

Barriers to the adoption of cleaner and energy efficient technologies in Vietnam

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Abstract

This paper identifies and ranks major practical barriers hindering wide-scale deployment of cleaner and energy efficiency generation technologies in Vietnam using the analytical hierarchy process based a questionnaire-interview survey. Lack of financial/infrastructure and institutional capacity, and deficiency in policies are ranked as predominant barriers to wider penetration of small hydro technology while barriers of information/awareness, R&D and industrial capability, and weak policies framework primarily obstruct proliferation of geothermal energy. For cleaner coal-fired technologies, weak industrial capability, lack of technical know-how, economic/financial constraints are judged as prevailing roadblocks for entering these into the electricity generation portfolio. Though both institutional and policies barriers are not ranked as most dominant they are judged by interviewed experts as latent barriers that could resolve the existence of remaining barriers and considered as “must-be-overcome” barriers. The study then comes across strategies to overcome the identified major barriers using a criteria/policy alternative matrix approach based interviewed experts’ opinions. The Government is viewed as a key market enabler. More investment for R&D activities and improving R&D capacity through joint-venture schemes as well as reforming investment policy/legislation for the electric power industry are recommended as most appropriate policies and measures.

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1. Introduction

Electricity generation in Vietnam is expected to soaring increase at a higher rate than the global average by 17–18% per annum over 2010–2030 (Institute of Energy, 2007, 2008b). Given such a surging growth of electricity demand, the sector is confronting the chronic problems of backward generating equipments, low energy efficiency of electricity generation system, and especially the increased air pollution emissions. Thus, how to debate the challenge of clean energy usage is the thorny question, to day, drawing much concern of the national experts and policy makers in Vietnam. In practice, there are a number of available technical options of cleaner and energy efficient technologies (called as CEETs hereinafter) that could help to overcome the challenging problem in developing economies (Chattopadhyay, 1994; IPCC, 1996; Shrestha and Marpaung, 1999; Climate Change, 2007; Nguyen and Ha-Duong, 2008; Nguyen and Ha-Duong, 2009). However, a majority of such CEETs have not been widespread adopted in a developing country like Vietnam due to the existence of certain typical barriers (PREGA, 2005; USAID, 2007a; Institute of Energy, 2004; Institute of Energy, 2005). In literature sources, there exist a considerable number of studies examining the barriers to adoption of energy efficient technologies in selected developing countries with similar circumstances of Vietnam using a variety of analytical approaches (Parikh et al., 1997; Reddy and Shrestha, 1998; Khanna and Zilberman., 1999; Wijayatunga et al., 2006; Climate Change, 2007; Mirza et al., 2009). This paper attempts to add to the existing literatures dealing with the existence of these practical barriers. It provides systematical processes of identification and ranking of the major barriers to greater adotion of CEETs in Vietnam's power sector using an analytical hierarchy process (AHP) based a questionnaire-interview survey. The appropriate policies and measures (PAMs) to promote the wide-scale deployment of CEETs are determined and evaluated employing a simple method of criteria/policy alternative matrix approach based interviewed experts' opinions and judgments. In this study, the CEETs are divided as small hydro and geothermal energy

generation technologies (called as RETs hereinafter) and cleaner coal generation technologies including pressurized fluidized-bed combustion (PFBC) and integrated gasification combine cycle (IGCC) coal-fired technologies (called as CCTs hereinafter). The next section summarizes the current adoption of cleaner and energy efficiency technologies in Vietnam's power sector and their potential. Section 3 presents the study design. The data built-in a survey method and the analysis approach are interpreted in section 4. Results of the survey 1 are analyzed in section 5 to identify and rank the major barriers to the wide-scale adoption of CEETs. Section 6 presents the assessment results of appropriate policies and measures (PAMs) to promote the proliferation of CEETs under the survey 2. Next, the robustness analysis of the study is carried out in section 7. Section 8 summaries and concludes.

2. Cleaner and energy efficiency technology in Vietnam: potential and current usage

2.1 Status of power sector and its development prospects

Electricity of Vietnam and its business domain

The electric power sector appears as one of the most promising businesses for domestic and foreign investors in Vietnam's market. EVN is a state-owned corporation that currently operates as a monopoly in the areas of generation, transmission, distribution and sales of electric power.

Power generation system

At the end of 2007, the total electricity generation capacity installed was 12948 MW, in which Electricity of Vietnam facilities accounted for about 71.9% including 34.6% hydropower, 22.7% gas-fired power plants, 11.6% coal-fired, 1.4% oil-fired, and 1.5% small hydro and diesel plants. The remaining 23.9% of capacity provided from Independent Power Producers (IPPs) and 4.2% of capacity imported from China (Institute of Energy, 2008a).

Electricity energy consumption

The electricity consumption in Vietnam experienced an average annual growth of 14.9% over 1996-2000 and over 15.3% during 2000-2005, far faster than the GDP growth rate of 7.2% for

the period 1996-2005. The electricity production sales increased from 22.4 billions kWh in 2000 to 50.4 billions kWh in 2006 to meet economic development need and residential usage. According to Vietnamese organizations, the demand for electricity in Vietnam is expected to increase by 15% per annum in the low-demand scenario and by 18% per annum in the high-demand scenario over the period of 2010–2030. This soaring demand is mainly due to increasing energy usage in industry and households (Institute of Energy, 2006; Institute of Energy, 2007).

2.2 Energy resource potential and current adoption of CEETs

Coal reserve and energy efficiency of existing coal-fired power plants: Vietnam' coal reserve is exploratory about 3808 million tons as of January 2002, in which 85% is anthracite coal (heat value ranges between 5200 kcal/kg and 5700 kcal/kg). Over 2002–2020 qualified coal yield is expected to increase from 13.8 million tons to 30 million tons per annum, and it could be possible to reach at 40 million tons per annum in 2030. Exception of natural gas combined cycle generating plants and few new installed coal-fired power plants, most of the existing thermal power plants were constructed with backward technology and low efficiency (28%-32%). The overall efficiency of these conventional plants is very low that leads to high consumption rate 650g-700g of standard coal/kWh. Recently, several new coal-fired plants installed using conventional pulverized technology with thermal efficiency of approximately 41% and circulating fluidized bed (CFB) technology, which allows for using low-grade coal in combustion process, with thermal efficiency of around 36%. To meet the increased need for electricity services over 2010-2030, the country plans to expand huge generation capacity system based coal-fired power plants. In addition to domestic coal material, coal (bitumen) with high average heat value of 6500 kcal/kg is considered to import from the neighboring countries in the region such as Indonesia, Australia...etc, (Institute of Energy, 2004, 2006). However, the usage of cleaner energy efficient coal-fired technologies such as supercritical or ultra-supercritical, PFBC, IGCC for the sector expansion has not been considered or clearly orientated in the

national development plan. The conventional pulverized and CFB technologies are continued to be in use for committed and new coal-fired generating stations planned for up to 2015.

Renewable energy sources and current renewables generation development: Vietnam is enormously endowed with renewable energy sources distributed throughout the country that could be potentially used for electricity generation. These renewables include small and mini hydro, wind, geothermal, biomass, biogas, and solar. To date, due to lack of Government's investment for research and development activities (R&D), deficiency in policy and regulatory framework, and insufficient systematic measurement and investigation systems...etc, the whole potentiality of renewable energy sources is only preliminarily assessed. In spite of such pre-estimated sources, most of them are effectively unexploited yet (Nguyen and Ha-Duong, 2009). Table 1 presents the current development of renewables for electricity generation, indicating very slow penetration of endowed renewable sources deployment in Vietnam.

Selected cleaner energy efficient generation technologies for research analysis: the Asian Regional Research Programme in Energy, Environment and Climate (ARRPEEC), funded by SIDA has suggested some carbon emission reduction options of cleaner and energy efficient technologies in Vietnam's power sector such as: fuel switching, energy savings for end use electrical appliances, renewables usage, environmental taxes adoption,...etc, (Institute of Energy, 2005). More specifically, recent studies by Nguyen and Ha-Duong 2008, 2009 all suggest that utilization of renewables predominantly by small hydro and geothermal energy would be least cost for electricity generation and bring significant co-benefits to Vietnam's development power sector. Also as their research results, the advanced energy efficiency coal-fired generation technologies such as supercritical, PFBC, IGCC would enter into Vietnam's power generation portfolio so as a result of future changes in the market and in the technological innovation progress as well as in the climate change policy. In this study, renewables generation technologies include small hydro and geothermal energy, and cleaner coal-fired generation

technologies (IGCC, PFBC) are representatively selected for analyzing major practical barriers that hinder their widespread deployment in Vietnam.

The following part of the paper presents the study design including data and analysis approach to identify these major barriers. To the end, necessary appropriate policies are evaluated to infer strategic recommendations for promoting the adoption of CEETs in Vietnam.

3. Study design

3.1 Identification and ranking of major barriers: 1st survey

In this study, three generation technologies of renewables (small hydro and geothermal) and cleaner coal (IGCC, PFBC) were selected as CEETs for analyzing the major barriers to their proliferation in Vietnam's electric power generation industry. Generally, barriers are defined as factors that inhibit the technology transfer process. There is an abundant literature broadly classifying barriers relevant to the transfer of CEETs (Meyers, 1998 and UNFCCC, 1998). These can be shortlisted as: (i) *Institutional*: lack of legal and regulatory frameworks, limited institutional capacity, and excessive bureaucratic procedures; (ii) *Political*: instability, interventions in domestic markets (for example, subsidies), corruption and lack of civil society; (iii) *Technological*: lack of infrastructure, lack of technical standards and institutions for supporting the standards, low technical capabilities of firms and lack of a technology knowledge base; (iv) *Economic*: instability, inflation, poor macroeconomic conditions and disturbed and/or non-transparent markets; (v) *Information*: lack of technical and financial information and of a demonstrated track record; (vi) *Financial*: lack of investment capital and financing instruments; (vii) *Cultural*: consumer preferences and social biases; (viii) *General*: intellectual property protection, and unclear arbitration procedures.

