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Barriers to the adoption of renewable and energy-efficient technologies in the Vietnamese power sector

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Abstract:

This paper examines the major barriers to the deployment of geothermal, small hydro and advanced coal power generation technologies in Vietnam. It ranks their severity by applying the analytical hierarchy process to data from a survey of 37 domestic experts and stakeholders. Key barriers to a wider penetration of small hydro generation technologies are insufficient capital, a lack of domestic suppliers and unsatisfactory government policies. Barriers to geothermal power are related to information and awareness problems, a lack of R&D and industrial capability, a weak policy framework and the remoteness of geothermal sites. For advanced coal power technologies, the barriers are weak industrial capability, high cost and a lack of technical knowledge. The experts consulted in this study view changes in government actions as the key to overcoming the abovementioned barriers. They recommend investing more in R&D activities, improving R&D capacity through joint-venture schemes and reforming investment policy/legislation for the electric power industry as the most appropriate solutions.

Keywords: *analytical hierarchy process; renewables; energy efficient technologies.*

Résumé :

Dans cette étude on examine pour le Vietnam les principales barrières au déploiement des technologies de la géothermie, de la petite hydraulique et de l'électrogénération avancée à partir du charbon. On les ordonne selon leur sévérité en appliquant la méthode AHP (Analytical Hiérarchy Process) aux données issues de l'étude de 37 experts et parties prenantes du pays. Les barrières clés à une pénétration étendue de la petite hydraulique sont l'insuffisance de capital, le manque d'offre domestique et des politiques gouvernementales insatisfaisantes. Les barrières pour la géothermie relèvent de problèmes d'information et de prise de conscience, du manque de capacité industrielle et de R&D, de la faiblesse de la politique d'encadrement, et de l'éloignement des sites géothermiques. Pour les technologies avancées du charbon, les barrières sont la faible capacité industrielle, le coût élevé et le manque de connaissance technique. Les experts consultés pour cette étude considèrent que des changements dans les actions gouvernementales sont la clé pour surmonter les barrières déjà mentionnées. Ils recommandent d'investir davantage dans les activités de R&D, de renforcer la capacité de R&D via des schémas de joint-ventures et en réformant la politique/législation de l'investissement dans l'industrie de la production d'électricité comme étant les solutions les plus appropriées.

Mots-clés : *analytical hierarchy process, énergies renouvelables, technologies d'efficacité énergétique.*

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1. Introduction

There are many clean and energy-efficient technologies available on the market that can contribute to sustainable development and energy security in developing economies. In practice, however, these technologies are rarely used. Carriers clearly exist that prevent energy-efficient technologies from being more widely utilized. Meyers (1998) and UNFCCC (1998) outline the following typical types of barriers:

i. *Institutional:* lack of legal and regulatory frameworks, limited institutional capacity and excessive bureaucratic procedures;

ii. *Political:* political instability, government intervention 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:* economic instability, inflation, poor macroeconomic conditions and disturbed and/or non-transparent markets;

v. *Information:* lack of technical and financial information as well as lack of a demonstrated track record;

vi. *Financial:* lack of investment capital and financing instruments;

vii. *Cultural:* particular consumer preferences and social biases; and

viii. *General:* insufficient intellectual property protection and unclear arbitration procedures.

While a number of publications examine the barriers to adoption of energy-efficient technologies in various developing countries (Parikh et al., 1997; Reddy and Shrestha, 1998; Khanna and Zilberman., 1999; Wijayatunga et al., 2006; Luken and Rompaey, 2008; Mitchell, 2008; Kavouridisa and Koukouzasb, 2008; Wang and Nakata, 2009; Mirza et al., 2009), none of this research is specific to Vietnam. This paper adds to the existing literature by using a systematic approach to identify and rank the major barriers to a wider adoption of cleaner, more efficient technologies in Vietnam's power sector.

The technologies under consideration in this paper are small hydro and geothermal energy generation technologies (collectively called RETs hereafter) and cleaner coal generation technologies, including pressurized fluidized-bed combustion (PFBC) and integrated gasification combined cycle (IGCC) coal-fired technologies (hereafter collectively called CCTs).

The question of how to promote cleaner energy generation is receiving much attention from national experts and policy makers in Vietnam. Currently, the power sector in Vietnam is facing both high demand for growth and increased concerns about air pollution, with the added problems of limited capital and outdated and inefficient generation plants.

In 2009, recently installed coal-fired plants using the conventional pulverized coal technology had a thermal efficiency of approximately 41%, and those using circulating fluidized bed technology had a thermal efficiency of around 36% (but were able to burn low-grade coal). Currently, Vietnam has a few modern natural gas-fired power plants, especially in the southern part of the country. However, most existing thermal power plants use old technologies (see Figure 1) and are relatively inefficient, in the 28%-32% range. This inefficiency leads to a relatively high consumption rate, about 650 g-700 g of standard coal/kWh.

Figure 1: *The Ninh Binh conventional coal-fired power plant was constructed over 20 years ago and continues to use outdated technology. Source: Daylife photo, 2009.*

To meet the increasing demand for electricity services expected in 2010−2030, Vietnam can rely largely on domestic coal reserves, which were estimated at 3.8 million tons as of January 2002 and are 85% anthracite coal (heat value ranges between 5200 kcal/kg and 5700 kcal/kg). Over the period of 2002−2020, the qualified coal yield is expected to increase from 13.8 million tons to 30 million tons per year, and it could reach 40 million tons per year in 2030. To exploit this resource, an intense generation capacity expansion plan based on coal-fired generation is already underway (Institute of Energy, 2006, 2007). So far, all coal-fired generating plants that have already been committed to and those planned in the years leading up to 2015 are based on conventional pulverized and circulating fluidized bed technologies. Advanced and cleaner coal-fired technologies such as IGCC and PFBC are not yet included in the long-term generation capacity expansion development master plan. If barriers to the adoption of these technologies can be overcome, overall efficiency will be significantly increased.

Vietnam has a large supply of coal, but it is also endowed with a variety of renewable energy resources (renewables) distributed throughout the country. These resources can be used for electricity generation. Their ultimate potentials are poorly known, but current estimates suggest that a very small portion of available renewable energy flows is being tapped at present (see Table 1).

