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

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Motivation

1. Electricity demand: **soaring increase** by 15%/yr (low-scenario) & 18%/yr (high-scenario) over 2010–2030. Power sector be hugely expanded based coal-fired generation.

2. But thermal coal generation system: **old, low** thermal efficiency (28-32%)

3. Vietnam is most affected by **climate change:**
+ Sea-level rise, 0.7m - 1m over next 100 years, could lead to a capital loss of 17 billion USD/yr (WB, 2008).
+ Flood damage, drought, typhoons will intensify by 2070. About 80-90% of populations affected (UNDP, 2007).

4. **Local health and environmental effects:**
Air pollutants caused 22% of chronic pneumonia cases & 1/3 of respiratory inflammation, 2001-2003 (USAID, 2007).

Outline

1. **Vietnam power sector up to 2030.**
2. **Identification and ranking of major barriers: 1st survey.**
3. **Identification and evaluation of policies and measures: 2nd survey.**
4. **Data and questionnaire samples**
5. **Results:**
   - **Results of 1st survey: financial/infrastructural, institutional capacity, and policy deficiency as predominant barriers to adoption of CEETs.**
   - **Results of 2nd survey: government as key market enabler. R&D capacity improvement needed, and reforming investment policy in power sector.**

1. Present situation and trends

7.6%yr^{-1} GDP Growth, 2000-2007

Sector	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture, Forest & Fishing	4,63	2,98	4,06	3,2	4,36	4,0	3,7	3,4
Industry & Construction	10,1	10,4	9,4	10,3	10,2	10,6	10,4	10,6
Service	5,32	6,1	6,54	6,57	7,26	8,5	8,3	8,7
Total	**6,8**	**6,9**	**7,0**	**7,2**	**7,8**	**8,4**	**8,2**	**8,5**