First step, an overall review of existing literatures and country reports is carried out to do screening up barriers that have hindered the wide-scale adoption of cleaner and energy efficient technologies in the power sector. Then, these necessary data are further gathered throughout

interviewed discussions with the country's key experts related to the field, who have different perceptions about the barriers and their effects, and summed up as the information basis for identifying and ranking the major barriers. This screening-up process aims at narrowing down to full list of relevant barriers then creating a shortlist of 5 major barriers for each of three selected generation technologies.

The second step, the study determines the priorities (weights) of various interviewed expert groups involved using the AHP based on opinions and judgments among interviewed experts.

The next step, basing on barriers' characteristics the study defines 5 criteria for evaluating and ranking barriers. These criteria are: monetary cost to remove barriers, level of efforts required creating awareness, level of political or bureaucratic efforts needed to remove barriers, level of impact of adoption, and life of barriers. These criteria are then weighted by AHP based on interviewed experts' opinions and judgments.

The fourth step, the study weights barriers for each technology, each criterion, and each interviewed expert. It then aggregates the weight within each expert group.

Finally, the ranking results for the major barriers are obtained by aggregating the weights of criteria and various experts groups.

3.2 Identification and evaluation of policies and measures: 2nd survey

Similarly, review of literature and existing policies, discussion with policy makers and experts in the field is executed to identify an appropriate set of policies and measures. There are varieties of policies and measures discussed for proliferation of CEETs adoption in a developing country like Vietnam (IPCC, 1996; Halsnae, 1998, UNFCC, 1998; PREGA, 2005; USAID, 2007; Institute of Energy, 2004; Institute of Energy, 2005). These can be generally summarized in five categories: (i) economic instruments: taxes, subsidies, sector reforms; (ii) innovative financial mechanisms; (iii) information, education and technical assistance programs; (iv) command and control measures; (v) research and Development. The policy assessment process is performed subjective to opinions and judgments of the experts involved in the survey. Therefore, the study constructed

a criteria/policy evaluation matrix integrated in the questionnaire of interviews. The main task in evaluating policies and measures is filling in all the cells of the evaluation matrix with predicted impacts of each criterion of the policy. Because of unavailable sufficient information/data, these predictions are only qualitatively performed, i.e., “poor,” “good”, “very good” or “excellent”. All data and detailed evaluation approach for policies and measures are described in Section 3 and 5.

4. Data and analysis approach

4.1 Questionnaire

In this study, the data used to identify barriers and policy measures were mainly obtained throughout an overall review of existing literatures, specific studies, country reports and discussions with experts in the field. Opinions and judgments for ranking and evaluating processes were collected from the interviewed experts through an interviewed questionnaire survey.

The questionnaire is designed for clearly understanding and simply practicing without causing any confusion among the experts. For more a convenient opinion-collection process, the pair-wise comparison matrix was converted into question tables with appropriate instructions and the goal of the study was highlighted in the questionnaire. The questionnaire is designed to rank the barriers for each technology option based on five selected ranking criteria. In order avoid any bias, the questionnaires were distributed in a balanced ratio to the experts relevant.

4.2 Sample

The National Institute of Energy in Vietnam conducted the research survey based interviewed questionnaire. The interviewed survey was performed to obtain further relevant information and specially to collect opinions/judgments of the country’s experts, who have concerned with the power sector and experienced on cleaner and energy efficient generation technologies, on major barriers hindering the widespread adoption of these technologies in Vietnam. They are from Ministry of Industry and Trade (MOIT), Ministry of Natural Resources and Environment

(MNRE), Ministry of Planning and Investment (MPI), Electricity of Vietnam (EVN), Institute of Energy of Vietnam (IE), Electric Utility, Ha Noi Polytechnic Institute, and private companies and manufactures/suppliers. For consistently ranking and evaluating, we classified these experts into 6 key expert groups as indicated in Table 3: energy experts (A1), environment experts (A2), policy-makers (A3), project developers and power facilities owners (A4), equipment manufacturers/suppliers (A5), electricity users (A6).

All involved respondents possessed thorough knowledge of all the criteria and factors affecting the concerned study. The process of selection of opinions and judgments was identically and equally treated to all participants. Respondents were face to face interviewed, based a questionnaire at their offices and via post mail correspondences.

Except for few inconsistent responses¹, we collected 37 consistently qualified questionnaire samples over the total 62 ones distributed to all key actor groups.

4.3 Analysis: the analytical hierarchy process (AHP)

The analytical hierarchy process is a structured technique to help dealing with complex decisions developed by L. Saaty in the 1970s. The basic step is the pair-wise comparison of two so-called stimuli, two alternatives under a given criterion, for instance, or two criteria. According to L. Saaty (2006), the AHP computes estimation of priority weights of a set of criteria or alternatives from a square matrix of pair-wise comparison $A = [a_{ij}]$, which is positive and it is reciprocal should the paired comparison judgment is perfectly consistent, i.e., $a_{ij} = 1/a_{ji}$ for all $i, j = 1, 2, 3 \dots n$. The final normalized weight w_i of its i^{th} element is given as:

¹ The pair-wise comparison matrix should have a consistency level within 10%. It means the response from different experts while making pair-wise comparison can be inconsistent by over 10%. And the required level of consistency of the judgment is maintained through a re-examination process when necessity arises. We, thus, did not consider any questionnaire response with inconsistent level of over 10% in practice. For detailed test of consistency, refer to subsection 3.3.

$$w_i = a_{ij} / \left(\sum_{k=1}^n a_{kj} \right) \forall k = 1, 2, \dots, n \quad (1)$$

In practice, an error on the judgment is unavoidable. The suggested eigenvalue method computes w as the principal right eigenvalue of the matrix A or w satisfies the following system of n linear equations:

$$A w = \lambda_{\max} w \quad (2)$$

where $\lambda_{\max}$ is the maximum eigenvalue of A .

Thus:

$$w_i = \frac{\sum_{j=1}^n a_{ij} w_j}{\lambda_{\max}} \forall j = 1, 2, \dots, n \quad (3)$$

To rank the priorities of alternative criteria and the importance of experts and their judgments, the AHP uses the underlying comparison scale with values from 1 to 9 to rate the relative preferences (see Table 2). The underlying comparison scale and consistency for the pair-wise comparison in practice can be mathematically expressed as below.

Using the law of Ernest Heinrich Weber (1795-1878), Gustav Theodor Fechner (1801-1887) denotes the sequence of just noticeable stimuli as:

$$s_n = s_0 \times \left(1 + \frac{\Delta s}{s} \right)^n = s_0 \times (1 + r)^n = s_0 \times \alpha^n \quad (4)$$

where $n = 0, 1, 2, \dots$, s is a stimulus; Δs is the just noticeable difference and ratio $r = \Delta s/s$ does not depend on s .

Deriving (4), we have:

$$n = \frac{(\log s_n - \log s_0)}{\log \alpha} \quad (5)$$

If we denote M as the sensation, a linear function of the logarithm of the stimulus and stimulus of s , the psychophysical law of Weber-Fechner is then expressed as:

$$M = a \times \log s + b, a \neq 0 \quad (6)$$

Assuming the stimuli arise in making pair-wise comparisons of relatively comparable activities, we are interested in responses whose numerical values are in the form of ratios. Thus $b_0 = 0$,

then we have $\log s_0 = 0 \Rightarrow s_0 = 1$, which is possible by calibrating a unit stimulus. This is done by comparing one activity with itself. The next noticeable response is due to the stimulus:

$$s_1 = s_0 \times \alpha = \alpha \quad (7)$$

This yields a response $\frac{\log \alpha}{\log \alpha} = 1$. The next stimulus is $s_2 = s_0 \times \alpha^2$ which yields a response of 2.

In this manner we obtain the sequence 1, 2, 3...

In practice, there are 5 intensities well presented for making qualitative distinctions. These are: equal, moderate, strong, very strong, and extreme. We can make compromises between adjacent intensities when greater precision is needed. Thus we use the nine consecutive absolute values shown in Table 2 as the scale to make pair-wise comparisons in the study.

After collecting of pair-wise comparison tables, there are two steps involving in the AHP calculation group aggregation and test of consistency.

Group aggregation

The individual pair wise matrices provided by the group members for the alternative options in each criterion is used to get the aggregated pair wise matrix for each criterion. In this study, geometric mean method is used, shown as following formula:

$$\overline{W}_i = \left(\prod_{j=1}^n a_{ij} \right) \frac{1}{n} \quad (8)$$

where n is number of members; a_{ij} is preference of a member for element ' i ' over ' j '.

After normalization of vector $\overline{W}_i$, we could get aggregating vector $W = (w_1, w_2, \dots, w_n)^T$ by the

following formula:

$$W_i = \frac{\overline{W}_i}{\sum_{i=1}^n \overline{W}_i} \quad (9)$$

Test of consistency

In order to test the consistency of the matrix of pair wise comparisons, consistency index ($C.I.$) is

introduced as:

$$C.I. = \frac{\lambda_{max} - n}{n - 1} \quad (10)$$

Where λ_{max} is the maximum eigenvalue of the matrix and always greater than or equal to n for positive reciprocal matrices, and is equal to n if and only if A is a consistent matrix. Thus, $(\lambda_{max} - n)$ provides useful measure of the degree of inconsistency. For each size of matrix n , random matrices were generated and their mean $C.I.$ value, called the random index ($R.I.$), was computed. Using these values, the consistency ratio ($C.R.$) is defined as the ratio of the $C.I.$ to the $R.I.$ Thus, $C.R.$ is a measure of how a given matrix compares to a purely random matrix in terms of their $C.I.$'s.

