Deploying Renewables in Southeast Asia

Trends and potentials

International Energy Agency

Samantha Ölz
and Milou Beerepoot

WORKING PAPER

INTERNATIONAL ENERGY AGENCY

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Executive summary

This study is part of the International Energy Agency's (IEA) ongoing analysis of global renewable energy markets and policies, building on the key principles for effective policy design identified in *Deploying Renewables: Principles for Effective Policies* (IEA, 2008).

The IEA chose to do an in-depth investigation in Southeast Asia because of its rapid economic growth, increasing energy demand, rising fossil fuel imports, growing environmental pressures, low rural electrification levels, and heavy reliance on fossil fuels and traditional biomass. Resource endowments vary greatly from country to country, but it is clear that the region offers large potentials for renewable energy sources, most still untapped.

This paper examines the situation in six of the ten countries that comprise the Association of Southeast Asian Nations (ASEAN): Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam (collectively identified as ASEAN-6).[1] In 2007, ASEAN-6 represented more than 95% of energy demand in Southeast Asia. Given their large populations and robust projected economic growth, these six economies are projected to account for more than 80% of energy demand growth in the medium term to 2030 (IEA, 2009).[2]

A main focus of the report investigates the potentials and barriers for scaling up market penetration of renewable energy technologies (RETs) in the electricity, heating and transport sectors in the ASEAN-6 countries. In addition to analysing the implications of effective policies on renewable energy market growth, it examines how to overcome economic and non-economic barriers that slow investment in renewable energy, and offers policy recommendations to encourage effective and efficient exploitation of renewable energy in Southeast Asia. As production is growing rapidly in the region, biofuels and their sustainability implications warrant special attention.

Energy sector trends in the ASEAN-6

The energy sectors of Southeast Asian countries have developed significantly over the past two decades. Energy demand more than doubled between 1990 and 2007, while power generation increased nearly fourfold over the same period.

In 2007, energy supply in the ASEAN-6 region derived from the following sources: fossil fuels (74%); combustible biomass and waste (22%), mostly traditional, inefficient and environmentally unsustainable; geothermal (3%) and hydro (1%). Renewables (mostly hydro and some geothermal) accounted for 15% of electricity generation in ASEAN-6.

The warm climate in ASEAN-6 countries means there is little demand for space heating. Heat is required, at varying levels, for a number of industrial and domestic processes. This offers opportunities for expanding the use of renewable heat. All ASEAN-6 countries have some experience with modern biomass in combined heat and power plants. Demand for space

[1] The paper does not cover the other four ASEAN countries, which include Brunei Darussalam, Cambodia, Laos and Myanmar. The paper reflects data available, sometimes referring to ASEAN-6, sometimes to ASEAN and sometimes to Southeast Asia.

[2] In some other ASEAN countries, problems with collection of energy data represent a substantial challenge to assessing the prospects for renewable energy.

cooling is growing in the region as disposable incomes rise and average temperatures increase as a result of climate change. Renewable energy technologies can contribute to satisfying this demand.

All ASEAN-6 countries except Vietnam produce first-generation ethanol and biodiesel. Production is highest in Thailand, followed by the Philippines and Indonesia. Favourable conditions for biomass cultivation, coupled with related economic and social factors, are expected to boost biofuel production in all these countries. Global innovations in technology and growing awareness among biofuel stakeholders of the need for sustainability criteria have prompted some countries to start research on second-generation biofuels.

Policy frameworks for renewable energy

In recent years, decision makers in most Southeast Asian countries have, through policy implementation, fostered deployment of renewable energy technologies in a more concerted manner. Chief among the driving forces are rising dependency on fossil fuel imports and the environmental impacts of fossil fuel use, including the potential effects of climate change.

Countries in the region have put considerable effort into setting renewable energy targets and are introducing supportive policy frameworks to attract private sector investment. Nearly all ASEAN-6 countries have adopted medium- and long-term targets for renewable energy. Indonesia, Singapore and Thailand also recently announced carbon dioxide (CO_2) emissions reduction targets in support of the Copenhagen Accord (UNFCCC Summit, December 2009). Interest in renewables varies considerably among the ASEAN-6 countries. Renewable energy targets for the medium and long term are much more ambitious in some countries than in others, with Thailand at the forefront (Table ES.1). Targets are important indications of a country's willingness and determination to tap its renewable energy potential.

An effective system of financial and non-financial incentives must also be in place to ensure appropriate conditions to exploit renewables potential. Several ASEAN countries have recently introduced price support systems for renewable energy or are about to do so. Thailand introduced renewable electricity feed-in tariffs (FITs) in 2007. As of early 2010, Indonesia was introducing a FIT for geothermal electricity, and Malaysia and the Philippines had just started drafting guidelines for the introduction of FITs. Other financial incentives for renewable energy in the ASEAN-6 countries include tax exemptions for certain renewable energy technologies in Malaysia, the Philippines and Indonesia, capital costs grants in Thailand and R&D incentives in Singapore.

Malaysia, Indonesia and Thailand have also introduced non-financial support mechanisms, including standard power purchase agreements (PPAs), preferential arrangements for small generators and information support. These initiatives help independent power producers enter the market more easily and reduce barriers specific to non-liberalised energy markets.

Table ES.1: Target and policy support for renewable energy in ASEAN-6 countries

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
RE targets (quantitative objectives)				Not applicable		
Financial incentives						
Non-financial incentives						

Level of support	
	High
	Medium
	Low

Note: RE = renewable energy. This ranking is based on a qualitative assessment of the policy support offered in the ASEAN-6 (a quantitative analysis was not possible in the absence of dedicated modelling).

Source: IEA data and analysis.

Prospects for renewables

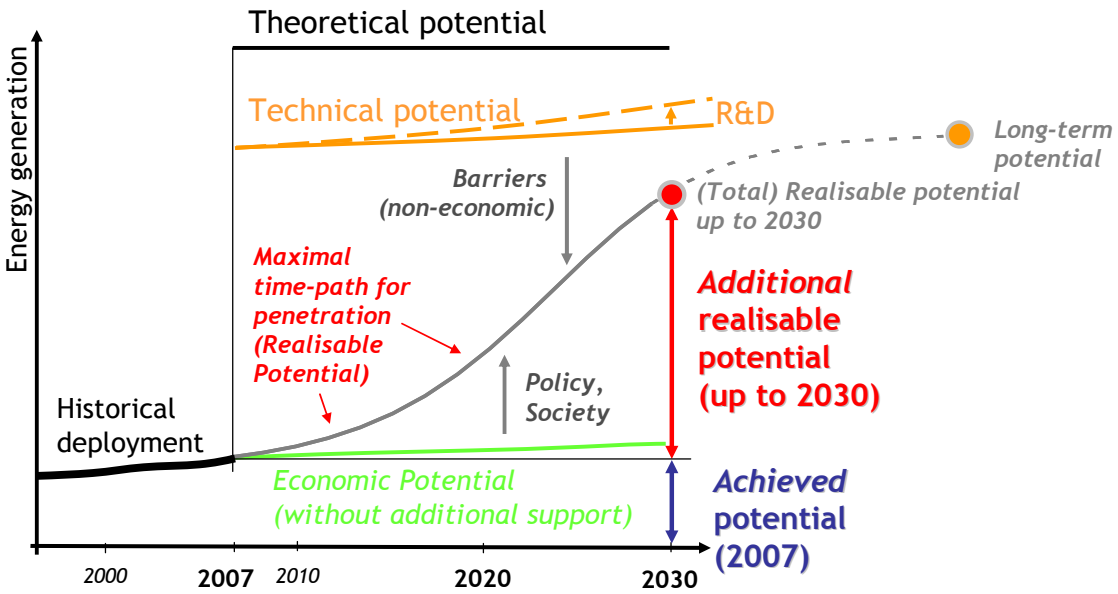
The focus of the potentials analysis is on the so-called medium-term (to 2030) "realisable potentials". The realisable potential represents the maximum achievable potential for a specific technology, assuming that all barriers can be overcome and countries have effective policies in place. The advantage of a realisable potentials approach is that it reveals the maximum deployment possible over a certain time period assuming best policy practice (see Figure ES.1 and a more detailed explanation in Chapter 3). The realisable potential calculations for the individual RETs consider overall energy system constraints. They do not, however, reflect relative costs and, thus, do not deliver a least-cost technology mix.

In the medium term to 2030, there is significant realisable potential for renewables in ASEAN-6 countries covering nearly all renewable energy technologies for electricity, heating, and transport fuel production.[3]

The total potential for renewable electricity (RES-E) in 2030, for example, is about 1.8 times the total 2007 electricity consumption in the region. The additional realisable potential in the ASEAN-6 countries could be as much as 12 times the current deployment of renewable electricity, especially for non-hydro sources. Among non-hydro renewables, significant contributors would be biomass, onshore wind, geothermal and solar photovoltaics (PV) (Figure ES.2).

[3] The realisable potentials calculations are preliminary and will be finalised and presented in the forthcoming IEA publication *Deploying Renewables: Worldwide Prospects and Challenges*.

Figure ES.1: Metrics relating to renewable energy technology potentials



Source: Adapted from *Deploying Renewables: Principles for Effective Policies*.

Key point: In the long run, the realisable potential tends towards the technical potential.

The realisable potential for renewable heating is equivalent to 18% of estimated heat demand in the ASEAN-6.[4] The potential is largest from modern biomass installations,[5] followed by solar thermal and geothermal heat potential.

Domestically produced biofuels for transport have a realisable potential in 2030 which is equivalent to 17% of the ASEAN-6's transport energy demand in 2007. This could make an important contribution to supporting rapid growth of the transport sector in the region, while helping to reduce CO_2 emissions.

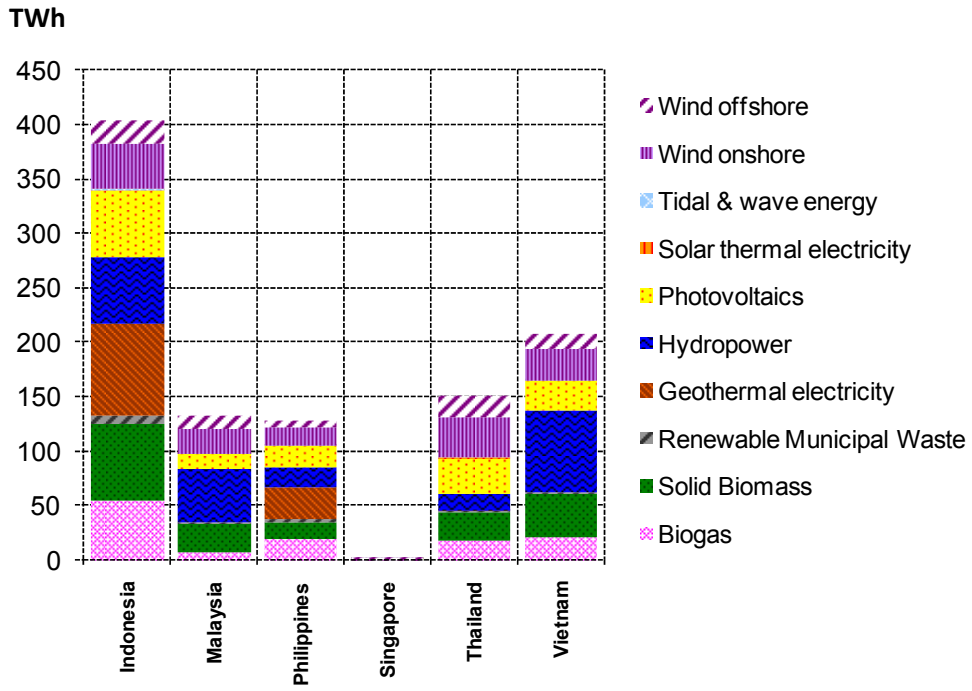
The realisable potential for renewables is significantly larger than the penetration projected in the 450 Scenario described in *World Energy Outlook 2009*. This demonstrates that the main factor hindering growth of renewables is not resource availability, but rather competition from less costly technology options, the prices of which do not adequately account for the external benefits of renewables. As explained in detail below, non-economic barriers can also make renewables more costly and less competitive against conventional energy technologies.

Important socio-economic benefits of large-scale penetration of renewables include improvements in energy security and noteworthy reductions of air pollution and CO_2 emissions, which would contribute to climate change mitigation These co-benefits are associated with high cost savings, although no uniform methodology exists to quantify these savings.

[4] Total residual final energy demand is used as a proxy for heat demand in non-OECD countries using the equation: Residual final energy demand = Total final energy consumption (TFC) – Energy demand for electricity – Transport energy demand – Non-energy use – Residential traditional biomass for cooking.

[5] As opposed to the unsustainable use of traditional biomass.

Figure ES.2: Total realisable potentials for RES-E in ASEAN-6 countries, by technology to 2030



Source: IEA data and analysis; and Resch, 2009.

Key point: The RES-E technologies with the potential to make major contributions in the medium-term to 2030 are primarily those which have already reached, or are close to market competitiveness.

Deployment challenges for renewables in the ASEAN-6

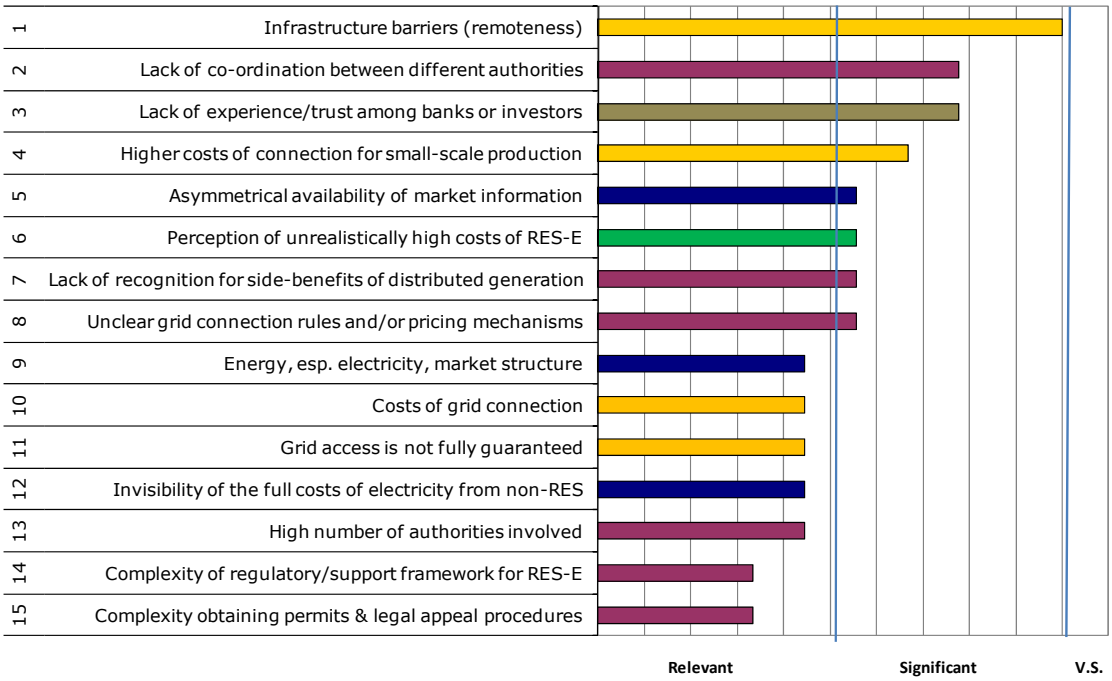
Important drivers for the deployment of renewables include increasing energy market liberalisation in most ASEAN countries, the introduction of favourable policy frameworks, and the rapidly improving economics of individual renewable energy technologies. The environment for investment and financing for renewables in ASEAN-6 countries has improved in recent years. However, current levels of renewable energy-related investment in the region fall far short of those required to achieve a low-carbon energy revolution.

Substantial non-economic barriers, such as infrastructure and grid-related problems and regulatory and administrative hurdles, continue to be a major impediment to the deployment of renewables (Figure ES.3). These barriers can have high economic impacts by increasing the return on investment required by financiers, especially if their impact is primarily in the earlier investment-intensive project cycle phases. Investors are likely to require a high risk premium to accept the possibility of policy changes affecting renewable energy project development.

A recent survey of international investors in wind energy and solar PV generation found that they perceived the following risk factors as most relevant: legal security, negative policy changes affecting renewables, the main financial support scheme and total revenues received.

A wide range of measures exist to help eliminate the non-economic barriers identified in the ASEAN-6 countries, but most require co-ordination among all major stakeholders. To unlock sufficient and well targeted investment in renewables, it is essential to implement effective and coherent renewable energy policies with a long-term strategic perspective.

Figure ES.3: Ranking of non-economic barriers in selected ASEAN countries



Legend:

- Technical/infrastructure barriers
- Administrative and regulatory barriers
- Market barriers
- Financing barriers
- Socio-cultural barriers

"Relevant", "Significant" and "V.S." refer to a barrier that is deemed "relevant", "significant" or "very significant" respectively based on the survey results.

Source: Lamers, 2009.

Key point: Technical/infrastructure barriers (including grid-related barriers) rank highest in obstacles identified in ASEAN countries, followed by administrative and market-related hurdles.

Another perceived challenge – specifically for large-scale expansion of biofuel production – is sustainability of the region's biofuel industry, which is currently exclusively geared towards first-generation biofuels. Concerns about land-use change and resulting greenhouse-gas (GHG) emissions have led to scientific discussion on how to measure the impact of land-use change on the greenhouse-gas balance of biofuels. ASEAN-6 governments are beginning to engage in

initiatives on developing and implementing sustainability criteria for biofuels.[6] Criticism of some first-generation biofuel pathways has focused attention on the potential of so-called advanced and second-generation biofuels.[7] To establish viable second-generation biofuel industries, ASEAN-6 governments need to strengthen framework conditions, including appropriate infrastructure, adequate skilled manpower and financing options.

Conclusions and recommendations

Key messages

- The realisable potential for renewables is large across all the ASEAN-6 countries except Singapore, due to its small land area. The composition and relative weight of individual renewable energy technologies are similar in all six countries, with hydro, biomass, wind and solar PV contributing significant shares. Geothermal electricity and heat are concentrated in Indonesia and the Philippines.
- The ASEAN-6 countries are diverse in terms of their renewables potentials when calculated on a per-capita or per-GDP basis. In absolute terms, Indonesia, for example, has the highest total realisable potential for renewables across all sectors; in per-capita terms, Malaysia has the largest renewable electricity potential; and Vietnam shows the highest potential for renewable electricity in terms of its level of economic development.
- Some countries have above average per-capita potential levels relative to their population share; for example, Malaysia for renewable electricity and Singapore for renewable heat (especially solar thermal). Thus, these countries probably still have substantial opportunity to further exploit their realisable potential.
- Countries such as Vietnam, which has low national income but relatively large realisable potential, may find it challenging to tap renewables potential through domestic efforts alone, partly because of the high cost of supporting development and deployment. Development assistance can play an effective role by supporting the implementation of coherent and comprehensive renewable energy policy frameworks and providing innovative co-financing options.
- The level of achieved deployment influences the realisable potential over a specific time period. ASEAN-6 countries, for example, currently have lower deployment and thus, lower potential. The average realisable potential per capita to 2020 in countries belonging to the Organisation for Economic Co-operation and Development (OECD) exceeds that of the ASEAN-6 by a factor of over eight. The group of emerging economies of Brazil, Russia, India, China and South Africa (BRICS) has a per-capita realisable potential which is at least twice that of the ASEAN-6. This is because the OECD and BRICS economies, particularly the OECD economies, have more mature renewable energy markets which will experience more rapid development.

[6] Key sustainability criteria being debated include minimum GHG emissions savings, definition of suitable land for biofuel cultivation and social standards.

[7] There are two different conversion pathways for second-generation biofuels: the *thermo-chemical* route, in which biomass is gasified to produce bio-Synthetical Natural Gas (SNG) or BTL-diesel (the latter via Fischer-Tropsch synthesis); and the *bio-chemical* route, in which enzymes or micro-organisms are used to convert cellulose and hemicellulose in the biomass to sugars, which are then fermented to produce ethanol.

- By contrast, the per-unit GDP potentials of the ASEAN-6 and OECD countries are quite similar. This indicates that, in terms of economic development, the ASEAN-6 countries are on average in a similar position to the OECD countries to exploit their renewable energy potential. However, the per-GDP potential for renewable electricity of the ASEAN-6 is less than half that of the BRICS. This is because, although they have similar per-capita GDP levels, the larger land area of the BRICS supports a larger overall deployment potential.
- Targets are important indications of a country's willingness and determination to tap its renewable energy potential. But an effective system of financial and non-financial incentives must also be in place to ensure appropriate conditions to exploit such potential. Both economic and non-economic barriers can skew the playing field against innovative renewable energy technologies, which require targeted support to help bring them into the energy market.
- All ASEAN-6 countries except Singapore have introduced medium- to long-term renewable energy targets. However, the targets vary greatly in their quantitative objectives, time horizons and specificity. This difference can be explained to some extent by the countries' different levels of economic development, but less so by population and resource potentials. Thailand and Malaysia have similar renewable electricity potential, but Thailand's per-capita GDP level is half that of Malaysia. Nonetheless, Thailand has implemented much more ambitious targets and incentive mechanisms than Malaysia.
- Several countries in the region have either not yet introduced incentives to support their national targets or have let such incentives languish at the drafting stage.

Recommendations

To achieve large-scale diffusion of renewables, Southeast Asia should:

- **Reduce as much as possible non-economic barriers to the diffusion of renewable energy.** Non-economic barriers (such as administrative hurdles, grid access issues, persistent fossil fuel subsidies, and lack of information and training) continue to hinder the deployment of renewables in the ASEAN-6 countries. Reducing these barriers should be a key priority for policy makers – and thus, a focus of policy design and implementation – irrespective of the type of incentive scheme planned.
- **Remove distortionary subsidies for fossil fuel consumption and production.** These subsidies often benefit more affluent segments of society rather than the poor. Removing them will help level the playing field so that renewable energy technologies can compete with other energy carriers. In this regard, it is critical to take into account all of the external benefits and costs of all energy technologies.
- **Ensure that renewable energy incentives do not shift a disproportionate share of the additional financial burden to the poorest households.** Adapting policy support to national development objectives can help minimise impacts on wealth distribution; for example, a national renewable energy development fund can foster renewables by providing a support mechanism to supplement a regulated end-consumer tariff.
- **Devise renewable energy policies that are predictable and consistent with the overall energy policy framework.** Such measures ensure that potential investors have adequate confidence in the stability of the support system. A wide variety of incentive schemes exist for renewables; their effectiveness in fostering market uptake depends more on design and implementation than on the specific type of incentive.

- **Encourage off-grid applications of renewable energy** to help advance electrification and socio-economic development objectives.
- **Promote sustainable production of biofuels** by actively supporting strong sustainability criteria and certification schemes.
- **Establish platforms to exchange experience in developing and implementing renewable energy policy, and in reducing barriers to deployment of renewables.** These could build on the ASEAN Plan of Action for Energy Co-operation or the APEC Energy Working Group.
- **Establish and evaluate** harmonised market rules and incentives for renewables across the region, in step with the ongoing expansion of the ASEAN Power Grid.
- **Design renewable energy policies to complement climate change policies and to derive maximum benefit from climate change financing options.** This will encourage sufficient investment flows and help meet climate, energy security and environmental objectives.

Introduction

This Working Paper forms part of the International Energy Agency's (IEA) ongoing analysis of global renewable energy markets and policies, which builds on the key principles for effective policy design identified in earlier IEA analysis, *Deploying Renewables: Worldwide Prospects and Challenges*. The study looks specifically at Southeast Asia and investigates in details the potentials for, and barriers to, scaling-up the market penetration of renewable energy technologies in the region. It aims to provide recommendations on how to put into practice the key principles for effective policy design.

Southeast Asia – and, more specifically, the Association of Southeast Asian Nations (ASEAN) of ten countries: Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam – has been chosen as it is a very dynamic region in terms of rapid and continuing economic growth prospects, increasing energy demand and rising fossil fuel imports. This is coupled with growing environmental pressures, such as greenhouse-gas emissions, regional air pollution, persistently low electrification levels in rural areas and a heavy reliance on fossil fuels and traditional biomass. At the same time, the region presents large potentials for renewable energy sources, though most of which remains untapped, and the resource endowments differ greatly from country to country.

This paper focuses on developments and prospects of renewable energy sources in six out of the ten countries in the region: Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam (ASEAN-6). These countries represented in 2007 more than 95% of energy demand of Southeast Asia. Given their large populations and robust projected economic growth, these six economies are projected to account for more than 80% of energy demand growth in the medium-term to 2030 (IEA, 2009b). In addition, energy data collection is also a substantial challenge in assessing the prospects for renewable energy in several of the other ASEAN countries.

Chapter 1 sets the scene by outlining the overall energy sector panorama in the individual ASEAN-6 countries as well as the market trends for renewable energy in the electricity, heating and transport sectors since 1990. In Chapter 2, the study identifies policy, environmental and economic drivers for the growing penetration of renewables in the region, detailing the different policy support offered in the six countries. Chapter 3 reviews the future prospects for the different renewable energy technologies in the six countries, assessing their respective substantial potentials as well as their projected market deployment, based on two distinct scenarios, and highlights the socio-economic benefits associated with a large-scale renewables penetration. Chapter 4 discusses financing and investment trends for renewables in the region and highlights the large gap between what is currently flowing into the sector and what is in fact needed for the ASEAN-6 to tap their renewables potential to a much larger degree. Chapter 5 analyses in detail the different challenges and perceived risks to the deployment of renewables, which affect the effectiveness of the policy mechanisms in place and the investment flows into the sector. Chapter 6 draws out conclusions, comparing the performance of the focus countries with respect to the exploitation of their renewables potentials, policy targets and support as well as the barriers standing in the way. It also offers recommendations on how the Southeast Asia region can encourage a large-scale diffusion of renewables through effective policy tools.

1. Current status of the energy sector in the ASEAN-6

Key findings

- The energy sector of the ASEAN-6 countries expanded significantly between 1990 and 2007. Energy demand more than doubled, from 230 million tonnes of oil equivalent (Mtoe) in 1990 to 490 Mtoe in 2007 (4% of world energy demand). Electricity generation in these countries increased nearly fourfold over the same period.

- In 2007, fossil fuels accounted for 74% of the energy supply in the ASEAN-6 countries, combustible biomass and waste 22%, geothermal 3% and hydro 1%. Renewables accounted for 15% of ASEAN-6 electricity generation (12% hydropower and 3% geothermal).

- In the ASEAN-6 countries, combustible biomass consists mainly of traditional solid biomass. Although considered a renewable energy source, traditional biomass is not an effective solution in this region, due to inefficient use (generally less than 10% efficiency) and associated environmental and health concerns.

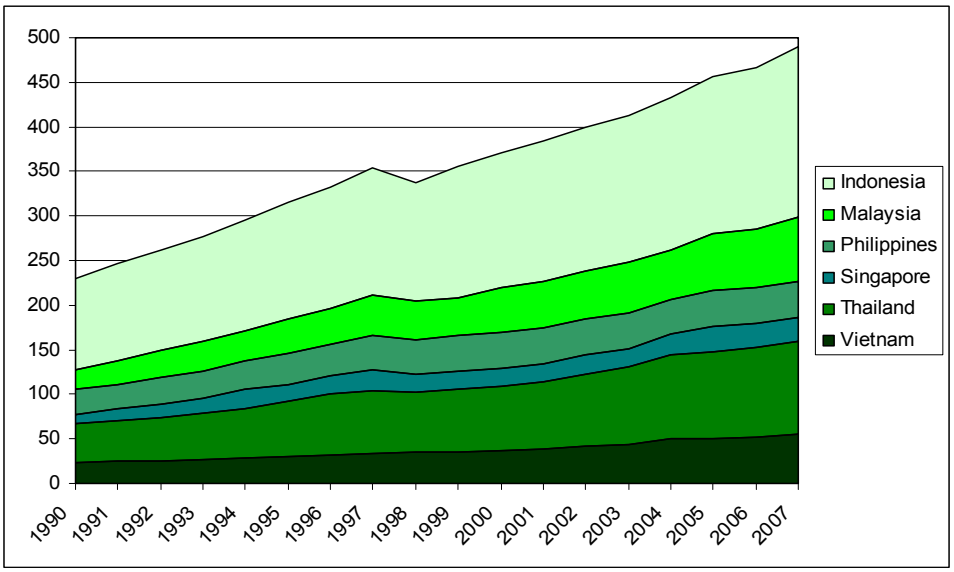
- The warm climate in ASEAN-6 countries means there is little demand for space heating; however, heat is required at varying levels for many industrial and domestic processes. This offers opportunities for expanding the use of renewable heat. All ASEAN-6 countries have some experience with modern biomass in combined heat and power plants.

- All ASEAN-6 countries except Vietnam produce first-generation ethanol and biodiesel. Production is highest in Thailand, followed by the Philippines and Indonesia. Favourable conditions for biomass cultivation, coupled with related economic and social factors, are expected to boost biofuel production in all these countries. Global technology development and growing awareness among biofuel stakeholders of the need for sustainability criteria have prompted some countries to start research on second-generation biofuels.

1.1. Primary energy

The energy sector of ASEAN-6 countries has shown a significant development over the last few decades. The energy demand more than doubled from 230 Mtoe in 1990 to 490 Mtoe in 2007 (Figure 1.1), which represents 4% of global energy demand in 2007.

Figure 1.1: Evolution of primary energy demand in ASEAN-6 (in Mtoe)



Source: IEA, 2009a.

Key point: Energy demand in the ASEAN-6 countries more than doubled from 230 Mtoe in 1990 to 490 Mtoe in 2007.

Fossil fuels accounted for 74% of the energy supply in 2007, followed by combustible biomass and waste with 22%, geothermal and hydro supplying 3% and 1% of energy, respectively (Table 1.1).

Traditional use of biomass for cooking still dominates a large part of total final energy demand in the ASEAN-6 countries. As of 2004, an average 75% of Indonesia's population still relied on traditional biomass for cooking, with the vast majority concentrated among the rural population (95%), double the share of the urban population (45%)[8] (IEA, 2006). The main use of biomass energy in these countries is firewood for cooking by people living in rural areas where low incomes and the lack of access to alternative, modern fuels explain their choice of traditional energy supply. Traditional biomass used for basic cooking and heating is usually locally available at very low cost and is converted to heat at very low efficiencies of less than 10% on open fires. Traditional biomass-fired stoves cause significant greenhouse-gas (GHG) emissions due to formation of products of incomplete combustion; also, exposure to smoke from these stoves causes serious health problems. Although traditional biomass is a renewable energy source, the

[8] The rest of Asia showed similar, if slightly lower, averages of the total population using traditional biomass for cooking, namely 65% (IEA, 2006).

inefficient use and associated environmental problems are reason for not advocating this kind of renewable energy use. This publication therefore does not take into account the use of traditional biomass in estimating the realisable potentials for renewable energy in the ASEAN-6 countries.

Table 1.1: Total primary energy supply in 2007 (in ktoe)

	Coal	Oil and oil products	Natural gas	Hydro	Geo-thermal	Solar and wind	Biomass	Electri-city	Total
Indonesia	36.780	60.084	34.392	971	6.036	0	52.385	0	190.647
Malaysia	8.854	25.833	34.654	558	0	0	2.885	-195	72.589
Philippines	6.329	13.434	3.032	736	8.782	5	7.662	0	39.980
Singapore	8	19.989	6.757	0	0	0	0	0	26.754
Thailand	14.225	41.919	28.304	698	3	0	18.535	307	103.991
Vietnam	9.890	13.332	5.456	2.570	0	0	24.538	0	55.787
ASEAN-6	**76.087**	**174.591**	**112.595**	**5.533**	**14.820**	**5**	**106.005**	**112**	**489.748**
Percentage	16%	36%	23%	1%	3%	0%	22%	0%	100%

Source: IEA, 2009a.

Key point: Fossil fuels accounted for 74% of ASEAN-6 energy supply in 2007, followed by combustible biomass and waste with 22%, geothermal and hydro supplying 3% and 1% of energy, respectively.

The rapid growth of energy demand, caused by an increasing population as well as favourable economic growth rates, results in ASEAN-6 countries being faced with pressure on energy access and energy security. This is reinforced by the complicated archipelagic geography of the region. Even though Southeast Asia is a net exporter of energy, the countries differ very much in their reserves of fossil fuels and are, except for Vietnam, dependent on imports of at least one fossil fuel. Mature renewable energy technologies, hydro and geothermal, are developed in the region but still have large potential for further expansion. New technologies like solar and wind start to see their deployment in recent years but their fraction in the total energy mix remains negligible.

Indonesia is one of the leading exporters of steam coal in the world and also one of the largest exporters of LNG. Since 2004, the country's oil production has been declining and as a result insufficient to cover the oil demand. Indonesia has therefore become a net importer of oil. Indonesia is one of the two countries in the region with abundant sources of geothermal energy that could be further developed.

Malaysia has large reserves of natural gas and oil and is one of the largest exporters of liquefied natural gas (LNG) in the world. Coal needs of the country are largely covered by imports. A small part of the country's electricity generation comes from hydro sources.

The Philippines are highly dependent on imports of fossil fuels. They have huge resources of geothermal energy. In 2007, geothermal provided at about 22% of energy demand of the country, and it still could be further developed.

Singapore has no reserves of fossil fuels but plays a very important role as an oil trading and refining hub for the region.

Thailand has a relatively diversified energy sector with production of all fossils fuels as well as hydro electricity. The production is not sufficient to cover country's energy needs: Thailand is a net importer of fossil fuels as well as electricity. Nevertheless, the uptake of renewable energy sources is actively promoted by the government in a 15-year development plan introduced in 2008 which targets an increase in renewable energy's share of total final energy demand to 20% by 2022.

Vietnam is a net exporter of oil and gas and is an important exporter of coal. It has the largest hydro electricity production in the region. Use of traditional biomass in rural areas remains still very high, with 44% of energy needs of the country covered by solid biomass.

In the Reference Scenario of the *World Energy Outlook 2009*, which assumes a business-as-usual trajectory based on existing trends and policies, the primary energy demand of Southeast Asia up to 2030 is projected to increase on average by 2.5% *per annum* (IEA, 2009b). Despite this rapid growth, this would still imply per capita energy consumption at one third of the current average OECD level.

In 2030, the energy mix in the Reference Scenario is projected to consist of 76% of fossil fuels, with rapid increase of coal consumption, 18% of biomass, down from 23% in 2007, and 5% and 1% covered by other non-hydro renewables and hydro respectively. The use of biomass changes over time and from country to country. Modern uses like biomass for power generation and liquid biofuels start to appear in more developed countries in the region, while traditional use of biomass, mostly for cooking, decreases. The highest growth rate over the outlook period is expected for non-hydro renewables like solar, wind and geothermal, with an average annual growth of 4.9%. Hydro is projected to grow at the pace which guarantees that its share in the primary energy mix stays relatively stable until 2030.

The more ambitious 450 Scenario[9] assumes that the region adopts policies and measures leading to improvement of energy efficiency across all energy sectors, and promoting low-carbon and renewable energy technologies. Under these assumptions, the growth of primary energy demand in Southeast Asia is slower than in the Reference Scenario. The decline with respect to the Reference Scenario is significant for coal as well as for oil demand. This is due to improved efficiency in the transport sector and coal-fired power generation as well as deployment of nuclear and renewable energy technologies which displace a part of coal-fired electricity generation. Low-carbon technologies cover 36% of total energy demand, with the most spectacular increase for solar, wind and geothermal technologies which together satisfy almost 11% of regional energy demand by 2030. Deployment of relatively costly low-carbon technologies in the 450 Scenario implies higher necessary investment in the energy sector.

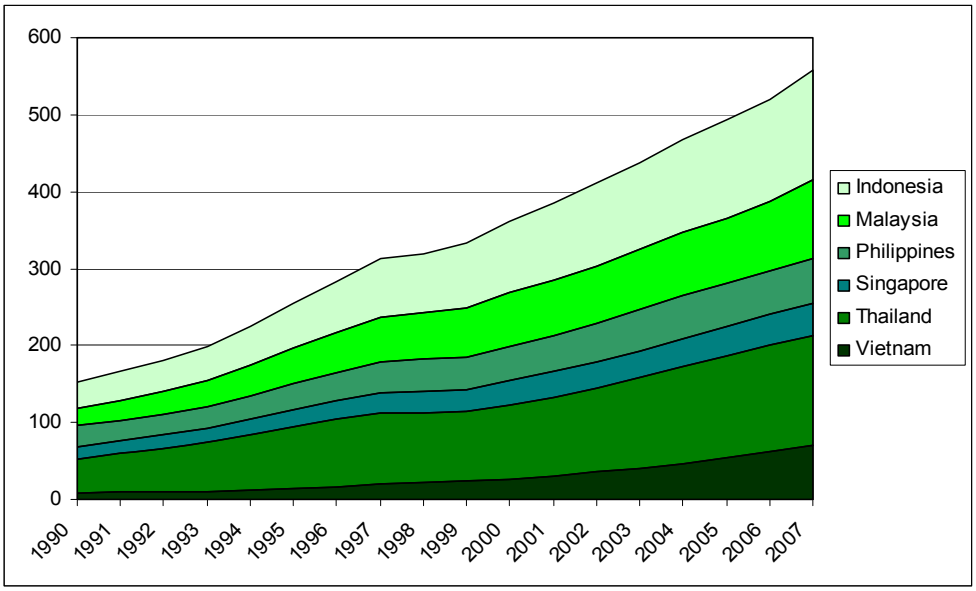
[9] The IEA ambitious 2009 *World Energy Outlook* 450 Scenario analyses measures to force energy-related CO_2 emissions down to a trajectory that – taking full account of the trends and mitigation potential for non-CO_2 greenhouse gases and CO_2 emissions outside the energy sector – would be consistent with ultimately stabilising the concentrations of all greenhouse gases in the atmosphere at 450 ppm of CO_2 equivalent. This level of concentration has a roughly 50% chance of giving rise to a global temperature increase of 2 °C.

However, savings implied by lower demand and higher efficiency in this scenario more than compensate for this excess investment compared to the Reference Scenario.

1.2. Electricity production

Electricity generation in ASEAN-6 countries has experienced a dramatic increase since 1990 and, in 2007, reached 557 terawatt-hours (TWh) (Figure 1.2).

Figure 1.2: Evolution of electricity generation in the ASEAN-6 (in TWh)



Source: IEA, 2009b.

Key point: Electricity generation in ASEAN-6 countries increased nearly fourfold from 1990 levels to 2007

In 2007, almost 85% of electrical power was generated from fossil fuels, whereas hydro and geothermal electricity generation represented 12% and 3% respectively, and other renewables only had a negligible share (Table 1.2).

Table 1.2: Electricity generation in the ASEAN-6 in 2007 (in GWh)

	Coal	Petroleum products	Natural gas	Hydro	Geothermal	Solar and wind	Biomass	Total
Indonesia	63.830	37.703	22.396	11.286	7.021	0	0	142.236
Malaysia	29.902	2.074	62.858	6.490	0	1	0	101.325
Philippines	16.837	4.495	19.442	8.563	10.215	59	0	59.611
Singapore	0	8.762	32.372	0	0	0	0	41.134
Thailand	30.681	3.848	96.542	8.114	3	0	4.190	143.378
Vietnam	14.839	2.466	22.299	29.883	0	0	0	69.487
ASEAN-6	**156.089**	**59.348**	**255.909**	**64.336**	**17.239**	**60**	**4.190**	**557.171**
Percentage	28%	11%	46%	12%	3%	0%	1%	100%

Source: IEA, 2009a.

Key point: In 2007, renewables accounted for 15% of ASEAN-6 electricity generation, consisting of 12% hydro electricity and 3% geothermal electricity.

Power generation, transmission and distribution are in most ASEAN-6 countries (except for the Philippines and Singapore) in the hands of vertically integrated state-owned utilities, with small independent power producers present. In the Philippines, the market has been unbundled, and Singapore has a liberalised market. In September 2009, Indonesia has passed the law that ends electricity monopoly of the state utility PT PLN and allows regional governments to set up their own electricity rates (IHS Global Insight, 2009a).

Electricity regulatory bodies are present in Malaysia, the Philippines, Singapore and Thailand. Independent power producers (IPPs) mostly provide distributed or stand-alone power generation, either produced from renewable energy sources or by co-generation. For grid-connected generation of IPPs, the excess production can usually be fed into the grid, except for Vietnam where every contract has to be negotiated with the state utility. The respective policies are listed in Table 1.3.

Table 1.3: Policies encompassing purchase of power generated using renewable energy

Indonesia	Ministerial Decree on Small Distributed Power Generation using Renewable Energy
Malaysia	Renewable Energy Power Purchase Agreement
Philippines	Renewable Energy Act
Thailand	Small Power Producer (SPP) and Very Small Power Producer (VSPP) Tariffs ("Adder" scheme for generation of renewable power)

Sources: ASEAN Centre for Energy, ICRA project; Australian Business Council for Sustainable Energy; IEA, 2009e.

Key point: Four ASEAN-6 countries introduced policies regulating renewable power generation by independent power producers (IPPs).

The presence of IPPs is certainly not sufficient to guarantee access to power in the region. Electrification rates vary across countries, with the lowest rate of 65% for Indonesia (IEA, 2009b). The archipelago geography of the country implies that isolated islands have very low electrification rates, pushing down the overall rate for Indonesia. Other countries of the region have significantly higher electrification rates, namely, Malaysia 99%, the Philippines 86%, Singapore 100%,[10] Thailand 99%, and Vietnam 89% (IEA, 2009b).

The dispersed geography of the region sometimes also implies that the closest power generation system is located in the neighbouring country. Establishing grid interconnections and institutional frameworks for electricity trade can therefore contribute to solving problems of energy access. For example, since 1996, Thailand has benefited from interconnection with Laos to import hydro-produced electricity and thereby cover the gap between demand and insufficient domestic power supply. Creation of the ASEAN Power Grid (APG) is addressed as one of six areas of the ASEAN Plan of Action for Energy Co-operation, in its third cycle for the years 2010-15. The APG can benefit from the fact that there are countries with abundant natural resources in the region, like hydro of the river Mekong, that are less developed and therefore have lower power demand. The countries with oversupply of electricity can benefit from selling their power production to more developed and richer neighbours which, on the other hand, would benefit from relatively cheap power imports. Creation of the functional regional grid that could provide more secure power supply to the region will not only mean construction of interconnections but also harmonisation of construction and O&M standards; harmonisation of regulatory frameworks; agreement on import, export and transit fees, which is a major challenge for all governments of the countries participating in the APG. At present three APG interconnections already exist, 12 others are planned to be put in place before 2015 (IEA, 2009b).

Southeast Asian power systems also, due to rapid development of the region, have problems to cope with the increasing electricity demand. For example, Electricity of Vietnam forecasts that power consumption in the country will grow by 13-14% in 2010, compared to 2009 (IHS Global Insight, 2009b). As a part of the effort to cover the increasing demand, Vietnam is planning to develop additional small and medium scale hydropower plants. This technology was chosen because the resource is abundant in Vietnam and construction as well as operation and maintenance costs are relatively low.

Indonesia introduced its second 10 000 MW Power Programme in 2009 (to be completed in 2014) in its efforts to scale up the power generation system (IHS Global Insight, 2009c). This programme will tender up to 83 power plants. The shares of future power production should be 12% from hydroelectric plants, 48% from geothermal plants and with the rest covered by fossil fuels, in particular by coal and gas. The Indonesian government is trying to reduce its dependence on oil-fired power generation and focuses its attention on locally available geothermal and hydro sources as well as relatively cleaner natural gas. Indonesia also works on strengthening its transmission network. A connection of six power plants in South Sumatra and an underwater power line between Sumatra and Java islands should be built in the period 2011-16 (IHS Global Insight, 2009d).

[10] Singapore Island is 100% electrified while Pulau Ubin has off-grid electricity.

