Technology Needs Assessment for Climate Change in Energy Management Sector: The Case of Thailand

Wongkot Wongsapai

***Abstract*—In developing countries, the technology needs assessment (TNA) is very important in defining the country development, especially in infrastructure issue. From UNEP RISØ Center approach, TNA with technology action plan in energy management sector in Thailand have been developed. By using the Multi-Criteria Decision Approach (MCDA) method, there are 29 energy technologies from four main area-based targets, i.e. (i) energy supply and transformation, (ii) renewable energy technologies (RETs), (iii) energy efficiency improvement in demand side, and, (iv) other energy technologies, which related to climate change impact mitigation are identified and assess the mitigation the effects of climate change technology. The ten factors consist of eight "readiness" and two "impact" factors have been applied and weighted to prioritize to all 29 energy technologies to find out the final technologies. The results of technology prioritization are concluded as all possible options as follows; i.e. (i) smart grid, (ii) waste to power generation, (iii) second and third generation of biofuels (iv) energy efficient in combustion in industry sector, and (v) carbon capture and storage (CCS). The technology action plans (TAP) of these five prioritized technologies have then been developed by using the mapping technique. The major barriers of TNA have also been analyzed with solution finding and diffusion preparation. All of the five selected technologies are vital mitigation technologies in the increasing of the capacity and efficiency of energy development and management in Thailand.**

***Index Terms*—Multi-criteria approach, technology needs assessment, Thailand**

I. Introduction

During the recent years, the changing of energy development situation in Thailand and the national policy on energy including its existing infrastructure and management situation were the primary facts used to analyze and summarize the country's top challenges in energy management [1]. Much pressure from international panels / agreements also accelerate the importance of energy as the major sector in greenhouse gas (GHG) emission in the world and also in Thailand after the UNFCCC and Kyoto Protocol in 90's. Even Thailand is not in the Annex I country of the protocol but however the mitigation of GHG is the necessary task for every country as the concept of common but different responsibility. Hence, the prioritization of energy technology including the technology action plan development to mitigate the impact of climate change is very importance for the country's long-term development.

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II. Procedure

This paper focuses only the mitigation technology by identifying the technology needs for energy sector in Thailand under the stress from climate change, reviewing the available technologies and prioritizing the missing ones based on the Multi-Criteria Decision Approach (MCDA) followed the TNA concept by UNEP [2]. From Fig. 1, all 29 energy technologies from four main energy sectors were prioritized through eight "readiness" factors and two "impact" factors to find out the needs assessment energy technologies. All factors are derived from the stakeholders and energy expert group meeting.

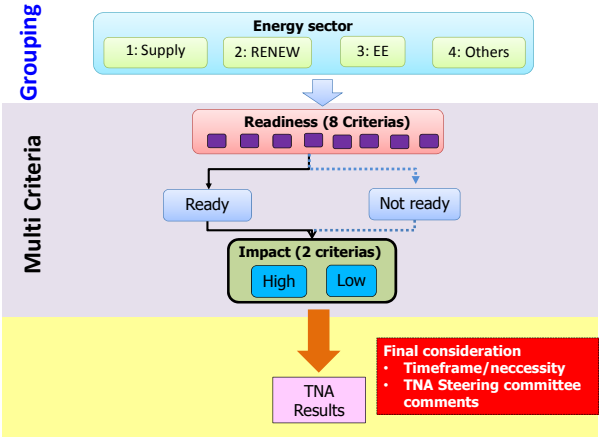

Fig. 1. Technology prioritization procedures.

After the selection of TNA, there are four major steps in identifying the technology action plan.

1) Identify and prioritize technology.
2) Analyze the main barriers of the selected technology
3) Solution finding
4) Identify the energy technology action plans

III. Technology Needs Assessment (TNA)

This section summarizes the current status of technologies in Thailand's energy sector. The four main groups of technologies include:

1) Energy Supply and Transformation
   - Electricity Generation from Commercial energy
   - Electricity distribution system
   - Oil Refinery plant
   - Natural gas separation plant and distribution system
   - Smart grid
2) Renewable Energy technology, analyzed sectors from [3]
   - Solar energy

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a) Solar photovoltaics (PV) for electricity
b) Solar thermal
- Wind energy for power generation
- Hydro energy for power generation
- Biomass
  a) For power generation
  b) For thermal use
- Biogas
  a) For electricity from Biogas engine
  b) For thermal use
- Biofuels
  a) Ethanol
  b) Biodiesel
- Other renewable energy technologies (If any)

3) Energy Efficiency improvement in demand side, analyzed sectors from [4]
   - Industry sector
   - Transport sector
   - Commercial sector and building
   - Residential Sector
   - Other sectors
4) Others
   - Carbon Capture and Storage (CCS)

