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AAECP ENERGY POLICY AND SYSTEMS ANALYSIS PROJECT

Third Regional Policy Study

Policies and Strategies toward Energy Trade and Sustainable Development in ASEAN

March 2006

Prepared by
ASEAN Center for Energy (ACE)

Australian Agency for International Development (AusAID)
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EXECUTIVE SUMMARY

Introduction

This report presents the results of the third regional energy policy study conducted under the Energy Policy and Systems Analysis Project (EPSAP) sponsored by AusAID. The goal of EPSAP is to:

"…Enhance the capacity of ASEAN energy policy makers and planners to assess the impacts and cost effectiveness of alternative energy policy options which could assist countries to formulate policies and programs to help meet the demand for energy services at least cost."

The ASEAN Centre for Energy (ACE) prepared the report with assistance from the Australian Managing Contractor for the project, with additional assistance from national project team members temporarily attached to ACE. Countries contributing directly were Indonesia, Malaysia, Philippines, Thailand and Vietnam which in this report will be designated the ASEAN-5.

The Study Topic

The topic of the report is "Policies and Strategies toward Energy Trade and Sustainable Development in ASEAN", having as goals an analysis of least cost strategies for controlling emissions from the energy sector and to examine further the impact on the energy trade options in the ASEAN region from environmental issues. This study, endorsed by the EPSAP's Project Coordinating Committee (PCC) covers the following matters:

- Assessment of the potential savings from energy efficiency and conservation measures and the impacts that these might have on energy trade and emissions;
- The longer-term potential for renewable energy technologies as part of a least cost solution to a range of policy options such as imposing limits on greenhouse gas (GHG) emissions;
- Optimised energy infrastructure development strategies for the region taking account of improved and efficient energy technologies, the use of renewable energy technologies, the future use of natural gas, and taking account of strategies to control emissions of the energy sector to meet environmental standards and targets;
- The costs of these strategies under a range of possible scenarios; and
- The possibility of GHG emission trading policies for sustainable development such as through the clean development mechanism (CDM) or other methods.

The study should take account of the database, conclusions, recommendations and review comments made on the first two studies and, specifically, include and update data on:

- Options for more efficient energy technologies;
- Options for fuel substitution in transport and in industry;
- Options for trade in petroleum products in ASEAN;
- Options for expanding the use of renewable energy technologies;
- Non-GHG emission coefficients; and

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- The latest GHG emission coefficients.

The third regional study is an extension of the first and second regional energy policy studies that focused on energy trade opportunities in ASEAN. The first regional study on the Trans-ASEAN Energy Network analyzed the strategies and benefits associated with increased integration and interconnection of electricity and natural gas transmission networks between the countries of ASEAN.

The second regional study on the Trans-ASEAN Energy Network analyzed the strategies and benefits associated with increased integration and interconnection of electricity and natural gas transmission networks between the countries of ASEAN. Possible cross-border gas pipelines and electricity transmission links were reviewed, guided largely by, but not limited to, the TAGP[1] and AIMS[2] studies. The study took account of committed energy policies of the ASEAN countries and the possibility of LNG trade within ASEAN.

Methodology

As with the first and second regional studies under EPSAP, the current study uses a MARKAL energy model of the ASEAN region assembled from the national MARKAL models developed by each national project team. ACE developed models for the non-participating ASEAN countries of Brunei and Singapore, while ACE and the National teams together developed the options for trade in gas, electricity, LNG, coal, oil and petroleum products, both within the ASEAN region and with the rest of the world. Many of these options were based on those considered by HAPUA[3] and ASCOPE[4] in their planning, while national teams provided others. Data and resource options and trade from Myanmar were new to the current study.

MARKAL is a model that optimises the production, conversion, transmission and use of energy to meet projections of the demand for energy services over a relatively long period, 40 years in this case. Based on a linear programming approach, it can solve systems with a very large number of variables and constraints. For the current study, apart from the existing components making up national energy systems, the inputs include:

- Trans-ASEAN natural gas pipeline options, including but not limited to those in the TAGP study;
- Trans-ASEAN electricity grid options, including but not limited to those in the AIMS study;
- Options for the production, transport, use, import and export of LNG;
- Facilities to take account of changing world oil and petroleum product prices;
- Revised resource estimates, especially for natural gas fields within ASEAN.