1.2.1. Electricity production from renewable sources, country-by-country

Electricity production from renewable sources in the ASEAN-6 region is significant. It represents more than 15.4% of the total power production of the region, which is the same share as for renewables-based power production in the OECD countries.

Indonesia is one of the two countries in the region that has abundant geothermal resources and also produces a noteworthy part of its power from hydro sources. In 2007 geothermal and hydro covered, respectively, 5% and 8% of the total power production of the country. New renewable energy technologies are being deployed. By 2008, 2 megawatts (MW) of wind and 12 MW of solar PV had been installed in the country. The Reference Scenario of the *WEO 2009* forecasts that the electricity production of Indonesia will almost triple by 2030 to achieve the level of 453 TWh, of which about 16% is projected to be covered by renewable energy sources (IEA, 2009b). In particular, Indonesia has potential to further significantly develop its hydro and geothermal production.

In 2007, **Malaysia** produced 6.5% of its power from renewable sources, mainly hydro. Installed solar PV capacity in the country in 2008 was almost 2 MW. Reference Scenario of the *WEO 2009* forecasts the country's power needs to double by 2030 to reach the level of 216 TWh. Hydro power is forecasted to supply only 4% of total power in 2030. Malaysia has very little geothermal resources but could develop its biomass and solar PV potentials. The target for the contribution of renewables in the power generation is 10% in 2010 and the ratio should be kept constant with further development of the power sector.

The power sector of the **Philippines** already has a very large share of renewables-based production in the region, with hydro covering more than 14% of electricity needs of the country and geothermal electricity providing more than 17%. The Philippines also have the most developed wind power generation in the region with cumulative installed capacity of 33 MW in 2008. The Philippines have potential for further substantial expansion of geothermal power generation. Under the International Action Programme (IAP)[11] the country is planning to have 4700 MW of renewables-based capacity installed by 2013, which should mean that the Philippines will lead in the global production of geothermal electricity and also make the country the largest producer of wind power in Southeast Asia. The hydro capacity is projected to double compared with the 2003 level.

Historical data for **Singapore**[12] show no officially reported power generation from renewables. Due to the very small size of this densely inhabited island country and low renewable energy endowment, the most exploitable potential is to develop solar PV power production. In fact, installed solar PV capacity has grown by more than a factor of 100 between 2005 and 2009, reaching 2 000 kW_p in 2009 (Jacobs and Sovacool, 2010). This rapid increase has been driven mainly by specific investment incentives to buy down the capital cost of PV systems, which has attracted commercial, industrial and large-scale residential project developers. In addition, support for research, development and demonstration projects, mostly for public facilities, has encouraged the installation of PV systems as part of the government's efforts for Singapore to become a test-bed for new energy technologies (*ibid.*)

[11] IAP is one of the main outcomes of the International Conference for Renewable Energies held in Bonn in June 2004. It includes concrete actions of governments, international organisations and other stakeholders towards development of renewable energies.

[12] Singapore Island is 100% electrified while Pulau Ubin has off-grid electricity.

Within the context of this Clean Energy Research and Test-Bedding Programme, Singapore also plans to completely power Pulau Ubin Island with clean and renewable energy. At present the island is not connected to the grid because it is not economical considering the island's low power demand. The island has no grid and is entirely powered by individual diesel generators. This gives a unique opportunity to displace diesel generation by building a micro-grid with distributed generation entirely powered by renewable energy sources like solar PV, wind and biomass.

The power sector of **Thailand** currently does not have sufficient capacity to cover electricity needs of the country. Thailand has for several years now been importing 3-4% of its electricity demand. Renewables-based electricity generation is not very significant. Hydro generation represents roughly 5.5% of electricity production of the country. Thailand is the only country in the region which uses modern solid biomass as well as biogas for electricity production, together representing 3% of the total power production. The Reference Scenario of the *WEO 2009* projects electricity demand to reach 325 TWh in 2030, up from 143 TWh in 2007, of which only 12% is projected to be covered from renewable sources (IEA, 2009b). In 2008, the Thai Ministry of Energy published the Renewable Energy Development Plan (REDP) to set targets for the deployment of renewable energy for the period 2008-22. It sets as a main target to increase renewable energy's share of total final energy demand to 20.3% in 2022.

Vietnam is the country with the largest potential as well as deployment of hydropower in ASEAN-6 region. Hydro represented 43% of country's electricity production in 2007. Vietnam, in its rural electrification projects, encourages the use of renewable energy like small hydro, wind, and solar PV in the electrification of isolated areas far away from the existing grid.

All countries in the ASEAN-6 region have feedstock sources for modern biomass-based power generation from agro-industrial and municipal wastes. Abundant feedstocks in the region are rice husk, sugar-cane bagasse from the sugar industry, empty fruit bunches from the palm oil industry, coconut husks, and cassava from tapioca production. Municipal waste, landfill gas and also gases produced from agricultural waste and wastewater from food processing and brewery industries can be used for waste-to-energy purposes. Malaysia, together with Indonesia, account for more than 80% of global palm oil production. Thailand ranks second in the world production of cassava, fourth in the production of sugar cane and palm oil, and sixth in the production of rice and coconuts (FAO, 2009).

The waste from all these industries could serve for power production, mainly cogeneration, which would be environmentally sustainable and economical at the same time. One of the barriers to rapid development of this production is uncertainty about prices of agro-industry wastes. In some countries wastes like rice husk are still dumped or burned, in others their prices can be relatively high. Another problem with supply comes from competition for feedstock with liquid biofuels industry. This will become even more pronounced once commercial production of second-generation biofuels starts.

At present the only ASEAN-6 country reporting biomass for power generation is Thailand, using mainly rice husks and bagasse. Singapore has several waste-to-energy incineration plants with recuperation of heat for electricity production, which incinerate all incinerable municipal waste including wood, paper, and food wastes.

1.3. Heat production

1.3.1. Typologies of heat demand and potential applications in ASEAN countries

Due to the tropical and sub-tropical climates in the ASEAN countries, heat demand for space heating is nearly absent. Remaining heat demand consists of industrial heat, heat for domestic hot water and heat for cooking. Low- and medium-income households have relatively low heat demand for domestic hot water since it is considered as a luxury service. The demand for domestic hot water is therefore limited to high income households, hotels and hospitals. However, the demand for domestic hot water is expected to increase in correlation with rising affluence. Industrial heat demand consists of several processes requiring low, medium or high temperature heat (Table 1.4). Renewable heat can be produced from biomass, geothermal sources or solar thermal heat.

Table 1.4: Heat demand temperature levels and applications in ASEAN countries

	Temperature level	Industrial processes	Domestic processes
Low temperature heat	< 100 °C	- Cooking (food) - Drying (food/textile) - Washing (textile)	- Hot water heating - Laundry
Medium temperature heat	100 °C to 400 °C	- Cooking (food) - Bleaching (textile) - Drying (food) - Air conditioning/ cooling	- Cooking (food)
High temperature heat	>400 °C	- Energy intensive industrial processes: food, pulp and paper, chemicals, metals and oil refining sectors	- Not applicable

Sources: Ecoheatcool, 2006; Balasankari and Mathias, 2009; Meyer, 2009.

Key point: A number of industrial and domestic processes require different heat demand levels and allow for coverage by renewable heat, although climatic conditions in ASEAN-6 countries mean that there is very little demand for space heating.

The tropical and sub-tropical climatic conditions of the ASEAN-6 countries offer favourable conditions for the use of solar energy. **Solar thermal technology** is a relatively simple technology, producing low temperature heat that is derived from solar radiation by heating a fluid circulated through a collector. Solar thermal technology does not require expensive manufacturing technology, providing good opportunities for the technology to be produced with locally available materials. Moreover, solar domestic hot water systems offer in ASEAN-6 countries a better rate of return in terms of investment to reduce carbon emissions than an investment in a photovoltaic system (JGSEE *et al.*, 2007).

Indonesia and the Philippines, being located on a volcanic belt, have huge potential for the use of **geothermal energy** with high temperature resources that are relatively easy to drill. Both countries already use their geothermal resources for electricity generation, but direct use of geothermal heat is still limited. Although there is no potential for direct use of geothermal heat for space heating in ASEAN-6 countries, there are possibilities of using geothermal heat directly for agriculture processes such as crop drying or refrigeration. Geothermal energy can also be used in small combined heat and power plants where the waste water of electricity production is cascaded for agriculture processes.

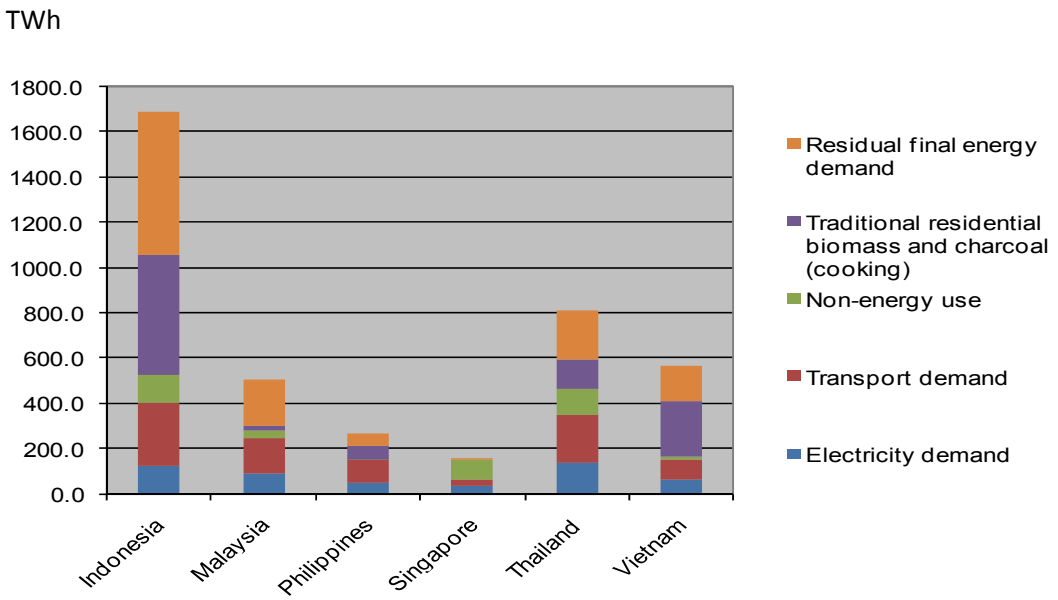
Similar to geothermal energy, **biomass** has the versatility to produce several types of energy carriers whereas next to electricity and heat it can also produce biogas and liquid fuels. The vast and variegated agriculture in ASEAN countries has given it a very good position in the development of biomass consisting of agricultural waste such as rice husks, bagasse, corn leaves, tapioca, palm shell and woodchips. More recently, ASEAN countries have deepened their interest in the modern use of agricultural residues as feedstock alternatives to fossil fuels. However, to date, regional policy making has focused on automotive fuel and power production from biomass rather than on heat

1.3.2. Estimate of current heating demand

Available energy balances of the ASEAN-6 countries allow for expressing the shares of electricity, transport, traditional residential use of biomass and charcoal and fuels used as raw materials for non-energy products (referred to as non-energy use) in the total final energy demand of the country for the year 2007 (IEA, 2009a). The remaining residual energy demand can be considered to represent a large part of heating demand although it still would need the conversion by efficiencies used to produce heat from these fuels in order to make a correct estimate of heat demand. However, electricity is also used to produce heat, since domestic hot water demand in more prosperous parts of the ASEAN-6 is often produced by electric water heaters. Electricity consumption for domestic hot water still consumes relatively small shares of total power demand though, as an estimate in 2007 in Thailand calculated energy demand for domestic hot water by means of electrical heaters to consist of 314 ktoe, which was 0.5% of total final energy consumption in Thailand at that time (JGSEE *et al*., 2007).

The shares in total final energy demand as indicated in Figure 1.3 demonstrate that although space heating demand is lacking in the ASEAN-6 countries, there still remains a notable residual energy demand that is estimated to represent heat demand, mostly for (agro-)industrial processes and to some extent for domestic hot water production.

Figure 1.3: Total final energy demand and shares for electricity, transport, traditional residential biomass, non-energy use and residual energy demand in the ASEAN-6, 2007



Source: IEA, 2009a.

Key point: Total final energy demand in ASEAN-6 countries is estimated to consist to a notable extent of heat demand, even though demand for space heating is negligible.

1.3.3. Renewable heat production

No historical heat supply data are available for ASEAN-6 countries even though several (geothermal and biomass) CHP plants are known to operate in a number of ASEAN-6 countries and solar thermal technology is also used to a certain extent (Lund and Boyd, 1999; Meyer, 2009; Balasankari and Mathias, 2009). Reasons for lacking CHP heat data can be that heat data in CHP plants are not measured as heat is often used on site and CHP plants can be small and therefore difficult to cover by national statistics.

Renewable heat production in the ASEAN-6 countries is only reported on a case-by-case basis. Biomass cogeneration plants are mentioned most often, as huge amounts of biomass residues arise from the vast agricultural industries that are easy to use as an alternative to current energy sources for mill operation at the site itself. Geothermal energy is mainly used for power production, though a few examples have been described where geothermal energy was used as a direct heat source. While solar thermal energy potentials were extensively studied in Thailand, no data are available for the other ASEAN-6 countries.

Many Southeast Asian countries are among the top producers of agricultural commodities. In Indonesia alone, some 147 tonnes of **biomass** is produced yearly from agro-industrial processes such as rice residues (65.6 million tonnes), sugar residues (23.6 million tonnes), rubber wood (41 million tonnes) and palm-oil residues (8.2 million tonnes) (IEA, 2008). These biomass sources can be used for producing electricity as well as heat. A study from 2007 reported 156 sites in the ASEAN-6 countries where biomass is used in cogeneration plants that produce electricity and

heat (Carlos and Khang, 2008). This study mentions that as a result of the introduction of policies promoting the use of renewable energy, 57 of these plants are solely for the production and selling of power and heat as a business venture (*commercial plants*). Apart from that, 56 plants function as an integral part of the mill's operation (*stand-alone plants*) and 43 plants supply both the energy demand from the mill itself while also selling surplus electricity to the national grid (*hybrid plants*).

The existence of biomass cogeneration plants that were built to produce and sell electricity and heat is said to be the direct result of the implementation of policy frameworks. In Thailand, 66 biomass cogeneration plants deliver 582 MW to the national grid (heat production data are not available) as a result of the Small Power Producer (SPP) programme that was introduced in Thailand in the early 1990s (Carlos and Khang, 2008). It is not certain though, that the heat produced in these commercial biomass cogeneration plants is used at all times. The development of a 22 MW biomass-fuelled plant in Thailand was reported to have no market for its steam (Kopetz, 2007).

Table 1.5: Reported combined heat and power biomass plants in ASEAN-6 countries, 2007

	Stand-alone[13]		Hybrid[14]		Commercial power and heat[15]	
	No of projects	*Capacity (MW)*	*No of projects*	*Capacity (MW)*	*No of projects*	*Capacity (MW)*
Indonesia	6	21.1	1	64.0	4	43.3
Malaysia	17	109.2	5	40.5	3	13.5
Philippines	11	11.5	8	230.0	2	45.0
Singapore	3	4.0	0	0	0	0
Thailand	13	46.6	29	556.9	45	735.4
Vietnam	6	24.0	0	0	3	4.0
Total	56	216.4	43	891.4	57	841.2

Source: Carlos and Khang, 2008.

Key point: Experiences with biomass combined heat and power plants exist in all ASEAN-6 countries.

Traditional use of biomass for cooking still dominates a large part of total final energy demand in the ASEAN-6 countries (IEA, 2006). Sustainable alternatives for traditional biomass cooking consist of using solar energy or biogas. Only a small number of pilot projects have been initiated to explore the potential of such alternatives, *e.g.* the use of biogas from animal waste in Vietnam and in the Philippines as well as parabolic solar cookers in several South Asian countries.

Indonesia and the Philippines, being located on a volcanic belt, can expand their use of **geothermal energy** considerably: they already produce respectively 5% and 14% of their electricity from geothermal energy. However, direct use of geothermal heat is still limited. Using

[13] Plants functioning as an integral part of the mill's operation.
[14] Plants supplying both the energy demand from the mill itself while also selling surplus electricity to the national grid.
[15] Plants producing and selling power and heat solely as a business venture.

the geothermal energy more efficiently by cascading the temperature will also improve the economics of the plant. Few examples of geothermal CHP plants in the ASEAN-6 countries have been described. In Thailand, near Egat, a multipurpose geothermal CHP plant uses a well of 116 °C to provide electricity (plant capacity 300 kWe) as well as hot water for refrigeration, crop drying and a spa. A geothermal CHP plant exists in the Philippines (Palinpinon) that uses the 160 °C well to produce electricity while the remaining heat is used in a drying plant producing copra (dried coconut meat). A number of examples of direct use of geothermal energy by means of bathing, balneology and swimming are reported in Indonesia, the Philippines, Thailand and Vietnam (World Energy Council, 2007).

Data on direct use of **solar thermal sources** are scarce. The IEA Solar Heating and Cooling Implementing Agreement reports 49 MW_{th} of glazed solar heating collectors in operation in Thailand at the end of 2007 (Weiss, Bergmann and Stelzer, 2009). For other ASEAN-6 countries, data are not available, which does not necessarily mean that solar collectors are not used in these countries.

Box 1.1: Case study: solar thermal systems in Thailand

The climatic conditions of Thailand offer favourable conditions for the use of solar energy with an average mean daily global solar radiation of 5 kWh per m^2 per day. Solar thermal systems producing hot water were introduced in Thailand already in the early 1980s, however progress in installed capacity in solar thermal systems in Thailand is developing slowly (JGSEE, IIEC and Fraunhofer ISE, 2007). The IEA Solar Heating and Cooling Implementing Agreement reports 49 MWth of glazed solar heating collectors in operation in Thailand at the end of 2007 (IEA SHC, 2008).

General technical barriers for the deployment of solar thermal hot water systems in Thailand consist of lack of training and education of suppliers and manufacturers, lack of availability of maintenance materials locally, lack of skilled technicians for repair and maintenance of the installations, and lack of monitoring of performances. Non-technical barriers consist of relatively high investment costs, absence of standards for collectors and system performance, absence of quality labels and certification and lack of awareness.

Solar thermal systems shares in Thailand have potential to increase in industrial applications where low temperature process heat is consumed, such as the food, textile, paper industries, and to some extent the chemical industries. In the commercial sector, particularly hotels and hospitals offer potential for deployment of solar hot water systems due to their high continuous hot water demand required for daily operation. In domestic hot water heating, solar thermal systems offer potential since they will replace electric heaters and therefore contribute to peak shaving in electricity demand.

The energy policy of the Thai government for the next few years (2008-11) contains a target for solar thermal energy use. According to the Thai Renewable Energy Development Plan, heat produced by solar thermal energy should increase by 5 ktoe additional production in 2011 compared to 2007.

The Thai government announced a solar thermal subsidy programme in 2008 with a planning to 2011. Whereas in 2008 subsidy was available for 5 000 m^2 solar collector surface, the subsidy will gradually increase to 7 500 m^2 collector in 2009, 10 000 m^2 in 2010 and 17 500 m^2 in 2011.

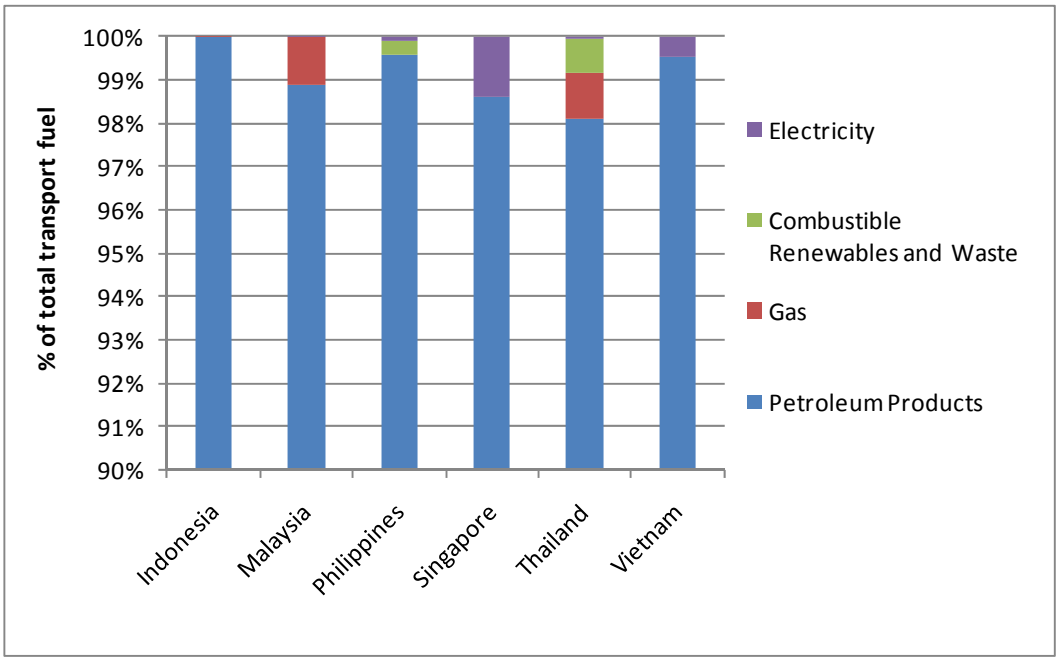
In Thailand, a study funded by the European Union looking at the potential for solar thermal systems, has prompted recent new attention for solar thermal systems (JSGEE *et al.*, 2007). Thailand is the only ASEAN-6 country to date which has introduced policies and targets for the encouragement of solar thermal systems (Thai Ministry of Energy, 2010). The Indonesian energy policy review acknowledges the use of solar thermal systems still being limited, though many private companies have recently started to supply these systems commercially (IEA, 2008). Whereas solar thermal heat is usually associated with domestic hot water production, it can also support industry processes requiring heat up to 200 °C. One case-study mentions a 330 m^2

solar thermal hot water system that is used to pre-heat a boiler for melting sugar in the production process of a chocolate factory in Bangkok (Meyer, 2009).

1.4. Transport sector

The transport sector in the ASEAN is dominated by fossil fuels, mainly petroleum products, which account for 99% of the total fuel demand in the sector. Natural gas (0.5%), biofuels (0.2%) and electricity (0.1%) only play a minor role to date, though specific shares are higher in certain countries (Figure 1.4). The transport sector in the region has been growing steadily over the last years, due to income growth and infrastructure development. Compared to 1990 levels fuel demand in the transport sector in 2007 increased by roughly 230%.

Figure 1.4: Consumption of transport fuel in the ASEAN-6, 2007



Source: IEA, 2009a.

Key point: The transport sector in the ASEAN-6 is currently dominated by fossil fuels, accounting for 99% of the total fuel demand.

In future, the transport sector in the ASEAN-6 is expected to grow steadily, mainly due to the growth in motor transport as result of urbanisation and increasing incomes. The IEA *WEO 2009* Reference Scenario projects an annual growth rate of 3.0% until 2030, with car numbers to increase by roughly 300% (IEA, 2009b). Since the vehicle population will mainly be concentrated in big cities such as Manila, Jakarta and Bangkok this will lead to serious congestion problems. While oil remains the main source of fuel in the transport sector, biofuels gain importance over the projection period, reaching a share of 5% in 2030, more than the projected world average of 4% (IEA, 2009b).

In the *WEO 2009* 450 Scenario, it is assumed that countries in the ASEAN-6 adopt sound policies and measures designed to curb greenhouse-gas emissions across all sectors. For the transport sector, such policies will mainly affect the efficiency of the fleet, and the increased consumption of low-carbon fuels (mainly biofuels). In this scenario, oil demand in 2030 is about 17% less than in the Reference Scenario; with roughly half of the savings in oil demand occurring in the transport sector. For the decarbonisation of the transport sector, biofuels will play an important role, since they can be produced domestically, with both economical and social benefits.

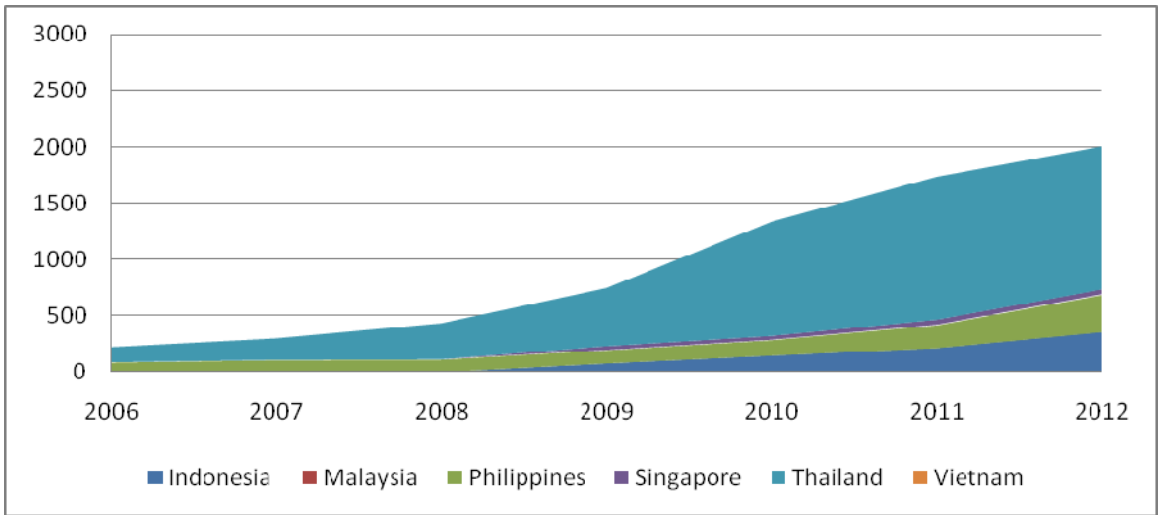
1.4.1. Biofuel production

Southeast Asia has experienced a rapid development of the region's biofuels sector in the recent past. Feedstocks like sugarcane, cassava, oil palm production level have steadily increased, profiting from the region's favourable climatic conditions for the cultivation of biofuels. This makes the region an increasingly important exporter of biofuels, for instance to the European Union. The development in the biofuels sector has been driven by several factors, including economic, social and to a smaller extent environmental reasons. Biofuel production can increase energy security by diversifying sources and decreasing import dependency for oil and oil products. Domestic production of liquid biofuels also brings economic benefits to the region, for instance through foreign currency savings or through provision of cheap transport fuel. Another benefit, which is of particular importance in the ASEAN-6, is the potential for job creation and subsequent development in rural areas. The Malaysian biodiesel industry for instance created an export volume of USD 13 billion in 2007 and employs around 500 000 people (Jai-In, 2009). With steadily increasing production volumes, both employment opportunities and export income could be significantly increased. Many countries in the ASEAN-6 have adopted biofuel support policies over the last years in order to promote the growing industry and set blending mandates for domestic consumption (see Chapter 2).

Southeast Asia has abundant feedstock sources for liquid biofuels and production of both bioethanol and biodiesel is growing steadily in several countries of the region. In the ASEAN-6, ethanol is produced mainly from sugarcane, but also cassava gained importance as feedstock. In Thailand, for instance, around 75% of current total ethanol production is based on cassava and the first plant running solely on this feedstock was opened in 2009 (Thai Ministry of Energy, 2009). Currently, the largest producer of ethanol within the ASEAN-6 is Thailand with 517 megalitres a year (Ml/yr), followed by the Philippines (116 Ml/yr), Indonesia (77 Ml/yr) and Singapore (34 Ml/yr) (Figure 1.5). To date, Malaysia and Vietnam do not produce ethanol for use in the transport sector. According to IEA projections, Thailand continues to lead ethanol production in the region for the next three years to come with an expected annual production of 1 276 Ml in 2012. The projections see Indonesian and Philippines production to further increase up to 355 Ml and 332 Ml, respectively in 2012 (IEA, 2009c).

The main feedstock for biodiesel in the ASEAN region is palm oil, which is mainly cultivated in large-scale plantations and to a smaller extent in small-scale agro-forest systems. Due to the favourable tropical climate, average palm oil biodiesel yields are around 4 000-4 700 l/ha (FAO, 2008), roughly three times the yields achieved by cultivating canola in Europe.

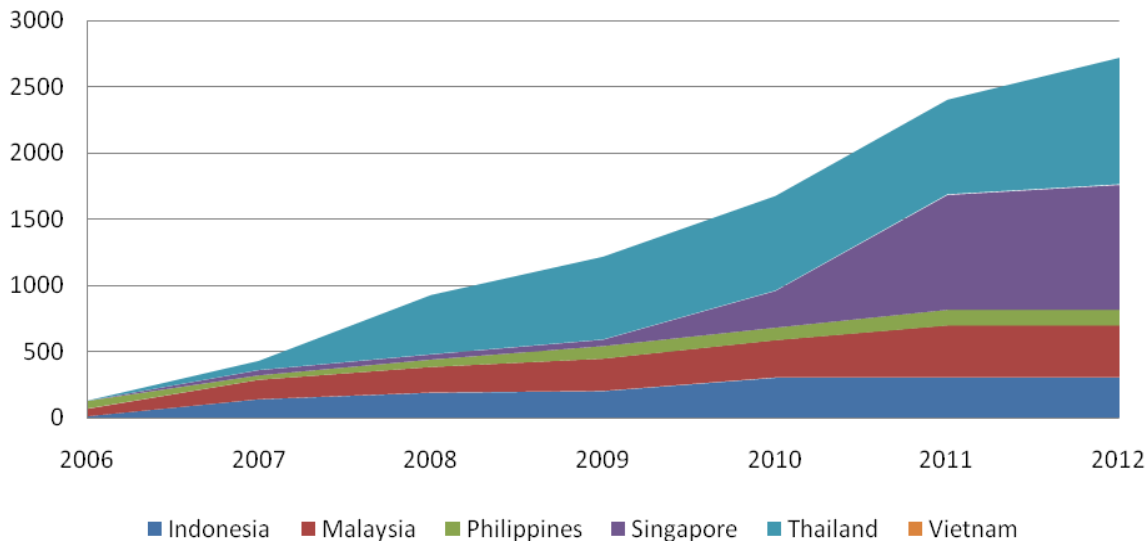
Figure 1.5: Current ethanol production and projections in the ASEAN-6



Source: IEA, 2009c.

Key point: Thailand dominates ethanol production in the ASEAN-6, followed by the Philippines, Indonesia and Singapore whereas Malaysia and Vietnam do not produce ethanol.

Figure 1.6: Current biodiesel production and projections in the ASEAN-6



Source: IEA, 2009c.

Key point: Biodiesel production in the ASEAN-6 is dominated by Thailand, although Singapore is expected to catch up in the near future.

Though of smaller size, the biodiesel sector in the ASEAN-6 shows a similar development as the ethanol sector. Biodiesel production in 2009 took place mainly in Thailand (625 Ml/yr),

Indonesia (243 Ml/yr), Malaysia (203 Ml/yr) and the Philippines (96 Ml/yr), whereas Singapore had a comparably small output of 48 Ml in 2009 (Figure 1.6). Vietnam is the only country in the ASEAN-6 that to date has no biofuel production. In the next three years, biodiesel production is expected to increase steadily, led by Thailand with an annual output of 955 Ml in 2012, followed by Singapore who is expected to increase its production almost twentyfold to 946 Ml/yr. This is mainly due to a large plant currently under construction that will increase the country's capacity by 900 Ml/yr. In Malaysia, Indonesia and the Philippines, increases in production are expected to be in the range of 25-60% (Figure 1.6).

Another biofuel option for the transport sector is biogas produced by anaerobic digestion of waste biomass and animal manure. While many biogas projects have been successfully initiated, for instance in Thailand, biogas is currently mainly used to produce electricity and plays only a minor role in the transport sector. However, the potential for biogas as low-carbon transport fuel should not be overlooked. Since natural gas is already used as transport fuel in several ASEAN-6 countries (Figure 1.4), a suitable vehicle fleet is in place as well as fuel stations. Options for the use of biogas should thus be considered, since it might offer a low-cost fuel option for the transport sector. However, infrastructure requirements, mainly related to fuel distribution – *e.g.* storage, transport to fuel stations – might become an obstacle in particular in rural areas, where the feedstock potential should be highest due to farming activities.

1.4.2. First- and second-generation biofuels

IEA long-term projections presented in the *WEO 2009* Reference Scenario see an increasing oil dependency in the ASEAN-6 over the projection period. In 2030, this will reach more than 80% for the Philippines, Thailand and Indonesia and almost 50% for Malaysia (IEA, 2009b). Over the same period, the demand for liquid biofuels is expected to increase by 17.5% annually. Developing a liquid biofuel industry can help the respective countries to meet their increasing oil demand, in particular in the transport sector.

Despite successful development of first-generation biofuel production in the ASEAN-6, the sustainability of this industry has been increasingly questioned. In particular large-scale palm oil plantations are criticised for exclusion of small-holders and destruction of valuable ecosystems like rainforests (UNDP, 2007). Some reports also claim that Southeast Asian biodiesel production releases more CO_2 than is avoided through the use of the produced biofuel, if, for instance, peat forest is converted into palm oil plantations (*e.g.* Fargione *et al.*, 2008). It is argued that such land use change (LUC) can offset the emission reduction potential of biofuels for decades or even centuries. The growing public awareness of these risks has led to a fundamental discussion on scientific level on how to measure the impact of land use change on the greenhouse-gas balance of biofuels.

As a result of public and scientific discussions, first steps have recently been undertaken to establish an internationally agreed standard methodology to measure LUC effects and to define criteria that ensure a sustainable development of the biofuel industry globally. Newly defined sustainability criteria for biofuels have for instance been included in the EU's Renewable Energy Directive and proposals for stringent sustainability standards in other countries are on their way (*e.g.* the United States Renewable Fuels Standard II). In order to maintain access to the markets and export biofuels to these regions, ASEAN-6 countries will need to comply with the various environmental and social requirements defined by the importing countries.

Since discussion on sustainability criteria is still ongoing, it is difficult to assess to which extend the ASEAN-6 countries will be affected by new legislations. Being confronted with increasing public criticism, several companies and governmental organisations in the ASEAN-6 started to engage in initiatives that work on sustainability criteria for biofuels. Stakeholders from Malaysia, Singapore, and the Philippines are for instance participating in the *Roundtable on Sustainable Biofuels*. They are also participating in the *Roundtable for Sustainable Palm Oil*, as are Thailand and Indonesia. This participation should be further promoted and intensified to ensure the sustainable development of the biofuel industry in the ASEAN-6.

The increasing criticism on some first-generation biofuel pathways has raised attention to the potential of so-called advanced and second-generation biofuels.[16] These fuels can be produced from virtually any type of biomass and could thus use the whole plant and not just the grain/fruit, yielding higher per hectare outputs. Depending on the feedstock choice and the cultivation technique, second-generation biofuel production has the potential to provide benefits such as consuming waste residues in the agricultural and forestry sector and making use of abandoned land. In this way, the new fuels could offer considerable potential to promote rural development and improve economic conditions, which is an important driver for biofuel production in the ASEAN-6 region.

Based on projections in the *WEO 2009* 450 Scenario, commercial deployment of second-generation biofuels is expected to start around 2015. On a global scale, the potential for second-generation biofuels from residues looks very promising. A recent IEA publication assessed that using 10% of the residues in the agricultural and forestry sector would be sufficient to meet 50% of the global biofuel demand in 2030, forecast in the WEO 450 Scenario (IEA, 2010). As mentioned before, ASEAN-6 countries have abundant sources of agro-industrial residues. These can serve as a feedstock for production of second-generation biofuels in the future, if the countries manage to provide suitable framework conditions like infrastructure and skilled labour.

Currently most research and development (R&D) projects are being installed in North America and Europe, whereas outside the OECD only a few pilot or demonstration plants already exist. In particular, in less developed countries, research on second-generation biofuels has not yet expanded due to limited financing possibilities as well as a lack of skilled labour and suitable infrastructure. In the ASEAN-6, many countries have started to recognise the potential for second-generation biofuels and mention them in their biofuel development plans (*e.g.* Thailand, Malaysia, and Indonesia). However, to date only few countries in Southeast Asia have set up R&D projects on second-generation biofuels. Since the first-generation ethanol and biodiesel industry is relatively young in many countries, R&D focuses mainly on this industry rather than second-generation biofuels. In the long term, however, some countries might face a shortage of land suitable to biofuel production and residues from the agricultural and forestry sector could thus become a suitable feedstock in these countries. In particular the sugarcane and palm oil industry are favourable starting points for the new technologies, since much of the required infrastructure is already in place and vast amounts of feedstocks like bagasse and empty fruit bunches are available. However, competition with other uses (*e.g.* electricity production, biomaterials) will determine the potential of second-generation biofuels in the ASEAN-6 region.

[16] There are different conversion pathways for second-generation biofuels: The **thermo-chemical route**, in which biomass is gasified to produce bio-Synthetical Natural Gas (SNG) or BTL-diesel (latter via Fischer-Tropsch synthesis); the **bio-chemical route**, in which enzymes or micro-organisms are used to convert cellulose and hemicellulose in the biomass to sugars, which are then fermented to produce ethanol.

As one of the first countries in the region, Thailand has established several R&D projects on second-generation biofuels, partly through collaboration between the National Innovation Agency, universities and research institutes. Thailand's long experience with biofuel production and the existing infrastructure form a favourable framework for the set-up of a second-generation biofuels industry, though high-skilled labour might become one of the bottlenecks in the start-up phase. A detailed country profile on the current situation and potential of second-generation biofuels in Thailand can be found in a recent IEA publication (IEA, 2010).

Another biofuel option, which recently gained attention of industry and policy stakeholders, are algae based biofuels. Algae are grown in open ponds or photo-bioreactors and can be produced in areas unsuitable to agriculture. Due to their high productivity, current yields of algae fuels in test facilities lie well above those of first-generation biofuels. Nonetheless, they are below the theoretical maxima, which are expected to be close to 100 000 l biodiesel a year (IEA, 2009d). Interest for this technology is growing in the ASEAN and algae based biodiesel are mentioned in several national biofuel development plans. However, reliable estimates on production costs are scarce, which forms a considerable barrier for investments in this technology.

2. Policy support for renewable energy

Key findings

- Many factors are driving deployment of renewable energy technology in the ASEAN-6 region. Rising dependency on fossil fuels, coupled with concern about their environmental impacts (CO_2 emissions and air pollution), has sparked interest in renewable energy to diversify the energy mix. Local economic development, job creation and off-grid renewable energy solutions for electrification of rural areas are also triggering enhanced uptake of renewable energy.

- Nearly all ASEAN-6 countries have adopted medium- and long-term targets for renewable energy. Indonesia, Singapore and Thailand also recently announced CO_2 emissions reduction targets in support of the Copenhagen Accord (UNFCCC Summit, December 2009). Interest in renewables varies considerably among the ASEAN-6 countries. Renewable energy targets for the medium and long term are much more ambitious in some countries than in others, with Thailand and Indonesia at the forefront.

- Several ASEAN countries have recently introduced renewable energy feed-in tariffs (FITs); others are about to do so. Thailand introduced renewable electricity FITs in 2007. As of early 2010, Indonesia introduced a FIT for geothermal electricity, while Malaysia and the Philippines began drafting guidelines for the introduction of FITs. Other financial incentives being applied include: tax exemptions for certain renewable energy technologies in Malaysia, the Philippines and Indonesia; capital costs grants in Thailand; and R&D incentives in Singapore.

- Malaysia, Indonesia and Thailand have also introduced non-financial support mechanisms, including standard power purchase agreements (PPAs), preferential arrangements for small generators and information support. These initiatives help independent power producers enter the market more easily and reduce barriers specific to non-liberalised energy markets.

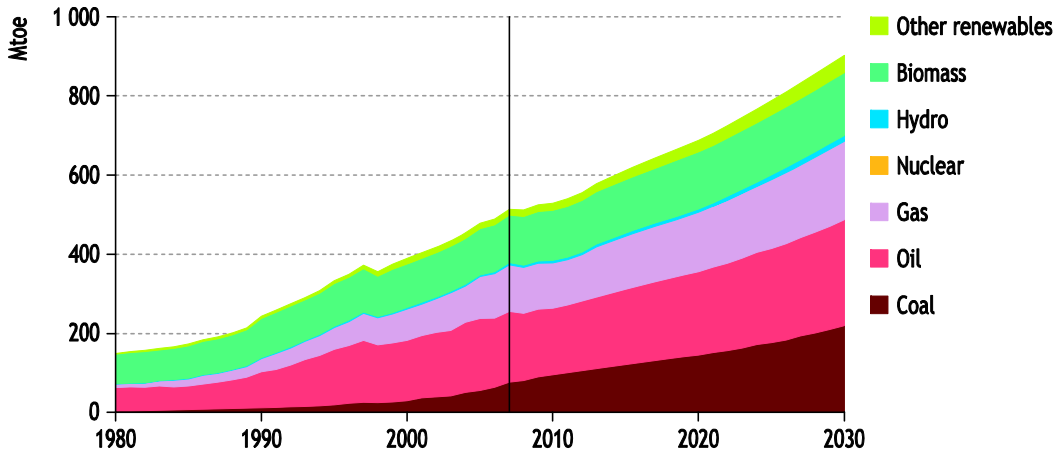
- By setting national renewable energy targets and providing financial incentives, ASEAN-6 countries have made steady progress towards building stable, long-term policy frameworks and attracting private sector investment. To ensure policies to support renewable energy are effective, it is essential to address non-economic barriers, especially in countries with non-liberalised energy markets.

2.1. Driving forces for renewable energy deployment

The 2009 ASEAN Energy Demand Outlook estimates a growth in primary energy demands in the entire ASEAN region of ten member countries at an annual rate of 4.0% from 474 Mtoe in 2005 to 1 252 Mtoe in 2030 in the Reference Scenario (ACE, 2009). The High Scenario – reflecting even higher targeted GDP growth rates than estimated by the ASEAN member countries themselves – results in a predicted primary energy demand of 1 548 Mtoe in 2030.

Although a number of ASEAN countries, such as Malaysia, Vietnam, Brunei Darussalam and Indonesia, currently are net energy exporters of natural gas, coal and oil, due to rising demand and maturing oil and gas fields the region can soon become a net energy importer. Whereas Indonesia traditionally was a net exporter, it is already starting to become a net importer of crude oil as well as oil products. This is why the Government of Indonesia has released a new policy with the main objective of reducing the dependency on oil products through increasing the use of other energy alternatives and efficiency. The rising dependency on fossil fuels is one of the incentives for the ASEAN countries to look for enhanced uptake of renewable energy in order to diversify the energy mix and to decrease dependency on imported energy.

Figure 2.1: ASEAN primary energy demand projection by fuel, *World Energy Outlook 2009* Reference Scenario



Source: IEA, 2009a.

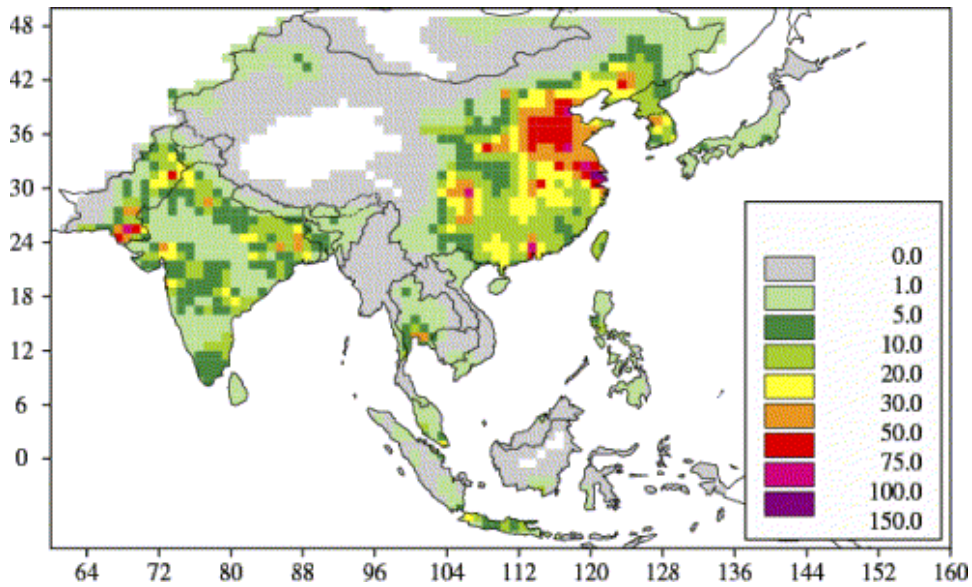
Key point: Rising dependency on fossil fuels is one of the driving forces for enhanced uptake of renewable energy and diversification of the energy mix in the ASEAN-6.