A. Technology Prioritization

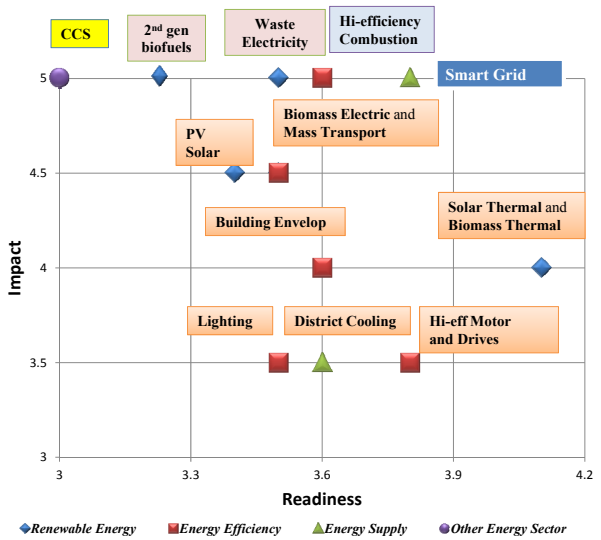
The results of technology prioritization were separated of the two steps, the readiness step and the impact step, based on the two criteria mentioned above. Ranking from country's experts from both public and private sector was initiated.

1) First step: Prioritization according to the readiness

From the first prioritization step which focused mainly on the "Readiness" factor, the energy management technologies, which have more than 3.5 point out of 5 point, consist of 14 technologies in four groups of technology

2) Second step: Prioritization according to the impact

The 14 technologies were further prioritized according to the "impact" factor. Considering the readiness and the impact, the final five technology options from the four groups of technology needed in the energy sector (which have the score greater than 8.5 out of 10)



Note: Selected technologies consist of smart grid, high efficiency combustion, waste to power, the second and third generation biofuels, and CCS.

Fig. 2. Results of technology prioritization.

The results of technology prioritization based on the two criteria. The five technologies selected for Technology Action Plans include smart grid, high efficiency combustion, waste to power, the second and third generation biofuels, and CCS, as shown in Fig. 2.

Fig. 3 presents the technology needs for the energy sector which are smart grid, waste-to-power, efficient burner, CCS, and second generation biofuels. Those technologies cover from the energy supply, transformation, distribution and end-use consumption.

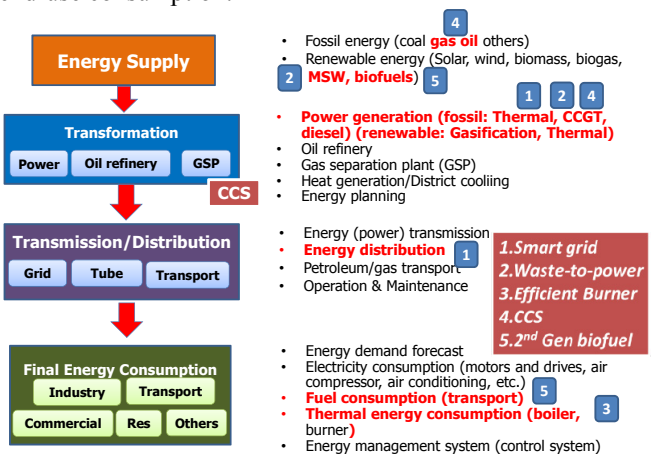


Fig. 3. Technology needs assessment.

IV. Technology Action Plan (TAP)

There are four major steps in identifying the technology action plan.

1) Identify and prioritize technology: The criteria and the selection process were described in five technologies.
2) Analyze the main barriers of the selected technology: There are four aspects related to the barriers (i) economic, (ii) regulatory, (iii) institutional, and (iv) capacity building.
3) Solution finding: Investigating possible solutions to address the barriers for the transfer and diffusion of technology.
4) Identify the energy technology action plans

A. Barrier and possible solution analysis

The barriers to the transfer and diffusion can be summarized into four aspects: policy, technology, financial, and capacity building barriers. The overall technology barrier involves inefficient budget for fundamental research and project investment. In addition, research essential for the technology application are still in a nascent stage of development. Besides, the lack of data integration and collaboration among research institutes is one of the key challenges for technology development. All barriers and solutions of smart grid, waste to power, efficient fuel combustion, CCS, and 2nd generation biofuel are presented in Table I to V, respectively.