To study the issues in the Terms of Reference, the study team devised scenarios for around 20 study cases to run with MARKAL. Each MARKAL case run produces an optimised energy development strategy for ASEAN, together with associated marginal cost pricing (including taxes and subsidies if relevant). These are reported in detail in the body of this report and are summarised below. All dollar amounts quoted are estimates expressed in year 2000 US$.

[1] Trans-ASEAN Gas Pipeline
[2] ASEAN Interconnection Master Plan Study
[3] Heads of ASEAN Power Utility/Authority
[4] ASEAN Council on Petroleum

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Reference Case

The Reference Case established for the study, which serves as a baseline to which other cases are compared, has as basic fuel price assumptions:

- Crude oil $30/bbl;
- Imported coal $30/tonne;
- LNG $2.5/GJ (exports fob ASEAN) and $4/GJ (imports re-gasified).

Some other important assumptions are as follows:

- Discount rate 10%;
- Normalised technical and economic characteristics for CCGT[5] plant;
- National pipelines and links as per National Project Team (NPT) specification;
- Gas trade Malaysia to Singapore restricted;
- Cross-border pipelines and links unrestricted except as above;
- No pipeline losses;
- Mid-case gas reserves;
- Demand projections as per NPT but linearised from 2020;
- No special assistance to renewables;
- Fuel substitution allowed in industry (but restricted according to retirement of existing capacity), except for non metallic industry in Thailand;
- National energy policies included except those relating specifically to use of renewables.

Important issues relating to handling of electricity links:

- Thailand / Vietnam limited to 650 MW;
- Sumatra / Peninsula Malaysia and Sumatra / Singapore one direction only and based on dedicated coal plant in Sumatra;
- Malaysia / Thailand limited to 600 MW;
- Other links can expand freely.

ExecSum 1 shows the sources for electricity supply in the ASEAN-5 countries under the Reference Case assumptions. Under these assumptions, the major sources for electricity supply are coal, gas and hydro with their relative shares varying in different countries. Coal has the majority share in Indonesia, Thailand and Vietnam; coal and gas approximately equal shares in Malaysia; while in the Philippines renewable energy including large hydro has a share comparable to gas and coal. Large hydro also takes a large share in Vietnam and to a lesser extent in Malaysia. Nuclear finds a small market share in Vietnam. The renewable share is generally small (less than 6%) although when combined with large hydro, contributes in Indonesia (7%), Malaysia (21%), Philippines (28%), Thailand (5%) and Vietnam (34%).

[5] Combined cycle gas turbine.

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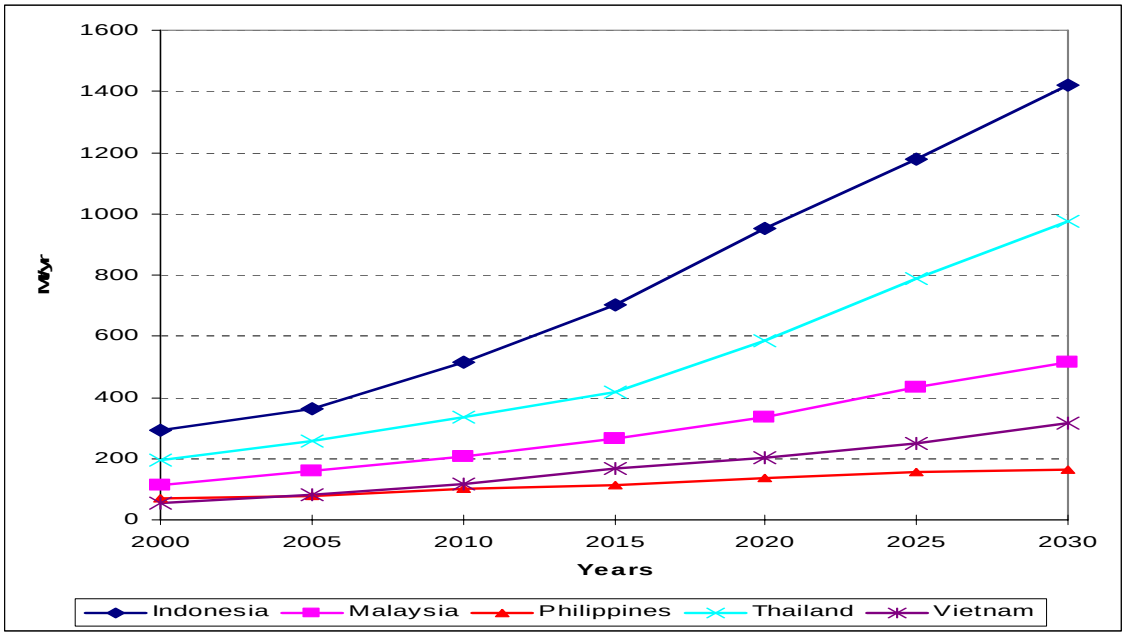
ExecSum 1: Electricity supply in ASEAN-5 countries