The projected rise of energy demand in the ASEAN region will have a considerable effect on CO_2 emissions. CO_2 emissions in the ASEAN countries as a share of global energy related emissions are projected to rise to 5% by 2030, up from 3.5% today (IEA, 2009a). Per capita emissions rise as well and, although still considerably lower than OECD countries, the gap narrows from a factor six in 2007 to a factor three in 2030 (IEA, 2009a).

Apart from climate change effects, the energy sector is also responsible for a considerable contribution to other environmental impacts. Air quality often is a serious problem, especially in cities and towns. With the rapid economic growth, the use of fossil fuels, and the consequent

emission of air pollutants, has been increasing in Asia and may do so in the coming decades. As a result, sulphur dioxide (SO_2) emissions may increase fast in the future, and critical loads for acidifying deposition may be exceeded for a range of ecosystems in large parts of Asia (Boudri, A. *et al.*, 2002). Large cities such as Jakarta, Bangkok, Manila, Kuala Lumpur and Ho Chi Minh City often suffer from local air pollution resulting from increased vehicle use, rapid rates of industrialisation and urbanisation, the heavy reliance on coal and the locations of industries close to residential areas. Other environmental impacts related to the energy sector include land degradation as a result of coal mining and loss of biodiversity and forest cover as a consequence of the non-responsible use of biomass resources.

Figure 2.2: Excess sulphur deposition in Asia in 2020 above the critical loads: business-as-usual projections



Note: Units are acid equivalent/ha/year. These projections stem from a business-as-usual energy scenario for 2020 while taking into account current legislation for SO_2 emission control.

Source: Cofala *et al.*, 2004.

Key point: Severe air quality problems in ASEAN-6 countries contribute to environmental impacts being a driving force for renewable energy uptake in ASEAN-6 countries.

Although the ASEAN countries are very disparate in their stages of economic development, they all show considerable growth rates with on average 4% a year to 2005 and then 3.7% to 2030 (IEA, 2009a). Encouraging the uptake of renewable energy technologies can create market opportunities for small and medium enterprises (SMEs) and support economical development. Renewable energy project deployment creates useful employment for both skilled and unskilled workers, more so than for operating the equivalent energy output capacity of plants in the fossil fuel industry (IEA, 2007). For instance, the implementation of biofuel projects in developing countries is often driven by the intention to create jobs and regional growth (Domac *et al.*, 2005). For both current and second-generation biofuels, there are opportunities for new jobs

along the entire pathway chain, from biomass production or collection, to biomass transport, biomass handling, conversion and finally product distribution.

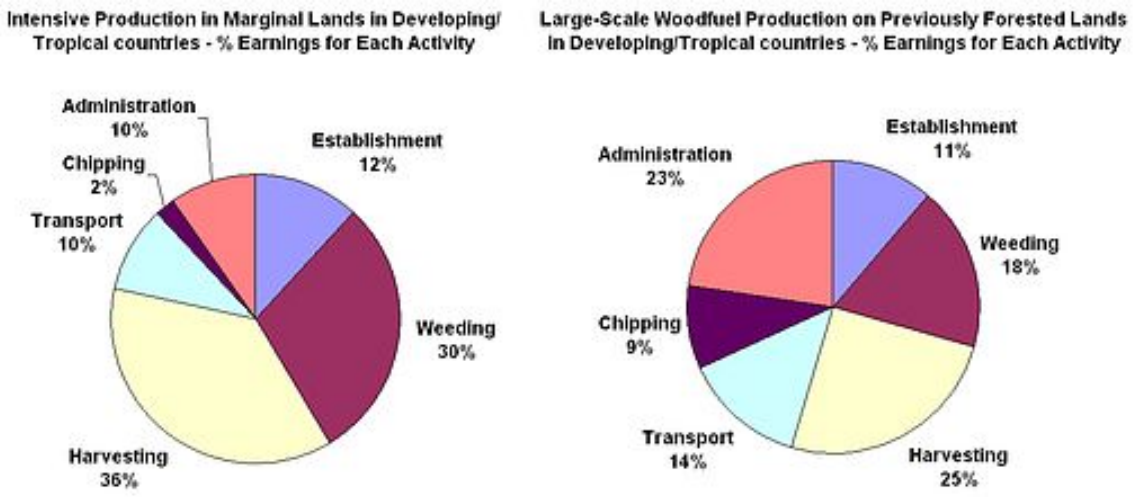
Although many renewable energy technologies will be imported, for a relatively simple technology such as the solar thermal system, local fabrication can prove to be a cheaper option. In that case, quality labelling and certification will be very important in order to prevent for poor and inconsistent quality products that can hamper demand and risks spoiling future market development.

Currently, limited capacity in renewable energy technology manufacturing and servicing and the lack of skilled technicians for installation and maintenance of technologies impede the introduction of renewable energy technologies. Training and R&D programmes for industry and technicians are needed in order to overcome this problem.

Figure 2.3: Employment and income generation from biofuel production in tropical developing countries

Employment and earnings from selected studies among developing/tropical countries (partial) biofuel production [9]

	Establishment	Weeding	Harvesting	Transport	Chipping	Administration	Total
Person years/PJ							
Intensive production, farmers	112	338	248	70	13	19	799
Intensive inter-cropping	71	196	251	71	13	19	620
Large-scale "energy forestry"	34	59	85	51	13	11	252



Source: Domac et al., 2005.

Key point: Governments may target enhanced deployment of renewable energy to support the (local) economy and create employment, while shares of activities can vary considerably depending on the type of bioenergy supply chain.

Whereas in developed countries, main drivers for an increased deployment of renewable energy consist of energy security, climate change mitigation and economic development, in the ASEAN region another important driver are electrification targets, mainly for rural areas. In 2008, 160 million people in Southeast Asia had no access to electricity, corresponding to 28% of

the region's population (IEA, 2009a). Especially Indonesia (81 million), Myanmar (43 million) and the Philippines (13 million) contribute to this figure whereas Singapore has an electrification rate of 100% (*ibid.*). Increased electrification will not only result in comfort, but also contributes to improved health and social circumstances. Several renewable energy sources allow for fulfilling basic rural energy needs since a number of renewable energy technologies, such as wind energy, hydro-energy and solar PV, offer good possibilities to serve as off-grid solutions.

Table 2.1: Electrification rates in the ASEAN-6 countries

	Population (millions)	Electrification rate (%)	Population without electricity (millions)
Indonesia	228.3	65	81.1
Malaysia	27.0	99	0.2
Philippines	89.5	86	12.5
Singapore	4.7	100*	0
Thailand	64.2	99	0.4
Vietnam	86.1	89	9.5

* Singapore Island is 100% electrified while Pulau Ubin has off-grid electricity.
Source: Adapted from IEA, 2009a.

Key point: Electrification of rural areas by means of off-grid renewable energy solutions can be a driving force for enhanced deployment of renewable energy in countries with low electrification rates.

2.2. Targets

Nearly all ASEAN-6 countries drafted renewable energy targets for the medium- and long-term future, while recently a number of ASEAN-6 countries also announced CO_2 emission reduction targets in the light of the UNFCCC summit in Copenhagen in December 2009.

An integrated and long-term approach in encouraging increased uptake of renewable energy is recommended. A long-term policy framework will allow the private sector to benefit from a stable investment climate: setting national renewable energy targets is a first essential condition for a stable policy framework (IEA, 2008b).

The study of policies has the problem of being faced with continuous change and development. The next section will discuss national renewable energy targets country-by-country in the ASEAN-6 on the basis of available information during the second half of 2009.

2.2.1. Indonesia

The development of energy policy and renewable energy targets in Indonesia falls under responsibility of the Ministry of Energy and Mineral Resources (MEMR). Policies that encourage renewable energy are the Green Energy Policy (Ministerial Decree No. 2/2004), the National

Energy Policy and its Blueprint of National Energy Management 2005-25 (Presidential Decree No. 5, 2006) and the Energy Law No. 30 (2007).[17] The Indonesian government is currently drafting a new law on renewable energy which is meant to include plans for supply and demand of renewable energy as well the introduction of fiscal incentives.

The objective of the Green Energy Policy is to achieve sustainable energy supply by encouraging development of renewable energy and efficient use of energy while at the same time raising public awareness for renewable energy and energy efficiency. The strategy to reach these goals includes development of renewable energy infrastructure; prioritising the use of renewable energy based on its potential and its economical and technical feasibility; improvement of co-operation on regional, national and international levels to ease the transfer of technologies, improve information sharing and financing.

The National Energy Policy includes the Blueprint of National Energy Management 2005-25 that sets targets for the energy mix by 2025. The objectives are to improve diversity of the fuel mix by reducing the share of oil in the mix to 20% while increasing that of CO_2 neutral energy and renewables by 17% with biofuel targeted at 5%, geothermal energy at 5%, biomass, nuclear, hydro solar and wind energy targeted at 5% and liquefied coal at 2%. A roadmap for biofuel development is still under discussion, aiming for 10% of biodiesel consumption replaced by biodiesel in 2010 and 20% of biodiesel by 2025 (Girianna, 2009). A press release in November 2009 by the Indonesian Energy and Mineral Resources Ministry announced that Indonesia had allocated USD 62.4 million for 2010 to construct solar PV installations with a total capacity of 2 200 kW_p for 150 000-200 000 rural households and that it aimed to construct 250 solar-powered plants under the ministry's 2010-14 power generation blueprint (Sasistiya, 1 November 2009).

In 2007, Indonesia passed the Energy Law, which determines major institutional and legal changes influencing formulation of energy policy in the future. The law urged the establishment of a National Energy Council with the task to formulate and draft national energy policy. It also wishes to ensure for the future that energy prices are based on fair economic value and that the central government and regional governments create a subsidy fund for poor segments of the population.

Specific regulations focusing on a particular type of renewable energy source include Law No. 27 (2003) on Geothermal Energy and Presidential Instruction No.1 (2006) on Supply and Utilisation of Biofuels as Alternative Energy. These specific regulations reflect the largely untapped potential of Indonesia for development of geothermal energy and liquid biofuels. The laws promote sustainable development of geothermal energy and utilisation of biofuels as substitute for fossil fuels. Under its biofuels roadmap, Indonesia imposes in the transport sector 10% of biodiesel in diesel consumption and 5% of bioethanol in gasoline consumption by 2010. By 2025, biodiesel should represent 20% and bioethanol 15% of consumption of their respective oil-based alternatives.

Other specific technology policies include the Micro Hydro Project Programme, the Energy Self Sufficient Programme and the Solar Home Systems Programme. The Micro Hydro Project Programme, implemented since 1990, has to date supplied 20 000 rural households with micro-hydro energy. The 2005 Energy Self Sufficient Programme aims at the electrification of rural villages through off-grid renewable energy systems. The Solar Home Systems Programme has been running for more than a decade and so far installed some 5 MW of solar power

[17] Sources: World Resources Institute SD-PAMs Database, REEEP Policy Database, APEC Energy Overview.

throughout Indonesia (IEA, 2008a). All these efforts aim to improve energy self-sufficiency of Indonesia.

Box 2.1: Indonesia's Crash Programmes I and II for accelerated additional power capacity including renewables

Indonesia has announced two Crash Programmes to meet growing power demand. Crash Programme I aims to establish new coal-based electricity generation with a total capacity of 10 000 MW. To ensure that the target of 15% renewable energy by 2025 is reached, Crash Programme II has been announced for another 10 000 MW additional power capacity, to be realised in the period from 2009 to 2014. Crash Programme II will consist of over 60% new capacity from renewable resources, in particular 5 000 MW from geothermal resources and 1 250 MW from hydro resources. Crash Programme II also aims to increase access to electricity in the outer islands, with 55% of the planned geothermal capacity to be developed outside the Islands of Java and Bali.
Investment needs for these programmes are on the one hand expected to come from the private sector – for which Presidential Decree 67/2005 aims to provide payment assurance under certain conditions for independent power producers (IPPs). On the other hand support is expected from international financial institutions and bi-lateral agencies such as the World Bank, UNDP and the governments of the Netherlands and Denmark (Girianna, 2009).

In January 2010, the Indonesian government committed in its Copenhagen Accord pledge to a target of either 26% CO_2 emission reduction by 2020 relative to business-as-usual (BAU) projections, based on domestic funding, or a 41% reduction from projected BAU levels if international funding of IDR 168 trillion (USD 18.2 billion) is made available to Indonesia. Thus, Indonesia appears to commit itself to a reduction in absolute terms, whereas many other developing countries have stated relative terms like an intensity or indexed target. Such a commitment makes Indonesia one of the few emerging economies to announce a reduction target in fixed terms, together with Brazil and Mexico. In doing so, Indonesia intends to express its responsibility and encourage its industry sector to develop low-carbon technologies.

2.2.2. Malaysia

In Malaysia, the Economic Planning Unit (EPU) and the Implementation and Coordination Unit (ICU) develop and control Malaysian energy policy. The Ministry of Energy, Water and Communications regulates the non-oil and gas energy and security sectors. The Energy Commission of Malaysia regulates the energy supply activities and enforces energy supply laws.

In the 8th Malaysia Plan (2001-05) energy policy was formulated by including aims for a safe, cost-effective, secure energy supply which means promoting renewables, cogeneration, diversification, efficiency and using auditing, financial and fiscal incentives, technology development, and labelling. The 8th Plan includes several incentive mechanisms for the promotion of environmental measures and the use of renewables in the private sector. Originally the four fuel diversification policy focused on oil, gas, coal and hydro. In the 8th Plan, it was broadened to include renewable energy as a fifth fuel in the new Five Fuel Strategy. In the 9th Malaysia Plan (2006-10) the energy policy of the 8th Plan has been continued while providing a more conducive environment to support renewable energy projects. Additionally, the 9th Plan announced a target of 350 MW of grid-connected renewable electricity generation by 2010.

The 10th Malaysia Plan (2011-15) will include a comprehensive National Renewable Energy Policy and an Action Plan which will focus on intensifying energy efficiency initiatives. The plan will increase efforts to develop alternative energy such as solar, wind and biofuels and explore the possible use of nuclear energy. The new Renewable Energy Plan includes the announcement of long-term renewable energy targets to 2050 and the introduction of a feed-in tariff for renewable electricity (see also Section 2.3).

2.2.3. The Philippines

The Philippines' Department of Energy (DOE) is responsible for all planning and programmes related to energy exploration, development, utilisation, distribution and conservation in the Philippines. In 2005 and in 2007, it drafted an update of the Philippine Energy Plan (PEP), being an affirmation of the state's commitment to pursue the energy independence agenda. The energy sector's agenda has two main goals: it focuses on achieving 60% energy self-sufficiency by 2010, and it wants to introduce considerable power market reforms promoting a globally competitive energy sector.

The Philippines Energy Plan's strategy in realising 60% energy self-sufficiency in 2010 is anchored on accelerating the exploration, development and utilisation of indigenous energy resources; intensifying renewable energy resource development; increasing the use of alternative fuels; and enhancing energy efficiency and conservation. The Philippines Energy Plan 2005 update includes targets to: increase renewable energy capacity by 100% from the 2005 level in 10 years; become the world leader in geothermal energy; and be the largest wind power producer in Southeast Asia.

As part of the goal of obtaining 60% energy self-sufficiency by 2010, the Alternative Fuels Programme (AFP) draws attention to several options to support development of biodiesel and bioethanol, natural gas for vehicles and public transport and also hybrid, fuel cell, hydrogen and electric vehicles. The Biofuels Act (2007) sets a target for a minimum blend of 5% bioethanol by 2009, increasing to 10% in 2011, and sets a target for a minimum blend of 1% biodiesel in 2007, increasing to 2% by 2009 (IEA, 2009b). Under the Biofuels Act the introduction of E-5 blends started early 2009, requiring 220-230 million litres (Ml) of alcohol in year one. By 2011, when an E-10 blend will become mandatory, consumption will rise to 480-490 Ml a year.

2.2.4. Singapore

In Singapore, the Ministry of Environment and Water Resources published its National Climate Change Strategy in 2008. Being a city-state with limited natural resources and due to geographical constraints, Singapore estimates large-scale adoption of alternative energy beyond oil and gas to be unlikely. The National Climate Change Strategy concludes that forms of renewable energy that will be more applicable to Singapore besides waste-to-energy would comprise solar energy and biofuels. The Singapore government has explored research into renewable energy, but has not as yet set targets for enlarging the share of renewable energy in its energy mix. Just before the start of the UN Climate talks in Copenhagen on 7 December 2009, Singapore announced that it would pledge to cut carbon emissions by 16% versus projected business-as-usual levels by 2020, contingent on a global binding deal being reached after the UN talks in Copenhagen (MTI Singapore, 2007).

Because of the limited possibilities for deployment of renewable energy, Singapore has made energy efficiency a key strategy in tackling energy security and environmental sustainability objectives (MTI Singapore, 2007). In 2009, the Sustainable Singapore Blueprint was launched by the Inter-Ministerial Committee on Sustainable Development in order to set out a national framework and strategy for Singapore's sustainable development for the next two decades until 2030 and to reflect on the Singapore Green Plan. The 2009 Sustainable Singapore Blueprint announces the goal of reducing its energy intensity (energy consumed per dollar GDP) by 35% from 2005 levels by 2030. These efforts are put in perspective when considering the results that Singapore has already realised in lowering its energy intensity (Box 2.2).

Box 2.2: Singapore's power generation efficiency comparable to OECD countries

Singapore's fossil-fuelled power production improved its efficiency considerably by a combination of efficiency measures. From 2000 to 2006, the overall power generation efficiency has increased from 38% to 44% through the adoption of combined cycle using steam and gas turbines. This strategy has accounted for 15.8% reduction in CO_2 emissions. A switch from oil-fired power plants to dual-fuel plants with a 75.8% share of natural gas has reduced CO_2 emissions by another 25%. The combined effect of the above measures has contributed to a 37% reduction in CO_2 from electric power generation, resulting in an efficiency of oil-fired plants in Singapore that is comparable to OECD countries (Thavasi and Ramakrishna, 2009).

2.2.5. Thailand

In Thailand, energy policy is developed by the Ministry of Energy and focuses on the principles of energy efficiency, energy security, energy price monitoring, renewable energy and sustainable development.

In 2008, the Ministry of Energy published the Renewable Energy Development Plan (REDP) to set targets for the deployment of renewable energy for the period 2008-22. It sets as a main target to increase renewable energy's share of total final energy demand to 20% in 2022. The REDP targets are divided in three phases with phase I (2008 to 2011) focusing on proven RE technologies such as biofuels, cogeneration from biomass and biogas. The target for phase I is to reach an increase in the renewable energy's share in the energy mix of 15.6% of total energy consumption in 2011.

Phase II (2012 to 2016) of the Renewable Energy Development Plan will focus on development of alternative energy technology industry, encourage new alternative energy R&D to achieve economic viability including new technologies for biofuels production and introduce a model development of a "Green City" to communities for sufficient economy and sustainability development. At the end of phase II, renewable energy is expected to represent 19.1% of total energy consumption.

The third phase (2017 to 2022) of the REDP aims to enhance the use of new available alternative energy technologies such as hydrogen and bio hydrogenated (BHD), to extend green city models throughout Thai communities and to promote Thailand as the hub of biofuels and alternative energy technology exports in the ASEAN region. At the end of phase III, the share of renewable is expected to have developed to 20.3% of total final energy consumption.

The Renewable Energy Development Plan (REDP) is accompanied by several measures such as financial incentives, the promise to revise obstructive legislation and the development of technical standards for RE technology (see Section 2.3).

2.2.6. Vietnam

In Vietnam, the Ministry of Industry and Trade's Energy Department is responsible for the development of its energy policy. The Vietnamese National Energy Policy, published in September 2004, sketches priorities for the period 2000-20. It raises attention on renewable energy by stating that "development of various forms of renewable energy needs to be encouraged".

The Vietnam government's Decision No. 1855/QD-TTg (2007) presents the Vietnam energy development strategy up to 2020, with a vision towards 2050 and targets for a share of 3% renewables in 2010, 5% in 2020 and 11% in 2050 of the total amount of commercial primary energy. The government Decision No. 110/2007/QD-TTg plans additional capacity of renewable electricity in the future to consist of 241 MW/year in the period 2006 to 2015 and 160 MW/year in the period 2016 to 2025, equalling a total 4 050 MW renewable electricity capacity by the year 2025.

In Decision No. 177/2007/QD-TTg, the Vietnamese government presents a scheme on the development of biofuels up to 2015 with a vision to 2025. It aims for an annual output of 100°000 tons of E5 and 50 000 tons of B5 by 2010 in order to satisfy 0.4% of the whole country's gasoline and oil demand by that time.[18] By 2015, ethanol and vegetable oil projection is planned to reach 250°000 tons (enough for blending 5 million tons of E5 and B5), satisfying 1% of the whole country's gasoline and oil demand. By 2025 the ethanol and vegetable oil output should reach 1.8 million tons, satisfying some 5% of the whole country's gasoline and oil demand.

A Renewable Energy Master Plan is announced to being finalised in 2009. In the first announcement of the Renewable Energy Master Plan, it is stressed that the plan will give priority to low cost renewable energy sources such as small scale hydropower, sugarcane bagasse, municipal solid waste, geothermal power, wind, rice husk, renewable heat, and bioenergy. Priority will also be given to off-grid projects related to rural electrification in remote areas with a focus on developing RE for areas where costs of RE are lower than diesel electricity or connection to the national grid.

2.2.7. Overview of renewable energy targets

Table 2.2 presents an overview of renewable energy targets and, where available, CO_2 emission reduction targets in ASEAN-6. It demonstrates that most ASEAN-6 countries formulated targets for renewable energy deployment for the near and medium future. Ambition levels differ though, with Indonesia and Thailand being frontrunners in the region.

As the sole ASEAN-6 country with no rigid renewable energy targets, Singapore is less directed in its renewable energy policy. Singapore's specific situation is that of small land area with a relatively low natural endowment of renewable energy sources. This has spurred energy

[18] E5 is gasoline with a 5% volumetric bioethanol content. B5 is diesel with a 5% volumetric biodiesel content.

efficiency, and its long-term efforts have resulted in an energy intensity index for power production comparable to OECD countries.

Table 2.2: Renewable energy targets and CO_2 emission reduction targets in the ASEAN-6

	Renewable energy (RE) targets	CO_2 emission reduction targets
Indonesia	5% geothermal (2025) 5% biomass, hydro, solar and wind energy (2025); this target also includes nuclear power, which is a non-renewable energy source. 5% biofuels (2025)	26% from business-as-usual (BAU) level by 2020 with domestic funding OR: 41% from BAU level by 2020 with international funding (IDR 168 trillion or USD 18.2 billion)
Malaysia	350 MW grid-connected RE power (2010)	
Philippines	100% increase RE capacity from 2005 level in 2015 5% bioethanol blend by 2009 10% bioethanol blend in 2011	
Singapore		16% from projected 2020 business-as-usual levels
Thailand	15.6% RE in 2011 19.1% RE in 2016 20.3% RE in 2022	30% from 2009 level by 2020/42 million tonnes CO_2e in 2020
Vietnam	3% RE in 2010 5% RE in 2020 11% RE in 2050 100 000 tonnes E5 and 50 000 tonnes B5 (equivalent to 0.4% of oil and gasoline demand) in 2010 250 000 tonnes ethanol (to produce 5 million tonnes E5 to satisfy 1% of projected gasoline demand) by 2015 500 million litres ethanol (E5) and 50 million litres of biodiesel (B5) by 2020 1.8 million tonnes ethanol (to produce 5 million tonnes of E5 to satisfy 5% of projected gasoline demand) by 2015	

Key point: ASEAN-6 renewable energy targets for medium and long term show varying levels of ambition and interest with Indonesia and Thailand at frontrunner positions in the region.

A number of ASEAN-6 countries specifically formulate targets for biofuels; in the Philippines they are even the main focus of the renewable energy policy targets. This shows the importance given to the development of a biofuels industry in the region, relating to the abundant availability of biofuel resources and the economic development and encouragement of employment expected from this industry.

The development of medium- and long-term renewable policy targets serves as an essential condition for developing a stable and integrated policy framework that will allow the private sector to benefit from a stable investment climate. However, although the renewable energy

targets show good intentions in the ASEAN region, the number of policies related to the formulation of such policy sometimes seems complex and overlapping. The combination of an integrated policy framework consisting of an overall renewable energy strategy, a renewable energy regulatory framework, a renewable energy authority invested with decision-making power and standard power purchase agreements (PPAs) could be essential for investors to "actually come to the party".

2.3. Policy programmes

Nearly all ASEAN-6 countries introduced policy programmes to support renewable energy targets by means of financial incentives and to some extent non-economic support mechanisms.

A predictable and transparent support framework is needed to attract investments (IEA, 2008b). Ideally, incentives should guarantee a specific level of support to different technologies based on their degree of technology maturity, in order to exploit the significant potential of the large basket of renewable energy technologies over time (*ibid.*). However, in order for renewable support policies to be effective, firstly non-economic barriers will have to be solved. Chapter 5 will discuss non-economic barriers in ASEAN-6 countries into detail.

The study of policies has the problem of being faced with continuous change and development. The next section will discuss national renewable energy policy programmes country-by-country in the ASEAN-6 on the basis of available information during the second half of 2009.

2.3.1. Financial incentives

Feed-in tariffs

Renewable energy feed-in tariffs (FITs) are price-driven policies which historically have been designed to support renewable electricity. Under such a system, electricity generated from renewable energy sources (RES) is paid a premium price for delivery to the grid. In many countries the scheme functions without using state budget: the government sets the price per kWh and utilities are obliged to purchase a given amount of this energy at this premium price which they then pass on to consumers. Another advantage of FITs is their guarantee of actual output since premiums are only paid for renewable electricity produced. Feed-in tariffs are also expected to accelerate cost reductions of renewable energy technologies, speeding up cost competition with conventional technology (Mendonça and Jacobs, 2009). FITs are growing in popularity as one of the most effective mechanisms of promoting renewable energy development. Where they started in Western, mainly European countries, FIT schemes are now being introduced all over the world, including a number of ASEAN countries.

Despite the fact that FITs have proven to be an effective and efficient policy for encouragement of renewable electricity, the specific design of this policy is crucial for its success. In developing countries, the design of a feed-in tariff scheme might have to be adjusted to local circumstances due to the vulnerability of electricity consumers, especially the poorest, to price increases and the characteristics of monopoly or oligopoly electricity markets. Mendonça and Jacobs (2009) suggest two specific design options for introduction of FITs in developing countries. Firstly, distributing costs of FITs across all ratepayers may not be equitable in developing countries and some of the additional costs could be taken over by a national fund for renewable energy deployment, although including

government contributions or international donor aid flows could harm the stability of the system. Secondly, the authors suggest limiting installed renewable capacity in order to control costs for the final consumer even though such caps can have disruptive effects.

Research by the EU Joint Research Centre demonstrated that renewable energy technologies used for electrification of rural areas by means of mini-grids can also be financed by means of an adapted feed-in tariff scheme (JRC, 2008).

In **Thailand**, the state electricity provider EGAT (Electricity Generating Authority of Thailand) is still responsible for 59% of the nationwide energy production although several structural reforms concerning liberalisation and privatisation of the energy sector have been introduced (see also Section 2.3.2). As part of the implementation of the Renewable Energy Development Plan (REDP), aiming to achieve the 20.3% target by the year 2022, a support scheme for renewable electricity production was introduced in 2007, called the "Adder Provision" whereby an additional energy purchasing price is guaranteed on top of the normal electricity market price. The amounts of adders in this feed-in premium scheme vary, depending on the technology used (Table 2.3), whereas the selling price of conventional power varies between USD 0.06-0.075/kWh. The duration of the support varies from seven to ten years.

Table 2.3: Feed-in premiums ("Adder") for renewable power generation in Thailand

	"Adder" per kWh – VSPP	"Adder" per kWh – SPP	Special "Adder" for southern provinces per kWh	Support period (years)
Wind				
Installed capacity <= 50 kW	THB 4.5 (USD 0.13)	Not applicable	THB 1.5 (USD 0.05)	10
Installed capacity > 50 kW	THB 3.5 (USD 0.104)	THB 3.5 (USD 0.104)	THB 1.5 (USD 0.05)	10
Solar PV	THB 8.0 (USD 0.25)	THB 8.0 (USD 0.25)	THB 1.5 (USD 0.05)	10
Biomass				
Installed capacity <= 1 MW	THB 0.5 (USD 0.016)	Bidding	THB 1.0 (USD 0.03)	10
Installed capacity > 1 MW	THB 0.3 (USD 0.01)	Bidding	THB 1.0 (USD 0.03)	10
Biogas				
Installed capacity <= 1 MW	THB 0.5 (USD 0.016)	Bidding	THB 1.0 (USD 0.03)	10
Installed capacity > 1 MW	THB 0.3 (USD 0.01)	Bidding	THB 1.0 (USD 0.03)	10
Mini and micro hydropower				
Installed capacity 50-200 kW	THB 0.8 (USD 0.02)	Not applicable	THB 1.0 (USD 0.03)	10
Installed capacity < 50 kW	THB 1.5 (USD 0.05)	Not applicable	THB 1.0 (USD 0.03)	10

Note: THB refers to the Thai Baht currency. All figures are in USD 2010, evaluated at market exchange rates.
VSPP: Very Small Renewable Energy Power Producer Programme.
Source: Thai Ministry of Energy, 2010.

Indonesia's Crash Programmes I and II (Box 2.2) aim to realise new electricity generation capacity on the short term. Crash Programme II focuses specifically on increased geothermal power capacity, however several non-economic barriers related to the Indonesian electricity

sector and its electricity price mechanisms severely impede such development (see Chapter 5). Since there is only one buyer and distributor of electricity in Indonesia, the state-owned enterprise PLN, there is no bidding process to determine an acceptable price for geothermal electricity because of the monopolistic situation. This means that the basic economic principles for negotiating a fair electricity tariff are absent. Currently, the electricity tariff is determined and fixed by the government at a rate that is way too low to account for the full electricity generation costs from any energy source. Since the Asian Financial Crisis in the late 1990s, PLN has been forced by the central government to sell electricity at prices below production costs. Government subsidies on electricity have resulted in a situation where electricity prices are lower than the production costs and where PLN has to be continuously compensated for its losses by the central government. In order to reverse this situation, the Indonesian government announced in late 2009 setting a higher price for electricity produced by new geothermal power plants in order to attract investment in the sector (Thomson Reuters, 2009). The Indonesian government has set a recommended ceiling price of USD 0.097 per kWh as a FIT for geothermal electricity compared to the current USD 0.04 per kWh. However, the recent announcement was not accompanied by plans to lower electricity price subsidies, although earlier this year a government official stated that "with elections now out of the way, fossil fuel subsidies could drop below the distortion level that discourages renewable energy within a year" (Creagh, 29 July 2009).

Malaysia is currently in the process of updating its energy policy by means of the 10th Malaysia Plan (2011-15) with a new National Renewable Energy Policy and Action Plan. As was recently presented on a conference in Malaysia, the Malaysian government is considering a comprehensive FIT programme to be part of the 10th Malaysia Plan (Renewable Energy World.com, 2009). The Malaysian proposal includes all renewable energy technologies, differentiates tariffs by technology, and derives the tariffs based on the cost of generation. In the proposal it is also suggested that the FIT programme would add 2% to the average electricity price in the country. However, an exemption for this rise in electricity costs is available for low-income consumers. The Malaysian government acknowledges that some basic non-economic barriers will need to be overcome in order for the scheme to be successful such as guaranteed grid access and legal obligation for utilities to purchase renewable electricity, streamlined (local) procedures, FITs preferably to be fixed for 20 years and implementation by a competent agency that includes constant monitoring and progress reporting. It also acknowledges as a critical factor for success the installation of a renewable energy fund manager.

The **Philippines** are taking first steps towards the introduction of FITs in the near future. The National Renewable Energy Board (NREB), created under the Renewable Energy Act of 2008, has set up committees to study the country's renewable portfolio standards (RPS) and feed-in tariff for the use of "green" energy and targets to complete guidelines on renewable energy use in the country by the first quarter of 2010 (ManilaTimes.net, 2009) .

Tax exemption

A wide array of tax incentives is available to increase competitiveness of renewable energy technologies. Tax incentives can include tax credits, tax reductions or tax exemptions and can be designed in different ways. The effectiveness of tax incentives has a direct relation with the applicable tax rate (IEA, 2008b). Tax incentives can apply to value-added tax (VAT) for energy, but can also be applied to customs duties on imported materials needed for developing

renewable power plants. A number of ASEAN countries introduced tax exemptions to create incentives for renewable energy.

In **Malaysia**, companies that undertake forest plantation projects or energy conservation measures or use energy from renewable biomass, mini-hydro or solar are eligible for Pioneer Status with a tax exemption of 100% of the statutory income[19] for 10 years; or Investment Tax Allowance of 100% on the qualifying capital expenditure incurred within five years, which can be offset against 100% of the statutory income for each year of assessment. For the energy related measures, companies can also qualify for higher exemptions or allowances if the activities take place in "promoted areas".

With the introduction of the Renewable Energy Act (2008), power plants in the **Philippines** using renewable energy sources are exempt from income tax for the first seven years of operation (IEA, 2009b). After that, the power plant will pay a reduced tax rate of 10% annually and property tax is capped at 1.5%. Furthermore, companies building renewable energy power plants pay no customs duties on materials imported into the country for power plant construction. Also, no value-added tax is to be paid on the green electricity these power plants sell. The Philippines Biofuels Act 2007, mandating various minimum percentages of locally sourced biofuels, is accompanied by an incentive scheme comprising various fiscal incentives (IEA, 2009b). The biofuel component (local or imported) in fuel is exempt from specific tax, and raw materials used for the production of biofuels are exempt from value-added tax. Water effluents resulting from biofuel production are exempt from payment of wastewater charges.

In **Indonesia**, since 2007, geothermal exploration equipment is exempt from import duties and geothermal exploration activities are exempt from taxes. The Indonesian government introduced wider tax incentives for other renewable energy technologies at the end of January 2010, including a reduced income tax base, accelerated asset amortisation and exemption from import duties and value-added tax for strategic equipment and machinery.

In **Thailand**, reflecting the high priority attached to renewable energy and energy efficiency development, the Ministry of Energy and the Board of Investment have introduced import duty exemptions and eight-year tax holidays on renewable energy equipment.

Capital cost grants

Capital cost grants reduce investment costs and are a common means to overcome high initial capital costs of many renewable energy technologies. A disadvantage of capital cost grants is that there is no guaranteed renewable energy output since there is no specific incentive to produce renewable energy once the technology is installed. Another disadvantage of capital cost grants is that they depend heavily on state budgets which can affect stability of such scheme. The lacking financial means in developing countries results in limited possibilities for introduction of capital cost grants.

In the ASEAN-6 countries only **Thailand** introduced financial incentive schemes with (elements of) capital cost grants. The Thai Ministry of Energy introduced the National Energy Conservation Programme (ENCON) as of 1992. Since then, this programme has being funded by a fossil fuel tax and has provided financial assistance and incentives for projects related to energy

[19] Statutory income is assessable income under a specific provision of the taxation legislation. For example, net capital gains are not ordinary income but may be included in a taxpayer's income as statutory income.

conservation, renewable energy, research and development as well as public awareness and training. In 2008, the Thai Department of Alternative Energy Development and Efficiency (DEDE) introduced investment grants of 30% for solar thermal systems in commercial applications targeting a total surface of 30 000 square meters, 30% for biogas installations and 10% for municipal solid waste (MSW).

Other financial incentive schemes

The **Singapore** Clean Energy Research and Test-bedding Programme (CERT) provides opportunities for companies to develop applications and solutions to test-bed their clean energy technologies in Singapore, with government agencies providing the test-bedding locations as well as facilitate these projects. The programme seeks to promote and support R&D in clean energy technologies through a competitive bidding process. Each bidding round will seek applications in specific technologies and asks for R&D project proposals that last up to three years. Specific R&D interests included so far consisted of materialisation of solar PV, process and equipment design for solar cell manufacturing, solar thermal, building integrated PV, solar in off-grid applications and distributed generation and system integration for solar applications (EDB Singapore, 20 August 2007).

Singapore's Solar Capability Scheme (SCS) seeks to encourage innovative design and integration of solar panels into buildings. SCS aims to build up the capabilities of designers, architects and system integrators in solar energy companies through increased implementation by lead users in Singapore (EDB Singapore, 6 May 2008; EDB Singapore, 2010).

2.3.2. Overview of financial incentives for renewable

Table 2.4 presents an overview of financial incentives for renewable energy in ASEAN-6 countries.

The overview demonstrates that financial incentive schemes focus on FIT schemes as well as tax exemption schemes. FIT schemes seem to become even more popular in time with the Philippines and Malaysia currently preparing such schemes for the near future. The advantage of FITs is that the scheme functions without using state budget – since utilities are obliged to purchase this energy at the premium price which they then pass on to consumers. The price vulnerability of electricity consumers in these countries should be kept in mind though.

Table 2.4: Financial incentives for renewable energy in ASEAN-6

	Feed-in tariffs	Tax exemption	Capital grants	Other
Indonesia	**Feed-in tariff for geothermal power (2009)**	Geothermal exploration equipment and activities exempt from taxes (2007)		
Malaysia	*Comprehensive feed-in-tariff scheme proposed for 10th Malaysian Plan (2011-15)*	**Small Renewable Energy Power** Programme: RES-E 10 years tax holiday		
Philippines	*Draft rules on feed-in-tariffs published in January 2010*	**Renewable Energy Act** (2008): RES-E receives 7 years tax holiday, after that reduced tax rates. No customs duties on imported materials, no VAT on renewable electricity sold		
Singapore				R&D investment: **Clean Energy Research and Testbedding Programme** (CERT, 2007); **Solar Capability Scheme** (SCS, 2008)
Thailand	**Feed-in premium** "Adders" on top of regular tariffs (2007)	**Board of Investment (BOI) tax holidays and import duty exemptions**	**National Energy Conservation** Programme (ENCON, 1992): funded by a fossil fuel tax, financial incentives for projects related to energy efficiency, renewable energy, R&D, public awareness and training **Investment grants for solar thermal, biogas and MSW** (2008-10)	
Vietnam				

Key point: ASEAN-6 financial incentive schemes focus on tax exemption and feed-in tariff schemes, with the latter rapidly expanding throughout the region.

2.3.3. Non-economic support mechanisms

A number of ASEAN countries introduced non-economic support mechanisms, mainly aiming at facilitating independent power producers (IPPs) to be able to enter the market more easily and to solve barriers related to the characteristics of non-liberalised energy markets.

In **Malaysia**, the Small Renewable Energy Power Programme (SREP) was introduced to enable power generated from renewable sources to access the national grid (IEA, 2009a). SREP developers can sell renewable power from biomass, biogas, municipal solid waste, solar small hydropower and wind, to utilities through the Renewable Energy Power Purchase Agreement (REPPA) which gives plants a license for a period of 21 years to sell up to 10 MW to the national grid system (*ibid.*).

Indonesia issued a number of decrees in order to stimulate private investment in the power sector. Presidential Decree 67/2005 aims to provide payment assurance under certain conditions for IPPs (Girianna, 2009). The Ministerial Decree on Small Distributed Power Generation Using Renewable Energy and the Ministerial Regulation on Medium Scale Power Generation Using Renewable Energy allow the private sector to sell renewable power to the local utility's power grid with contracts for ten years or longer being negotiable (IEA, 2008a).

The **Thai** government introduced a variety of programmes to encourage IPP investments. In 1992, the Small Power Producer Programme (SPP) was introduced to promote combined heat and power (CHP) and renewable energy sources (RES). With this programme, the Electricity Generating Authority of Thailand (EGAT) is committed to buying electricity produced by small power producers with a maximum installed capacity of 90 MW. In 2002, the SPP was supplemented by the Very Small Renewable Energy Power Producer Programme (VSPP). The VSPP was initiated to promote even smaller projects with a maximum power capacity of 10 MW_{el} by using simplified and more flexible regulations.

Moreover, Thailand also places emphasis on awareness-raising and information support, establishing publicly accessible databases on renewable energy potentials and equipment manufacturers on the Ministry of Energy website. The Ministry has also founded a one-stop service centre for renewable energy and energy efficiency to provide information and guidance to investors, companies active in these sectors and private individuals.

3. Prospects for renewable energy deployment

Key findings

- Calculation of realisable potentials assumes that countries have effective policies in place and have removed barriers to the uptake of renewables. In the medium term to 2030, there is significant realisable potential for renewables in the ASEAN-6 countries. (These results give an indication of the order of magnitude, but, in the absence of cost competition among technologies, the realisable potentials should not be interpreted as projection results.)
- If it were possible for an energy mix to fully exploit the potential of all renewable energy technologies, for example, the realisable potential in 2030 could be equal to about 1.8 times the total 2007 electricity consumption in the region. Looking forward to 2030, the additional realisable renewable electricity potential in ASEAN-6 countries could be as much as 12 times the current deployment, especially for non-hydro sources. Among non-hydro renewables, significant contributors would be biomass, onshore wind, geothermal and solar photovoltaics.
- For heating, the realisable potential for renewable heating could be equal to 18% of estimated heat demand in the ASEAN-6. The potential is largest for modern biomass applications, followed by solar thermal and geothermal heat.
- For transport, the realisable potential of domestically produced biofuels is equivalent to 17% of the ASEAN-6's transport energy demand in 2007. This could make an important contribution to supporting rapid growth of the transport sector in the region. The potential for second-generation biofuels is particularly significant, but their large-scale development depends on appropriate policy support.
- Except for biofuels, the realisable potential for renewables in ASEAN-6 is significantly larger than the projected penetration in the 450 scenario described in the IEA *World Energy Outlook 2009* (IEA, 2009a). This demonstrates that resource availability is not the main factor hindering growth of renewables, but rather competition from less costly technology options that do not fully account for the external benefits of renewables.
- Important socio-economic benefits of large-scale penetration of renewables include improvements in energy security and noteworthy reductions of air pollution reductions and CO_2 emissions that would contribute to climate change mitigation. These co-benefits are associated with high cost savings, although no uniform methodology exists to quantify these savings.

3.1. Introduction

This chapter examines the future outlook for renewable energy technologies (RETs) in the ASEAN-6 countries, reviewing their respective potentials and the projected market penetration of RETs. The projections differ by scenario: a reference business-as-usual scenario based on unchanged energy-related policies contrasting, with a second scenario assuming ambitious policies relating to climate change mitigation and the wider socio-economic benefits associated with an expansion of renewables.

3.2. Potentials for renewables

3.2.1. Methodological approach[20]

There is much discussion of the potentials of various energy resources in existing literature. However, terminologies vary. Therefore, this report uses the definitions clearly mapped in recent IEA analysis, which assessed renewable energy potentials for OECD countries and Brazil, Russia, India and South Africa (IEA, 2008).

Theoretical potential: This represents the theoretical upper limit of the amount of energy that can be generated from a specific resource, over a defined area, based on current scientific knowledge. It depends on physical flows only, *e.g.* average solar irradiation in a certain region.

Technical potential: The technical potential can be derived on the basis of technical boundary conditions: efficiencies of conversion technologies, or overall technical limitations such as available land area for wind turbine installation. For most resources, the technical potential is dynamic: with improved research and development, conversion technologies may be enhanced, with resulting improvement in the technical potential.

