

TRADE AND INVESTMENT POLICIES TO PROMOTE CLIMATE FRIENDLY TECHNOLOGIES IN APEC ECONOMIES

Office of the Chief Economist
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Vice President	James W. Adams (EAPVP)
Task Team Leader and Lead Economist	Ahmad Ahsan (Office of the Chief Economist and EASPR)

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PREFACE

This report was prepared as part of the APEC Finance Ministers' Policy Initiatives of 2008¹. Under this initiative, the World Bank was asked to prepare studies on the current state of economic policies concerning climate change and recommendations for strengthening these policies. This is one of the series of studies which have been prepared on Climate Change and Economic Policies in APEC Economies. The synthesis report based on these studies and the Climate Change and Fiscal Policy in APEC Economies were presented to APEC bodies such as the Senior Finance Officials Meetings in Tokyo in September 2010 and were tabled at the Finance Ministers' Meetings in November, 2010.

The original draft of this report was prepared by a team from BAEconomics (Australia) led by Anna Matysek and then finalized by a World Bank team consisting of Syud Amer Ahmed (DECAR) and Michael Toman (DECEE) with input and overall guidance from Ahmad Ahsan (Office of the Chief Economist, East Asia and Pacific). Francis Ng (DECTI) provided important inputs on trade policy. Milan Brahmbhatt (PRMVP) provided very helpful comments on an earlier draft of this report. This report has benefited from comments provided by Vijay Jagannathan (EASIN), John A. Roome (EASSD), and participants in a review meeting on August 2010. Maskai Takahashi (ESMAP) provided many helpful comments. Mildred Gonsalvez (EASPR) and Katherine Sarah Patrick (EASPR) assisted the processing of this report. The Treasury of Australia provided support for this study.

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank	kW	Kilowatts
APEC	Asia-Pacific Economic Cooperation	kWh	Kilowatt-hour
AR4	Intergovernmental Panel on Climate Change's Fourth Assessment report	LPG	Liquefied Petroleum Gas
ASEAN	Association of Southeast Asian Nations	MAC	Marginal Abatement Cost
CBA	Cost Benefit Analysis	MRV	Monitoring, Reporting, and Verification
CCT	Clean Coal Technology	MTCO ₂	Metric Tonnes of Carbon Dioxide
CDM	Clean Development Mechanism	MW	Megawatts (Thousand kW)
CER	Certified Emissions Reduction units	LPG	Liquefied Petroleum Gas
CERC	China Electricity Regulatory Commission	NAMA	Nationally Appropriate Mitigation Action
CFT	Climate Friendly Technology	NDRC	National Development and Reform Commission
CFL	Compact Fluorescent Lamp	NGCC	Natural Gas-Fired Combined Cycle
CHP	Combined Heat and Power	NOAA	National Oceanic and Atmospheric Administration
CO ₂	Carbon Dioxide	NTB	Non-Tariff Barrier
CO ₂ e	Carbon dioxide equivalent emissions	OECD	Organization for Economic Cooperation and Development
CPO	Crude Palm Oil	PV	Photovoltaic
DHC	District Heating and Cooling	R&D	Research and Development
EET	Established Environmental Technologies	RGGI	Regional Greenhouse Gas Initiative
EG	Environmental Goods	RPO	Renewable Purchase Obligations
EGS	Environmental Goods and Services	SASAC	State-owned Assets Supervision and Administration Commission
EPP	Environmentally Preferable Products	SERC	State Electricity Regulatory Commission
ETS	Emissions Trading System	SHS	Solar Home Systems
FDI	Foreign Direct Investment	Tce	Tonne of coal equivalent
FIT	Feed-in-Tariff	TNA	Technology Needs Assessment
G20	Group of Twenty	UNFCCC	United Nations Framework Convention on Climate Change
GDD	Growth Degree Days	WB	World Bank
GDP	Gross Domestic Product		
GHG	Greenhouse Gas		
GLS	General Lighting Service		
GW	Gigawatts (Thousand MW or Million kW)		
GWh	Gigawatt-hours (Million kWh)		
IAEA	International Atomic Energy Agency		
IEA	International Energy Agency		
IGCC	Integrated Gasification Combined Cycle		
IPCC	Intergovernmental Panel on Climate Change		
IPR	Intellectual Property Regulations		
kcal	Kilocalories		

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EXECUTIVE SUMMARY

Introduction

1. ***Climate friendly technologies (CFT) reduce the emissions of greenhouse gases (GHG) by reducing the carbon content of economic activity.*** Climate change due to greenhouse gases is expected to affect many sectors, and present risks to many APEC economies in Asia. These risks include falling freshwater availability, rainfall volatility, frequent hurricanes and droughts, and a greater risk of coastal flooding. All these will cause significant negative impacts on APEC member economies. Given that APEC economies account for more than half of global GHG emissions, the adoption of emissions reducing CFTs in this region is critically important for the global emissions mitigation agenda.
2. ***This report, first, describes the wide range of different CFTs already in use in middle-income APEC economies and their potential.*** As such, it is a comprehensive reference on CFTs that are used and produced in middle-income APEC economies, and on the factors that have contributed to their uptake, including domestic FDI legislation and energy security policies. This report combines regional reviews and analyses with country level analyses of China, Indonesia, Thailand, and Vietnam.
3. ***Second, it discusses the potential of further use and production of CFTs in APEC economies and the challenges facing their adoption.*** Several APEC economies are emerging as leaders in the production of CFTs for domestic use as well as trade, consistent with their ambitious energy efficiency and GHG reduction targets. The report discusses issues facing further CFT uptake, and how these issues could be addressed through policies for further trade and investments in CFTs. However, the report also notes that achieving this potential will require removing an array of impediments through trade and investment policy reforms, and identifies these reforms in this report.
4. ***Third, it attempts to identify CFTs that have the most potential for further use.*** For example, this report identifies wind power technologies in Thailand as one of two CFTs with the most potential for further expansion of installed capacity and that may benefit the most from targeted trade and investment policies. However the report also makes the case that there is currently insufficient information to design a cost-effective wind power promotion policy. By providing estimates of possible investment requirements, estimating potential CO₂ equivalent emissions reductions, and by describing current policy impediments, this report provides a foundation upon which to conduct further investigations for well-designed CFT promotion policies.
5. ***Finally, the report addresses issues concerning the design of effective technology-based policies that support economic development through the adoption of CFTs.*** First, this will require a substantial mobilization of international investments in CFTs. An additional US\$ 200 billion annually by 2030 is the estimated level of investment required to return GHG emissions to current levels. The United Nations Framework Convention on Climate Change (UNFCCC) estimates that a higher percentage of international investment to reduce GHG emissions will need to be directed towards the adoption of CFTs in developing and middle-income countries. Second, it will require trade policies that facilitate transfer of CFTs across borders. This report identifies a range of tariff and non-tariff barriers that currently impede this.

Climate Friendly Technologies in APEC Economies

6. ***A diverse range of CFTs are used in developing APEC economies.*** These technologies, at various stages of development, range from large-scale to micro-scale (household level), and from relatively generic technologies to sector-specific technologies. Energy is the most important for reducing GHG emissions, as shown in the UNFCCC's Technological Needs Assessments (TNAs), and technologies targeting end-use efficiency and energy conservation represent some of the most cost

efficient and important demand-side options. Advanced fossil fuel power generation and alternative energy sources are also technologies that have tremendous mitigation potential. The study of emission abatement costs of these technologies shows that cost-effective emissions reduction strategies must include a combination of approaches. APEC economies are also using combinations of different technologies.

7. ***There are four major sets of large-scale generic technologies: (i) energy efficiency and conservation improving; (ii) advanced fossil-fuel; (iii) renewable energy technologies; and (iv) carbon capture and storage.*** The first set includes technologies in building design improvements, combined heat and power (CHP) generation, efficient lighting systems, and automobiles. The majority of savings in energy efficiency in buildings can be achieved through the use of widely accessible mature technologies in building design. The IPCC (AR4) reported that international evidence suggests that up to 29 percent of baseline 2020 emissions in the residential and commercial building sectors could be reduced cost effectively. Combined heat and power (CHP) generation (or cogeneration) increases the efficiency of power and heat generation facilities. The IEA further estimates that if the most efficient forms of lighting currently available, such as compact fluorescent lights (CFLs), were implemented globally, electricity consumption in lighting could be almost halved by 2030. Strong advances in fuel efficiency technology and alternate fuels are thus required to achieve significant reductions in this rate of growth of emissions from automobiles, and to reduce the current dependence on petroleum fuels (IPCC, 2007). The hybrid electric engine has the ability to reduce GHG emissions by between 30-50 percent compared to petrol, and without a reduction in power or safety performance (Romm, 2006).

8. ***The second set includes advanced fossil fuel based electricity technologies that can significantly reduce emissions intensities.*** About 41 percent of global electricity is generated by coal or peat and an additional 5.8 percent by oil. Advances in reducing the emissions intensity of fossil fuel based power stations are being led by the development of natural gas combined cycle (NGCC) or integrated gasification combined cycle (IGCC) power plants. The key advantage of IGCC power plants is their relatively high energy efficiency potential. This efficiency is currently approximately 50 percent; as with NGCC, this is expected to improve. In addition, the high concentration of carbon dioxide in the flue gas offers potential for efficient carbon capture and storage. Currently there are six commercially operating IGCC plants –two in the United States, three in Europe, and one in Japan –with combined installed capacity of 1,700MW (EPRI, 2008).

9. ***The third set of major CFTs that needs to be a part of a comprehensive mitigation strategy is renewable energy technologies.*** Renewable energy technologies have substantially lower emission intensities than coal-based technologies. However, their generally higher current investment costs have so far inhibited their uptake. Traditional electricity generation technologies, such as coal and nuclear based generation, generally have lower costs than up and coming technologies. However, the costs of the newer technologies at the lower end can be competitive vis-a-vis traditional technologies. Despite the high costs, governments continue to support renewable energy technologies because they recognize that such technologies are maturing and have many other benefits (like lower emissions). Major renewable energy CFTs in Asian APEC economies include hydro-electric power, wind power, biofuels (including biomass), and photovoltaic solar power.

10. ***The fourth technology is carbon capture and sequestration, which has been tested to be technically feasible and, if economically viable, can have a large impact in reducing emissions in a cost effective way.*** If it becomes viable at the scale needed it would provide an option for future abatement of carbon dioxide emissions, while still allowing coal based electricity generation. The power generation sector is the most promising sector for the implementation of CCS technology. The IEA estimates that between 52-89 percent of CO₂ emissions captured will be from the electricity generation sector over 2020-2040. In addition, by 2030, up to 22 percent of global electricity is projected to be generated from fossil fuel based power plants fitted with CCS technology; this penetration rate is projected to increase to approximately 40 percent by 2050 (Gielen, 2003). CCS technology is expected to become commercially

viable over the next 10-15 years despite currently limited full scale experience or current commercial capacity. However, this conclusion relies on the introduction of carbon prices in the range of US\$ 25-30 t/CO₂ (IPCC, 2005).

11. ***Hydro-electric power already accounts for significant shares of total power generation, and has the potential for further development.*** The world's largest producer of hydroelectricity is China, representing almost 14 percent of global installed capacity, and producing 478 TWh of hydroelectricity (World Energy Council, 2008). The ASEAN-10 also has 16,110 MW of installed hydro power, representing more than three-quarters of their total installed capacity in renewable energy.

12. ***Wind energy CFTs follow hydro-electricity in power-generation.*** The development and installation of wind turbines of up to 750kW in size is considered to be a mature commercial industry in China. The country has doubled its wind power installations for four straight years and is on track to become the world's second largest wind energy producer by 2010 (Li et al., 2007). China has approximately 20 domestic manufacturers, and was the seventh largest exporter of wind energy technology in 2008. Wind power in Indonesia and Vietnam also has the potential to provide cost-efficient energy to remote and rural areas. Installed wind power capacity in Indonesia is around 0.5MW to 1MW. Wind power generation is predominantly located in eastern regions of Indonesia and used for powering water pumping stations and recharging batteries. In Vietnam, wind power has been considered for use in island and rural areas since the 1980s but only accounts for a very small proportion of domestic power generation. The technical capacity for wind power in Vietnam is approximately 1,780MW.

13. ***Middle-income APEC economies are major producers of biofuels.*** In 2005 China was the third largest global producer of biofuels after Brazil and the USA (USDA, 2006). Indonesia is currently the world's largest producer of crude palm oil (APEC Energy Working Group, 2008b). Thailand is the world's third largest producer of biodiesel, with the predominant feed stock of palm oil. The biofuels market in Vietnam is currently in the early stage of development, but with vast resources of biomass, the government has announced goals of up to 500 million liters of production of fuel ethanol by 2020, and 50 million liters of biodiesel. Biomass power accounted for around 9 percent of total power generation in the ASEAN-10 in 2000. Biomass biofuels can be competitive with coal based generation. If feedstock can be supplied at low or zero cost, then electricity can be generated for as little as \$20/MWh. However, at present, power from biomass gasification on average generates electricity at around twice the cost of most fossil fuel based power generation plant, constraining its expansion.

14. ***Solar photovoltaic (PV) electricity systems are not only major contributors of installed capacity but can also provide valuable off-grid power.*** Indonesia is characterized by a large number of small and highly dispersed communities, and PV solar technology is currently mainly used to supply households that are not connected to the grid. Overall, around 12 MW of PV capacity has been installed, corresponding to around 100,000 solar home systems (SHS) for purposes such as lighting, television, communication, battery charging and refrigeration. On current plans, another 30,000 systems will be installed in Indonesian households. The application of photovoltaic (PV) solar technology in China is also set to change rapidly. China is already the world's largest producer of PV cells, a large proportion of which are exported. Installed PV solar capacity expanded significantly between 2007 and 2008, from 100MW to 140MW (UNEP, 2009).

Current Investment Policies to Promote CFTs

15. ***Middle-income, emerging and developing APEC economies are well placed to take advantage of CFTs available through international trade and investment.*** With the international community facilitating discussions about the use of CFTs and promoting investment in CFTs, developing countries have the potential to use this momentum, facilitating international and domestic investment to promote development and increase their presence in the market for these technologies. Strengthening trade and foreign investment requires the existence of a transparent and consistent overarching policy framework.

16. ***Financing investment for CFTs, however, is a key policy challenge and four main channels for financing CFTs have been used in APEC economies.*** First, the Kyoto Protocol's Clean Development Mechanism (CDM) permits industrialized countries to invest in ventures that reduce emissions in developing countries, and CDM represents an effective mechanism to enable the transfer, diffusion and adoption of CFTs. The importance of technology types encouraged by the CDM varies by country. Of China's 579 CDM projects, 275 are in hydroelectric power and 127 in wind power generation projects. Indonesia has 24 CDM projects of among which there are 8 biomass and 6 methane avoidance projects. Similarly, biomass and methane avoidance projects account for 16 of Thailand's 18 CDM projects. Vietnam has one CDM project each for fugitive emissions, landfill gas usage, reforestation, and wind power, and two hydropower CDM projects.

17. ***Second, public investment and subsidy programs in CFTs have played a leading role, highlighting the gap between their costs and other alternatives that can attract investment in the market.*** China has committed large amounts of resources toward the development of renewable energy. By 2020, the Chinese government will commit approximately US\$ 125 billion into further development of hydropower facilities, equaling the entire value of Chinese renewable energy projects in 2007 (APEC, 2009). In July 2009, the Chinese government announced a new subsidy program directed at utility scale operations and facilities. These facilities are required to generate at least 300 kW of peak capacity, be operational within 12 months and have a minimum operational life span of 20 years. The Ministry of Finance has committed to subsidizing 50 percent of total investment in the solar power projects, as well as supporting transmission and distribution systems to connect to the grid. In remote regions not connected to the national grid, the subsidy is increased to 70 percent.

18. ***The intense interest in commercial PV solar development in China illustrates the importance of public sector support.*** The support for this sector includes the enactment of several policies like regional feed-in tariffs (FITs) and subsidies for solar PV installations. For instance, the Jiangsu government put in place an attractive FIT, which nearly covers project costs. The FIT has encouraged several leading PV manufacturers, including Suntech and Trina Solar, to oversee the development of 80MW and 30MW rooftop PV projects, respectively. By 2011, 400MW of PV capacity are scheduled to be completed in Jiangsu.

19. ***Thailand also has a number of policy measures to support investment in CFTs.*** Renewable and alternative sources of energy are given priority in terms of tax incentives and import duty exemptions. Thailand has attractive investment policies supporting CFT development, such as import duty reduction for machinery, corporate tax exemptions, import duty exemption on raw materials for manufacture of domestic and foreign sales, discount from transport, electricity and water costs and additional incentives for relocation of existing facilities to regional areas.

20. ***Third, the private sector plays a key role in the transfer of CFTs through investment, sometimes motivated by policy driven incentives.*** Corporate R&D, venture capital, asset financing arrangements, and funds raised on public markets have been the main financing instruments. The 2009 World Economic Forum reports that total investment in clean energy increased from approximately US\$ 33 billion in 2004 to approximately US\$ 148 billion in 2007, then dropping slightly in 2008 to approximately US\$ 142 billion. Of this, US\$ 42.6 billion was invested directly into companies via venture capital, company based R&D funds, government research and development funds and public markets. This investment was used to finance equipment manufacturing and production up-scaling, as well as technology development. In terms of investment in specific technologies, wind, solar and biofuels technologies attracted the largest proportion of third party investment in 2008, with wind power accounting for almost half of capacity investment worldwide in 2008.

21. ***Fourth, FDI is an important channel for investment in CFTs.*** Vietnam's legislative framework thus provides tremendous support to FDI generally. Recent legislation includes the Law on Technology Transfer (2006), Law on Investment (2005), Law on Enterprises (2005), Law on Intellectual Property

(2005) and Law on Competition (2004). In addition, recent legislation is supportive of renewable energy projects. Relevant legislation supporting the development of renewable energy and rural electrification includes the Vietnam Power Sector Development Strategy (2004) and the National Energy Strategy Development (2007).

22. ***Given the current costs of CFTs, their financing requires a policy environment that encourages more certainty on investment incentives and encourages more FDI flows for CFTs.*** For example, the Chinese government introduced the “Temporary Implementation Rules for Setting up Feed-in Tariffs for Renewable Energy Power and the Sharing of Expenses in Purchasing Electricity from Renewable Energy” in 2007. The intention of this policy was to share the additional charges for renewable energy nationwide, thus supporting utility development in provinces that are incapable of self-sufficient funding. However, Li et al. (2007) pointed out that policy also needed to provide more certainty around the time horizon of these incentives. This would have boosted confidence amongst potential investors, and thus increased the uptake of the incentives and the efficiency of the policy. Also, cross-border merger and acquisition activities in China have been curbed by legislations such as ‘Regulations on the Acquisition of Domestic Enterprises by Foreign Investors’.

Current Trade Policies to Promote CFTs

23. ***International trade has become an important conduit for transferring CFTs in the APEC region, even from developing economies.*** A review of global flows of established environmental technologies (EETs) shows that China is a major importer and exporter for integrated gasification coal cycle (IGCC), wind, solar photovoltaic (PV), and compact fluorescent light (CFL) technologies, and that Indonesia and Thailand are also major exporters of CFL technologies. Malaysia, Thailand and the Philippines are net exporters of component goods required to construct renewable/clean energy technologies, hydrogen peroxide, hydraulic turbines, water wheels and regulators, parts for hydraulic turbines, instantaneous gas water heaters, solar water heaters, wind-powered generating sets, and photosensitive semiconductor devices, including solar cells. China, the Republic of Korea, and Chinese Taipei are important exporters, primarily to other Asian countries, in the water and wastewater management sectors.

24. ***Future CFT transfers through trade need to address two issues. First,*** high tariffs on environmental-related technologies are a major barrier to the wider use of such technologies. Economies involved in the production of CFTs often impose an escalating tariff structure. That is, lower tariffs are imposed on parts and equipment used as input in the production CFTs, while higher tariffs are applied to complete CFT products. One example of this was China, where tariffs for wind turbines were 3 percent for individual parts, 8 percent for assembled components, and 17 percent for entire pre-assembled turbines.

25. ***Eliminating tariffs alone would increase trade by around 7 percent from current levels.*** Middle income APEC economies have many opportunities to take advantage of tariff liberalization. Average applied tariffs on CFTs in countries like China, Thailand, and Indonesia are currently higher than applied tariffs in developed countries. Tariffs on CFTs also tend to be higher than average tariffs on other industrial products, as in the case of CFL tariffs in Thailand or wind power technology tariffs in Indonesia.

26. ***Second, non-tariff barriers (NTBs) or non-trade-related barriers would also need to be addressed for effective diffusion of CFT to take place.*** Out of 105 CFTs, only about 32 products are affected by tariffs and NTBs are the major barrier to trade for most products. The World Bank estimates that the complete elimination of tariffs and non-tariff barriers (NTBs) would lead to an average increase of trade in clean coal technology, wind/solar power generation, and energy efficient lighting technology by 13.5 percent at the current level, with some variation across technologies and countries (World Bank, 2008).

27. ***Among NTBs, standards, certifications, subsidies and environmental regulations can also create obstacles to trade in established environmental technologies.*** Technical standards and certification requirements, for instance, limit trade because products from developing countries face difficulties when entering the market of developed countries due to lack of appropriate standards for their products. For Asian countries, marketing restrictions, labeling, packing, documentation requirements, harassment of imports, distribution, logistics and banking restrictions are major barriers. The lack of technical capacity is another major barrier to CFT trade. In particular, the technological capacity building would be particularly effective in the solar energy sector and in the chemicals industry.

28. ***Many middle-income APEC economies have taken steps to facilitate international investment and trade in CFTs.*** For example, Indonesia has introduced a number of reforms and incentives to increase the attractiveness of the country as an investment location, and has capitalized on international cooperative efforts. Investment in Indonesia is hampered by the range of restrictions to foreign investment that have been put in place.

Other Policy Impediments

29. ***A number of other policies currently in use middle-income APEC economies also pose impediments to reducing emissions.*** Energy security policies promoting energy self reliance of a country are potentially very costly for the economy concerned and/or for the environment. Trade related investment policies restricting investors tend to raise costs for investors and for consumers. Also, policies that facilitate energy consumption through the use of high cost energy subsidies, encourage wasteful behavior and risk broader economically distortionary outcomes.

30. ***There are several institutional issues that constrain the expansion of CFTs in addition to costs and financing.*** These include problems related to legal and policy framework, planning and implementation, adequacy of inputs, and lack of information along with other institutional weaknesses such as quality assurance. The top part of Table 1 summarizes these issues and offers recommendations for addressing them. The bottom part summarizes issues related to cost and financing and lists options for addressing them. Which of those options could be recommended depends on circumstances and requires further assessment before any broader conclusions can be drawn.

Table 1: Overview of issues constraining the adoption of CFTs and policy recommendations

Issue	Recommendation
Inadequate Policy and Legal Framework	
Unclear specification of energy project	Targets should be defined in terms of useful capacity or output (rather than targets that can be circumvented)
Ineffective targets	Improve capability within government to set effective targets
Overlapping government agencies	Improve monitoring of targets
Unclear legal framework	Establish coordinating body to align policies
	Seek consultation with key stakeholders, including members of industries and foreign investors
	Improve tender and approval processes
	Combat corruption
	Encourage communications with investors
Lack of confidence in intellectual property rights	Create framework for patent registration and enforcement
Weak planning and implementation capacity	
Insufficient data on installed capacity and their effectiveness	Structured inventory of capacity
Mismatch between estimated/theoretical and actual capacity of energy from renewable	Formal resource assessment

Issue	Recommendation
Mismatch between geographical availability of CFT and local requirement	Coordinated national planning processes for rural/urban developments Consideration of decentralized/small scale technologies Consideration of off-grid small scale technologies Require providers to offer complete package of services Establish training programs for:
Lack of grid connectivity to CFT Insufficient support after installation Lack of technical expertise in installation and maintenance	- Industry and technicians; - Government staff; - Small private companies; - Community based providers; - Consumers
Challenges in Supplying CFT inputs Competition for CFT inputs (biofuels)	Introduction of specific CFT inputs, e.g. inedible biomass sources
Volatility of CFT inputs (wind, water)	Alternative (smaller scale) technologies Use of complementary technologies
Information and institutional challenges	
Lack of public information	Raise community awareness Improved education Create technical & training institutions
Complex institutional arrangements Unreliable quality of CFTs Reduced effectiveness of CFTs	Application of a more decentralized approach Create standards and specifications for CFTs Put in place longer term institutional/contractual arrangements
Cost and financing issues High up-front costs of SHS	Potential Options Limited use of targeted subsidies Use of microfinance institutions Use of commercial/development banks Examine quality standard required
Funding and project risks	Focus on small scale/pilot projects until technology is proven/established Create stable policy framework for investors
Funding difficulties for small/ start up ventures	Government-managed special funds Low interest loans Cooperation with commercial banks
Financing of energy efficiency measures	Targeted financing opportunities in cooperation with government Targeted financing mechanisms with third parties
Economic and pricing barriers	Undertake energy price reform Establish FITs to underwrite financial viability Fiscal incentives, such as tax exemption, depreciation

31. *The following examples illustrate some of the challenges listed above described. **First, CFT promotion challenges can be exacerbated by inadequate legal and institutional arrangements.** For example, Thailand currently offers subsidies for the production of liquefied petroleum gas (LPG), but not for the production of biomass. This distortion makes it much more difficult for the unsubsidized biomass technologies – like small scale biomass producers – to compete with the subsidized LPG sector.*

32. ***Second, weak planning creates mismatches between capacity creation and their use, leading to wastage.*** The Chinese wind sector illustrates this mismatch. Some studies indicate that up to 30 percent of wind assets are either not in use, or not connected to the national power grid. Thus, while wind power represents 1.5 percent of installed electrical capacity, it accounts for only 0.4 percent of generated electricity. Furthermore, the coastal areas have a large power load but less wind resources while the northern areas are richer in wind resources but have lower power load (Li et al., 2007). In order for companies to satisfy installed capacity specifications, some turbines have been opportunistically built in areas where there is no connection to the national power grid (Kwok, 2009).