Looking ahead, governmental organizations state that by 2030, about 5% of all electricity generated should come from renewable sources. This goal is rather modest compared to those of other countries. Thailand, for example, aims to have 20% of its energy coming from renewable sources by 2020 (Institute of Energy, 2008a). Overcoming barriers to the use of small hydro and geothermal energy would definitely improve Vietnam's energy security and climate change posture.

The next section describes two surveys that were used to gather experts' opinions about (1) barriers to implementing efficient energy technologies and (2) policies and measures related to these technologies. It also discusses the characteristics of the sample and outlines the mathematical principles of the Analytical Hierarchy Process (AHP). Sections 3 to 5 present the results and examine barriers to energy efficiency in both concrete and specific terms. Renewable energy technologies are discussed, as are cleaner coal technologies. Finally, this paper provides an overview of appropriate policies and measures for overcoming barriers to energy efficiency. Section 6 concludes the paper.

2. Methods

The fundamental question of barrier analysis is "Why are many commercially available technologies that seem to satisfy a purely economic cost-benefit criterion not used?" To some extent, this question challenges the cost-benefit criterion itself, which requires the evaluation in monetary units of the positive and negative consequences of different policy choices. Indeed, it is difficult to account for the fuzziness and aleatory elements of the different economic, environmental and social dimensions that inform decisions about energy technology use; different actors make different value judgments about what matters most. Moreover, satisfactory guidelines and sufficient data for evaluating the total costs of various energy policies are largely unavailable, especially for developing countries. For these reasons, extending the scope of the cost-benefit analysis to include all social costs and environmental externalities is not feasible. Our approach, therefore, is to use the Analytical Hierarchy Process, a qualitative evaluation approach based on stakeholders/experts' opinions.

2.1 The sample

The National Institute of Energy in Vietnam conducted a questionnaire-based research survey over 2004-2005. Opinions and judgments were collected from domestic experts and stakeholders. All respondents were knowledgeable about the power sector and familiar with clean and efficient energy generation technologies and the barriers hindering their widespread adoption in Vietnam. The experts were from the Ministry of Industry and Trade (MOIT), the Ministry of Natural Resources and Environment (MONRE), the Ministry of Planning and Investment (MPI), The Electricity Corporation of Vietnam (EVN), the Institute of Energy of Vietnam (IE), Electric Utility, Ha Noi Polytechnic Institute, and private companies, manufacturers and suppliers.

For consistent ranking and evaluation, we classified these experts into six groups, as shown in Table 2: energy experts (A1), environmental experts (A2), policy-makers (A3), project developers and power facility owners (A4), equipment manufacturers and suppliers (A5) and electricity users (A6). To maintain a diversity of points of view, we aimed at a balanced distribution of the number of respondents across groups.

Excluding non-replies and inconsistent replies[1], we collected 37 completed questionnaires from the total of 62 expert questionnaires distributed (Table 2). Expert Choice software (2000) was used to compute the final weight for each barrier and to check the consistency of the analysis.

2.2 Identification and ranking of major barriers: First survey

Generally, barriers are defined as factors that inhibit technology transfer. In this study, three electricity generation technologies were considered: small hydro, geothermal, and high-efficiency coal. As discussed above, there seem to be major barriers to the diffusion of these technologies in Vietnam. The study was organized according to the following steps:

Step 1: An overall review of the academic literature and technical reports was carried out to list all of the barriers that have been noted as hindering the widespread adoption of clean and energy-efficient technologies in the power sector. The lists were further refined through discussions with the country's key experts. The full list of relevant

[1] The pair-wise comparison matrix should have a consistency level within 10% (L. Saaty, 2006). Inconsistent replies are those in which the pair-wise comparisons are inconsistent by over 10%. The required level of consistency was maintained through a re-examination process when necessary. Thus, we did not consider any questionnaire response with an inconsistency level of over 10% in the analysis.

barriers was then narrowed down to a short list of five major barriers for each of the three selected generation technologies.

Step 2: Five criteria were developed to evaluate and rank the barriers: monetary cost to remove the barriers, level of effort required to create awareness, level of political or bureaucratic effort needed to remove barriers, impact of barriers on the adoption of a technology and lifespan of the barriers.

Step 3: Each expert provided weights for each pair of technologies or criteria.

Step 4: These weights were aggregated within each expert group.

Finally, the barriers were ranked by aggregating the data across criteria and groups using weighted averages. The weights used for the five criteria are presented in Table 4, and those for the expert groups are presented in Table 2. These weights are based on the judgments of the experts.

Mathematically, AHP estimates priority weights for a set of criteria or alternatives from a square matrix of pair-wise comparisons, $A = [a_{ij}]$, which is positive. Should the paired comparison judgment be perfectly consistent, the matrix is reciprocal, i.e., $a_{ij} = 1/a_{ji}$ for all $i,j = 1, 2, 3... n$. The final normalized weight w_i for the i^{th} element is given as:

$$w_i = a_{ij} / \left(\sum_{k=1}^{n} a_{kj} \right) \forall_k = 1,2...n \tag{1}$$

The individual pair-wise matrices provided by the group members for the alternative options in each criterion are used to obtain the aggregated pair-wise matrix for each criterion. In this study, the geometric mean method is used, with the formula:

$$\overline{W_i} = \left(\prod_{j=1}^{n} a_{ij} \right) \frac{1}{n} \tag{2}$$

where n is number of members and a_{ij} is the preference of member a for elements 'i' through 'j'.

2.3 Identification and evaluation of policies and measures: Second survey

The energy literature offers a wide variety of policies and measures to promote the adoption of clean or efficient power generation technologies in developing countries like Vietnam (IPCC, 1996; Halsnaes, 1998, UNFCC, 1998; PREGA, 2005; USAID, 2007; Institute of Energy, 2004, 2005). The recommendations are generally grouped into 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 and (v) research and development.

In this study, the policy assessment process was performed using the experts' opinions. The study used the experts' judgments to construct a criteria/policy evaluation matrix. Each expert's main task was to assess, for each of the cells in the evaluation matrix, the predicted impact of each criterion on the policy. For a more convenient opinion-collection process, the pair-wise comparison matrix was converted into a sequence of questions including instructions and a description of the goal of the study. The second part of the study was organized as follows:

Step 1: A review of the literature and existing policies was performed, and discussions with experts and policy makers in the field were conducted to establish criteria for evaluating policies and measures and to create a short list of policies and measures that could potentially remove the identified barriers.