Therefore:
$$C.R. = \frac{C.I.}{R.I.} \quad (11)$$

A value of the $C.R. \leq 0.1$ is typically considered acceptable, larger values require the decision maker to reduce the inconsistencies revising judgments. The required level of consistency of the judgment is maintained through a re-examination process when necessity arises.

The Expert Choice software (2000) was used to compute the final weight for each barrier and to check the consistency of the analysis.

5. Results of survey 1

5.1 Barriers to small hydro energy technology

Exploiting small hydro energy source (≤ 30 MW) for electricity generation is determined to bring in significant economic benefits to the country. Over the last 10 years, the Vietnamese Government has experienced certain programs to appeal to investors' financial resources for exploiting this kind of renewables. However, only about 10% over the country's capacity potential (4 GW) has been developed up to 2007 due to the existence of some major barriers. As a ranking result based interviewed survey in Table 5, the predominant barriers to wider development of small hydro technology in Vietnam are: finance, infrastructure, institution, information, and policy.

Lack of capital investment and scarcity of financial resources

Almost interviewed experts judged that small hydropower plants in Vietnam could not be smoothly implemented in accordance with their original plans due to the chronic financial problem. Table 5 indicates that the lack of capital investment and scarcity of financial resources would be evaluated and ranked as the most leading barrier to greater deployment of small hydropower for providing electricity. More specifically, a recent report from MOIT states that 99% of small hydropower projects achieved very slow construction progress due to lack of capital investment. This financial barrier is often arisen from difficult geographical features of small hydro sites, weak financial and managerial capabilities of appointed investors, poor qualifications of commercial banks, inadequate electricity pricing system, deficiency in Government's policies and incentives.

Small hydropower sites are mostly located in Vietnam's remote areas where are far away from load centre and have hard transportation access (Figure 1). Life condition is bad and economy development is still at slow stage. People living in these areas are very poor and under-educated. The development of small hydro energy projects, thus, could not be easily implemented together with such a low economic condition and poorly developed infrastructure. Capital investments would still low to come to these areas if encouraging policies and incentive measures are not available. Recent years, the Vietnamese Government has implemented a series of investment plans to deploy small hydropower stations for providing electricity to economic development as well as to serve remote areas. Nevertheless, the effectiveness of these projects is very low due to inadequate business management capability and insufficient finance-ability. Many appointed owners/investors of small hydroelectric projects, which are state-owned companies or enterprises, could not finance enough capital for these projects. Over 80–90% of these projects' capital borrowed from the source of bank loans, especially domestic commercial banks. In addition, some joint-stock small hydroelectric companies, which are the subsidiaries of the state enterprises, often tend to expect interventions or sponsorships from the central Government rather than must be active in negotiating and seeking an agreement for the projects' finance

security, and power purchases before execution. They even failed to estimate the project cost and financial need that often results in delay or postpone of small hydropower projects.

Due to the needs of capital, domestic commercial banks have played an increasing important role in financing small hydropower projects in Vietnam. However, the poor qualification of some of them in project appraising has caused obstacles to implementation of these projects. This banking problem, so far, has led to acceptance of some ineligible investors while some of others qualified could not be accepted.

Another issue related to irrationalization of prices for fossil fuels and electricity that makes renewable energy projects in general, and small hydroelectric projects in particular less attractive to private investors or independent power producers. As a result of subsidized prices for fossil fuels and electricity, and no national wide cost sharing system is available, the investment rates of some small hydroelectric projects are beyond the existing fuel prices and electricity tariffs. In addition, Electricity of Vietnam (EVN), the single-buyer of electricity uses its monopoly to control electricity prices and is not strategically required to create an equitable level playing field for clean energy development. Thus, this results in insufficient willingness and ability to finance small hydroelectric projects with higher risk premiums, compared to fossil fuel-fired projects.

Low capability of technological development and lack of domestic equipment suppliers/services

For small hydropower plants, the technical and technological aspects take a very important function because a great majority of capital investment is expended upon it. Technical and technological matters, unexpectedly, have been the major threat to many small hydropower plants in Vietnam over the last decade. This is because most existing and committed stations have been using poor qualified equipments and technologies then problems came just after several years in operation. The interruptions of services have been occurring frequently. At present, there are no commercial enterprises supplying renewable electricity technologies and services including small hydro. Most small hydro technologies are not fabricated domestically but are imported, mainly from China via sub-quota. The price is cheap but the technology is so

backward. And they are often utilized under conditions of beyond designed capacity while necessary spare parts are hardly available on market that often decreases plants' efficiency quickly.

Moreover, lack of mechanism for establishment and operation of domestic commercial enterprises (suppliers/manufacturers) for renewable technologies/equipments makes the country no choices for accessing the usage of advanced energy efficiency technologies and continues to over-depend on imported technologies with inappropriate quality from China.

AHP result indicates this kind of barrier as the second dominant major hindering the greater deployment of small hydroelectric plants in Vietnam. Beyond this finding, the AHP suggests that a more significant ranking weight would be identified for this barrier if the priority among expert groups was equally treated (Table 5).

Behind the weak capability of technical and technological infrastructure, it implies a lack of serious concerns and adequate investment for research and development (R&D) in Vietnam. Though the country's authority has recently recognized the importance of R&D for the country development but it still remains at awareness for renewable energy technology deployment. There is no national research centre and research facility for R&D programs on renewable energy technology innovation, at least at regional level. The existing renewable energy research projects are usually spontaneous with limited budgets and undertaken as pilot projects only.

Weak Government policy and regulatory frameworks for clean energy development

Among South-East Asian countries, Vietnam embraces abundant potential of small hydro energy that could be utilized for economic development but they are not economically exploited yet because renewable electricity development is not primarily set up as a national goal. To date, the Government gives no clear specific strategies on the usage of national renewable energy sources including small hydro for generating electricity and the country is now at a drafting footstep for making an overall development policy for renewable electricity usage. As expected by Government organizations, Vietnam could integrate about 5% renewables sources in the

electricity generation system by 2030. This rate is rather low compared to that of the neighbor country Thailand with about 10% by 2020 (Institute of Energy, 2008a).

Deficiency in policies and weak policy implementation at both central and local level is mainly claimed to fail accelerating the scaling-up of this clean energy option. No national funds or other appropriate incentives are established for promoting the deployment of small hydro stations. Supporting policy measures like small power purchasing agreements (PPAs) are not yet strategically included in national regulatory framework to meet the needs' financiers or developers of on-grid projects. Moreover, legislation and market-oriented reform in power sector is developed sluggishly so that the monopolistic electricity energy market controlled by EVN causes unguaranteed grid access and no fair feed-in tariffs for independent power producers. As a result, decentralized small-scale hydroelectric potential would not be realized then would be kept out of the energy market.

Though perceptions of awareness of hindrances and difficulties related to financial sources, availability of advanced technology, price rationalization etc. to the exploitation of renewables sources, the Vietnamese Government hardly execute positive changes in their policy framework in short term. This is because of conflicting objectives and interests among policy-makers/decision-makers that causes power shifts to lobbyist, hinders formulation of policies, and creates incoherent strategies.

Furthermore, lack of policy and legislation clarity is the roadblock for on-grid power projects, in which legislative procedures for approval and authority handing-over process to project developers are still hard and complicated, particularly for private investors. This situation creates doubts and uncertainties for financiers/developers to invest their money in this business.

Even this kind of barrier would not be ranked by AHP as the most dominant barrier to the widespread adoption of small hydropower technology in Vietnam, interviewed key experts emphasized that deficiency in Government policies and weak regulatory frameworks for clean

energy development is the must-be-overcome barrier that could have an overall negative effect on the existence of the remaining barriers.

Multiplicity authorities and insufficient local capability to develop and operate the networks

As ranked here, insufficient co-ordinations and multiplicity bodies within the Government authorizations is evaluated as the fourth major barrier hindering the greater adoption of this technology. Interviewees pointed out management mission of small hydroelectric sources in Vietnam exists too much inadequateness and irrationality. There are various functional bodies of the Government from central to local authorized for exploiting these resources. And they have run their responsibilities in an irregular overlapping way. Specially, poor coordination and insufficient collaboration among these units has caused bad influences on the enforcement of regulations and also prolonged decision-making process anyway. For example, before lots of small hydropower stations were due to local investment, management and operation, and mini hydropower were self invested and managed by individuals (Figure 2). They themselves operated the stations with superannuated systems based on their own experiences only, without any appropriate management process or modern control system. Therefore, when operation fails occurred they could not request technical supports from the sector's specialist units or maintenance services timely. This resulted in long term operation halts, or permanent standstills. Besides, there is a lack of local enthusiasm to policy implementation by state functional bodies. For instance, before EVN had a plan to model purchasing electricity from some renewable power projects through power purchasing agreement and applicable to the 49 small hydropower plants, but many localities were not ready and did not favor for that plan (PREGA, 2005).

Recently, the Vietnamese Government has implemented numerous small hydroelectric stations (with good hydrographical conditions and energy potential) by their own budgets or by funded-aid programs (a few). But it is still absent from clearly decentralized administration between state functional unit such as EVN with provincial and local authorities in managing and operating these energy sources. After some stations were constructed and put into services, the

operation and maintenance responsibility among relevant parties was still unclear. Provincial and local units did not have enough capability and human resource to manage and maintain those plants' long term operations. While EVN has sufficient capability but it is hardly to request their collaboration because there is no adequate incentive policies to convince their staffs who would work in these remote stations for a long period (Figure 3). No one wills to remain responsibility for taking over the operation task due to insufficient human resource reason and until now some of these projects have been delayed accordingly.