Source: General Statistics Department of Vietnam, 2008

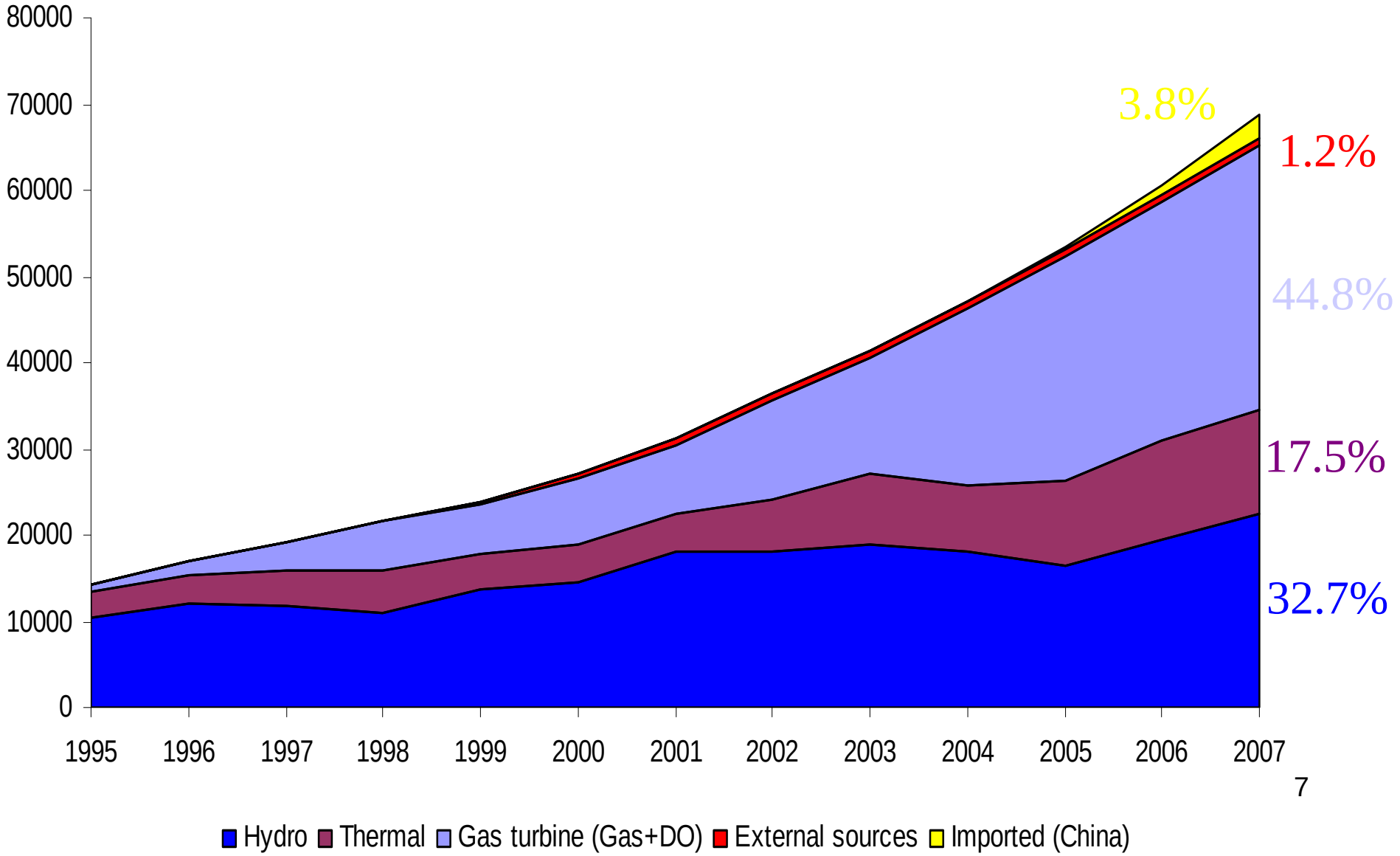
Power generation grows faster than GDP

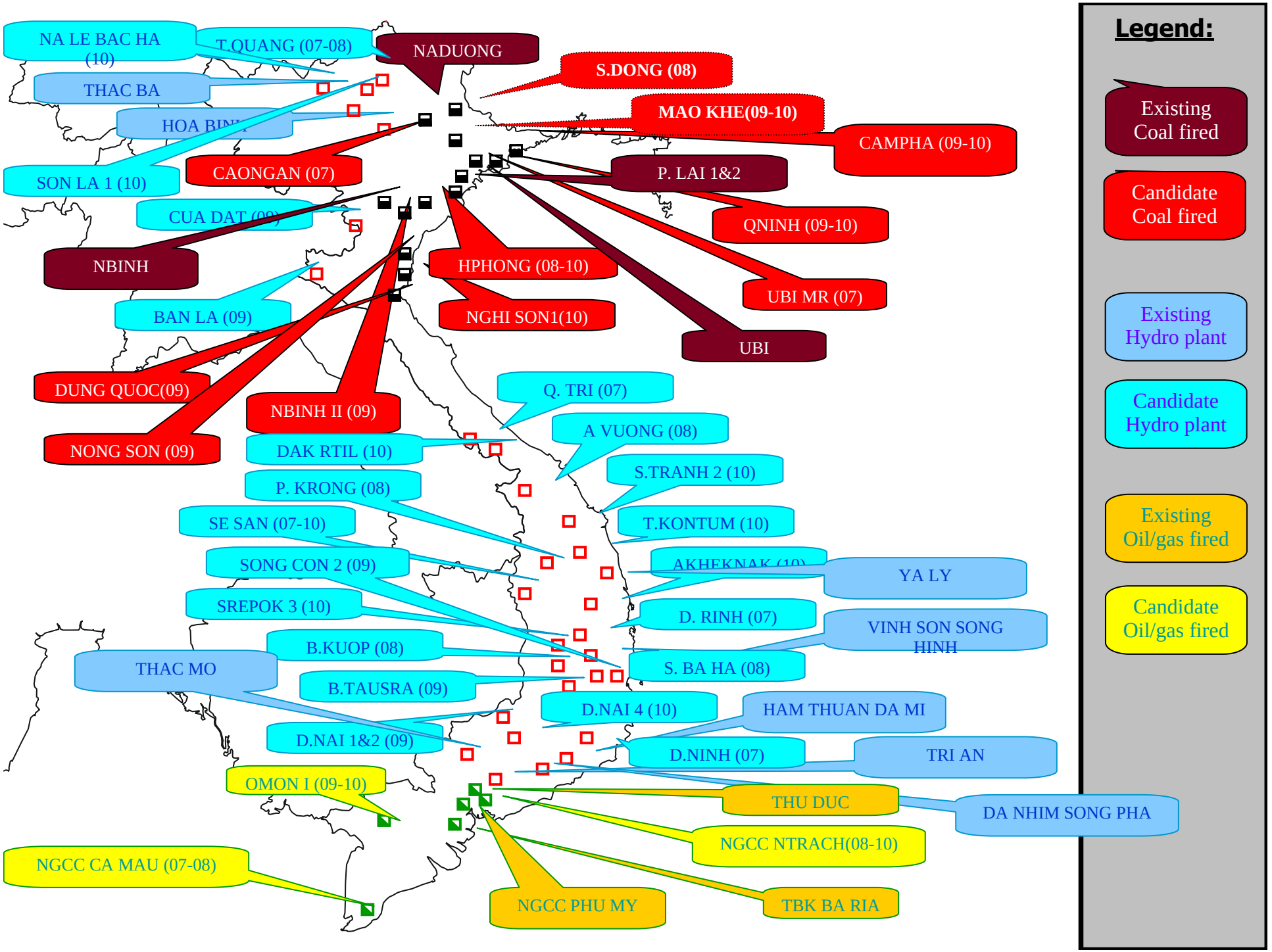
Installed capacity in 2007	**Generation** in 2007	Average annual growth rate	
		Total generation (2000-2007)	Thermal generation (2000-2007)
13512 MW	68.7 TWh	19.3%	22.7%