TABLE I: Barriers and Solutions-Smart Grid (A)

Barriers	Solutions
Financial: • High investment cost and require high energy potential	**Financial:** • Plan to get more supports from abroad in high technology equipment **[Short term]** • Government support the financial for smart device though the projects/measures (e.g. Tax incentive, ESCO fund)**[Medium term]**

TABLE I: BARRIERS AND SOLUTIONS-SMART GRID (B)

Barriers	Solutions
	• Implement and deploy energy authorities for education and/or research **[Short term]** • CDM-PoA/Credited NAMAconcept**[Short term]**
Policy and Regulatory: • Roadmap policy appear in	**Policy and Regulatory.** • Put smart grid in the national action plan along and clearly assign the related authorities responsibility **[Short term]** • Study and push the clear policies/regulations for support in appropriate period and internalize smart grid to REDP and EEP with clear success framework and time duration **[Medium term]** • Study the international standard (IEEE, IEC, ISO) of the smart equipment and may establish the National Smart Grid • Certification center**. [Short to Medium term]** Set the policy to test both security and stability of smart grid by both system and each device **[Short term]**
Technology: • All technology need to import and the equipment has various types. However, it should be start developing from the mostimportance and high potential, • The research and develop in Thailand is at beginning in institute or university level but not in wide-spread, • No information of smart grid in climate change impact, • System must be maintained by power utility.	**Technology:** • Prioritize the smart grid devices and start plan to developing that device such as start metering and storage **[Short term]** • Potential and feasibility analysis in country level and beginning area and demonstrate the full pilot project operation. **[Short to Medium term]** • Study the impact of the smart device market **[Short term]** • Analyze the climate change impact of smart grid **[Short term]** • Suggest and push for Utility to invest and develop the main control system **[Short term]**
Capacity Building: Lack of technology knowledge from technology design to maintaining	**Capacity Building:** • Develop a research network from academic institutes with best practices case-study **[Short term]** Develop international smart grid network. **[Medium Term]**

TABLE II: BARRIERS AND SOLUTIONS-WASTE TO POWER

Barriers	Solutions
Economic: • High investment cost • *Seasonal fluctuations in the quantity of* waste *being collected*	**Economic:** • Plan to get external support for expensive device [Short term] • Government support the financial for smart device though the projects/ measures (e.g. Tax incentive, ESCO fund)[Medium term] • CDM-PoA/Domesticor Credited NAMAconcept[Short term]
Policy and Regulatory: • REDP has Roadmap and clear policy • Require policy to cover all stakeholders e.g. scavenger etc.	**Policy and Regulatory:** • Law or regulation that promotes waste separation [Short term]
Technology: • Main equipment need to import, • This technology belongs to Japanese license (HTT)	**Technology:** • Plan for technology transfer and promote for Thai entrepreneurs to domestic production [Short term] • Study of the impact of the waste/trash market. [Short term] • Analyze the climate change impact from waste to energy technology [Short term]
Capacity Building: • Lack of knowledge management in the long-term, • Protest from community, • Lack of waste separation management. • PEA's plan but no clear policy or action plan for EGAT and MEA • No equipment standard and IT Security system • No cooperation with international organization.	**Capacity Building:** • Advance technology transfer of HTT [Short term] Capacity building in local community and NGO and public promotion in waste separation system [Short term]

TABLE III: BARRIERS AND SOLUTIONS-EFFICIENT FUEL COMBUSTION (A)

Barriers	Solutions
Finance: • High investment cost (especially in SMEs) • Potential depends on steam demand pattern of each industry	**Finance:** • Government support in financial measures (e.g. tax incentive or ESCO fund[Medium term] • CDM-PoA/Domestic NAMA[Short Term]
Policyandregulatory: • Develop National energy efficiency plan	**Policy and regulatory** • Action and implement plan including loan incentive[Short term]

TABLE III: BARRIERS AND SOLUTIONS-EFFICIENT FUEL COMBUSTION (B)

Barriers	Solutions
	• Regulatory/guideline/standard on fuel use per ton of steam production in each fuel type[Long-term]
Technology: • Need to import technology, • Property right for domestic production.	**Technology:** • Technology transfer • Support domestic based production • Study the impact of implementing especially in boiler equipment market[Short term] • Study on impact to climate change [Short term]
Capacity building: • Lack of knowledge in operation and maintenance in long-term Lack of good practice in boiler operation, especially in SME level.	**Capacity building:** • Technology transfer and approach [Short term] • Technician/operator training/development by using the Best practices case [Short term]

TABLE IV: BARRIERS AND SOLUTIONS-CCS

Barriers	Solutions
Financial: • High investment cost andrequire large area site • CCS to CDM is now in process	**Financial:** • Require international support [Short term] • Promote the study and/or research in pilot scale. [Short term] • Support CCS to CCS-CDM and Credited NAMAconcept [Short term]
Policy and Regulatory: • Policy and regulation are not clear in CCS, especially in monitoring, operating, and reporting leakage • International Law	**Policy and Regulatory:** • Study and deploy policies and regulations support in the appropriate time [Short to Medium term] • 10 years→ Design approval and construction • 20-30 years→ CCS Operate and Injection • after20 years→ Monitoring site and post-injection • StudyInternational std/regulations inboth the international covenant and sea borders[Medium term]
Technology:	**Technology:**