Step 2: The selected evaluation criteria were evaluated (score weighted) for their priority preferences using AHP, based on the expert responses. These criteria include: (i) anticipated effectiveness, (ii) economic consideration (cost of policy implementation), (iii) macro-economic consideration, (iv) political acceptability and (v) administration feasibility.

Step 3: Each policy and measure on the short list was evaluated and judged for each technology, using the criteria specified by the experts. The subjective judgments for both the criteria and the policies and measures were given using qualitative scores: "poor" = 1, "good" = 2, "very good" = 3 and "excellent" = 4. Intermediate scores were acceptable when compromise was necessary (i.e., 1.5, 2.5, and 3.5) (Table 3).

Finally, the total weighted average score for each identified policy or measure, for every technology, was aggregated by a simple calculation using the criteria/policy matrix. Desirable policies and measures are those that garnered more than 50% in total weighted average score. The study recommendations were made based on this determination of the desirability of the policies and measures.

Formally, let $a_i^{j,k}$ denote the score given by expert i to alternative j based on the criterion k . The variable n denotes the total number of experts interviewed. Scores were first averaged across experts:

$$S^{j,k} = \sum_{i=1}^{n} \frac{1}{n} \times a_i^{j,k} . \tag{3}$$

Then, the criteria were aggregated using a weighted average. The weights w_k of the criteria k were based on experts' opinions.

$$p^j = \sum_k w_k \times S^{j,k} . \tag{4}$$

3. Barriers to geothermal and small hydroelectric power generation

Table 5 shows the results of Study 1. For each technology, it lists the five barriers that emerged from the literature review and ranks them according to the aggregation of the experts' judgments. This section discusses barriers to the adoption of geothermal and small hydro technologies only. Barriers to cleaner coal technologies (lower third of the table) are discussed in the section that follows.

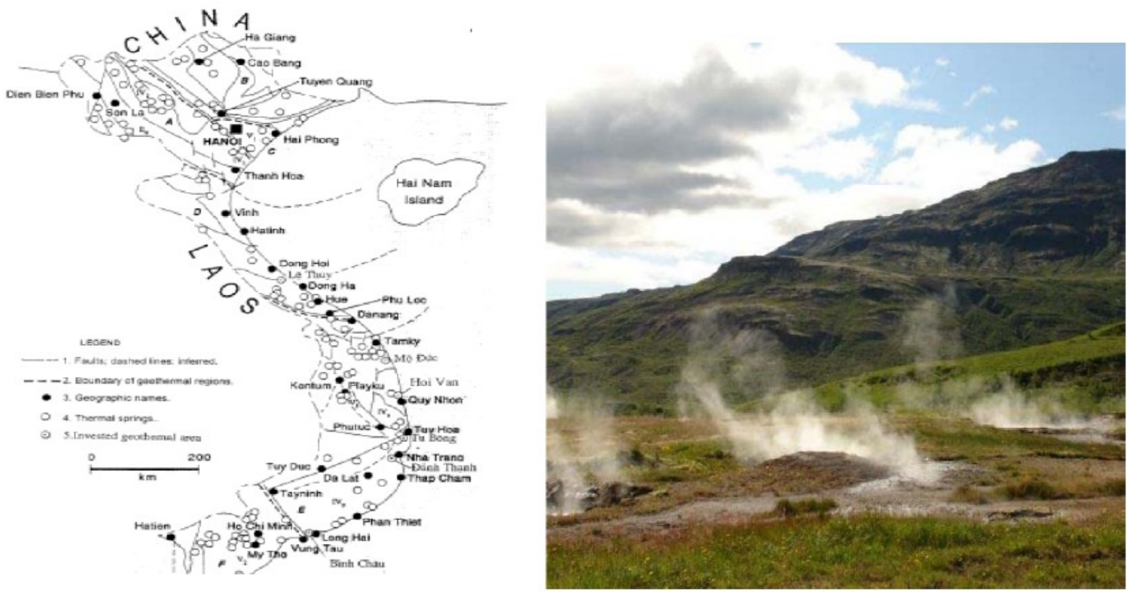
This section addresses barriers that fall into the categories of economic/financial (high initial investment and production cost, lack of capital investment and scarcity of financial resources), awareness/information, institutional, and political/regulatory. In addition, for small hydropower technology, it assesses the lack of domestic equipment suppliers and technical services. For geothermal technology, the remote location of renewable resources is examined.

3.1 Economic/financial barriers

As in other developing countries, economic and financial issues appeared crucial for the development of RETs in Vietnam. The experts and stakeholders interviewed asserted that small hydropower in Vietnam could not be widely implemented mainly due to a lack of capital. High electricity production costs (compared to those for conventional fossil fuels) are considered to be a major barrier preventing the utilization of geothermal power. AHP rankings (Table 5) show that in the case of small hydropower, among the five major barriers, the financial hurdle is the most important barrier, and the economic issue of high production cost the least.

Figure 2: *Vietnam has many small hydro resources with the potential to generate electricity. Source: International Small-Hydro Atlas, 2009 and Research Center for Energy and Environment in Vietnam (RCEE), 2009.*

Figure 3: *Sites in Vietnam with geothermal energy potential are located mainly in remote areas, and have not yet been exploited for the purpose of generating electricity. Source: Global Energy Network Institute (GENI), 2009, Vietnam Forum of Environmental Journalists (VFEJ), 2009*



The extra costs preventing the widespread adoption of renewables in the Vietnamese power sector arise as a result of difficult geography, the weak financial and managerial capabilities of investors and project developers, the poor qualifications of commercial banks, an inadequate electricity pricing system, and a deficiency in the government's policies and incentives.

Figures 2 and 3 illustrate that renewable resource sites are located primarily in remote areas of Vietnam, away from load centers and difficult to access. The people living in these areas are poor and under-educated. Inadequate infrastructure makes it difficult to develop renewable resources for generating electricity. Capital investments and financial resources are difficult to attract to these areas because of a lack of incentives.