Source: Institute of Energy of Vietnam, 2008

Generation sources, 2000-2007

Source: Institute of Energy of Vietnam, 2008

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DA NHIM SONG PHA
NGCC NTRACH(08-10)
NGCC CA MAU (07-08)
NGCC PHU MY
TBK BA RIA
Legend:
Existing Coal fired
Candidate Coal fired
Existing Hydro plant
Candidate Hydro plant
Existing Oil/gas fired
Candidate Oil/gas fired

Policy Options

* Improve end use energy efficiency→ barriers to advanced cleaner coal-fired technologies (PFBC, IGCC) to be discussed.

* Develop renewable energy sources→ barriers to small hydro, geothermal technologies to be discussed.

* Develop nuclear power (2020→)

* Import electricity (Laos, Cambodia, China, 2010→)

* Import coal (Australia, Indonesia, 2015→)

* Import natural gas (ASEAN pipeline, 2016→)

2. Identification and ranking of major barriers: 1st survey

1. First: identification of major barriers from an overall literature review and a research survey based interviewed questionnaire with the country's key experts.

2. Second: ranking process based on interviewed experts' opinions/judgments using analytical hierarchy process (AHP).
+ ranking priority (importance) among involved expert groups, using the AHP based on their opinions and judgments.
+ ranking 5 criteria for evaluating barriers.
+ ranking barriers for each technology, each criterion, and each interviewed expert. It then aggregates within each expert group.
+ ranking for the major barriers are obtained by aggregating the weights of criteria and various experts groups.

3. Third: to synthetically analyze the AHP ranking results for the major barriers.

The analytical hierarchy process

The analytical hierarchy process (AHP) is a structured technique to help dealing with complex decisions developed by L. Saaty in 1970s.

The basic step is pair-wise comparison of two so-called stimuli, two alternatives under a given criterion, for instance, or two criteria.

AHP computes estimation of priority weights of a set of criteria or alternatives from a square matrix of pair-wise comparison $A = [a_{ij}]$. The normalized weight w_i of its i^{th} element is given as:

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

5 criteria defined for ranking barriers based barriers' characteristics: (i) monetary cost to remove barriers, (ii) level of efforts required creating awareness, (iii) level of political or bureaucratic efforts needed to remove barriers, (iv) level of impact of adoption, and (v) life of barriers (Expert Choice software).

3. Identification and evaluation of policies and measures: 2nd survey

1. First: identification of suitable policies and measures (PAMs) to overcome identified barriers from literature review and a second research survey based interviewed questionnaire.

2. Second: using AHP to rank policy evaluation criteria based on interviewed experts' opinions/judgments.

3. Third: each PAM is evaluated for each technology under various specified criteria by individual expert. The subjective judgments given by interviewed experts are qualitative into scores, for instance: "poor" = 1, "good" = 2, "very good" = 3 and "excellent" = 4.

4. Four: total weighted average scores for each identified PAM of each technology are aggregated by a criteria/policy matrix method. Desirable PAMs are those garnered > 50% in total weighted score. Recommendations were made based on results of PAMs determined.