Lack of information on national energy resources potential

As information on the potential of national energy resources and technological development market are very important to project developers or private investors, but they are often not available or confidential in Vietnam. Therefore, the potential and positive side benefit of small hydro energy has been underestimated. In addition, the database for the country potential of renewable energy resources is insufficient, scattered, dispersed, and less updated that causes difficulties to investors in analyzing and evaluating the feasibility of their investments.

At present, lack of reliable data on small hydroelectric sources makes many difficulties for making plans. The data are available but dispersed in various sectors and not enough details for making an overall program. For instance, some hydropower sites were identified but their data are not detailed enough for preparing a specific action plan. This insufficiency of information basis has been leading to no, or wrong, decisions by project investors, in some cases. It can be observed that this non economic/technique barrier is not only due to un-adequate investment for R&D activities but also from the weak legislation and easygoing coordination among departments responsible for energy related issues in Vietnam. Should this barrier not being eliminated, it would continue causing a lack of awareness among decision makers at different political and administrative levels and remaining doubtful for private/foreign investors who are seeking investment opportunities in small hydro energy business in Vietnam.

5.2 Barriers to geothermal energy technology

Using a well-proven and mature technology worldwide, geothermal energy has been developed to supply both heat and electricity services. Despite the fact that the research and investigation works on usage of geothermal energy were started in Vietnam 30 years ago, the dissemination of this kind of renewable energy technology has been hardly ever proliferated in Vietnam. Table 6 summarizes the identified major barriers to the deployment of geothermal energy generation technology in Vietnam based on the analytical hierarchy process.

Lack of information and awareness about technical know-how, technological development and national resource potential

Table 5 indicates that lack of information and awareness about technical know-how, technological development and national resource potential would be ranked as the most superior major barrier.

A general lack of information about and awareness of resources potential and their positive side benefits of renewables is considered as one of the principal barriers to greater adoption of renewable energy technologies in developing countries. This is the situation of geothermal energy technology development in Vietnam. With more than 300 geothermal sources ranging from 30⁰C to 148⁰C, the country is preliminarily estimated to have 1,400MW that could be developed for direct heating usage and electricity generation. But due to less interest of Government authorizations and insufficient resource investigation this richly endowed energy resource was sunk deep into oblivion for long time before being raised nowadays. Few recent studies were carried out to preliminarily estimate about 340–400 MW could be developed for producing electricity by 2020.

In addition, throughout the interviewed survey it is observed that geothermal energy generation technology seems to be an early stage of development in the eyes of some key experts even this basic well-proven technology has been using worldwide nowadays. This is due to a lack of information on the state of technology development, prices and its effectiveness among

policymakers, experts, potential investors, financing institutions and functional agencies of the Government. Hardly accessing to such information by involved entities would continue to deactivate the adoption of geothermal energy technology and relevant deployment strategies in Vietnam.

Weak level of scientific, technological and industrial capability

As just discussed above, weak level of scientific, technological and industrial capability is determined as one of the important major barriers to build up the penetration of geothermal energy generation technology in Vietnam.

As a developing country with a young industrial stage, Vietnam is still ranked among the low-income classification of nations in the world but this is not only the main motive of this barrier. There is, in fact, too little attention given to R&D movement and a lack of platform facilitated by the Government for doing science activities and enlarging specialists. The current national mechanism and policy does not really favor for accessing to the proliferation of high qualified technique and technology although industrialization and modernization is a long-term objective of the Government. And development of renewable energy technology for long-term economic development is not yet in the Government's strategy plan. There is no national research centre for renewable energy development, at least at regional level with necessary basic research facilities and infrastructures. The existing renewable energy research projects are usually spontaneous with limited budgets and currently undertaken in forms of demos, pilot projects or reporting only.

Insufficiency of incentive measures and promotion policies, and regulatory framework

Currently, there is no sufficient policy and regulatory framework for promoting grid-connected renewable power development in Vietnam, even there are least costs at some sites. Typically, there is no effective regulatory framework for the present electricity tariffs in order to aid the penetration of geothermal energy technology for generating electricity. For example, in 1990s an American company named ORMAT carried out a feasibility study for exploiting geothermal

energy resources for generating electricity in Vietnam with total preliminary capacity of 200 MW. There were several areas determined for constructing geothermal plants including Mo Duc (Quang Ngai province), Hoi Van (Binh Dinh province), Nghia Thang (Quang Ngai province), Danh Thanh (Khanh Hoa province), Tu Bong (Khanh Hoa province) and Le Thuy (Quang Binh province). According to the results of the feasibility study report, power purchasing price suggested by ORMAT was 4.9 cent \$US/kWh. However, this proposed power purchasing price was not acceptable to EVN and those geothermal generating projects were rejected (Institute of Energy, 2005). Today, the average electricity pricing is higher than 4.9 cent \$US/kWh (about 6 cent \$US/kWh) in Vietnam and ORMAT was back to offer EVN an even lower power purchasing price with most advanced technology, but it is still under consideration by EVN.

Most key experts argued that the existing regulatory framework is not less effective to support development solutions such as small power purchase agreement (SPPA) and feed-in tariffs system for attracting foreign/private investors. Specially, it doesn't have sufficient legal stipulations to obligate EVN to deal renewable energy projects considering clean energy's extra benefits different from conventional power projects. For instance, investors often claim that they would be bankrupt by doing their investment in renewable energy projects should EVN insist purchasing their electricity production at same pricing level of fossil fuel projects. EVN debates that their selling prices are controlled at ceiling level and they are also in heavy loss condition so that they could not buy electricity energy at more expensive cost. It can be understood that this problem is due to insufficiency of national funds and incentive measures like national wide cost sharing system, taxation exemptions, or environmental taxes/charges...etc for promoting geothermal energy usage in Vietnam.

For investors, moreover, they often face many difficulties with administrative procedures for establishment and operation of their business in Vietnam's monopolistic energy market. They are still complicated, changeable and not consistent sometimes while the legal system is insufficient and harmonious, hard manageability for running agreements. Furthermore, local private or

foreign investors often have unfavorable conditions in seeking approval, licensing, and borrowing loan from banks, or taxation exemptions.

To date, deficiency in national policies and legal basic to stimulate the usage of geothermal energy in Vietnam still exists despite energy prices fluctuations occurred recently, and recent increasing concerns of environmental degradation caused by fossil fuels usages. The enforcement of current renewable energy laws is still insufficient and not updated for effective practice in promoting the deployment of geothermal energy technology. Similar to the small hydroelectric, many experts suggested that this kind of major political barrier should be overcome by priority otherwise the geothermal energy technology for producing electricity in Vietnam would be hardly effectively deployed.

Geothermal energy sources are distributed in remote areas

Similar to small hydro energy, most geothermal energy sources are distributed in remote areas with low economic development, poor living and educating conditions (Figure 4). The development of geothermal generation plants thus faces difficulties in investigation, construction, operation and maintenance of the plants (Figure 3). Local authorities are not capable enough to provide human resources of managing, operating and maintaining these. Investors, therefore, would not be willing to invest their capital into these plants and human resources would not be available should Government's encouraging policies and incentive measures are still missing.

Though this barrier would not be ranked as the most dominant barrier but it would have an important impact not only on the deployment of geothermal energy technology but also on industrialization progress in Vietnam. Because implementing geothermal or small hydro energy plants in remote areas would create significant jobs for the society, and promote the process of poverty reduction and modernization of rural.

High electricity production cost of geothermal energy technology

Ranked as least priority major barrier among the five identified major ones (Table 5), but, this specific barrier existed reflects a missing updated information on technological development and its production market. Situation in global power generation industry nowadays has significant differences from several years ago. Increasing fossil fuel prices recently creates more favors for building up the adoption of geothermal generation technology worldwide. Nguyen and Ha-Duong, 2008 discusses even at moderate assumptions of fuel prices in Vietnam, compared to current high prices in year 2008, geothermal energy technology now enters cost-effective yet for producing electricity under long-term integrated resource planning perspective. This perspective implies that should the Vietnamese Government is planning the long-term power sector development with a national cost sharing system, this would be the right moment for them to deploy the widespread adoption of geothermal energy technology for producing electricity in Vietnam.

5.3 Barriers to cleaner coal-fired technologies

The usage of coal for economic development in Asian developing countries has been soaring. The burning of coal for meeting energy demand is expected to increase four-fold in the region by 2030, leading to 13 billion tonnes of CO₂ being emitted into the atmosphere each year (ECO-Asia programme). Many financial institutions and global organizations, hence, have assisted these regional developing countries, including Vietnam to advance policies and best practices for using cleaner coal technologies in recent years.

To meet the expected increasing demand for electricity services over 2010–2030, the Vietnamese Government orients coal-fired technology as the dominant major generation source to expand its electricity generation portfolio. In addition to the country's abundant coal reserve, coal (bitumen) is to be imported for producing electricity as soon as 2015. EVN is also assigned to coordinate with other stakeholders like the Viet Nam Coal-Mineral Industry Group (Vinacomin) to promote the adoption of cleaner and higher energy efficient coal technologies, including coal washing, heat-rate improvements and high energy efficient coal combustion

technologies. Until 2008, there still exist coal-fired plants operating with backward technology and low efficiency (Figure 5). The circulating fluidized bed coal technology (CFB) has been only applied on a trial basis in two coal-fired plants implemented by Vinacomin at Na Duong and Cao Ngan plants. Vinacomin plans to construct additional three coal-fired power plants using similar cleaner coal technologies by 2010 (Electricity of Vietnam, 2008). Nevertheless, the widespread usage of advanced cleaner coal-fired technologies (CCTs) such as IGCC and PFBC are still not clear oriented by the Vietnamese organizations for long-term power sector development. This is because of the existence of many barriers.