Realisable potential: The realisable potential represents the maximum achievable potential, assuming that all existing barriers can be overcome and all development drivers are active. In this respect, general parameters such as market growth rates and planning constraints are taken into account. It is important to note that the realisable potential is also time-dependent: it must relate to a certain year. In the long run, the realisable potential tends towards the technical potential.

Mid-term potential: The mid-term potential is defined as the realisable potential in 2030.

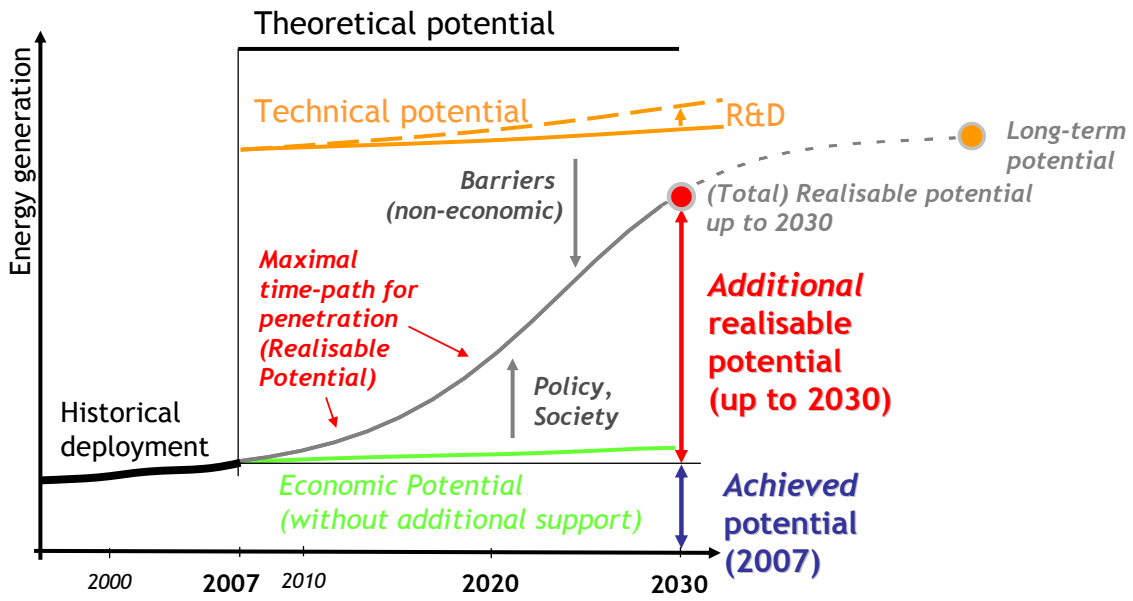
Economic potential: The economic potential is defined as that potential which can be exploited without the need for additional support, *i.e.* whose exploitation is competitive compared with conventional incumbent technologies.

The **total realisable potential** is the sum of the achieved potential (cumulative installed capacity) by 2007 plus the **additional realisable potential** in the remaining timeframe (2007-30).

The relationships among the different metrics of potential are depicted in Figure 3.1.

[20] This report adopts the same methodology as used in existing recent IEA analysis (see IEA, 2008).

Figure 3.1: Metrics relating to RET potentials



Source: Adapted from IEA, 2008.

Key point: In the long run, the realisable potential tends towards the technical potential.

The assessment of the realisable mid-term potentials of RETs up to 2030 for the ASEAN-6 was carried out using the "WorldRES" model.[21]

Further detail on the methodology and how the potentials of the individual RETs were derived is available in Annex C of this report.

3.2.2. Technical potentials for renewables

The technical potentials for most renewable energy technologies in the ASEAN-6 countries are very large. Nevertheless, even for the most mature RETs such as large-scale hydropower, the current use of these energy sources lies far below their technical potential (see Chapter 1).

In terms of **hydropower**, the ASEAN-6 potential totals about 150 gigawatts (GW) which includes significant mini- and micro-hydro potentials in Indonesia, Malaysia and the Philippines (WEC, 2007; Lidula *et al.*, 2007).

[21] The projections of renewable energy technologies (RETs) for the IEA *World Energy Outlook 2009* publication (IEA, 2009a) were derived in the model "WorldRES", allowing an assessment of the future deployment. This model has been developed for this purpose by the Energy Economics Group (EEG) at the Vienna University of Technology in co-operation with the Wiener Zentrum für Energie, Umwelt und Klima. This builds on previous work completed in a fruitful co-operation with the IEA's *World Energy Outlook* series.

Bioenergy resources are large in all of the ASEAN-6 countries, totalling approximately 90 GW (with the exception of the small coastal economy of Singapore), and show wide variety. Feedstocks include agricultural and forestry residues, energy and forestry crops, animal residues, and municipal solid waste (Fungtammasan, 2009; Lidula *et al.*, 2007; Pacudan, 2005). With all ASEAN-6 countries having substantial agricultural sectors, there is considerable biogas potential based on animal waste in the region.

On average, the ASEAN-6 countries, located in tropical latitudes, receive very **high daily insolation** of 4-7 kWh per square metre (sqm). **Solar photovoltaics (PV)** are used in Indonesia, the Philippines, Thailand, Vietnam for **off-grid applications** and rural energisation:[22] water pumping, home and street lighting, telecommunication networks, navigational aids. **Grid-connected penetration** of PV, which is the focus of this report, is nearly non-existent in the ASEAN-6 but has huge potential for peak-load shaving, especially as cooling demand plateaus in the region coincide with daily insolation peaks. The technical potential for **low temperature solar thermal heat** is very large.

The potential for **solar thermal electricity** (also referred to as concentrating solar power) **is extremely low** due to high relative humidity which increases atmospheric scattering and limits direct normal radiation, which concentrator systems require (Lidula *et al.*, 2007; Pacudan, 2005).

Wind potential totals tens of gigawatts (GW) across the ASEAN-6 with Vietnam and the Philippines leading. Technical potentials in Indonesia, Thailand and Singapore are substantially smaller (Lidula *et al.*, 2007; Pacudan, 2005).

Indonesia and the Philippines have technical potentials for **geothermal** which rank among the world's largest: about 27 GW and 2.6 GW respectively. The Philippines have the second-largest utilisation worldwide of geothermal energy for power generation, followed by Indonesia; although the latter's technical potential is substantially larger but remains underexploited (Lidula *et al.*, 2007; Pacudan, 2005; MEMR, 2008).

The technical potential for **ocean energy** has not been assessed in detail, but first indications are that at least the Philippines and Indonesia have huge potentials (in the range of about 170 GW and 240 GW respectively) to exploit wave, tidal and or thermal gradients (Pacudan, 2005; Suharta, 2008). However, these potential figures should be treated with caution, as they relate to non-mature technologies which are currently progressing from the research and development to the demonstration stage and still need to prove their technological worthiness before they move towards commercialisation.

3.2.3. Realisable potentials for renewables

The focus of the potentials analysis is on the so-called medium-term (to 2030) "realisable potentials". The advantage of a realisable potentials approach is that it reveals the maximum deployment possible over a certain time period assuming best policy practice. The realisable

[22] The potential for rural and off-grid applications of renewable energy technologies in the ASEAN-6 countries, although very large, is not discussed in details as it is beyond the scope of this analysis. Deeper separate research on this topic is warranted as the policies and financing mechanisms needed to unlock the off-grid renewables potentials, as well as the associated development objectives, are distinct from those required for on-grid renewables growth. Relating to this topic, the IEA has recently published a comparative study on rural electrification policies in emerging economies (IEA, 2010).

potential calculations for the individual RETs consider overall energy system constraints. They do not, however, reflect relative costs and, thus, do not deliver a least-cost technology mix.

Depending on the extent to which favourable market and policy environments for renewables are fostered, countries in the region will be able to exploit the *realisable potential* of the renewable energy technologies (Table 3.1).

Table 3.1: Total realisable mid-term potentials for RETs: ASEAN-6 countries

Total realisable generation potentials for RE to 2030 (in TWh)	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam	ASEAN-6
Renewable electricity							
Biogas	55.43	7.41	20.23	1.14	17.90	21.64	**123.75**
Solid biomass	69.58	25.95	15.19	0.11	25.91	38.68	**175.41**
Renewable municipal waste	7.71	1.06	3.02	0.21	2.41	2.85	**17.26**
Hydropower	60.80	50.34	17.83	0.00	14.66	74.21	**217.83**
Onshore wind	41.75	22.77	15.65	0.08	37.97	29.09	**147.31**
Offshore wind	21.34	13.39	6.96	0.22	19.42	14.87	**76.21**
Geothermal electricity	84.66	0.00	28.96	0.00	0.02	0.00	**113.63**
Solar photovoltaics	61.70	12.37	20.44	0.02	32.95	27.26	**154.75**
Solar thermal electricity	0.44	0.04	0.08	0.00	0.13	0.01	**0.69**
Tidal and wave energy	0.66	0.14	0.22	0.00	0.12	0.11	**1.25**
Biofuels (domestic)*							
1st generation biofuels*	25.74	5.56	1.55	0.00	3.11	1.66	**37.62**
2nd generation biofuels*	43.87	11.20	12.79	0.00	24.00	16.74	**108.61**
1st generation bioethanol	24.90	5.24	1.55	0.00	2.66	1.66	**36.01**
2nd generation bioethanol	33.78	8.04	8.28	0.00	16.29	11.13	**77.51**
1st generation biodiesel	25.74	5.56	1.06	0.00	3.11	0.14	**35.60**
2nd generation biodiesel	43.87	11.20	12.79	0.00	24.00	16.74	**108.61**
Renewable heat							
Biomass heat (CHP, mainly autoproducers)	42.73	13.91	13.26	0.69	17.35	19.67	**107.61**
Biomass heat (small-scale, off-grid)	8.82	7.02	3.61	0.15	1.37	22.35	**43.32**
Geothermal heat	14.48	0.36	3.60	0.00	1.62	1.89	**21.95**
Solar thermal heat	24.10	7.81	2.09	0.09	12.19	5.91	**52.18**

Note: Expressed data refer to the biofuel option characterised by the highest yield – depending on the specific feedstock – among the competitive pathways (*i.e.* biodiesel versus bioethanol). It is important to note that the potentials for the alternative pathways are not additive.
Source: Based on IEA calculations and Resch, 2009.

This section gives an overview of the outcomes of the preliminary assessment of realisable mid-term potentials (to 2030) for the range of considered RETs in the ASEAN-6 countries.[23] Total future potentials[24] are given by technology and country.

At the regional scale (comprising all ASEAN-6 countries) large mid-term potentials exist in the electricity sector. If it were possible for an energy mix to fully exploit the potential of all RES-E

[23] The realisable potentials calculations are preliminary and will be finalised and presented in the forthcoming IEA publication *Deploying Renewables: Worldwide Prospects and Challenges*.
[24] The assessed total realisable mid-term potentials comprise both the already exploited potential – which for non-hydro renewables is relatively small – and the one to be realised in the mid-term future to 2030.

technologies, the realisable potential to 2030 could be equivalent to at least 1.8 times of total ASEAN-6 electricity consumption in 2007. The realisable potential for renewable heat from modern conversion technologies[25] could be equal to 18% of total 2007 estimated heat demand in the ASEAN-6.[26] The realisable potential for biofuels for transport can make an important contribution, being equivalent to 17% of total ASEAN-6 road transport fuel demand in 2007.

3.2.3.1. The renewable electricity (RES-E) sector

The following discussion illustrates the extent to which RETs may contribute to meeting demand for electricity up to 2030, by considering the specific resource conditions.

Figure 3.2 depicts the total realisable mid-term potentials for RES-E, by country, in absolute terms, relative to production in 2007. For most countries, the additional realisable potential to 2030 far outstrips the achieved deployment of renewables to date. In absolute terms, this is particularly significant in Indonesia, due to the country's vast RES-E potential.

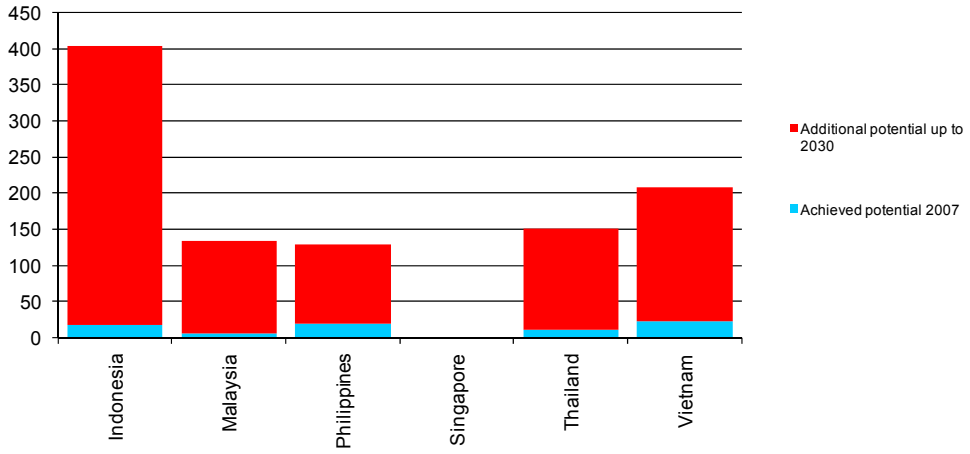
Underlying the high realisable RES-E potential in 2030 is accelerated growth in additional deployment after 2020, as many RETs are anticipated to follow a best-practice[27] path of technology diffusion only in 2020 or shortly thereafter. Technology dynamics, *i.e.* the general patterns by which technologies diffuse through competitive markets, is illustrated in Figure 3.3. In accordance with general innovation diffusion theory, market penetration of any new technology typically follows a pattern resembling an S-curve. Applying such a curve to the potential reflects both technical and non-technical constraints. An example of the former is, for instance, the scaling-up of component and technology manufacturing capacity which requires time. Non-technical constraints include for instance market and administrative barriers.

[25] Current production of heat from biomass feedstocks, either grid-connected, *e.g.* on-site combined heat and power production by industrial autoproducers, or small-scale decentralised applications, is only estimated because of a lack of data on non-commercial use of bioenergy in the ASEAN-6.

[26] Total residual final energy demand is taken as a proxy for heat demand in non-OECD countries using the equation "Residual Final Energy Demand = Total Final Energy Consumption (TFC) – Energy demand for Electricity – Transport energy demand – Non-energy use – Residential Traditional Biomass for cooking".

[27] A best-practice path of technology diffusion is characterised by high levels of annual growth often associated with the implementation of effective policies, as in many of the current market-leading countries.

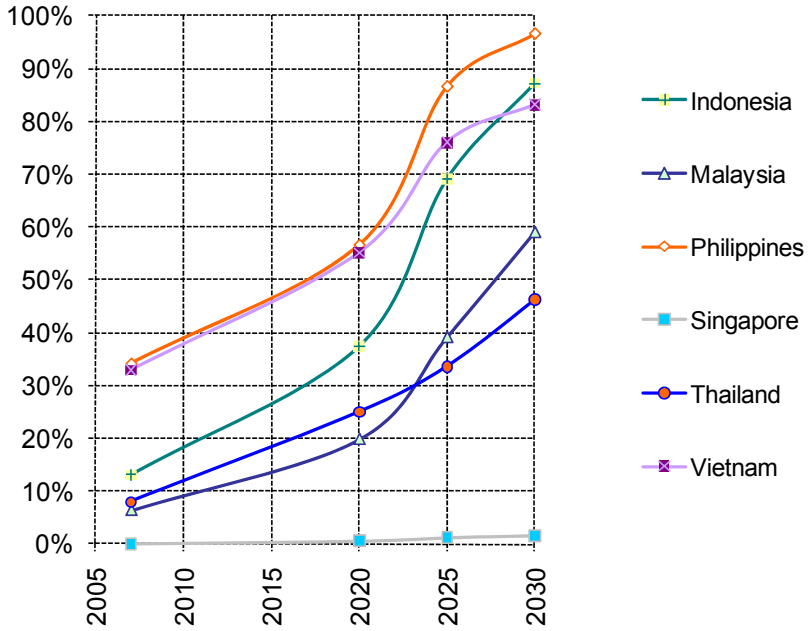
Figure 3.2: Production/achieved potential (TWh) in 2007 and additional realisable potential (to 2030) for RES-E: ASEAN-6



Source: Based on IEA calculations and Resch, 2009.

Key point: For all ASEAN-6 countries, the additional realisable potential to 2030 far outstrips the achieved deployment of renewable electricity to date, especially for non-hydro sources.

Figure 3.3: Dynamic contribution to realisable RES-E generation potential in the period 2007 to 2030 as share of gross electricity demand: ASEAN-6



Source: Based on IEA calculations and Resch, 2009.

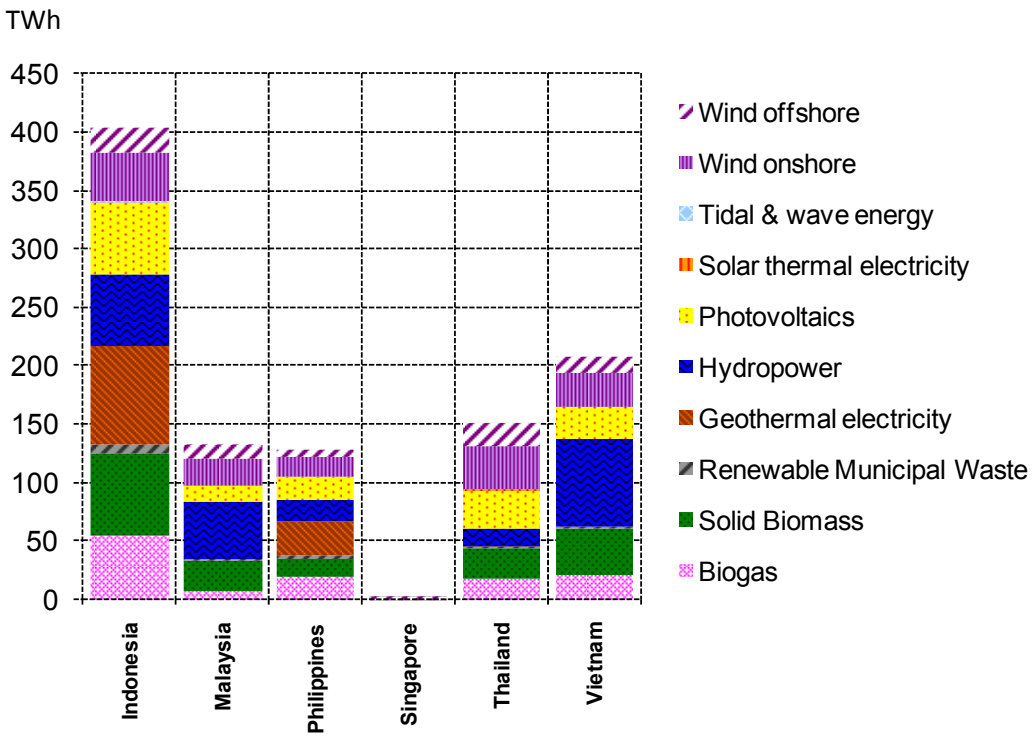
Key point: For all ASEAN-6 countries, the total realisable potential in 2020 is equivalent to a sizable share of projected electricity demand.[28] Over the subsequent decade to 2030, as the deployment of renewables accelerates, renewables' share of electricity demand increases by at least half in all countries, and even doubles in the case of Indonesia and triples in Malaysia.

[28] Based on the *IEA World Energy Outlook 2009* Reference Scenario (IEA, 2009a).

The additional mid-term (2030) realisable potential calculated by the model is calibrated backwards from the long-term technical realisable potential, which represents the maximum achievable potential assuming that all existing barriers can be overcome and all driving forces are active. It is important to note that applying such an S-curve also accounts for the starting point of deployment.

For example, if a certain country has a significant long-term technical wind energy potential, but its achieved starting potential in 2007 is low, the exploitation of the entire technical potential will require significant time. As a consequence, the realisable mid-term potential by 2030 will be significantly lower than the long-term technical potential.

Figure 3.4: Technology-specific total realisable mid-term potentials (to 2030) for RES-E by country: ASEAN-6



Source: Based on IEA calculations and Resch, 2009.

Key point: The RES-E technologies with the potential to make major contributions in the medium-term to 2030 are primarily those which have already reached, or are close to market competitiveness.

At the regional level, as well as in several individual ASEAN countries, **hydropower** will remain the largest renewable contributor to electricity needs. As is evident from Table 3.1, hydropower has a share of 24% of the total RES-E potential in the ASEAN-6. However, 26% of this is already exploited and much of the growth in developed potential takes place by 2020. In absolute terms, the largest potentials are in Vietnam, Indonesia, and Malaysia.

Biomass is another important renewable energy source. RES-E generation based on solid biomass, biogas and municipal renewable waste represents 35% of total RES-E potential in the ASEAN-6, and it overwhelmingly (99%) remains to be exploited. All ASEAN-6 have diverse biomass feedstocks in their resource portfolio, ranging from residues of agriculture and forestry to forestry products. Not only do a variety of biomass feedstocks exist, but also a variety of corresponding technology options, from co-firing in conventional power plants to small-scale combined heat and power (CHP) plant.

Environmentally beneficial use as well as a consideration of possible social impacts is of key importance when striving for a massive market introduction. Electricity generation potentials, as indicated, refer largely to a combined use, *i.e.* where, besides electricity, heat production is also emphasised (CHP mode).

Similarly to biomass, **wind energy** is characterised by a large future potential in the ASEAN-6, especially in Indonesia, Thailand and Vietnam: more than 99% of the total realisable mid-term potential remains to be exploited. The share of wind energy in total RES-E potential for the ASEAN-6 countries is 15%, reflecting this technology's maturity. Although the market for offshore wind technology is growing rapidly in countries with targeted policies, the realisable potential in the ASEAN-6 to 2030 is only moderate, representing 5% of the region's total renewable electricity potential.

Geothermal electricity generation using hydrothermal fluids[29] is already a proven RET option in two ASEAN-6 countries: Indonesia and the Philippines. Geothermal represents a considerable 12% of overall ASEAN-6 RES-E potential. Innovative technologies, such as hot dry rock (also called enhanced geothermal systems) which use hydraulic fracturing to "enhance" geothermal resources, are likely to be developed and deployed more beyond 2030.

Solar photovoltaics (PV) are a promising option that lags behind expectations. Recently, growing emphasis has been put on both photovoltaics (PV) and solar thermal electricity generation – especially in Europe, but also in the United States and China, where a large PV manufacturing industry is being developed. A 9% share of the total RES-E potential can be expected for grid-connected PV in the ASEAN-6 countries if effective support were implemented in each country. Although not a focus of this analysis and not quantified, the realisable potential for off-grid PV installations in the ASEAN-6 countries can be estimated to lie in the range of up to 20% of the on-grid PV potential by 2030.

While the technical potential for marine energy may be huge, **tidal and wave energy** technologies are still insufficiently mature at the current time to make a major contribution to the realisable RES-E potential in the ASEAN-6 in the medium term.

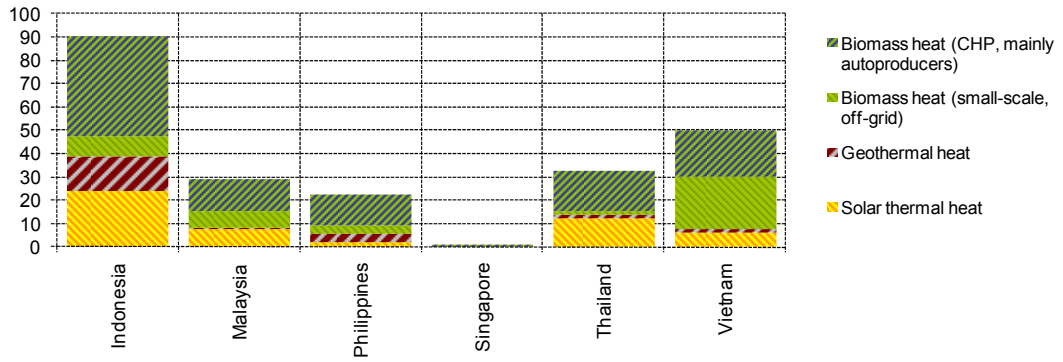
3.2.3.2. The renewable heat (RES-H) sector

This section assesses the potential of selected RETs to meet the demand for heating in the medium term to 2030, accounting for specific resource conditions (Figure 3.5). Due to favourable climate conditions in the ASEAN-6 located in the tropical latitudes, heating needs are generally restricted to hot water preparation and heating for industrial purposes (*e.g.* low-temperature drying and high-temperature heat for on-site power generation), with minimal demand for space heating.

[29] Hydrothermal refers to the circulation of hot water close to heat sources within the Earth's crust, often close to areas of volcanic activity.

However, it can be assumed that a certain portion, which has not been quantified, of the identified potential for renewable heating could instead be tapped for cooling purposes, assuming the development and commercialisation of renewable cooling technologies progress sufficiently. The ASEAN-6 region has high and rapidly expanding cooling needs (refrigeration of food and drink products, space cooling) as disposable incomes rise in the region. Annex D to this report analyses the drivers behind this increasing demand for cooling.

Figure 3.5: Technology-specific total realisable mid-term potentials (to 2030) for RES-H by country: ASEAN-6



Source: Based on IEA calculations and Resch, 2009.

Key point: For all ASEAN-6 countries the realisable potential to 2030 for heat from modern biomass installations[30] is more than double the potential production of heat from solar and geothermal sources.

The production of **heat from biomass in combined electricity and heat plants for industrial users, often autoproducers,** offers sizable potentials (40% of the ASEAN-6's total RES-H potential) that are mostly still to be exploited. As stated in the previous section, all countries have some forms of biomass in their resource portfolio. An environmentally beneficial use as well as a consideration of possible social impacts is critical when aiming for mass market introduction. Heat production in **small-scale, mostly off-grid or decentralised** modern biomass installations, such as stoves for hot water preparation, makes a decent small 22% contribution to total realisable RES-H potential.

Solar thermal heat contributes about a quarter of the realisable mid-term potential for RES-H in the ASEAN-6. High solar irradiation across the ASEAN-6 presents ideal resource conditions for solar thermal heat potential, which can be used to satisfy water heating demand, *e.g.* for domestic showers.

The realisable potential for **geothermal heat** is not substantial in the ASEAN-6, representing 14% of the total RES-H potential, with only Indonesia enjoying sufficient geothermal resources and overall heat demand.

[30] As opposed to the unsustainable use of traditional biomass.

3.2.3.3. The renewable transport fuel (RES-T) sector

This section discusses the feasible contribution of domestically produced biofuels to meet demand for transport liquid fuels, as currently mostly covered by diesel and gasoline, in the medium term to 2030.

Biofuel production is already expanding in most ASEAN-6 countries (see Chapter 1) and biofuels have a high future potential in all ASEAN-6 countries except Singapore (due to the island-state's restricted land area), as in general they include some forms of biomass in their resource portfolio.

In the medium term to 2030, there is potential both for first-generation and second-generation biofuels, although the relative balance between the two categories evolves over the period as the commercialisation of more advanced biofuels is expected to accelerate beyond 2020. The increasing criticism on some first-generation biofuel pathways[31] has raised attention to the potential of so-called advanced and second-generation biofuels.[32] These fuels can be produced from virtually any type of biomass and can thus use the whole plant and not simply the grain or fruit, thus providing higher per hectare yields. Depending on the feedstock choice and the cultivation technique, second-generation biofuel production has the potential to provide benefits such as consuming waste residues in the agriculture and forestry sectors and making use of abandoned land. In this way, the new fuels could offer considerable potential to promote rural development and improve economic conditions, which is an important driver for biofuel production in the ASEAN-6 region.

In the period to 2020, the potential for first-generation biofuels is dominant, with energy crops constituting relevant feedstocks for large-scale biofuel production. In the ASEAN-6 overall, the production of first-generation biodiesel, especially palm oil, has a larger potential than that of first-generation bioethanol, mostly from sugarcane. However, in individual countries, such as Thailand and Vietnam, the potential for first-generation bioethanol is larger than that of biodiesel.

Commercial deployment of second-generation biofuels is expected to begin around 2015 assuming that appropriate policy support is implemented (IEA, 2009a). In the decade from 2020 to 2030, the potential for second-generation biofuels in the ASEAN-6, based on abundant agro-industrial and forestry residues, expands rapidly while that of first-generation biofuels grows at a far slower pace.

The preceding discussion highlights the key importance of environmentally beneficial use as well as a consideration of possible social impacts. Delayed introduction of such sustainability criteria may hinder the diffusion of promising conversion technology options, and consequently affect the realisable mid-term potential tremendously. Additionally, competition with electricity and heat generation for feedstocks, which may further impact the future potential, occurs if ambitious targets are introduced for both options.

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[31] See Chapter 1 for a discussion on the sustainability challenges of first-generation biofuel production in the ASEAN-6 and the existing opportunities for second-generation biofuels.

[32] There are different conversion pathways for second-generation biofuels: the **thermo-chemical route**, in which biomass is gasified to produce bio-Synthetic Natural Gas (SNG) or Biomass to Liquid (BTL)-diesel (latter via Fischer-Tropsch synthesis); the **bio-chemical route**, in which enzymes or micro-organisms are used to convert cellulose and hemicellulose in the biomass to sugars, which are then fermented to produce ethanol.

3.3. Projections for medium-term renewables diffusion

3.3.1. Projected growth for renewables

The IEA undertakes medium-term projections to 2030 of energy sector trends at the global level on an annual basis.[33] The IEA *World Energy Outlook 2009 (WEO)* looks in detail at the ASEAN region of ten countries,[34] of which the ASEAN-6 countries represented 95% of the region's energy demand in 2007 and 98% of electricity generation.

In the **Reference Scenario** of the *WEO*(IEA, 2009a), which assumes a business-as-usual trajectory based on existing trends and policies, RES-E in fact declines to 15% in 2030 from 16% in 2007, due to a sharp decline in hydro electricity's share from 12% to 8% A moderate increase in biomass and waste-generated electricity over the projection period (from 1% to 3%) does not offset this hydro's decreasing significance in the ASEAN region's power mix (IEA, 2009a). The indicative target of a 15% share of renewable energy technologies in power capacity by 2015 – which is a decline of 3% relative to 2007 – included in the ASEAN Plan of Action for Energy Cooperation 2010-15 is already significantly exceeded in the Reference Scenario (IEA, 2009a).

In terms of transport fuel consumption, biofuels are projected to represent 5% of the market by 2030, growing by an annual average of 17.5% from 2007 onwards (IEA, 2009a).

It should be highlighted that at the global level, the projections of the Reference Scenario are profoundly unsustainable, corresponding to catastrophic projected average global temperature increases of 6 °C above pre-industrial levels.

An international consensus is emerging on the need to limit the global temperature increase to 2 °C above pre-industrial levels to avoid the most detrimental and irreversible of climate change impacts (IEA, 2009a; IPCC, 2007). The IEA ambitious 2009 *WEO* 450 Scenario analyses measures to force energy-related CO_2 emissions down to a trajectory that, taking full account of the trends and mitigation potential for non-CO_2 greenhouse gases and CO_2 emissions outside the energy sector, would be roughly consistent with ultimately stabilising the concentrations of all greenhouse gases in the atmosphere at 450 ppm of CO_2 equivalent (CO_2e). This level of concentration has a 50% chance of giving rise to a global temperature increase of 2 °C.

For the ten-member ASEAN region, renewables' penetration in the power mix reaches 32% by 2030 in the **450 Scenario**, a doubling compared to the 2007 share of 16% and an increase of 85% in total RES-E generation over the Reference Scenario (IEA, 2009a). This is due to an increase in hydropower's share from 12% in 2007 to 13%, a significant stepping up of biomass and waste-based generation from 1% to 7% of the power mix and of geothermal from 3% to 7%. Although starting from a very low base in 2007, onshore wind and solar PV show the fastest annual growth rates of 30% and 47% respectively (IEA, 2009a). Non-hydro renewables alone represent 30% of electricity generation increase from 2007-30.

In the transport sector, biofuels are projected to grow by 21% a year to 2030, when they should represent 10% of transport fuel consumption, or double that projected in the Reference Scenario, in the entire ASEAN region.

[33] While the *World Energy Outlook* projections distinguish electricity generation and transport production from renewables, renewable heating is not specifically set apart.

[34] To a large extent, the ASEAN-6 countries analysed in this report are not differentiated in the projections.

3.3.2. Relationship between projected growth and realisable potentials

Table 3.2 gives an indication of how the realisable generation potentials compare with the growth in renewable energy production projected in a scenario assuming ambitious climate policies.

Despite the fact that the *WEO* projections relate to the entire 10-country ASEAN region, it is clear that overall the realisable potentials are substantially, although not by orders of magnitude, larger than the projected generation by 2030.

This comparison, thus, illustrates two important conclusions: (i) that the 450 Scenario projections, although ambitious, are achievable given that they sit well within the boundaries of the calculated realisable potentials; and (ii) that there is indeed realistic scope in the ASEAN-6 for achieving higher penetrations of renewables beyond the 450 Scenario projections, if the countries foster suitable policy framework conditions to level the playing field for all energy technologies by pricing their respective external costs and benefits.

Table 3.2: Comparison between 450 Scenario projections (ASEAN-10) and realisable potentials (ASEAN-6) to 2030[35]

	450 Scenario projections as share of Realisable Potentials to 2030
RES-E: TOTAL	**46%**
Hydropower	80%
Biomass and waste	29%
Onshore wind	17%
Offshore wind	6%
Geothermal	79%
Solar PV	9%
Tidal and wave	26%
RES-T (biofuels)	**108%**[36]

Source: IEA calculations based on IEA, 2009a and Resch, 2009.

3.4. Benefits and costs of large-scale penetration of renewables in the ASEAN region

The benefits of a large-scale market uptake of renewables as in the 450 Scenario, and significantly more so if a larger share of the realisable potentials were exploited, are manifold. Important socio-economic advantages of renewables diffusion relate to climate change mitigation, air pollution reduction and consequent public health improvements, increase in

[35] Renewable heat is not considered in this comparison as the *World Energy Outlook* and the assessment of realisable potentials use different classifications of renewable heat technologies.

[36] The fact that the *WEO 2009* 450 Scenario projections for biofuel exceed the realisable potential for biofuels by 2030 by 8% is due to the ASEAN region, as modelled in the *WEO 2009,* comprising four additional countries with projected biofuel production, including Cambodia and Laos, beyond the ASEAN-6 taken into consideration in the assessment of realisable potentials.

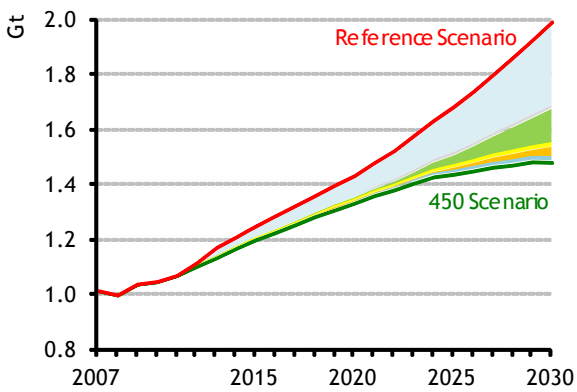
energy security, employment creation, and economic revitalisation by fostering innovative industries with sustainable growth prospects.

This section will focus on two of the important benefits of renewables: climate change mitigation and air quality improvements.

3.4.1. Potential CO_2 emission reductions

In this report, CO_2 emission reductions are used as an indicator of contributions to climate change mitigation effects. In the absence of analysis on the carbon reduction impacts of exploiting the full medium-term realisable potential for renewables, the 450 Scenario projections of the IEA *WEO 2009* are assessed to provide a floor or minimum estimate of the possible CO_2 emission reductions linked to the realisable potentials (Figure 3.6).

Figure 3.6: Energy-related CO_2 emission reductions by source in the 450 Scenario relative to the Reference Scenario: ASEAN region



	Abatement (Mt CO_2) 2020	2030
Efficiency	84	319
End-use	*82*	*308*
plants	*1*	*11*
Renewables	2	121
Biofuels	9	20
Nuclear	3	33
CCS	1	18

Source: IEA, 2009a.

Key point: Renewables, especially in power generation, are the second-largest contributor to CO_2 emission abatement (28%) by 2030 in the ASEAN region – behind efficiency measures.

Regarding CO_2 savings relating to power generation in the ASEAN region, RES-E technologies represent close to 70% of abatement from less carbon-intensive generation technologies (IEA, 2009a).

3.4.2. Air pollution improvements

Co-benefits[37] from increased renewables diffusion include reduction in local and regional air pollution due to a displacement of dirtier energy technologies with coincident emissions of air pollutants, such as sulphur dioxide (SO_2), nitrogen oxides (NO_x) and particulate matter (PM).

[37] Co-benefits or positive co-impacts are meant as those technology-driven environmental benefits besides those directly related to greenhouse-gas emission reductions and their role in mitigating climate change.

Significant sources of these pollutants, which lead to health problems, acid rain and urban smog, are power generation and industrial activity for SO_2, road transport for NO_x and residential and commercial combustion as well industrial emissions in the case of PM2.5. Local air pollution is a major public health concern in ASEAN countries, especially in major conurbations, such as Jakarta, Bangkok, and Kuala Lumpur.

Numerous studies indicate that improvements in air quality can have substantial economic value, with the highest estimates reported in developing countries. The economic values of air pollution reduction and the resulting reductions in pollution control equipment and public health expenditures are highest in developing countries, possibly resulting to an extent from higher *ex-ante* pollution levels where incremental health benefits are larger (Nemet *et al.*, 2010). Given that the order of magnitude of these estimated economic benefits is similar to that of medium-range marginal abatement cost estimates (*e.g.* IEA, 2009a) strengthens the rationale for large-scale renewables diffusion in ASEAN countries – as the short-term benefits linked to air quality improvements likely balance the costs associated with climate change mitigation (Nemet *et al*., 2010).

The human health impacts of air pollution are significant, with 3.4 billion life years lost (YOLLs) in 2005 in China, India and Europe due to PM exposure (without taking indoor air pollution into account) (IIASA, 2009). YOLLs are modelled to increase to 5.7 billion by 2030 based on energy sector developments as per the IEA *WEO 2009* Reference Scenario. In contrast, overall health impacts are projected to be less severe in the 450 Scenario linked to the implementation of ambitious climate change targets and appropriate policies: the human health impacts are estimated to amount to 4.5 billion YOLLs by 2030. Using even a floor estimate of EUR 25 000 as representing the average value of a life year[38] (Desaigues *et al.*, 2006), the relative saving of 1.2 billion YOLLs worldwide in the 450 Scenario could provide an astronomical economic benefit of USD 30 trillion, or about 43% of total global economic output (as measured in GDP in power purchasing parity terms) in 2008.

Besides this economic benefit related to public health improvements, the benefit of cost savings in required air pollution control equipment is also important. At the global level, the costs of currently (as of 2005) implemented air pollution control regulation are calculated to be around EUR 155 billion (USD 217 billion) in 2005. While these costs are projected to increase threefold to 2030 due to higher economic activity levels and efforts in reducing road transport emissions, the cost increase is less pronounced in the 450 Scenario, with an associated cost savings of 17% relative to the Reference Scenario (IIASA, 2009).

For the four largest countries in the ASEAN-6, namely Indonesia, Malaysia, the Philippines and Thailand, currently high air pollution emissions experience only modest growth in the Reference Scenario due to projected changes towards use of cleaner fuels by households and stricter pollution controls on power plant and industrial installations (IEA, 2009a). Further reductions in the major air pollutants to 2030 in the 450 Scenario beyond the Reference Scenario are impressive, with Indonesia playing a dominant role in these reductions.

The energy sector trajectory projected in the 450 Scenario for these four major ASEAN economies leads to a 12% reduction in NO_x to 3 941 thousand tonnes a year, 11% reduction in

[38] This assessment of the external costs associated with mortality and morbidity risks due to air pollution was carried out within the framework of the comprehensive NEEDS (New Energy Externalities Developments for Sustainability) project co-funded by the European Commission under the Sixth Framework Programme.

SO_2 emissions to 1 859 thousand tonnes a year and 4% reduction in PM2.5[39] emissions to 2 293 thousand tonnes a year (IEA, 2009a). In terms of cost savings, the annual estimated air pollution control costs in the 450 Scenario reach EUR 12.1 billion (USD 17 billion) by 2030, which is a saving of EUR 2.3 billion (USD 3.2 billion) or 16% compared to the projected Reference Scenario trends.

3.5. Challenges for tapping the RES potential

In order for the substantial potential for renewables in the ASEAN-6 to be harnessed to a greater extent, certain fundamental challenges need to be tackled. These obstacles include electricity sector reform, energy market distortions, administrative hurdles for planning and licensing, relative absence of adequate and targeted renewable energy incentives, grid constraints to integrate large shares of variable renewable electricity, lack of awareness among decision makers and financial institutions and lack of suitable financing options (IEA, 2009a). Specific non-economic barriers and recommendations to the uptake of renewables are discussed in Chapter 5.

A fundamental trade-related issue is the need to safeguard intellectual property rights associated with innovative clean energy technologies, such as renewables, when they are introduced into new markets, such as Southeast Asia, by foreign companies. Technology is a cornerstone of corporate competitive advantage, so strong legal and regulatory protection of intellectual property is necessary to enhance investor confidence.

A challenge for countries worldwide is the implementation of smart grid infrastructure.[40] For Southeast Asia's "megacity" conurbations, smart grids may be the key to turning the challenges of rapid urbanisation and rising energy demand into an opportunity to exploit the potential of renewables for distributed generation, hand-in-hand with demand-side management by enhancing system reliability.[41]

[39] PM2.5 are particulate matter with an average diameter of 2.5 mm.

[40] "Smart grid" which is a relatively new still evolving concept refers to the integration of information technology into the current electricity infrastructure resulting in a grid that is responsive and adaptive.

[41] See (IEA, 2009b) for an analysis of the potential for enhanced deployment of renewables in urban environments.

4. Investment and financing of renewables

Key findings

- The environment for investment and financing for renewables in ASEAN-6 countries has improved in recent years. Important drivers for deployment of renewables include increasing energy market liberalisation in most ASEAN countries, the introduction of favourable policy frameworks for renewables and the rapidly improving economics of individual renewable energy technologies.
- The 450 Scenario of the IEA *World Energy Outlook 2009* (IEA, 2009a) analyses an energy-related emissions trajectory to stabilise greenhouse-gas concentrations at sustainable levels. It projects that by 2030 renewables penetration in the power mix of the entire ASEAN-10 region will double to 32%. The cost of enabling this low-carbon energy revolution to 2030 is projected to require USD 9.7 billion a year for renewable power capacity – a step change in renewables investment.
- In comparison, the *World Energy Outlook 2009* Reference Scenario projects annual investment costs of USD 3.9 billion to 2030. However, current actual investment flows into the region from different funding sources do not reach even this figure.
- Financing for renewable energy assets in Southeast Asia (excluding large hydro) has increased rapidly since 2004. Until 2008, financing was mainly for biofuels; investment has since grown steadily in geothermal, biomass power, small hydro and onshore wind.
- To date, carbon finance has been a relatively minor vehicle for deployment of renewables in the overall ASEAN region. Based on the renewable energy Clean Development Mechanism (CDM) projects currently in the pipeline, expected credit revenues will account for a relatively small share of financing available for renewables.
- Development assistance funding for renewables (including carbon financing) represents a substantial portion of existing investment flows. Innovative new public finance mechanisms, which focus on reducing risk in the local investment environment, show potential to significantly boost available deployment financing.
- As of early 2010, total *announced* (as opposed to actual) near-term funding for renewables in the region is estimated at roughly USD 4 billion a year. This amount may cover the investment needs set out in the *World Energy Outlook 2009* Reference Scenario, but it falls far short of the investment required to achieve the low-carbon energy revolution of the 450 Scenario.
- To unlock sufficient and well-targeted investment in renewables, it is essential to implement effective renewable energy policies.