Criteria/policy matrix method

The mathematical expression of this method is given:

$$S^{j,k} = \sum_{i=1}^{n} \frac{1}{n} \times a_i^{j,k} \qquad (1) \qquad p^j = \sum_k w_k \times S^{j,k} \qquad (2)$$

i is expert interviewed; *j* is policy alternative identified by the experts; *k* is the specified criterion for evaluation of policy alternatives; *n* is the number of experts interviewed; *a* is evaluated score given to policy alternative by interviewed experts; $S_{j,k}$ is 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 total aggregated weighted average score to each policy alternative.

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

4. Data and questionnaire samples

Data used to identify barriers and policy measures: existing literatures, country studies/reports, discussions with experts in the field. Basic judgments for ranking and evaluating process: experts through surveys.

The pair-wise comparison matrix was converted into question tables in the questionnaire. Questionnaires were distributed in a balanced ratio.

The National Institute of Energy conducted the survey interviewing the experts from MOIT, MONRE, MPI, EVN, IE, Electric Utility, Polytechnic Institutes, private companies, and manufactures/suppliers.

Priority ranked	Key expert 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	Manufactures/suppliers	4	0.131
6	Users of electricity	4	0.106
Total		*n*=37	1

Except few inconsistent responses, we collected 37 qualified samples over the total 62 ones distributed to experts.

4.1. Results of survey 1st: identifying & ranking of major barriers

For renewables: financial, infrastructure, institutional constraints, and deficiencies in government policy ranked as primary barriers to effective penetration of small hydro while information and technical know-how, R&D and industrial capability, and weak policy framework are predominant barriers against development of geothermal technology.

For cleaner coal: weak industrial capability and lack of technical know-how, scarcity of financial resources and inadequate current electricity tariff structure judged as specific dominant barriers preventing the entering of these into generation portfolio.

A key finding: although institutional and policy barriers not ranked as highest score-weighted by AHP but both considered as the "must be overcome" barriers by interviewed respondents.

barriers weights calculated by AHP

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

4.2. Results of survey 2nd: identification & evaluation of PAMs

Overall:

+ improving local R&D
+ promoting joint-ventures foreign companies
+ reforming investment policy and legislation
+ establishing information, training centre

$\Rightarrow$ the most desirable policies & measures for greater penetration of CEETs in Vietnam

For renewables: setting up a national goal and national wide cost sharing system, codes and standards for renewable energy development, regulations for grid connected power purchasing agreement. Developing indigenous projects under the CDM and public private partnerships to create funds and remove economic/financial barriers .

For cleaner coal: tax incentives, soft loans and financing projects through the CDM would be an appropriate measure to remove high initial cost barrier. Carbon/energy tax would be suggested to promote building up of CCTs in the power sector.

ranking PAMs for small hydro using criteria/policy alternatives matrix

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	-	3	5	2	4	1

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.

ranking PAMs for geothermal using criteria/policy alternatives matrix

Criteria	Weighted scores of criteria	Weighted scores for policies and measures				
		PM1	PM2	PM3	PM4	PM5
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	-	3	2	4	5	1

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.

ranking PAMs for cleaner coal using criteria/policy alternatives matrix

Criteria	Weighted scores of criteria	Weighted scores for policies and measures				
		PM1	PM2	PM3	PM4	PM5
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	-	1	3	2	5	4

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.