Sources	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	TWh	%	TWh	%	TWh	%	TWh	%	TWh	%
Supply										
Gas	4,875	30.7%	2,417	37.8%	1,642	36.6%	3,452	33.3%	373	7.4%
Coal	8,889	56.0%	2,538	39.7%	1,528	34.1%	5,104	49.2%	2,797	55.3%
Oil	550	3.5%	25	0.4%	67	1.5%			2	0.0%
Hydro	534	3.4%	960	15.0%	270	6.0%	186	1.8%	1,650	32.6%
Nuclear									67	1.3%
Renewable	554	3.5%	384	6.0%	974	21.7%	308	3.0%	78	1.6%
Import	475	3.0%	72	1.1%			1,324	12.8%	94	1.8%
Total	15,876	100.0%	6,396	100.0%	4,482	100.0%	10,373	100.0%	5,062	100.0%

Under reference conditions, CO_2 emissions could be expected to increase greatly in ASEAN countries in the coming decades due to increased use of fossil fuels, and coal in particular. ExecSum 2 shows the projected growth in CO_2 emissions under the Reference Case assumptions for the study.

ExecSum 2: CO_2 emissions for Reference Case



For the ASEAN-5 countries, CO_2 emissions are projected to increase from around 720 Mt/yr in 2000 to 3,500 Mt/yr in 2030, an increase of over 5.5% per annum. Of the individual countries, Vietnam has the largest proportionate increase (factor of 7.3) followed by Indonesia (4.9), Thailand (4.8) and Malaysia (4.6). Philippine emissions increase by a relatively modest factor of 3.7 over the study horizon because of the use of high efficiency CCGTs and renewable fuel.

Renewable Energy

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A 5% Renewable Portfolio Standard[6] (RPS) was a case examined in the current study and this showed an increase in system cost of $777 million compared to the Reference Case. Together with the results in ExecSum 1, it indicates that if the study assumptions for renewable energy are correct, then a modest (say, 5 – 10%) RPS could be instrumental in promoting uptake of renewable energy that is economic or near economic but is not being installed because of perceived risk, lack of knowledge, or market failure with respect to investment. This could apply in all countries except possibly Vietnam.

Although the decrease in emissions with the application of an RPS as indicated by the study results is small this should be viewed in relation to the renewables that are already being installed in the Reference Case but might not be installed in reality in the absence of an RPS.

The study included a number of cases that had as their primary objective GHG reduction but nonetheless could impact on renewable energy use as one means of attaining the primary goal. It was found that these cases did have significant benefit in promoting renewable energy use rather than just a change in the fuel mix such as from coal to gas. The high oil price case also had a significant effect on renewable uptake, thus indicating that a permanent movement in the oil price from $30/bbl to $60/bbl would see a large block of renewable energy made economic and could support an increase in an RPS to say 10%.

Emissions Mitigation

A number of policy approaches have been examined in the study that could be looked upon as a means of GHG mitigation although that may not be their primary goal (for example, the primary goal of an RPS is promoting renewable fuel use). They include:

- Limit on CO_2 emissions applied separately to each country;
- Limit on CO_2 emissions applied regionally;
- Emissions tax;
- Renewable portfolio standard;
- RPS plus limit on CO_2 emissions applied regionally;
- Promoting industrial conservation; and
- Biodiesel standard[7].

ExecSum 3 provides a summary of the effectiveness of each approach both in terms of overall reduction and average cost. The following points can be made:

- A comparison of the Reference Case with Case 18 where energy trade is restricted indicates that encouraging energy trade in the region is an effective mechanism for reducing emissions since it encourages the use of gas and hydroelectricity (see Section **Error! Reference source not found.**).
- As expected, applying an emissions limit directly is the most cost effective way of controlling emissions.