In light of this difficulty, the Vietnamese government has recently appealed to sources of financial capital to help implement a series of investment plans that call for the creation of small hydropower plants. These plants are intended to spur economic development as well as to serve remote areas. State-owned companies or subsidiaries of state enterprises are often appointed as the owners of these hydroelectric projects, which are to be realized in the form of small joint-stock hydroelectric companies. Most owners cannot acquire enough capital to finance the projects, and 80–90% or more of the capital for these projects takes the form of bank loans, especially from domestic commercial banks. Therefore, these joint-stock companies often have a tendency to expect interventions or sponsorships from the government, rather than to be active in negotiating and seeking adequate financing agreements (local, national, and international) for the projects through power purchasing agreements before beginning work on the projects. Some owners even fail to estimate the financial requirements of the projects, which can result in delays or postponements.

Domestic commercial banks play an increasingly important role in financing renewable resource projects, including those using small hydropower technology. However, the insufficient capacity of some of the banks to appraise projects has been problematic. This has sometimes led to ineligible projects receiving loans while qualified projects are denied funding.

Another economic barrier is the manipulation of the prices of fossil fuels and electricity, which can make renewable resources less attractive to investors and independent power producers in Vietnam. As a result of subsidized prices for fossil fuels and electricity, and without a nation-wide cost sharing system, the investment rates for renewable resource projects are generally still much higher than fossil fuel prices and electricity costs. For example, in the 1990s an American company named ORMAT carried out a feasibility study on exploiting geothermal energy resources for generating electricity in Vietnam with a total preliminary capacity of 200 MW. The ORMAT proposal suggested a power purchasing price of 4.9 cents (US$)/kWh. However, this proposed power purchasing price was not acceptable to EVN[2] because it was higher than the average electricity cost and not commercially competitive relative to the power purchasing prices for other larger coal-fired power projects (Institute of Energy, 2005).

As of March 2009, the average electricity price in Vietnam had increased to about 5.8 cents (US$)/kWh (at the exchange rate of US$1 = 16.500VND), compared to 5.5 cents (US$)/kWh in 2006. However, this increased price is still lower than the average electricity retail tariff in the region and therefore would not be attractive to domestic/foreign developers to invest in generating capacity of renewables in Vietnam.

[2] The Electricity Corporation of Vietnam (EVN), a Government-owned utility, plays the central role in power production. EVN holds and operates dominantly the existing power generation sources and has shares in a number of independent power plants (IPPs). EVN owns a monopoly function in transmission and sales of electricity.

More specifically, EVN argued that if the sale price is below 7.5 cents (US$)/kWh, this will not attract investors to the power sector's business, in general, as the production cost is between 7 to 7.2 cents (US$)/kWh (Institute of Energy, 2009).

Furthermore, in Vietnam the electricity prices are governed and often used to help control inflation, and the Government attempts to keep up uniform national electricity tariff across the country. Therefore, the major problem that EVN encounters is that to add and deliver a kilowatt-hour of electricity to users is more costly than that they are now allowed to charge for (Fulbright, 2008; Institute of Energy, 2009). Thus, it seems to be challenging to the deployment of renewables, especially geothermal energy, for producing electricity in Vietnam for the years to come if there are no nation-wide cost sharing system or full supportive program actions launched by the Government.

3.2 Awareness and information barriers

The potential positive side benefits of renewables, including small hydropower and geothermal energy, have not yet been systematically estimated with any precision. Information on local markets and physical potentials is crucial to project developers, but this information is often unavailable. Vietnam's databases on the potential of renewable energy resources are limited, scattered, dispersed, and infrequently updated, creating difficulties for developers in analyzing and evaluating the feasibility of their projects.

The AHP analysis (Table 5) shows that a lack of information and awareness about technical know-how, technological development and national renewable resource potential is the number one barrier to the deployment of geothermal energy for electricity generation in Vietnam. With more than 300 geothermal sources ranging from 30°C to 148°C, it is clear that substantial potential for geothermal energy exists within the country. Hoang (1998) suggests that up to 1,400 MW of geothermal capacity could be developed for direct heating usage and electricity generation. The Institute of Energy (2008a) states that roughly 340 to 400 MW of electricity generation could be developed by 2020. The experts interviewed argued that geothermal energy generation technology seems to be at an early stage of development in the country, even though the technology is well established in the world. This gap results from insufficient levels of awareness and information about the state of technological development and the costs and effectiveness of technology among policymakers, energy experts, potential investors and government functional agencies.

In the case of small hydropower technologies, the information barrier was not ranked as the biggest obstacle to development, but it was nonetheless considered to be a predominant barrier that must not be ignored (Table 5). Many respondents argued that a lack of reliable data on small hydroelectric resources has posed many difficulties for making development plans. Even when the data are available, they are often dispersed in various sectors and may not be detailed enough to help project developers and investors make good decisions.

3.3 Institutional barriers

Many of the experts and stakeholders interviewed considered both insufficient coordination, due to a multiplicity of government bodies with energy authority, and institutional capacity limitations (R&D, demonstration and implementation) as critical institutional hindrances to the proliferation of renewable technologies in Vietnam. According to the AHP rankings, the barrier of insufficient coordination among authorized government bodies and insufficient local capability to develop and operate the networks is the fourth most important hindrance to greater adoption of small hydropower, while institutional capacity limitations in R&D and technological and

Figure 4: *Many mini hydropower stations are built using individual investments and managed by individual households. They often use outdated technologies and tend to be very inefficient. Source: Research Center for Energy and Environment in Vietnam (RCEE), 2009.*

industrial capability form the second most important major barrier to the penetration of geothermal energy technology.

The experts surveyed believed that the management missions of small hydroelectric sources in Vietnam are inadequate and irrational. There are various functional government bodies from the central to the local levels that are authorized to exploit renewable resources. In some cases, these responsibilities have been managed in a way that prolonged the investment decision-making process or obstructed the execution of renewables projects. For instance, EVN once had a plan to purchase electricity from 49 small hydropower projects, but many local organizations were unprepared or unwilling to cooperate with the plan, which caused long delays in the execution of those projects (PREGA, 2005).