Weak level of science and technology, insufficient industrial capability, and difficulty in technology transfer

Table 5 presents ranking results for the major barriers to proliferation of CCTs in Vietnam. As ranked here, the country's weak level of science and technology, and insufficient industrial capability as well as difficulty in technology transfer would be evaluated as the most dominant hurdles. The usage of CCTs such as IGCC technology, which will be the ground for the expansion of carbon capture and storage (CCS), would require high scientific and technological experiences that beyond industrial capability of a developing country like Vietnam. For instance, among countries in the Asian region China has been building and adopting several supercritical and ultra-supercritical coal-fired power plants recently, and there is little experience with implementation and operation of cleaner high efficient coal-combustion systems like IGCC, PFBC. The current development in most these developing economies are focusing on CFB systems only as these allow for using low-grade coal for combustion process (APEC, 2007).

Besides, there are lacking of national policies and insufficient incentive measures such as Clean Development Mechanism (CDM), tax incentives, subsidies and expedited regulatory review, or supporting environmental schemes to aid a transfer of cleaner coal technologies, to finance for clean coal projects, and to support encouraging the growth of R&D and indigenous expertise in Vietnam as well.

High initial investment cost and high technology electricity price

As of today, global cost of installation and operation of advanced cleaner coal technologies (CCTs) for electricity generation are still more expensive than conventional technologies and this basically creates major barrier to the widespread promotion of these advanced technologies in Vietnam. Interviewees judged that coal-based power technology has a long investment cycle, about 40 years or even longer. Investors of advanced coal-based power projects must be confident of high initial capital in long-term operation life for sufficient payback period. This becomes more important especially when it is compared to the lower capital investment but higher efficiency of a natural gas combined cycle gas turbine (CCGT). Beside that, the current electricity pricing scheme in Vietnam is still not effective/incentive enough to make it attractive to investors for laying out their capital resources in advanced low CO₂ emissions coal-fired power business. Therefore, it is, even, very likely that the situation of expensive technology investment costs would be changing with the growing experience and technology innovation, financiers/developers may consider these technologies in Vietnam highly risky, which leads to costly high risk premiums.

Lack of technical know-how and technological development information

USAID, 2007b argued that many Asian developing countries prefer using conventional technology (e.g. sub-critical pulverized coal). The design of high-efficiency pulverized coal such as supercritical or ultra-supercritical, which are already commercially proven and competitive especially when coal prices are high, are not widely used. This is mainly because of the perceptions that they are still costly, unproven and unsuitable for use with local coals. Although CCTs (IGCC and PFBC) are more highly efficient and, hence, much cleaner than conventional coal-based power plants, a full record of commercial operation experiences of these is hardly ever available to date. Besides, Vietnamese industrial organizations and technical business stack-holders seem not be ready yet to endorse these advanced technologies due to lack of exposure to them. The country, therefore, could not be able to have a favored access to this

CCTs option with such a barrier of insufficient technical know-how and technological development information. Over recent years, lots international organizations have worked with EVN and Vinacomin, through specific workshops, to assist them better understanding about CCTs and guide them the access to the sources of information and finance. Since the usage of CCTs such as IGCC is currently limited to non-anthracite coal, interviewed experts recommended that Viet Nam should consider imported bitumen coal, which could be available as soon as 2015 to the wide-scale deployment of cleaner coal technologies (CCTs) in Vietnam.

Scarcity of financial resources

Scarcity of financial resources for expansion of power generating system has been blamed as one of the main reasons resulting in electricity shortages over several years. Meanwhile, to ensure social economic development electricity prices must be kept at moderately low enough to enable Vietnamese products competitive in the world market. These two goals are hardly going abreast to the achievement at the same time, especially whenever the monopoly driven power generation industry controlled by EVN still exists. Thus, EVN monopolist scheme and its current average electricity pricing systems could not encourage investors to lay out their capital to experiment on such a large scale investment with highly risks. Moreover, the existing environmental legislation is not sufficient to stimulate demand for CCTs and the country does not have an emission reduction obligation except for the locally imposed emission standards, the deployment of expensive CCTs could hardly financially justified and viable at this stage. The investors will continue to deploy cheaper conventional coal technologies, which are cheaper for the coming years.

Inadequate current electricity pricing system

Actually, this major barrier has relations of identity with the above standing major barrier of financial source scarcity. EVN as an electricity singer buyer and de facto price-setter, uses its prerogative to control the allocation of electricity energy productions or services. The current electricity pricing scheme does not enable them to look at promoting CCTs over the cheaper

conventional coal-based power plants. As a result, this electricity market failure eliminates the competitive prospect of CCTs' energy production and remains it out of the expansion plan for electricity generation system. The proliferation of this cleaner coal option for electricity generation in Vietnam seems to be far away should the energy market failure still endures.

Transparency, the existence of identified major barriers is the most challenging hurdle for the wide-scale deployment of cleaner and energy efficient technologies in the power sector. The next section presents essential policies and measures (PAMs) that were identified and evaluated as desirable solutions to promote the widespread adoption of RETs and CCTs in Vietnam.

6. Survey 2: an assessment of appropriate policies and measures

6.1 Method of identification and assessment of policies and measures

Firstly, a review of literatures and existing policies, discussions with experts and policy makers in the field are performed to establish criteria for evaluation of policies and measures, and to shortlist a desirable set of identified policies and measures that could potentially remove the identified barriers.

Secondly, the selected evaluation criteria including: (i) anticipated effectiveness, (ii) economic consideration (cost of policy implementation), (iii) macro-economic consideration, (iv) political acceptability, (v) administration feasibility are evaluated (score weighted) for their priority preferences by the AHP based interviewed respondents' judgments.

Thirdly, each particular shortlisted policy and measure is evaluated and judged for each technology under various specified criteria by individual involved key actor. The subjective judgments for either the criteria or the policies and measures given by interviewed experts/respondents are qualitative into scores, for instance: "poor" = 1, "good" = 2, "very good" = 3 and "excellent" = 4. Intermediate scores between the two adjacent judgments, when compromise needed are: 1.5, 2.5, and 3.5.

Finally, the total given weighted average scores for each identified policy and measure of each technology are aggregated by a simple calculation of criteria/policy matrix. Desirable policies and measures are those that garnered more than 50% in total weighted average score. Recommendations were made based on determination of these desirable policies and measures.

6.2 Mathematical expression of the criteria/policy matrix approach

The mathematical expression of this calculating method is given as below.

$$S^{j,k} = \sum_{i=1}^n \frac{1}{n} \times a_i^{j,k} \quad (12)$$

$$p^j = \sum_k w_k \times S^{j,k} \quad (13)$$

where: i is the expert interviewed; j is the policy alternative identified by the interviewed experts; k is the specified criterion for evaluation of policy alternatives; n is the number of the experts interviewed; a is the evaluated score given to the policy alternative by the interviewed experts; $S^{j,k}$ is the average evaluated score given to the policy alternative; w_k is the weight of selected policy evaluation criterion k ranked by AHP based on experts' opinions; p is the total aggregated weighted average score given to each considered policy alternative.

6.3 Results of survey 2

Overall, all respondents judged that the most desirable PAMs to advance the widespread usage of RETs and CCTs for electricity generation in Vietnam are quite common and similar. They, include improving R&D and enhancing investment policy for power sector development, garnered highly significant total weighted average scores (approximate 65% to 74%) compared to the other PAMs. Table 6 and Table 7 present ranking results for evaluation criteria and for selected PAMs to promote the further development of RETs and CCTs respectively.

Improving R&D and establishing joint-ventures foreign companies

The study finds that improving local R&D and establishing joint-ventures with foreign companies would be evaluated as the most significantly effective and desirable PAM for widen

the deployment of RETs in Vietnam and while it would be judged as the most second significant PAM for CCTs under the same evaluation criteria described in Table 6.

Evaluating result indicates that this PAM would be most favored by respondents with a highest total weighted average score beyond 74% in the case of geothermal energy. For more specific, interviewees judged that this PAM could help the country to possess reliable data on national renewables and financial resources and for making development plans. This, moreover, could potentially mitigate the difficulties of information and awareness of technical know-how and technological development stages for RETs and CCTs innovation and aid building scientific/industrial capacities and human resources to enhance the country's capability. To establish joint-ventures with involved foreign companies from developed countries with experienced renewable industries would be needed to solve the barrier of lacking domestic renewable electricity technology/equipment and services, and to facilitate the process of renewable technology transfer. Similar to CCTs, establishing joint-ventures with cleaner coal technology experienced entities from developed countries would assist the growth of indigenous expertise and technical business/services with cleaner coal technologies and building necessary relevant infrastructure and regulatory framework. Specially, this establishing foundation is the best approach to the sources of information and finance. Moreover, experienced practices suggest that there are various codes and standards systems being in use in industry and energy sectors such as American, Germany, Japanese, Russian that causes many problems for executing and managing the technology transfer. Therefore, establishing joint ventures would aid correction of codes and standards for Vietnam's industry and energy sectors.

Needless to say, this PAM could assist the country to seek for independency in development of alternative generation technologies including conventional and renewable energies as well as in usage of the nation's primary energy resources for long-term economic development. To make this practicable to renewables, the Vietnamese Government is suggested to set a national macroscopic goal for developing renewables in long term, at least. Unless this is done, in all

likelihood the country's great potential of renewables: small hydro and geothermal continued to be forgotten and the wider adoption of renewables technology can be little grown.

For CCTs, the widespread dissemination of these cleaner energy efficiency technologies would only be promoted for electricity generation in Vietnam if this kind of PAM implemented together with necessary supporting environmental legislation.