4.1. Introduction

This chapter investigates the possible gap between:

- what is **needed** in terms of renewable energy investment in the ASEAN region to place the energy sector on an emissions trajectory to stabilise greenhouse-gas (GHG) emissions at a non-catastrophic level of 450 ppm of CO_2 equivalent (CO_2e); and
- the **current trends**, in terms of structure and amounts, of investment into renewable energy technologies in the ASEAN-6 countries.

The financing figures refer mostly – where not explicitly mentioned otherwise – to deployment investments in renewable energy plant/applications and do not consider research, development and demonstration (RD&D) spending on renewables. Little data are available on public renewables RD&D spending in most, even the large emerging, non-OECD countries; and private sector RD&D efforts are even more difficult to access and assess, even in OECD countries.

Although it is not explicitly delineated, the bulk of the renewable energy investment flows assessed in this chapter relate to *mitigation* financing, *i.e.* investments into low-carbon technologies, such as renewables, which reduce or mitigate GHG emissions. In contrast, investments for *adaptation* to the effects of climate change in developing countries are not delineated, although renewable energy technologies (RETs), especially in decentralised applications, are considered playing an important role in improving vulnerable developing country populations' capacity to adapt to climate shocks and longer-term incremental climate trends (South Centre, 2008).

4.2. Context of renewable energy financing

Historically, in the ASEAN-6 countries, with their predominantly vertically integrated energy sectors, two main financing sources have supported renewable energy projects – similarly to conventional energy projects:

- State-owned energy companies have in the past developed and financed grid-connected renewable energy projects only to a limited extent. The exception was large-scale hydro power capacity which is generally competitive with conventional power production in those countries with large hydropower potentials, such as Vietnam, Malaysia, and Indonesia. In contrast, ASEAN-6 countries, which (with the exception of Singapore) have struggled with generally low electrification rates and high relative poverty,[42] have channelled financing for rural electrification programmes including renewable energy technology (RET) applications through their respective national development budgets and the implementing development agencies, such as BAPPENAS in Indonesia (IEA, 2008a).
- Multi- and bilateral donor funding exists i) for large-scale grid-hydropower projects and ii) for rural energisation to help achieve poverty reduction (ADB, 2009a; World Bank, 10 September 2009).

A confluence of energy sector, policy and technology developments over the past decade have combined to change the investment and financing landscape for renewable energy across the ASEAN-6 region:

[42] See IEA, 2009a.

Firstly, the increasing and continuing energy market liberalisation in many ASEAN-6 countries[43] and to some extent privatisation (such as in Singapore), have fostered the overall attractiveness of energy investments and encouraged private sector players (domestic and foreign) to enter the market. Independent power producers (IPPs) in all ASEAN-6 countries have been granted access to the generation sector and some regulatory framework conditions implemented – although grid access conditions and power purchase agreements are not yet standardised in many jurisdictions, compounding investment uncertainty.

IPPs are regarded by many ASEAN-6 countries as a crucial element to help bring online much-needed new generating and transmission grid capacity to meet burgeoning energy, and especially electricity, demand in the region. The *World Energy Outlook 2009* projects in its business-as-usual Reference Scenario that primary energy demand in Southeast Asia grows by 2.5% a year to 2030 compared with a world annual average of 1.5% and a yearly growth rate for OECD countries of 0.2%. Four of the ASEAN-6 countries represent nearly 75% of total Southeast Asia's energy demand growth: Indonesia (36%), Thailand (18%), Malaysia (11%) and the Philippines (9%). Power generation is projected to increase its contribution to final energy demand from 25% in 2007 to 37% by 2030 mainly due to increasing urbanisation and efforts to improve rural electrification (IEA, 2009a).

Nevertheless, the continued existence of non-cost reflective energy prices and substantial fossil-fuel subsidies in the ASEAN-6 region[44] dampens the enthusiasm of prospective private sector investors to finance the necessary expansion of energy sector generating and transmission capacity (*e.g.* in Indonesia; see IHS Global Insight, 3 November 2009).

A second driver of growing interest in renewable energy investments in the region is the introduction of favourable policy frameworks and targets for renewables in the past 10-15 years: regional governments have realised the benefits of up-scaling renewable energy penetration to improve their country's energy security situation by reducing the need for fossil fuel imports and adapt to climate change.[45] However, investment certainty is affected by a widespread absence of specific regulations to flesh out these framework programmes and of financial incentives to support less mature RETs to compete with incumbent subsidised conversion technologies. An additional important global trend contributing to a growth in non-hydro RET investment in the ASEAN region's recent past are the rapidly improving economics and declining costs of RETs, which result from technology improvements and economies of scale, as the technologies progress down their respective learning curves (IEA, 2008b). The observed technological learning has been substantially pulled by the production and investment incentives and generous policy support for renewable energy, especially renewable electricity, in many OECD countries and emerging economies.[46]

Renewable energy market shares have witnessed dramatic growth over the past five years, with installed wind power capacity growing by 250% to 121 GW by the end of 2008, solar photovoltaics (PV) to 16 GW and total renewable capacity excluding large hydro increasing by 75% to 280 GW. The accompanying manufacturing capacities have also kept pace to a large extent, with renewable energy industries expanding rapidly and manufacturing locations

[43] See Chapter 1 for an overview of general energy sector trends in the ASEAN-6 region and (IEA, 2009a) for a more detailed discussion.

[44] Chapter 5 discusses the barriers to the deployment of renewables in the region.

[45] Chapter 2 analyses the policies and support mechanisms for renewables in the region.

[46] The IEA has published analysis of the effectiveness and efficiency of renewable energy deployment policies for electricity generation, heating and transport fuel production in OECD countries and Brazil, Russia, India, China and South Africa (IEA, 2008c).

diversifying from largely being centred on OECD economies to include major emerging economies. China, for example, in 2008 overtook Japan to become the leading country for PV cell production.[47]

Annual investment in new renewable energy generation capacity (power generation – wind, solar, biomass, geothermal – and biofuel refineries) worldwide increased fourfold from 2004 to reach USD 120 billion in 2008 (REN21, 2009).

4.3. Investment needs for renewable energy

The threat of climate change is very tangible for the ASEAN-6 countries. As many as 1.2 billion people in the Asia-Pacific region face the prospect of freshwater shortages by 2020, while crop yields in Central and South Asia could drop by half between now and 2050. Many key coastal cities could also see increasingly serious flooding (ADB, 2009a). The East Asia and Pacific region is also estimated to bear the highest cost of adaptation to climate change effects among all global regions between 2010 and 2050 with net annual (non-discounted) costs for all economic sectors of USD 19.5 billion within a global annual total of USD 76.8 billion (World Bank, 2009a).

An international consensus is emerging on the need to limit the global temperature increase to 2 °C above pre-industrial levels to avoid the most detrimental and irreversible of climate change impacts (IEA, 2009a; IPCC, 2007). Nevertheless, opinion is mixed on what might be considered a sustainable, long-term level of annual CO_2 emissions for the energy sector, which plays a critical role due to its responsibility for 84% of global CO_2 emissions and 64% of global greenhouse-gas emissions (*ibid.*).

The IEA most recent projections on energy investment needs are analysed to provide an approximate benchmark of the necessary investment required in renewables in order to stabilise atmospheric GHG concentrations and thus global temperature increases to manageable levels, as indicated by available scientific evidence.

The *World Energy Outlook 2009* **Reference Scenario** projects that investment in energy supply infrastructure totalling USD 1.15 trillion (in 2008 USD) will be necessary over 2008-30, or 2% of the region's annual average GDP – compared with a world average of 1.4% of average annual global GDP. Of this, 55% or USD 635 billion will need to be devoted to the power sector (generation, transmission and distribution assets) to meet projected high electricity demand growth of 4.2% *per annum* due to increases in urbanisation and rural electrification rates. In undiscounted terms, this translates into USD 27.5 billion a year over the period. The planned ASEAN Power Grid (APG), one of the three main areas of the 2012-15 ASEAN Plan of Action for Energy Co-operation (IEA, 2009a), which envisages up to 14 cross-border grid interconnection projects involving all ten ASEAN countries, forms part of this projected power investment.

In the Reference Scenario, the total required investment in renewable energy power generation capacity between 2010 and 2030 amounts to USD 156 billion, representing 25% of total power sector investment needs. This translates into an annual (non-discounted) investment figure of USD 3.9 billion. Close to 40% of the investment is needed for hydro, biomass power and solar PV[48] investments.

[47] A concise and holistic snapshot of major trends in renewable energy markets, policies, investments and industry trends is given in REN21, 2009.
[48] Solar PV includes investments in building-integrated PV.

In the **450 Scenario**, additional power sector investment, which is mostly due to investment in higher-cost low-carbon generation technologies, is a comparatively modest USD 55 billion over the total period[49] (IEA, 2009a). The total required investment for renewable power capacity in the ASEAN region to move on to a 450 ppm trajectory is USD 193 billion over the projection period (calculations based on IEA, 2009a). This represents 59% of total power sector investment needs in the 450 Scenario, which is more than double the share of renewable power capacity investment in the Reference Scenario. In annual, undiscounted terms this translates into USD 9.7 billion a year.

Three-quarters of the investment needs are for hydro, biomass, and solar PV. The overwhelming bulk of this investment (81%) is required in the decade beyond 2020, because the predominant share of GHG emission reductions will occur then. This is due to several reasons including (i) a higher rate of natural capital stock replacement in the later period – although this is balanced by the region's pressing need to build new generating capacity in the very near-term to meet burgeoning electricity demand and a consequent window of opportunity to choose low-carbon renewable energy alternatives over conventional fossil fuel technologies; and (ii) the sufficiently large-scale deployment of innovative low-carbon technologies which have achieved substantial cost reductions in the near term to 2020.

In addition to investment in renewables in power generation, a relatively minor share of total energy-supply infrastructure investment is also projected to be devoted to expanding **biofuel production and refining capacity**, requiring USD 4 billion to 2030 in the Reference Scenario and an assumed additional USD 3 billion in the 450 Scenario.[50] In annual undiscounted terms, this would mean **about USD 0.5 billion a year spending in the 450 Scenario.**

Renewables for heating or hot water preparation are not projected to account for a significant share of final energy consumption in the ASEAN countries in the 450 Scenario.

In sum, aggregate investment needs for renewables, taking into account electricity and transport fuel production capacity, in the 450 Scenario lie in the range of at least USD 10.2 billion *per annum*.

4.4. Current renewable energy investment trends

4.4.1. Investment in renewable energy production capacity

Globally, investment in new renewable energy capacity, which encompasses renewable electricity (RES-E) generation assets and biofuel refining capacity, increased by 13% to 117 billion in 2008. This is a marked slowdown compared to the average annual growth of 60% between 2004 and 2007. This is mainly due to the impact of the financial and economic crisis which hit the renewables sector dramatically from the second half of 2008 onwards (UNEP SEFI/NEF, 2009).

[49] Lower energy demand over the projection period in the 450 Scenario is expected to dampen investment in fossil fuel assets, such as coal, gas and oil, relative to the Reference Scenario.

[50] This assumption of additional biofuel investment needs in the 450 Scenario relative to the Reference Scenario is based on the projection that final energy consumption of renewables in road transport, *i.e.* biofuels, doubles its share from 5% in 2030 in the Reference Scenario to 10% in the 450 Scenario (IEA, 2009a).

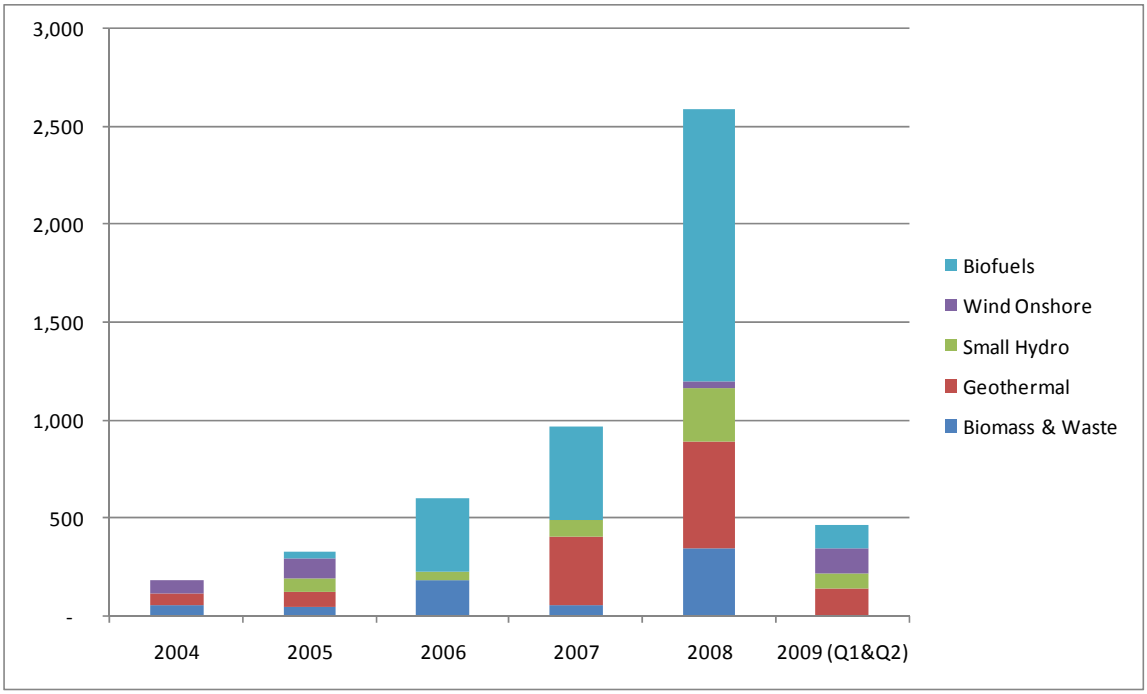
In the ASEAN countries for which data are available,[51] the trend since 2004 has been even more impressive than at the aggregate global level, with production capacity investment on average nearly doubling every year and even increasing 1.5 times year-on-year in 2008 to reach USD 2.6 billion. Of this total, investment in renewable power generation assets amounted to USD 1.2 billion in 2008.

It is important to note that private sector and public sector asset financing cannot be distinguished in the analysed data. This is a relevant caveat for the ASEAN countries whose power sectors are mostly characterised by dominant public ownership or control. With a lack of detailed data on public investment levels in general energy infrastructure in the ASEAN region, and even less so on public finance for renewable energy capacity, it is difficult to make any strong inferences from the available data on a reasonably accurate split between public and private sources of investment. Using only Thailand and Indonesia as examples,[52] the average ownership balance for power capacity ranges from a 77%:23% in 2005 division between the state-owned electricity company PT Perusahaan Listrik Negara (PT PLN) and IPPs to a nearly even split between public (Electricity Generating Authority of Thailand, EGAT) and IPP ownership in Thailand as of the end of 2008 (IEA, 2008a; EGAT, 2009). However, for most RETs, with the exception of large hydro – where the public sector still greatly outweighs the private sector as owner and operator, as in Indonesia –, IPPs companies own and operate plant capacity, even if state-owned utilities may be the main or only off-taker.

The leap in investment in 2008 is mainly due to a near-tripling in (first-generation) biofuel refinery financing in 2008. In contrast to the global picture, **biofuel refining capacity** in the ASEAN countries has in recent years represented a much larger share of total investment flows into new renewable energy production assets. While in the ASEAN countries biofuel plant investment made up 54% of total new asset financing in the record year 2008, the worldwide total share was three times lower (Figure 4.1 and UNEP SEFI/NEF, 2009). The lively interest in investing in first-generation biofuel refining plant in major ASEAN economies (Figure 4.2) until 2008 stemmed from a combination of driving forces: (i) the ambitious biofuel targets and support policies in developed economies as a major pull factor for ASEAN countries to expand their export capacity; (ii) the large potential for biofuels in these countries.[53] and (iii) relatively high profit margins resulting from a combination of high oil price levels and relatively low biofuel production costs (low feedstock costs and labour costs) (IEA, 2010).

[51] Data on Southeast Asia have been distinguished for Indonesia, Malaysia, the Philippines, Thailand and the "Other ASEAN" countries.
[52] This is for data availability reasons.
[53] See Chapter 5 for a discussion on potentials for the individual renewable energy technologies.

Figure 4.1: Investment in new renewable energy production capacity in Southeast Asia* (in USD million), Q1 2004-Q2 2009



* Due to data constraints, "Southeast Asia" extends to Indonesia, Malaysia, the Philippines, Thailand and "Other ASEAN" countries.
Note: Data for 2009 is limited to the first two quarters of the year.
Source: New Energy Finance databases; IEA analysis.

Key point: Investment in biofuel refining capacity was the main driver for the sharp increase in renewable energy asset financing witnessed in 2008 in Southeast Asia.

As the economic crisis unfolded and deepened in the second half of 2008, asset financing conditions became increasingly difficult with higher cost of credit which also became more restricted to access (IEA, 2009a). As economic activity contracted and with it energy demand and the outlook for a rapid economic recovery dimmed, oil prices sharply declined from their historic highs from mid-2008 onwards. Lower oil prices impact negatively on the economics of biofuels, although – in the case of the ASEAN countries – this is mitigated to a certain extent by relatively low, but rising, production costs.

During the same period, policy changes regarding sustainability criteria were announced in major biofuels importers, such as EU member states, which have a 10% binding target for the share of renewables in transport fuel consumption by 2020.

This confluence of factors has seen the interest as well as the ability to invest in first-generation biofuel refining capacity drop sharply, both worldwide and in Southeast Asia.

As Figure 4.1 shows, the investment trends for renewable power generation capacity in Southeast Asia on the whole show an irregular pattern for the individual RETs with increases and subsequent declines. Thus no financial close of any wind project was registered in 2006 and

2007 before picking up again in 2008 and expanding in the first half of 2009 to reach near parity with biofuels and geothermal investment.

Growing investment in **geothermal power** capacity, which was the second most significant RET in terms of aggregate new investment and capacity additions over the period 2004-first half of 2009, can be attributed mostly to supportive policies introduced to boost geothermal power installations in Indonesia and the Philippines which enjoy the region's only sizable resource potential (Figures 4.2 and 4.3).

Investment in **biomass power** has gained interest in Southeast Asia, especially in Malaysia and Thailand. This is encouraged by carbon finance opportunities through the Clean Development Mechanism (CDM), one of the flexible mechanisms of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) (see Box 4.1 in Section 4.4.2 for a more detailed assessment) as well as, in Thailand's case, the medium-term renewable energy development plan to 2022, providing regulatory predictability, and the generous feed-in premiums on offer (Thai Ministry of Energy, 2009).

Small hydro, which encompasses investments above 1 MW and below 50 MW capacity, *i.e.* including mini-hydro but excluding micro-hydro and pico-hydro[54], has seen most investment activity in Indonesia, the Philippines and Vietnam. In the absence of strong dedicated renewable energy policies and support incentives in these countries in the analysed period, the main driver appears to be CDM revenue streams. This inference is also supported by a visible correlation between the small hydro plant capacity financed by the investment flows analysed (Figure 4.3) and the installed capacity of small hydro CDM projects developed in the three countries from 2004 to 2008 (UNEP Risoe, 1 December 2009).

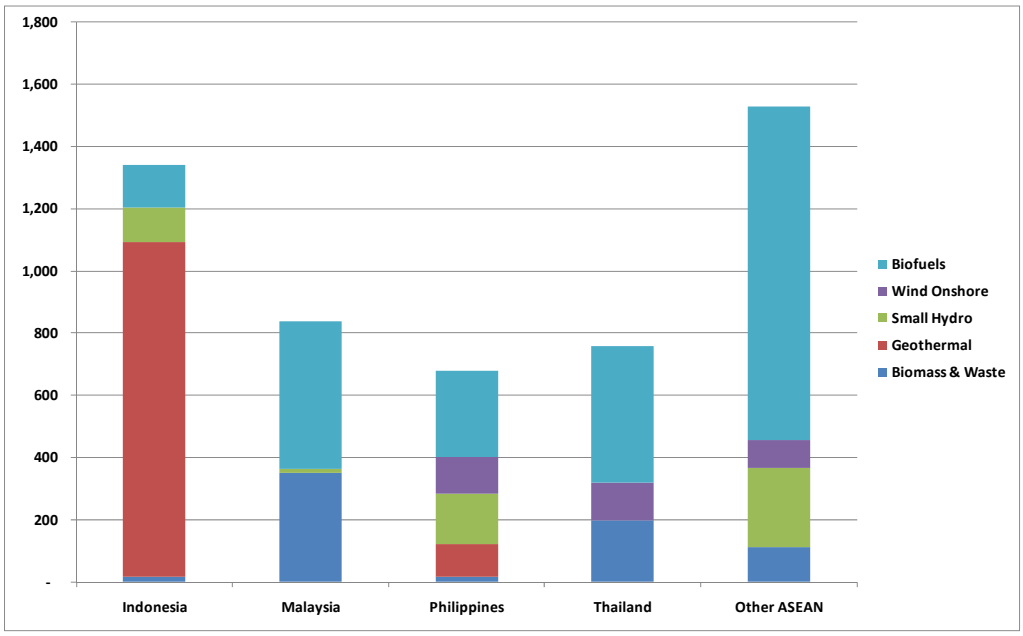
Investment in **onshore wind** is beginning to see growth, with the Philippines and Vietnam showing promise due to high potentials and increasingly favourable policy support (renewable energy incentives and carbon finance) (UNEP SEFI/NEF, 2009).

No investment in grid-connected **solar PV**[55] is visible in the presented data for ASEAN countries, despite the region's overall high solar potential. This is most likely related to the regional governments emphasis on, and promotion of, the role of solar PV more as a tool for rural energisation and modular off-grid (mini-grid and stand-alone) applications instead of the technology's grid-tied expansion (REN21, 2009). Modular solar home systems (SHS) for single household use in remote areas can meet energy service needs for telecommunications, pumping, refrigeration and lighting. Alternatively, small solar PV plants can also be designed to provide village-scale electricity in a mini-grid (ESMAP, 2007).

[54] Mini-hydro is commonly defined as installations with less than 1 MW capacity, while micro-hydro is less than 100 kW capacity and the upper boundary for pico-hydro ranges from 5 to 10 kW.

[55] Only installed solar PV capacities above 0.5 MW are reflected in the underlying datasets. Solar home systems generally range in size from 50-300 W and solar PV mini-grids for community use have average capacities of 25 kW (ESMAP, 2007).

Figure 4.2: Aggregate investment in new renewable energy production capacity in selected ASEAN countries (in USD million), Q1 2004-Q2 2009

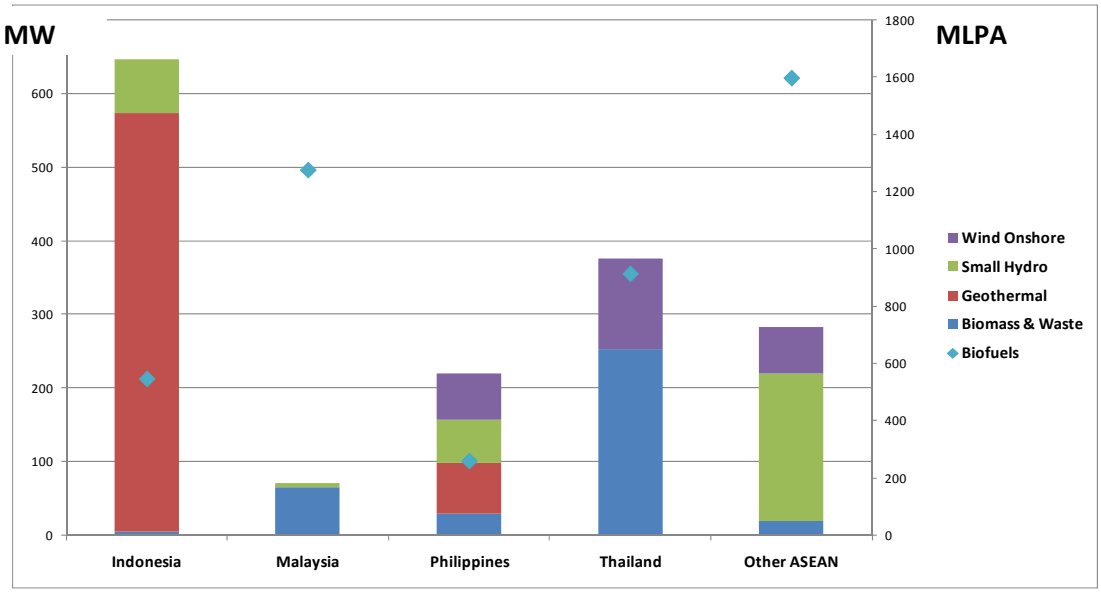


Note: Data for 2009 are limited to the first two quarters of the year.
Source: New Energy Finance databases; IEA analysis.

Key point: Investment in the individual RETs differs between Southeast Asian countries depending on resource potentials and policy support.

The share of the individual RETs in the overall investment flows differ among ASEAN countries, reflecting on the one hand the differing resource potential make-up and, on the other, their differing policy ambitions for fostering less mature RETs, such as onshore wind or solar PV, compared with more mature technologies, *e.g.* solid biomass electricity or geothermal electricity, requiring less financial support (Figure 4.2). However, it is not evident to what extent either factor influences the renewable energy investment flows in the individual countries.

Figure 4.3: Aggregate new renewable energy production capacity financed by investment flows[56] in selected ASEAN countries (in MW for power and MLPA[57] for biofuels refining capacity), Q1 2004-Q2 2009



Note: Data for 2009 are limited to the first two quarters of the year.
Source: New Energy Finance databases; IEA analysis.

Key point: The technology shares of the capacity financed by the asset financing flows correspond, to a large extent, to the RETs' relative share in investment.

4.4.2. Carbon financing for renewable energy

4.4.2.1. What is carbon finance?

Carbon finance refers to the "monetisation of future cash flows from the advanced sale" of carbon reduction credits, such as Certified Emission Reductions (CERs), Emission Reduction Units (ERUs) and European Union Allowances (EUAs) (Box 4.1), generated by greenhouse-gas (GHG) reducing, including renewable energy, projects (UNEP SEFI, 2008). This funding can contribute to covering project investment costs or improving revenue streams for all types of RET projects. Carbon finance can have an especially significant beneficial impact for small-scale projects, replacing early stage project development capital, while for large-scale projects it may cover a portion of the investment costs (*ibid.*).

[56] The investment flows in question are displayed in Figure 4.2.
[57] MLPA stands for million litres per annum.

A global market for tradable carbon reduction credits already exists through several mechanisms:

- the EU Emissions Trading Scheme (ETS), which is indirectly relevant for ASEAN countries;[58]
- the UNFCCC's Kyoto Protocol and its "flexible mechanisms" (Box 4.1) for compliance, whose purpose is to allow developed countries to reduce emissions in developing countries as a lower-cost alternative to more expensive emission reductions in their own countries;
- a growing voluntary carbon market, trading in voluntary emission reductions which are often called Verified Emission Reductions (VERs).

Box 4.1: Overview of the main existing carbon "currencies" and challenges for the near future[59]

CERs, ERUs and EUAs are co-existing carbon reduction currencies. CERs are generated by Clean Development Mechanism (CDM) projects and ERUs by Joint Implementation (JI) projects, which are both project-based "flexible mechanisms" under the UNFCCC's Kyoto Protocol. CDM projects are hosted by developing non-Annex 1 countries, while JI projects are developed in other industralised or transition economies. Both CDM and JI are so-called "baseline and credit" systems, while international emissions trading, the third flexible mechanism under the Kyoto protocol is a "cap and trade" system trading in Assigned Amount Units (AAUs). EUAs are allocated to EU installations covered by the EU Emissions Trading Scheme (ETS), the largest regional emissions trading scheme also following a "cap and trade" approach.

The project-based CDM is, at the time of writing, due to expire at the end of 2012. It was conceived as a means to generate both cost-effective GHG control and sustainable development benefits for host developing countries. However, in practice, the CDM has shown drawbacks, including difficulties with assessing the necessary "additionality" of projects, as well as lengthy and costly administrative procedures, which add to the high transaction costs of the project-by-project approach. A large-scale transformation of the energy sector towards a low-carbon future will arguably be better served with large-scale programmes. A deeper discussion of the experiences with the CDM and recommendations for alternative approaches are available in IEA, 2009a and 2009b.

Public finance mechanisms are being introduced to reduce the regulatory risk to credit buyers of investing in post-2012 carbon reduction activities in the absence (to date) of a regulatory framework, also taking into account the long lead times for many projects which may span several economic cycles (UNEP SEFI, 2008). Wide support exists for appropriate carbon insurance, using public finance but also open to the private insurance industry, to help share the risk relating to the generation of carbon reduction credits and delivery risks of GHG mitigation projects (UNEP FI, 2009).

The World Bank has proposed a Carbon Partnership Facility (CPF) as an attempt to foster the demand for post-2012 carbon assets (World Bank, 2009b). If implemented, the CPF aims to focus on programmatic[60] and sectoral[61] approaches for post-2012 carbon emission reduction, going beyond the project-oriented funding support to date, linked to the CDM in the period up to 2012.

[58] Kyoto Protocol signatory countries, which are eligible as hosts of CDM and JI projects, may benefit indirectly from the EU ETS via the Linking Directive mechanism. The Linking Directive (European Commission, 2004) allows greenhouse-gas emission credits earned through the Kyoto flexible mechanisms, *i.e.* the CDM and JI, to be used for compliance by operators of EU installations covered by the EU ETS.

[59] See UNEP SEFI/NEF, 2009.

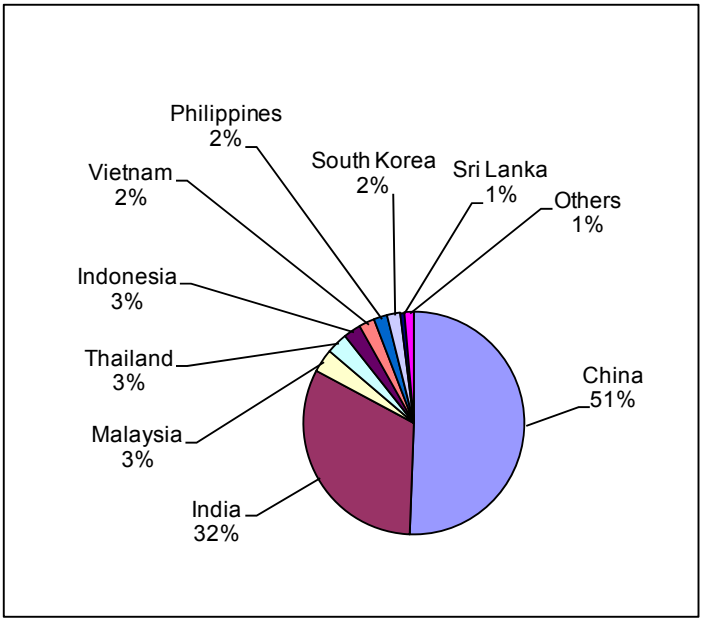
[60] The programmatic approach of the CDM aims to support low-carbon policies of governments, *e.g.* financial incentives or regulatory support, or a stated programme objective of private or public sector entities, which foster the large-scale deployment of GHG reducing technologies through projects whose resulting carbon reductions are verifiable.

[61] The term "sectoral approach" covers diverse proposals for transnational mitigation efforts of energy-intensive industries, such as cement or steel. In order to encourage broad participation also of major emerging and developing economies, carbon reductions in each sector/industry would be subject to voluntary targets, determined within each industry, according to different metrics, *e.g.* carbon intensity.

4.4.2.2. CDM developments

Within Asia, the ASEAN countries are not a significant host for CDM projects compared to the global leading CDM project hosting and CER issuing countries, China (40% of CDM projects in the pipeline) and India (25%) (UNEP Risoe, 1 December 2009) (Figure 4.4). The main reasons for the dominance of China and India is their sheer size and rate of economic growth, which offer substantial opportunities to reduce their GHG emission intensity, especially through low-cost mitigation of potent GHGs in industrial processes, so-called "low hanging fruit" (cf. UNEP Risoe, 1 December 2009).

Figure 4.4: Number of total CDM projects (excluding rejected projects) by country in Asia



Source: UNEP Risoe, 1 December 2009.

Key point: China and India dominate Asian CDM projects.

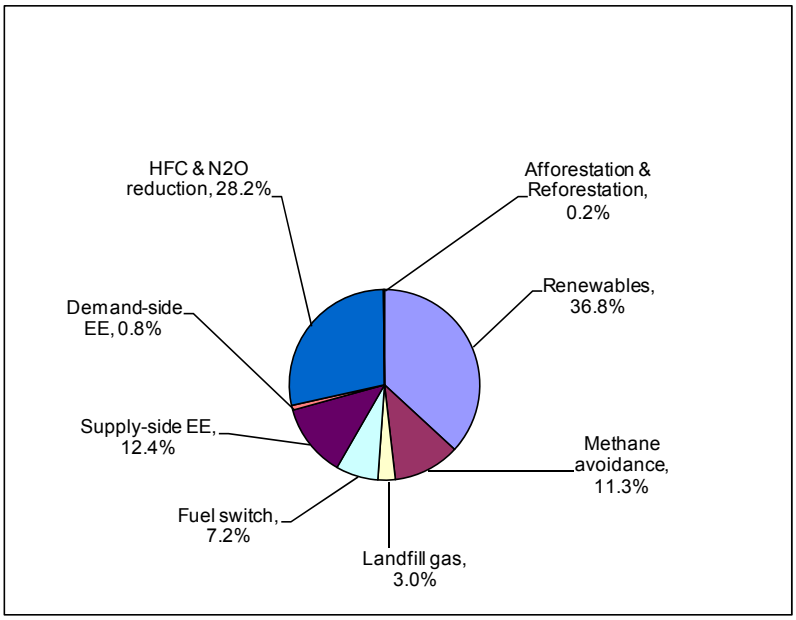
Asian renewable energy CDM projects are expected to contribute a 37% share of GHG emission reductions, as certified by CERs, in the regional cumulative CER total of 2.29Gt CO_2e in 2012 (Figure 4.5.), which is more significant than the global average of 35% (UNEP Risoe, 1 December 2009).

Assuming conservatively that these renewable energy-related CERs can be sold forward at an average price of EUR 9, using an approximate primary CER price in 2009 as a proxy, this CDM project portfolio could generate total CER revenues of EUR 7.6 billion (USD 10.7 billion)[62] by 2012. This can be used as a benchmark for the order of magnitude of potential export revenue that Asian countries could earn through the CDM which would at the same time stimulate renewable energy deployment.

[62] The exchange rate used is EUR 1 = USD 1.42 (2009 average).

Compared with the Asia region as a whole, all 188 ASEAN-6 renewable energy projects in the CDM pipeline represent 8% of all 2 780 renewable energy CDM projects currently planned in Asia and 4% of the associated 74 498 MW capacity (UNEP Risoe, 1 December 2009). As a very rough estimate – assuming in a simplification that all renewable energy technologies generate the same CO_2e reduction and thus the same number of CERs per unit of capacity – these planned ASEAN-6 renewable energy projects could generate 1.6% of the accumulated Asian CERs by 2012, as calculated forward from the current CDM pipeline. Using the assumed forward CER price of EUR 9, this would translate into potential CDM revenue of EUR 334.1 million (USD 473.3 million).

Figure 4.5: Cumulative volume of CERs until 2012 in Asia



Source: UNEP Risoe, 1 December 2009.

Key point: All renewables combined contribute the largest number of expected carbon reduction credits in Asia by 2012.

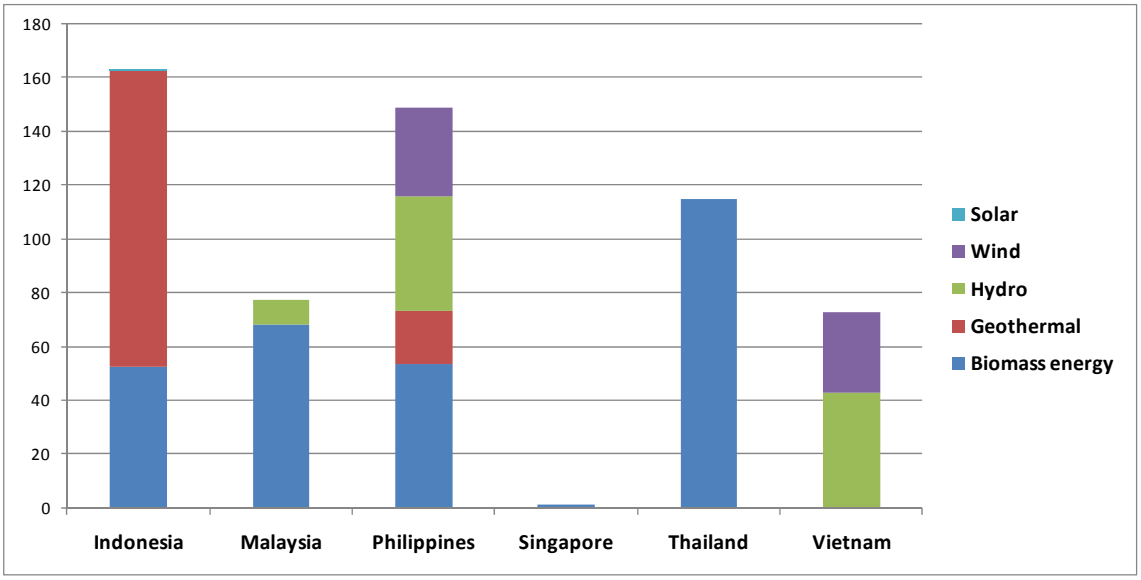
The capacity of all renewable energy CDM projects registered in the ASEAN-6 countries by the end of November 2009 amounts to just under 600 MW (Figure 4.6), while the planned capacity of projects at earlier stages in the pipeline, *i.e.* those at earlier stages in the CDM project approval process (excluding rejected projects), is nearly fivefold (UNEP Risoe, 1 December 2009). To put it in perspective, the registered and still pending renewable power CDM projects together represent around 10-20% of cumulative installed renewable energy power capacity in the ASEAN-6 countries.

The top two renewable electricity (RES-E) technologies for registered CDM projects in the ASEAN-6, which have all been registered since 2006, are biomass power representing 41%, followed by hydro with 33% of the capacity.

A large majority of the registered projects are small-scale projects under 10 MW, which are often located in remote, off-grid areas in countries with relatively low electrification rates

(UNFCCC, 2009a; IEA, 2009a). The significant non-economic barriers to develop such projects, which are assessed in detail in Chapter 5, may help explain the low 22% issuance success[63] to date of the registered renewable energy projects in ASEAN-6.

Figure 4.6: Capacity of all registered renewable power CDM projects in the ASEAN-6 countries until end November 2009 (in MW)



Source: UNEP Risoe, 1 December 2009.

Key point: Biomass energy represents just over half of the total capacity of registered renewable power CDM projects and geothermal over one-fifth of capacity.

4.4.2.3. Relationship between CDM-based carbon finance and renewable energy financing

To gain a better understanding of the relevance of CDM-based carbon finance for renewable energy financing in the ASEAN-6 countries, the capacity and type of registered renewable power CDM projects (Figure 4.6) are compared with the capacity financed by the investment flows analysed in Section 4.4.1 and, more specifically, in Figure 4.3.

The relative importance of the individual RETs in registered CDM projects (Figure 4.6), as measured by their order in capacity share, mirrors that of the asset capacity inherent in the renewable energy asset investment figures (Figure 4.3).

However, as the investment flow data are not comprehensive and include renewable energy power projects above a certain capacity threshold with less data coverage on decentralised or

[63] To 1 December 2009, merely 10 of 46 registered renewable energy projects in the ASEAN-6 had been issued with CERs (UNEP Risoe, 1 December 2009).

on-site industrial auto-producer installations, the conclusions are only indicative and need to be interpreted cautiously.

Comparing both datasets, it is apparent that the extent to which the investment flow data are able to capture CDM project financing for the ASEAN-6 is linked to the scale and the degree of decentralisation of the RES-E projects registered in the CDM process. The usual project scale depends on the individual RET. So, for example, the capacity of registered geothermal and wind CDM projects, which are all larger than 15 MW in average size, may represent between 20 and 26% of the capacity financed by the asset investment for the respective RET.

An important point to highlight – which may reduce the level of correlation between the two datasets – is that the asset financing period covered by the investment flow data (January 2004-June 2009) does not correspond entirely with the period in which the CDM projects were registered (January 2006-November 2009) due to possible differences in the project cycle stages that the datasets correspond to.[64]

A lack of accessible data hampers the determination of the main funding streams for CDM projects in the ASEAN-6 region. Judging from a sample of the registered renewable power CDM projects in the ASEAN-6, many of them are financed by private entities (both individual companies and carbon funds) with a smaller number of OECD governments (UNFCCC, 2009a).

4.4.2.4. Possible future directions for the CDM

With regard to the ASEAN-6 countries, the Carbon Partnership Facility (CPF, Box 4.1) plans to support Vietnam's renewable energy action plan by providing financing facilities as well as technical assistance to local commercial banks to leverage loans to private sector renewable energy projects. The initial phase of the national CPF programme aims for a total 210 MW capacity composed of small-scale hydro, wind and biomass projects installed after 2012, covering about 1% of the country's electricity. In Indonesia, the government aims to increase its current geothermal power capacity sixfold to 6 000 MW by 2020. The planned CPF initiative to pre-purchase CERs from eligible geothermal projects should help meet this objective by reducing project development risk in the face of existing barriers[65] and improving the financial viability of projects (World Bank, 2009b).

Similarly, the Asian Development Bank's Carbon Market Initiative,[66] introduced in 2006, includes a Future Carbon Fund (FCF) to help co-finance and leverage private investment for carbon reduction projects that will continue CERs beyond 2012 in the ADB's developing member countries (DMCs). Envisaged as a public-private partnership, the FCF will provide up-front capital to project developers by pre-purchasing CERs. The FCF became operational in 2009 with initial financing commitments of USD 100 million and the aim of doubling the available funding to USD 200 million if there is sufficient demand.

[64] This is because financial closure for a CDM project's assets will often, although not always, be possible once investors are satisfied that a project has been successfully registered under the CDM (CD4CDM & Ecosecurities, 2007). Thus, the asset financing of CDM projects registered from late 2008 onwards will not be included in the asset financing data. A factor supporting this assertion is the extensive time-lag of more than a year generally witnessed between project registration and the first CERs being issued (UNEP Risoe, 1 December 2009).

[65] Chapter 5 discusses the barriers to the deployment of renewables in the region, including Indonesia.

[66] Source: http://www.adb.org/Climate-Change/cc-mitigation-carbon-market.asp

Within all of ADB's carbon and clean energy funding mechanisms (discussed further in Section 4.4.3 on development financing in the ASEAN region), special focus is placed on renewable energy and energy efficiency projects given the understanding that this will foster both increased energy security and help decarbonise the Asia-Pacific region's power sector, thereby mitigating the effects of climate change, which poses a major threat to the region.

4.4.3. Development funding for renewable energy

4.4.3.1. Objectives and elements of development finance for renewables

Development finance institutions (DFIs), both bilateral and multilateral, provide funding to foster the deployment of renewable energy technologies (RETs) through:

- project-based investments; and
- technical assistance, typically related to capacity building.

In contrast, supporting technology innovation in clean energy and providing the required risk capital has historically not featured strongly in DFIs' funding priorities. Currently, research and development (R&D) in clean energy is largely concentrated in large developed countries (IEA, 2009a; UNFCCC, 2009b), and only a small part (10-20%) of total estimated financing resources (USD 70-165 billion) for global technology research, development, deployment, diffusion and transfer is currently devoted to the development and transfer of technologies to developing countries (UNFCCC, 2009b).

Analysis in recent years has shown that coherent policy frameworks and well-targeted public investment can contribute significantly in plugging the funding gap that innovative technologies often face in the early commercialisation stages of the technology innovation chain, namely during their demonstration and initial deployment (Figure 4.8). In this "valley of death" phase, investment costs can be high and risks also remain significant, while neither the public nor the private sector consider it their duty to finance commercialisation. Therefore, projects can easily fail at this stage.