Our interviews also revealed that there is no clear division of authority between units functioning at the state level, such as EVN, and provincial and local authorities when it comes to exploiting and developing renewable resources for electricity production. For example, some renewable resource power stations were constructed and put into service by the government, but the operation and maintenance responsibilities of the relevant parties remained unclear. Provincial and local units did not have the capacity or the human resources to manage and maintain the long-term operations of the plants. While EVN is capable of helping, local-level actors are unlikely to request this help because there are no adequate incentives for their staff to work in these remote locations for long periods of time. No one wants responsibility for the operation of the plants due to insufficient human resources, and projects continue to be delayed as a result.

There is a lack of adequate guidance and technical support for operators that prevents the efficient exploitation of renewable resources. As Figure 4 illustrates, many very small hydropower stations are local investments managed by independent individuals, with no involvement from utilities companies or any modern control system. Without timely access to technical support and maintenance services, small operational failures are more likely to escalate to long-term operational halts or permanent standstills.

As Table 5 shows, a "weak level of scientific, technological and industrial capability" is the number two barrier to geothermal power. Interviewees argued that this barrier exists not only because Vietnam is still a low-income country, but also due to inadequate government attention to R&D and the government’s failure to facilitate science activities and improve human resources. There are no regional or national research centers with the necessary basic research facilities and infrastructures for renewables development. The current renewables research projects have usually been spontaneous, with limited budgets, and have been undertaken in the form of demonstrations, pilot projects or for reporting purposes only.

3.4 Political and regulatory barriers

To date, the government of Vietnam has not set up clear or specific policy and regulatory frameworks for clean energy development. The country is still taking its first steps toward drafting an overall development plan for renewables usage. Through the survey, we learned that a deficiency in the policy and regulatory framework and weak policy implementation at both the central and local levels are considered to be chronic constraints to the wider adoption of small hydropower and geothermal energy for Vietnam's power sector. The importance of this barrier is confirmed by the analytical results (Table 5), which rank political and regulatory constraints as barrier number three. Moreover, political and regulatory barriers are considered by most of the experts and stakeholders interviewed to be "must-be-overcome" barriers that prevent other barriers from being overcome.

There is a lack of national funding or other appropriate incentive mechanisms to promote cleaner electricity usage through R&D, demonstration, implementation, and utilization. Supportive policy measures related to small power purchasing agreements (SPPAs), feed-in tariffs, pricing reflective of clean energy's extra benefits, cost sharing systems, etc., need to be strategically included in the national regulatory framework to meet the needs of financiers and developers of on-grid renewables projects.

Moreover, legislation to reform the electricity market progresses sluggishly. The historical electricity market operator, EVN, provides very limited grid-connected access to renewables. On one hand, developers argue that they will go bankrupt investing in renewable energy projects if EVN insists on purchasing their electricity production at the same pricing level as that for fossil fuel projects. On the other hand, EVN answers that their selling prices are already at the ceiling level and that they are in a critical financial situation and therefore cannot buy electricity at a higher cost.

Many experts say that the Vietnamese government is aware of these issues but does not seem dedicated to making effective changes in the short term. Conflicting objectives and interests among policy-makers have the effect of causing power to shift to lobbyists, hindering the formulation of policies and creating incoherent strategies.

The lack of clear legislation and bureaucratic issues are cited as additional roadblocks to renewables projects for investors and developers, and particularly for private and foreign investors. Investing money in renewables development in Vietnam is presently fraught with doubts and uncertainties.

3.5 Technical and geographical barriers

As Table 5 shows, the lack of domestic equipment suppliers and technical services hinders the development of small hydropower, and the remote locations of the necessary resources are problematic for geothermal power.

Survey respondents stated that technical issues have been a major threat to many small hydropower plants in Vietnam over the last decade. This is because most existing and planned small hydropower stations utilize poor-quality equipment and technologies. Technical problems usually arise after just a few years of operation, and interruption of service occurs frequently. At the moment, there are no domestic commercial enterprises manufacturing or supplying small hydropower technologies/equipment and services. Cheap, but often insufficient, equipment is mostly imported from China.

Figure 3 illustrates that most geothermal energy resources are distributed in remote rural areas with low levels of socio-economic development. The development of geothermal generation stations thus faces many difficulties related to investigation, construction, operation and maintenance. Local workers are not qualified to manage, operate and maintain these stations. Encouraging policies and incentive mechanisms from the government are still missing.

4. Barriers to cleaner coal-fired technologies

The survey data show that institutional barriers (weak science and technology, insufficient industrial capability and difficulty in technology transfer), economic/financial barriers (high initial investment cost and production price, scarcity of financial resources and inadequate current electricity pricing), and awareness/information barriers are the major barriers to the adoption of cleaner coal technologies in Vietnam (Table 5).

4.1 Institutional barriers

Although cleaner coal technologies are more efficient than conventional technologies, their adoption using technology transfer is barely promoted in Vietnam, where there continue to be low levels of science and technology and insufficient industrial capabilities. The usage of cleaner coal technologies such as PFBC and IGCC, which allow for the expansion of carbon capture and storage, require more advanced scientific and technological capacities.

Experts were asked why Vietnam still prefers to use conventional technologies (e.g., pulverized and sub-critical pulverized coal) over high-efficiency technologies such as supercritical or ultra-supercritical coal. The answer was that these technologies are still perceived to be costly, unproven and unsuitable for usage with local coal types. Among countries in the region, only China has succeeded in building several supercritical and ultra-supercritical coal-fired power plants, and there tends to be little experience with the implementation and operation of cleaner high efficient coal-combustion systems like IGCC and PFBC in this area of the world (APEC, 2007). In most developing economies in the region, and especially in Vietnam, any focus on circulating fluidized bed systems occurs only because these systems allow for the use of low-grade coal in the combustion process.

A lack of previous exposure is another reason why Vietnamese industrial organizations and technical business stakeholders do not seem to be ready to endorse these advanced technologies. In recent years, several international organizations have worked with EVN and other institutions to provide a better understanding of clean and renewable technologies. Specific workshops were held during which sources of information and financing were presented. However, all of this occurred only at a preliminary level.

Furthermore, since the usage of cleaner coal technologies is currently limited to non-anthracite coal, the experts and stakeholders interviewed suggested that Vietnam should promote the adoption of cleaner coal technologies for electricity generation with imported bitumen coal that will be available as soon as 2015.