33. ***Third, several other sectors are competing for critical CFT inputs raising their costs.*** In the case of biofuels in China, Indonesia, Thailand and Vietnam, there is competition for biomass input from pharmaceutical, food and beverage industries. The risk is that biofuels expansion damages other industries, including food-producing industries. Crops used for food supply are the main competitors for biodiesel, with the potential for increased production of biodiesel-specific feed stocks putting increased pressure on food supplies.

34. ***Fourth, lack of technical capacity can severely limit CFT uptake. Indonesia and Thailand have faced this challenge in their plans to promote photovoltaic (PV) solar power.*** In Indonesia, PV solar technology is widely available, yet its uptake remains limited due to a shortage of trained technicians to install and maintain the systems and poor after sales services. Given the challenges in providing the after-sale support, and in procuring the necessary spare parts, many households are reluctant to commit their own resources towards this technology. Thailand's application of solar power technologies has faced a similar lack of skilled manpower and technical capacity.

35. ***Fifth, limited public awareness leads to low consumer support and lower rates of CFT adoption.*** In Indonesia, a lack of public education on a number of levels – including among technicians, government officials and the general public – on the economic benefits and costs of CFTs has also resulted in public resistance to adopting new CFTs. Households taking up new CFT products in Indonesia have faced issues concerning a lack of quality control, warranties, after-sales service and spare parts, further undermining the acceptance of these new technologies.

36. *Another example is from Thailand, where mobilizing consumer support has included the establishment of a community level network of leaders through the 'Community Energy Volunteers' program.* This program developed community based prototype energy sources to demonstrate the ability of renewable energies to power communities. To build an energy saving culture, Thailand has implemented energy efficiency measures such as energy performance labeling of electrical appliances and mandatory provisions on standby power allowances through the "Standby power 1-watt" program. The government also provides incentives for the consumption of power generated by renewable energy through tax credits and privileges, and capital subsidies.

37. ***Sixth, high up-front costs of adopting CFTs, such as PV technology at the household level, can be a challenge for consumers.*** Thus financing of CFTs at the household level is another challenge. Given the challenges in providing the after-sale support, and in procuring the necessary spare parts, many Indonesian households are reluctant to commit their own resources towards this technology. To overcome this barrier, the government's approach has often been to purchase the systems from private companies through a bidding process, and provide the systems to households for free.

38. ***Other issues with policy design can be found in China, Indonesia, Thailand, and Vietnam.***

- China has a number of laws and regulations to support the investment and up take of renewable technologies. However, policy targets are not framed in terms of achieving a useful output, but instead focus on installed capacity targets.

- Indonesia's ambitious energy targets may not be consistent with stated environmental aims due to their strong focus on the construction of coal-fired generation capacity.
- Thailand has announced various targets to increase the share of renewable energies. However, it is not clear how these would be implemented, given a lack of funding. Thailand may need to draw on funding support from external sources. Additionally, existing fossil fuel subsidies are likely to hamper the greater use of CFTs.
- Vietnam has similarly determined a range of renewable energy targets. The key impediments to the adoption of CFTs relate to a lack of information about the potential scope of these technologies in the country, but also low electricity prices that do not reflect true costs.

39. ***Analyses at the country level identify CFTs that have the greatest potential in each country for expansion and diffusion.*** These are presented in Table 2. For example, biomass, small/mini hydroelectric power and solar power have been identified as being the CFTs with the greatest potential for expansion in Vietnam. At the same time, the country's potential for CFT trade is influenced by its attractiveness as a low cost FDI location, and its scope for more CDM projects.

Table 2: CFT Potential by Country

Country	CFT energy potential	CFT trade potential
China	Clean coal	Preferred location for FDI
	Cogeneration	Key exporter of wide range of CFTs for South-North/North-South trade
	Wind	Key regional trading partner for South-South trade
	Small/micro hydro	
	Solar	
	Household & community biogas	
Indonesia	Clean coal	Key exporter of CFLs and forestry products
	Solar	Technology transfer with China to develop CCT, wind technology
	Wind	International collaborative efforts for CCT & other technologies
	Geothermal	
	Flared gas	
	Biofuels	
Thailand	Solar	Key exporter of a range of CFTs
	Wind	Attractive FDI location
		Scope for securing more CDM projects
Vietnam	Biomass	Attractive low cost FDI location
	Small/micro hydro	Exporter of CFTs
	Solar	Scope for securing more CDM projects

1. INTRODUCTION

1. ***The industrialization of the world economy has led to increasing concentrations of Greenhouse Gases (GHG) in the atmosphere.*** The Intergovernmental Panel on Climate Change (IPCC) reporting an increase in emissions over the period 1970 to 2004, equal to an average annual growth in carbon dioxide equivalent emissions of 1.6 percent. The IPCC also highlights the increasing evidence of the link between human activities and climate change. The resulting climate change is expected to affect many different sectors, and several potential risks to middle-income APEC economies in Asia have been identified (IPCC, 2007; World Bank, 2010a).

2. ***APEC economies are not only threatened by climate change, but are also crucial for global GHG emissions mitigation, being accountable for more than half of current global GHG emissions.*** Very significant negative impacts on individual countries, including countries in Asia, are expected unless adaptation and emission reduction policy responses are taken. This requires a substantial strategic mobilization of international investments. The United Nations Framework Convention on Climate Change (UNFCCC) estimates that a higher percentage of international investment to reduce GHG emissions will need to be directed towards developing and middle-income countries, with the investment directed towards R&D in climate friendly technologies, and supported through targeted government policies.

3. ***For developing and middle-income countries, the immediate challenge is to design climate change policies that mitigate GHG and increase resilience to climate change, while also supporting ongoing economic growth.*** There is a growing recognition that trade and investment policies aimed at reducing GHG emissions can produce a wide range of economic co-benefits. In some instances they are “no regrets”, in that they would be good development policies even if they were not implemented with the aim of reducing emissions.

4. ***The objectives of this report are to:***

- Review climate friendly technologies that are of most interest to APEC economies, in particular Indonesia, Thailand, China and Vietnam;
- Describes global trends in the industries related to climate friendly technologies;
- Examines the potential for middle-income developing economies to become producers and traders of climate friendly goods and services; and
- Discusses how current trade and investment policies can encourage the diffusion of CFTs.

5. This report is structured as follows:

- Chapter 2 provides an overview of emissions mitigation technologies.
- Chapter 3 reviews the current state of selected CFTs in middle-income APEC economies, including country based production, trade and innovation, as well as investment flows and diffusion.
- Chapter 4 considers the relevant policy environment, including policy for technology development, adoption and diffusion, and outlines foreign direct investment, trade, and energy policies of the middle-income APEC economies.
- Chapter 5 considers opportunities and impediments to the use of CFTs in middle-income APEC economies, including general and technology specific opportunities and impediments.

- Chapter 6 provides an overview of the identified impediments to the diffusion and adoption of CFTs and how these can be addressed, as well as an assessment of the CFT trade potential for middle-income APEC economies.

1.1 Drivers and Impacts of Climate Change

6. ***The IPCC concluded that the marked increases in the concentrations of GHGs are very likely to be the result of human activities, in particular the use of fossil fuels and land-use changes.*** There is now very high confidence that the global average net effect of human activities over the last 250 years has been one of warming. Most of the increase in global average temperatures since the mid-20th century is therefore very likely due to the observed increase in anthropogenic (that is, manmade) GHG concentrations. Overall, the IPCC concludes that it is likely that there has been significant anthropogenic warming over the past 50 years in each continent except Antarctica.

7. ***The IPCC forecasts a warming of around 0.2°C per decade over the next two decades (IPCC, 2007).*** Even if concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade can be expected. Climate change is expected to impact many different systems, sectors and regions, including:

- Ecosystems, including plant and animal species;
- Food availability, as crop productivity and the ability of countries to feed their populations;
- Coasts, which are projected to be exposed to increasing risks of coastal erosion and sea level rise;
- The health status of millions of people as climate change events are expected to greater malnutrition, disease, and injury due to extreme weather events; and
- Water availability, where climate change is expected to exacerbate current stresses on water resources from population growth and economic and land-use change.

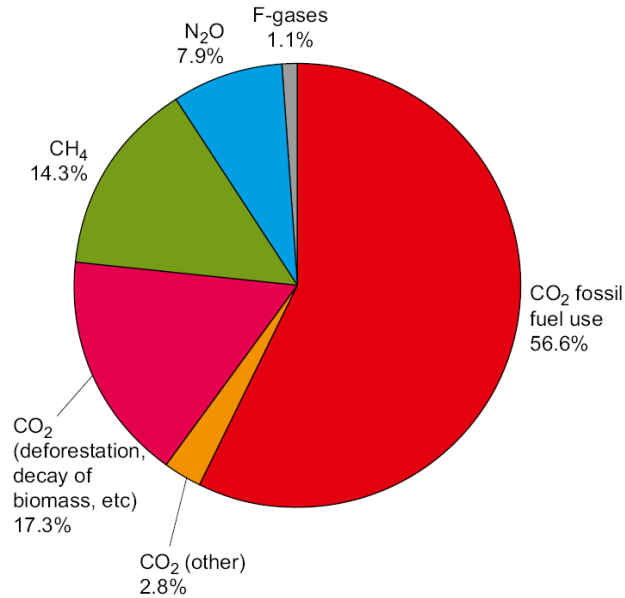
8. ***For Asia, where many middle-income APEC economies are located, the IPCC (2007) has identified a number of potential risks from climate change.*** These include:

- A decrease in freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, by the 2050s;
- A greater risk of flooding in coastal areas, especially for the heavily populated mega-delta regions in South, East and South-East Asia;
- Stresses on natural resources and the environment that are additional to existing pressures associated with rapid urbanization, industrialization and economic development; and
- A rise in endemic morbidity and mortality due to diarrheal disease that is primarily associated with floods and droughts in East, South and South-East Asia due to projected changes in the hydrological cycle.

1.2 Current Emissions Trends

9. ***Current emissions trends can be analyzed by country, by type of GHG, and by the economic sector from which they originate.*** In 2004, more than three quarters of global GHG emissions were from carbon dioxide (measured in terms of CO₂e – carbon dioxide equivalent emissions), as shown in Figure 1. These emissions are predominantly from fossil fuel combustion, deforestation, and decay of biomass (IPCC, 2007). Methane, nitrous oxide, and various other gases (PFCs, HFCs and SF₆) are also major GHGs, and are from a range of different sources. For example, methane is generated by livestock, landfill, biomass combustion, rice cultivation, burning fossil fuels and wastewater treatment. Methane accounted for 14.3 percent of global GHG emissions and nitrous oxide for 7.9 percent.

Figure 1: Global GHG emissions in 2004



Source: IPCC (2007)

10. ***APEC economies account for almost 60 percent of global GHG emissions.*** Table 3 describes the allocation of total global emissions in 2005 attributable to select middle-income APEC economies. In terms of total emissions, China dwarfs the other four economies. However, measured in per person emissions, Thailand has a slightly higher level than China.

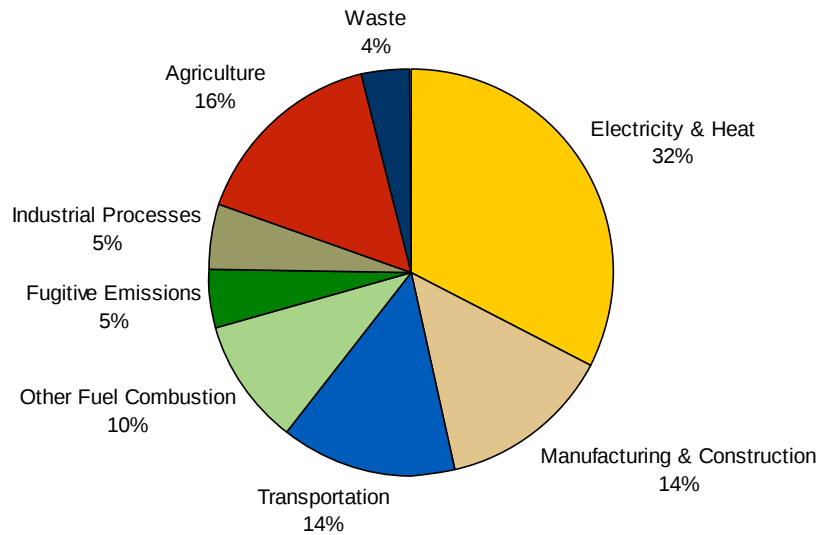
Table 3: Emissions of middle-income APEC economies (excluding land use change)

Country	Emissions (MtCO ₂ e)	Percent of global emissions	Per person emissions (tCO ₂ e per person)
China	7,219	19.1	5.5
Indonesia	594	1.6	2.7
Thailand	351	0.9	5.6
Vietnam	177	0.5	2.1

Source: World Resources Institute (2009).

11. ***The global energy sector accounted for 75 percent of global GHG emissions in 2005.*** The emissions from the energy sector can be further divided into electricity and heat, manufacturing and construction, transportation, other fuel combustion, and fugitive emissions. Of these, electricity and heat were the largest components, accounting for 32 percent of global emissions (Figure 2). Manufacturing and construction accounted for 14 percent, and transport for 14 percent.

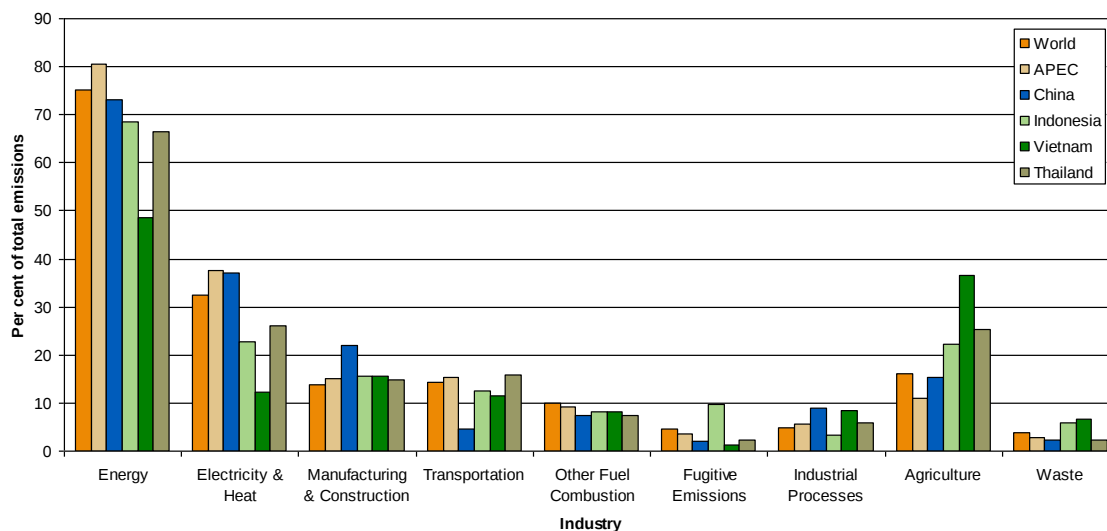
Figure 2: Global GHG emissions by sector, 2005 (excluding land use change)



Note: N₂O data not available for fugitive emissions.
Source: World Resources Institute (2009)

12. ***There are strong differences in the relative importance of industrial emissions between APEC economies (Figure 3).*** The differing profiles of emissions have important consequences for assessing the most efficient technologies for mitigation. For example, energy accounts for over 80 percent of APEC region emissions, and 73 percent of China's emissions, but only 48 percent of Vietnam's GHG emissions. This difference is due to the high proportion of Vietnamese emissions sourced from the agriculture sector (36 percent).

Figure 3: Breakdown of APEC member emissions by industry, 2005



Note: Energy sector emissions are the sum of electricity and heat, manufacturing and construction, transportation, other fuel combustion and fugitive emissions.
Source: World Resources Institute (2009).

1.3 International Policy Challenge

13. ***The potential magnitude of climate change effects and the size of emissions highlight the importance of policies that are directed at cutting GHG emissions to reduce the rate and magnitude of change.*** Specifically for developing and middle-income countries, the challenge will be to adopt policies that are effective at adapting to or mitigating the effects of climate change while laying the foundations for sustained economic growth.

14. ***As developing and middle-income countries industrialize, their rising demand for fuels, consumable products, and transport will mean that they will account for an increasing proportion of international emissions.*** At the same time, limiting and eventually reducing these emissions will come at a significant economic cost. The development of low cost, environmentally effective, and cleaner technologies will therefore be a key factor in combating climate change while allowing for continued and increasing growth in middle-income APEC economies. The United Nations Framework Convention on Climate Change (UNFCCC, 2007) estimates that a higher proportion of international investment in low cost cleaner technologies will need to be directed toward developing and middle-income countries.

15. ***The importance of concerted efforts to promote low cost clean technologies and ensure that the outcomes of research and development are available to all countries is being brought to the forefront of many forums.*** The Bali Action Plan, an outcome of the UNFCCC of the Parties 2007, outlined among other things, agreement on:

(d) Enhanced action on technology development and transfer to support action on mitigation and adaptation, including, inter alia, consideration of:

- (i) Effective mechanisms and enhanced means for the removal of obstacles to, and provision of, financial and other incentives for scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies;*
- (ii) Ways to accelerate deployment, diffusion and transfer of affordable environmentally sound technologies;*
- (iii) Cooperation on research and development of current, new and innovative technology, including win-win solutions;*
- (iv) The effectiveness of mechanisms and tools for technology cooperation in specific sectors.*

16. ***The level of investment required to return GHG emissions to current levels is estimated to be in the order of an additional US\$ 200 billion annually by 2030.*** If this investment occurs, it is likely to be targeted directly R&D into advanced CFTs, as well as investment through targeted government policies. Such investments would be designed to promote the accessibility of low cost cleaner technologies, goods and services, and knowledge and understanding in all countries.

17. ***Joint and coordinated efforts from both public and private sector parties will be required to increase investment in R&D and international knowledge diffusion.*** While progress is being made in this direction, there is still more work to be done. Currently (and this trend is expected to continue) the majority of international investment in R&D is undertaken by the private sector (Newell, 2008). However, the interaction between public and private investment strategies in technology development and diffusion is also important. Strengthening and supporting the upstream supply of technology innovations is likely to be driven through coordinated public expenditure on initial technology implementation strategies and through the reduction of impediments to knowledge transfer.

18. ***The effectiveness of investment in mitigation of GHG emissions depends heavily on the current and projected 'business as usual' emissions profiles of these regions.*** Fast growing economies, basing industrial growth on the expansion of emissions intensive activities, present a wide range of options for cost effective and efficient mitigation through the application of modern technologies. The challenge then is to make the appropriate technologies accessible to the developing countries.

2. CLIMATE FRIENDLY TECHNOLOGIES

1. ***In the context of climate change mitigation, the role of climate friendly technology can be described as lowering the costs of achieving the societal goal of stabilizing GHG emissions and concentrations to some defined level.*** This chapter outlines some of the key technologies being developed and applied internationally to address this goal.

2. ***Mitigation technologies vary along several dimensions.*** They differ by stage of development, from commercially implemented, to proven but not yet commercially viable, and technologies in the research phase. They include relatively generic technologies implemented at large scales, sector-specific technologies also implemented at relatively large scale, and more micro-level technologies applied in a more customized way at the level of the individual household or firm. Technologies targeting end-use efficiency and energy conservation represent some of the most cost efficient and important demand-side options. Advanced fossil fuel power generation and alternative energy sources are also technologies that have tremendous mitigation potential.

3. ***Some specific technologies with low-carbon capability, like hydro-electric power in China and biomass energy in ASEAN countries, already account for significant shares of total power generation, and have potential for further development.*** Industry and agriculture, which are important for APEC economies and are also major sources of global GHG emissions, can utilize sector-wide and process-specific changes in technologies, as well changes in specific practices. Mitigation actions such as reduced emissions from deforestation and forest degradation or forest management, can allow the forestry sector to have a high impact on GHG emissions.

2.1 Mitigation Technologies

4. ***The major emissions mitigation technologies are summarized in Table 4.*** The IPCC has defined four major categories through which advancements in CFTs may be made (IPCC, 2007):

- Hardware development – machines, devices and infrastructure networks;
- Software development – knowledge or programming routines used to implement technical hardware;
- Organizational/institutional settings – providing the settings to develop appropriate market and non market incentives; and
- Deployment strategies – guidance and controls such as standards that promote the development and wider use of given technologies

Table 4: Overview of Mitigation Technologies

Technologies	Key technology types	Application
Generic, large scale technologies	End use efficiency and conservation	Building design and lighting CHP, DHC Efficient lighting systems Building codes and standards Automobiles
	Advanced electricity generation from fossil fuels	NGCC, IGCC
	Carbon capture and storage	Pre-, post- and oxy-combustion
	Alternative energy sources	Wind, hydroelectric, nuclear*, solar,

Technologies	Key technology types	Application
		wave & ocean, geothermal, biomass, transport biofuels,
Sector-specific large scale technologies	Manufacturing	Sector wide
	Forestry Agriculture	Process specific (steel, cement) Operating procedures
Micro-level mitigation technologies	Methane digesters Fuel efficient stoves	

Note: * Nuclear power is mentioned in this table as an alternative to fossil-fuel based power that is used in several countries. However, it is not covered in depth in this report. For discussions about nuclear power and technologies in the context of climate change, please see World Bank (2010b, 2010c).

2.1.1 End Use Efficiency and Conservation

5. **Technologies that target end use efficiency and energy conservation represent some of the biggest demand side options in mitigating GHG emissions, as well as some of the most cost efficient emissions reduction strategies.** They include: (i) building design; (ii) combined heat and power generation, district heating and cooling; (iii) efficient lighting systems; (iv) building codes and standards; and (v) automobiles.

6. **First, the majority of savings in energy efficiency in buildings can be achieved through the use of widely accessible mature technologies in building design.** For example, in 2004, carbon emissions from the global buildings sector (including both direct emissions and electricity generation) were approximately 8.6 Gt – almost one quarter of global carbon emissions for the year. In addition, the IPCC (2007) reported that there is international evidence to suggest that up to 29 percent of baseline 2020 emissions in the residential and commercial building sectors could be reduced cost effectively. That is, even without an international carbon price, approximately 3.2 Gt of carbon dioxide emissions could potentially be removed annually in a cost efficient manner by 2020, through measures such as more efficient heating and cooling, energy efficient lighting as well as more stringent building codes and standards (IPCC, 2007).

7. **Second, combined heat and power (CHP) generation (or cogeneration) increases the efficiency of power and heat generation facilities.** What would otherwise be wasted heat produced through power generation is collected and supplied as thermal heat or as additional fuel for increased electricity generation. Cogeneration is seen as potentially offering low emissions based power and heating options for developing countries. For example, currently 13 percent of China's domestic power is provided through cogeneration facilities. However, the IEA projects that this could increase to approximately 28 percent by 2030 (IEA, 2009). When cogeneration facilities are combined with district heating and cooling (DHC) systems, further synergies are created. Depending on the construction and implementation of a DHC facility as well as the size and number of buildings, total capital and investment costs can be lower than more traditional options for heating and cooling individual buildings (IPCC, 2007).

8. **Third, if the most efficient forms of lighting currently available were implemented globally, electricity consumption accounted for by lighting in 2030 could almost be halved according to the IEA.** This would be equivalent to approximately 16Gt of abatement over 30 years. Over this time period, the IEA estimates that there could be substantial worldwide savings by lighting users due to reductions in energy intensity of lighting options. CFLs can provide up to 75 percent energy savings while operating, compared to incandescent globes. Global production of CFLs reached just over 2.5 billion units in 2006 and is projected to reach up to 4 billion units annually by 2010 if current trends continue. China accounts

for 90 percent of global production of CFLs (USAID, 2007a). Further efficiencies lie with the potential for development of Light Emitting Diode (LED) based lighting. LEDs can burn for up to 10 times longer than CFLs, and 130 times longer than incandescent lamps, and are considered to be up to 3 times more energy efficient than CFLs.