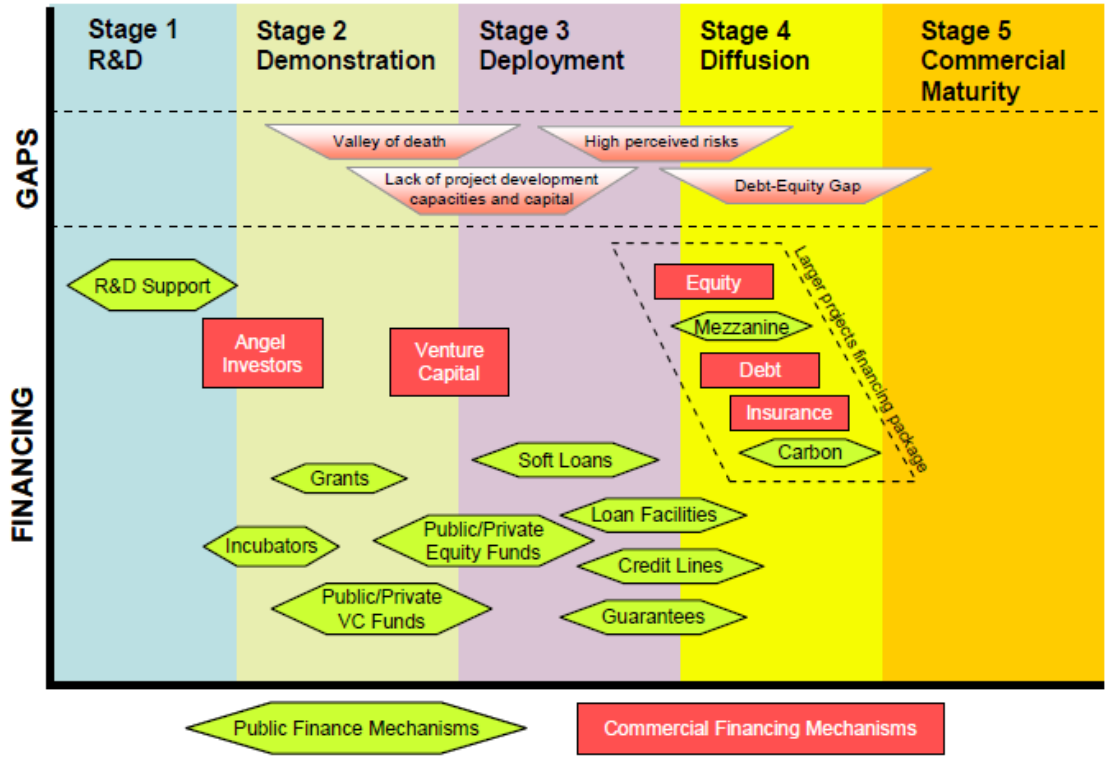
Building on these findings, DFIs are beginning to integrate public finance mechanisms (PFMs) into their development assistance programmes with the aim of up-scaling clean energy technology transfer to developing countries. PFMs being introduced in this regard include (i) loan guarantees; (ii) loan softening programmes to incentivise commercial finance institutions (CFIs) in developing countries with little experience of renewables to extend loans for renewable energy applications to ends users; (iii) technical assistance grants to enhance the capacity of the main market players for *e.g.* staff training, development of technical standards.

In most cases, DFI support of technology transfer remains focused on boosting capacity to install, operate, maintain and improve clean energy technologies as well as assisting in removing existing barriers to create an enabling environment.

However, the third vital element in technology transfer, namely of enhancing participation of developing countries in research, development and demonstration (RD&D), is often still neglected. Fostering greater co-operation on RD&D between experts in developed and developing countries would allow all participants to learn from best practice and reduces the costs of innovation through the sharing of results and increased synergies in invested RD&D efforts (Climate Strategies, 2009; Philibert, 2004). Since its creation in 1974, the IEA has

provided a structure for international collaboration in energy technology R&D and deployment, with over 40 active Implementing Agreements. Most Implementing Agreements' work influences technology transfer. Over the past decade, participation from developing countries as well as corporate partners has increased, including in the ten renewable energy-related technology agreements. While only Malaysia currently participates in an IEA renewable energy technology agreement, on solar PV, other ASEAN countries have expressed interest in joining the collaborative research activities on other renewable energy technologies.

Figure 4.7: Financing vehicles by stage of technology maturity



Source: UNEP SEFI, 2008.

Key point: Public finance mechanisms can be integrated at key phases of the energy technology innovation chain to address financing gaps.

Nevertheless, a groundswell of DFI investments to support clean energy technology companies and demonstration projects is gradually appearing – with several multilateral development banks (MDBs) creating private equity and also venture capital funds to stimulate and leverage equity investments in less mature low-carbon energy technologies, such as the Asian Development Bank's clean energy private equity investment funds (discussed further in Section 4.4.3.2.).

In the case of many multilateral donors, the increasing push for deploying new non-hydro renewables, which on average has started within the last five years, is integrated within broader strategies to support climate change mitigation (World Bank, 2009c; IFC, 2009; ADB, 2009a). As of the end of 2008, the World Bank was managing over USD 1.6 billion of capital in climate

funds (not all focused on developing countries) with a portfolio of USD 186 projects representing over USD 2.3 billion in carbon asset value (World Bank, 2009d).

While information is generally available for aggregate financing of renewable energy at a global scale, few institutions differentiate regional or country-specific investment amounts for renewable energy in the ASEAN region.

Box 4.2: Development finance institutions (DFIs) active in funding renewables deployment in developing countries

As the world's largest multilateral development organisation, in terms of its geographical scope and the size of its lending portfolio, the **World Bank Group**[67] has made large strides in surpassing its pledged commitment at the Bonn Renewable Energies International Conference in 2004 to increase support for the renewable energies and energy efficiency sectors by 20% *per annum*, or by a total of USD 1.9 billion, over Financial Year (FY) 2004-09. In fact, the World Bank Group's funding for new renewables[68] (excluding large hydro above 10 MW installed capacity) and energy efficiency grew by 61% a year over that period to reach USD 3.1 billion in FY 2009. Of FY2009 lending, 43% (or USD 1.4 billion) was dedicated to new renewables. Financing for large hydro has fluctuated over the past four years but, with the introduction of the 2008 "Strategic Framework on Development and Climate Change" and its intensified focus on new renewables and energy efficiency, committed large hydro investments declined by more than 80% from 2008 to 2009 to USD 117 million (World Bank, 10 September 2009).

Since 2008, the World Bank Group-wide climate change strategyhas informed the **International Finance Corporation (IFC)**, the investment arm of the World Bank Group providing long-term loans to private enterprises, which has increased its support for climate change mitigation activities in the recent past. As a result, its investments in the renewable energy sector have grown and stood at USD 1.3 billion worldwide at the end of the IFC's 2008 fiscal year, increasing together with energy efficiency by 64% over the previous year. The IFC aims to more than double its global portfolio of renewable energy investments to USD 3 billion a year from 2009 to 2011.

The **Asian Development Bank (ADB)**, whose regional remit covers all ASEAN countries, has scaled up its clean energy investments – encompassing renewable energy, energy efficiency as well as cleaner fossil fuels –markedly in the past two years as a result of its re-oriented energy policy. A new energy policy was finalised in mid-2009 which reflects the ADB's new priorities in the face of burgeoning energy demand in the Asian region due to rapid economic growth, the threat of rapid and detrimental climate change impacts, the need to improve energy security, while not neglecting the need to provide access to modern and reliable energy services to the region's population living in abject poverty. The 2009 energy policy is aligned with the ADB's overall long-term strategic framework for 2008-20 which emphasises energy security, the transition to a low-carbon economy, universal access to energy, and the vision of a region free of poverty. It aims to help its developing member countries (DMCs) to provide reliable, adequate and affordable energy for inclusive growth in a socially, economically and environmentally sustainable way. Promoting renewable energy and energy efficiency is one of the three pillars next to maximising energy access for all and promoting energy sector reform and capacity (ADB, 2009b). The ADB supports the uptake of clean energy in developing Asia by distributing funds for three main uses: (i) clean energy investments through grants; (ii) technical assistance, and, the smallest component; and (iii) a quick release of funds for contingencies to support project activities and capacity building.

[67] The World Bank Group encompasses i) the International Bank for Reconstruction and Development (IBRD), ii) the International Development Agency (IDA), which together are often called "The World Bank", iii) the International Finance Corporation (IFC), the Multilateral Investment Guarantee Agency (MIA), and the International Centre for Settlement of Investment Disputes (ICSID).

[68] The World Bank Group defines "new renewables" as comprising solar, wind, geothermal, biomass and small hydro below 10 MW installed capacity.

The **Climate Investment Funds**, introduced in 2008 and managed by the World Bank with pledged developed country donor funding of USD 6.1 billion in total, are interim measures[69] in the absence of a binding post-2012 climate change policy regime aiming at supporting low-carbon and climate-resilient development in developing countries through scaled-up financing. The CIF consist of two funds, the **Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF)**, whose investments are implemented by multilateral development institutions, *e.g.* the Asian Development Bank, the African Development Bank, and the International Finance Corporation, and are designed to complement existing bilateral or multilateral financing mechanisms. While the CTF focuses on middle-income countries financing scaled-up demonstration, deployment and transfer of low-carbon technologies for large-scale , the SCF seeks to support low-income countries by piloting approaches that have the potential to be scaled-up for mitigating climate change through (i) reducing emissions from deforestation and degradation, (ii) integrating climate risk mitigation, resilience and adaptation strategies into development planning, and (iii) demonstrating the social, economic and environmental benefits of scaling-up low-carbon technologies for energy access and income generation.

4.4.3.2. Examples of renewables-related development finance streams

The following snapshot of development funding relating to renewable energy relevant to the ASEAN region, which makes reference to the DFIs introduced in Box 4.2, does not claim to be representative nor does it include examples of bilateral development assistance on renewable energy, which is also present in the ASEAN countries – although not much detail is available.

The World Bank does not provide more granular detail on renewable energy or the ASEAN region in its official reporting than to indicate that portfolio lending on energy and mining activities has increased in **the East Asia and Pacific region**, which comprises all ASEAN countries, from 2.6% of lending in the region in fiscal year (FY) 2004 to 11.6% in FY 2009. Lending in the East Asia and the Pacific region constituted 19% of the World Bank's total portfolio in FY 2009, or USD 26 billion (World Bank, 2009c). An example of a renewable-energy related World Bank project is an **International Development Association (IDA)**[70] credit to Vietnam, which is the IDA's only ASEAN-6 member country, worth USD 202 million to foster the country's ability to increase its renewable electricity share. This World Bank loan is linked to the CPF programme outlined in Section 4.4.2.4 and Box 4.2.

In the **East Asia and Pacific region**, the International Finance Corporation's (IFC) renewable energy portfolio, including solar, hydroelectric and geothermal energy sources, reached USD 330 million in FY 2009 with an additional USD 40 million invested through clean energy funds (IFC, 2009). A specific example of a **renewable energy-related IFC investment in the ASEAN-6** is the Sustainable Energy Finance Programme in the Philippines, which aims to encourage commercial financing for sustainable energy (both renewable energy and energy efficiency) through USD 3 million of risk-sharing facilities for commercial financial institutions and USD 2.3 million advisory services, which will help build capacity.

Mirroring the Asian Development Bank (ADB)'s revised priority-setting (Box 4.2), clean energy investments – to a large extent in public sector projects – leapt by more than 250% from

[69] The sunset clauses of the twin CIF constituent funds state that the funds will take "necessary steps to conclude [their respective] operations once a new financial architecture of a future post-2012 climate change regime is effective".

[70] The IDA provides interest-free, long-term loans to the world's 82 least developed countries. ASEAN member countries include Cambodia, the People's Democratic Republic of Laos, Myanmar and Vietnam.

USD 668 million in 2007 to USD 1.7 billion in 2008, having increased by a more moderate 31% *per annum* from 2003 to 2007 (ADB, 2009c), and representing a respectable 16% of total ADB investments (USD 10.6 billion). This positive boom meant that the ADB surpassed its stated target of investing USD 1 billion annual in clean energy from 2008 to 2010 already in the first year. In the 2009 Energy Policy, this target has been increased to USD 2 billion annually from 2013 on. The **ADB's Clean Energy Financing Partnership Facility (CEFPF)**, established in 2007, assisted substantially in achieving the ADB's target by leveraging its USD 18.6 million grant-based investments 16-fold to encourage approximately USD 300 million in additional private sector clean energy financing.

However, to date, renewable energy, and especially non-hydro renewables, has not featured strongly within the ADB's clean energy portfolio, with 28% (USD 1.2 billion) of the USD 4.3 billion in total ADB clean energy investments having been invested in renewables in the developing member countries (DMCs) in 2003-08, of which 60% in large hydro and 11% in power grid development benefitting the exploitation of renewable energy resources. In 2008 and the first half of 2009, the share of new renewables (excluding large hydro) did jump to 35% (USD 919 million) of total ADB clean energy investments, primarily for small hydro, waste-to-energy, wind, biomass and geothermal energy projects. Over the same period, large hydropower's contribution dropped to 23% (ADB, 2009c).

Between 2003 and 2009, the **ASEAN-6 countries** benefited from only 7% of all ADB clean energy investment, with Vietnam as its main beneficiary therein – possibly due to its status as the only low-income and IDA member country in the group.

Investments by the **ADB** in **private sector renewable energy projects** started in 2008, primarily in wind projects. Within this context, the ADB created in 2008 five private equity clean energy funds with a regional focus which will use USD 100 million of ADB-disbursed seed capital to stimulate up to USD 1.2 billion of private investment in renewable energy, energy efficiency and other low-carbon alternatives. Two of these **clean energy funds** are relevant for the ASEAN-6 countries: (i) the MAP Clean Energy Fund with USD 400-500 million target investment from Gulf Cooperation Countries for about 15 large-scale projects to invest in Southeast Asia as well as India and China, such as geothermal power projects in Indonesia or sustainable bioethanol production; and (ii) the USD 200 million Asia Clean Energy Fund for 15 projects of USD 10-15 million each, such as solar PV plants and manufacturing.

For Southeast Asian countries, the expected financing for renewables through the **Climate Investment Funds (CIF)** is likely to be much more substantial than the funding disbursed to date. Between late 2009 and early 2010, Clean Technology Fund (CTF) investment plans worth a total of USD 1 200 million were approved for four middle-income ASEAN countries, Indonesia, the Philippines, Thailand and Vietnam. The planned activities to foster low-carbon technologies, especially in support of the countries' respective renewable energy and energy efficiency policy frameworks, are expected, in the World Bank's opinion, to catalyse about USD 9.7 billion in co-financing from the national governments, MDBs, carbon finance and the private sector. The co-financing anticipated is substantial, with an assumed leverage factor of above 12, which may be overly optimistic. Priority CTF activities comprise risk mitigation measures and investment support for national financial institutions to encourage the latters' renewable energy and energy efficiency project financing, infrastructure improvements in power transmission, distributed generation through renewables and building sustainable urban transport systems (World Bank, 16 December 2009; World Bank, 16 March 2010).

One of the three targeted programmes under the SCF, the so-called Programme for Scaling up Renewable Energy in Low-Income Countries (SREP), became effective at the end of 2009 with initial funding of USD 261 million, for which Vietnam is eligible (World Bank, 14 December 2009).

In terms of **technical assistance (TA),** the ADB devoted USD 123 million to clean energy TA from 2003 to mid 2009 (ADB, 2009c), with annual financing growing rapidly from 2007 onwards to more than USD 30 million. TA linked to renewable energy represents a substantial share of this, especially capacity building and financial assessment of projects for rural electrification with distributed renewable energy sources, local grids and productive uses of renewable energy for poverty reduction. The emphasis on regional co-operation is evident in the TA initiatives to foster regional energy strategies, the regional interconnection of national grids and power trade, such as in the Mekong region which would allow Thailand to benefit from Laos' hydropower resources (*ibid.*).

4.5. Overview of existing financing flows for renewable energy

Table 4.1 summarises the investment amounts currently directed at renewable energy deployment in the ASEAN region, indicated in the previous section, and – where more granular data are available – more specifically in the ASEAN-6 countries. This overview is only indicative due to substantial data gaps.

Table 4.1: Indicative availability of financing for renewable energy power capacity in the ASEAN countries

Sources of funding flows	Countries covered	Technology focus	Financing amount (in USD million)	Expected co-leverage (in USD million)	Total available financing	Period
Investment in renewable energy production capacity[71]	**Southeast Asia** (specifically, Malaysia, Indonesia, Philippines, Thailand and other ASEAN countries)	Biofuels, onshore wind, geothermal, biomass and waste power generation, small hydro	2 600	n/a	2 600	2008
- **of which renewable power generation assets**[72]	**Southeast Asia** (specifically Malaysia, Indonesia, Philippines, Thailand and other ASEAN countries)	Onshore wind, geothermal, biomass and waste power generation, small hydro	1 200	n/a	1 200	2008
CDM revenue	**ASEAN-6**	Solar, wind, hydro, geothermal, biomass energy	470	n/a	470	2008-12

[71] This funding amount is not taken into account for calculation purposes, as it also encompasses investment into biofuels, whereas the other financing estimates refer mainly to renewable power generation investment.

[72] This bottom-up aggregation of investments in renewable power generation assets does not distinguish between private and public sector financing. Thus, there is likely to be some overlap with the investment figures relating to the multilateral development banks further down in Table 4.1. To reduce the risk of double counting, this financing amount is taken into account at a 75% value for the purposes of calculating an estimated total.

DEVELOPMENT ASSISTANCE						
- World Bank Group	[Worldwide[73]]	[New renewables (solar, wind, geothermal, biomass energy, small hydro below 10 MW)]	[1 400]	[n/a]	[1 400]	[Financial Year 2009 (to end June 2009)]
	East Asia and Pacific	RETs (not specified)	270 (approximately)	n/a	270 (approximately)	Financial Year 2009 (to end June 2009)
- International Finance Corporation	**East Asia and Pacific**	RETs (not specified)	330 + 40 (clean energy funds)	Not available	370	Financial Year 2009 (to end June 2009)
- ADB direct investments	**Southeast Asia**	RETs (not specified) (power generation and transmission network upgrades)	400	n/a	400	2008-09
CURRENT ANNUALISED TOTAL (USD MILLION)			**2 000**	**n/a**	**2 000**	

[73] This funding amount is not taken into account for calculation purposes, as it refers to a global aggregate and there are no data to disaggregate to a regional estimate.

ANTICIPATED FUNDING FOR FUTURE DISBURSEMENT						
- **ADB Clean energy funds (seed capital in private equity funds)**	**Southeast Asia**	RETs (not specified)	40 (MAP Clean Energy Fund and Asia Clean Energy Fund)	700	740	2010 onwards (assumed to 2015)
- **CTF/Climate Investment Funds**	**Indonesia, Philippines, Thailand, Vietnam**	Low-carbon technologies (energy efficiency, renewable energy, sustainable transport)	1 200[74]	12 400[75]	13 600	2010-16
- **SREP/SCF/Climate Investment Funds**	**Low-income countries: including Vietnam**	RETs (not specified)	261	Not available	261	Not available
ANTICIPATED ANNUALISED TOTAL (USD MILLION)			**200**	**1 800**	**2 000**	

Notes: Where the funding relates to a multi-year period, the amount is recalibrated to an annualised non-discounted amount. Worldwide funding amounts are not included

n/a: not applicable; ADB: Asian Development Bank; CDM: Clean Development Mechanism; CTF: Climate Technology Fund; SREP: "Programme for Scaling up Renewable Energy in Low-Income Countries", part of the Strategic Climate Fund (SCF) under the Climate Investment Funds.

Sources: New Energy Finance databases; UNEP Risoe, 1 December 2009; World Bank, 10 September 2009; World Bank, 14 December 2009; World Bank, 16 December 2009; World Bank, 2009b and 2009c; ADB, 2009a; IEA analysis.

[74] As the CTF funding includes energy efficiency and sustainable transport activities besides renewable energy, it is assumed that 60% of this CTF financing and leveraged co-financing will be devoted to renewable energy.

[75] The assumed leverage ratio of above 12 is very optimistic, so the co-leverage amount should be considered with caution.

Putting the ASEAN region's energy sector on a sustainable emissions path, with a 50% chance of limiting global average temperature increases to 2 °C above pre-industrial levels, will involve an annual investment of around USD 9.7 billion in renewable power generating capacity. This compares to USD 3.9 billion annual investment in the business-as-usual *World Energy Outlook 2009* Reference Scenario (IEA, 2009a).

However, trends of current investment flows into renewable energy in the region[76] indicate that only approximately USD 2 billion a year is currently available from different sources of funding (Table 4.1). This is approximately half the annual renewables investment projected to underpin a business-as-usual evolution of the energy mix in the ASEAN region according to the Reference Scenario.

Taking into account future investments as announced and outlined at the end of 2009 should help boost to a ballpark figure of USD 4 billion a year, including private-sector financing catalysed through public finance mechanisms. It is reasonable to assume that this rough estimate of near-term available financing for renewables could be sufficient to cover the Reference Scenario investment needs, at least in aggregate. A caveat should be highlighted that that the anticipated leverage rates for co-financing are very optimistic, putting a large question mark over whether the figure of USD 4 billion is realistic (Table 4.1).

However, notwithstanding this caveat, it is clear that this estimate of near-term financing only represents only about one third of what is needed in the 450 Scenario, which is wholly inadequate. It should be noted that the vast bulk (81%) of renewable power investment in the 450 Scenario is projected to be needed beyond 2020, which means that there is a window of opportunity to substantially scale up investment into renewables in the next few years.

This underscores the crucial role of effective renewable energy policies encouraging investment into renewables at sufficient levels by i) fostering a conducive investment climate, and ii) helping to guide investment towards upscaling and inducing cost reductions for those technologies which, depending on the local context, have a large potential for cost-effective GHG reductions, energy security improvements as well as socio-economic benefits.

[76] The different geographical scope of the individual strands of renewable energy financing listed in Table 4.1 corresponds approximately with the ASEAN region, which is the reference region for the 450 Scenario (IEA, 2009a).

5. Barriers to renewable energy deployment

Key findings

- Non-economic barriers are as important as economic barriers in shaping the cost of renewable energy projects. They are, however, much more difficult to address, because they are less obvious and often linked to perceptions of individual market players.
- In the ASEAN-6 countries, significant non-economic barriers include administrative hurdles, market issues, grid-related concerns and socio-cultural factors.
- Persistent non-economic barriers, such as government energy policies skewed against renewable energy technologies or heavy administrative requirements, can ultimately have high economic impacts. When such barriers affect early investment-intensive phases of a project cycle, it drives up the required return on investment and therefore the levelised generation costs for the particular renewable energy technology.
- A recent survey of international investors in wind energy and solar photovoltaic generation found that they perceived the following risk factors as most relevant: legal security, negative policy changes affecting renewables, the main financial support scheme and total revenues received.
- Investors are likely to require a high risk premium to accept the possibility of policy changes affecting renewable energy project development. Effective and coherent policies are crucial to minimise investors' perception of risk and consequently the risk premia they expect. Such policy stability is especially crucial at certain stages of renewable energy projects, including project development and operation phases.
- A wide range of possible measures exist to help reduce the barriers identified in the ASEAN-6 countries. To be effective, these require co-ordination among all major stakeholders.

5.1. Introduction

Depending on their level of technology maturity, renewable energy technologies (RETs) differ in their competitiveness relative to conventional energy technologies. This can constitute an economic barrier to their deployment. Some RETs are close to becoming commercial and should be the first to be deployed on a massive scale. Other RETs, which have a large potential, are less mature and require longer-term visions and a comprehensive support strategy to enable their utilisation.

As the deployment of modern renewable electricity (RES-E) conversion technologies is relatively recent in many countries, past initiatives for the development of RES-E have largely focused on the economic factors, and the reduction of economic barriers has been the main focus of support measures undertaken. Past success stories for the development and deployment of renewable energy sources (RES) (*e.g.* in certain European Union countries) underline that barriers can be overcome by targeted policy action (Ragwitz *et al*., 2007).

However, non-economic barriers play just as important a role in shaping the cost of renewable energy projects and are judged more difficult to address than economic barriers (IEA, 2008a). One reason is that economic barriers are often apparent due to their financial nature while non-economic barriers appear more subtle and hidden as they are often linked to the perceptions of individual market players.

The successful market penetration of renewable energy technologies, as with any new technology, depends on the cost of implementing renewable energy projects, which is an interplay between the (relative) costs of the technology *per se*, *i.e.* purely economic factors, and the risks perceived by renewable energy project investors (de Jager and Rathmann, 2008).

Risks associated with renewable energy projects stem both from underlying economic factors and barriers that are non-economic in nature. Findings from earlier analysis suggest that it is non-economic barriers that stand in the way of significantly scaling up the contribution of renewables to a future sustainable energy mix (IEA, 2008a).

This chapter investigates the prevalence and specificity of non-economic barriers in the ASEAN-6 countries, the perceived risks arising from the identified barriers and possible strategies to mitigate these barriers. Its objective is to empirically measure the relative importance of different non-economic barriers in private and public renewable energy investment decisions.

5.2. Methodological approach

The assessment builds on two complementary sets of analysis using distinct methodological approaches:

- **Identification of the main non-economic barriers, the resulting risk perceptions and possible mitigation strategies:** Interviews and surveys with representatives of key stakeholder groups, namely government officials/policy makers, energy companies, project developers, RET manufacturers, investors, financiers, academic experts, civil society that are involved in the deployment of grid-connected renewable electricity from biomass and geothermal in several ASEAN countries with high resource potentials (Indonesia, the

Philippines and Thailand).[77] However, due to the relatively small number of stakeholder responses, which limit their representativeness, the analysis is complemented by an in-depth desk-based literature review.

The above qualitative assessment was complemented with a study which attempts to determine the price of these non-economic barriers and the resulting policy risk perception from an investor's perspective:

- **The price of renewable energy policy risk:** Using an online survey platform, choice experiments were performed with international wind and solar PV investors using conjoint analysis (IWOe, 20109). A detailed description of the underlying methodology is available in an annex to this report.

The above research studies focus on renewable electricity technologies due to the challenges in identifying a sufficiently large and representative sample of stakeholders and especially investors in renewable heating in the ASEAN region. The omission of renewable heating and renewable transport fuels from these analyses is not a reflection of an absence of barriers to their market uptake, but rather evidence that the market, especially for the former, is still very fragmented in the ASEAN region with little concerted policy guidance nor larger-scale private sector involvement.

5.3. Overview of non-economic barriers

Within the analysis, non-economic barriers are classified as (Lamers, 2009; Painuly, 2001):

- **Administrative barriers**, which encompass political, institutional and regulatory conditions that disadvantage RES-E.
- **Market barriers** which consist of asymmetrical information, market power and the effects of non-internalisation of external costs.
- **Technical/infrastructure barriers** which mainly centre on grid-related issues and standards.
- **Financing barriers** associated with an absence of adequate funding opportunities and financing products for renewable energy.
- **Socio-cultural barriers** which deal with socio-cultural perceptions and conditions related to RES-E.

Results from the stakeholder surveys suggest that non-economic barriers are perceived in most cases to have at least the same influence as economic barriers when making investment decisions (Lamers, 2009; IWOe, 2010). Nevertheless, this general finding needs to be qualified.

The maturity of the technology and the status of its market commercialisation in the target country play a crucial role in the weight assigned to economic factors in the investment decision. A pertinent example are the Philippines, which has already exploited a significant share of its large high-enthalpy geothermal resources – it has the world's second-highest installed capacity – and has developed a mature market for the technology which competes at low production costs and represented 19% of power generation in 2007 (IEA, 2009a). In this case, economic barriers are deemed not to be as important as non-economic issues such as the technical challenges of the high level of acidity associated with volcanic activity in the

[77] Lamers, 2009; Gamba and Lamers, 2009a, 2009b and 2009c; Hagedoorn and Lamers, 2009; Lamers *et al.*, 2009.

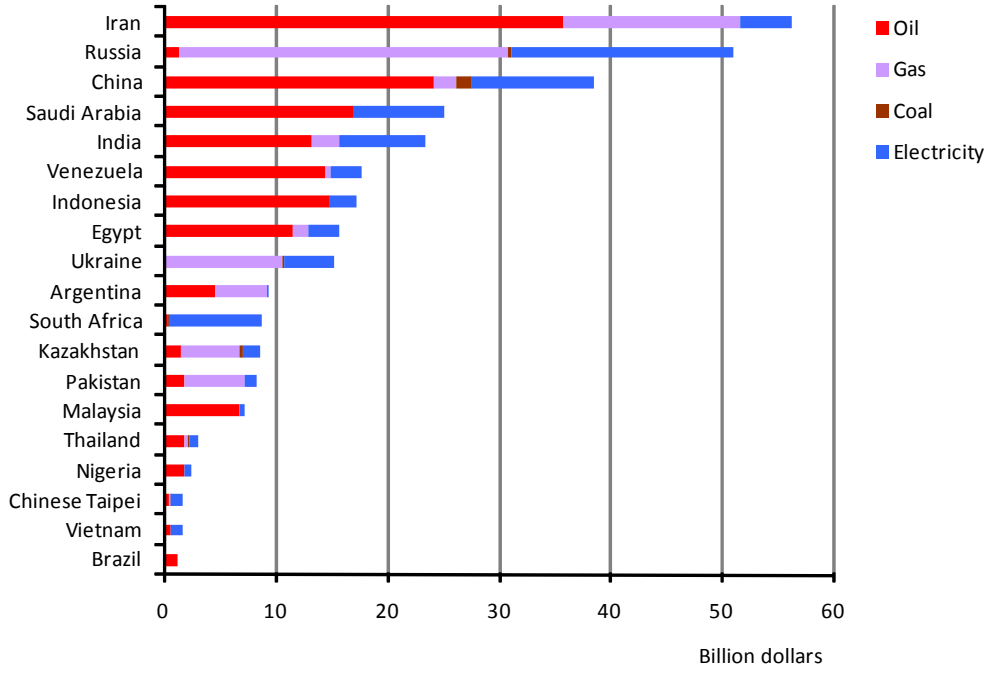
Philippines which causes equipment corrosion and can interrupt or even indefinitely prevent production (Hagedoorn and Lamers, 2009).

In addition, the affiliation of stakeholders appears to influence the importance attached to non-economic barriers relative to economic factors. It appeared that governmental officials ranked non-economic barriers lower than commercial parties such as project developers and industry representatives, which may be linked to their different perspectives.

Moreover, persistent non-economic barriers, such as government energy policies skewed against RETs and high administrative burdens, can translate into high economic impacts, especially if the former obstruct primarily the earlier investment-intensive project cycle phases (project development, financial closure, construction). This increases the required investment return thereby raising levelised generation costs.[78] Thus, a clear distinction between the two overarching barrier categories is not always possible. For example, high obstacles or even the impossibility in obtaining grid access authorisations will necessarily increase the risk premium demanded and thereby the investment cost of the project.

A biased energy market structure, which is *per se* a non-economic barrier, can generate economic impacts. Subsidies for conventional fossil-fuel generated electricity which are common in most ASEAN-6 countries (Figure 5.1) create a strong economic disadvantage for RES-E technologies which generally face high up-front project capital costs (Sovacool, 2010).

Figure 5.1: Energy subsidies by fuel in non-OECD countries, 2007 (billion USD)[79]



Source: IEA, 2008c.

Key point: Nearly all ASEAN-6 countries feature among the non-OECD countries with the largest absolute energy consumption subsidies.

[78] The impact of barriers and associated risks on project financing costs is discussed in more detail in Sections 5.9 and 5.10.

[79] As requested by the G20, the IEA will publish a special analysis on energy subsidies in the *World Energy Outlook 2010*.

The countries surveyed reveal a significant number of non-economic barriers that impede the further deployment of grid-connected RES-E. However, the types of non-economic barriers vary in prevalence and relevance across the ASEAN-6 countries. In general, the larger the number of barriers in a country and the more significant they are, the higher will be the investment risk perceived by potential investors in a target market.

5.4. Relative importance of non-economic barriers

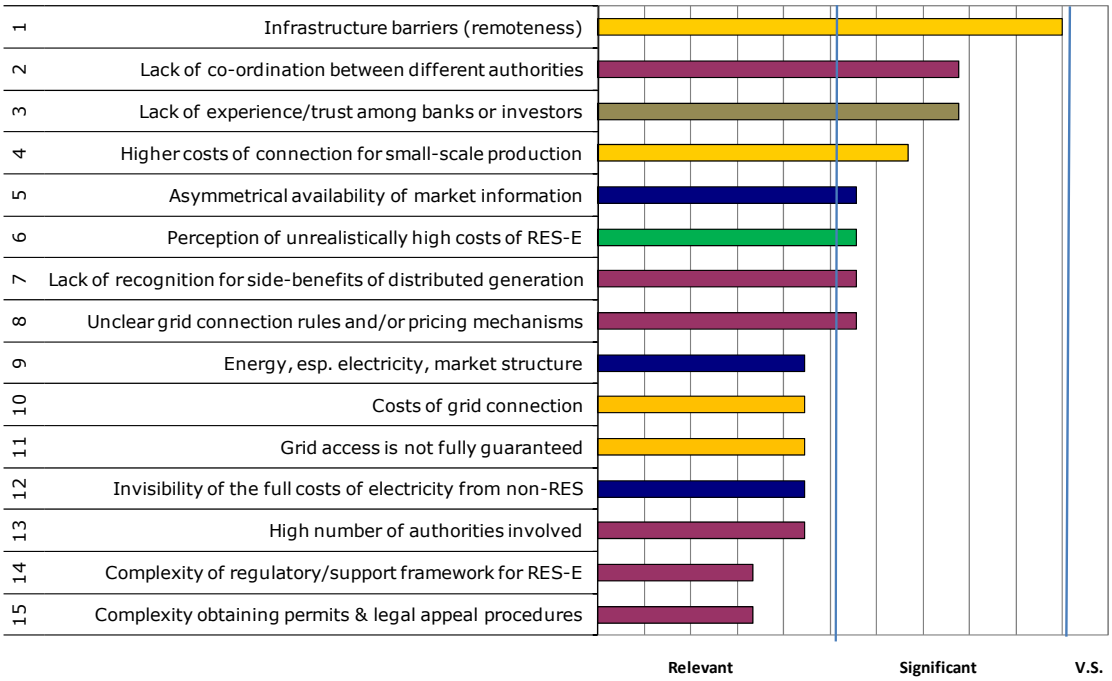
As evidenced in Figure 5.2, grid-related (technical/infrastructure) barriers are significant in ASEAN-6 countries, with the natural geographical constraints of the Indonesian and Philippines archipelagos exemplifying the infrastructural challenge of building adequate grid and road connections. Moreover, varying grid connection rules and unclear pricing mechanisms are common across the region.

The continued dominance of state-controlled national transmission operators skews the playing field towards incumbent market players. This is also reflected in the high ranking of market-related barriers in the ASEAN countries surveyed (Lamers, 2009).

Administrative barriers are a further serious obstacle in the way of large-scale market growth for modern renewables. Long delays in obtaining permits, large number of authorities involved and a lack of co-ordination among these authorities are major reasons cited by stakeholders as hindering.

The relatively high average rank of the invisibility of the full costs of conventional fossil-based electricity suggests that energy market distortions, especially with regard to electricity and oil product subsidies, are also seen as an important barrier. Historically, conventional fuel and electricity subsidies were common across many ASEAN countries, notably Indonesia, Malaysia and Vietnam. Such non-cost reflective tariffs created market distortions (*e.g.* IEA, 2009b) which contributed to renewable energy projects not being seen as economically viable. In recent years, there have been promising moves by certain countries to gradually phase out such subsidies, although a sustainable trend in making tariffs more cost reflective cannot be discerned yet.

Figure 5.2: Average ranking of the most important non-economic barriers in selected ASEAN countries[80]



Legend:

- Technical/infrastructure barriers
- Administrative and regulatory barriers
- Market barriers
- Financing barriers
- Socio-cultural barriers

"Relevant", "Significant" and "V.S." refer to a barrier that is deemed "relevant", "significant" or "very significant" respectively based on the survey results.

Source: Lamers, 2009.

Key point: Grid-related barriers are viewed as most significant in major ASEAN countries, followed in importance by administrative and market-related hurdles.

The following sections examine the occurrence of the different barrier types in the countries analysed and how relevant they are. It is important to note that the different barrier categories are often interlinked and influence each other.

[80] The analysis relies to a large extent on desk-based research and responses to stakeholder surveys. It needs to be underscored that the survey responses may not be representative and, therefore, only cautious conclusions may be drawn from these findings.

5.5. Administrative and regulatory barriers

A range of administrative and regulatory barriers exist in developing countries – some of which can hinder general energy project developments while others are more specific to RES-E.

Major barriers affecting energy projects in general include uncertain regulatory regimes governing the energy sectors, with heavy political influence over electricity pricing for example (as in Indonesia) and the diffusion of regulatory responsibilities resting with institutions lacking, as yet, sufficient capacity (as in Thailand). The high administrative burden of obtaining grid access, with long delays in authorisations and the absence of standardised access conditions, can affect independent power production projects based both on conventional fossil fuels as well as RES-E.

These challenges often lead to a heightened sense of regulatory and political risk on the part of investors and a consequent higher reluctance to invest in those environments (Hagedoorn and Lamers, 2009; Jarvis, 2009).

Nevertheless, the fact that all ASEAN-6 countries are engaged in efforts to promote renewable energy show that policy makers are indeed interested in tapping the benefits of RET deployment. This is also reflected in the findings of the stakeholder analysis.

Despite this apparent political will, the survey results show that there is, in many cases, a significant lack of regulatory security and policy enforcement.

Key obstacles include:

- **A large number of organisations involved in permitting procedures and a lack of co-ordination among involved authorities:** The inadequate co-ordination and number of redundant transactions with a multitude of government agencies is exacerbated by inadequate provision of general information on permitting and legal appeal procedures. This barrier is highlighted in the interviews and survey responses for Indonesia and the Philippines.
- **Absence of a comprehensive and strategic RES development plan**: In the Philippines and to a lesser extent in Indonesia, this barrier may be accentuated by the absence of a comprehensive RES-E development plan (Elauria *et al*., 2002). Various government bodies remain uncertain about their role in the promotion and development of the different RES-E technologies. Many agencies and organisations have pursued their own development strategies in a rather uncoordinated manner. To avoid this practice in the future, RES should be strategically incorporated in the national energy plan including an outline of the responsibilities and necessary institutional/administrative structure regarding the implementation.
- **Lack of experience regarding RES among decision makers:** In addition to a lack of co-ordination among authorities, many policy makers are seen not to be fully aware of the characteristics and benefits of RES (Gamba and Lamers, 2009a and 2009b; Elauria *et al*., 2002). The interviewees agreed that, at present, there is a strong need for "institutional capability to identify, manage and address issues related to the promotion and development of RES" (in the words of a project developer). Strengthening the capacity building of government decision makers and especially of energy regulators, where they exist, is a crucial component in this regard.

Existing research on barriers to renewable energy market take-up in developing countries adds weight to these indicative survey results. A lack of policy clarity and consistency concerning the long–term strategy of RES-E including promotional policies contribute to hampering investments in RES (Brouns *et al.*, 2007; Brown *et al.*, 2005). Furthermore, conflicting objectives and interests amongst policy makers, and unclear ministerial responsibilities and insufficient co-ordination between the involved institutions lead to the effect that support policies are delayed or not implemented, as the authors point out. In comparison to long(er)-established institutions favouring the use of fossil fuels, national institutions for RES-E promotion appear rather powerless. This underlines the institutional path dependencies found in the case of *e.g.* Indonesia and Thailand in the analysis. An administrative barrier that was not identified in the current research, however, is the strong hierarchical structure of public institutions which impedes the diffusion of know-how and innovative ideas including RES (Brouns *et al.*, 2007).

Table 5.1: Incidence of administrative and regulatory barriers in the ASEAN-6 region

Market-related Barriers	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Lack of legal/regulatory framework for RES	•		•		o	
High number of authorities involved	o		o		o	
Lack of co-ordination between different authorities			•			
RES insufficiently taken into account in spatial planning	o		o		o	
Complexity of support framework for RES-E			o			
Regulatory restrictions for development of new energy technologies						
Lack of experience/trust among decision makers	•		•			
Low awareness of benefits from RES development on local and regional authority level					•	
Lack of involvement of stakeholders in decision making	o		o		o	
Complexity/duration of obtaining permits and legal appeal procedures	•		•			
Complexity/duration for grid connection authorisation	•		•		•	

Important note: The absence of any mark does not imply that these barriers are not relevant for the individual countries. It may indicate that there is insufficient publicly available information to verify the existence of specific barrier types.

Legend: "o" indicates the relevance of a barrier in a country while "•" indicates that a barrier has a (more or less) significant impact.

Source: IEA analysis, adapted from Painuly, 2001; Lamers, 2009, IWOe, 2010.

5.6. Market barriers

Market-related barriers relate to electricity market structure, *i.e.* the distribution of information and power due to the relative market positions of certain key players.

The **(often monopolistic) structure of electricity markets** in the ASEAN-6 region, with the notable exception of Singapore and, to an extent, the Philippines,[81] is characterised by the continued dominance of a state-owned or -controlled utility. The main trend taken by ASEAN governments is to retain state ownership of the utility and to open the generation sector to independent power producers (IPPs), while introducing some form of regulatory framework for independent production. The utility is also generally the sole off-taker for IPPs' output (IEA, 2009b) but, with few exceptions, is not obliged to purchase the output of IPPs, *e.g.* renewable electricity from biomass or geothermal sources.

Box 5.1: Position of small renewable electricity producers in Thailand

In Thailand, the state electricity provider EGAT (Electricity Generating Authority of Thailand) has a commitment to purchasing output from small and very small power producers under its Small Power Plant Programme introduced in 1992 and the Very Small Power Plant Programme introduced in 2002. The terms of SPP operations, access to customers, and power purchase agreements, are set by EGAT and the Thai energy ministry. Both IPPs and SPPs have long-term power purchase agreements with EGAT as the single buyer. The PPAs allocate market risk to EGAT (and its captive ratepayers) leaving SPPs and IPPs to manage the operating and fuel price risks. SPP contracts are between 5 and 25 years with terms and specifications set by EGAT, the national power monopoly.

EGAT has defined two types of purchasing rates for buying SPP power, non-firm and firm power.[82] Firm power means the SPP can guarantee availability of electricity supply during the system peak months. Judging from the government's latest Power Development Plan to 2021, which is prepared by EGAT, it seems that the firm capacity of biomass-based SPPs is determined by EGAT to be low relative to the SPP capacity deemed to be "firm" running on natural gas or goal (EGAT, 2009). This indicates a possible institutionalised bias against a renewable energy source as biomass which is generally seen as dispatchable and able to provide base-load firm capacity.

About two-thirds of the installed non-firm capacity, most of which is based on sugar-cane bagasse residues from the sugar processing industry, goes to EGAT, with the rest supplied to industrial customers (EGAT, 2009). SPPs are allowed to contract directly with industrial customers located near the SPP power plants using private distribution lines, but there is no provision for SPPs to access the state-owned distribution grid, which would enable them to also access commercial or residential consumers.

The **electricity tariff structure** is, in the energy sector of many ASEAN-6 countries, either set by the state utility or, where electricity regulatory bodies have been established, heavily influenced by utilities against the background of low institutional capacities of the regulatory bodies (*e.g.* Jarvis, 2009).

[81] Singapore has been the first ASEAN country to liberalise its electricity market from 1995 and more forcefully from 2000 onwards. In the Philippines, electricity sector reform began in 2001 with the Electric Power Industry Reform Act (EPIRA). However, the government has had only partial success in achieving its objectives of a fully liberalised and competitive electricity market with unbundled generation, transmission and distribution, monitored by an independent regulator (IEA, 2009b; Villamejor-Mendoza, 2008; Lamers *et al*., 2009).