4.2 Economic/financial barriers

The study's key finding is that economic/financial barriers are predominant among the major barriers to the adoption of cleaner coal technologies in Vietnam. Many interviewees argued that the cost of renewable electricity production is still more expensive than that of conventional technologies, and that this high cost creates major barriers to the widespread promotion of these technologies. Moreover, coal-based power technology has a long investment cycle of about 30 years or even longer. Project developers and investors must have high initial capital and be confident in the long-term operation life of the project for a sufficient payback period. This issue becomes particularly important when one considers the lower capital investment but higher efficiency of a natural gas combined cycle gas turbine (CCGT).

Currently, low electricity pricing in Vietnam does not account for environmental effects. The existing average electricity cost of 5.8 cents (US$/kWh) in Vietnam is hardly adequate to make up for the high costs of advanced coal-fired generation technologies. The benefits of cleanliness are not fully accounted for, which prevents investors from laying out capital resources for advanced low CO_2 emissions coal-fired power. Even as innovation drives down the cost of low CO_2 emissions coal-fired technologies, it is likely that these technologies will remain uncompetitive relative to conventional technologies.

Furthermore, a scarcity of financial resources[3] for the expansion of the power generating system has been blamed as a key cause of electricity shortages over several years. Thus, the deployment of expensive technologies hardly seems financially justifiable and viable at this stage. Policy makers lean toward less costly generation options that maintain electricity prices at levels moderate enough to enable the country's products to remain competitive in the global market. In order to secure funds to finance such a massive expansion of power generation system and manage the sector effectively and efficiently, the Government of Vietnam has drawn out a roadmap, which was approved by the Prime Minister in 2006 (PM, 2006), to reform the Vietnamese electricity market. With this reform, the Government plans to increase the price of electricity to the long run marginal cost of 7.5 cents (US$/kWh) by year 2012. In the context of CO_2 emissions reductions, this reform could provide an opportunity to reconsider the deployment of advanced coal-fired generation technologies for producing electricity in Vietnam.

5. Assessment of policies and measures

Survey 2 examined policies and measures that could potentially help the country to overcome the identified barriers. Results show many commonalities between the RETs and CCTs. Key measures include improving R&D and enhancing investment policy for the power sector. Moreover, investment subsidies and financial incentives were also considered as an attractive policy measure to promote RETS and CCTs. Other policies and measures, including implementing taxation and establishing information/training centers, etc., were identified. Table 6 presents the AHP ranking results for the criteria that were used for evaluating policies and measures. Table 7 shows the rankings of policies and measures for promoting the wider adoption of RETs and CCTs, based on expert and stakeholder opinions.

5.1 Improving R&D and establishing joint ventures with foreign companies

The key finding of this study is that promoting local R&D and establishing joint ventures with foreign companies are the most desirable policy measures for promoting the adoption of these technologies in Vietnam. Though this policy measure may not directly stimulate electricity production from renewables and more funding for R&D activities may not directly translate into a higher installed capacity of renewables, this policy measure was most favored by respondents, with the highest total weighted

[3] The development of power generation source and power network would require an estimated fund of 4.5 billions USD per annum, while the EVN's revenue of electricity sales reached only 2.4 billions USD in year 2005 (Institute of Energy, 2007).

average score (75%) in the case of renewables and the second-highest score (66%) in the case of CCTs.

The experts and stakeholders interviewed expressed the view that improving R&D could help Vietnamese authorities to gather reliable data on national renewables for making development plans. This measure would mitigate the barriers of information and awareness of technical know-how and technological development stages and assist in building indigenous scientific/industrial capacities, human resources, and relevant regulatory frameworks. Establishing joint ventures with foreign companies with advanced experience would help to overcome the lack of domestic renewable electricity technology/equipment and services and would facilitate technology transfer progress. Moreover, establishing joint ventures could help to correct the system of codes and standards in the Vietnamese industry and energy sectors, which are a mixture of various systems, including those of America, Germany, Japan, and Russia.

Moreover, respondents also realized that funding for R&D activities is limited. It was therefore suggested that R&D should focus primarily on development and demonstration rather than on research. In other words, the country should follow the approaches of “taking a shortcut” and “waiting in front” by enhancing the process of transfer and adaptation of advanced technologies while attempting to lower manufacturing costs, rather than concentrating on costly basic research that focuses on achieving high conversion efficiencies.

5.2 Enhancing investment policy and legislation for power sector development

Another interesting finding is that the current policy and regulatory framework in the Vietnamese power sector is not adequate or rational enough to promote the adoption of clean and energy-efficient generation technologies. Table 7 shows that enhancing existing policies and legislation in the power sector was considered to be the second most desirable policy measure for promoting the adoption of RETs. It garnered a total weighted average score of 65% in the case of small hydropower and 70% in the case of geothermal energy. This policy measure was ranked as the most desirable policy measure in the case of CCTs, with a total weighted average score of 74%. Due to market and cost constraints, it will be difficult to establish cleaner generation technologies in Vietnam without new policies and regulatory features that account for the benefit of emissions reductions and encourage a switch to cleaner options. Such measures could be elaborated through thermal efficiency standards, technology-based standards, tax exemptions, subsidies, tradable emissions permissions, etc.

Looking at international practice and lessons learnt from neighboring countries like Thailand, Indonesia and China, we observed that renewable resource development is most successful when national targets and laws on clean energy usage are introduced and legal and regulatory frameworks support administrative procedures and schemes and encourage the efficient exploitation of these resources for economic development. Moreover, the more advanced countries have established national funds and other incentive schemes for promoting clean energy development. Wide cost sharing, feed-in-tariffs systems, grid-connected power purchasing agreements, renewable portfolio standards, etc., have also been adopted. The development of indigenous renewables projects financed through the clean development mechanism and public-private partnerships has been especially successful in China.

A key finding is that unless the entire development policy and regulatory framework for the power sector is thoroughly enhanced, the country’s ample potential for renewable energy generation will continue to be wasted, and the wider adoption of CCTs will not occur in Vietnam.