[6] Renewable Portfolio Standard is the term used for a policy whereby a minimum specified percentage of electricity generation must be derived from renewable energy.
[7] Policy requiring a minimum fraction of diesel use in transport to be biodiesel.

- The average cost of 5% and 10% emission reductions compared to the Reference Case are \$7/tonne CO_2 and \$12/ tonne CO_2 respectively when applied to individual countries.
- Co-operative sharing of the reduction burden reduces the average cost to \$5/ tonne CO_2 and \$9/ tonne CO_2 respectively
- Both an RPS and biodiesel standard have negligible impact on emissions at least at the levels applied.
- The average cost for GHG emission reduction for biodiesel is very high at \$87/tonne CO_2. Thus, biodiesel is not an effective policy approach for GHG reduction with crude oil at \$30/bbl. Its cost effectiveness would obviously improve at higher oil prices but that was not examined in the study.
- For the RPS, the reduction cost is relatively low at \$15/tonne CO_2, but this is still much higher than for policies that limit CO_2 directly.
- Industrial conservation and substitution of gas in industry can both make useful contributions to emissions reduction and should be encouraged.

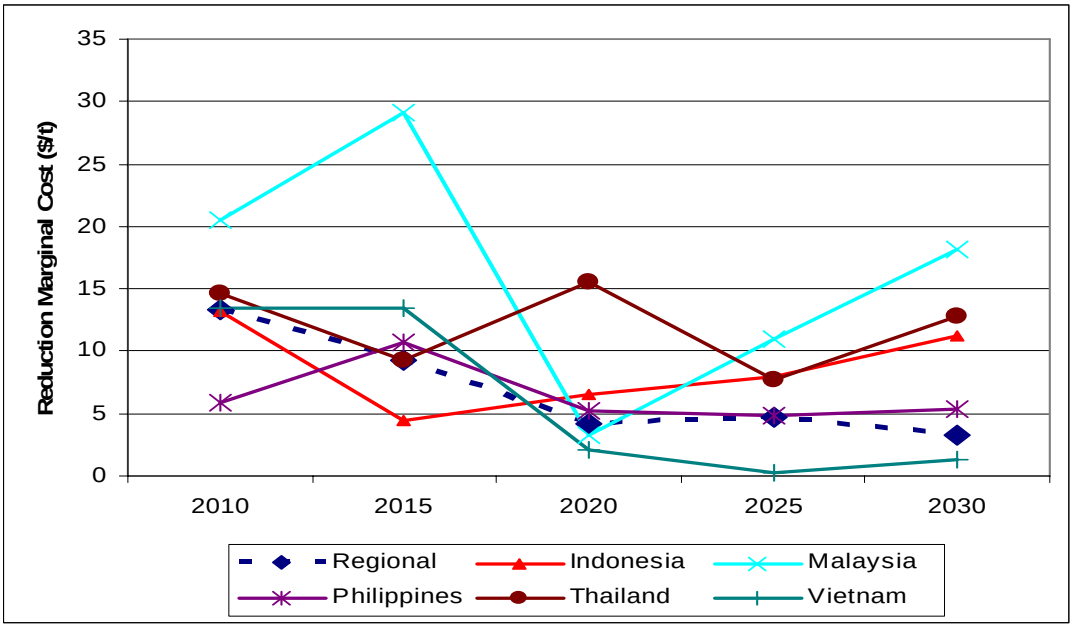
ExecSum 3: Assessment of GHG mitigation

Case	Description	Increase in Cost over Reference ($m)	Cumulative CO_2 emissions				
			Absolute (Mt)	Relative to Reference		Discounted CO_2 saving (Mt)	Unit Reduction Cost[8] ($/t)
				Mt	%		
CASE1	Reference Case	-	72,980	-	-	-	-
CASE2	CASE1 + NOINDSUB	21,241	74,420	1,440	2	-162	
CASE3	CASE1 + CO2LIM5	3,044	70,080	-2,900	-4	448	7
CASE4	CASE1 + CO2LMR5	2,190	70,080	-2,900	-4	448	5
CASE5	CASE1 + CO2LIM10	10,654	67,175	-5,805	-8	896	12
CASE6	CASE1 + CO2LIMR10	7,628	67,175	-5,805	-8	896	9
CASE7	Case 1 + SOXNOX5	2,425	70,915	-2,065	-3	322	8
CASE8	CASE1+ TAXENV	6,547	66,850	-6,130	-8	901	7
CASE9	CASE1 + RPS	777	72,485	-495	-1	51	15
CASE10	CASE9 + CO2LMR5	2,643	70,080	-2,900	-41	448	6
CASE11	CASE1 + INDCSV	-4,521	72,555	-425	-1	56	
CASE13	CASE1 + BIODSL	1,954	72,830	-150	-0	23	87
CASE18	No gas, electricity, PP and LNG trade	32,502	77,120	4,140	6	-521	
CASE19	Trade within ASEAN only	3,809	73,690	710	1	-77	