Enhancing investment policy and legislation for power sector development

The current policy and regulatory framework for usage of renewables for producing electricity in Vietnam is still inadequate and irrational. There would be a necessary demand to rebuild its adequateness and performance. The study results suggest that the existing policy and regulatory framework must be concretely re-built then soon entered into force by the Government in order to provide essential drivers to accelerate wider deployment of RETs. Table 7 shows that enhance of existing policy and legislation for the power sector would be considered as the most second desirable PAM to widen the adoption of RETs with over 65% of total weighted average scores given by respondents' judgments. More detailed suggestions by interviewed experts the following legal fundamental should be intensified as much as possible:

- + Renewables (including small hydro and geothermal) electricity should be developed whenever they are least cost and economically viable. To build up clear regulations for grid connected power purchasing agreement, administrative procedures from central to local in exploiting, and managing renewables resources.
- + Set up a national wide cost sharing system, national funds and other incentives for promoting renewables development. And renewables electricity should be supplied on a commercial basis and its cleaner energy's extra benefits should be taken into account.
- + Remove the monopoly privilege of EVN in electric power business and allow private sectors, foreign entities or NGOs, cooperatives to invest for grid connected renewables projects. Specially, equality/fair competition in power business should be regulated.

Communities, individual consumers or investors could actively contribute to and participate in renewables development plan.

In contrast, the finding in Table 7 indicates enhancing investment policy and legislation would be the most critical PAM (with highly total weighted average score of 74%) for making CCTs a viable option in a developing country like Vietnam. To date, Vietnam has relied mainly on emission limits to control pollution from the existing and new coal-fired power plants. Due to practicality and cost reasons, it seems hardly to adopt cleaner coal technologies (CCTs) in Vietnam should new regulatory features building on the existing frameworks for emissions and pollution control come out to encourage a switch to cleaner option. This could be elaborated through thermal efficiency standards, technology-based standards, taxes, subsidies, and tradable emissions permissions etc.

Implementation of financial aids and other incentive forms including increased electricity price

Results in Table 7 explicit indicates that implementation of financial aids or other incentive measures including increased electricity price would identified as one of the most significantly desirable PAM to promote the electricity generation from CCTs and RETs, especially small hydro technology in the Vietnamese power sector.

The current economics of CCTs is still highly beyond the average electricity pricing in Vietnam and coupled with inadequate regulatory drivers and financial incentives that hardly create competitive conditions for the widespread adoption of CCTs in the power sector. Therefore, investments may be still slow to come unless the increased price of electricity or other incentive forms make them competitive. To do this, the Government should eradicate gradually the subsidized financial mechanism so that the electricity price could reflect the true values of different costs of electricity production or the Government and other stakeholders need to take some incentive measures such as subsidies, tax exemptions, and tradable permissions through CDM projects as economic initiatives.

Though the dimension of a typical small hydro plant is not large but its development requires large capital (investment rate on average for each is of several dozen up to several hundred billion VND). The problem of insufficient capital mainly leads to delayed or suspended construction of lots of projects in Vietnam in recent years. Therefore, more financial aids and incentives needed are recognized by interviewed experts as an important measure to overcome the major barrier to the wider penetration of small hydro stations. They mostly believed that increasing the access to financial incentives of different forms (subsidy, tax exemption, low interest loan, long-term credit, specific funds for grid connected projects in rural/mountainous areas etc.) could potentially improve financial viability of businesses and affordability of services for renewable energy projects, especially in case of small hydro. In addition, mobilization of capital from a variety of sources, establishment of banking network system sponsoring credit loans for hydropower projects, are also identified as attractive policies to promote the adoption of small hydro energy technology. Moreover, lots of specialists debated the Government to reform the regulatory framework of a reasonable price to attract more capital investment in renewables business. The availability of resources, however, is limited to provide enough financial incentives in Vietnam. The Government is, hence, proposed to develop indigenous renewables (small hydro and geothermal) projects financing through Clean Development Mechanism (CDM) as a desirable measure to generate funds.

These days, a recent report of MOIT states that the Government will establish a specific funding program for renewables development. This program sets up a channel for capital mobilization from donors to ensure long term sustainable projects of renewables in rural and mountainous areas. For instance, this budget will firstly finance 4 pilot projects in two provinces of Ha Giang and Quang Nam then will spread to other provinces.

Implementing environmental taxation including carbon tax

More specific to geothermal and cleaner coal-fired technologies (CCTs), the study results also suggest that implementing environmental taxation including carbon tax would be identified as a

significantly desirable policy measure to remove the major barriers of lack of promotion policies and development mechanism and high production cost for geothermal technology as well as to help overcome the critical major hurdles of high investment and production cost for CCTs. However, application of fiscal instruments like environmental taxes for promoting the greater penetration of geothermal and cleaner coal-fired generation technologies is still a relatively new concept in Vietnam. The elaboration and implementation of environmental taxes, hence, would raise a number of complexities. Therefore, it is necessary to require more specific consideration of the economic, social and legal circumstances under which the tax is applied. Although the study has no quantitative assessment accurately the impact of environmental tax usage to the economy but the study's analysis allows looking at the impact and evaluating this impact through the evaluation criteria of anticipated effectiveness, economic and macro economic consideration. The implementation of this environmental policy measure remains difficulties in practice, so the total weighted average scores computed based interviewed experts' opinions and judgments would be relative lower than those of the above discussed policy measures for both geothermal and cleaner coal-fired generation technologies. However, this policy alternative, with total weighted average score above 50% given, would be enough significantly evaluated as a feasible measure for advancing the deployment of geothermal and cleaner coal-fired technologies for generating electricity in Vietnam. As resulted in Table 7, implementing environmental tax would be ranked as the third desirable option for geothermal technology but the fourth desirable option for CCTs.

Priority development of local and remote area economy

Renewables development ought to be derived from the triple development objectives of economic, society and environment. In Vietnam, most abundant renewables resources are mainly distributed in remote/mountainous areas with low economic development and living condition. By executing priority development of the local and remote economy, this policy measure would assist poverty reduction and increase living standard in remote and mountainous areas as well as

facilitate the exploitation of endowed abundant potential of renewables resources in these remote.

Results through an analysis of individual experts suggest that priority development of local and remote area economy would be identified as a direct contribution solution to attract more capital investment from investors for remote renewables projects and would also help to eliminate the major of shortage of local human resources for managing and operating these renewables plants. Nevertheless, on the ground of the study's comparative framework based opinions and judgments from interviewed experts, this identified policy measure would be less effective and would not be considered enough significant as a whole of the desirable policies and measures to promote the widespread adoption of RETs in Vietnam. The study results in Table 7 points out this policy alternative garnered the total weighted average score of less than 50% in both cases of small hydro and geothermal technologies.

Establishing policy consulting, technical-support, training centers

Likewise, establishing policy consulting, technical-support, training centers would be identified as a practical measure to remove an individual major barrier of insufficient information and specialists/human resources for the wide-scale deployment of both renewables and cleaner coal-fired technologies. But, this policy option would not be significantly evaluated as one of the most desirable policies and measures to promote the wider adoption of both RETs and CCTs because this policy alternative could not garner more than 50% of total weighted average score computed by the study's comparative framework as presented in Table 7.

7. Robustness analysis

This section carries out a sensitivity analysis of the robustness of ranking results for the major barriers to the adoption of CEETs based interviewed experts' opinions and judgments without priority of expert groups weighted as presented in Table 3, i.e. the importance of involved expert groups were equally treated throughout the evaluation process. Next, it discusses the robustness

of the evaluating course for policies and measures to overcome the identified major barriers and deliberate on the extent of the selected cleaner and energy efficient technologies.

As a result of sensitivity analysis, either the importance among experts groups were unequally priority weighted or equally treated the ranking outputs of the major barriers to the wide-scale adoption of CEETs would not be much different with overall inconsistency level of less than 10%, except for the case of geothermal energy technology. Result suggests that when the importance among experts groups were equally treated the major barrier of weak level of scientific, technological and industrial capability, in stead of the lack of information and awareness would be ranked as the most dominator to the proliferation of geothermal energy technology in Vietnam. To the remaining technologies, there would be not much changed in weighted scores among major barriers and would remain identical in ranking orders when experts' priority changed. This sensitivity finding implies that the significance of ranking barriers to CEETs seems to be achieved based the involved experts' high concurrence.

To evaluate alternative policies, it would theoretically require assessing the benefits and impacts that each alternative policy could produce against different identified criteria on economical, political and social considerations using suitable quantitative and qualitative tools. In this study, it was hardly able to quantify or fully evaluate the policy implementing costs and macro-economic impacts. According to IPCC (1996), cost-evaluation might not be completed because cost depends on the specific policy options promoted and the means of implementation, and evaluation of policies cost has not been documented by developing countries, and is hardly available in the literatures. Moreover, macroeconomic assessment is often time-consuming and requires extensive data. In many developing countries macroeconomic models and data on essential macroeconomic variables are hardly obtainable. With this limitation, the study formulated an appropriate qualitative evaluation approach for identifying the appropriate policies and measures to promote the proliferation of CEETs in Vietnam based interviewed experts' judgments and opinions. Nevertheless, the study also attempted to take into account whatever

minimal available data on indicative values of policy costs implemented and other relevance during discussions/interviews with experts and evaluation course.