9. ***Fourth, up to 75 percent of new building energy savings can be achieved through the design and operation of buildings as complete systems.*** Due to the long life cycle of buildings, it is crucial to incorporate energy efficiency in the initial construction phase through the use of passive solar design to access natural light, high efficiency lighting and appliances, high efficiency ventilation and cooling systems and insulation (IPCC, 2007). Retrofitting existing buildings to improve energy efficiency could lead to energy savings in the order of 12-30 percent for residential houses and 50-75 percent in commercial buildings (IPCC, 2007). Building energy codes may be implemented as performance based codes that require a certain level of energy efficiency to be achieved throughout the building, or as prescriptive codes that mandate efficiency ratings and targets for major areas and appliances in the building, for example, thermal insulation of walls and window heat loss/gain characteristics.

10. ***Fifth, road transport currently accounts for the largest share of transport emissions (74 percent) as of 2007 and emissions reduction technologies for automobiles will be critical.*** Currently 36 percent of transport emissions are generated in non-OECD countries, but this is expected to climb to 46 percent by 2030 if current trends continue. As economic growth continues and larger shares of the global population joins the market for motorized transport, the global transport sector is projected to increase its energy use by up to 80 percent over the period 2002-2030 under “business as usual” (World Business Council for Sustainable Development, 2004). Strong advances in fuel efficiency technology and alternate fuels are thus required to achieve significant reductions in this rate of growth and reduce the current dependence on petroleum fuels (IPCC, 2007). The hybrid electric engine has been considered one of the leading options for climate friendly transport in the future. It has the ability to reduce GHG emissions by between 30-50 percent compared to petrol, and without a reduction in power or safety performance (Romm, 2006).

2.1.2 Advanced Fossil Fuel Based Power Generation

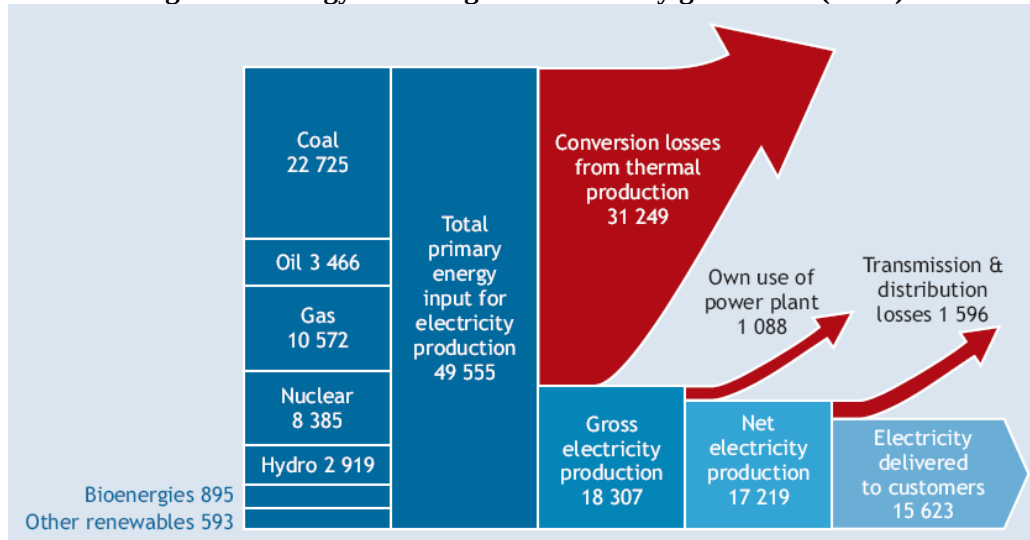
11. ***The power generation sector is the largest proportional contributor to GHG emissions of any sector internationally*** (Matysek et al., 2005; IPCC, 2007). It accounts for 26 percent of all GHG emissions, and up to 40 percent of CO₂ emissions. There is room for efficiency improvements, since the the current system loses up to 63 percent of energy generation through conversion losses. Figure 4 describes the energy flows in global electricity generation.

12. ***Advances in reducing the emissions intensity of fossil fuel based power stations are being led by the development of natural gas combined cycle (NGCC) or integrated gasification combined cycle (IGCC) power plants.*** With 41 percent of global electricity generated by coal and an additional 5.8 percent by oil, the potential for reducing the emissions intensity of fossil fuel based electricity generation through technologies like NGCC and IGCC has marked benefits over other alternatives (IEA, 2008a).

2.1.3 Carbon Capture and Storage

13. ***Carbon capture and storage (CCS) technology is a technically viable option for future abatement of carbon dioxide emissions, while still allowing coal based electricity generation.*** The Australian Bureau of Agriculture and Resource Economics has modeled the global impacts from an imposed CO₂ abatement task, focusing on the power generation sector. The model estimates that by 2050, the reduction in global GDP due to an imposed carbon penalty could be up to 5 percent. However, with advances in CCS technologies, this reduction could be limited to just over one percent (Matysek et al., 2005).

Figure 4: Energy flows in global electricity generation (TWh)



Source: IEA (2008)

14. ***The power generation sector is the most promising sector for the implementation of CCS technology.*** By 2030, up to 22 percent of global electricity is projected to be generated from fossil fuel based power plants fitted with CCS technology; this penetration rate is projected to increase to approximately 40 percent by 2050 (Gielen, 2003). The National Energy Technology Laboratory (2008) estimates that the least cost technologies per tonne of CO₂ avoided are associated with IGCC and NGCC plants (Table 5).

Table 5: Estimates of avoided CO₂ by type of power plant (US\$/t CO₂)

Technology	US\$/t CO ₂
Subcritical pulverized coal	75
Supercritical pulverized coal	68
Ultra-supercritical pulverized coal	61
Supercritical oxyfuel	57
Ultra-supercritical oxyfuel	50
Integrated gasification combined cycle	35-46
Natural gas combined cycle	-

Notes: Refers to captured CO₂ only. Transport and storage cost estimates refer to a 50 mile pipeline using saline storage 4,500 ft below the surface with monitoring for 100 years.

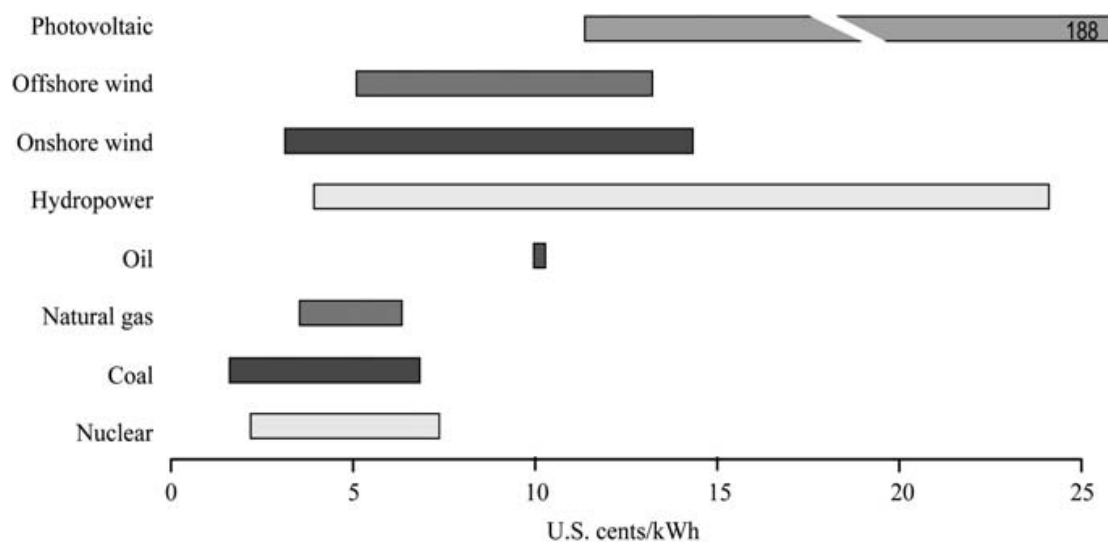
Source: National Energy Technology Laboratory (2008)

2.1.4 Alternative Energy Sources

15. ***Alternative energy sources accounted for 41 percent of global additions to electricity generation in 2008, equivalent to approximately 65GW of installed renewable energy capacity (UNEP, 2009).*** However, relative costs per unit of energy have been a major constraint to the expansion of alternate energy technologies. A comparison of cost estimates shows that while the lower bounds of expectations for some alternative energy sources are in the range of coal based technologies (for example wind, biomass and small hydropower), in general, traditional power plants have lower investment and capital costs, as well as lower generation costs (Figure 5). Despite the relatively higher costs, renewable

energy technologies produce lower emissions than coal-based energy options (Table 6). Alternative sources are discussed in more detail below².

Figure 5: Costs Associated with New Construction for Different Electricity Generation Technologies (US cents kWh)



Note: The costs are “normalized”, equal to the constant dollar price of electricity that would be required over the life of the plant to cover all operating expenses, interest and repayment obligations on project debt, and taxes plus an acceptable return to equity investors over the economic life of the project.

Source: Kessides (2010)

² It should be noted that only non-nuclear energy technologies are discussed at length in this report. Nuclear technologies are discussed in detail in other World Bank reports (e.g. World Bank, 2010b, 2010c).

Table 6: Greenhouse intensity summary for non-nuclear technologies in Australia (gCO₂e/kWh)

Technology	Typical	Minimum	Maximum
Black coal PF fuel	941	843	1171
Black coal supercritical	863	774	1046
Brown coal subcritical	1175	1011	1506
Natural gas turbine – open cycle	751	627	891
Natural gas – combined cycle	577	491	655
Wind power	21	13	40
Photovoltaic generation	106	53	217
Hydropower	15	6.5	44

Source: Lenzen (2008)

16. Wind: This is considered to be a mature renewable technology that is competitive with conventional power generation technologies when implemented in windy areas. Global installed capacity of wind power grew by 45 percent over 2005-06 and by a further 21 percent in 2006-07, the highest growth rate of any renewable form of electricity generation (IEA, 2008b, 2008c). The flexibility of wind technology is one of the key advantages of the technology, assuming sufficient wind availability. Turbines can be adapted from small scale operations of less than 1 kW (with less than 1kW of installed power) to large scale off-shore wind farms with turbines in excess of 2,000 kW (with greater than 100MW of installed capacity). On average, new turbines currently being installed provide 500 kW to 4.5 MW of installed capacity. However, the supply of wind power is related closely to the reliability of wind supply. That is, if wind supply is unreliable, then power system operators will need to worry about contingent power sources when wind is low. Public concerns about aesthetics also limit wide scale deployment of wind power technology.

17. Hydroelectric: This is considered to have a mature market, and can be cheap to produce and access if resources are available. Hydropower accounted for 17 percent of global electricity supply. Projections of the global capacity for hydropower generation are in the order of 2,800 GW of installed capacity, more than three times current capacity (Environmental Resources Group 2010). However, environmental concerns and economic constraints are likely to constrain the world from reaching this technical capacity. As well as relying on the existence of suitable water resources at suitable locations, the large scale inundation of land areas associated with damming waterways raises environmental concerns. These have an impact on the feasibility of certain hydropower projects. Other concerns relate to increased methane emissions from reservoirs and inundated areas (Whittington, 2007), and the effects of climate change related impacts, such as reduced rainfall, snowfall and snowmelt on output levels of hydroelectricity plant (Pirker, 2007).

18. Solar: This is growing in a few markets, although it is currently not considered to be commercially competitive with electricity generated from fossil fuels. However, it has lower life-cycle emissions intensities than traditional coal-fired power plants (IPCC, 2007). Growth rates of up to 30 percent annually are being observed in developing countries' installed capacity. While electricity generated from solar photovoltaic (PV) technologies is uncompetitive with traditional grid-connected electricity generation technologies, the technologies are used in a number of niche applications, including for off-grid standalone systems that supply electricity for telecommunications and for lighting in areas where grid connection is prohibitively expensive (Matysek et al., 2005). There is substantial potential for the broad application of PV systems, both in developing countries and in regional and remote areas of developed countries.

19. Nuclear: Approximately 14 percent of global electricity was generated in nuclear reactors. There is a non-uniform distribution of installed capacity, with the proportion of domestic power sourced from

nuclear energy varying widely, and ranging from up to 78 percent in France to 2 percent in China. In 2006, the IAEA estimated global emissions from the electricity generation sector to be approximately 10.6 Gt CO₂ and estimated that without nuclear energy, this figure could have been as high as 13 GtCO₂, implying significantly lower GHG emissions from global electricity generation due to nuclear power (IAEA, 2006). However, the future growth in the nuclear power sector is uncertain due to concerns about proliferation, waste disposal, operational safety, as well as, in some instances, the economic competitiveness of nuclear power compared to alternate electricity sources (IPCC, 2007).

20. Wave and Ocean: There are three experimental, main ocean-based technologies for energy. The first, oceanic thermal energy conversion is very expensive and poses significant technical challenges. The potential for wide scale implementation is therefore limited, and future deployment is likely to be located in a few specific areas. The second, tidal energy systems, require minimum tidal differences to power turbines, despite high capital costs, is considered to have large potential. There are tidal power stations in China, and in South Korea, where the Sihwa-Lak tidal plant is expected to begin operations in 2009 (World Energy Council, 2007). The third technology uses wave power to drive turbines, but is not widely commercially available. This is primarily because estimates of current generating costs for wave energy technology are high (in excess of US\$ 300/kWh). Costs are high because of the high fixed costs associated with surveys, R&D, grid connections and permits for a single device. Moreover, over-engineering often occurs to withstand the unpredictable conditions in which the technology must operate

21. Geothermal: The costs of geothermal power plants have been declining since the 1980s. These are highly site specific, and depend on a number of factors, including the size of the plant, the power plant technology, the understanding of the resource, the temperature of the resource, the chemistry of the geothermal water, and resource depth and permeability. While the upfront costs of constructing a geothermal power plant are high relative to other technologies, the long term cost of geothermal power can be competitive with natural gas. The Philippines and Indonesia produce major shares of the electricity from geothermal power globally, while China is the world's largest user of direct use geothermal energy Table 7. Geothermal power accounts for a significant share of the Philippines' generation mix at 18 percent (World Energy Council, 2007). Geothermal power currently accounts for around 3 percent of Indonesia's generation mix. However, this share is expected to grow over time as Indonesia has perhaps the world's richest geothermal resources and current installed capacity is only 4 percent of potential.

Table 7: Major geothermal countries, 2004

Geothermal electricity production		Geothermal direct use	
Country	GWh	Country	GWh
USA	17917	China	12605
Philippines	9253	Sweden	10000
Mexico	6282	USA	8678
Indonesia	6085	Turkey	6900
Italy	5340	Iceland	6806
Japan	3467	Japan	2862
New Zealand	2774	Hungary	2206
Iceland	1483	Italy	2098
Costa Rica	1145	New Zealand	1968

Source: World Energy Council (2007)

22. Biomass: This may be used as the basis for alternative fuel sources in both the transport and power generation sectors, and has strong prospects in South East Asia (Table 8). Projections for key countries of interest are also promising with biomass potential estimated at around 50,000MW in Indonesia, 3000MW in Thailand, 1100MW in Malaysia (Balce et al., n.d.). Using biomass to generate power can have beneficial GHG implications, depending on the type of feedstock used and how it is

grown. While there is some scope for the increased use of biomass in many middle-income APEC economies, there are also some risks where biomass competes for scarce inputs or conflicts with food producing capability.

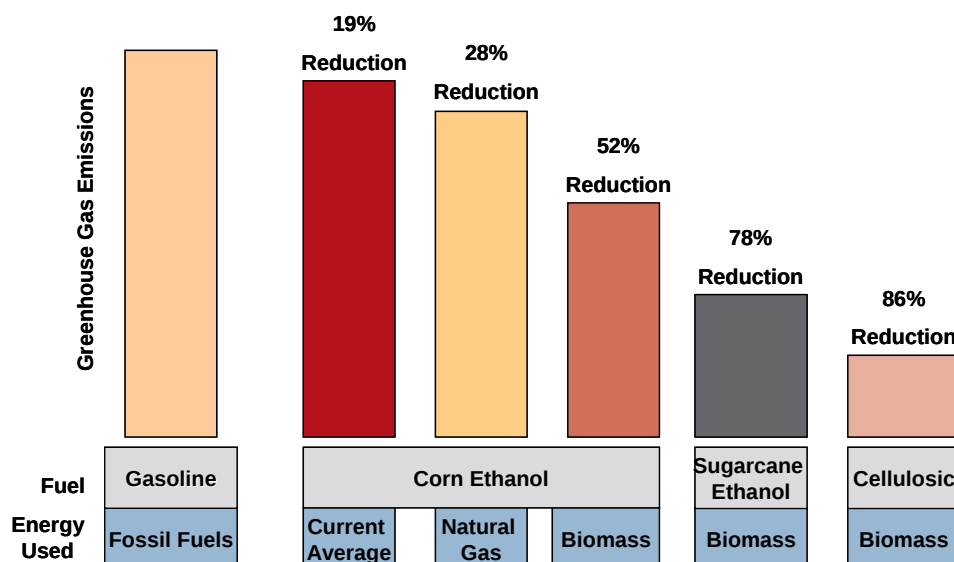
23. *The two most prevalent biofuels being used internationally in the transport sector are ethanol and biodiesel.* There is global potential for ethanol to mitigate up to 500-1200 MtCO₂, and up to 100-300 MtCO₂ for biodiesel by 2030. Ethanol generates significant reductions in GHG emissions compared to petrol, due to the relatively high efficiency of production (Figure 6). Competition for feedstocks of biodiesel is more intense than for biofuels, hence production costs are generally higher. Crops used for food supply are the main competitors for biodiesel, and greater production of biodiesel thus puts greater pressure on food supplies. Ligno-cellulosic biofuels, although currently not commercially available, are considered to be a promising area of future development. Currently there are a number of cellulosic plants under construction in the United States, with pilot plants operating in China and one in Japan (APEC Energy Working Group, 2008b).

Table 8: Renewable energy status for power generation in South East Asia (2000) in MW

Country	Biomass	Geo-thermal	Hydro	Mini micro-hydro	Solar	Wind	Total (MW)
Brunei D.	-	-	-	-	0.0024	-	0.0024
Cambodia	n.d.	-	18	0.96	1.13	-	19.09
Indonesia	302	363	4246	21	8	0.4	4940.4
Lao PDR	n.d	-	621	6	0.16	-	627.16
Malaysia	213	-	2225	6	2.19	0.15	2446.34
Myanmar	-	-	340	83	0.24	-	423.24
Philippines	21	1960	2480	230	0.44	0.016	4691.5
Singapore	220	-	-	-	-	-	220
Thailand	1230	0.3	2886	94	8	0.17	4218.47
Vietnam	n.d	-	3294	62	0.11	0.15	3356.26
ASEAN-10	1986	2323.3	16110	502.95	19.27	0.93	20942.46

Source: Balce et al. (n.d.)

Figure 6: Potential GHG emissions reductions for selected biofuels



Source: Wang et al. (2007)

2.1.5 Large-Scale Sector-Specific Technologies

24. ***In the manufacturing sector, mitigation technologies can be generally divided into cross-sectoral technologies and sector specific technologies.*** Energy efficiency can be increased substantially through cross-sectoral approaches that improve power motor design, that improve design of boiler systems, that allow for switching between fuel options (between fossil fuels as well as between fossil and non-fossil fuels), and that adopt industry-wide options to recover heat and power. Sector specific technologies are available and being researched in all major sectors. The majority of technologies are directed at reducing the energy intensity of production and applying broader categories of technologies to specific industries, for example, fuel switching, CHP, re-use of waste gas, and CCS. Here specific technologies in steel and cement manufacturing are considered.

25. ***In the forestry sector, there are a number of methods to mitigate GHG emissions.*** These include:

- Reduced emissions from deforestation and forest degradation;
- Improved sequestration rates in existing and newly established forests;
- The use of wood based fuels as substitutes for fossil fuels; and
- The use of wood products for more energy intensive materials.

26. ***Forest management practices*** also have a strong impact on the level of GHG emissions from the forestry sector. Management practices that are directed at reducing net GHG emissions include:

- Harvest methods that maintain partial levels of forest cover;
- Minimizing the loss of dead organic matter or soil carbon through soil erosion; and
- Avoiding slash and burn practices.
- Management of offsite carbon stocks in wood products.

27. ***Afforestation practices*** represent about 30 percent of the global mitigation potential, with the potential varying by region (Table 9). While further international research on modeling assumptions is progressing to address these divergences, initial results can provide indications on the relativities of options to mitigate GHG emissions from forestry. Differences in the projected costs are significant across industrialized and developing countries. The costs of forestry mitigation projects in developing economies have been estimated to be in the range of USD0.5-7/tCO₂, compared to those in industrialized countries of USD1.4-22/tCO₂ (Richards and Stokes, 2004).

28. ***In the agriculture sector, there are number of commercially available agricultural technologies to mitigate GHG emissions.*** The technologies that are currently available include (IPCC, 2007):

- Improved crop grazing and land management to increase soil carbon storage;
- The restoration of cultivated peaty soils and degraded land;
- Improved rice cultivation techniques, and livestock and manure management to reduce methane emissions;
- Improved nitrogen fertilizer application techniques to reduce nitrous oxide emissions;
- Dedicated energy crops to replace fossil fuel use; and
- Improved energy efficiency.

2.1.6 Micro-Scale Technologies

29. Methane digesters are based on the avoided use of wood and other fuel products, as well as the reduced use of chemical based fertilizers, and provide multiple benefits. These include improved health and sanitation through the disposal of waste, the generation of fertilizer, and access to clean and efficient energy for cooking and lighting. The biogas produced is approximately 60 percent methane, and a single digester can provide up to 60 percent of a family's energy needs. Small scale household methane digesters have been utilized for decades, with China having promoted the use of underground anaerobic digesters for rural waste since 1970. Currently, up to 16 million households worldwide are utilizing small scale methane digesters. It is estimated that in China, approximately 6.5 billion cubic meters of methane was produced in 2005 from 17 million household methane digesters, generating approximately 135,902TJ (Yu, 2008).

Table 9: GHG mitigation potential, 2030, by forestry activity for selected regions

Region	Activity	Mitigation potential in tCO ₂ at 2030, price of less than USD100/tCO ₂	Fraction of mitigation achieved at cost USD1-20/tCO ₂	Fractions of mitigation achieved at cost of USD20-50/tCO ₂
Non-annex I East Asia	Afforestation	605	0.26	0.26
	Reduced deforestation	110	0.35	0.29
	Forest management	1200	0.25	0.28
	Total	1915	0.26	0.27
Countries in transition	Afforestation	545	0.35	0.3
	Reduced deforestation	85	0.37	0.22
	Forest management	1055	0.32	0.27
	Total	1685	0.33	0.28
Other Asia	Afforestation	745	0.39	0.31
	Reduced deforestation	670	0.52	0.23
	Forest management	960	0.54	0.19
	Total	2375	0.49	0.24
Total	Afforestation	4045	0.4	0.28
	Reduced deforestation	3950	0.54	0.28
	Forest management	5780	0.34	0.28
	Total	13775	0.42	0.28

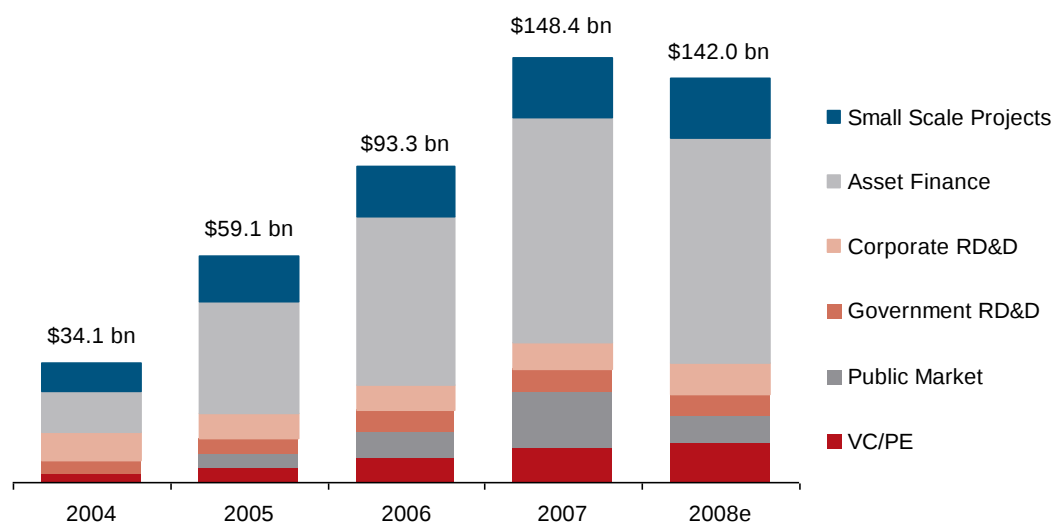
Source: IPCC (2007); Sohngen and Sedjo (2006); Sathaye et al. (2007); Benítez-Ponce et al. (2007); Vuuren et al. (2007).

30. Fuel efficient stove technologies reduce the amount of fuel utilized in cooking through higher combustion efficiency and also have lower GHG emissions. Depending on the type of fuel used, and the previous levels of efficiency, anywhere between 1.6 and 3 tonnes of CO₂ may be mitigated annually through the use of ore efficient cooking stoves (Practical Action, 2010). The use of fuel-efficient stoves has a range of positive impacts on development, such as reducing the amount of biomass used to fuel the stoves. A further benefit is the increase in indoor air quality, which can in turn reduce the overall health costs of the community (IPCC, 2007). The development of fuel efficient stoves over the past decades means that the technology has surpassed the development and demonstration phase and is currently being implemented, with stove operation occurring in many developing communities throughout the world (FAO, 2010).