If the policy adopted for emission control is a tax rather than a cap on emissions, the required tax can be inferred from the "shadow price" of the constraint in the model that enforces the reduction. The shadow prices also indicate the cost at the margin for emission reduction. Since the marginal costs for mitigation vary widely between countries, it is advantageous to view emissions reduction in a regional sense with compensation between countries or instigate a mechanism for emissions trading. This is illustrated in ExecSum 4 showing the uniform regional mitigation cost at the margin compared to that of individual countries.

[8] Discounted system cost increase divided by discounted CO_2 saving.

ExecSum 4: Marginal emission cost Regional vs National



The potential benefits that can be gained from meeting a defined reduction target regionally rather than nationally are shown in ExecSum 5. The cost savings for the 5% and 10% targets are $0.6 billion and $3.1 billion respectively, illustrating that the desirability of emissions trading becomes more pronounced the tighter the reduction target imposed. The average reduction costs also decrease as illustrated in the table.

ExecSum 5: GHG mitigation Regional vs National

Case	Description	Increase in Cost over Reference ($m)	Saving from Carbon Trade ($m)	Unit Reduction Cost[9] ($/t)
CASE3	5% restriction nationally	3,044	-	7
CASE4	5% restriction regionally	2,190	854	5
CASE5	10% restriction nationally	10,654	-	12
CASE6	10% restriction regionally	7,628	3,026	9

Clean Development Mechanism

The Clean Development Mechanism (CDM) was proposed as a part of the 'flexibility mechanisms' of the Kyoto protocol. These mechanisms of the protocol were devised to assist Annex 1 countries to fulfil their commitments in a flexible and co-operative manner. At the same time they provide an opportunity for developing countries, not bound to reduce their emissions under the protocol, to participate in the process of global GHG mitigation.

The CDM has been designed to be innovative and market-based so that developed countries may invest in bankable projects in the developing ones. Emissions resulting from the project should

[9] Discounted system cost increase divided by discounted CO_2 saving.

be lower than what would have occurred had the prevalent technology been used. Emission reductions are expected to be real, measurable, and long term.

MARKAL has been used in the third regional policy study to examine various aspects of CDM in ASEAN. It is concluded that the model can be used in four respects:

- Establish a standard baseline as a starting point for analysis. This would model the expected evolution of the energy system under normal economic criteria.
- Identify projects or generic technologies that qualify for CDM.
- Calculate the value of CER[10]s that would make qualifying projects economic. This could be time variant as both cost of competing technologies and the qualifying project may change over time.
- Calculate the CERs generated by a specific project by comparing a case with project implementation to the baseline.