Among cleaner and high energy efficiency solutions, energy savings and energy efficiency programs are most priority considered by policy-makers in connecting global policies on climate change and security of energy supply. Needless to argue that the adoption of energy efficiency technologies based energy savings, energy efficiency and conservations programs in a developing country like Vietnam could play an even more important role in executing sustainable socio-economic development. As estimated, the potential of demand-side energy conservation and energy efficiency in Vietnam is very high and would bring in high economic effectiveness, reduction of investment contribution in reduction of green house gases (GHG) emissions (PREGA, 2005; USAID, 2007a; Institute of Energy, 2008b). More specifically, a result of the program “Demand-side management assessment for Vietnam” commenced by EVN under World Bank’s assistance since 1997 indicates that DSM could play an important role in stabilizing the growth of electricity demand in Vietnam and offer opportunities for cost savings in a number of sectors and end-use applications. This program started a two or three-phase itinerary for implementing DSM program in households sector, avoiding an estimated 770 MW of expansion generation capacity and saving over 3.6 GWh per annum by the year 2010 (Institute of Energy, 2004). Nguyen and Ha-Duong, 2008 argues that improving end use energy efficiency on the Vietnam’s electric power sector is a no-regret option and a free lunch reduction in CO₂ emissions could be significantly obtained. It estimates that replacing incandescent and fluorescent lamps by compact fluorescent and high efficient ones in the sectors of household and commerce, the country could significantly save capital investment for expanding generation system and cut down the sector’s cumulative CO₂ emissions by 14.1% over 3.6 Gt of CO₂ emissions would be emitted into the atmosphere over 2010-2030 and could mitigate 143 kt of SO₂ and 323 kt of NO_x emissions over the same period. However, similar to the adoption of supply-side energy efficiency the deployment of demand-side energy efficiency has also been

confronting many barriers in practice. Result of a specific study (PREGA, 2005) indicates plenty of subjective and objective barriers in implementing energy conservation, and efficiency programs in Vietnam. They include institution and policy, finance, human resource and awareness/information barriers. Within a limited timeframe and a pre-specified research domain, this paper only focused on the analysis of major barriers to the adoption of cleaner and energy efficiency technology for the supply side. Further assessment and more detailed analysis on major barriers to deployment of demand-side energy efficiency technologies in Vietnam should be necessarily carried out in another specific study.

8. Summary and conclusion

This paper presents the results of a study involved in identifying and ranking the major barriers to the wide-scale deployment of cleaner and energy efficient technologies and strategies to promote these technologies for electricity generation in Vietnam.

For renewables technologies (RETs), the key finding indicates that financial and infrastructure hurdles, institutional constraints, and deficiencies in Government policy as the primary barriers to effective penetration of small hydro technology while the major barriers of information and technical know-how, R&D and industrial capability, and weak policy framework would be predominant barriers against the proliferation of geothermal technology in the power sector.

For cleaner coal technologies (CCTs), weak industrial capability and lack of technical know-how are identified as the country specific dominant barriers slowing down the adoption of these technologies in Vietnam. Moreover, the study result indicates that economic barrier and scarcity of financial resources and inadequate current electricity tariff structure are identified as the roadblock of entering these advanced technologies into the electricity generation industry.

A key finding is that although institutional and policy barriers would not be ranked as the highest dominant barriers to the widespread adoption of CEETs but they are both considered as the “must be overcome” barriers by interviewed respondents.

Improving local R&D, promoting joint-ventures foreign companies, and reforming investment policy and legislation for the power sector would be identified as the most significantly effective and desirable policies and measures for widen the deployment of CEETs in Vietnam. More specific for RETs, the country should set up as a national goal and renewable energy Law should be soon established and entered into force. The Law should, at least, include setting up national wide cost sharing system, codes and standards for renewable energy development, regulations for grid connected power purchasing agreement, administrative procedures from central to local in exploiting, and managing renewables resources, encouragement of joint venture foreign companies for enhancing human capacity and expertise, science, technology transfer...etc.

Besides, development of indigenous RETs projects financing through CDM and public private partnerships would be identified as some of the desirable policies to create funds and to remove high capital cost of RETs. Tax incentives, soft loans and financing the CCTs projects through CDM scheme would be an appropriate policy measure to remove the barrier of high initial cost of CCTs. Instruments like carbon/energy tax would be suggested to promote building up of CCTs in the power sector. Establishing information and consulting/training centers on CEETs and priority development of remote areas for RETs were also identified by interviewed experts but these would not be evaluated as most significant policies and measures under this study's analysis approach.

Conclusively, most the appropriate policies and measures identified based interviewed experts' opinions and judgments explicitly draw out the need for policy intervention by the Government and suggest the Government should act as the key market enabler for proliferation of cleaner and energy efficient technologies otherwise the rich potential of renewables including small hydro and geothermal energy continued not to be waken up and little can be grown in the deployment of cleaner energy efficient coal-fired generation technologies in Vietnam.

Tables

Table 1: Potential of renewable energy sources for electricity generation in Vietnam: assessment until the end of 2007.

Energy resources	Economical potential	Current development until end of 2007	Future development planned up to 2025 by Vietnamese agencies	Remarks
Large hydro (>30 MW)	18-20 GW	4793 MW	16.6 GW by 2020	(1) This potential includes small hydro and back-up diesel capacity; (2) This economical potential is estimated for electricity generation and heating purposes; (3) This economical potential of wind energy is estimated with different feed-in tariffs varying from 5 to 8 \$cent/kWh; (4) In the southern and central areas, solar radiation levels range from 4 to 5.9 kWh/m ² /day uniformly distributed throughout the year. The solar energy in the north estimated to vary from 2.4 to 5.6 kWh/m ² /day
Small hydro (<30 MW)	2-4 GW	611 MW (1)	2.5-3.2 GW	
Mini hydro (<1 MW)	100 MW			
Hydro pump storage	10.2 GW	Negligible	10.2 GW	
Geothermal	1.4 GW (2)	Negligible	300-400 MW by 2020	
Wind energy	120.5 GW (3)	Negligible	500 MW	
Solar energy	(4)	Negligible	2-3 MW	
Biomass (rice husk, paddy straw+ bagasse)	1000 MW	158 MW		
Wood residue	100 MW	Negligible	500 MW	
Municipal waste	230 MW	Negligible	100 MW	

Sources: Nguyen and Ha-Duong, 2009; Institute of Energy, 2008a.

Table 2: Pair-wise comparison scale for the analytical hierarchy process preference

Verbal judgment of ranking	Numerical rating	Explanation
Equal important	1	Two activities contribute equally to the objective.
Moderate importance of one over the other	3	Experience and judgment slightly favor one activity over another.
Essential or strong importance.	5	Experience and judgment strongly favor on activity over another.
Very strong importance.	7	An activity is strongly favored and its dominance demonstrated in practice.
Extreme importance.	9	The evidence favoring one activity over another is of the highest possible order of affirmation.
Intermediate values between the two adjacent judgments	2,4,6,8	When compromise is needed.

Source: L. Saaty (2006)

Table 3: Numbers of respondents and priority weight of the 6 interviewed expert groups

Priority ranked	Key Actor groups	Numbers of respondents	Priority weight calculated by AHP
1	Energy experts	10	0.213
2	Policy makers	7	0.199
3	Environment experts	6	0.196
4	Project developers and power facilities owners	6	0.155
5	Equipment manufactures and suppliers	4	0.131
6	Users of electricity	4	0.106
Total		<i>n</i> =37	1

Table 4: Priorities of evaluation criteria for ranking barriers: calculated by AHP based experts' opinions

Criteria for ranking barriers	Weighted by AHP	Definition of criteria (*)
Monetary cost to remove the barriers	0.307	Cost of removing barriers varies with type and nature of barriers. Cost in form of subsidy can be used to remove barriers related to high initial investment. Although, it is difficult to assess the exact amount of cost involved in removing the barrier, one can give the qualitative judgment about the cost.
Impact on adoption of the technology	0.209	Different barriers have different level of impact on the adoption of efficient options. Removing a particular barrier could result in a higher level of introduction of efficient options than some other barriers. This feature implicitly recognizes the importance of barriers. Barrier that is easy to overcome may have less impact in terms of adoption of options. On the other hand, barrier that is difficult to remove may have larger impact in adoption of options.
Life of the barriers	0.221	Each barrier has its own life, i.e., the time it takes to cease. Without any external intervention, some barriers tend to last long compared to other barriers. This means that barriers can be assessed from its life. Normally, barriers with shorter life would be preferable to longer ones.
Level of efforts to create awareness	0.138	Awareness about the efficient technology plays a major role in overcoming the barrier. Once the user is aware of the existence of technology and nature of the technology, then adopting such technology becomes relatively easy. Therefore, it is very important to create awareness among the users. However, the level of effort required to create awareness depends on the type of barriers. Some barriers require less effort to create awareness, while other requires high effort.
Level of political efforts to remove the barriers	0.125	Political and bureaucratic effort could play major role in removing the barriers. Such effort may be in form of lobbying by politician, bureaucratic initiatives, and clear instruction of policy makers. However, the barrier is complexity in nature. Barriers could be intertwined with other social and political aspects. The barrier may be linked to different policies of the government. The complex the barrier is the more difficult to overcome it. Therefore, the level of political and bureaucratic effort required to remove the barriers depends upon type of barrier considered.

(*) Source: IPCC (1996), Shrestha and Abeygunawardana (2003).