[82] Payment to firm SPPs is determined by EGAT's avoided long-run marginal costs (including capacity costs), while the value of non-firm power is determined by EGAT's avoided short-run marginal energy cost.

A related obstacle is **asymmetrical market information** whereby the dominant utility benefits from remaining personnel and institutional links with divested entities, such as in the Philippines where the National Power Corporation (NPC) maintains close ties with the transmission company TRANSCO. This can create information asymmetries and disadvantage new market entrants, often IPPs with smaller generation capacity than the incumbent. Inadequate information on renewable energy sources availability, market demand, tariff structure, regulatory obligations play a role in preventing RES-E technologies from effectively competing with conventional energy technologies. This issue is raised by survey respondents for Indonesia and the Philippines (Lamers *et al.*, 2009) and in Sovacool, 2010.

At least in Indonesia, the **lack of transparency regarding subsidies for, and the full costs of, electricity from fossil fuels** is perceived as among the most detrimental market barrier to encouraging a higher market penetration of renewable electricity. Electricity and fossil fuel consumption are heavily subsidised in Indonesia (Figure 5.1). In most ASEAN-6 countries, the very low electricity tariffs established by the energy authorities do not allow for a level playing field for RES. This economic disadvantage creates a situation in which RES-E appears to be an expensive alternative in the eyes of the general public. Hence, this market distortion leads to a generally negative perception of RES and represents a strong obstacle for the further development of biomass power plants.

This distorted view also applies to geothermal electricity generation in Indonesia, despite the fact that the country enjoys world class resources and can produce electricity at costs that are competitive with the average fossil-based generation costs in Indonesia: USD 0.04-0.08/kWh versus USD 0.12/kWh (Hagedoorn and Lamers, 2009). However, the situation changes when the basis of comparison is the sales revenues of USD 0.06/kWh due to the deep subsidies of electricity prices (IEA, 2008b).

Box 5.2: How electricity subsidies skew the playing field against renewables in Indonesia

In Indonesia, the state-owned electricity utility Perusahaan Listrik Negara (PLN), which in 2006 owned 86% of the country's grid-connected power generation capacity (IEA, 2008b), is not permitted to charge cost-reflective electricity supply tariffs. The country's electricity tariff structure is highly complex with many customer classes, although tariffs within these classes do not reflect ability to pay. However, the Indonesian government limits PLN's tariff adjustment, with the utility's revenue shortfall being compensated by the government itself. The size of this electricity subsidy has spiralled in recent years, as global oil prices skyrocketed. In early 2008, the electricity subsidy was estimated to represent about 6.5% of the Indonesian government's total 2008 budget, with the combined fuel and electricity subsidies amounting to USD 20.5 billion, which represented 20% of total government spending for 2008 and exceeded combined expenditure on housing, education and law enforcement (IEA, 2008b).

Although the deep economic recession and concurrent decline in global oil prices in late 2008 and early 2009 have helped ease the budgetary pressure on the Indonesian government, the government still has a limited capacity to mobilise the investment required to finance the required expansion of its power infrastructure. Chronic under-investment has led to the current electricity network suffering from black-outs, brown-outs, enforced supply cuts pointing to substantial unserved demand, possibly above 10% of current installed capacity (IEA, 2008b). Private sector investment, especially from foreign sources, retracted in the recession caused by the 1997-98 Asian financial crisis, as the currency devalued and PLN was unable to honour its USD-denominated PPAs with foreign-owned IPPs. Increasingly non-market reflective tariffs in the past decade have on the whole discouraged further foreign direct investment in the Indonesian power sector. However, the Indonesian government is reliant on attracting private sector investment, as its public finances are stretched.

To keep up with burgeoning electricity demand, projected to increase by 5.5% *per annum* by 2030 in the *WEO 2009* business-as-usual Reference Scenario (IEA, 2009a), generation capacity needs to expand significantly and the existing transmission network to be upgraded and expanded substantially (IEA, 2008b). This need for a step increase in investment in the capital-intensive power sector is heightened by the Indonesian government's objective of pushing national electrification from below 60% to 93% by 2020. To achieve its even more ambitious target of 100% grid connection over the same time horizon, PLN has estimated a required investment of USD 60 billion in generation and grid infrastructure (IEA, 2008b).The country announced its second 10 000 MW Fast Track/Crash Power Programme in mid 2009, which should be completed in 2012. In order to reduce the country's dependence on fossil fuel imports for oil-fired power generation, the programme – tendering up to 83 power plants – will favour indigenous energy sources, including 12% from hydropower, 48% from geothermal electricity and the remainder satisfied by fossil fuels, in particular coal and relatively cleaner gas (IHS Global Insight, 20 August 2009). However, the devastating 7.6 magnitude earthquake which hit Sumatra Island, the largest island in Indonesia and home to 19% of the country's population, at the end of September 2009 may delay the implementation of this programme, as spending by the state-owned utility PLN may be diverted to repair damage to fundamental energy supply facilities (IHS Global Insight, 9 October 2009).

With close to 18% of Indonesia's population living below the national poverty line and nearly 50% on less than USD 2 per day, major power price adjustments for residential customers are not politically acceptable. Therefore, the government's decision to eliminate subsidies to larger industrial electricity customers and to introduce cost-recovering tariffs is a more socially equitable and politically digestible mechanism which should allow the government to create more attractive investment conditions for private investors.

In addition, at the G20 Pittsburgh Summit in September 2009, the Indonesian President publicly highlighted the country's commitment to step up its efforts to mitigate climate change – the country being the world's third-largest CO_2 emitter in absolute terms, with deforestation the major source – by pledging to reduce CO_2 emissions by either 26% or 41% to 2020 from business-as-usual projections (IHS Global Insight, 30 September 2009). The higher reduction value depends on international funding of IDR 168 trillion (USD 18.2 billion) being made available to Indonesia to help fund the 15% target increase.

In a similar vein, a senior Indonesian climate change official recently suggested that the government might be willing to reduce fossil fuel subsidies and increase the use of renewables in electricity generation, especially geothermal power, by introducing a renewable power purchase obligation on PLN (Creagh, 29 July 2009). This is in line with the objectives of the afore-mentioned 10 000 MW Fast Track/Crash Power Programme Phase 2.

Earlier research distinguishes between economic, regulatory, and institutional barriers (Beck and Martinot, 2004). Similar to the findings of the survey-based analysis, the authors stress that powerful public utilities act as a major market barrier. This is termed a lack of utility acceptance of innovation (Beck and Martinot, 2004) caused by historical biases and prejudices. The electricity utilities (generators and transmitters) present in the countries within this analysis are large organisations (partly or still fully state controlled) which are hesitant to develop, acquire, or maintain innovative technologies with which they are unfamiliar. Hence, little or no attention has historically been accorded to them in power capacity or transmission network planning (see cases for the Philippines or Indonesia). This historic path dependency is often amplified by a lack of financial capital that these utilities face, *e.g.* as in Indonesia and the Philippines.

Table 5.2: Incidence of market-related barriers in the ASEAN-6 region

Market-related barriers	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Energy, esp. electricity, market structure, *e.g.* dominance of monopoly state-owned utilities	•		•			
Lack of market competition	•				•	
Asymmetrical availability of market information	•		•			
Restricted access to technology						
High transaction costs						
Missing market infrastructure						
Subsidies to conventional energy	•	•	•			•
Taxes on RETs						
Invisibility of full (economic and external) costs of electricity from non-RES	•	•	•			•

Important note: The absence of any mark does not imply that these barriers are not relevant for the individual countries. It may indicate that there is insufficient publicly available information to verify the existence of specific barrier types.

Legend: "o" indicates the relevance of a barrier in a country while "•" indicates that a barrier has a (more or less) significant impact.

Source: IEA analysis, adapted from Painuly, 2001; Lamers, 2009, IWOe, 2010.

5.7. Technical/infrastructure barriers

Technical infrastructure barriers are a major constraint for energy project development in general, especially in Indonesia and the Philippines, whose topography and geography are defined by a majority of small, widely distributed islands, rugged mountainous countryside, frequent seismic activity and a tropical climate with intense rainy seasons.

This also significantly hampers electrification efforts in a region where one-third of the population does not have access to electricity (IEA, 2009b) with the majority (82%) living in rural areas. In the ASEAN region, Indonesia and the Philippines show the highest (93 million) and third-highest (13 million) number of people in absolute terms without electricity; Indonesia's electrification rate stood at about 60% in 2008, which is below the average electrification rate of 71.8% in developing countries overall (*ibid.*).

Infrastructural barriers pose a major challenge especially for remote and small-scale grid-connected renewable energy installations.

Box 5.3: Benefits of renewables for rural off-grid applications

The infrastructure challenges for expanding grid-connected renewable energy do not preclude renewables from having useful applications for reducing energy poverty in off-grid rural areas, where the population often relies on traditional biomass (including animal dung, roots, agricultural residues and fuelwood) for their energy needs. Renewable energy technologies (RETs) can for instance provide cooking and heating fuels, *e.g.* through biogas digesters which save time in collecting traditional fuelwood, free up income and reduce indoor air pollution relative to traditional biomass or kerosene. Moreover, electricity through small-scale renewable energy applications, such as solar home systems, small wind turbines or micro-hydro schemes, can provide lighting, communications, refrigeration and other modern conveniences such as telephone or Internet access to rural households, allowing them in turn to engage in income-generating activities and small enterprises. In many cases, these innovations are particularly beneficial to women and girls.

Specifically **for biomass projects, the availability and sourcing of feedstock** can be complicated by lacking road infrastructure, which, in addition to seasonal heavy rains, make long-range sourcing of biomass difficult.

The **costs of grid connection** can be particularly relevant for small and, notably in the case of Thailand, very small power producers (SPPs and VSPPs, respectively), a sub-set of IPPs with smaller generation capacity,[83] which are common in ASEAN regulatory regimes (Gamba and Lamers, 2009c; IEA, 2009b).

However, where access, reliability or quality of electricity supply is limited in many ASEAN-6 countries, **auto producers and co-producers (of power and industrial process heat)** are common. This is particularly the case in countries with high biomass potentials, such as Indonesia, Malaysia, the Philippines and Thailand, and agricultural and forest industries that are distant from the grid using feedstock such as rice, sugar-cane and timber (IEA, 2009b).

A relative **lack of transparency about grid connection procedures and/or price mechanisms** are mentioned by stakeholders as major barriers for geothermal and biomass projects, which are in most cases developed by IPPs. Given that in many ASEAN-6 countries, the state-owned or -controlled electricity companies exert influence or control over transmission and/or distribution networks, grid barriers are linked to the market barriers discussed in Section 5.6.

A significant technical barrier appears to be the **absence of technical standards and their lack of enforcement**, which is a common issue in technology-importing countries (Sovacool, 2010). As an example, for biomass power generation components in Thailand a lack of standards for performance monitoring may hinder the components development and implementation, as developers are loath to use equipment without performance insurance (Prasertsan and Sajjakulnukit, 2006).

An important **consequence of high poverty levels** in the region is that the additional costs for grid-connected RES-E developments cannot be borne by the majority of final electricity consumers.

[83] In the case of Thailand, SPPs are IPPs with an installed capacity between 10 and 90 MW while VSPPs are generators with capacity below 10 MW.

Table 5.3: Incidence of technical/grid/infrastructure barriers in the ASEAN-6 region

Technical/grid/infrastructure barriers	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Insufficient available grid capacity						
System constraints, *e.g.* weak local/regional transmission/distribution network			•			
Grid access not guaranteed	o		o		o	
Unclear grid connection rules and/or pricing mechanisms	•		•			
Grid connection costs			•			
Disadvantageous connection costs for small-scale capacity/variable RES-E production	•		•			
Infrastructure barriers: remoteness from grid, limited opportunities to connect new and/or small-scale RES-E capacity	•		•			
Lack of recognition for side-benefits of distributed generation	•					
Lack of standard and codes and certification	o	o	o		o	o
Lack of operation and maintenance (O&M) facilities						
Energy, esp. electricity, market structure, *e.g.* dominance of monopoly state-owned utilities	•		•			

Important note: The absence of any mark does not imply that these barriers are not relevant for the individual countries. It may indicate that there is insufficient publicly available information to verify the existence of specific barrier types.

Legend: "o" indicates the relevance of a barrier in a country while "•" indicates that a barrier has a (more or less) significant impact.

Source: IEA analysis, adapted from Painuly, 2001; Lamers, 2009, IWOe, 2010.

5.8. Financing barriers

In this analysis, financial barriers for RES deployment are defined as a lack of adequate financing options for RES projects. Anecdotal evidence suggests that a **lack of experience and understanding of RES among financial institutions and investors** leads to low participation of national financiers (Gamba and Lamers, 2009a) and may increase the cost of capital for RES-E projects with foreign investors more likely to require a higher risk premium than national players (Sovacool, 2010).

In Indonesia, biomass-based power projects are viewed as facing additional hurdles linked to a general lack of experience in bioenergy project development and related feedstock supply issues among banks and national investors.

Table 5.4: Incidence of financial barriers in the ASEAN-6 region

Financing barriers	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Lack of experience/trust among financiers and/or investors	•	o	•		o	o
High cost of capital	o		o		o	o
Lack of access to capital						
Lack of access to consumer credit	o	o	o		o	o
Absence of appropriate financing						

Important note: The absence of any mark does not imply that these barriers are not relevant for the individual countries. It may indicate that there is insufficient publicly available information to verify the existence of specific barrier types.

Legend: "o" indicates the relevance of a barrier in a country while "•" indicates that a barrier has a (more or less) significant impact.

Source: IEA analysis, adapted from Painuly, 2001; Lamers, 2009, IWOe, 2010.

5.9. Socio-cultural barriers

Socio-cultural barriers encompass conditions arising from contextual/cultural perceptions of a certain population or sub-set thereof, such as an ethnic minority. On the whole, these barriers are considered by the respondents to be less significant in terms of their significance than the other barrier categories.

Nevertheless, as the example of the European Union shows, the broad public support and resulting demand for RES-E can trigger political decisions and act as a strong driver in favour of RES-E developments. The absence of these drivers could result in socio-cultural barriers, *i.e.* disinterest in or mistrust of renewables.

The following socio-cultural barriers are indicated as having a medium impact on the development of renewable electricity projects in the region:

- **Limited public awareness of renewable energy technologies:** Interviewees agreed that there is generally a lack of environmental consciousness across most ASEAN-6 countries. This is not surprising because, with the exception of Singapore, high shares of the respective populations live below the national poverty line.[84] There is a general need for information dissemination regarding the available and most appropriate renewable energy technologies and the direct benefits for quality of life and income generation they can offer.

[84] The following are the most up-to-date population shares estimated to live below the respective national poverty lines in the ASEAN-6 countries except Singapore: Indonesia (17.6% in 2006); Malaysia (5.1% in 2002); Philippines (30% in 2003); Thailand (10% in 2004); Vietnam (14.8% in 2007). Source: CIA *The World Factbook*: https://www.cia.gov/library/publications/the-world-factbook/

Table 5.5: Incidence of socio-cultural barriers in the ASEAN-6 region

Socio-cultural barriers	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Prevalence of vested interests	o	o	o		o	o
Land tenure issues, *e.g.* unclear legal situation of land ownership, permitting procedures	•		•			o
High risk perception related to RETs						
Perception of unrealistically high costs of RES-E	•		•		•	
Lack of awareness of social and/or environmental impacts of non-renewable energy sources	•		•		•	
Low legal stability/confidence in rule of law[85]	o		o			o
Lack of skills and adequate training for RET installations	•	o	•		•	•
Unbalanced access to, or lack of, information, *e.g.* on resource availability	•		•		•	
Corruption	o		o		o	

Important note: The absence of any mark does not imply that these barriers are not relevant for the individual countries. It may indicate that there is insufficient publicly available information to verify the existence of specific barrier types.

Legend: "o" indicates the relevance of a barrier in a country while "•" indicates that a barrier has a (more or less) significant impact.

Source: (IEA analysis, adapted from Painuly, 2001; Lamers, 2009, IWOe, 2010).

- **Lack of experience and technical capacity on RES in the respective national energy industries:** Interviewees assessed a relative lack of technical expertise as an important concern, in Indonesia, the Philippines and Thailand. A representative of a local non-governmental organisation (NGO) in the Philippines responded that at present, technical support systems for RES-E installations are absent (Hagedoorn and Lamers, 2009). This observation is supported by existing research suggesting that local technicians and end-users are largely unfamiliar and do not have the know-how to deal with the sophistication level of RES-E technologies, especially with respect to after-sales service and maintenance (Elauria *et al.*, 2002).
- **Land tenure issues** linked to project developments planned in conservation areas, such as planned geothermal electricity plants which may encroach on protected forest areas, or land dedicated for exclusive use by ethnic minoritiessuch as many natural parks with large untapped geothermal resources protected by the Indigenous People Right Act in the Philippines (Hagedoorn and Lamers, 2009).

[85] "Rule of law" measures the extent to which agents have confidence in, and abide by, the rules of society, in particular the quality of contract enforcement, the police, and the courts, as well as the likelihood of crime and violence.

- **Lack of adequate resource potential data:** This appears to be case with geothermal electricity development in Indonesia, where no national geothermal database has been compiled to date. Instead, government officials provide resource estimates based on surface survey data and exploratory drilling is uncommon. Investors and project developers reflect this uncertainty with higher risk premiums (Hagedoorn and Lamers, 2009).
- Opinions on the influence of **corruption** among decision makers on the ease of developing renewable electricity projects in the ASEAN-6 countries vary between the different stakeholder groups. Selected surveyed representatives from the respective national research communities perceived a lack of interest in encouraging renewable energy projects among government officials due to the preference they may have for generally larger-scale fossil-fired projects often backed by large foreign corporations, which enjoy the advantages of strong institutionalised relationships with government counterparts. In contrast, interviewed project developers feel that corruption among government officials is declining and does not represent a significant constraint for biomass or geothermal power projects (Gamba and Lamers, 2009a and 2009b; Hagedoorn and Lamers, 2009).

5.10. Renewable energy policy risks

The non-economic barriers discussed in the previous sections influence project developers and other stakeholders in their perceptions of the risks connected to developing and financing RES-E installations (de Jager and Rathmann, 2008; Lamers, 2009).

The importance of non-economic barriers on renewable energy investment decisions and of risk reductions through policy improvements is investigated in a study commissioned by the IEA (IWOe, 2010), concentrating on wind and solar photovoltaics (PV). Both RES-E technologies have large future market potential in a large number of countries worldwide and also in the ASEAN region.[86]

The objective of the study was to empirically measure the relative importance of different non-economic and other market barriers in private and public renewable energy investment decisions. These barriers include policy risks, such as administrative hurdles, political instability and grid access. The adopted methodology is briefly introduced in Box 5.4.

The study was based on a country-independent conception, *i.e.* the questions and choice tasks presented were not associated to any specific geography. The focus was rather on the general assessment of non-economic barriers (*e.g.* grid access, administrative process, legal security) related to investments in wind energy and PV projects. In total, eight factors (or risk attributes) with four to six attribute levels are included in the experimental design, based on the conducted expert interviews, analysis of relevant academic literature, and results of previous IEA research (IEA, 2008a): (i) mainly financial support scheme,(ii) total remuneration,[87] (iii) support duration, (iv) administrative process duration, (v) risk of negative renewables policy changes in the subsequent two years; (vi) grid access; (vii) legal security, and (viii) currency risk. Specifically, the attribute "total remuneration" was included so as to be able to calculate the "willingness-to-accept" (see Box 5.4) values for different non-economic barriers.

[86] The potentials for individual renewable energy sources in the ASEAN-6 countries are discussed in detail in Chapter 3.

[87] This attribute encompasses the sum of the wholesale energy price plus any premiums and/or incentives received for every unit of renewable electricity generated.

The preferences for wind energy and solar PV project investors were analysed separately. The study sample included international private investors (*e.g.* international utility and energy companies, international investment banks and funds, international renewable energy project developers) and public investors (*e.g.* development banks, government ministries) in wind energy and PV power production projects.

Box 5.4: Brief description of adaptive choice-based conjoint (ACBC) methodology

Conjoint analysis allows the simulation of real decision situations by requiring respondents to choose between different investment possibilities. Preferences are then calculated based on the outcomes of these choice tasks instead of asking individuals to directly indicate their preferences. This reduces significantly the likelihood that respondents indicate responses that are at odds with their real-life decisions (*e.g.* Graham, 2004). This is because individuals reflect a bias towards their own behaviour, avoid talking about potential mistakes or non-rational behaviour and can lack insight in to their own decision-making process (*e.g.* Zacharakis and Meyer, 1998). Conjoint analysis is appropriate for overcoming shortcomings of other methodologies analysing investment decision making. Studies analysing decision-making using *post-hoc* methodologies may generate biased results.

The preferences, or part-worth utilities,[88] elicited from the respondents help estimate the relative importance of each attribute by considering what difference each attribute makes in the investor's overall perceived utility of the national policy framework, *i.e*. the difference between the highest and the lowest utility value of each attribute.

In a next step, the part-worth utilities are converted into investors' implicit willingness-to-accept certain policy risks. The "total remuneration" attribute is used as a proxy to measure willingness-to-accept by showing what total remuneration (in much US-cent/kWh), or risk premium, an investor requires to accept shouldering the burden of a specific attribute level featuring a low utility.

This is followed by country-specific analysis of the data using market simulation software, yielding specific recommendations on how to improve local RES policy frameworks in order to increase the attractiveness for investors.

5.10.1. Relative importance of RE policy risks for investment decisions

The investor preferences for the hypothetical markets based on the conjoint survey results show similar pictures for both RES-E technologies. For the wind investment framework, the non-economic barriers perceived as most important overall are legal security, the risk of negative policy changes affecting renewables and the main financial support scheme. In the solar PV framework, investors likewise rated legal security as the most important policy attribute overall, followed by the risk of negative policy changes affecting renewables and total remuneration.

The wind sample segmented by investment stage reveals that for both segments – early-stage investors[89] and late-stage investors –,[90] legal security and the main financial support scheme are of high importance. Different preferences can be found regarding the total remuneration and the duration of the support, which reflects the relative significance of specific non-economic

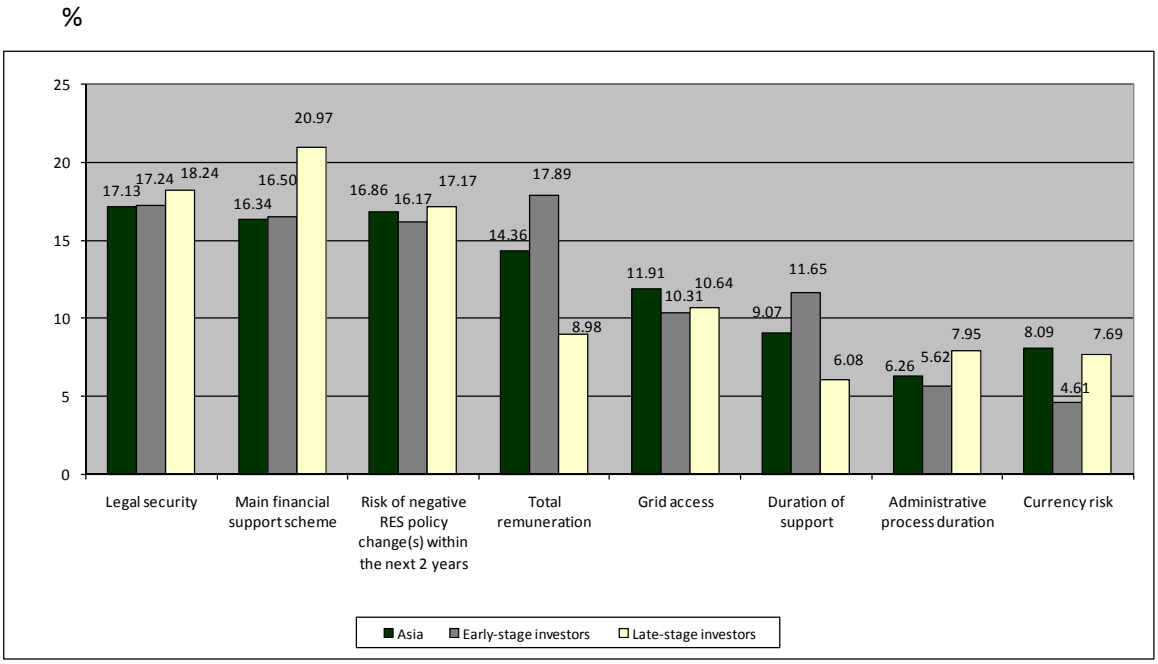
[88] Part-worth utilities measure the contribution of attribute levels to an investor's overall utility, *i.e.* the influence that a change of the respective variable has on the investor's likelihood to invest in a specific market context.

[89] Early-stage investors invest either only in the planning phase (*e.g.* feasibility study, contracting, siting, etc.) or in the planning and construction phase of the project development cycle.

[90] Late-stage investors invest only in the operation phase or in the construction and operation phase of project development.

risks at the different stages of the project development cycles (Table 5.7). Figure 5.3 suggests that total remuneration is much more important for early-stage investors than for late-stage investors. Further, duration of support is of minor importance for late-stage investors, whereas it is of medium importance for early-stage investors.

Figure 5.3: Wind energy: relative importance of renewable energy policy attributes – project development stage segmentation (in %)

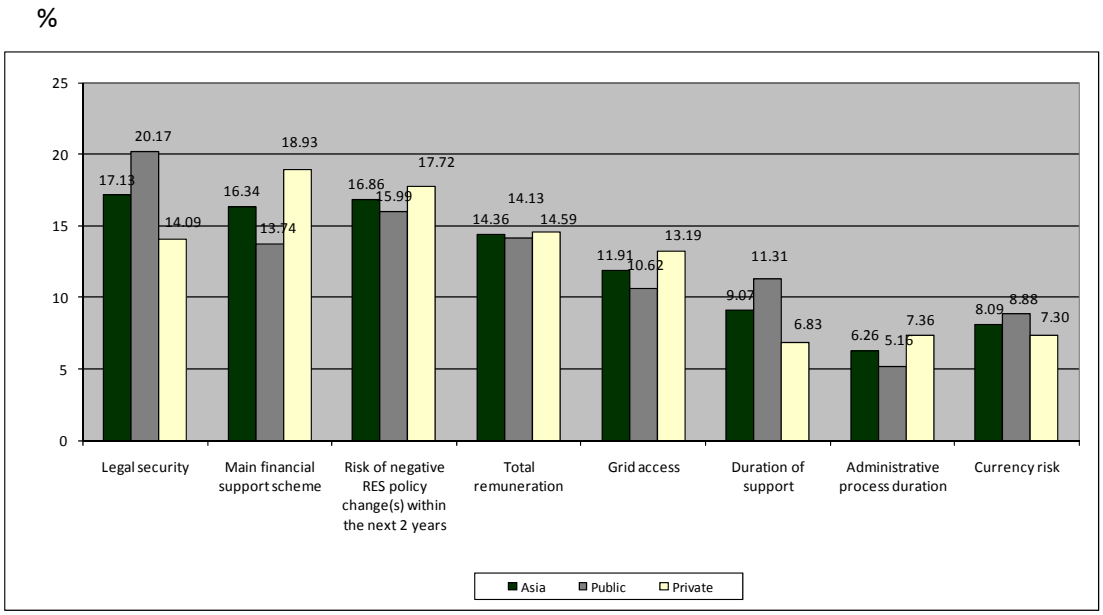


Source: IWOe, 2010.

Key point: Legal security is the most important policy attribute overall regardless of the investment stage focus of wind energy investors.

Comparing private sector and public investors in the wind investment sample (Figure 5.4) shows that the risk of negative RES policy changes and total remuneration is of approximately equal importance for private investors and public investors. Legal security is rated higher in the public sector segment than by the private sector respondents. For the latter, the main financial support scheme is of higher importance than for public investors. Duration of support is of medium importance for the public sector, but of only low importance for the private sector segment.

Figure 5.4: Wind energy: relative importance (in %) of renewable energy policy attributes – investor type segmentation



Source: IWOe, 2010.

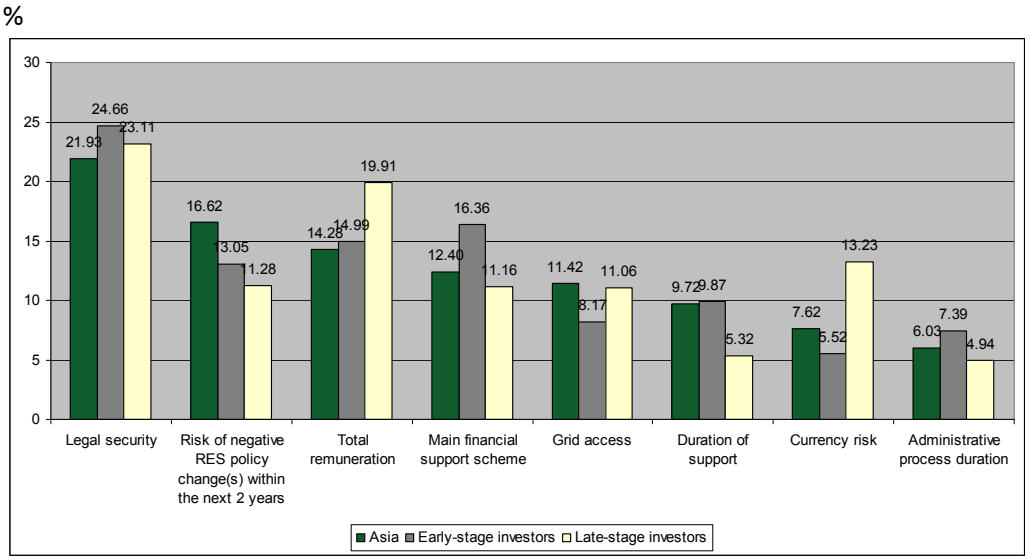
Key point: Legal security is the most important policy attribute for all investor types of wind energy investors. For private sector investors, the second-most important factor influencing investment decisions is the main financial incentive scheme is, while for public investors it is regulatory risk.

Figure 5.5, comparing early-stage and late-stage investors for solar PV, shows that both segments rate legal security as the most important factor, but early-stage investors attach higher priority to the type of main financial support scheme than late-stage investors. On the other hand, late-stage investors rate currency risk to be the third-most important factor (followed by legal security and total remuneration) whereas early-stage investors place greater importance on total remuneration.

Separating public and private investors in solar PV (Figure 5.6) shows that for both groups legal security is rated as the most important attribute. Total remuneration seems to be more important for private sector actors in the sample than for public sector actors. Public sector investors instead give high attention to the duration of support, whereas private sector investors in the sample rank this attribute only in seventh place.

The observed differences in relative importance of certain risks between private sector and public investors are more pronounced in the case of solar PV (as compared to wind). This result is statistically insignificant and is most likely caused by the small number of public investor respondents relative to private sector respondents in the solar PV survey sample.

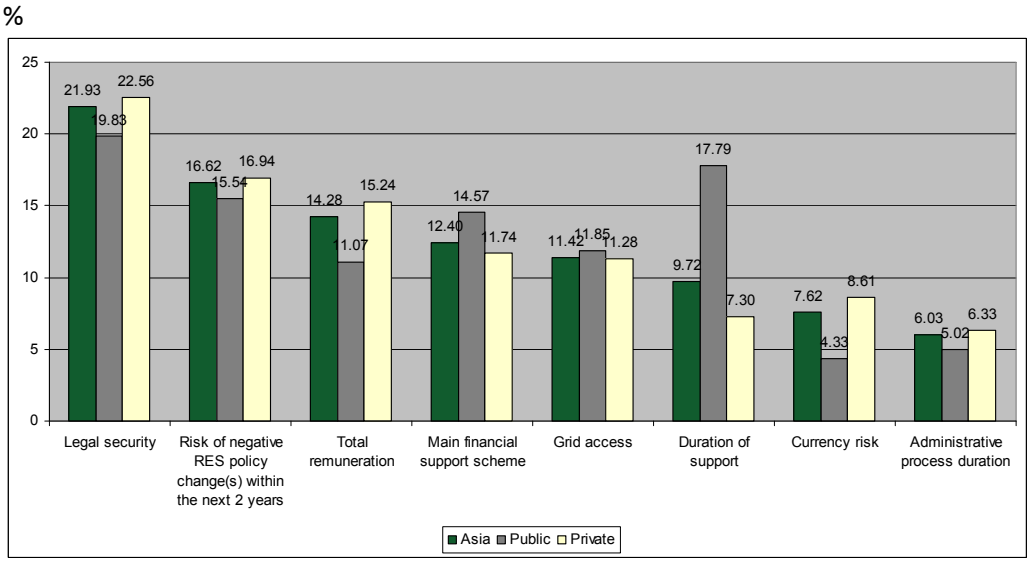
Figure 5.5: Solar PV: relative importance (in %) of renewable energy policy attributes – project development stage segmentation



Source: IWOe, 2010.

Key point: Legal security is the most important policy attribute overall regardless of the investment stage focus of solar PV investors. For early-stage investors, the second-most important factor influencing investment decisions is the main financial incentive scheme is, while for late-stage investors it is regulatory risk.

Figure 5.6: Solar PV: relative importance (in %) of renewable energy policy attributes – investor type segmentation



Source: IWOe, 2010.

Key point: Legal security is the most important policy attribute for all types of solar PV investors. For private sector investors, the next-most important factors influencing investment decisions are regulatory risk and total remuneration while for public investors it is duration of support followed by regulatory risk.

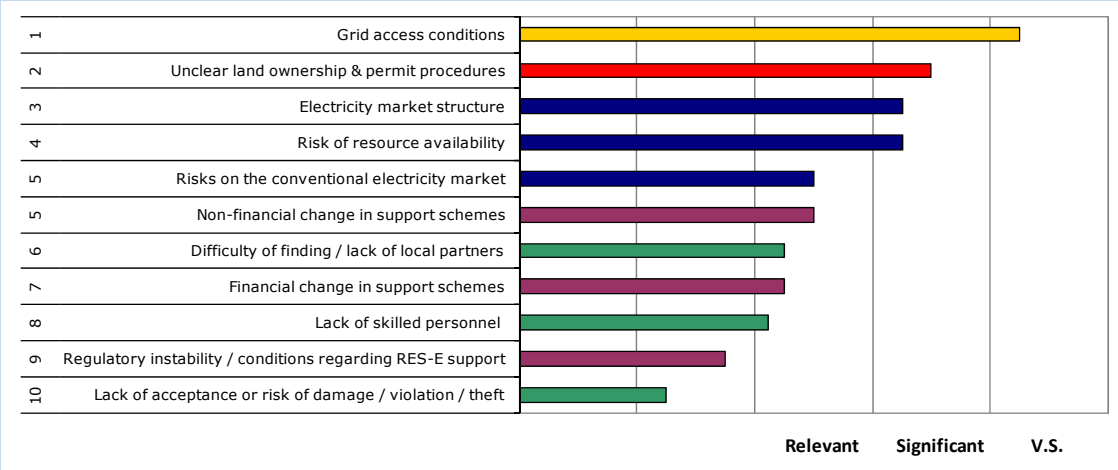
Box 5.5: Survey-based stakeholder risk perceptions for RES-E deployment

The survey-based barrier analysis for the ASEAN (see Sections 5.3-5.7) revealed that grid-related, administrative and regulatory, and market hurdles appear to be the most prevalent.[91] In line with these findings, the most critical risks identified in the survey belong to the groups of grid, planning and permit, and market risks (Figure 5.7).

While the energy sectors of the ASEAN countries analysed still show evidence of high influence of their (formerly) state-owned electricity companies, standardised grid access conditions are often still lacking. Thus, project developers face a significant risk of changing network access conditions including impacts on their power purchase agreements (PPAs). This issue is also reflected in the high ranking of risks arising from the electricity market structure in these ASEAN economies. Inadequate infrastructure, *i.e.* grid and road connections, currently limit viable and bankable sites for grid-connected RES-E projects.

These project-related risks identified by a diverse group of stakeholders are similar to the risks perceived by investors in the conjoint adaptive analysis.

Figure 5.7: Average ranking of the most important risks for RES-E project development in selected ASEAN countries[92]



Legend:

- Technical/infrastructure risks
- Regulatory risks
- Market risks
- Planning and permit risks
- Socio-cultural risks

"Relevant", "Significant" and "V.S." refer to a risk that is deemed "relevant", "significant" or "very significant" respectively based on the survey results.

Source: Lamers, 2009.

Key point: Grid-related technical risks, planning risks and market-related risks are perceived as the most critical ones for RES-E project development by the survey respondents.

[91] The analysis relies to a large extent on desk-based research and responses to stakeholder surveys. It needs to be underscored that the survey responses may not be representative and, therefore, only cautious conclusions may be drawn from these findings.

[92] The countries analysed in the case studies are Indonesia, the Philippines and Thailand.

5.10.2. Investors' willingness-to-accept RE policy risks

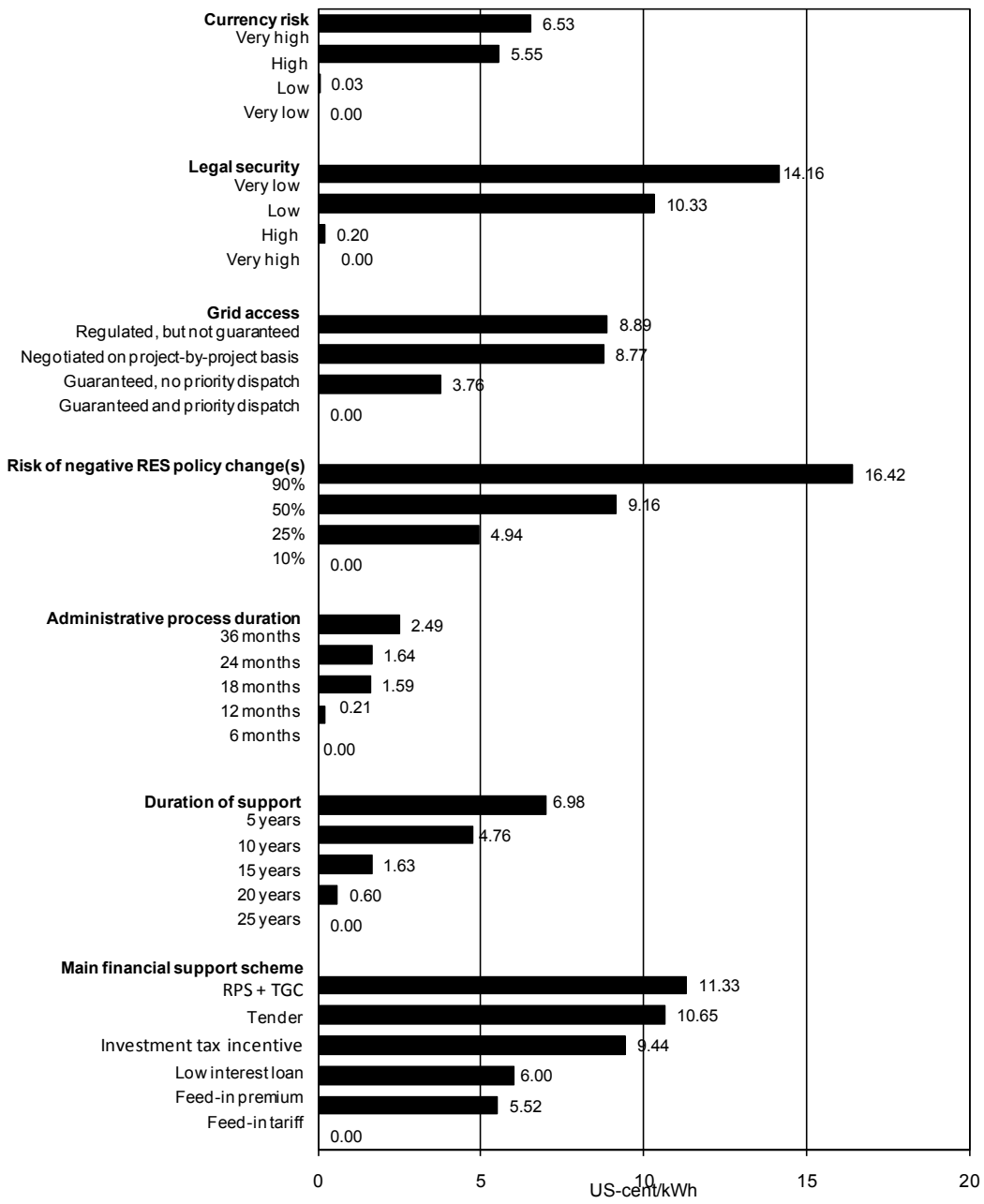
The measure of willingness-to-accept (WTA) shows what remuneration or risk premium (in US-cent per kWh)[93] an individual investor requires or is "willing to accept" as compensation for shouldering the burden of a specific attribute level with a low utility (Figures 5.8 and 5.9). The WTA is high for attribute levels that constitute high risk for investors and low for attribute levels that imply a lower risk. The highest WTA or risk premia are associated with those attributes or factors that are deemed to be important.

In the hypothetical Asian wind energy market, the highest additional remuneration is required for a high possibility of renewable energy policy risks, followed by very low legal security (Figure 5.8). This reflects the fact that the attributes "risk of negative policy changes" and "legal security" are perceived as the most important compared to all other attributes included in the conjoint study (Figures 5.3 and 5.4).

The most important factor in the solar PV market is also perceived to be legal security, followed by main financial support scheme and risk of negative RES policy change(s). These rankings are also mirrored in the willingness-to-accept simulation results. The unstable values for the attribute "administrative process duration" seem to result from the relatively low importance that the respondents have assigned to this factor. Another reason might be the relatively small number of respondents in the sample.

[93] Note that the hypothetical risk premium levels in US-cent/kWh reflect only the WTA with regard to the hypothetical markets that were investigated in the study. Therefore, the indicators allow only for a relative comparison between the different risks.

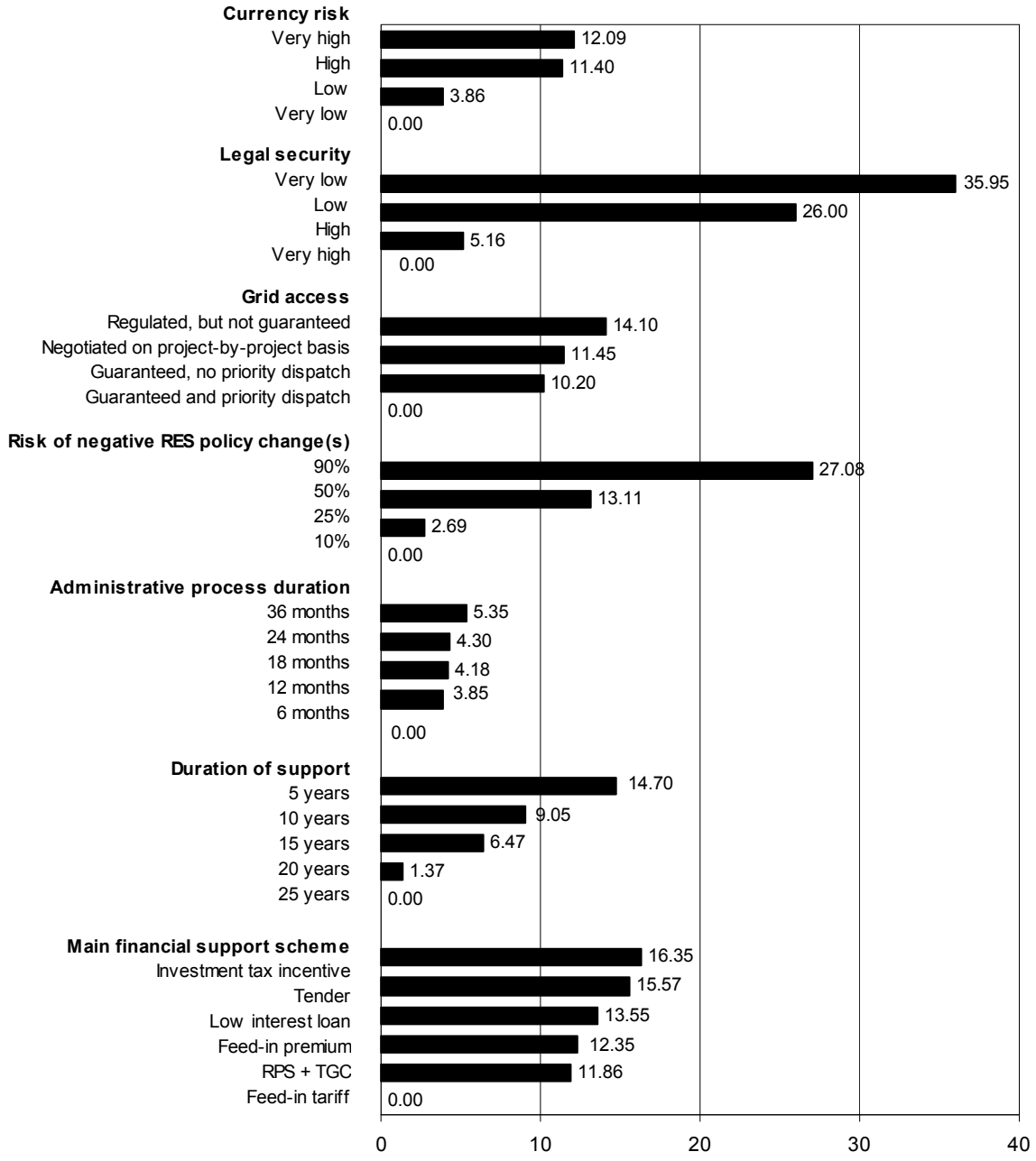
Figure 5.8: Investors' implicit willingness-to-accept certain policy risks for wind energy investments



Note: All attribute levels are sorted in ascending order based on their values.
Source: IWOe, 2010.