Barriers	Solutions
• Thailand NG contains 15-35% CO2 but still lack of research and develop in institute or university in CCS potential	• Potential and site (area) analysis of CCS [Short to Medium term]
• Lack of deep stratum analysis both on- and off-shore • Lack of impact information in off-shore case that may impact to other country • Lack of study in CCS impact to climate change	• Study and research the geology and related data [Short term] • Impact analysis of CCS to climate change [Short Term]
Capacity Building: • Lack of all technology knowledge from design to maintenance • May encounter protest against CCS in long term • Long-term safety operation and maintenance.	**Capacity Building:** • Establish the CCS research network from academic institute[Medium term] • Capacity building in CCS main issues to stakeholders including the understanding of environmental impact. [Medium term]

TABLE V: BARRIERS AND SOLUTIONS-2ND GENERATION BIOFUELS (A)

Barriers	Solutions
Technical: Conversion Process • 2nd generation biofuel technology has been developed in certain countries • Technology development in Thailand is still in the early stage • Limited number of experts in this area	**Technical: Conversion Process** • Require fundamental research on the production [Short to Medium term] • Fiscal support in pilot scaleand Demonstration plant[Short term] • Develop post-harvest separation and collection system including equipment and post-harvest machines [Medium term]
Technical: Value chain products and technology • Lack of research and development thus those advance technology must be imported	**Technical:Value chain products and technology** • Support fundamental and applied research [Short to Medium term]
Finance: • High investment cost	**Finance:** • Investment fiscal support[Short to Medium term] • Focus on credited NAMA [Medium term] • Investment support for local usage and export [Short to Medium term]
Policy: • Require clear policy that encourages and supports both researchers and private sectors to invest on the technology • Lack of national plan	**Policy:** • Develop national plan the encourage the production and the use of biofuel[Short term] • Development national plan for 2nd-gen biofuel supporting industry [Short term]

TABLE V: BARRIERS AND SOLUTIONS-2ND GENERATION BIOFUELS (B)

Barriers	Solutions
Capacity building: • Lack of national research institute • Lack of national research institute setting and value chain study for all details.	**Capacity building:** • Set up national institute to response all R&D [Short term] • Set up the study in value chain [Short term] Prepare for the promotion to all sector [Medium term]

The previous section described the barriers related to the implementation of technologies for the country. To implement those technologies, there are common barriers among technologies which are summarized as follows:

- The lack of fundamental knowledge from the technology design to maintenance
- High investment cost of the technology, especially in CCS, smart grid, and second generation biofuels
- Require technology transfer
- Require training program, as well as research collaboration in all prioritized technologies
- Supportive and clear policy

According to the TNA , the TAPs of all five prioritized technologies have been developed. In this process, barriers to the transfer and diffusion of the prioritized technologies were identified. The TAPs were established and divided into 3 phases, short-term (3 years), medium term (5 years) and long term (5-10 years).

Thailand needs an international support on technology knowledge transfer. One is a training course through a consortium of leading international universities, local universities, research centers and private companies. Linking with international organizations and experts is also desirable to ensure the portable application with the state of the art technologies. Moreover, sufficient funding from international agencies isthe key to successes since most technologies, e.g. smart grid, CCS, second and third generation biofuel, which requires tremendous amount of investment on technologies and infrastructure. For the domestic development, the priority must be placed on adjusting the national energy policy with conceptually clear, simple, and theoretically sound. Importantly, the government should consistently support the policy throughout the implementation stage

V. CONCLUSIONS

The technology needs assessment of the energy management sector in Thailand has been investigated from five main technologies, from supply- to demand-side, by using the multi-criteria decision approach. The results are (i) smart grid, (ii) waste to power generation, (iii) second and third generation of biofuels (iv) energy efficient in combustion in industry sector, and (v) carbon capture and storage (CCS). Then, the technology action plans (TAP) of all five prioritized technologies have been developed by using the mapping technique. The major barriers of TNA have been analyzed in each technology in four main topics; i.e. (i) financial issues; (ii) policy and regulatory issues, (iii) technology issues, and (iv) capacity building and development issues. Barriers are systematically and seriously taken from author's experiences and stakeholder consultation through national technology action plan seminars and expert group meeting. The solutions of all barriers have also been presented and technology action plans with the priority ranking in all TAP, timeline and responsible agency(s) have been developed For maximum utilities, all technologies should also be considered, by both public and private sector, as appropriate tools for driving the country toward its national policies and strategies in energy which is one of the most important infra-structure to all sectors.

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