Table 5: Selected technologies: barriers weights calculated by AHP based experts' opinions

Barriers of selected technologies	Actor groups unequally prioritized	
	Weight	Ranking
Small hydro		
Lack of capital investment and scarcity of financial resources	0.214	<u>1</u>
Low capability of technological development and lack of domestic equipment suppliers/services	0.210	<u>2</u>
Weak Government policy and regulatory frameworks for clean energy development	0.205	<u>3</u>
Multiplicity authorities and insufficient local capability to develop and operate the networks	0.205	<u>4</u>
Lack of information on national energy resources potential	0.166	<u>5</u>
Geothermal		
Lack of information and awareness about technical know-how, technological development and national resource potential	0.213	<u>1</u>
Weak level of scientific, technological and industrial capability	0.204	<u>2</u>
Insufficiency of incentive measures and promotion policies, and regulatory framework	0.200	<u>3</u>
Geothermal energy sources are distributed in remote areas	0.198	<u>4</u>
High electricity production cost of geothermal technology	0.185	<u>5</u>
CCTs		
Weak level of science and technology, insufficient industrial capability, and difficulty in technology transfer	0.235	<u>1</u>
High initial investment cost and high production price	0.221	<u>2</u>
Lack of technical know-how and technological development information	0.197	<u>3</u>
Scarcity of financial resources	0.174	<u>4</u>
Inadequate current electricity pricing system	0.173	<u>5</u>

Table 6: Establishing priorities of criteria for selecting and evaluating alternative PAMs by AHP based a questionnaire interview

Criteria for evaluation of alternative policies	Weighted by AHP	The foundations of selecting criteria (*)
Anticipated effectiveness	0.363	Different policies have different levels of effectiveness. Implementing a particular policy could result in a higher level of introduction of efficient options than some others. Thus, how well does the policy remove barriers, does the policy's effectiveness erode over time, and does the policy create continual incentives to wider adoption of CEETs should be considered as a criterion for evaluating alternative policies.
Policy implementing cost	0.214	One of the main criteria that may guide the policy analysis is the cost including administrative cost, cost of financial incentives, cost of advertising the program, etc. Costs may also depend on specific policy options promoted and the means of implementation.
Macro economic impacts	0.169	The introduction of policies and measures will have a series of impacts to society. Hence indirect costs of these impacts should also be anticipated in addition to direct implementing costs. To do this, impacts should first be identified per sector of the society. For instance, impacts to macro-economic factors like GDP, jobs created/lost, implications for long-term development, etc.
Political acceptability	0.131	In most developing countries, it is difficult to get political support for most emissions reduction policies because policy makers are more likely to have their priority on economic and social needs rather than giving attention to environmental issues. The passing of emissions mitigation policies through political and bureaucratic process can be a challenge for developing countries. Hence, political acceptability should be one of the evaluation criteria.
Administrative feasibility	0.123	Implementation of policies to remove barrier would require a good organizational set-up with appropriate infrastructure, manpower and technical support. More often, this is another constraint besetting developing countries. Therefore, administrative feasibility should be considered as one of the evaluation criteria.

(*) Source: IPCC (1996), Shrestha and Abeygunawardana (2003).

Table 7: Ranking results of PAMs for different CEETs using criteria/policy alternatives matrix evaluation approach based interviewed experts' opinions and judgments

Small hydro energy technology						
Criteria	Weighted scores of criteria	Weighted scores for policies and measures				
		PM1	PM2	PM3	PM4	PM5
Anticipated effectiveness	0.363	1.452	0.363	0.726	0.363	1.452
Economic consideration	0.214	0.214	0.642	0.428	0.856	0.214
Macro-economic consideration	0.169	0.338	0.338	0.676	0.169	0.676
Political acceptability	0.131	0.131	0.393	0.524	0.131	0.262
Administration feasibility	0.123	0.369	0.123	0.246	0.431	0.123
Total weighted average score	1	2.504	1.859	2.600	1.950	2.727
Weighted average score (%)	-	62.6	46.5	65.0	48.7	68.2
Ranking results	-	<u>3</u>	<u>5</u>	<u>2</u>	<u>4</u>	<u>1</u>
Note: [PM1]: Financial aids and other forms of financial incentives; [PM2]: Priority development of local and remote area economy; [PM3]: Enhancing investment policy and legislation for power sector development; [PM4]: Establishing policy consulting, technical-support, training centers; [PM5]: Improving R & D, establishing joint-ventures companies.						
Geothermal energy technology						
Anticipated effectiveness	0.363	0.726	1.089	0.363	0.363	1.452
Economic consideration	0.214	0.535	0.428	0.428	0.214	0.214
Macro-economic consideration	0.169	0.169	0.507	0.169	0.338	0.676
Political acceptability	0.131	0.262	0.524	0.131	0.262	0.393
Administration feasibility	0.123	0.369	0.246	0.369	0.123	0.246
Total weighted average score	1	2.061	2.794	1.46	1.3	2.981
Weighted average score (%)	-	51.5	69.9	36.5	32.5	74.5
Ranking results	-	<u>3</u>	<u>2</u>	<u>4</u>	<u>5</u>	<u>1</u>
Note: [PM1]: Implementing carbon tax; [PM2]: Enhancing investment policy and legislation for power sector development; [PM3]: Establishing policy consulting, technical-support, training centers; [PM4]: Priority development of local and remote area economy; [PM5]: Improving R & D and establishing joint-ventures.						
Cleaner coal technologies (CCTs)						
Anticipated effectiveness	0.363	1.452	0.726	1.089	0.363	0.726
Economic consideration	0.214	0.214	0.856	0.214	0.428	0.642
Macro-economic consideration	0.169	0.507	0.169	0.676	0.338	0.169
Political acceptability	0.131	0.524	0.262	0.524	0.262	0.131
Administration feasibility	0.123	0.246	0.492	0.123	0.246	0.492
Total weighted average score	1	2.943	2.505	2.626	1.637	2.16
Weighted average score (%)	-	73.6	62.6	65.7	40.9	54.0
Ranking results	-	<u>1</u>	<u>3</u>	<u>2</u>	<u>5</u>	<u>4</u>
Note: [PM1]: Enhancing investment policy and legislation for power sector development; [PM2]: Financial incentives including increased electricity price; [PM3]: Improving R & D and establishing joint-ventures; [PM4]: Establishing policy consulting, technical-support, training centers; [PM5]: Implementing of environmental taxation.						

Figures

Figure 1: Vietnam has ample resources of small hydro potential for generating electricity.
Source of illustrative photos: International Small-Hydro Atlas, 2009 and RCEE, 2009.



Figure 2: Lots of mini hydropower stations are self-invested and managed inefficiently by individual households with old and backward technologies.
Source of illustrative photos: RCEE, 2009 and RR Energy, 2009.



Figure 3: Most of renewable resources (small hydro and geothermal) are located in remote areas that cause difficulties in investigation, construction, and operation of the projects.
Source of illustrative photos: RCEE, 2009 and Daylife photo, 2009.



Figure 4: Vietnam is endowed with geothermal energy potential, mainly located in remote areas but this has been unexploited yet for generating electricity.
Source of illustrative photos: GENI, 2009 and VFEJ, 2009.

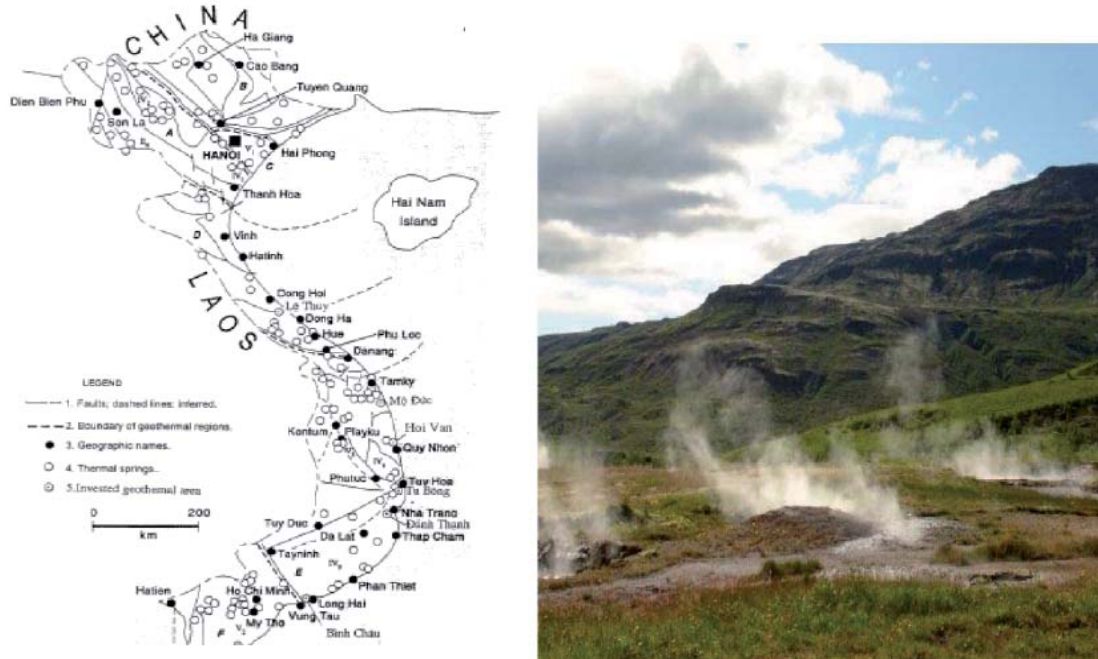


Figure 5: Ninh Binh conventional coal-fired power plant was constructed over 20 years ago with backward technology and it has been under operation.
Source of illustrative photos: Daylife photo, 2009.



Acknowledgements

This research work has been implemented under a research grant for a Ph.D. program offered by Centre National de la Recherche Scientifique (CNRS) in France. The research method was developed by Energy Program of Asian Institute of Technology, Bangkok, Thailand under the framework of the Asian regional Research Program on Energy Environment and Climate phase III (ARRPEEC-III) funded by SIDA. The survey based a questionnaire interview, relevant data,

and pre-analysis were carried out and provided by the Institute of Energy of Vietnam. The major development and analysis jobs to reach up the research outreach were conducted by the Centre International de Recherche sur l'Environnement et le Développement (CIRED/CNRS). Any remaining errors and opinions are our own.

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