2.2 Global Investment Flows and Requirements

31. ***The Stern Review reported annual investment requirements of approximately US\$ 500 billion from 2007-2050 to cap atmospheric concentrations of GHGs at 550ppm CO₂e (Stern, 2006).*** As shown in Figure 7, global investment has not kept up with these estimates.

Figure 7: Total global new investment in clean energy, 2004-2008 US\$ billions



Note: Figures marked * are based on industry estimates from various sources; all others are extrapolated values based on disclosed deals from the New Energy Finance Industry Intelligence Database; figures are adjusted to remove double-counting.

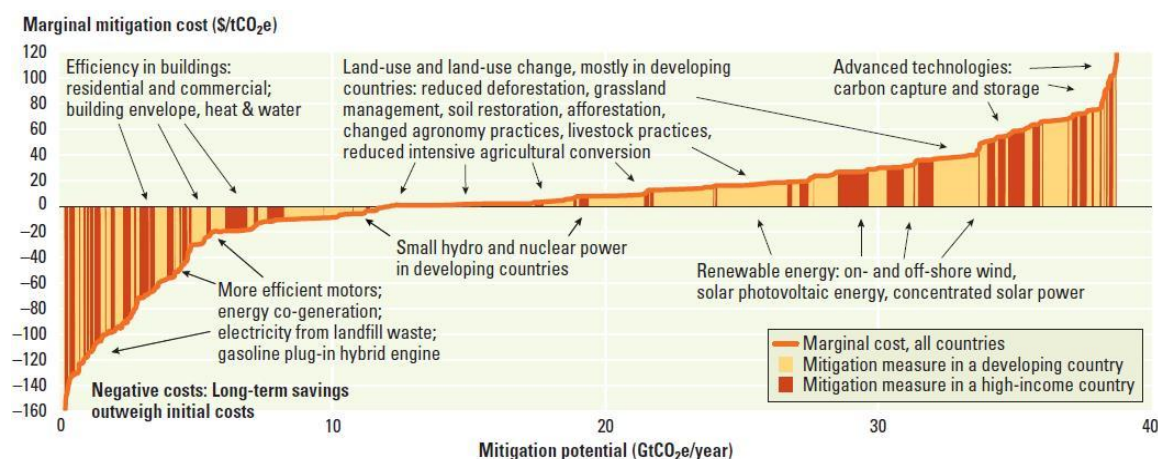
Source: World Economic Forum (2009)

32. ***There are a number of challenges in estimating the global cost of mitigating emissions.*** The costs of different mitigation technologies will differ across the globe. Drivers of the cost effectiveness of mitigation technologies will rely on current conditions such as domestic power generation profile (for example, the GHG emissions intensity of current power generation), as well as on access to resources, time to replacement of current infrastructure, government policies and cultural characteristics.

33. ***There are a number of international and national studies that consider the global and regional marginal abatement schedules for carbon dioxide emissions and GHG emissions.*** The World Bank's World Development Report 2010 (World Bank, 2010a) provides a potential global marginal abatement cost curve including various mitigation measures, with the width of each bar indicating the amount of emission reduction each measure would achieve and the height indicating the measure per ton of avoided emissions. Tracing the height of the bars creates a marginal mitigation cost curve (Figure 8). A similar figure developed by the Asian Development Bank (ADB, 2009a) for Indonesia's marginal abatement cost (MAC) projected at 2020 is presented in Figure 9. Figure 10 shows a combined MAC for Indonesia, Thailand, Vietnam and Philippines. All of the MAC assessments are based on 'bottom-up' studies of the costs of mitigation and generally underestimate the total costs of abatement by not including the very real costs of barrier removal for penetration of potentially lower-cost alternatives. However, they can provide some information on potential choices among alternative technologies for mitigation³.

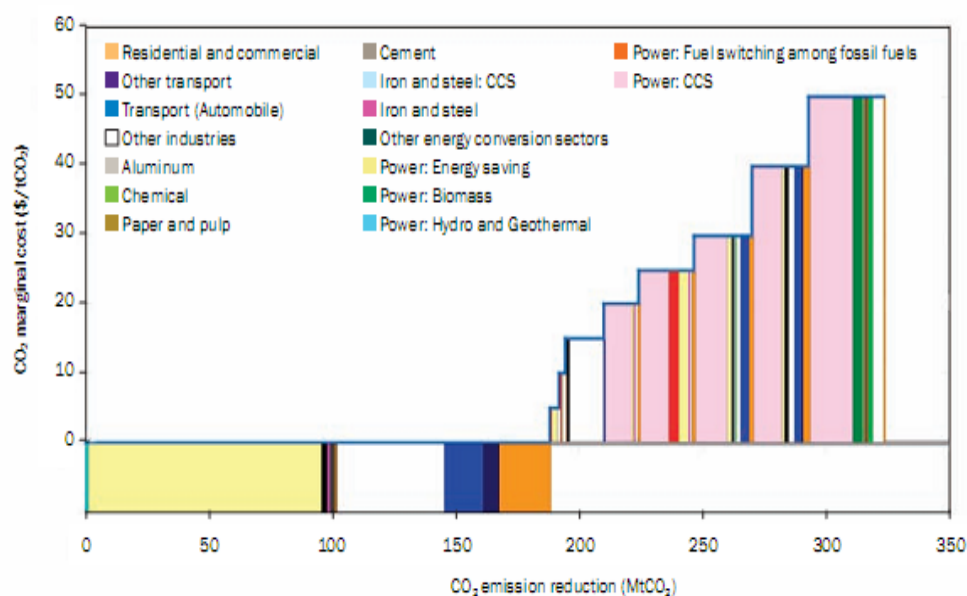
³ It is important to add the caveat that this marginal abatement curve is a potential cost curve that by design does not include a whole range of relevant costs including those associated with reducing price distortions, increasing, increasing awareness and

Figure 8: Global greenhouse gas mitigation marginal cost curve beyond 2030 under the business-as-usual scenario



Source: World Bank (2010a)

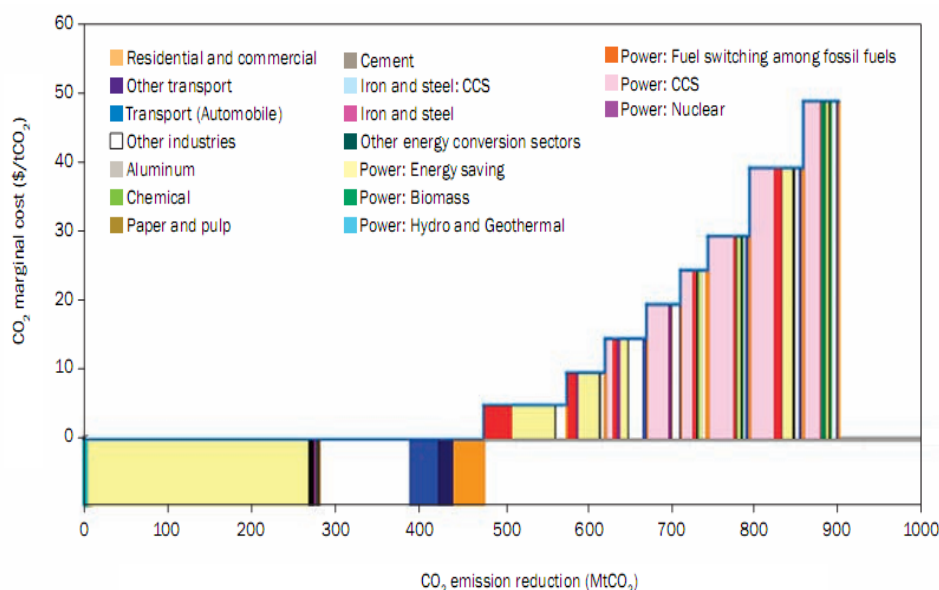
Figure 9: Aggregate marginal abatement cost curve at 2020: Indonesia



Source: ADB (2009a)

institutional capacities for technology change, shake-out periods for new technologies, and so forth. The actual MC curve will have larger cost (or smaller negative costs) for just about all the listed items.

Figure 10: Aggregate marginal abatement cost curve at 2020: Indonesia, Vietnam, Thailand and Philippines



Source: ADB (2009a)

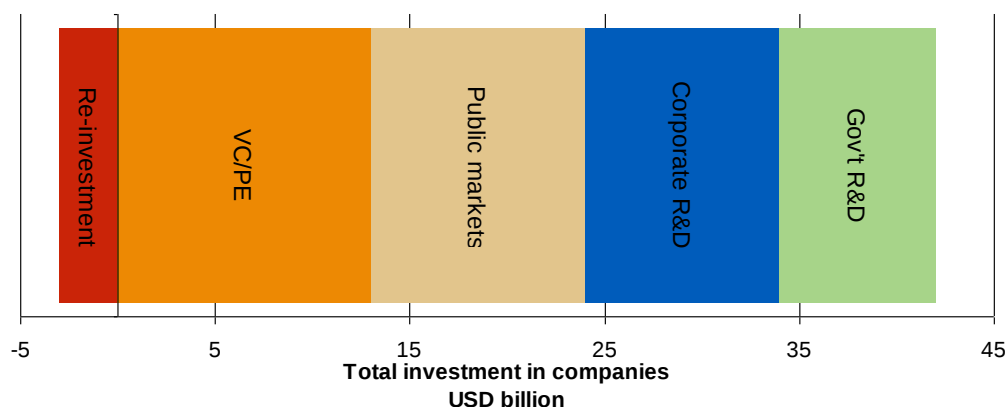
34. **Total investment in clean energy⁴ has increased from approximately US\$ 33 billion in 2004 to approximately USD148 billion in 2007, dropping slightly in 2008 to approximately USD142 billion (World Economic Forum, 2009).** Of this figure, US\$ 42.6 billion was invested directly into companies via venture capital, company based R&D funds, government research and development funds, and public markets. This investment was used to finance equipment manufacturing and production up-scaling, as well as technology development. The majority of global investment in CFTs and technology transfers are made via the private sector in the form of corporate R&D, venture capital or asset financing arrangements, or via funds raised on public markets (UNEP, 2009a). The breakdown of company based investment, by source, is presented in Figure 11⁵.

35. **The majority of global investment in clean energy – such as may be produced by climate friendly technologies – was sourced from third party investors, through asset financing, public markets and venture capital and private equity with these investments accounting for US\$ 121 billion of clean energy investment in 2008.** This was made up of US\$ 97 billion of asset financing, US\$ 9.4 billion from public markets and US\$ 14.2 billion from venture capital and private equity. These investment trends identify third party investors as the largest source of international financing of clean energy technology. Corporate and government based research and development accounted for a total of US\$ 19 billion in 2008, while third party investors accounted for approximately US\$ 121 billion.

⁴ Defined by New Energy Finance (2009) to include renewable energy and energy efficiency but to exclude nuclear power and large scale hydropower

⁵ These investment figures do not include asset financing for the development and deployment of clean energy projects, where asset financing takes the form of internal company balance sheets, debt financing or equity financing. Total asset financing of clean energy projects in 2008 is estimated to be US\$ 97 billion (World Economic Forum, 2009; UNEP, 2009).

Figure 11 Global, company based investment in clean energy, 2008



Note: VC/PE refers to venture capital/private equity.

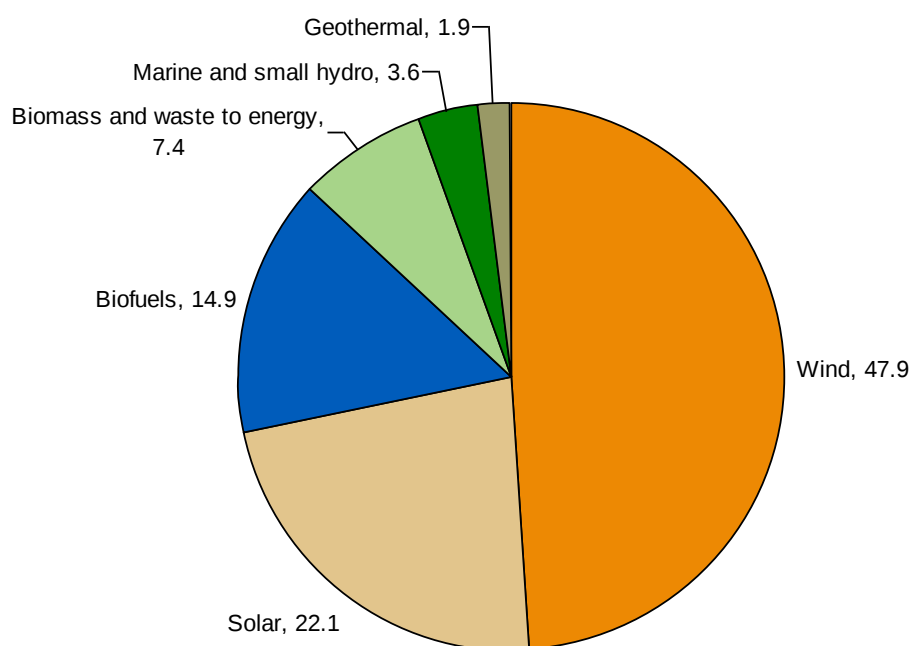
Source: UNEP (2009a)

36. Services and companies facilitating investment in companies researching and developing CFTs have also seen significant growth over the period 2004-2007. In 2004, the market for investment vehicles to finance investment in clean energy was limited to 10 quoted equity funds, predominantly run by specialized companies. By 2007, there were more than 30 funds with in excess of US\$ 42 billion of assets. These funds were run by a wide array of companies, including large banks and specialist companies (World Economic Forum, 2009).

37. ***In terms of investment in specific technologies, wind, solar and biofuels technologies attracted the largest proportion of third party investment in 2008.*** Wind power alone accounts for almost half of capacity investment worldwide in 2008 (Figure 12). With these patterns have evolving over time:

- Asset financing for new build wind farming increased by 1 percent from US\$ 41.3 billion in 2007 to US\$ 47.9 billion in 2008, maintaining its position as the most heavily investor supported sustainable energy technology.
- New build solar projects experienced a large increase in investment over 2007 to 2008, almost doubling from US\$ 12.1 billion to US\$ 22.1 billion. With an average annual growth rate of 70 percent over 2006 to 2008, solar power is the fastest growing sustainable energy sector for new investment. In 2008, solar power was the leading technology invested in through private markets, accounting for 56 percent of public market investment, or US\$ 6.4 billion (UNEP, 2009a).
- Global investment in biofuels fell by 9 percent in 2008 to US\$ 17 billion. Market conditions that contributed to this decline in new investment were high levels of investment in early 2007, higher global wheat prices in 2008, lower world oil prices, and increased debate over the tension between food and biofuel prices. A significant outcome of these developments was that investment in second generation (wood based lignocellulosic products) biofuels exceeded that in first generation (starches, sugar and animal and vegetable fats) biofuel technologies for the first time during the second half of 2008 (UNEP, 2009a).

Figure 12: Asset financing of new build power projects, by type, 2008 (US\$ billions)



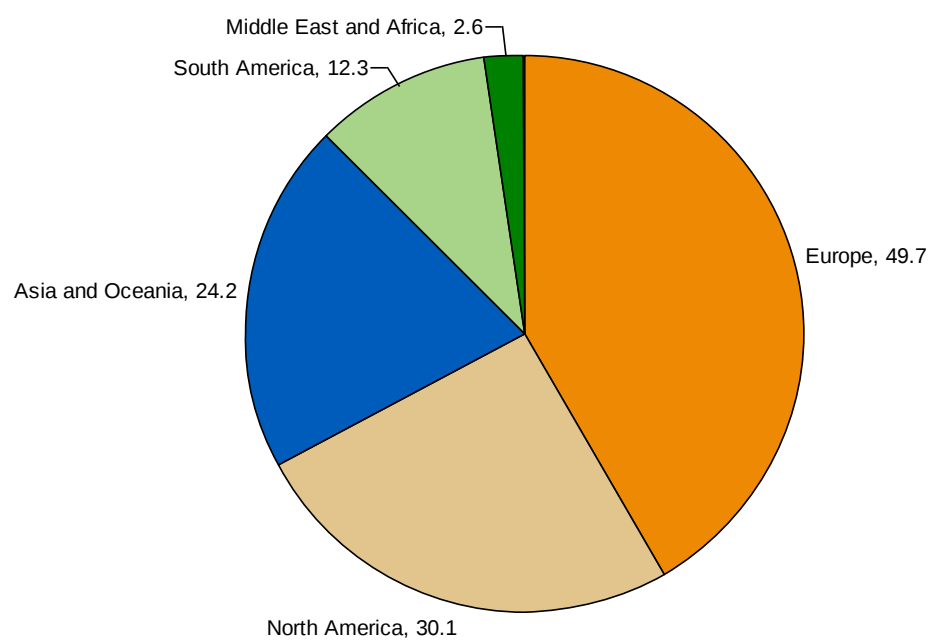
Source: UNEP (2009a)

38. ***Investment in clean energy has become increasingly geographically diversified.*** In 2004, non-OECD developing economies accounted for only 13 percent of global asset financing in clean energy. In 2007 non-OECD developing economies accounted for up to 23 percent of clean energy asset financing (or US\$ 26 billion). Investment in developing countries remains concentrated, however, with the majority of investment in 2007 directed at the fastest growing economies of China, India and Brazil. In 2008, 31 percent of global investment in clean energy and energy efficiency technologies was invested in developing countries, an increase from 26 percent in 2007 (Figure 13). Of the total investment value of approximately US\$ 36.6 billion in developing countries in 2008, 43 percent, or US\$ 15.6 billion was destined for the Chinese market (UNEP, 2009a).

39. ***Investment in CFTs was also affected by the 2008 global financial crisis.*** With global investment in sustainable energy technologies approximately US\$ 148 billion in 2007, there was only a 5 percent increase in total investment from 2007 to 2008. Despite this aggregate increase, investment in the second half of 2008 fell by 17 percent relative to the first six months, and was 23 percent below the second half of 2007 (UNEP, 2009a, 2009b).

40. ***To support the industry, many governments have listed CFTs as target sectors for economic stimulus packages.*** The level of funding for CFTs varies greatly across governments. For example, while China and the US allocated approximately US\$ 67 billion each to sustainable energy, the EU-27 has allocated only US\$ 11 billion and Japan US\$ 8 billion - or around 3 percent of total stimulus spending (UNEP, 2009a).

Figure 13: New investment in sustainable energy by region, 2008 (US\$ billions)



Note: Total financial new investment of USD119 billion, made up of asset financing, VC/PE and public market investments.
Source: UNEP (2009a)

3. CURRENT STATUS OF CFTs IN MIDDLE INCOME APEC ECONOMIES

1. *This chapter describes the current status of selected major CFTs in China, Indonesia, Thailand and Vietnam.* Section 3.1 discusses the current usage and production of specific technologies. Section 3.2 discusses the transfer of technologies through investment and trade, while Section 3.3 discusses the importance of financing mechanisms in guiding use and production choices of CFTs. Section 3.4 uses patent statistics to examine the state of R&D in CFTs in APEC.

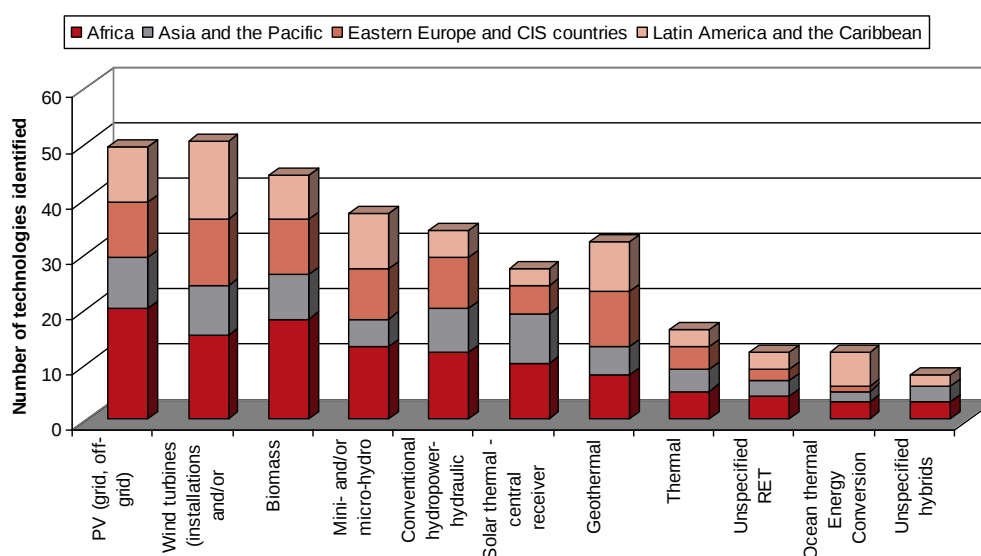
2. *APEC member countries have substantial potential to develop and absorb a range of different CFTs into their significant projected growth.* Putting this potential into context, the 21 APEC member economies account for approximately 41 percent of the world's population, 56 percent of world GDP, and 60 percent of global energy demand. At the same time, these countries vary a great deal in terms of geography and natural resources, degree of development, and production and industrial profiles. The analysis of CFTs applied in middle-income APEC economies accordingly highlights significant differences in the extent to which different technologies have been used, produced, and traded.

3.1 Status and Potential of Mitigation Technologies

3. *The UNFCCC Secretariat identifies those CFTs that are considered to be of greatest interest to middle-income APEC economies (UNFCCC, 2009).* As illustrated by Figure 14 within the Asia Pacific region, the key major technologies are:

- Wind power;
- Conventional hydro-power, and mini and/or micro hydropower;
- Photovoltaic (both on and off-grid connectivity) and solar thermal power;
- Electricity generated from biomass; and
- Geothermal power.

Figure 14: Renewable Energy Technologies Identified in Technology Needs Assessment Reports



Source: UNFCCC (2009)

3.1.1 Wind

4. ***Wind power is widely used in China, Indonesia, Thailand, and Vietnam.*** Wind power in China accounted for 25.1 GW of electricity generating capacity in China as of 2009 (New York Times, 2010). In Indonesia, installed wind power capacity is around 0.5MW to 1MW, with power generation predominantly located in eastern regions of Indonesia for powering water pumping stations and recharging batteries. There was 0.7MW of installed capacity in Thailand, as of 2006, with the energy being used in agricultural water pumping and electricity generation. Wind power projects in Vietnam include the Phuong Mai 3 Wind Power Plant (55 MW), and the Tuy Phong project with a capacity of 7.5 MW in 2010 (Unibros, 2010).

5. ***There is potential for further use and production in these countries.*** China has doubled its wind power installations for four straight years and is on track to become the world's second largest wind energy producer by 2010 (Li et al., 2007). China is also one of the developing economy leaders in the production of wind energy. With the development and installation of wind turbines of up to 750 kW, the wind sector is considered to be a mature commercial industry (Brewer, 2009). China has approximately 20 domestic manufacturers, and was the seventh largest exporter of wind energy technology in 2008. The installed capacity from wind energy in Vietnam is low, yet the technical capacity for wind power in Vietnam can be up to 2000 MW (Unibros, 2010).

3.1.2 Hydro Power

6. ***Hydropower is widely used in China, Indonesia, and, to a lesser extent, Vietnam.*** China accounts for approximately 14 percent of global installed hydroelectric capacity. Over the last five decades, China's hydropower growth has been rapid, and, as of 2008, the installed capacity of hydropower was 145.26 GW (Huang and Yan, 2009). In 2006, Indonesia produced around 9.53GWh of energy from hydroelectric power stations (Index Mundi, 2010). 34.8 percent of electricity in 2007 in Vietnam was generated from large and medium hydropower sources (APEC, 2009). Small hydropower units accounted for around 200MW of installed capacity. At present, there are about 300 off-grid small hydropower plants with a unit capacity between 5 and 200kW and around 150,000 small hydropower systems (0.1-1kW) for households (Asian Development Bank, 2009).

7. ***China and Indonesia have potential for further production and use.*** China has the richest hydro resources in the world with a total theoretical hydropower potential of 694GW. The capacity for hydropower in Indonesia has been estimated at approximately 76GW. However due to financial, legal and political factors, only about 6 percent of this capacity has been utilized. Due to the location of water resources, the remote location of villages, and island nature of the country, the potential for hydroelectric development is limited to small and micro level hydroelectric power plants. Recent moves and government support for the development of hydropower has provided a renewed emphasis on market and capacity development. One such program is the Mini Hydro Power Program (MHPP), a joint initiative between the Indonesian government's Directorate General for Electricity and Energy Utilization, the German Organization for Technical Cooperation (GTZ), and the Dutch SenterNovem (SenterNovem, 2009).