Policy recommendations

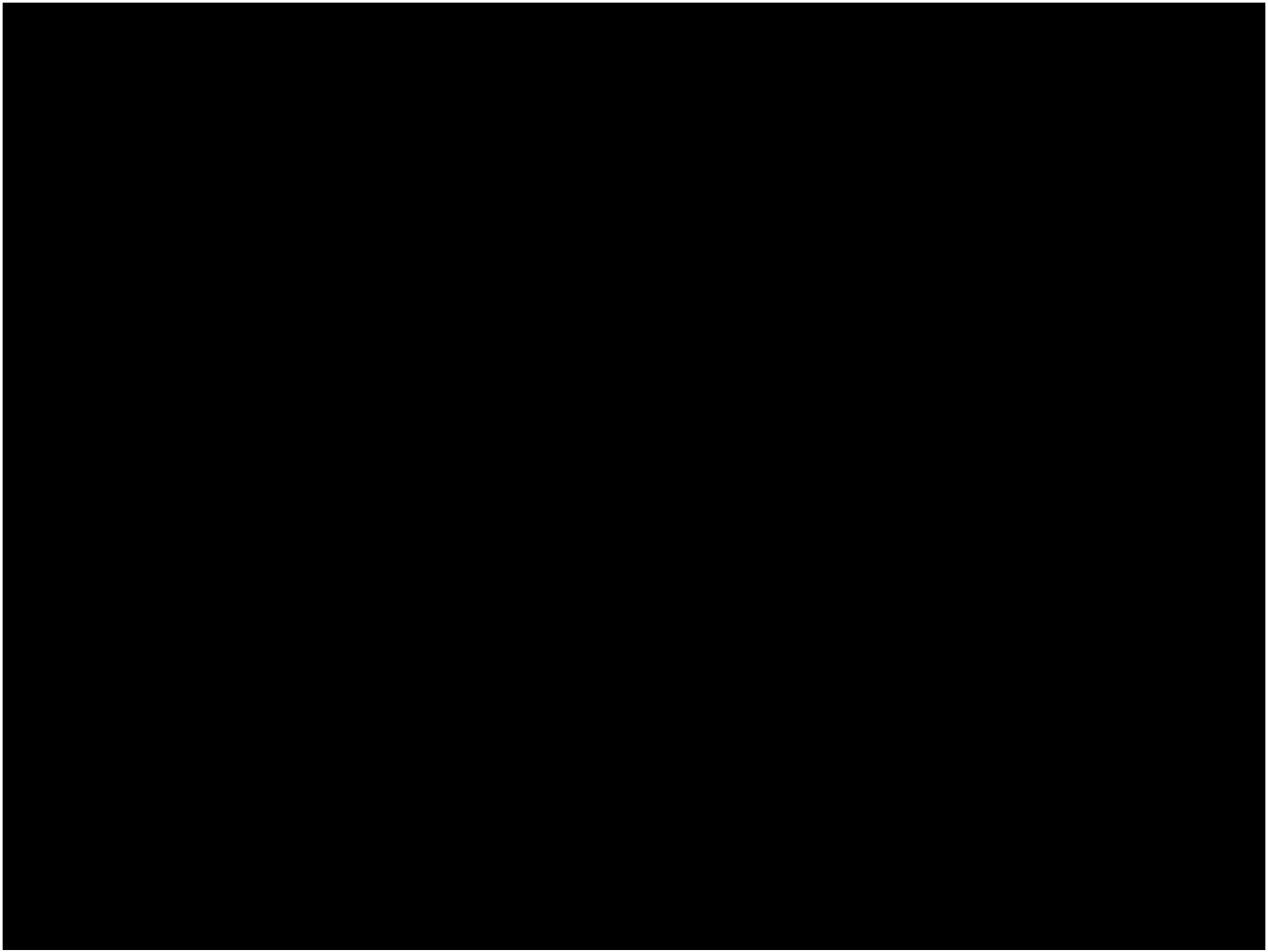
The Government is viewed as a key market enabler:

+ more investment for R&D activities to enhance local R&D capacity.

+ deregulating the electric power industry.

+ turning climate challenge into opportunities for sustainable development through international climate schemes such as the CDM.

$\Rightarrow$ most appropriate policies and measures for proliferation of cleaner and high energy efficient technologies in Vietnam.



Potential of renewable sources: assessment until 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	500 MW	
Wood residue	100 MW	Negligible		
Municipal waste	230 MW	Negligible	100 MW	

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

Pair-wise comparison scale for the AHP 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)

Vietnam has ample resources of small hydro potential for generating electricity

Sources: Small-Hydro Atlas, 2009 and RCEE, 2009

lots of mini hydropower stations are self-invested and managed inefficiently by individuals with old, backward technologies

Sources: RCEE, 2009 and RR Energy, 2009

most of renewable resources (small hydro and geothermal) are located in remote areas that cause difficulties in investigation, construction, and operation of the projects

Sources: RCEE, 2009 and Daylife photo, 2009

Vietnam is endowed with geothermal energy potential, located in remote areas but this has been unexploited yet for generating electricity

Sources: GENI, 2009 and VFEJ, 2009

Ninh Binh conventional coal-fired power plant was constructed over 20 years ago with backward technology and been under operation

Sources: RCEE, 2009 and Daylife photo, 2009