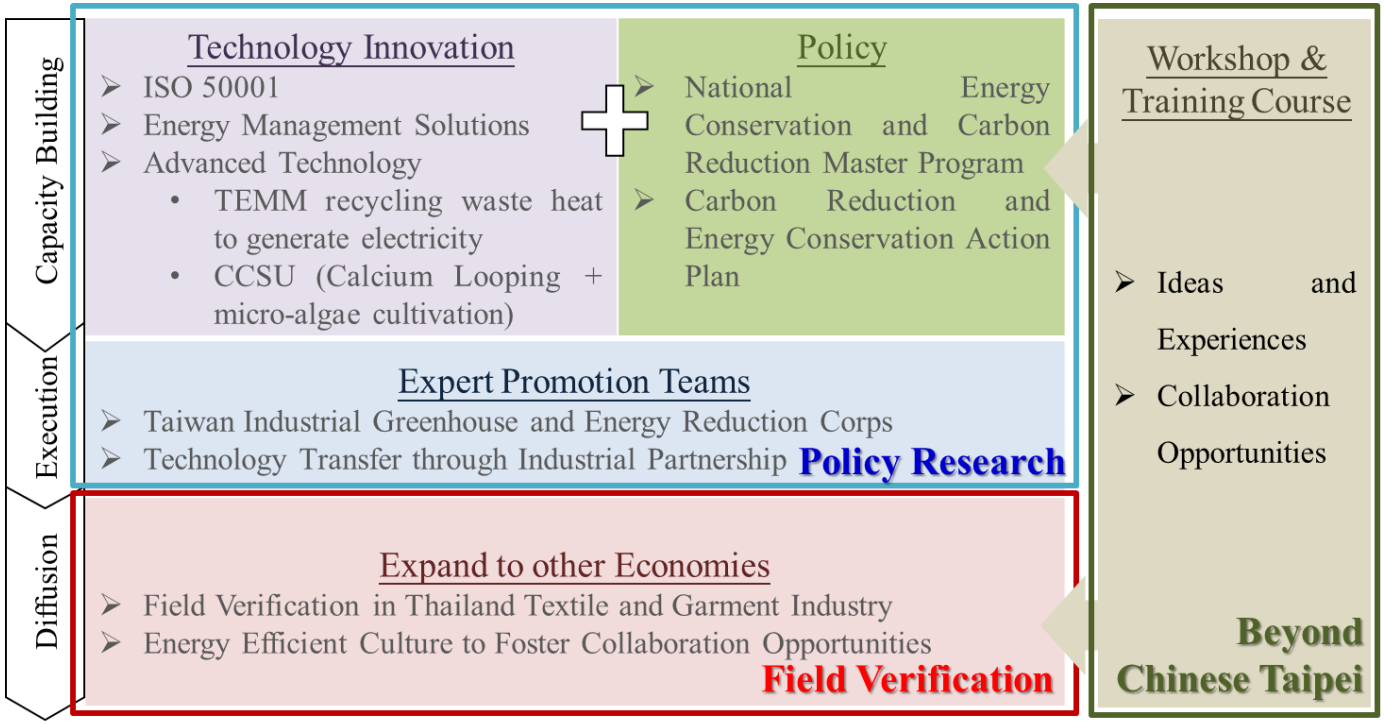

Figure 5.4 Milestones delivered by the project to cultivate energy conservation culture in APEC community