3.1.3 Biofuels – Ethanol and Biodiesel

8. ***The APEC region accounted for approximately 40 percent of the world's ethanol production in 2006, that is, 20,600 million liters, as seen in Table 10 (APEC Energy Working Group, 2008b).*** The majority of production was in the USA, although there was growth in production in Australia, Canada, China, Indonesia, and Thailand. Biodiesel production was also substantial within APEC member economies, with approximately 2,000 million liters produced in 2006, close to 32 percent of total world production.

9. ***China, Indonesia, and Thailand are among global leaders in biofuels production.*** China was the third largest global producer of biofuels in 2005, behind Brazil and the USA (USDA, 2006). More than 90 percent of Chinese biofuel production is from ethanol production, with the primary feedstock being wheat and corn (Weyerhaeuser, 2007). Biodiesel production in China has been relatively limited, with an estimated 117 million liters of production in 2007. Indonesia is currently the world's largest producer of crude palm oil (CPO), while Thailand is the world's third largest producer of biodiesel, with the predominant feed stock of palm oil (APEC Energy Working Group, 2008b). Thailand had nine operating plants in 2008 with a total production capacity of approximately 435 million liters.

10. ***Thailand and Vietnam are anticipating further increases in the use of biofuels.*** The Thai government has announced the goal of replacing 10 percent of diesel consumption with biodiesel by 2012, and an additional 440 million liters of capacity is planned for construction across nine additional plants. In Vietnam, the government has announced goals of up to 500 million liters of production of fuel ethanol by 2020, and 50 million liters of biodiesel (APEC Energy Working Group, 2008c).

11. ***Most of biofuels are produced for domestic consumption.*** The majority of China's ethanol is consumed in the pharmaceutical and beverage industry, not as transport fuel. China had four operating bioethanol plants in 2006, with an additional four scheduled for completion in 2007 (APEC Energy Working Group, 2008b). Currently, relatively small amounts of Indonesian biodiesel are exported to China, the European Union and the United States, with CPO being the main traded commodity. With approximately 17.4 million tonnes of CPO produced in Indonesia in 2007, just over 13 million tonnes of CPO are estimated to have been exported. In Thailand, only 4 million liters of ethanol was exported to Singapore, the Philippines, Chinese Taipei, Australia and Europe out the approximately 193 million liters produced in 2007 (APEC Energy Working Group, 2008c)

Table 10: Biofuel Production in APEC Economies (million liters)

	Ethanol			Biodiesel	
	2006 (all grades)	2006 (Fuel)	2007 E (Fuel)	2006	2007 E
Australia	149	84	250	76	117
Brunei Darussalam	0	0	0	0	0
Canada	569	455	800	47	105
Chile	N/A	0	0	0	0
China	3,550	1,300	1,600	35	117
Hong Kong SAR, China	N/A	0	0	0	0
Indonesia	170	82	140	590	1,550
Japan	134	0.03	N/A	3	N/A
Korea, South	160	0	0	50	94
Malaysia	N/A	0	0	141	217
Mexico	50	0	0	15	N/A
New Zealand	15	0	0	N/A	N/A
Papua New Guinea	N/A	0	N/A	N/A	N/A
Peru	16	0	0	27	N/A
Philippines	84	0	0	70	94
Russia	560	0	0	0	0
Singapore	30	0	0	23	35
Chinese Taipei	10	0	0	2.4	3.8
Thailand	383	130	200	35	58
USA	21,000	18,500	24,600	882	2,000
Vietnam	80	0	0	0	0
APEC Total	26,960	20,601	27,590	1,996	4,391

Source: APEC Energy Working Group (2008b).

3.1.4 Photovoltaic and Solar Thermal Power

12. **Various types of solar technologies are in use in the region.** Thermal solar power, particularly solar water heating is a mature and commercialized market in China. In Indonesia around 12 MW of PV solar power capacity have been installed, corresponding to around 100,000 solar home systems (SHS) for purposes such as lighting, television, communication, battery charging and refrigeration. Currently around 7.5MW of grid-connected PV capacity is installed in Thailand (PVResources.com, 2010). Additionally, nine PV-based hybrid systems have been installed in rural and remote communities in recent years (PV/wind, PV/diesel, and PV/wind/diesel hybrid systems). These hybrid systems range from 5 to 82.5 kW, with a total installed capacity of about 285 kW (Phuangpornpitaka and Kumar, 2007). Around 2,250 kW of solar PV systems are currently installed in Vietnam, of which around 800kW supply homes, hospitals and schools (ADB, 2009b). Solar water heating also plays a substantial role.

13. **Indonesia currently plans to install another 30,000 solar home systems, reflecting the emphasis on using PV technology to supply households that are not connected to a grid.** The ability to establish decentralized PV power systems offers many advantages in countries where there is a substantial proportion of the population located in rural and regional areas. This is the case of Indonesia which is characterized by a large number of small and highly dispersed communities, consisting of uniformly poor households located in difficult-to-access terrain. Given this potential, there are a number of rural, off-grid PV power projects in middle-income APEC economies (Retnanestri et al., 2005, 2008).

14. **On the manufacturing side, China was reported to be the world's largest manufacturing base for solar PV cells in 2008.** About 95 percent of these cells were exported (UNEP, 2009). Expansion of the domestic industry is continuing with installed capacity at 140MW by the end of 2008, with 40MW of newly installed capacity in 2008. A large proportion of this is utilized to power remote areas that may not be connected to the power grid. Current policies are aimed at demonstrating the potential for roof-top mounted, grid connected PV systems (Junfeng et al., 2005).

3.1.5 Cogeneration – CHP/DHC Systems

15. **Combined heat and power (CHP) cogeneration technologies are widely used in middle-income APEC economies, with China possessing the most installed capacity.** In 2006, CHP capacity in China was over 80 GW, providing 18 percent of nationwide thermal generation capacity and heating supply of nearly 2,300 petajoules (PJ) (IEA, 2007). This is largely due to several decades of policies promoting CHP/DC systems. Beijing Gas Group Building CCHP project has demonstrated the first application of CHP/DHC for a 32,000m² office building, providing electricity generation, heating and cooling. The biggest users of CHP/DHC systems are the industrial sector, particularly the chemical industry, papermaking, pharmaceuticals, textiles, iron and steel, as well as residential heating, and district heating. 329 cities out of a total of 661 nationwide have district heating infrastructure in place. Construction of new CHP plants is expected to increase installed capacity to 120 GW by the end of 2010.

16. **CHP usage in Indonesia, Thailand, and Vietnam is currently small, but growing.** In Indonesia, 25 operating cogeneration plants accounted for 5 percent of domestic power generation capacity (or 1,200MW). The three largest industrial users of cogeneration are pulp and paper, chemicals and textiles. Indonesia also has a number of operational biomass and biogas based cogeneration operations, including plants utilizing palm oil, wood and sugar. In 2003, cogeneration accounted for approximately 8 percent of Thailand's installed power generation capacity, or 1,959MW. With only 700MW of cogeneration attributed to the agricultural sector, growth is expected through the use of abundant supplies of rice husk based fuel stock for cogeneration. Table 11 shows the cogeneration facilities operational in Vietnam in 2003, and alongside projected cogeneration potential by industry. As of 2003, cogeneration plants were deployed in the sugar, paper and cement industries. Significant additional potential was identified in the textiles and fibers, and chemical industries.

Table 11: Cogeneration potential, Vietnam, 2003

Industry	Existing in 2003 (MW)	Potential growth 2003-2010 (MW)
Sugar	123	20
Paper	185	300
Cement	2.5	20
Textile, fibers	-	200
Wood processing	-	5
Chemical	-	600
Other	-	15
Total	310.5	1,160

Source: COGEN3 (2003)

3.1.6 Clean Coal Technologies

17. ***With 70 percent of electricity in China generated through the use of coal, there is pressure for the development and implementation of cleaner coal technologies for power generation.*** China is currently developing, ultra super-critical and IGCC technology in power plants. In addition to these power-plant based technologies, other clean coal technologies currently being developed and utilized in China include:

- Coal washing, which can reduce the amount of ash produced in combustion, increasing the energy efficiency of combustion. In 2003, up to 34 percent of coal used in China was washed coal.
- Coal briquetting, the use of which by households has the potential to be approximately 50 million tonnes.
- Coal liquefaction, which provides an alternative to oil, but does not produce less CO₂ emissions, unless used in combination with CCS or biofuels. There are only two coal liquefaction plants going ahead in China due to environmental concerns, and it is reported CCS technology will be operational at one of them within the next two years (CoalTrans, 2009).
- Circulating fluidized bed technology, which burns lower grades of coal and other fuels, while meeting emissions requirements at what is termed, reasonable efficiency (APEC Energy Working Group, 2008a).

18. ***Indonesia produces and exports steam coal, being the largest exporter of steam coal in the world.*** In 2008, exports reached 200-210 Mt, and were set to rise further in the future. With domestic demand and exports projected to grow significantly (Baruya, 2009), there is pressure on the state-controlled electricity industry to invest in and build adequate infrastructure.

3.1.7 Household and Community Biogas Plants

19. ***The use of biogas digesters for waste management and biogas power generation are considered mature technologies and are being used in China, Indonesia, Thailand, and Vietnam.*** Penetration rates of biogas digesters are high in rural areas of China, with up to 17 million biogas digesters being utilized in 2005, and with reports of up to 22 million in operation by the end of 2006 (Yu et al., 2008). In Indonesia, 6,000 biogas plants have been installed over the past 25 years, through a range of programs initiated by the government, NGOs and other stakeholders. In Thailand, plants have been promoted through partnerships with international investors through the Thai Biogas Energy company. Across Thailand, the Energy Conservation Promotion Fund (ENCON Fund) of the Thai government is the main government funding resource. In Vietnam, there were 73000 operational biogas digesters as of 2007, supported by various government initiatives and partnerships with international governments.

3.1.8 Landfill Gas

20. ***Approximately 46 percent of GHG emissions from the waste management sector in 2004 were methane from landfill, and the expansion of methane capture and use technologies are necessary to reduce these emissions.*** As will be seen later in this chapter for CFTs more generally, the use of landfill gas has been influenced to a large extent by the availability of the Kyoto Protocol's Clean Development Mechanism (CDM). Looking at landfill gas projects in middle-income APEC economies, there are 18 CDM projects in China associated with landfill gas, 2 in Indonesia and 1 each in Vietnam and Thailand. However, in China, the use of technology to convert land fill gas to energy is facilitated by both the CDM as well as by private industry. Large scale operations, processing up to 6,000 tonnes of waste material daily and 14,000MWh of electricity annually, as well as smaller scale operations are in use across China (DNV, 2010).

3.1.9 Efficient Light Globes

21. ***China currently accounts for 90 percent of global production of compact fluorescent lights (CFLs), equivalent to 2.4 billion units in 2006 (Australian Greenhouse Office, 2006).*** Indonesian domestic sales of CFLs in 2006 were reported to be approximately 90 million units, for Thailand this figure was 15 million units, and for Vietnam 11 million units.

3.2 Technology Transfer through Investment and Trade

22. ***Analysis of technology transfers has traditionally concentrated on the flow of technologies and investment from North to South, or from developed to developing economies, although this is changing.*** The increasing prevalence of multinational companies involved in the development of CFTs creates an additional layer of complexity when considering the major producers of CFTs. Such multinational corporations operate with head offices in a given country, typically either the US or Europe, although this is changing as major companies establish headquarters, wholly owned subsidiaries or joint ventures (JVs) in developing countries. Broad research and development programs are generally combined with manufacturing facilities located across different continents.

23. ***Within an increasingly globalised economy, R&D facilities do not necessarily need to be located close to production facilities, which, depending on transport costs and distribution channels, also need not necessarily need to be located close to the final consumer.*** In addition, as developing economies continue to be characterized by strong levels of economic growth, increasingly open and accessible investment markets, and a capacity to absorb and produce new technologies, their position in the market for CFT development and production is also strengthened.

24. ***One result of the trend towards multinational operations and technology transfers moving predominantly through companies is that production and trade are increasingly being sourced from developing and emerging economies.*** This reversal of the historical trend of purely North-South transfers has begun a change in paradigm surrounding technology transfer, investment and trade more generally. For example, a review of the global status of renewable technologies investment lists China as one of the top five countries in 2009 (by installed capacity) for three major renewable power sources. China also has the world's greatest amount of installed renewable capacity in total (Table 12).

Table 12: Top five countries by installed capacity, by technology, 2008

	#1	#2	#3	#4	#5
Total renewable installed capacity	China	United States	Germany	Spain	India
Small hydro	China	Japan	United States	Italy	Brazil
Wind power	United States	Germany	Spain	China	India
Biomass power	United States	Brazil	Philippines	Germany	
				Sweden	
				Finland	
Geothermal	United States	Philippines	Indonesia	Mexico	Italy
Solar PV grid connected	Germany	Spain	Japan	United States	South Korea
Solar hot water/heat	China	Turkey	Germany	Japan	Israel

Source: REN21 (2009)

3.2.1 Trade in CFTs

25. ***In 2003, the global size of the environmental goods and services (EGS) market was estimated at USD500 billion, with developed countries accounting for about 90 percent (Claro et al., 2007).*** The USA, Western Europe and Japan together account for 84 percent of this market; many of the largest firms producing CFTs are located in these countries. While the global environmental industry is estimated to have grown rapidly in recent years, saturation has slowed market growth in the developed countries. Most of the future demand growth is expected to occur in developing countries and countries in transition. If the focus is on environmental goods (EG)⁶ only, in 2003 global exports of EG were approximately USD370 billion, of which almost 80 percent originated in developed countries, and 20.1 percent in developing countries.

26. ***Developing countries from Asia and Oceania are now important actors in the global trade in established environmental technologies (EET), accounting in 2003 for 11.9 percent of exports and 22.4 percent of imports.*** Although the region as a whole is a net importer of EET, there are a few products for which it is a net exporter, especially in the renewable and clean energy areas. For instance, Malaysia, Thailand and the Philippines are net exporters of component goods required to construct renewable/clean energy technologies, hydrogen peroxide, hydraulic turbines, water wheels and regulators, parts for hydraulic turbines, instantaneous gas water heaters, solar water heaters, wind-powered generating sets, and photosensitive semiconductor devices, including solar cells. China, the Republic of Korea, and Chinese Taipei are important exporters, primarily to other Asian countries, in the water and wastewater management sectors.

27. ***China, the Republic of Korea, and Chinese Taipei are also important in the global trade in environmentally preferable products (EPP), accounting for 45.3 percent of exports and 31.4 percent of imports.*** EPP exports by Asian developing countries include organic products, certified timber products, non-timber forest products, natural resource- or biological-material-based products based on traditional knowledge, and products made from natural fibers and biofuels, like ethanol and methanol. For example, forestry exports are dominated by China, Indonesia, and Malaysia, although China is also a major

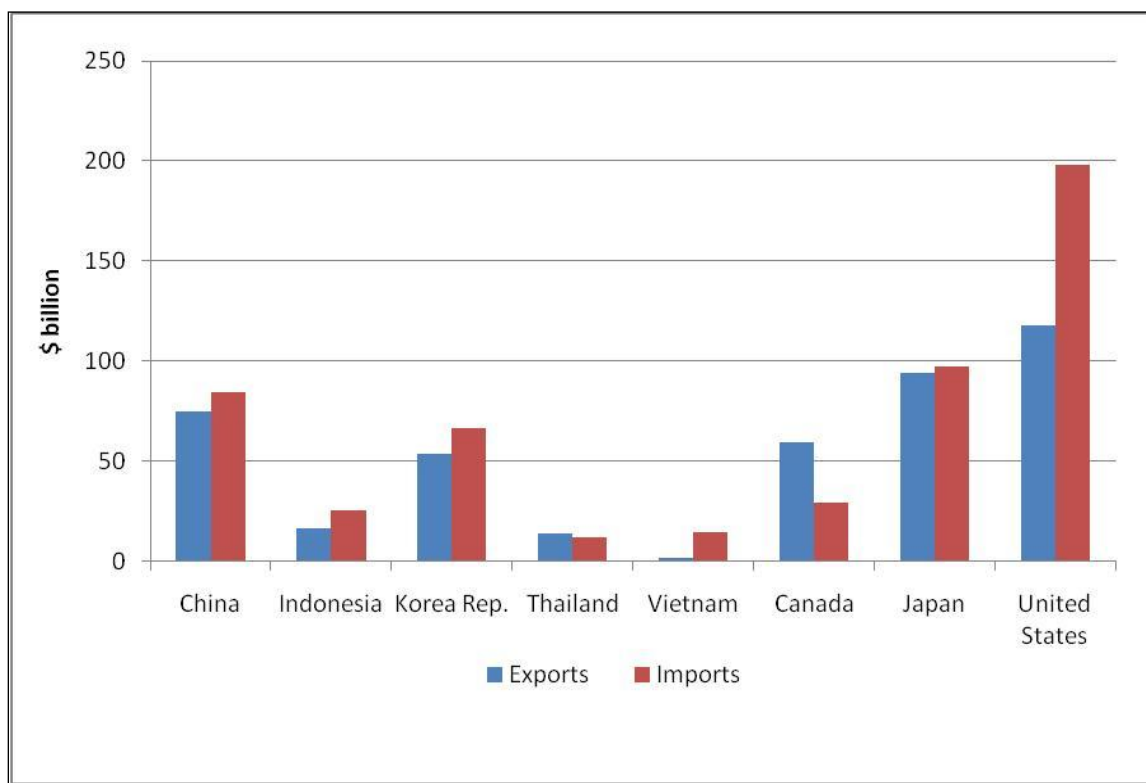
⁶ This term encompasses two categories – established environmental technologies (manufactured goods and materials directly used in the provision of environmental services) and environmentally preferable products (industrial and consumer goods not primarily used for environmental purposes but whose production, end-use and/or disposal have positive environmental characteristics relative to similar substitute goods).

importer of forestry products. Where biofuels are concerned, China is becoming an important producer, and Asian countries are expected to become the most cost efficient bioethanol producers worldwide.

28. **Generally, the major exporters in developing countries are China and Republic of Korea.** Their exports are substantially higher than those of other APEC economies, reaching US\$ 75 and 54 billion accordingly in global markets and both almost at US\$ 40 billion in APEC markets in 2008. Exports of CFT products from Indonesia, Malaysia, and Philippines have a more regional focus, with about 80 percent going to APEC markets. Imports are similar, with the exception of Vietnam that imports mainly from APEC economies. In term of trade openness in CFTs (measured as the ratio of total trade in exports and import to GDP), South Korea, Malaysia and Vietnam were more open than other APEC members, even though developed countries tend to have very low ratios for relative close markets.

29. **For the trade balance in CFTs, most major APEC economies were net importers, except Canada, Malaysia, and Thailand as net exporters (Figure 15).** China and South Korea are important producers of CFT as well as major importers in the developing country group, with Japan and USA in similar roles among developed group countries. In terms of specific technologies, biofuel and photovoltaic solar products were the leading technologies on exports and imports in both developing and developed countries. For other categories, China's exports were focused on wind power, biogas, waste heat/gas recovery, and energy efficient lighting globes etc which reached US\$ 23 billion a year, while South Korea had US\$ 8 billion of exports in hybrid vehicles and waste heat/gas recovery products (Table 13). For developed countries, waste heat/gas recovery was also the major sector for both Japan and USA exports. Furthermore, Japanese hybrid vehicles and US advanced fossil fuel power were their dominant exports in CFTs.

Figure 15: Exports and Imports of CFT Products in Selected APEC economies 2008



Source: Computations based on UN COMTRADE Statistics

Table 13: Exports of CFT Products by Category in Selected APEC economies 2008 (US\$ Millions)

CFT Category	China	Indonesia	Korea Rep.	Malaysia	Thailand	Vietnam	Australia	Canada	Japan	USA
Advanced Fossil Fuel Power	2,845	109	729	118	340	3	113	1,492	4,323	13,668
Wind Power	6,195	270	1,213	145	278	186	323	1,710	6,821	8,121
Biogas	7,219	326	2,209	433	153	20	48	712	3,821	2,153
Biofuels	16,314	14,356	37,516	22,693	9,111	914	11,733	50,809	20,541	62,821
Waste Heat/Gas Recovery	6,368	410	3,660	789	1,257	272	289	1,869	20,892	13,379
Hydro Power	253	0	27	1	0	1	3	30	57	50
Photovoltaic Solar	27,028	86	2,293	2,244	1,463	151	333	1,478	12,898	9,569
Solar Thermal	500	25	1,014	116	51	4	20	218	527	1,003
Fuel Cells	44	77	1	73	29	1	8	5	2	99
Agriculture	2,337	303	1,276	704	580	47	155	1,191	5,680	3,954
Water Resources	1,521	43	132	84	115	67	24	357	92	896
Combined Heat and Power	587	2	192	16	6	25	5	23	558	2,040
Building	431	0	7	0	5	0	6	123	29	424
Hybrid Vehicles	1,379	513	3,893	54	699	0	8	37	19,053	1,528
Energy Efficient Light Globes	2,887	116	20	6	58	5	1	98	37	116

Source: Computations based on UN COMTRADE Statistics. HS-6 Classification of CFTs available in Appendix A.

30. ***In the product breakdown and market share analysis, developed countries have been the key exporters and importers in the APEC markets, with about 50 percent in both export and import shares.*** On the developing country side, China and South Korea are the relatively more important ones, but each of those had still no more than 10 percent in APEC export and import market shares in 2008. Most other developing countries were indeed very small players in CFT trade, e.g. Indonesia, Thailand, Vietnam etc. The relative importance of CFT exports and imports were biofuel products in APEC markets, it dominated almost the top three items on the list totaled over US\$ 200 billion a year and with more than 50 percent of export/import shares. The second important item was photovoltaic solar products which appeared popularly on the top 10 list in export and imports categories. Furthermore, wind power products and waste heat/gas recovery products also become relative important CFTs in China and South Korea. Overall, the trade volume and market shares of CFTs in East Asia developing countries have remained relative small.

3.3 Financing of CFTs

31. ***Of the total US\$ 2.8 billion raised in public markets by Chinese clean energy companies, only 7 percent was raised in domestic markets.*** The majority of investment was sourced from the USA through secondary offerings and convertible notes that were issued by established US companies (UNEP, 2009a). Domestic investment in Chinese markets was down on the US\$ 698 million raised in 2007. In terms of asset financing, China was the world's third largest investment destination by value (after the US and Spain), attracting US\$ 14.9 billion, 70 percent of which was allocated to wind power (UNEP, 2009a).

32. ***Relatively little information is available about investment flows in other middle-income APEC economies.*** However, reports indicate that investment activity in Thai markets was concentrated in the development of bioethanol, biodiesel, and wind, while mini-hydro and biofuels attracted the largest proportion of investment in Vietnamese markets (UNEP, 2009a).

33. ***The type and availability of financing available to countries can have a strong influence on the type of technologies being used, produced, or exported.*** The financing can be domestic or international and public, private, or some combination thereof. One important indirect financing mechanism is the Kyoto Protocol's Clean Development Mechanism (CDM) that allows industrialized countries (Annex 1 countries under the Kyoto Protocol) to invest in ventures that reduce emissions in developing countries through the sale of certified carbon credits. While the CDM was established to enable developed countries to engage in low cost abatement in developing countries, it also provides a mechanism through which information and technologies may be transferred. The CDM can therefore enhance climate friendly development in these host countries.

34. ***To date, project implementation through the CDM is highly concentrated in a few developing countries.*** As of November 2008, 37 percent of CDM projects in the CDM pipeline were located in China, 27 percent in India and 19 percent across Latin America. In addition, 53 percent of total expected certified emissions reduction units (CERs) were allocated to China (ENTTRANS, 2008).

35. ***China has been highly attractive to foreign investment in CDM and other clean technology transfer mechanisms.*** With over 140 million CERs issued in China by February 2009, there were 579 registered CDM projects (Table 14). Hydropower projects, of varying scales, represent the greatest category by number; however, HFC reduction programs have resulted in the greatest number of CERs issued (due to the increased warming potential of HFCs compared to CO₂).

Table 14: CDM projects registered in China, as of February 2009

Project type	No of projects	Average annual ktCO ₂ e to 2012	Total ktCO ₂ e to 2012	Issued CERs (,000)
Biomass energy	12	1,749	9,207	246
Cement production	4	1,015	3,842	0
Coal bed/mine methane	22	12,830	59,588	1,262
EE own generation	64	15,325	70,586	2,865
Fossil fuel switch	14	16,146	69,278	986
HFCs	11	65,651	362,784	116,296
Hydropower	275	28,067	119,579	3,410
Landfill gas usage	18	3,358	18,507	321
Methane avoidance	3	235	1,026	0
N ₂ O	26	20,932	98,715	9,779
Reforestation	1	26	174	0
Solar power	2	71	263	0
Wind power	127	14,997	71,668	5,926
Total	579	180,403	885,215	141,093

Source: UNEP (2010)

36. *As of July 2009, there were 24 registered CDM projects in Indonesia with flared gas one of the most promising options to reduce GHG emissions and provide a substitute energy source (Table 15).* The 24 registered CDM projects were projected to generate 18 million tonnes of carbon dioxide equivalent reductions by 2012. As of July, 326,000 CERs had been issued.. As of February 2009, flared gas (waste gas/heat utilization) projects in particular accounted for 113,446 issued CERs under the CDM in Indonesia. Other major recent allocations of CERs in Indonesia include 91,000 CERs for geothermal energy in June 2009, and 81,000 CERs for biomass energy. The Bekasi Landfill Gas Recovery Project in West Kalimantan Indonesia is developing facilities to collect and flare methane gas from landfill. Some gas will be utilized to meet power needs of the project (PT Gikoko Kogyo, 2009). The second Indonesian CDM project in Bali will collect land fill gas and biogas from anaerobic digesters providing electricity to the local power grid, and generating greater additional reductions in GHG emissions than direct flaring of the collected gases (PT Navigat, 2006).