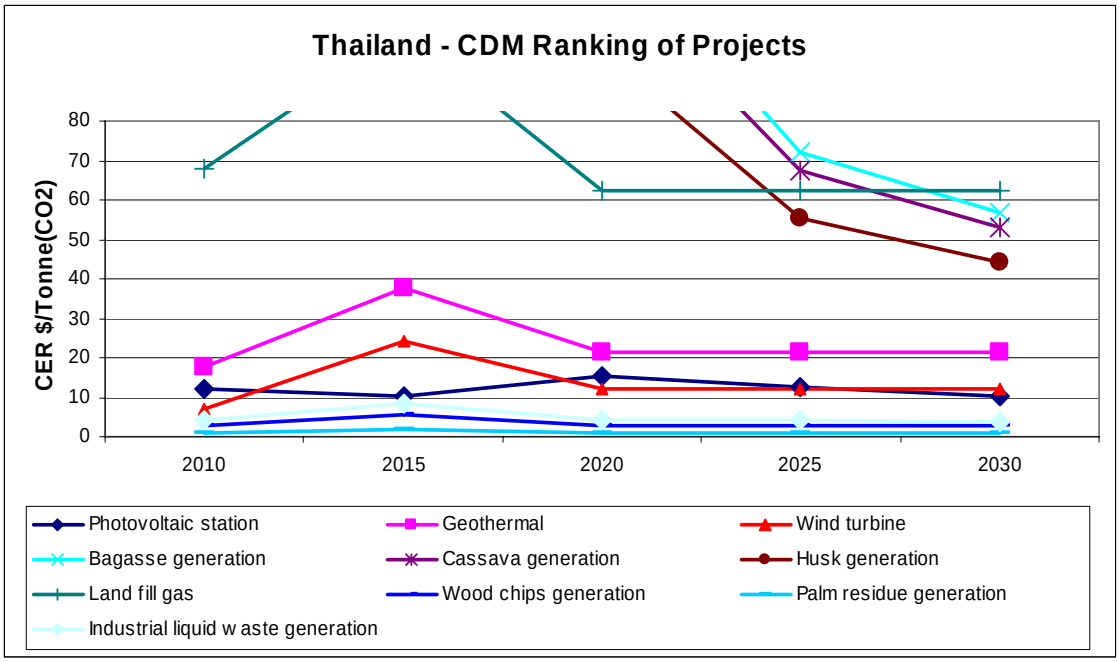
For the current study, the following plants in ASEAN-5 countries are not selected by MARKAL in the Reference Case (considered here as the baseline) and are therefore eligible candidates for CDM support:

- Indonesia – Photovoltaic;
- Malaysia – Landfill gas, palm oil EFB (West Sabah), photovoltaic (home);
- Philippines – Bagasse, biomass, solar;
- Thailand – Photovoltaic station, geothermal, wind, landfill gas, industrial liquid waste, different forms of biomass (bagasse, cassava, rice husk, wood chips and palm residue).

For illustration, ExecSum 6 shows the ranked CDM compliant projects for Thailand as determined in the analysis. For comparison, carbon credits under the EU emissions trading scheme were reported by PointCarbon [50] as trading around €22 – 23/tonne CO_2 (US$27/tonne) in October 2005. On that basis, a number of options in Thailand especially could find viability with CER income including wood chip, palm residue, industrial liquid waste, PV station and wind, while photovoltaics in the remote regions of other countries could also be favoured.

[10] Certified emission reduction – the decrease in emissions resulting from the project.

ExecSum 6: CDM ranking of projects in Thailand



Energy Efficiency

Two ways of improving on the impact of energy use in industry is to switch to more environmentally friendly fuels and to encourage better efficiency in use. In preparation for the study, information was assembled on programs and targets in the ASEAN-5 countries for increasing the efficiency of energy use. Although many of these programs are amenable to analysis within the MARKAL framework, time did not permit data to be gathered so that they could be examined in a meaningful way. However, the case studies include a simple scenario where the efficiency of industrial boilers was assumed to increase by 5% to assess the system impacts.

This could be considered as highly conservative given that measures surveyed include:

- Indonesia – potential energy saving of 10 – 30% for large industry and 5 – 40% for small industry;
- Malaysia – based on eight industrial sectors, firms lacking an energy management program can save up to 23% via efficiency measures;
- Vietnam – program to raise the efficiency of coal-fired boilers from 50%-65% to 65% - 75%, and oil-fired boilers from 60% - 70% to 70% - 80%.

The model did not include any extra cost for installing higher efficiency boilers or for back-fitting existing boilers so the results need to be treated with some caution. Nonetheless, the impact was significant with a reduction of $4.5 billion in total system costs and 425 million tonnes or 1% in CO_2 emissions.

Trade Impacts

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ExecSum 7 shows energy trade both within ASEAN and with the outside world for the Reference Case, and variations from the Reference for a variety of environmental policies. The table also includes Case 2 where future fuel use in Industry is fixed at the current mix.