Key point: Wind energy investors demand the relatively highest risk premium (or willingness-to-accept) for high regulatory uncertainty, followed by low levels of legal security and the type of financial support available.

Figure 5.9: Investors' implicit willingness-to-accept certain policy risks for solar PV investments



Note: All attribute levels are sorted in ascending order based on their values.
Source: IWOe, 2010

Key point: Solar PV investors demand the relatively highest risk premium (or willingness-to-accept) for low levels of legal security, followed by regulatory uncertainty and the type of financial support available.

5.10.3. Country-specific analysis

Among the ASEAN-6 countries, country-specific analyses were performed for Thailand and Vietnam, whereby the information obtained from expert interviews was used to define and generate the national "base-case scenarios", *i.e.* the current state (as of mid-2009) of the RES-E policy frameworks for wind energy and solar PV within each country. The base case scenarios are the foundation for the subsequent country-specific simulations.

A market simulation software[94] is used to run a **simulation**, which produces so called **"shares of preference".** The simulation assumes a certain global market[95] and then computes what share of this market a given country will obtain based on (changes in) its policy environment.

Table 5.6: Overview share of preference per country and technology

	Wind energy		Solar PV	
Country	**Share of preference (in%)**	**Standard error**	**Share of preference (in%)**	**Standard error**
China	26.00	5.02	1.93	0.83
India	23.53	4.38	22.81	4.17
Thailand	8.47	1.49	24.14	5.22
Vietnam	0.29	0.16	0.16	0.07
Brazil	3.94	1.18	21.21	5.36
Chile	18.33	3.69	3.84	1.09
Egypt	2.10	0.40	10.40	1.96
Kenya[96]	3.82	1.25	*Not included*	*Not included*
Morocco	10.05	2.46	11.82	4.10
Tunisia	3.47	1.60	3.69	1.24
Total	*100*		*100*	

Source: IWOe, 2010.

Sensitivity analysis by means of market simulation offers a way to report preference scores for each level of the policy framework attributes. This approach shows how the overall preference for a market situation can be improved or worsened by changing its attribute levels one at a time, while holding all other attributes constant at the base case levels.

First, market shares in a base case situation are simulated. Second, one level of the policy framework characteristics is changed, while all other attributes are held constant at base case levels. The market simulations are run repeatedly to capture the incremental effect of each attribute level upon market condition choice. After having tested all levels within a given

[94] Sawtooth Software's Market Simulator.

[95] The total market is constituted by the focus countries of the conjoint design study, namely Brazil, Chile, China, Egypt, India, Kenya, Morocco, Thailand, Tunisia and Vietnam.

[96] Kenya was not taken into account for the solar PV simulations as there are insufficient data available on any grid-connected projects in the country. The majority of solar PV applications are small off-grid facilities.

attribute, that attribute is returned to its base case level prior to testing another attribute (Orme, forthcoming).

An important caveat is that conjoint part-worth utilities cannot account for many real-world factors that shape market shares, such as length of time in the market, awareness, and reactive competitive measures. Conjoint analysis predictions also assume that all relevant attributes which influence market share have been measured. Therefore, the share of preference predictions can only be interpreted as relative indications of market shares.

5.10.3.1. Example of Thailand

Ease of grid access in Thailand differs for IPPs (individual power producers) and state-owned power companies. Grid access is regulated by national law but not guaranteed for IPPs. Simulation results show that if the Thai government were to change this so that IPPs were also assured grid access, the country's share in the hypothetical market for wind energy would markedly increase (Figure 5.10). Overall study results show that investors in the sample are highly in favour of FITs.

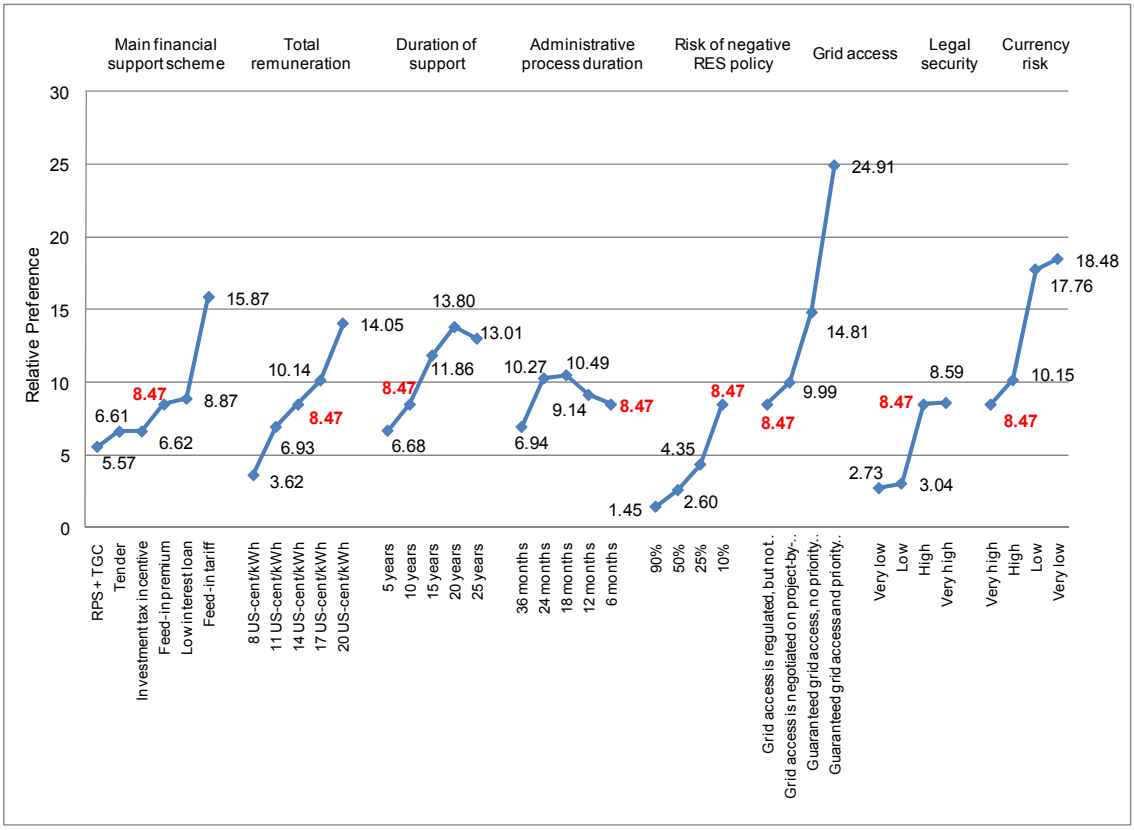
Thailand currently has a feed-in premium[97] in place for both wind energy and solar PV power generation (see Chapter 2 for a deeper analysis of the renewable energy policy support in the ASEAN-6). Thus, such a support scheme creates considerable market risk for the investors. Feed-in tariffs, on the other hand, are fixed guaranteed prices at which power producers can sell renewable power into the electric power network.

Replacing the feed-in premium with a feed-in tariff system would also grow by half Thailand's market share in overall investment in the hypothetical photovoltaic market.

Reducing currency risk from its current high level would also have a considerable positive effect on the country's relative market share both in the wind energy and in the solar PV simulations.

[97] Feed-in premium refers to a fixed premium that is provided on top of the market price.

Figure 5.10: Thailand: sensitivity analysis of market preference share over all policy attributes – wind energy investment



Legend: Figures in red display the base case share of preference. The attribute "total remuneration" does not display the base case share of preference due to extrapolation in the data.
Note: Attribute levels without a clear *a priori* preference order (attributes: main financial support scheme and grid access) are sorted in ascending order based on their values.
Source: IWOe, 2010.

Key point: Grid access, the main financial support scheme and currency risk are major policy risk factors, where improvements would possibly improve Thailand's market share for wind energy.

5.10.4. Factors affecting investor risk perceptions

Overall, the results of the conjoint design study show the high importance of legal security.

Factors that are typically rated quite high by other studies investigating investor preferences, such as grid access, duration of support, and administrative process duration (Lüthi and Wüstenhagen, forthcoming; Menichetti, forthcoming), are ranked lower by the average respondent in this study.

Reasons for this difference can be diverse, but the following two hypotheses seem reasonable.

Previous studies had often had a focus on European markets, whereas the present study analyses developing and emerging markets. While legal, political and currency conditions, etc., are quite favourable and stable and play a subordinate if any role in investment decisions (*e.g.* currency risk within the European Union as the majority of EU member states have adopted the Euro as their national currency), these conditions appear to remain problematic in developing and emerging markets, therefore increasing their relative importance among investors.

Another hypothesis that may have influenced the preference order of attributes is the investment stage that the respondents are active in. Late-stage investors (construction and operation phase) in wind energy and solar PV infrastructure projects seem to have different preferences than early-stage investors such as project developers (planning phase) when it comes to ranking investment barriers in the RES-E markets. Factors that are typically rated quite high by the second group, such as grid access, duration of support, and administrative process duration, are ranked lower by the average representative of the first group. Attributes with high preference scores among the investors in the sample are more related to the national legal environment and political stability of the target countries for direct investments. The type of main financial support scheme is also an important determinant.

5.11. Mitigation strategies to reduce non-economic barriers and related risk perceptions

The analysed non-economic risks relate to different stages of the project development cycle (Table 5.7), with some having an impact on energy projects in general, while others are especially significant for renewable energy installations (de Jager and Rathmann, 2008).

The role of policy is especially important in the *project development phase*. Thus, risks arising particularly at this stage can be reduced by formulating optimising policy features such as introducing long-term targets, with policy schemes that are predictable and have sufficiently long lifetimes, implementing complete government organisation, and minimising legal and institutional procedures, *i.e.* reducing the bureaucratic burden. Investment subsidies and/or fiscal measures can contribute to the bankability of a project by reducing the debt leverage.

In the *construction phase*, the role of policy is more limited. Some governments reduce risks for project investors by providing credit facilities to suppliers.

In the *operation phase*, policies can help to reduce regulatory and market risks by optimising different parameters, such as for instance the design of renewable energy policies and/or targets, the design of support schemes (*e.g.* feed-in tariff, feed-in premium, quota obligation with tradable green certificates), or the stability of the policy context. Improving the regulatory predictability of the energy market in general and, more specifically, the renewable energy incentive has a substantial impact on the required return on equity expected by equity investors (de Jager and Rathmann, 2008).

The findings of the analysis suggest that the main lever in renewable energy policy design is the reduction of risk in project financing. Thus, the cost of financing is not only related to the design of financial support schemes, but is also influenced by wider risks such as legal insecurity, grid access problems and political instability. This study shows that in emerging markets, legal issues and renewable energy policy stability are the main barriers to the development of renewable energy.

Table 5.8 summarises the key barriers identified in the analysis and recommends several potential mitigation strategies as well as their implementing agents on international, national, and local level. The fundamental aim of the recommendations is to improve RET market and policy functioning in the ASEAN-6 region.

Table 5.7: Incidence of non-economic risks in renewable energy project development

RE project cycle	Associated non-economic risks
Phase 1: ***Project development* (Project feasibility, Contracting, Siting/Permitting, Engineering design) *and financial closure***	• Permit acquisition risk • Grid connection risk • Risk of not signing a PPA • Legal or institutional risk delaying the project development • Risks related to changes in the policy support schemes
Phase 2: ***Construction***	• Construction risk (duration of construction, technical specifications) • Counterparty risk
Phase 3: ***Operation***	• Performance risk • Resource risk • Market risk • Regulatory risk (especially regarding support schemes) • Credit risk • Counterparty risk
Phase 4: ***Decommissioning***	• Risk of budget overrun

Source: Adapted from de Jager and Rathmann, 2008.

Table 5.8: Summary of identified non-economic barriers, recommendations and implementing organisations

Administrative and regulatory barriers	Recommended mitigation strategies	Suggestions for appropriate facilitating organisations
Lack of experience/awareness and political will	Strong educational campaign and awareness raising	International and local NGOs International/intergovernmental organisations interested in renewable energy
	Establishment of a coherent and sensible strategy for integrating RES-E into the national energy mix	National ministries and regulatory boards (depending on the country)
Conflicting policies, inadequate framework	Design of specific support regulations for individual renewable energy technologies including grid access conditions and power purchase agreements	National ministries, *i.e.* energy, agriculture, etc. (depending on country), supported by external advisors *e.g.* specialised consultancies and development aid organisations
	Creation of an individual institution or agency ("one-stop-shop") that sets targets, tracks, and monitors the developments over time. It should streamline activities between the authorities and involve rural energy agencies or build upon existing rural electrification agencies	New national energy agency (or) national regulatory commissions (depending on the country), rural energy and electrification agencies
Corruption and vested interests	International call for good governance and transparency (enforced) requirements by international donor organisations	International NGOs (*e.g.* Transparency International)

Technical barriers	Recommended mitigation strategies	Implementing bodies
Infrastructure barriers	Awareness raising among politicians and within the energy sector	International/intergovernmental organisations active in renewable energy
	Grid extension, road construction	National ministries with the support of international multilateral and bilateral donor organisations
	Incorporation of RES potentials in grid extension strategies	National ministries, *i.e.* energy, agriculture, etc. depending on the country specific context and renewable energy resource potential
Varying grid connection conditions	Introduction of a standard power purchase agreement (PPA) which takes into account different RETs and installation sizes	Design of standard PPA by national regulatory bodies with the support of international development aid organisations and experts in the field of RES support scheme design and integration Enforcement by national regulatory bodies
Structure of land ownership	Public awareness raising	National and local level activities targeted at local communities, implemented by national and rural energy agencies
	Streamlining registration procedures	National ministries and regulatory bodies (potentially also a new national energy agency)
	Central authority point for information about land ownership structures across the country	

Market-related barriers	Recommended mitigation strategies	Implementing bodies
Absence of industry standards	Setting, enforcing and monitoring industry standards in construction and commissioning	National RET industries in co-operation with standards organisations and other national institutions. Potential support by international organisations
Electricity market structure	Unbundling of the generation and transmission monopolies	National governments
	Introduction of a legal standard which allows IPPs to sell power directly to customers	National governments and regulatory commissions on energy, national generation and transmission companies
Lack of information	Creation of public databases on RES potentials and dissemination of such information *e.g.* through a national RES development plan	National ministries (*e.g.* for biomass: Energy, Agriculture, and Forestry) supported by international organisations with experience in the field. Dissemination and "neutral" guarding of the database could be done by the national energy agency

Socio-cultural barriers	Recommended mitigation strategies	Implementing bodies
Lack of skills and adequate training for RET installation and maintenance	Capacity building, training, sharing of skills and expertise through successful project examples	National institutions (*e.g.* national energy agencies) with the support of international development aid organisations
	Support of dedicated research and training institutions	National governments, international bilateral and multilateral donor organisations
	Promotion and dissemination of pilot examples	Promotion of successful examples by local NGOs, industry, and political institutions (*e.g.* national energy agency)
Lack of awareness regarding real costs of electricity	Educational campaigns	Local representatives who are perceived to be "neutral" by the local public (*e.g.* NGO representatives, school teachers)
Lack of awareness of potential local benefits	Promotion and dissemination of pilot examples, capacity building, involvement of communities, creation of local benefits (*e.g.* employment)	Promotion of pilot examples by local communities Benefit creation by local industry Capacity building by national or local institutions (*e.g.* schools, rural energy agencies) with the support of international development aid and donor organisations
Weak lobby groups	Strengthening of local NGOs and agencies through facilitation and collaboration	International development aid organisations

Source: Adapted from Lamers, 2009.

6. Conclusions and recommendations

6.1. Conclusions

Expanding the share of renewables in the energy mix can bring extensive socio-economic benefits to the ASEAN-6 countries. These include: improved air quality, with accompanying improvements in public health, reduced mortality and lower medical costs; improved energy security through fuel diversification; jobs in new growth industries with export opportunities; and climate change mitigation through greenhouse-gas emissions reduction.

6.1.1. Potentials for renewables in the ASEAN-6

The realisable potential for renewables is large across all the ASEAN-6 countries except Singapore (due to its small land area). To provide an objective basis, this report compares each country's share of the total ASEAN-6 potential for renewable electricity (RES-E), renewable heating (RES-H) and biofuels for transport (RES-T) against its share of the region's aggregate population and economic output (GDP). Generally, countries with higher potentials in terms of population and GDP have a larger scope to exploit these potentials.

Table 6.1 shows that Indonesia has the highest share of the aggregate ASEAN-6 realisable potential for renewables across all sectors (Table 3.1). Malaysia has the highest renewable electricity potential compared to its share of the ASEAN-6 population. Vietnam has the highest renewable electricity potential relative to its share of the region's aggregate GDP.

Countries such as Vietnam, which has low national income but relatively large realisable potential, may find it challenging to tap renewables potential through domestic efforts alone, partly because of the high cost of supporting development and deployment. As discussed in Chapter 4, development assistance can play an effective role by supporting the implementation of coherent and comprehensive renewable energy policy frameworks and providing innovative co-financing options.

Some countries have high above average per-capita potential levels relative to their population share; for example Malaysia for renewable electricity and Singapore for renewable heat, especially solar thermal. This indicates that these countries probably still have substantial opportunity to further exploit their realisable potential.

To demonstrate how the realisable potential of the ASEAN-6 countries compares with other countries that have already made significant advances in expanding renewables growth – namely the group of OECD countries and the emerging BRICS economies (Brazil, Russia, India, China and South Africa) – this report calculates and contrasts realisable potentials for 2020[98] on per-capita and GDP basis.

The level of achieved deployment influences the realisable potential over a specific time period. ASEAN-6 countries, for example, currently have lower deployment and thus, lower potential.

[98] Realisable potentials for OECD and BRICS were calculated over the time horizon to 2020 for the IEA publication *Deploying Renewables: Principles for Effective Policies* (IEA, 2008). These potentials will be updated and extended to 2030 in a forthcoming publication due out in late 2010.

The average realisable potential per capita to 2020 in countries belonging to the Organisation for Economic Co-operation and Development (OECD) exceeds that of the ASEAN-6 by a factor of over eight. The BRICS group of emerging economies has a per-capita realisable potential which is at least twice that of the ASEAN-6. This is because the OECD and BRICS economies, particularly the OECD economies, enjoy a higher starting point in terms of achieved deployment.

Table 6.1. Total realisable mid-term potentials for RETs: shares of ASEAN-6 countries

	RES-E		RES-H		RES-T	
	per capita	per unit of GDP (PPP*)	per capita	per unit of GDP (PPP*)	per capita	per unit of GDP (PPP*)
Indonesia	1.57	0.41	1.37	0.36	0.33	0.09
Malaysia	4.73	0.31	2.64	0.17	0.68	0.05
Philippines	1.23	0.37	0.42	0.13	0.16	0.05
Singapore	0.73	0.01	3.97	0.06	0.00	0.00
Thailand	1.85	0.23	1.96	0.25	0.46	0.06
Vietnam	2.18	0.78	1.52	0.55	0.23	0.08
ASEAN-6 AVERAGE	**1.79**	**0.34**	**1.38**	**0.26**	**0.31**	**0.06**

Note: PPP refers to purchasing power parity, which compares the costs in different currencies of a fixed basket of traded and non-traded goods and services, and yields a widely based measure of standard of living. This approach helps in analysing the main drivers of energy demand (IEA, 2009).

Sources: IEA data and analysis; Resch, 2009; and World Bank, 2010.

By contrast, the per-unit GDP potentials of the ASEAN-6 and OECD countries are quite similar. This indicates that, in terms of economic development, the ASEAN-6 countries are on average in a similar position to the OECD countries to exploit their renewable energy potential. However, the per-GDP potential for renewable electricity of the ASEAN-6 is less than half that of the BRICS. This is because, although they have similar per-capita GDP levels, the larger land area of the BRICS supports a larger overall deployment potential.

Table 6.2. Total realisable mid-term potentials to 2020 for RES-E: ASEAN-6 versus OECD and BRICS

	RES-E	
	per capita	per unit of GDP (PPP*)
Indonesia	0.40	0.11
Malaysia	1.05	0.07
Philippines	0.51	0.00
Singapore	0.09	0.00
Thailand	0.81	0.10
Vietnam	0.87	0.31
ASEAN-6 AVERAGE	**0.58**	**0.11**
OECD AVERAGE	**4.72**	**0.14**
BRICS AVERAGE	**1.36**	**0.25**

Note: PPP refers to purchasing power parity. PPPs compare the costs in different currencies of a fixed basket of traded and non-traded goods and services, and yield a widely based measure of standard of living. This helps in analysing the main drivers of energy demand (IEA, 2009).

Source: Based on IEA calculations; Resch, 2009; Resch *et al.*, 2008.

6.1.2. Support for renewables in the ASEAN-6

All ASEAN-6 countries except Singapore have introduced medium- to long-term renewable energy targets (Table 6.3). However, the targets vary greatly in their quantitative objectives, time horizons and specificity (see Chapter 2). This difference can be explained to some extent by the countries' different levels of economic development, but less so by population and resource potentials. Thailand and Malaysia have similar renewable electricity potential, but Thailand's per-capita GDP level is half that of Malaysia. Nonetheless, Thailand has implemented much more ambitious targets and incentive mechanisms than Malaysia.

Thailand has set the most ambitious target, aiming for a 20.3% share of renewable energy in final energy demand by 2022. Some countries, such as the Philippines, have targets that provide indications only to 2015; others, such as Indonesia, have targets to 2025. Indonesia, Malaysia, the Philippines and Thailand have sectoral targets for electricity and biofuels for transport; other countries, such as Vietnam and Thailand, focus their targets on the overall share of renewables in the energy mix. In general, longer time horizons (but including interim milestones) and more specific targets in terms of sectoral contributions, provide greater predictability for potential investors and more confidence in the country's commitment to achieving its goals.

Targets are important indications of a country's willingness and determination to tap its renewable energy potential. They must, however, be supported by an effective system of

financial and non-financial incentives to ensure appropriate conditions to exploit a country's renewables potential in the face of economic and non-economic barriers. These barriers, foremost infrastructure and grid-related problems as well as regulatory and administrative hurdles, are evident in all ASEAN-6 countries. Most are reported to exert at least a medium impact on deployment of renewables, primarily because they can skew the playing field against innovative renewable energy technologies (which require targeted support to help bring them into the energy market).

Several countries in the region have either not yet introduced incentives to support their national targets or have let such incentives languish at the drafting stage. Malaysia is a case in point. As of early 2010, the financial incentives in place for renewable electricity production in the ASEAN-6 are mostly tax exemptions and feed-in tariffs (FITs). However, the remuneration level and duration of some FIT programmes are not sufficient to attract investment. With more developed FIT incentive schemes, other countries outside the ASEAN region have achieved higher renewable energy market growth. For biofuel production, tax incentives or low-interest loans are often used to promote investment in production capacity. In addition, governments often reduce or eliminate fuel duties to promote biofuels consumption.

A number of ASEAN-6 countries have introduced non-financial incentives designed to stimulate private sector investment in generation assets and infrastructure for renewable energy, mostly from independent power producers (IPPs). These regulations allow the sale and purchase of IPP-generated renewable energy at negotiated contracts. To date, these incentives have had limited success in fostering the expansion of renewable energy markets in many ASEAN-6 countries.

Table 6.3. Renewable energy targets and policy support for renewables in ASEAN-6 countries

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
RE targets (quantitative objectives)				Not applicable		
Financial incentives						
Non-financial incentives						

Level of support	
	High
	Medium
	Low

Note: RE = renewable energy. This ranking is based on a qualitative assessment of the policy support offered in the ASEAN-6. A quantitative analysis was not possible in the absence of dedicated modelling.
Source: IEA data and analysis.

6.1.3. Non-economic barriers to renewables in the ASEAN-6

Non-economic barriers continue to be a major impediment to achieving mid-term realisable renewables potentials (see analysis in Chapter 5). They are, to some extent, responsible for the comparatively low positive impact that available policy support has had on renewables market

growth in ASEAN-6. All categories of non-economic barriers are found in all ASEAN-6 countries, with most of these challenges exerting at least a medium impact (Table 6.4).

Administrative and regulatory barriers include gaps in regulatory and legal frameworks, as well as a lack of authoritative institutions tasked with renewable energy issues. Technical infrastructure barriers, such as insufficient grid capacity and extension, represent a major bottleneck for expanding the market insertion of renewable electricity. Market barriers, such as consumption and production subsidies and a general bias towards conventional energy technologies, are compounded by a lack of easily accessible information and awareness of renewables among stakeholders.

Ultimately, such non-economic barriers create challenges for the financing of renewable energy projects. Capital costs for renewable energy investments can be pushed higher because of a perceived higher risk associated with renewable energy applications. This is exacerbated by high upfront costs, while zero or low fuel costs (especially relevant for off-grid projects) over the long term are often ignored.

In Singapore's liberalised energy market, administrative and regulatory barriers for renewable energy are least pronounced among the ASEAN-6 countries. Nevertheless, policy targets and measures indicate limited interest in expanding the use of renewables, largely due to Singapore's low renewables potential, at least for renewable electricity and biofuel production.

The combination of perceived risks and high-impact, non-economic barriers associated with renewable energy projects affect the flow of investment in renewable energy in the region (see Chapter 5). More seriously, these factors also reduce the likelihood of closing the gap between current investment levels and the investment required to achieve a low-carbon energy trajectory (see Chapter 4).

Table 6.4. Significance of non-economic barriers in ASEAN-6 countries

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Administrative & regulatory						
Market-related						
Technical & infrastructure						
Financial						
Socio-cultural						

	Low importance
	Medium importance
	High importance

Note: This ranking is based on a qualitative assessment (case studies and investor survey) of the non-economic barriers encountered in the ASEAN-6.
Source: IEA data and analysis.

Another perceived challenge – specifically for large-scale expansion of biofuel production – is sustainability of the region's biofuel industry, which is currently exclusively geared towards first-generation biofuels. Concerns about land-use change and resulting greenhouse-gas emissions have led to scientific discussion on how to measure the impact of land-use change on the

greenhouse-gas balance of biofuels. ASEAN-6 governments are beginning to engage in initiatives to develop and implement sustainability criteria for biofuels. [99]

Criticism of some first-generation biofuel pathways has focused attention on the potential of so-called advanced and second-generation biofuels.[100] To establish viable second-generation biofuel industries, ASEAN-6 governments need to strengthen the necessary framework conditions, including appropriate infrastructure, adequate skilled manpower and financing options.

6.2. Recommendations

The objectives of renewable energy policy extend beyond climate change mitigation to encompass energy security, economic development and improved environmental quality. It is not possible to tap the potential of the broad range of renewable energy technologies (which are at different stages of maturity) solely through a carbon price signal (domestic or international). This creates a risk that currently promising technologies which are less mature could be locked out of a future low-carbon energy system.

To allow a smooth transition towards mass market integration of renewables, application of technology-specific support should be used to foster renewable energy technologies according to their level of technology maturity. This creates a more level playing field. Those technologies that are most mature and closest to market competitiveness can compete against each other (assuming that carbon and other externalities are priced appropriately). Meanwhile other less mature technologies can be proven and established in more "protected" market niches, while still being underpinned by targeted R&D support, demonstration incentives or market-based mechanisms (depending on their innovation stage). The text in Box 6.1 distils key principles for designing effective and efficient renewable energy policies.

Box 6.1. Key principles for renewable energy policies

- Reduce as much as possible non-economic barriers, such as administrative hurdles, obstacles to grid access, poor electricity market design and inadequate information and training. At the same time, tackle social acceptance issues.
- Establish a predictable and transparent support framework to attract investments.
- Consider the social impact of renewable energy incentives.
- Introduce transitional incentives (which decrease over time) to foster and monitor technological innovation and as a means of advancing technologies quickly towards market competitiveness.
- Develop and implement appropriate incentives that guarantee a specific level of support to different technologies, based on their degree of technology maturity. This will make it easier to exploit, over time, the potential of the wide range of renewable energy technologies.
- Consider the impact of large-scale penetration of renewable energy technologies on the overall energy system, especially in liberalised energy markets, with regard to overall cost efficiency and system reliability.

Source: Adapted from IEA, 2008.

[99] Key sustainability criteria being debated include: minimum greenhouse-gas emissions savings; definition of suitable land for biofuel cultivation; and social standards.

[100] There are two different conversion pathways for second-generation biofuels. The *thermo-chemical* route gasifies biomass to produce bio-synthetical natural gas (SNG) or BTL-diesel (the latter via Fischer-Tropsch synthesis). The *bio-chemical* route uses enzymes or micro-organisms to convert cellulose and hemi-cellulose in the biomass to sugars, which are then fermented to produce ethanol.

The following recommendations aim to encourage the effective and efficient exploitation of renewable energy potentials in the ASEAN-6. They build on the findings of recent IEA analysis on renewable energy policy effectiveness and efficiency in OECD countries and Brazil, Russia, India, China and South Africa (IEA, 2008).

To achieve large-scale diffusion of renewables, Southeast Asia should:

- **Reduce as much as possible non-economic barriers to the diffusion of renewable energy.** Non-economic barriers (such as administrative hurdles, grid access issues, persistent fossil fuel subsidies, and lack of information and training) continue to hinder the deployment of renewables in the ASEAN-6 countries. Reducing these barriers should be a key priority for policy makers – and thus, a focus of policy design and implementation – irrespective of the type of incentive scheme planned.
- **Remove distortionary subsidies for fossil fuel consumption and production.** These subsidies often benefit more affluent segments of society rather than the poor. Removing them will help level the playing field so that renewable energy technologies can compete with other energy carriers. In this regard, it is critical to take into account all of the external benefits and costs of all energy technologies.
- **Ensure that renewable energy incentives do not shift a disproportionate share of the additional financial burden to the poorest households.** Adapting policy support to national development objectives can help minimise impacts on wealth distribution; for example, a national renewable energy development fund can foster renewables by providing a support mechanism to supplement a regulated end-consumer tariff.
- **Devise renewable energy policies that are predictable and consistent with the overall energy policy framework.** Such measures ensure that potential investors have adequate confidence in the stability of the support system. A wide variety of incentive schemes exist for renewables; their effectiveness in fostering market uptake depends more on design and implementation than on the specific type of incentive.
- **Encourage off-grid applications of renewable energy** to help advance electrification and socio-economic development objectives.
- **Promote sustainable production of biofuels by actively** supporting strong sustainability criteria and certification schemes.
- **Establish platforms to exchange experience in developing and implementing renewable energy policy, and in reducing barriers to deployment of renewables.** These could build on the ASEAN Plan of Action for Energy Co-operation or the APEC Energy Working Group.
- **Establish and evaluate** harmonised market rules and incentives for renewables across the region, in step with the ongoing expansion of the ASEAN Power Grid.
- **Design renewable energy policies to complement climate change policies and to derive maximum benefit from climate change financing options.** This will encourage sufficient investment flows and help meet climate, energy security and environmental objectives.

Annex A: Definitions, abbreviations, acronyms and units

Abbreviations and acronyms

ADB	Asian Development Bank
BAU	business-as-usual
BRICS	Brazil, Russia, India, China, South Africa
CDM	Clean Development Mechanism
CHP	combined heat and power
CSP	concentrating solar power
DFI	development finance institutions
EU	European Union
EU ETS	European Union Greenhouse Gas Emissions Trading Scheme
EU-25	the European Union between 1st May 2004 and 31st December 2006, comprising 25 member states
EU-27	the European Union as of 1st January 2007, comprising 27 member states
EU-OECD	OECD countries which are also European Union member states
FID	foreign direct investment
FIT	feed-in tariffs
FY	fiscal year
GHG	greenhouse gas
IEA	International Energy Agency
IFC	International Finance Corporation
IPP	independent power producers
LNG	liquefied natural gas
LR	learning rate
LUC	land use change
MDB	multilateral development banks
MoU	Memorandum of Understanding
n/a	not applicable
NB	Nota Bene (note well)
NIMBY	Not-In-My-Backyard

OECD	Organisation for Economic Co-operation and Development
PFM	public finance mechanisms
PPA	power purchase agreement
PV	photovoltaics
R&D	research and development
RD&D	research, development and demonstration
RE	renewable energy
RES	renewable energy sources
RES-E	electricity generated from renewable energy sources
RES-H	heat produced from renewable energy sources
RES-T	transport fuels produced from renewable energy sources
RET	renewable energy technology
SME	small and medium enterprise
TFC	total final consumption
TPES	total primary energy supply
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value-added tax

Units

CO_2	carbon dioxide
CO_2e	CO_2 equivalent
GW	gigawatts
GWh	gigawatt-hour, 1 kilowatt-hour equals 109 watt-hours
ha	hectare
J	joule
ktoe	kilotonne of oil equivalent
kWe	kilowatt electric
kWh	kilowatt-hour, 1 kilowatt-hour equals 103 watt-hours
kWp	kilowatt peak
kWth	kilowatt thermal
l	litre
m^3	cubic metre
Ml	million litres/megalitre

MSW	municipal solid waste
Mtoe	million tonnes of oil equivalent
MW	megawatts
MWel	megawatt electric
MWh	megawatt hour, 1 megawatt-hour equals 106 watt-hours
MWth	megawatt thermal
NO_x	nitrogen oxide
PJ	petajoule, 1 petajoule equals 1015 joules
PM	particulate matter
SO_2	sulphur dioxide
sqm	square metre
TJ	terajoule, 1 terajoule equals 1012 joules
toe	tonne of oil equivalent
TWh	terawatt-hour, 1 terawatt-hour equals 1012 watt-hours

Annex B: References

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Annex C: Assessment of realisable renewable energy potentials

The detailed approach for the assessment of the future potentials differed by renewable energy technology (RET), as in general a resource-specific methodology was developed. Nevertheless, the following general approach illustrates the overall procedure for the derivation of realisable long-term potentials in the time horizon 2050 for RETs in the assessed countries.

Data collection on historic deployment: As a first step, data on historic deployment of the various RETs were collected for each assessed country. IEA statistics were used as a primary source, and, where appropriate, extended and refined with alternative sources.

Survey on (technical) potentials (literature review): A comprehensive literature survey was performed to collect data on previous potential assessment undertaken for the various RETs in the assessed countries. Collected information was then categorised according to the classification of potentials (see Section 3.2). In this context, a focus was taken to access data on technical potentials.

Calculation of feasible long-term potentials (based on technical potentials and energy system constraints): The approach for the calculation of feasible long-term potentials was two-fold:

- On the one hand, the prior undertaken literature survey on technical potentials (as far as applicable) was used as source. Additionally, current land-use practice (derived from FAOSTAT) combined with feasibility constraints and additional resource-specific information served as an alternative basis for the derivation of feasible long-term potentials of the individual RETs from the resource perspective.
- On the other hand, a comparative assessment was undertaken building on the expected future energy system (by 2030) at country level. Information on the current energy system (*i.e.* energy balances) combined with recent WEO projections were used to identify future capacity and demand patterns. For renewable energy sources (RES) such as wind power, in addition minimum load constraints were taken into account to derive feasible long-term potentials from the energy system perspective.

The minimum of both figures, *i.e.* the derived long-term potentials from (i) the resource and (ii) the energy system perspective, was then classified as the feasible long-term potential. Notably, in several cases, energy system constraints appear more stringent than resource limitations. Bioenergy represented an exception to this rule in most cases, where feedstock constraints appear to dominate.

Econometric assessment of historic deployment patterns (for S-curve approach): The collected information on historic deployment combined with the identified feasible long-term potentials served as basis for an econometric assessment to identify past diffusion patterns. Derived parameters represent an input for the next (final) step – the calculation of realisable future potentials.

Econometric assessment of realisable potentials up to 2030 (S-curve approach): As a final step, an econometric approach (S-curve) was used for the calculation of realisable potentials up to 2020 and 2030. This calculation builds on three key inputs:

- Country-specific deployment patterns (*i.e.* the above mentioned parameter) as derived from the assessment of historic deployment – describing a "business-as-usual" case.
- Technology-specific "best-practice patterns" as derived from a cross-country comparison of historic deployment patterns.
- Identified feasible long-term potentials.

Obviously, for the calculation of the feasible future deployment, the *status quo* is also taken into account. Maximum realisable deployment potentials for future years are calculated applying the S-curve approach. The deployment path assumes that current non-economic deployment constraints are gradually removed. In other words, the S-curve shape reflecting past deployment patterns changes over time to the "best practice" pattern. The assumed duration of this transition phase differs by technology, taking into account its current stage of market maturity.

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Annex D: Demand for cooling in the ASEAN region

In ASEAN countries, heat is either used for industrial purposes where process heat is required or for domestic purposes consisting of heating water and cooking. In a number of ASEAN countries, heat demand for space heating is completely absent: the cities of Bangkok, Manila and Jakarta are registered as having zero annual heating degree days (Sivak, 2009). Due to the tropical and sub-tropical climates in the ASEAN countries, there is a high potential cooling demand though. In contrast to developed countries with hot climates, where air-conditioning systems already have high penetration rates, in most developing countries air-conditioning in residential buildings is still quite rare (Figure D.1).

Rising affluence in developing countries with high numbers of annual cooling degree days can cause rapidly growing energy demand. Another factor influencing increase in air conditioning is climate change. Modelling results predict both rising affluence and climate change to have an equal effect on increase in energy demand for cooling for the residential sector in warmer climates (Isaac and van Vuuren, 2008).

Figure D.1: Degree days, climate maximum saturation for residential air-conditioning systems and saturation data in ASEAN countries

ASEAN country	Annual heating degree days (city /country average)[1]	Annual cooling degree days (city /country average)[2]	Climate maximum[3] (in %)	Saturation (in %) (year of survey)
Indonesia	0 (Jakarta)	3 390 (Jakarta)	100%	2.7% (1997)
Philippines	0 (Manila)	3 438 (Manila)	100%	5.0% (2003)
Thailand	0 (Bangkok)	3 884 (Bangkok)	100%	10.8% (2000)
Singapore	0 (country average)	3 261 (country average)	100%	72.0% (2003)
Vietnam	81 (country average)	3 016 (country average)	100%	Data not available
Malaysia	0 (country average)	3 411 (country average)	100%	Data not available
For comparison:				
Canada	4 493 (country average)	263 (country average)	42%	41.7% (2003)

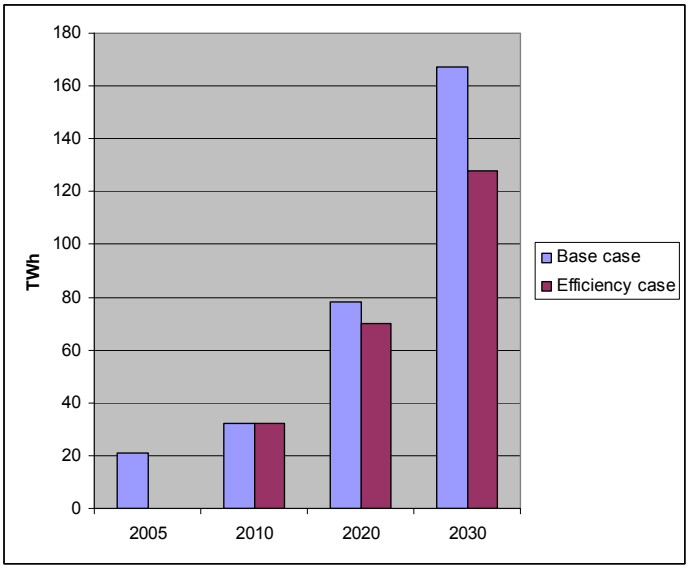
1 = heating degree days = (18 °C – mean outdoor temp.) over 365 days; 2 = cooling degree days = (mean outdoor temp. – 18 °C) over 365 days; 3 = maximum saturation for air conditioning systems given the climate conditions.

Source: Isaac and van Vuuren, 2008.

Increase in energy demand for cooling as a result of rising affluence

Rising affluence in the ASEAN countries is expected to result in increases of energy demand for cooling. Whereas heating is generally considered to be non-correlating with income, since heating is an essential demand to be fulfilled, cooling is generally to be considered a latent demand that is only fulfilled once there is sufficient capital. With growth rates of GDP ranging between 5 to 6% in the past five years, ASEAN countries can expect a correlation with energy consumption for cooling according to the common S-curve with very gradual increase at low incomes and a steeper increase after reaching a certain basic income. Modelling results demonstrate a rise in saturation of air conditioning systems in Southeast Asia from the current lows, as indicated in Figure D.1, to an average 20-30% share by 2030, assuming an expected 5.5% annual GDP growth rate (McNeil and Letschert, 2007). Energy consumption by air-conditioning systems is projected to increase from 21 TWh in 2005 to 167 TWh in 2030 in the base-case scenario, while energy consumption is expected to increase to 128 TWh in 2030 in the case of a high-efficiency scenario, due to rising affluence in the region (not considering climate change effects) (McNeil and Letschert, 2007). Interestingly, available data on the increasing saturation in air-conditioning use in China appear not to follow the expected S-curve, but show much higher ownership rates then expected on the basis of average income (McNeil and Letschert, 2007). This may indicate that the projected rise in energy consumption due to increasing ownership rates as a result of rising income may even be much higher then currently expected.

Figure D.2: Energy consumption and savings due to residential air conditioning in Southeast Asia due to GDP increase (climate change not included) (in TWh)



Source: McNeil and Letschert, 2007.

Increase in energy demand for cooling as a result of climate change

Next to the expected growth in demand for cooling technology as a result of rising GDP in developing countries, another important factor influencing this development is climate change. Countries with considerable heat demand will expect less heating degree days and a higher number of cooling degree days that will cause a trade-off. The expectation is that for these countries, the net energy delivered will decrease although energy demand is expected to shift towards electricity and therefore CO_2 emissions can still appear to rise as long as carbon intensity of electricity is not drastically changed (Aebischer *et al.*, 2007). However, most ASEAN countries have no heating degree days at all, so that there is no trade-off between decreasing heating demand and rising cooling demand. In fact, cooling degree days are expected to increase: India, currently experiencing an average of 3 120 annual cooling degree days, is predicted to face an increase of average annual cooling degree days towards 4 651 by the end of the 21st century (Isaac and van Vuuren, 2008). Energy consumption for cooling is expected to increase linearly with rising cooling degree days (Isaac and van Vuuren, 2008). According to Isaac and van Vuuren, 2008, the region most strongly affected by climate change is the Southeast Asia region where rising temperatures will result in increase in energy demand for cooling.

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