Table 15: CDM projects, registered in Indonesia, as of February 2009

Project type	No of projects	Average annual ktCO ₂ e to 2012	Total ktCO ₂ e to 2012	Issued CERs (,000)
Biomass energy	8	935	4,709	81
Cement	1	470	3,329	0
EE Industry	2	53	199	0
EE supply side	1	43	209	17
Fugitive (flared gas)	1	391	1,922	113
Geothermal	1	652	3,587	91
Landfill gas usage	2	173	817	0
Methane avoidance	6	537	2,893	22
N ₂ O	1	81	258	0
Solar	1	4	24	1
Total	24	3,338	17,947	326

Source: UNEP (2010)

37. As of July 2009, Thailand had 18 registered CDM projects (Table 16). With 715,000 CERs issued as of July 2009 (from a total of 815,000 CERs issued in Thailand), biogas development from wastewater treatment (methane avoidance) has proven its potential for Thailand's biogas sector as either

an additional energy source or as a flaring option. Currently CERs have only been issued from biogas and biomass electricity generation through the use of rice husks. In Thailand, the only registered CDM project managing landfill gas was located at the Rachathewa landfill site, Bangkok. The project includes a landfill gas collection system, as well as a 1MW electricity generator. Excess gas that is not used to power the generator will be flared (Jaroensompong Corporation, 2007). In addition to this project, there are also a number of addition landfill gas projects at validation stage under the CDM in Thailand (UNEP, 2010).

Table 16: CDM projects, registered in Thailand, as of February 2009

Project type	No of projects	Average annual ktCO ₂ e to 2012	Total ktCO ₂ e to 2012	Issued CERs (,000)
Biomass energy	5	434	2,958	101
Landfill gas	1	58	291	0
Methane avoidance	11	806	4,967	715
N ₂ O management	1	142	504	0
Total	18	1,441	8,720	815

Source: UNEP (2010)

38. *As of July 2009, there were 6 CDM projects registered in Vietnam* (Table 17). These projects covered the capture of fugitive emissions, hydro and wind power, land fill gas use and reforestation. Only one project had been issued CERs – the Rang Dong Oil Field Associated Gas Recovery and Utilization plant, a joint initiative between Vietnam, Japan and the United Kingdom. In Vietnam, the registered CDM project on landfill gas management is located in the northern Ho Chi Min City region, utilizing collected landfill gas to produce electricity and supply it to the grid (KMDK Vietnam Co. Ltd, 2006).

Table 17: CDM projects, registered in Vietnam, as of July 2009

Project type	No of projects	Average annual ktCO ₂ e to 2012	Total ktCO ₂ e to 2012	issued CERs (,000)
Fugitive emissions	1	677	6,770	4,487
Hydropower	2	18	72	0
Landfill gas usage	1	148	542	0
Reforestation	1	3	10	0
Wind power	1	58	217	0
Total	6	903	7,610	4,487

Source: UNEP (2010)

3.4 Patents and Geographical Distribution of Technologies

39. *Patent statistics can characterize the research and development of CFTs in the APEC region.* A recent study utilized the EPO/OECD World Patent Statistical Database (PASTAT) to map the source of innovation in climate change mitigation technology, and its diffusion globally between 1978-2003 (Dechezlepretre et al., 2008). PATSTAT incorporates information from 81 national and international patent offices, focusing predominantly on sources in developed and middle-income economies (due to the lack of information and observations from least developed countries). In total, the dataset incorporates 273,900 patents filed in 76 countries over 25 years⁷.

40. *Over the period 1998-2003, Lighting and Fuel injection were the most patented technologies, with on average 2,000 and 1,500 patents registered annually, respectively.* Patent registration numbers in biomass, hydropower and geothermal power were on average less than 500 annually, most likely due to the mature status of these technologies (even if they are not yet commercially viable). CCS technologies

⁷ Note that clean coal technologies and electric vehicles were excluded from the dataset due to identification difficulties driven by the potential for dual use technologies that are not necessarily associated with climate change mitigation.

and ocean energy also had on average less than 500 patents registered, however these technologies are currently in the early stages of research and development.

41. ***Japan accounted for just over 40 percent of global patent registration in climate change mitigation (Table 18).*** In all listed technologies, Japan accounted for the major component of global invention, apart from biomass technology where it ranked second. In terms of emerging economies, China, South Korea and Russia were placed 4th, 5th and 6th in the rankings of global inventors.

Table 18: Leading countries for mitigation inventions

Country (in order of ranking)	% of world inventions	Most important technology classes
Japan	40.8	All technologies
United States	12.8	Wind, solar, hydro, methane, buildings
Germany	12.7	Biomass, ocean, waste, CCS, wind, solar
China	5.8	Cement, geothermal, solar, hydro, methane
South Korea	4.6	Lighting, ocean, hydro, biomass, cement
Russia	4.2	Geothermal, cement, hydro, CCS, ocean
France	2.4	Cement, CCS, buildings, biomass, hydro
United Kingdom	1.9	Ocean, biomass, wind, methane
Canada	1.5	Hydro, wind, CCS, ocean
Brazil	1.1	Ocean, building

Source: Dechezlepretre et al. (2008)

42. ***Patterns of transfer and diffusion of inventions were measured by considering the registering of patent applications in other countries.*** This process permits for intellectual property to be protected in new markets where it is expected that the invention will be used commercially. Table 19 provides an overview of the direction of movement in inventions over the period 1978-2003. The majority of exported patents are sourced from developed countries, with the majority destined for developed countries. There was extremely limited transfer of patents originating from emerging and middle-income economies. The results also indicate that the bulk of transfers occur between developed countries.

Table 19: Origin and destination of exported inventions (number and % of total) 1978-2003

	Destination	
	Developed countries	Emerging and middle-income economies
Developed countries	5,812 (75.9%)	1,360 (17.8%)
Emerging and transition countries	377 (4.9%)	112 (1.5%)

Source: Dechezlepretre et al. (2008)

43. ***The most recent survey of patent applications in the middle-income APEC economies that are the subject of this report dates from 1998, and is reproduced in Table 20.*** APEC does not appear to publish up-to-date patent statistics about its member countries⁸. Although out of date, these figures suggest that the great majority of patent applications were filed by non-residents.

⁸ We note that there are limits in the extent to which patent data can be compared. Many inventions are not patented, and the propensity to patent differs across countries and industries. There are also differences in patent regulations among countries

Table 20: Patent Statistics for China, Indonesia, Thailand and Vietnam (1998)

Member country	Patent applications filed by residents	Patent applications filed by residents and non-residents	Number of Patents in force per million inhabitants
China	14,004	82,289	0.17
Indonesia	n/a	32,910	n/a
Thailand	477	5071	0.11
Vietnam	30	35778	n/a

Source: APEC (2010)

44. ***There are some known limitations on the use of patent data in mapping the development and diffusion of technology invention that need to be kept in mind when considering these data:***

- First, patents are not the sole method of protecting invention and therefore are not likely to cover all forms of invention. However, given the large number of countries and organizations involved in the development of PATSTAT, the use of patent data offers some insights into the sourcing and transfer of patents across borders.
- Second, the use of patents to measure the transfer of inventions is affected by the strength of intellectual property regulations (IPRs) within an economy. Where there is limited scope or development of IPRs, there is also limited incentive for patent registration, since patents are unlikely to be enforceable. This limitation is important, since developing and emerging economies are less likely to have such laws in place in the recent past and this could either reduce the number of patents registered (although with continuing transfer of inventions), or reduce the flow of inventions. The latter is more likely.

4. POLICY ENVIRONMENT FOR CFT EXPANSION

1. ***Given their position on the economic growth path, middle-income, emerging and developing countries are well placed to take advantage of opportunities offered by expanded international trade and investment in CFTs.*** In the context of international discussions about the expanding use of and promoting investment in CFTs, developing countries have the potential to use the momentum created by these discussions to facilitate international and domestic investment to increase their own use of these technologies, and to increase their presence in the provision of these technologies.

2. ***However, the ability to capitalize on identified opportunities depends on several factors, such as the cost of CFTs relative to existing options.*** Where the former are more costly, as is often the case at present especially in investment at scale, the economic impact of decisions to expand the use of CFTs depends on the availability of possibilities for reducing the cost differences. These possibilities can include (i) the sustained availability of concessional international co-financing, including but not limited to the indirect systems like the CDM; (ii) the possibility of declining costs as CFT investments are scaled-up, making initially costly investments beneficial in the longer-term; (iii) the possibility, related to (ii), of securing longer-term comparative advantage as a supplier as well as user of CFTs; and (iv) the availability of other national co-benefits from increased utilization of CFTs, such as reduced local environmental degradation. The ability to realize any of the opportunities implied by (i) through (iv) depends on the existence of an appropriate government policy framework that can facilitate adoption and diffusion of technologies, facilitate trade, and reduce energy inefficiency.

3. ***This chapter of the report describes policies directed at facilitating the economically beneficial provision, adoption and use of CFTs internationally.*** These are then contrasted with current trade and energy policies as they are implemented in middle-income APEC economies. The discussion in this chapter focuses on some overarching principles that are important and corresponding general government policy initiatives. The practical application of these policies within a specific context is discussed in more detail in the context of the country case studies presented in Chapter 6.

4. ***This chapter also discusses a number of less desirable policies that have been applied in most middle-income APEC economies that can limit expansion of CFTs.*** These include:

- Policies that promote the energy self reliance of a country, based on the perception that this enhances “energy security,” but which are nonetheless potentially very costly for the economy concerned and/or for the environment;
- Trade related investment policies (TRIMs) that place restrictions on investors, for instance in terms of local content, but that tend to raise costs for investors and for consumers, and
- Policies that facilitate energy consumption through the use of energy subsidies. These policies are potentially high-cost, encourage wasteful behavior and risk broader economically distortionary outcomes.

5. ***The report finally comments on impediments to technology transfer and diffusion arising from tariff- and non-tariff barriers.*** While consistent information on these issues is often difficult to compile, it appears that middle-income APEC economies tend to apply higher import tariffs to CFTs than higher income economies. This is consistent with broader trends in taxation observed between developing and developed economies.

4.1 Technology Transfer for Developing Countries

6. ***The traditional technology transfer paradigm assumed that the main source of technology for developing and emerging economies was through North-South transfers and government based financial flows.*** This paradigm led to an emphasis on policies directed at facilitating unidirectional

movements of technology. For example, strong emphasis was placed on intellectual property laws in developing and emerging economies as the main impediment to technology transfer. More recently, the focus has shifted towards an assessment of FDI policies and restrictions on global flows in capital and goods trade. This changed view coincides with an increase in the prevalence of multinational enterprises that are heavily involved in transfers of technology. Table 21 summarizes the two paradigms and key policy issues to be considered in assessing policy for technology adoption and diffusion.

Table 21: Summary of traditional and broadened technology transfer paradigms

Elements	North-South transfers of technology and financial flows	Global technology, trade and investment flows
Geographic flows	North to South	South to North South to South North to North North to South
Analytical units	Country based financial flows	Firm based trade and investment in both goods and services
Important barriers	Technological and administrative capabilities as well as intellectual property rights in developing countries only	Trade and investment policies in all countries
Institutional frameworks	International development banks and bilateral official development assistance	Multilateral, regional and bilateral trade and investment agreements and organizations

Source: Brewer (2009)

7. ***With the changing paradigm surrounding technology transfer and the direction of transfer, there is also a change in focus in terms of policy negotiation and the identification of best practice policy options.*** Technological transfer is no longer only embodied in trade in goods and services. Studies have demonstrated that intra-industry trade provides a greater level of technology transfer than inter-industry trade (Hakura and Jaumotte, 1999)⁹. This is an important outcome for developing countries as intra-industry trade requires the presence of a given industry within the economy. It suggests that the domestic use, production, and general market based activities of an industry will further facilitate the transfer of technologies. Domestic policies on FDI flows and capital flows will necessarily be important determinants for development of CFT transfer.

8. ***Openness to trade and investment are necessary but not sufficient conditions for successful technology transfer.*** Open channels to receive new technologies and information resources must be complemented by capacity to absorb and utilize the technology. Human capital investment, domestic R&D capabilities to adapt the technology to the domestic situation, as well as operating market incentives are required (Hoekman et al, 2004).

9. ***An enhanced market for the international transfer of technology into developing and middle-income economies must take five factors into account. First,*** new technologies have potentially lower system integration costs in middle-income economies due to initially lower levels of modern infrastructure. Since most infrastructure has a long life, replacement prior to the end-of-life can be costly. Taking advantage of ‘catch up’ moves in terms of upgrading old or constructing new infrastructure and technology networks, middle-income economies occasionally have lower implementation costs than more developed economies with existing highly capital intensive infrastructure.

⁹ Similar findings were reported in a 2007 paper that considered the productivity effects of knowledge and other type of spillovers, using a cross-section of 13 OECD countries and 15 manufacturing industries. While there are sizeable knowledge spillover effects on productivity transmitted through both inter- and intra-industry use of intermediate goods, the direct effect of an increase in an industry’s (own) R&D is about twice as large (in terms of its impact on the elasticity of productivity) (Badinger and Egger, 2008).

10. ***Second, mechanisms to facilitate investment and absorption must reduce the transactions cost of transferring technology in developing and middle-income economies.*** For example, institutional reliability and ensuring the protection and promotion of technologies within a clearly articulated legal and economic framework is important. Economic and political institutions provide the incentives and surety of investment to allow production and deployment to take place domestically, instead of through more trade related channels.

11. ***Third, related to the concept of institutional reliability is the requirement of a well functioning market environment.*** Increased competition, or at least the potential for competition, provides incentives and mechanisms through which advances in technologies and markets are achieved and utilized. In terms of technical research, a competitive environment may not be a high priority in middle-income economies; however, competition in production markets, both domestically and between middle-income economies, will be important.

12. ***Fourth, education and training facilities within the domestic economy are crucial to promoting international technology transfers into middle-income economies.*** Middle-income economies will have limited ability to take advantage of new technologies without the technical capacity to produce and utilize them, or to recognize their evolving position in the global market. Further, citizens must understand the benefits of these technologies for there to be greater use of technologies within the economy, across rural and regional areas, and within businesses and urban households. Information barriers as well as expertise barriers are often some of the strongest impediments to technology transfer in developing economies.

13. ***Fifth, access to domestic or alternate resourcing options is an essential component to successful international technology transfer.*** It requires a financing portfolio design based on both current characteristics and future projections of the structure of the economy such that costs can be managed and technologies remain competitive and affordable.

14. ***Technology transfer is more likely to be successful for mature technologies that have been proven in developed economies prior to transfer to developing countries.*** The main reason for this is that developmental technologies have more uncertainty associated with them and issues to iron out, and so are more difficult to implement in challenging institutional, political or economic environments.

15. ***It is important to measure the success of technology transfer programs as a basis for assessing whether the program should be continued, expanded, improved or ended.*** Both the objectives of a particular policy measure and an assessment of its success or failure need to be assessed in the specific context in which it is undertaken (Hall et al., 2008). For instance, it is well known that there is significant scope for greater energy efficiency in developing economies¹⁰, where such an objective would be specified as target energy reductions according to a defined timetable. In turn, the success or failure of a program of technology transfer will depend on a broad range of factors, including the capabilities of relevant government departments, which are in many instances understaffed and underfinanced, and may lack the capacity to effectively implement policies. In turn, these types of concerns will require specific policy responses to be developed to assist developing countries, such as:

- Partnerships with relevant national agencies to provide technical assistance and capacity building;
- Assistance in the public procurement of efficient products;
- Extending efficiency labeling and standards, which require manufacturers to provide information about products; and
- Support for energy service companies.

¹⁰ For instance, it is estimated that efficiency improvements in the residential and commercial building sector could reduce emissions in non-OECD countries by 1.5 GtCO₂ per year in 2020.

16. ***The overall policy framework influences the success of expansion of domestic technology industries as well as the scale of use of CFTs.*** Stable economic policies directed at facilitating investment in a manner that promotes both return on investment and future growth potential will expand incentives for investment from abroad, and this in turn will facilitate growth in domestic supply capacity for CFTs. Policies to promote efficient capital flows including FDI should consider:

- Reduction of “systemic” risks, in particular the reduction of sovereign risk, in terms of large scale policy changes, nationalization or changing legal frameworks; and
- The strength of market based operations, which provide incentives for investment through competitive institutions and flexibility, in terms of the scope and scale of company development.

17. ***Under a conducive overall policy environment, the development and transfer of information and technologies internationally can occur via a number of different routes.*** The main channels include:

- Direct trade in goods and services.
- FDI, where technology shared with subsidiary companies leaks into the wider domestic economy.
- The establishment of joint ventures (JVs), in which the transfer of technology is facilitated through commercial operations.
- Direct trade in licensing, where technologies and methodologies are transferred through a license arrangement and local firms are entitled to implement in their domestic operations.
- The temporary transfer of employees, noting that many technological advances are directly related to human capital. For example, in terms of management and organizational skills as well as technical skills.
- There is also significant scope for public sector investment from foreign governments. For example, international development assistance still provides an important conduit for the transfer of resources, information and capability.

18. ***Government can facilitate private sector investment in expanded use of CFTs and, as appropriate, their supply to the global market.*** There measures by which to do this include:

- Framing regulations and policies carefully to ensure that the process is not over-specified (that is, multiple pieces of legislation targeting a single problem). A general rule is to use a single policy instrument to achieve a single policy goal. This allows for greater understanding of national policies and objectives on the part of investors and reduces the risk faced by investors of missing clauses and caveats buried within different pieces of legislation.
- Avoiding multiple pieces of legislation and complicated regulatory systems to limit the risk of unintended consequences and conflicting incentive structures. For instance, the objective of commissioning large scale electricity networks may provide incentives for fossil fuel based generation while hindering the development and expansion of renewable based generation, the latter of which may be more conducive for lower emissions. The challenge here is to shape domestic development policies by taking into account the long life of such assets, an economy’s access to natural resources, the longer term costs, and market movements to ensure that policy does not inadvertently promote investments that will later become stranded assets with little or no economic return.

- Considering a variety of risk sharing arrangements to manage the inherent risk associated with untested and emerging technologies, without creating adverse incentives for investment efficiency in the process. Some carefully targeted and time-limited government subsidies to demonstrate the value and applicability of specific technologies can be used to increase the initial uptake of new technologies that are otherwise considered to be too risky by domestic firms. The converse is that such experiments may demonstrate that a seemingly promising technology is not so beneficial. In that case the government subsidy has still provided a social value in the form of the information garnered, but the next step is to shut down the subsidy – even in the face of domestic constituencies for its continuation.

19. ***General policies regarding the flows of human and physical capital (that is people and goods) across borders, patents, and intellectual property rights (IPRs) will also influence climate friendly technology transfers.*** Investments in workforce development can provide co-benefits in access to new technologies, and vice versa. In contrast, Trade Related Investment Measures (TRIMS) will strongly influence the flow of human and physical. This will occur through mechanism like local content requirements and minimum export requirements that inhibit movement of goods and people. These are heavily scrutinized by the WTO and all members have in force policies to counter act such measures. In addition to imposing potentially higher costs of intermediate goods on producers, policies such as minimum levels of domestic sourcing can also hinder the transfer of technology embedded in physical goods trade.

20. ***The promotion of domestic education and training facilities and allowing international investment in domestic education and training sectors supports an improvement in absorptive capacity.*** Emerging and middle-income economies can only take advantage of the progress already made internationally in terms of technological advances, if there is a given level of education and skills. Adaptation of international technologies to domestic conditions can also be achieved more readily within established domestic research and production capabilities, as opposed to from a zero base level (Hoekman et al., 2004). Good education policies are also required for users of the technologies, ensuring that the benefits and future role of CFTs are understood.

21. ***Patents and IPRs may have a significant bearing on the trend of technology transfers.*** IPRs play an important role in encouraging or discouraging investment in research, the development of technologies, and the export of technological knowledge. Empirical surveys provide some indication of the impact of IPRs on technology transfers, as well as their interaction with trade policies. For example, some studies have shown that trade flows in patent sensitive industries respond positively to improvements in patent regulations in middle-income and large developing economies. Where there is a suitably high level of productive and imitative capacity in a recipient country, patenting and IPRs have a tendency to shift the focus of technology transfers from goods trade and FDI flows towards an increase in licensing agreements (Nicholson, 2002).

22. ***The implicit value of domestic IPRs to international investors rises in line with the expected returns from transferring technologies into the host country.*** Countries with lower levels of development and a lower ability to produce and absorb technology transfers therefore do not benefit from improvements in IPRs. In contrast, countries in which there is a higher level of absorptive capacity and ability to implement technology transfers are also likely to be required to have higher levels of IPRs to induce these transfers, thus potentially increasing the rent able to be extracted by these investors. A counter-acting policy would be to allow for increased competition within given markets to limit concentration.

4.2 Energy Policies

23. ***Current energy policies in middle-income APEC economies are predominantly directed at utilizing domestic resources first, before providing for development issues like rural electrification and supply reliability, with climate concerns considered last (APEC, 2009).*** However, this is not to say that climate change implications of energy policy are not considered, since these issues are clearly emphasized in legislation. The order of priorities does, however, highlight the tensions being faced by middle-income and developing economies when considering current and future energy policies. These tensions are driven mainly through the increased costs associated with the development of renewable and more CFTs, as well as issues associated with access to hardware and technical expertise.

24. ***National energy policies aim to balance the costs and risk of energy supply (such as fluctuations in coal and oil prices), as well as other pricing factors (such as food versus biofuels production).*** Achieving self sufficiency in terms of energy supply is another common theme through the supporting literature to national energy policies. In general, middle-income and developing APEC economies are striving to reduce their reliance on imported energy, which, depending on the type of national resources, can mean either a decrease or increase in emissions intensity of energy.

25. ***Rural electrification programs in middle-income APEC economies illustrate some of the electricity supply and policy challenges that governments face.*** In several countries, there are substantial numbers of villages that are both remotely located, and where communities typically do not have the resources to pay for the services. Connection to a national grid may not be economically feasible, or physically impossible. In these cases, self sufficient renewable power supplies are widely used in middle-income APEC economies, with many additional incentives offered to the deployment of such regional programs compared to more centralized projects.

26. ***Subsidy programs for electricity are thus widespread in middle-income APEC economies, but are not without problems.*** When subsidies are provided, they need to be clearly defined, and to address a specific market failure or social development goal that could not be achieved through a more efficient option. Targeted subsidies can overcome identified issues, such as information deficiencies or improved energy access for the poor to achieve social goals. Examples include demonstration projects for new and emerging power sources and the provision of rural power supply options based on renewable energies. Both policies have a targeted and clearly outlined goal.

27. ***In general, subsidies can be considered be blunt economic instruments that are unresponsive to changes in market conditions, and can often entrench market behavior in the status quo.*** In this way, subsidies reduce incentives for innovation and diversification. In its review of energy policies within Indonesia, the IEA noted that subsidized pricing of services is (IEA, 2008d):

A blunt instrument and imposes immense distortions on all of Indonesia's energy sectors: it inhibits and misallocates public and private sector investment, undermines diversification of energy sources and technologies, undermines energy efficiency, reduces enterprises' capacity for environmental compliance, and locks Indonesia into non-sustainable choices. It takes funds from the GOI that could be used to provide the development of services that are essential to economic growth and poverty reduction.

28. ***Energy self-sufficiency policies are another major set of issues that APEC economies must consider when thinking about climate friendly technologies.*** Energy self-sufficiency programs are often justified by the perceived need for increased security of supply. The underlying assumption is that domestic supply channels will be able to provide energy sources with increased surety and a reduction in price volatility, under the assumption that domestic energy prices will be more stable than prices in international markets.

29. ***While the rationale for implementing these policies is understandable, the underlying assumptions driving the move to self-sufficiency need to be carefully assessed and justified.*** Increased security and reduced volatility will most likely come at the cost of increased domestic prices for energy, and, when unforeseen domestic market outcomes arise, may even result in increased price volatility due to a reduction in supply options. That is, if the domestic market is negatively affected, there are limited options for alternate avenues of supply within the domestic market, than in the international market, and hence, smaller supply shortages may result in larger price fluctuations. If these policies are to be implemented they should be supported by underlying contingency type policies that outline actions to be taken in certain circumstances to alleviate some of the additional problems generated through concentration of supply sources¹¹.

30. ***In all policy development, it is important that a dynamic and forward looking perspective is taken.*** For example power generation facilities being constructed now will still be operating in 30-50 years time when global carbon markets and emissions trading schemes are likely to be in place. A lack of flexibility and diversity within the electricity generating technology portfolio of an economy could mean higher long run costs and potential pressure for the early write off of valuable assets. The current status of FDI and corresponding investment policies in each of the middle-income APEC economies of interest is summarized in Table 22, with detailed country descriptions following.