ExecSum 7: Energy trade within and outside ASEAN (PJ/a)

Case	Description	Gas in ASEAN		LNG with outside world		Electricity	Coal	Oil & PP
		Pipeline	LNG	Import	Export			
CASE1	Reference Case	63,227	25,717	37,018	2,048	8,647	44,444	304,335
Variation from Reference								
CASE2	CASE1 + NOINDSUB	-16,796	-828	-17,011	3,106	41	3,519	44,162
CASE3	CASE1 + CO2LIM5	5,194	210	7,150	-753	687	-20,021	-1,389
CASE4	CASE1 + CO2LMR5	2,531	1,330	3,136	-324	269	-22,077	-502
CASE5	CASE1 + CO2LIM10	5,706	-4,257	28,879	-2,048	3,645	-35,182	-2,125
CASE6	CASE1 + CO2LIMR10	5,663	511	18,951	-2,048	1,036	-35,681	-2,824
CASE8	CASE1+ TAXENV	5,925	590	22,946	-1,042	302	-37,734	-1,768
CASE9	CASE1 + RPS	-388	-516	-718	19	-3	-3,496	-160

For the Reference Case, it is seen that:

- Oil and petroleum products have by far the largest trade indicating the continuing importance of sound policies towards pricing and utilization of liquid fuels;
- Gas trade in energy terms is much larger than electricity trade but these are much closer in dollar terms because of the quality and value differential of electricity versus gas;
- Gas trade within ASEAN is substantial and mostly by pipeline (71%) although LNG trade (29%) also takes a significant share;
- LNG imports into ASEAN are substantial and around 42% of gas trade (pipeline and LNG) within ASEAN;
- Coal imports and use are large contributing to high growth rates in GHG and other pollutants.
- The potential role of LNG indicates the need for infrastructure planning to handle that fuel.

The above table indicates that:

- If gas can penetrate industrial markets, pipeline trade and imports are much higher replacing mostly petroleum products. Necessary infrastructure would need to be developed for this to happen.
- Both gas pipeline and electricity trade are encouraged by policies to restrict CO_2 emissions either on a national or regional basis, or by a carbon tax.
- LNG imports are similarly favoured.
- CO_2 restrictions advantage electricity trade more than a carbon tax. Also, electricity trade is most encouraged when restrictions are on a national basis.

The major factors influencing outcomes for various pipelines are:

- Level of energy prices and especially the LNG price compared to other fuels;
- Extent of LNG trade with rest of world; and

- The extent to which natural gas is able to penetrate industrial markets.

In the cases analysed, emission reduction policies can have a significant effect on pipelines strategies but policies to promote renewable energy have no discernible impact on pipeline trade. The impact of environmental policies on pipeline infrastructure is examined with respect to investment out to 2020 as this covers the interval of most current interest. Notable impacts include:

- East Natuna – JDA and JDA – Block B start advanced by 5 years under all policies;
- JDA – Erawan and Block B – Vietnam all policies result in much increased capacity in 2020;
- Sabah – Philippines disadvantaged by CO_2 limits and carbon tax;
- East – West Natuna disadvantaged by 5% national limit and 10% limit national and regional;

Unlike for gas pipelines, the RPS to promote renewable fuels does have an impact on some transmission links. Most notably it advantages Sabah – Sarawak but disadvantages Brunei – Malaysia. The impacts from other policies include:

- Cambodia – Thailand much strongly favoured with all emission policies except 5% CO_2 reduction regionally;
- Laos – Thailand very much advantaged by emission limits;
- Laos – North Vietnam advantaged by emission limits;
- A carbon tax has a favourable impact on Sabah – Sarawak, Laos – Central Vietnam and Laos – North Vietnam; but disadvantages Kalimantan – Sarwawk, Sumatra – Peninsular Malaysia and Sumatra – Singapore, the latter two not been chosen with a tax.
- Trade in carbon emission rights disadvantages Cambodia – Thailand and Laos – Thailand and Central Vietnam while it advantages Sabah – Sarawak and Kalimantan – Sarawak. Rights trading advantages Brunei – Malaysia with a 5% limit but the reverse is true for a 10% limit.

In summary, environmental policies can impact on pipeline and transmission links strategies and the possible imposition of such policies needs to be examined in the planning process.

LNG

Because of continuing improvement in the supply economics for LNG, LNG could assume an important role in future fuel strategies for ASEAN in any of three ways – LNG trade within ASEAN as well as LNG exports and imports with the outside world.