5.3 Implementation of investment subsidies and financial incentives of different forms

The results in Table 7 suggest that investment subsidies and other incentive measures (with scores ranging between 52% to 63%) are desirable for scaling up electricity generation from RETs and leading the way for bringing CCTs to the power sector.

Different forms of investment subsidies and financial incentives (investment subsidies and tax credits, tax exemptions, access to credit, soft loans, etc.) were identified as attractive policy measures for promoting RETS and CCTs. Many interviewees also noted that the availability of financial resources in Vietnam is limited and that the government should consider ways to generate funds to promote RETs and CCTs by looking at international practice. The adoption of a program like the Energy Conservation and Promotion Fund (ENCON) in Thailand is an example. The purpose of this program is to encourage the completion of projects that are nearly but not quite cost-competitive using a combined formula of economic and financial rates of return to determine viability and incentive levels. Financing through the Clean Development Mechanism was proposed as the most desirable potential policy measure to ameliorate the high capital investment costs of clean generation technologies in Vietnam, especially for renewables.

More specifically, for CCTs, the experts and stakeholders suggested that it is hard to create competitive conditions for integrating CCTs into the Vietnamese electricity generation portfolio. Hence, financial incentive mechanisms such as the clean development mechanism should be used. Moreover, the current cost of electricity should be increased because the current cost of 5.8 US cents/kWh is still very low compared to that of other countries in the region. For example, Thailand's current electricity price is about 10 US cents/kWh (Institute of Energy, 2008a), while the production cost of CCTs is much higher.

In the case of small hydropower, most respondents believed that solving the problem of insufficient investment capital depends on creating financial incentives of different forms, as well as mobilizing capital from a variety of sources/donors and establishing a banking network system to sponsor credit loans.

5.4 Marginal policies and measures

The findings in Table 7 regarding geothermal energy and CCTs suggest that implementing environmental taxation is a satisfactory measure. However, this policy measure garnered a total weighted average score of only around 52% to 54% as a means of helping overcome the critical hurdles of high investment and production costs for geothermal energy and CCTs. However, the application of the fiscal instrument of environmental taxation is still a relatively new concept in Vietnam and receives little political support from the Vietnamese public. The elaboration and implementation of environmental taxes, hence, would raise a number of complexities. Therefore, more specific study is necessary on the economic, social and legal circumstances under which such taxes can be applied.

The interviewees identified the policy of priority development of economies in local and remote areas as an effective measure to attract more investment capital for renewables projects and to help eliminate the major shortage of local human resources for managing and operating projects. Nevertheless, under the study's analysis framework, this policy measure did not prove to be a desirable one. Table 7 shows that this policy measure garnered a total weighted average score of less than 50% in both renewables cases.

Likewise, establishing policy consulting, technical support and training centers was identified as a practical measure for removing the major barriers of insufficient information and lack of specialists/human resources for the widespread deployment of both renewables and cleaner coal-fired technologies. However, this policy option was not deemed sufficiently desirable as a policy measure as it could not garner a total weighted average score of more than 50%.

6. Conclusion

Many countries have set up a national target for the long-term development of renewables and are integrating clean energy use into a national regulatory framework. Communities, individual consumers and investors are also actively contributing to and participating in renewables development plans. Given its abundant natural resources and its high vulnerability to climate change, why is Vietnam not a leader in this area? A formal survey of 37 domestic experts was used to analyze the major barriers to a wider adoption of geothermal, small hydro, and cleaner coal electricity generation technologies in Vietnam. The results of the expert survey can be summarized as follows:

The dominant barriers to wider adoption of small hydropower are as follows: financial/ infrastructure hurdles, institutional constraints, and deficiencies in government policy.

The main obstacles to the use of geothermal energy are as follows: a lack of information and technical know-how, weak R&D and industrial capability and poor policy framework.

The top barriers preventing the adoption of cleaner and more energy-efficient coal-fired generation technologies are related to institutional, economic/financial and awareness/information issues. Although institutional and policy barriers were not ranked as the most significant barriers, they are both considered to be "must-be-overcome" barriers because they prevent other barriers from being overcome.

The expert sample was divided into six groups according to the interviewees' positions in the energy sector. The weights displayed in Table 2 were used to aggregate the opinions across these six groups. We checked that the results were robust to this weighting scheme by examining the rankings of the barriers using equal weights. The results were mostly unchanged, with the exception of geothermal energy, where the first and second ranked barriers switched ranks. This robustness suggests that there was little divergence in the views of the different expert groups.

The results of the second study, exploring how to overcome the barriers, are as follows:

For wider development of cleaner and more energy-efficient coal-fired generation technologies in Vietnam, interviewees recommended improving local R&D and promoting joint ventures with foreign companies as the most productive policies and measures. The focus on development and demonstration rather than on research itself was considered to be the most suitable strategy for R&D activities in the Vietnamese context. In addition, respondents strongly felt that the government should deregulate the power sector and enhance and reform investment policy and legislation.

To encourage the wider employment of geothermal and small hydro technologies, experts suggested the creation of incentives, including investment subsidies and tax credits, tax exemptions, access to credit, soft loans and loan guarantees. Attention was drawn to the efficacy of indigenous renewables projects under the Clean Development Mechanism and financing through public-private partnerships. Different forms of financial incentives, including financing projects through the Clean Development Mechanism, were suggested as appropriate policies and measures to decrease *production costs. Instituting a carbon/energy tax and increasing electricity costs were considered to be desirable measures.*

Overall, the analysis of the opinions of experts and stakeholders explicitly highlights the need for government intervention. The state is seen as the key enabler for promoting renewable and energy-efficient technologies.

Returning to the broader context, the focus of this research on generation technologies should not make one forget the demand side. Overcoming obstacles to energy saving, conservation and demand-side energy efficiency measures are also necessary to respond to Vietnam's energy security and climate change challenges. PREGA (2005), the Institute of Energy (2008b) and Nguyen and Ha-Duong (2009) all point out that the potential of demand-side management in Vietnam is very high. Realizing this potential would reduce the investment needs and mitigate the environmental impacts of the energy sector.