Table 22: Overview of Energy Policies in middle income APEC economies

Policies	Objective / measures
China	
Public sector energy savings regulation	Promote energy savings
Civil energy bill	Promote the use of renewable and alternative energy sources in newly constructed buildings
Law to promote circular economy	Increase reuse and recycling of materials
China Coal Legal System Framework	Coordinate electric power generation and mining industry
Solar PV subsidies	50 percent subsidy
Investment in hydroelectric facilities	Investment of USD125 billion
Indonesia	
National Energy Law (2006)	Reduce energy dependency Change energy mix Reform of energy pricing
Green Energy Policy (Ministerial Decree 2/2004),	Increase use of renewable energies Increase education
Small distributed power generation using renewable energy (Ministerial decree 1122/K/30/MEM/2002)	Incentives for small scale renewable power facilities
Medium scale power generation using renewable energy (Ministerial regulation 2/2006)	Incentives for medium scale renewable power facilities
Public/private initiatives	Micro-hydroelectric Energy self-sufficiency village program Solar home systems program
10,000 MW Crash Program (Presidential Decree 71/2006)	Construction of 10,000MW coal fired capacity by 2010 Construction of 10,000MW coal fired capacity by 2009-14
Bilateral Energy Cooperation Indonesia-Netherlands (BECIN)	Promote the use and deployment of renewable energy resources

¹¹ This is less accurate for coal-based power, since coal powered plants are generally located close to domestic coal mines, and are thus less affected by international volatility in coal markets

Policies	Objective / measures
Thailand	
Energy supply policy (2008)	Energy security Monitoring of energy prices Promotion of alternative energy production and R&D Energy savings and energy efficiency Environmental goals
Energy Conservation Plan (2009)	Increase the share of renewable energy to 8 percent by 2011
Vietnam	
National Energy Development Strategy(2009)	Increase share of renewables Installation of nuclear power plant Competitive markets for electricity, coal, oil and gas Rural energy program
Vietnam Power Sector Development Strategy (Oct. 2004)/ National Energy Strategy Development (Dec. 2007).	Development of renewable energy
Other policies	Incentives for international investment in domestic fuels Diversification of energy sources Incentives for exploitation of domestic fuels

4.2.1 Energy Policy in China

31. ***Operating under a centralized government and economic system, and with a very large and rapidly growing economy, Chinese energy policy is likely to be implemented through different mechanisms than other middle-income APEC economies.*** Faster growth rates and the size of China's economy allow for more resources to be expended on policy initiatives, and for greater energy savings and efficiency policies. In addition the centralized nature of China's government means that power generation policies can be implemented through central directives rather than through the introduction of market based incentives.

32. ***Energy policies in the Chinese government's 11th five-year plan are directed at reducing the energy intensity of GDP by 20 percent below 2005 levels in 2010 as well as reducing the emissions of "major pollutants" by 10 percent over the period 2006-2010.*** Implementation of such energy intensity reduction targets requires monitoring, testing and evaluation of progress. This is being supported by energy consumption per unit GDP indexing, testing and evaluation system.

33. ***With large amounts of coal reserves, and approximately 77 percent of installed electricity capacity from thermal power plants, coal industry policy in China can affect economic development and growth, as well as environmental outcomes.*** Proposed new laws on the coal industry include increasingly stringent requirements for new coal developments, and an increase in the ratio of industrial concentration (that is, consolidation of the sector) as well as directives to establish a strategic coal reserves system to promote increased security of supply.

34. ***Progress is being made on policies encompassing coal industry operations into a complete institutional framework, in addition to various restructuring measures.*** Policy moves like the China Coal Legal System to consolidate the industry's institutional framework should improve manageability while maintaining centralized government control. Further restructuring of the Chinese coal industry is being implemented through the closing of small scale coal mines, which are both the most inefficient and have a significantly higher fatality rate than larger state owned mines. In addition, the Chinese government is also progressively closing small thermal power plants, further consolidating the industry into larger mining and power generation facilities. However, such policies can only be undertaken in line with complementing options for alternative power sources, for example, as reported by the IPCC (2007),

previous policies implemented to ban the use of small scale coke producing facilities in China were hampered by large scale demand for coke that could not be met without these facilities (IEA, 2006).

35. ***Large amounts of government resources are being directed toward the development of renewable energy within China.*** By 2020, the Chinese government will commit approximately US\$ 125 billion into further development of hydropower facilities, equaling the entire value of Chinese renewable energy projects in 2007 (APEC, 2009). It is proposed that more than 30 large hydropower stations are to be built across the country, and individual and community based investment in smaller hydropower systems is also to be encouraged. A unification of hydropower policies into a national framework is being developed.

36. ***In July 2009, the Chinese government announced a new subsidy program to promote the installation of photovoltaic (PV) solar power facilities across the country.*** The subsidy program is directed at utility scale operations and facilities are required to generate at least 300 kW of peak capacity, be operational within 12 months and have a minimum operational life span of 20 years. The Ministry of Finance has committed to subsidizing 50 percent of total investment in the solar power projects, as well as in transmission and distribution systems to connect to the grid. In remote regions not connected to the national grid, the subsidy is increased to 70 percent. In addition, there is a requirement for grid companies to purchase surplus electricity generated at prices comparable to coal based generation prices (Bai and Walet, 2009). This PV solar power policy is reportedly in response to over supply issues being faced within the Chinese domestic production sector following the global financial crisis and reductions in subsidies offered by the Spanish and German governments. It is unclear whether the policy will be enough to overcome the oversupply issues, or its ability to support longer term uptake within the domestic industry.

37. ***Specification of subsidies to connect power generation facilities to the national grid and requirements for power purchase are important clauses to note within the new PV subsidy policy.*** Construction of generating capacity alone is not representative of the level of renewable energy actually utilized within the economy. Policies directed at the development of renewable energy generation facilities and especially wind power within China have not included specifications of the amount of power use that should be made up of renewable sources, only installed capacity is specified and this has led to the construction of assets in windy but inaccessible locations (Kwok, 2009).

4.2.2 Energy Policy in Indonesia

38. ***Indonesia holds large coal reserves, and was a member of OPEC till 2008.*** In 2008 its OPEC membership was suspended when Indonesia's status changed from being a net oil exporter to a net importer. The majority of Indonesia's coal is made up of lower quality lignite (57 percent). The remainder of Indonesia's recoverable coal reserves is 27 percent sub bituminous coal, 14 percent bituminous coal and less than 0.5 percent anthracite.

39. ***In January 2006, the Government of Indonesia announced the National Energy Law, Indonesia's first piece of legislation on energy.*** The National Energy Law outlines Indonesia's goals for the utilization of energy resources, security of energy supply and protection of the environment. The law specifies a number of targets and essentially calls for the diversification of energy sources from oil and natural gas to coal, renewables including biofuels, and liquefied coal. Additional steps taken to achieve these targets include:

- International cooperative efforts, such as the bilateral cooperation effort with the Dutch Government through BECIN. Aside from promoting the use and deployment of CFTs in Indonesia, this joint initiative facilitates the transfer of knowledge and private investment from Dutch companies.

- Financial support for consumers, whereby the Indonesian government provides financial support to households in the adoption of CFT products. For example, Indonesia purchases PV systems from private companies through a bidding process, which are then installed free of charge in individual households.

40. ***Other goals are associated with reform of pricing principles, including introducing pricing policies directed at achieving these policy goals.*** Included are provisions to supply electricity to lower income Indonesian citizens. Indonesia has additionally adopted numerous measures to encourage the construction of both renewable and fossil-fuelled generation capacity, as well as various private-government and inter-government initiatives.

4.2.3 Energy policy in Thailand

41. ***Thailand is an energy importer, predominantly of oil, with approximately 58 percent of the primary energy supply imported in 2006.*** However, this is down from approximately 96 percent in 1980. Total final energy consumption in Thailand in 2006 was 55,122 ktoe (kilo tonnes of oil equivalent), an increase of almost 12 percent on 2005. However, despite an increase in overall energy consumption, there is increasing diversification of sources. Oil consumption decreased by approximately 12 percent over 2005 to 2006, natural gas consumption also decreased, while coal consumption increased.

42. ***Broad strategies with respect to energy supply policies in Thailand are:***

- Promotion of energy security based on the principle of self-reliance;
- Monitoring of energy prices to ensure that they are considered to be “appropriate, stable and in-line with the economic and investment situations”;
- On-going promotion of alternative energy production and research and development;
- Generation of an energy saving culture and the implementation of energy efficiency and savings measures; and
- Environmental goals to be achieved, through improvement in energy markets, both production and consumption, and promotion of CDM developments.

43. ***Thailand has accordingly put in place a number of policy measures to support investment in CFTs:***

- Specific investment policy targeting CFTs – All projects that are involved in renewable and alternative sources of energy are given priority in terms of tax incentives and import duty exemptions. Attractive investment policies supporting CFT development in Thailand include import duty reduction for machinery, corporate tax exemptions, import duty exemption on raw materials for manufacture of domestic and foreign sales, discount from transport, electricity and water costs and additional incentives for relocation of existing facilities to regional areas.
- Encouragement of joint ventures (JVs) – The Thai government encourages Thai entrepreneurs to undertake JVs in power generation projects in other countries, as part of its broad energy strategy.
- Promotion of market competition – Efforts to promote market competition in the energy industry include the establishment of an investor relation office dealing solely with the energy industry, facilitating of provision of business services for all market participants.
- Increasing public awareness and participation – Efforts include the establishment of community level network of leaders through the ‘Community Energy Volunteers’ program and a program of community based prototype energy sources to demonstrate the

ability of renewable energies to power communities. To build an energy saving culture, Thailand has implemented energy efficiency measures such as energy performance labeling of electrical appliances and mandatory provisions on standby power allowances through the “Standby power 1-watt” program.

- Government incentives to consumers – The Thai government provides incentives for the consumption of power generated by renewable energy through tax credits and privileges, and capital subsidies.

44. ***The government’s energy conservation plan aims to increase the share of renewable energy to 8 percent by 2011 and requires that 5 percent of the energy from new power facilities be generated from renewable sources.*** Incentives will be provided for the purchase of power generated by renewable energy, such as tax credits and privileges, and capital subsidies. The Thailand Board of Investment has designated solar cell manufacturing as a specially promoted industry (Thailand Board of Investment, 2009).

4.2.4 Energy Policy in Vietnam

45. ***The 12,721MW of installed electricity generating capacity in Vietnam, as of 2006, is generated by a range of different technologies.*** The breakdown of production was 4,538MW hydropower, 1,030MW coal power plants, 5,758MW gas and oil, 245MW diesel fired and 250MW small producers.

46. ***Since 1990, Vietnam has been a net exporter of energy exports, with major exports of crude oil and coal, although it has a high proportion of imported oil products.*** In 2006, coal exports accounted for 51 percent of coal industry earnings. Accounting for 29.3 percent of Vietnamese total primary energy supply in 2006, oil is the most important energy source for the domestic economy. At the same time, Vietnam has a high proportion of imported oil products, which is not considered to be strategically preferable to the Vietnamese government. There are thus a number of measures in place aimed at reducing dependence on imported oil. Additionally, greater emphasis is being placed on security of energy supply due to the projection that, by 2010, Vietnam is likely to become a net energy importer. Therefore, the move towards reduced dependence on oil imports is part of a wider reform of the energy market within Vietnam.

4.3 FDI Policies

47. ***FDI policies across middle-income APEC economies have been designed reflecting different country circumstances, with some economies taking a cautious approach, only opening selected sectors, and leaving others closed.*** A slower opening up of foreign investment markets can limit adjustment costs. Allowing a gradual progression to a more open economy with associated structural changes in the manufacturing and energy sectors within an economy can potentially reduce costs such as the dislocation of domestic businesses, sectors, and unemployment. At the same time, such a policy also delays the benefits that come from trade liberalization, in terms of greater access to international markets and technology transfer.

48. ***Another approach, used in particular in China, has selected geographical regions opened up one at a time, thus focusing investment and development in a given region and attaining a desired level of activity before opening up a wider area for investment.*** This process allows for a degree of learning by doing, and ensuring that development on a larger scale can progress smoothly. Variations on this approach also include the establishment of special economic zones and areas in which infrastructure and services investment are targeted, as well as the provision of tax and commercial incentives to attract FDI flows into a geographic region without restrictions being placed on investment in other locations.

49. ***Emerging and middle-income economies within the APEC region are generally viewed favorably as destinations for FDI flows, as Table 23 illustrates for middle-income APEC economies.***

An UNCTAD survey of the most attractive locations for FDI in the period 2008-10 listed China as the most attractive country, Vietnam as 6th and Indonesia as 8th (UNCTAD, 2008a). The following sections provide an overview of the history of investment and FDI policies within middle the income APEC economies of interest.

Table 23: Overview of FDI policies in middle-income APEC economies

Policies	Objective / Measures
China	
Catalogue for the Guidance of Foreign Investment Industries (2003, 2007)	Instrument for addressing macroeconomic/sectoral economic & growth objectives Measures: - Divides economic sectors into 'prohibited', 'restricted', 'permitted', and 'encouraged' with respect to FDI - 2007 change focused 'encouraged' FDI on technologies providing environmental protection, energy efficiency and recycling
Regulations on the Acquisition of Domestic Enterprises by Foreign Investors (2006)	Address concerns about: - Risks posed by powerful foreign owned enterprises to Chinese economic security; and - Risk posed by expansion of foreign businesses to expansion and innovation of domestic enterprises. Measures: - Delineation of 'no go' sectors for foreign investment; and - Preferential import tax incentives for intermediate goods.
Enterprise Income Tax Law (2008)	Encourage domestic development of technologies and sustainable economic development Measures: - Remove concessionary taxes for foreign enterprises; - Special incentives for renewable energy investment irrespective of ownership.
Property Rights Law (2007)	Establishes private property rights
Anti-Monopoly Law (2008)	Framework to regulate market competition
Indonesia	
Law No 25/2007 on Investment	Attract overseas investment
Government regulation No 1/2007 on Income Tax Facilities	Measures: - Incentives for new investors or expanding existing investors, provided some conditions are met; - Consistent legal status of domestic and foreign enterprises; - Protection of property rights; - Easing of immigration regulations; - Creation of central coordinating body.
Presidential Regulation No 76/2007 on requirements for investment	Encourage domestic growth & employment Measures: - Various criteria relating to technology transfer, location of investment, and training & employment of

Policies	Objective / Measures
Presidential Regulation No 77/2007 on negative and positive lists of investment	Indonesian workers; - Creation of Special Economic Zones (SEZ) Protect certain sectors of the economy Measures: - Negative investment list re restrictions/prohibition on foreign investment
Vietnam	
Certification requirements	Requirements to certify foreign led investment projects
Policies	Objective / measures
Policies	Objective / measures
Special zones	Creation of geographic zones to attract FDI
Law on Competition (2004)	Framework to regulate market competition
Law on Technology Transfer (2006)	Create a framework for promoting and restricting certain types of technology transfer
Law on Investment (2005)	Regulate investment Measures: - Lists forms of allowed private sector investment - Lists sectors closed to foreign investment
Law on Enterprises (2005)	Establish modern company structures
Law on Intellectual Property (2005)	Establish intellectual property rights
Thailand	
Directive to promote investment in renewable industries	Encourage investment in targeted CFTs Measures: - Tax incentives - Import duty exemptions - Discounts from transport, electricity and water costs
Investment incentives for certain provinces (2009)	Encourage investment in targeted locations Measures: - Tax incentives - Import duty exemptions - Incentives for infrastructure development
Thailand Investment Years initiative (2008-09)	Encourage investment in targeted industries

Notes: In some cases, dates of measures taken are not available.

4.3.1 Investment Policies in China

50. ***China is the destination for the majority of FDI into developing economies worldwide (OECD, 2008).*** Since 2006, four major pieces of legislation have been enacted in China to address issues of cross border mergers and acquisitions, the promotion of tax equality across foreign and domestic enterprises, the establishment of formal property rights, and legislation promoting market based competition.

51. ***At the same time, the increasing size of the domestic economy has meant that FDI is contributing less to economic growth in China, while self-propelled domestic growth and domestic investment is becoming more important.*** This change in reliance on FDI to promote economic growth, as well as its integration into the wider international economy (such as membership with the WTO) has resulted in a change in focus of FDI policy.

4.3.2 Investment Policies in Indonesia

52. ***The proportion of FDI in total investment in the Indonesian economy has been approximately 70 percent annually over the period 2002-2008.*** FDI flows have tended to be relatively more stable and have grown, while domestic investment has declined (BKPM, 2009). With a combined investment value

of approximately US\$ 9,810 million, the ‘transport, storage and communications’ and the ‘metal, machinery and electronics’ sectors accounted for 66 percent of total FDI flows in 2008. Other important sectors towards which FDI flows have been directed include ‘motor vehicles and other transport equipment’, as well as ‘chemical and pharmaceutical industries’.

53. ***Over the past 10 years, the Government of Indonesia has initiated a number of reforms aimed at increasing the attractiveness of the Indonesian economy to FDI.*** These include the creation of incentives for new investors or expanding existing investors, harmonizing the legal status of domestic and foreign enterprises, the protection of property rights, the creation of central coordinating body, and the establishment of Special Economic Zones (SEZ).

54. ***Indonesia has, however, also introduced a number of restrictions that apply to foreign investment.*** These restrictions are aimed at further encouraging the transfer of skills and technological developments to the population and economy of Indonesia (US Department of State, 2008). While these programs have the potential to increase the rate of transfer of technology and skills from existing investment operations, they also place an additional cost on investment located within Indonesia.

55. ***Implementing such policies requires explicit tradeoffs that should be recognized, and costs versus observed economic benefits should be acknowledged.*** Benchmarks for performance of the policies should also be included, as well as a guide for their removal (for example, when sufficient levels of training and education have been achieved). Further issues associated with requiring foreign companies to employ predominantly local labor are related to industrial relations disputes – where Indonesia is quoted to have some of the highest severance packages of any South East Asian economy (Global American Technology Alliance, 2008).

56. ***There are a range of other restrictions related to the type of investment that is permitted.*** There are 23 sectors that are closed to both domestic and foreign investment (mainly those related to weapons, ammunition and explosives), 43 sectors are reserved exclusively for small and medium sized enterprises, 33 sectors allow foreign partnership operations only, and 98 sectors are open to foreign investment. Included in sectors reserved for micro, small and medium sized enterprises are power generation facilities generating less than 10MW. Due to the high capital costs of small renewable power generation facilities, limiting the sector to investment to medium and smaller sized enterprises is likely to impede the development and investment in renewable power generation facilities (BKPM, 2009). .

4.3.3 Investment Policies in Vietnam

57. ***Vietnam has progressed significantly in moving from a centrally planned economy where economic activity was highly concentrated in the agriculture sector as recently as 1990 to a more diversified and market oriented economy (UNCTAD, 2008b).*** Agriculture accounted for 30 percent of GDP in 1990, while the industrial sector accounted for 25 percent of GDP. By 2006, agriculture accounted for 19 percent of GDP and an increasingly important industrial sector had been developed, accounting for 41 percent of GDP. The Vietnamese government has also promoted increased economic openness to the international economy, which has resulted in the integration of Vietnam in the international economic community. Vietnam joined ASEAN in 1995, APEC in 1998, and the WTO in 2007.

58. ***Through progressive liberalization of restrictions on international capital flows, the trend of declining FDI reversed in early 2000.*** Since then, FDI flows have been steadily increasing as Vietnam has established itself as a production base for manufactured exports with relatively low labor costs and increasingly wide economic structural reforms. Overall, FDI is considered to have played, and continues to play, a major role in the development and economic growth of Vietnam, potentially more so than in other regional economies. It is also considered that there is significant potential for FDI to expand further. While it currently represents a relatively high proportion of GDP, the level of FDI per person is significantly below levels of other regional economies.

59. ***There are, however, difficulties in the current system in Vietnam, arising from unnecessarily unwieldy multiple levels of administration and potentially contradictory pieces of legislation.*** Further, foreign led investment projects are required to undergo certification procedures. These investment certificates add an additional layer of complexity when foreign investment projects are being implemented, and are reportedly utilized to ensure that the proposed investment project will adhere to regional and national Master Plans for development. However, despite the initial levels of complexity, there are reports that the provision of such investment certificates can provide additional levels of investment security by explicitly outlining incentives applicable to the project such as income and company tax concessions. The procedures to obtain certification differ in scale and complexity depending on the ratio of foreign to domestic capital, as well as the ultimate scale of the projects. However, the process of certification under the 2005 Law on Investment has been decentralized to the level of provincial governments. If investment is located within a specially defined ‘zone’ such as an industrial, export processing, high tech or economic zone, certification is undertaken by the respective management committee. Such decentralization can offer advantages in respect of local knowledge and understanding of economic conditions in the area. At the same time, decentralization also raises issues about costs associated with the duplication of services, mismatched skills, experience, and general know-how across regions.

4.3.4 Investment Policies in Thailand

60. ***As part of the Thai Government’s 15 year renewable energy development plan, all projects that are involved in renewable and alternative sources of energy are given priority in terms of tax incentives, and import duty exemptions.*** Other policies are aimed at:

- The use of investment zones to encourage investment in outer regional areas of the country.
- Incentives to target investment in infrastructure in Southern provinces, including tax holidays, import duty exemptions and incentives to facilitate infrastructure development.
- Other investment incentives for infrastructure installation and construction that apply to the country in general include tax deduction for infrastructure installation and construction costs in addition to depreciation costs.

61. ***While the provision of regional incentives for investment is common through middle-income APEC economies; their implementation must be based on assessments of whether there will be sufficient returns on the government subsidies.*** These assessments must consider actual long term development of the surrounding region, provision of education and employment opportunities for the regional population, as well as increased provision of infrastructure in a form and nature that is required and valued by the regional economy.

4.4 Trade Policies

62. ***High tariffs and non-tariff measures on environmental-related technologies are major barriers to their wider use of such technologies (Brewer, 2008).*** The World Bank estimates that the complete elimination of tariffs and non-tariff barriers (NTBs), such as tariff free and quota free, would lead to an average increase of trade in clean coal technology, wind/solar power generation, and energy efficient lighting technology by 13.5 percent at the current level, with variation across technologies and countries (World Bank, 2008). Eliminating tariffs alone would raise trade level by around 7 percent from current level.

63. ***Within the multilateral trading system, Paragraph 31 (iii) of the Doha ministerial Declaration calls for ‘the reduction or as appropriate elimination of tariff and non-tariff barriers to environmental goods and services’.*** Increasing access to and use of Environmental Goods and Services (EGS) can yield

a number of benefits including, inter alia, reducing air and water-pollution, improving energy and resource efficiency and facilitating solid waste disposal. Greater access to and use of EGS may also be a tool for economic development and help facilitate the transfer of skills and technology from developed to developing nations (ICTSD, 2008). The International Centre for Trade and Sustainable Development (ICTSD) found that trade in EGS is associated with increasing FDI.

64. ***Another challenge to greater trade in Environmental Goods and Services (EGS) is the absence of a universally accepted definition.*** This makes it difficult to agree on the scope of lower tariffs and NTBs on EGS, despite the Doha mandate's calls for greater liberalization. Several lists have been proposed as a basis for negotiations, including the WTO 153 list, the US-EU 43 list and various submissions by individual countries. A popular approach used by the World Bank in earlier reports (World Bank, 2007; World Bank, 2008), focuses technologies that are expected to have the greatest potential to result in GHG emissions over the medium-term and where sufficient data is available. This approach uses the list of Harmonized Commodity Description and Coding System (HS) codes to identify trade in the key technologies (Appendix A)¹².

65. ***An issue with reliance on the HS system to identify EGS is that when products are classified at the HS-6 level, components of CFTs are included in broader categories that contain non-climate friendly goods, and goods with dual purposes.*** For instance, technologies that are relevant for clean coal electricity generation and for cleaner industrial use are not clearly classified under a separate HS category. For these reasons, the values calculated in the following sections represent over-estimates of the total value of global trade in these CFTs (as identified by the HS code groupings).

66. ***For Established Environmental Technologies (EET) the ICTSD (2007) identified a clear difference between average applied tariffs by developed and developing countries, with rates being uniformly lower among developed countries.*** Thus applied tariff rates of developed countries were less than 1 percent, while average rates applied by developing countries were almost 10 percent. Examples include:

- Waste water management technologies, where developed countries' tariffs were close to 2.4 percent and developing countries applied a rate of almost 9 percent; and
- Solid and hazardous waste management technologies, where developed countries applied an average rate of 1.8 percent and developing countries a rate close to 6 percent.

67. ***Relative to high-income OECD countries, tariffs on CFTs in middle-income APEC economies are high, and in some instances higher than average industrial tariffs in these countries (Table 24).*** Within these broad groupings of EET, there are significant differences:

- Tariffs applied by Malaysia were as low as those applied by developed countries;
- Whereas in some Asian markets - such as China, Malaysia, and the Philippines - tariffs on environmental products were as high as 40 percent, India imposed a 25 percent tariff to imported pollution control equipment;
- Many countries involved in the production of EET imposed an escalating tariff structure, so that while lower tariff were imposed on parts and equipment used as input in the production EET, higher tariffs were applied to EET themselves. One example of this was China, where tariffs for wind turbines were 3 percent for individual parts, 8 percent for assembled components, and 17 percent for entire pre-assembled turbines.