The study has shown that with an assumed crude oil price of $30/bbl and LNG (fob) at $2.5/GJ, gas in ASEAN is generally valued in excess of $1.7/GJ below which it would need to be to support new LNG exports. Thus the results indicate that at the extraction prices and reserves assumed, an optimal strategy has ASEAN gas resources largely reserved for use in ASEAN. However, it may be true that the opportunity value for ASEAN gas falls below the critical level in some periods thus warranting exports in those periods.

Circumstances that cause significant increases in LNG exports from ASEAN are:

- Lack of interfuel substitution in industry;
- Higher LNG price at base crude oil price;

- High oil price accompanied by similar increase in LNG price; and
- Trade limited in ASEAN.

The latter result suggests that without new discoveries, maintaining high levels of LNG exports will result in less ASEAN gas trade in the longer term to the detriment of the region. Overall, the results suggest that for the region as a whole, the gas resource could be better reserved for use within ASEAN under most assumptions.

Applying CO_2 restrictions advances the start year for imports by 5 years and generally increases the attraction for LNG compared to the Reference Case. The tightening of the restriction from 5% to 10% has a marked effect with imports much greater than with the lower limit. Interestingly, LNG imports are much lower with the emissions limit applied regionally as countries are under much less pressure to reduce their individual emissions.

The following sensitivities apply for variation in LNG prices:

- With the Reference Case assumptions LNG imports from outside ASEAN are approximately 60% of pipeline trade within ASEAN, and about one and a half times LNG trade within ASEAN.
- With a low LNG price, LNG is imported from outside ASEAN rather than traded within ASEAN. However, pipeline trade is not affected.
- LNG imports fall by 28% with a high LNG price but are still substantial. Exports to outside ASEAN increase significantly while pipeline trade is not greatly changed.
- With high energy prices in general (and high LNG price), both LNG imports and exports increase substantially. LNG trade within ASEAN falls 43% and pipeline trade increases by 14%.
- From the three previous comments, gas pipeline trade is not overly sensitive to LNG prices, at least over the range considered.

Conclusions

Important lessons from the third regional policy study can be listed as:

- Energy trade in ASEAN is an effective mechanism for emissions reduction (in addition to economic benefits) since it encourages the use of gas and hydroelectricity.
- The benefits of energy trade would be far more potent if policies and infrastructure are put in place to encourage the use of natural gas in industry.
- LNG is likely to become an important component of energy strategies in the region both with regards to import and export and trade within ASEAN.
- Valuing gas at its opportunity cost (as is done in MARKAL) rather than extraction cost suggests ASEAN gas should be reserved for use within the region rather than exported (additional). More export may be warranted if trade within ASEAN is restricted, gas fails to penetrate industrial markets significantly, or much higher reserves become available.
- Gas pipeline trade is not greatly sensitive to LNG price, at least over the range of LNG prices considered.

- A modest RPS may be necessary to make renewable projects bankable that might otherwise suffer from risk aversion and general lack of investment funding.
- Biodiesel does not appear an effective emission reduction mechanism at the assumed base oil price ($30/bbl). This conclusion may require revision if oil prices remain at 2005 levels.
- A carbon tax of $15/tonne CO_2 applied uniformly across ASEAN could reduce GHG emissions by between 5 and 10% annually for a cumulative reduction over the study period of 5% but could increase electricity prices substantially (in the range 15 – 40% for at least some countries).
- If GHG reduction becomes obligatory then a regional approach is preferable to a National one. However, a suitable scheme for carbon trading or other compensation would need to be developed.

Recommendations

Some further work that the results of this study suggest includes:

- Further analyse the benefits of energy trade in ASEAN for achieving sustainable development regionally.
- Analyse alternative strategies to enhance the opportunity of natural gas penetration in the industrial markets of ASEAN.
- In depth analysis of the possibility of LNG market penetration in ASEAN.
- Analyse policies and options for decreasing petroleum product use in the transport sector and developing alternative fuels in particular from renewable energy.
- Review impacts of existing RPS of ASEAN and analyse policies and options for RPS to enhance bankability of renewable projects for sustaining future energy development.
- Analyse further the best mechanism for GHG emissions reduction in ASEAN in particular regionally.
- Assess the impacts of energy efficient technologies in a range of end-use sectors but particularly in the transport sector.
- Analyse the policies and options for energy efficiency and conservation in ASEAN.
- Assess the possibility of nuclear power plants in an environment of high oil prices.