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Table 1: *Potential of renewable sources of electricity generation in Vietnam.*

Energy resources	Economic potential	Cumulative development as of 2007	2025 planned development, according to Vietnamese agencies
Large hydro (>30 MW)	18-20 GW	4,793 MW	16.6 GW by 2020
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)	1,000 MW	158 MW	500 MW
Wood residue	100 MW	Negligible	
Municipal waste	230 MW	Negligible	100 MW

Sources: Institute of Energy, 2008a; Nguyen and Ha-Duong, 2009.
Notes: (1) This figure includes small hydro and back-up diesel capacity; (2) The economic potential of geothermal resources is estimated for electricity generation and heating purposes; (3) The economic potential of wind energy is estimated with different feed-in tariffs; (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 is estimated to vary from 2.4 to 5.6 kWh/m^2/day

Table 2: *Numbers of respondents and priority weights of the six 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	Environmental experts	6	0.196
4	Project developers and power facility owners	6	0.155
5	Equipment manufacturers and suppliers	4	0.131
6	Users of electricity	4	0.106
	Total	*n*=37	1

Table 3: *Pair-wise comparison scale for the analytical hierarchy process preference*

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

Source: L. Saaty (2006)

Table 4: *Priorities of evaluation criteria for ranking barriers calculated by AHP, based on expert opinions*

Criteria for ranking barriers	Weighted by AHP	Definition of criteria (*)
Monetary cost of removing a barrier	0.307	The cost of removing barriers varies with the type and nature of the barriers. Subsidies can be used to remove barriers related to high initial investment. While it is difficult to assess the exact cost of removing a barrier, one can give a qualitative judgment about the cost.
Impact of a barrier on the adoption of a technology	0.209	Different barriers have different degrees of impact on the adoption of efficient options. Removing barriers is more or less likely to result in the introduction of efficient options, depending on the specific barrier. This feature implicitly recognizes the importance of barriers. A barrier that is easy to overcome may have a low impact on the adoption of options. On the other hand, a barrier that is difficult to remove may have a larger impact on the adoption of options.
Lifespan of a barrier	0.221	Each barrier has its own lifespan, i.e., the time it takes to cease to be a barrier. Without any external intervention, some barriers tend to last longer than others.. Normally, barriers with shorter life spans are preferable to those with longer ones.
Level of effort required to create awareness	0.138	Awareness about efficient technologies plays a major role in overcoming barriers. Adopting a technology is easier for users who know something about the technology. Therefore, it is very important to create awareness among 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 others require much effort.
Level of political effort required to remove barriers	0.125	Political and bureaucratic efforts play major roles in removing barriers. Such efforts may include lobbying, introducing bureaucratic initiatives, and providing clear instructions to policy makers. However, barriers can be complex in nature. Barriers are often intertwined with other social and political considerations. The barrier may be linked to various government policies. The more complex a barrier is, the more difficult it is to overcome. Therefore, the level of political and bureaucratic effort required to remove the barriers depends upon the type of barrier considered.

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

Table 5: *Selected technologies: barrier weights calculated by AHP, based on expert opinions. Groups of experts given unequal weights shown Table 2. For each technology, barriers from most to least important.*

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

Table 6: *Priorities of criteria for selecting and evaluating energy policy and measures. Established from experts by AHP using survey data*

Evaluation criteria	Weight	Reasons why the criteria is important (*)
Anticipated effectiveness	0.363	Different policies have different anticipated levels of effectiveness. Implementing one policy over another could result in a higher level of efficiency. Thus, how well the policy removes barriers, whether the policy's effectiveness erodes over time, and whether the policy creates continual incentives for the broad adoption of CEETs should be considered as criteria for evaluating alternative policies.
Policy implementing cost	0.214	A main criterion 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.
Macroeconomic impacts	0.169	The introduction of policies and measures will have a series of impacts on society. Hence, the indirect costs of these policies should be anticipated in addition to the direct costs of implementation. Impacts should first be identified in each sector of the society, e.g., macroeconomic 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 prioritize economic and social needs over environmental issues. The passing of emissions mitigation policies through political and bureaucratic processes 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 barriers requires a good organizational set-up with appropriate infrastructure, manpower and technical support. This constraint frequently limits developing countries. Therefore, administrative feasibility should be considered as one of the evaluation criteria.

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

Table 7: *Ranked policy and measures for the development of cleaner or more efficient energy technologies in Vietnam. Criteria/policy scores matrix evaluated based on expert opinions. Criteria and their weights in the total shown in Table 6.*

Small hydro energy technology

Policy or measure	Effectiveness	Cost	Macro impact	Acceptability	Feasibility	Total
1. Improving R&D, establishing joint-venture companies	1.452	0.214	0.676	0.262	0.123	2.73
2. Enhancing investment policy and legislation for power sector development	0.726	0.428	0.676	0.524	0.246	2.60
3. Financial aids and other forms of financial incentives	1.452	0.214	0.338	0.131	0.369	2.50
4. Establishing policy consulting, technical support and training centers	0.363	0.856	0.169	0.131	0.431	1.95
5. Priority development of the economy in local and remote areas	0.363	0.642	0.338	0.393	0.123	1.86

Geothermal energy technology

Policy or measure	Effectiveness	Cost	Macro impact	Acceptability	Feasibility	Total
1. Improving R&D and establishing joint ventures	1.452	0.214	0.676	0.393	0.246	2.98
2. Enhancing investment policy and legislation for power sector development	1.089	0.428	0.507	0.524	0.246	2.79
3. Implementing carbon tax	0.726	0.535	0.169	0.262	0.369	2.06
4. Establishing policy consulting, technical support and training centers	0.363	0.428	0.169	0.131	0.369	1.46
5. Priority development of the economy in local and remote areas	0.363	0.214	0.338	0.262	0.123	1.30

Cleaner coal technology

Policy or measure	Effectiveness	Cost	Macro impact	Acceptability	Feasibility	Total
1. Enhancing investment policy and legislation for power sector development	1.452	0.214	0.507	0.524	0.246	2.94
2. Improving R&D and establishing joint ventures	1.089	0.214	0.676	0.524	0.123	2.63
3. Financial incentives, including increased electricity price	0.726	0.856	0.169	0.262	0.492	2.50
4. Implementing environmental taxation	0.726	0.642	0.169	0.131	0.492	2.16
5. Establishing policy consulting, technical support and training centers	0.363	0.428	0.338	0.262	0.246	1.64