¹² The HS is an internationally standardized system of names and numbers for classifying traded products that is developed and maintained by the World Customs Organization. This system contains over 5,000 product codes, identified globally at the 6 digit level, with further regional and country level disaggregation at higher digit levels. Due to the requirement for consistency globally, trade codes at the 6 digit level were utilized. For each technology, the top ten importers and exporters are identified, over the period 2005-2008, as well as the proportion of world trade for each exporter or importer, by value, for 2008.

Table 24: Applied average tariffs for CFTs in middle-income APEC economies (%)

Country	Clean coal	Solar	Wind	CFLs	Average industrial tariffs
China	15	8	10	8	10
Thailand	1	10	10	20	16
Indonesia	0	10	15	5	7
High-income OECD	1	3	3	4	4

Notes: No data available for Vietnam.

Source: World Bank (2007)

68. *Non-tariff barriers to EET trade can take various forms, with the most quoted ones being standards, certifications, subsidies and environmental regulations.* Technical standards and certification requirements, for instance, limit trade because products from developing countries face difficulties when entering the market of developed countries due to lack of appropriate standards for their products.

69. *Marketing restrictions, labeling, packing, documentation requirements, harassment of imports, distribution, logistics and banking restrictions are among the most frequently cited barriers for Asian countries.* This is illustrated in Table 25, which summarizes the result of a worldwide survey of importers, marketers, applicators and distributors of environmental products in 15 economies in Asia, 9 economies in Africa, and 22 economies in Latin America and the Caribbean (ICTSD, 2007).

Table 25: Rank ordering of non-tariff barriers to EET trade by frequency of occurrence

Rank	Non-tariff barrier	Frequency
1	Standards	36
2	Harassment of importers	34
3	Labeling, packaging/documentation requirements	33
4	Sanitary & phytosanitary regulations	25
4	Importer restrictions	25
4	Discriminatory devices	25
5	Restrictions/distribution, logistics, banking services	21
5	Restrictions on marketing	21
6	Subsidies	14
7	Intellectual property infringements	10
8	Restrictions/investment and commercial relations	9
9	Others	6
10	Quotas	2

Source: ICTSD (2007)

70. *Technical standards and labeling are another major issue at the inter-linkage of trade and climate-friendly technology transfer (Meyer-Ohlendorf and Gerstetter, 2009).* Both are essential instruments for high potential to reduce energy consumption and constitute non-tariff barriers to trade. Standards often set legally binding benchmarks for producers, while labels serve as a consumer information tool. Countries can facilitate trade and apply efficiency standards and labeling regulations at the same time under the WTO's Agreements on Trade Related Aspects of Intellectual Property Rights (TRIPS) and on Technical Barriers to Trade (TBT).

71. **Issues with branding and traceability of product are linked to more general concerns that are being raised internationally about the lack of a harmonized quality control program for CFLs.** In response, a number of studies have commented on lower quality CFLs being produced internationally. Reduced CFL quality, for instance, a reduction in performance of 25 percent, could increase electricity consumption by up to 28,000 GWh/year (USAID, 2007a). Table 26 shows the corresponding analysis.

Table 26: Estimated annual production of low-quality CFLs, by country

Country	Estimated 2006 production (million units)	Estimated percentage of low quality CFLs (%)	Estimated number of low quality CFLs (millions of units)
China	2,400	55	1,320
Indonesia	30	29	9
Vietnam	13	39	5

Source: USAID (2007a).

4.5 Summary

72. **There is great diversity in the policy instruments that countries can apply to create an enabling policy environment for efficient investment and trade in CFTs.** Table 27 below provides a summary of the policy objectives and approaches, with illustrations from APEC middle-income economies in which they are applied.

Table 27: Implications of technology policies and their application in middle-income economies

Objective	Approach	Comment	Relevant initiatives in middle-income APEC economies
Reduce systemic uncertainty of investment	Set out clear government objectives	Essential to avoid conflicts and unintended consequences	Legislation to address cross border mergers, tax equality, formal property rights, market-based competition (China) Legislation to address legal standing, property rights, immigration, coordination (Indonesia) Legislation to support private investment, legal framework, property rights, competition (Vietnam)
	Flexibility in investment options	Increases attractiveness of FDI for multinational companies	Loosening of existing investment provisions (China)
	Risk sharing arrangements	Increases attractiveness of FDI for multinational companies for new technologies	n/a
Facilitate adoption and diffusion of technologies	Investment in physical and human capital through training and education	Central to ensure successful technology transfer	Education in renewable technologies (Indonesia)
	Investment by foreign governments	Can facilitate transfer of resources, infrastructure and capability	Cooperative projects with overseas governments (Indonesia)

Objective	Approach	Comment	Relevant initiatives in middle-income APEC economies
Facilitate trade	Efficient and transparent property rights framework	Supportive of trade in patent sensitive industries	Legislation to support property rights (China, Indonesia, Vietnam)
	Investment incentives	Increase incentives for FDI	Selective opening of geographical regions/trading zones (China, Indonesia, Vietnam) Tax incentives for investment in renewable technologies/ targeted locations (Thailand) Tax incentives to existing/new investors (Indonesia)
	Removal of trade restrictions on certain sectors	Increases incentives for FDI	Loosening of existing investment provisions (China)
Reduce energy intensity	Energy efficiency regulations	Need to be correctly targeted to be effective	Energy savings and efficiency regulations (China)
	Information to promote energy savings	Effectiveness depends on the context	Performance labeling, standards for appliances (Thailand)
Increase use of renewable energy	Subsidies for renewable technology investments	May be useful for overcoming initial cost barriers to expanding CFT supply Cost-effectiveness for expanding CFT use is uncertain; targeting of subsidy difficult	Subsidies for PV facilities (China) Subsidies for small scale hydroelectric facilities & other renewable technologies (Indonesia) Feed-in tariffs (Thailand)
	Promote take-up of renewable energies	May facilitate CFT diffusion through the economy	Community based demonstrations of prototypes (Thailand)
	Access to market-based carbon finance	More efficient than subsidies for expanding CFT utilization	CDM projects

5. FUTURE ROLE OF MIDDLE INCOME APEC ECONOMIES – OPPORTUNITIES AND IMPEDIMENTS

1. ***This chapter builds on the information discussed in earlier chapters of this report to assess, for each of the middle-income APEC economies of interest, the development potential of a number of CFTs.*** In particular, this chapter draws on the descriptions from earlier chapters of the different technologies, how these technologies are currently utilized in middle-income APEC economies, the role of trade, and how government policies enable the transfer, adaptation and diffusion of CFTs.

2. ***For each of the middle-income APEC economies considered in this report, this section discusses a selection of the CFTs that have been identified as having further development potential.*** Each case begins by summarizing the status of investment and energy policy initiatives, and contrast this with what information is available about the limitations to these policies. The potential for the further development of CFT technologies is then discussed, as well as corresponding government policies and targets and the practical and technical impediments that have been identified to achieving these.

3. ***The country analyses highlight the variation across countries in their comparative advantages and disadvantages.*** These variations range from advantages like attractiveness for FDI (e.g. China and Indonesia) or policy reforms to attract FDI (e.g. Vietnam) to disadvantages that are common across countries, like low public acceptance, lack of training or education about CFTs. The analyses also reveal that there is great variation across countries in their potential for specific of CFTs. China and Indonesia each have potential in up to six different CFTs, while Thailand and Vietnam have potential in relatively fewer, technologies. Solar power has development potential in all countries considered.

5.1 China

4. ***China is by far the largest of the APEC middle-income economies, and has come made significant progress in applying a broad range of technologies.*** These technologies include advanced clean coal and cogeneration technologies, as well as wind, solar, and hydroelectric. China also accounts for the greatest number of CDM projects by a single country and is also a major producer of a number of these technologies Chapter 5.

5.1.1 Comparative Advantages and Disadvantages

5. ***China has a number of comparative advantages in terms of strengthening the role of CFTs in middle-income APEC:***

- Attractive location for FDI flow – China is the destination for the majority of FDI into developing economies worldwide (OECD, 2008).
- Gradual progression to a more open economy – China has taken a gradual approach to opening up its economies to foreign trade. This strategy has a number of advantages, including reducing costs associated with the dislocation of domestic business, sectors and unemployment; allowing for a degree of learning by doing; and enabling the smooth progression in the development of CFTs on a larger scale. By the same token, gradual progression delays the benefits that come from CFT transfer.
- Incentives for domestic CFT production – To raise the competitiveness of and capacity for independent innovation of domestic industries, the Chinese government provides incentives such as preferential import tax incentives for intermediate goods.

6. ***A number of disadvantages have also been identified:***

- Lack of coordination in policies – Although the Renewable Energy Law clearly described the obligations of all the related departments, it is inevitable that each department will have its own priorities, arrangements and plans based on its set of constraints. For example, as of 2007, the Ministry of Science and Technology had set out in its R&D guideline to increase annual investment in wind power technology; however, the State Fund for Nature Science had also separately planned for R&D funding in wind power technology.
- Lack of certainty on investment incentives – As of 2007, the Chinese government had only introduced the “Temporary Implementation Rules for Setting up Feed-in Tariffs for Renewable Energy Power and the Sharing of Expenses in Purchasing Electricity from Renewable Energy”. The intention of this policy was to share the additional charges for renewable energy nationwide, thus supporting utility development in provinces that are incapable of self-sufficient funding. Li et al. (2007) commended the intention of this policy, but pointed out the need to provide more certainty around the time horizon of these incentives so as to gain greater confidence amongst potential investors, thus increasing the uptake of the incentives and the efficiency of the policy.
- Policies limiting FDI flow – While China is an attractive location for FDI flows, recent FDI legislation includes national security clauses, to the effect of the exemption of certain industries from increased levels of foreign ownership. Cross-border merger and acquisition activities in China have also been curbed by legislations such as ‘Regulations on the Acquisition of Domestic Enterprises by Foreign Investors’, which took effect on 8 September 2006.
- Dissemination of policies – The adoption of CFTs on a macro and micro level requires public acceptance and participation. A lack of public education on the economic benefits and costs of CFTs results in public resistance to adopting new CFTs. The information barrier between technical experts, government officials and the general public needs to be broken down to allow for the successful adoption of new CFTs.

5.1.2 Technology-Specific Issues in the Development of CFTS

7. ***Relative to other middle-income APEC economies, China has made significant progress in developing and applying sophisticated technologies, and the following sections briefly describe the potential for different CFTs.*** The impediments described here therefore tend to relate less to issues surrounding the availability of human capacity and technologies, as is the case for other middle-income, but tend to arise at the planning and policy level.

5.1.2.1 Potential for Clean Coal Technologies

8. ***China is the world’s largest producer and consumer of coal and there is therefore a strong movement for the development and implementation of clean coal technologies (CCT) for power generation.*** Given the current growth projections, the trend in coal use and production is expected to continue, further increasing the need for technologies like CCT. CCT development in China has been driven more by the government’s priority to maximize energy independence rather than the concern for air pollution since regulation of air pollutants in China has historically been relatively lax (APEC, 2007).

9. ***IGCC is one of the main potential applications for CCT in China, even though it is complex and remains costly to implement.*** Conventional coal IGCC projects in China have been implemented successfully without much resistance from stakeholders. The projects have also received financial support from external stakeholders. For example, the ADB has recently approved a loan of USD135 million to construct a 250MW coal-fired IGCC power plant in Tianjin City of China. (Statesman, 2010).

10. ***The second main area of focus for CCT is coal liquefaction/coal-to-liquid (CTL) technology.*** When the Shenhua group first launched its CTL technology, the prospect of turning coal to liquid was viewed very positively and drew significant investment interest for the technology in China. However, in

September 2008, the NDRC issued an order to stop all CTL projects except for two involving the Shenhua Group, because it believed that most domestic enterprises lacked the advanced technologies, management experience and equipment to pursue the CTL technology appropriately. Further, the investment risk of CTL was deemed to be too high to be assumed by small companies, which were mostly funded by bank loans. It was decided that allowing indiscriminate ventures into the technology in the experimental stage would have extended ramifications on the national banking system should a technical complication arise. Also, CTL was deemed inferior to normal liquid oil in reducing CO₂ emissions unless CCS is combined with the technology. Shenhua Group was the only Chinese producer with the CCS technology to integrate with CTL (Xinhua, 2008).

5.1.2.2 Potential for Cogeneration (CHP/DHC)

11. ***China has promoted cogeneration in the form of CHP and DHC over the last decades, although economic and institutional barriers to their increased uptake remain.*** There is great potential in further developing CHP and DHC as the economy continues to grow and industrial demand rises along with pressures for improved living standards. There remains a disconnect between the prices of fuels used to generate electricity and heat via this route, and electricity and heating prices set by the government (IEA, 2007). In particular, market prices of coal have increased significantly in recent years, while government-set electricity and heating prices have risen only slightly. The implication is that CHP/DHC installations cannot be installed and/or maintained profitably.

12. ***The absence of financial incentive for CHP/DHC technologies contrasts with stated government policy.*** Although the Chinese government has consistently supported development of CHP through the policy measures taken over the years, there have been few corresponding financial incentives. The lack of fiscal and tax incentives to support CHP/DHC is therefore an issue.

13. ***Comprehensive pricing reform is needed to overcome counterproductive incentives¹³.*** Although there has been some movement towards pricing reform¹⁴, in most instances DHC heat tariffs are developed on the basis of building area, rather than actual heat consumption. This creates a disincentive to improve the heating efficiency in district heat facilities and buildings, and also encourages wasteful consumption.

14. ***There are a range of other obstacles to the further use of this technology:***

- The limited extent to which CHP facilities are connected with the power grid: Limited or no interconnection will reduce the range of capacity options for developers and potentially raise costs, since excess energy cannot be on- sold. Improved scope to connect CHP facilities to the grid will, however, require the development of a broader electricity reform framework to address such issues as the price at which energy can be sold, conditions of grid access, as well as other technical requirements.
- The extent to which technological know-how is accessed to promote the technology: While existing CHP/DHC technologies are widely and successfully deployed in China, this is not the case for gas-fired district heating and cooling technology where expertise is limited. In addition, although the Chinese government is pursuing many cooperative energy efficiency projects with international agencies, this has not occurred in the context of CHP/DHC technologies¹⁵.

¹³ Pricing reform is covered in detail in World Bank (2010d).

¹⁴ For instance, the 'Enhancement Opinion on Urban Heating Reform' (2005) advocated heating price reform, among other things. The 'Urban Heating Price Management Temporary Measures' (2007) proposed reform in the heating price, including the gradual introduction of a basic heat price and the metered heat price.

¹⁵ For instance, the International CHP/DHC Collaborative was launched in March 2007 to evaluate global lessons learned and guide policymakers as they assess the potential of CHP as an energy technology solution. The Collaborative collects global data on CHP installation, addresses growth potentials for key markets, develops country scorecards with data and relevant policies,

- **Lack of monitoring and enforcement:** The limited monitoring and enforcement of these policies limits the efficient operation of CHP projects, even though the Chinese government has adopted a number of policies to improve the efficient design and operation of CHP projects¹⁶. A related issue is that while China has seen dramatic growth in CHP/DHC over the past two decades, no government agency has been responsible for all aspects of this technology and hence there is little coordination.
- **No overall targeted policy as regards CHP units:** In order to fulfill its energy conservation target, China is increasing the number of larger, more efficient power generation plants and closing down smaller, older units. It appears that some small CHP units with high efficiency are also being targeted for phase-out.
- **Lack of financing mechanisms:** A large number of existing district heating schemes in China are poorly managed and have low overall efficiency. The IEA (2007) has identified a number of areas where significant energy savings could be realized by modifying existing installations, for instance, by investing in improved heat pipeline infrastructure. More generally, heat losses in pipelines are high for many existing DHC projects, reducing the overall efficiency of the heating system. In addition, NDRC estimates that between 135 and 300 MW of existing condensing power units and a portion of existing heat boilers could be retrofitted to CHP service. The central obstacle to undertaking these efficiency measures is that funding is difficult to obtain for cost effective retrofit or energy conservation projects of this type.

5.1.2.3 Potential for Wind Energy

15. ***There is significant potential for wind energy in China throughout the country's vast land mass and long coastlines.*** According to the Global Wind Energy Council, the technically exploitable capacity for wind energy is 600-1,000GW on land and 100-200GW offshore (Li et al., 2007).
16. ***While there are no major impediments to the production, distribution and marketing of Chinese wind energy technology, there are some concerns regarding the levels of utilization of existing wind power assets in China.*** China is already one of the developing economy leaders in wind energy CFTs, has many domestic manufacturers and a developed international export market. However, there are reports that up to 30 percent of assets are not in use, or are not connected to the national power grid (Kwok, 2009). In addition, while capacity utilization of wind turbines has averaged 30 percent internationally, capacity utilization of Chinese wind turbines has averaged only 23 percent.
17. ***The main technical and economic challenge for China's wind power sector is the mismatch between the geographical distribution of the wind resource and the country's power load profile.*** The coastal areas have a large power load but less wind resources while the northern areas are richer in wind resources but have lower power load (Li et al., 2007). Compounding the problem is the loophole in Chinese renewable energy policies, especially for wind energy, which only provide specifications for installed capacity. As a result, in order for companies to satisfy the installed capacity specifications, some turbines have been opportunistically built in areas where there is no connection to the national power grid (Kwok, 2009). This has resulted in a relatively weak grid network and relatively high idleness rate of 30 percent, as compared to a rate of 23 percent internationally.

documents best practice policies for CHP and DHC, and convenes an international CHP/DHC network to share experiences and ideas. Participants include public and private partner organizations and other government, industry and non-governmental organizations that provide expertise and support.

¹⁶ For instance, the 'China Energy Conservation Technology Policy Outline' (2006) recommends the promotion of CHP and district heating over small heating boilers, the development of CHP and similar technologies in areas with proper heat loads and under appropriate conditions. The 'Implementation Scheme of the National 10 Key Energy Conservation Projects' (2007) further specifies important applications and supporting policies for CHP.

5.1.2.4 Potential for Hydropower

18. ***There is significant potential for hydropower in China, especially in the development of micro hydropower generation technologies.*** While China used to rely heavily on foreign imports for this technology, it is now considered self-sufficient in the design and production of hydropower turbines and the equipment needed to build hydropower stations. With the Three Gorges Dam project, China commissioned the world's largest hydroelectric power station; as of March 2009, Chinese firms built 19 out of the 24 largest hydropower plants under construction globally. The market for Chinese produced hydroelectric technology in China has also steadily been increasing. In 2007, total exports of power generating equipment totaled US\$ 228 billion and imports of USD124 billion.

19. ***The strength of Chinese manufacturers on a global scale remains in the market for small scale hydropower equipment, in the order of 40-100MW.*** This class of hydropower station accounted for approximately 45 percent of China's produced hydropower in 2007 (Godfrey, 2009). Strong domestic demand (China leads the world in micro-hydro installed capacity) has contributed to this position. The export market for Chinese products is also established, with hydropower electrical equipment being the second largest item within the power generating equipment export category, which netted a total of US\$ 104bn in 2007. Further, micro-hydropower technology has been proposed as one of the few potential economic solutions to the electrification of remote areas (ADB, 2009c), and as such the strengthening of Chinese production of micro-hydropower technology will ensure the steady growth of its export market share as other smaller middle-income APEC economies embark on hydropower generation.

20. ***Hydropower in China has benefited tremendously from the CDM.*** This is evident in the fact that almost half of the registered CDM projects in China belonged to hydropower projects as of February 2009. However, there is relatively less potential for inbound transfer through CDM into China for this technology, since China is already one of the leading producers of hydropower technology products and is becoming self-sufficient in its own technology production (Godfrey, 2009). Instead, the future role of China in terms of hydropower technology transfer lies more in outbound transfer, particularly South-South transfer, given that it has not yet been a major source for hydropower technology transfer.

21. ***China's strong development of hydropower has attracted some controversy.*** Concerns relate to the destruction of biodiversity in the construction of dams, the possible destruction of historical and cultural aesthetic values in the event of dam floods, downstream erosion and upstream sedimentation, potential national security threats related to the destruction of the dams by terrorists, inadequate structural stability of the dams, and the potential of dam breaches with earth-quake induced peak ground acceleration (Williams, 1993).

22. ***The Chinese government nonetheless remains a strong supporter of hydroelectric facility development and has pledged to commit approximately USD125 billion by 2020 to further develop the technology (APEC, 2009).*** The government has also proposed building more than 30 large hydropower stations and individual and community based investment in smaller hydropower systems. A unification of hydropower policies into a national framework is also being developed.

5.1.2.5 Potential for Biofuel

23. ***Biodiesel is considered to be in the early stages of development in China, with 30,000 tonnes of production in 2006 from a number of small scale operations.*** Feedstocks are the main constraint on the production of biodiesel in China, given that China is a net importer of vegetable oils such as soy and palm oil for food production. The main feedstock is waste cooking oil from restaurants, which is difficult to collect on a large scale (Beckman and Jiang, 2009). Despite uncertainty surrounding the preferred feed stock for biodiesel (from economic and environmental perspectives) up to 3 million tonnes/year of additional biodiesel productive capacity is currently under construction in China.

24. ***Where ethanol is concerned, trade is restricted by import and export tariffs and duties in the largest markets since domestic producers in the European Union and USA receive additional support through subsidies and duties (World Bank, 2007).*** The World Bank study (World Bank, 2007) does not consider increasing production of ethanol in developing and middle-income countries to be beneficial or particularly promising, due to these distortions, and the attendant concerns about food security, deforestation, biodiversity loss and water use. The exception is Brazil, which has an established substantial industry.
25. ***With the major feed stock for Chinese ethanol being land and energy intensive corn, there has recently been increased investment into research and production of cellulosic ethanol production.*** It is estimated that with approximately 1,500 million tonnes of forest and agricultural residues produced annually, up to 370 million tonnes of ethanol could be produced annually.
26. ***The rapid growth of this industry, driven by ethanol production, has brought about a major debate about the continued use of food stock to produce biofuels.*** Consequently, in June 2007, China's central government enacted a law to halt the approval of any new grain biofuel processing projects. The few exceptions include the use of cassava, sweet potato and sweet sorghum, but the current domestic Chinese production of these crops are not sufficient to sustain large scale biofuel production as most of these crops need to be planted on marginal, less fertile land. USDA Foreign Agricultural Service forecasts that this Chinese government policy will remain in place in 2009 and beyond, implying that the potential of the Chinese biofuel industry lies in adopting and developing advanced conversion technologies that enable production using "cellulosic" biomass and the cultivation of alternative biofuel feedstock such as the inedible and poisonous jatropha (USDA, 2006).

5.1.2.6 Potential for Solar PV

27. ***China is the world's largest producer of photovoltaic (PV) solar cells, a large proportion of which are exported, and the Chinese application of this technology is set to change rapidly.*** Installed PV capacity expanded significantly between 2007 and 2008 from 100MW to 140MW (UNEP, 2009). Moreover, the most recent 'Medium and Long-Term Development Plan for Renewable Energy' released by the NDRC in August 2007 has significantly expanded growth targets. The plan sets a target for installed renewable energy capacity and a target for solar PV of 1.85GW in 2020. These expanded growth targets follow a period of successful PV development, which has improved the confidence of the government that PV is a viable electricity source (Yotam, 2009).
28. ***Domestic use of solar PV cells has not received significant policy attention from the Chinese government in the past, due to the strength of the export market.*** Of the total government subsidies for renewable energy in China of US\$ 292 million, solar PV facilities only received US\$ 0.4 million. However, following the global economic downturn, combined with a global market that is reportedly facing oversupply, the Chinese government has announced generous subsidies for the development of building-integrated PV systems, approximately US\$ 2.93/W (UNEP, 2009a).
29. ***For a variety of reasons¹⁷, China is now applying the expertise it has developed to expand the scale of PV technology and develop it in new directions.*** Numerous significant PV solar projects are underway, including the 500 kW Wuwei facility (the first plant to be tested in desert conditions and connected to the grid), a planned 10MW PV solar plant at Dunhuang, and plans to build solar PV stations of 20MW or more in Gansu, Qinghai and Inner Mongolia (Watts, 2009).
30. ***The intense interest in commercial PV solar development is predicated on government support, with the enactment of several policies to support the industry using regional feed-in tariffs (FITs) and subsidies for solar PV installations (Yotam, 2009).*** For instance, the Jiangsu government put in place an

¹⁷ These include the downturn in PV cells exports, increasing demand for power domestically, the rapidly falling cost of solar power, and a desire to reduce dependency on thermal fuels.

attractive FIT, which nearly covers project costs. The FIT has encouraged several leading PV manufacturers, including Suntech and Trina Solar, to oversee the development of 80MW and 30MW rooftop PV projects, respectively. By 2011, 400MW of PV capacity are scheduled to be completed in Jiangsu.

5.1.2.7 Household and Community Biogas Plants

31. ***The use of biogas digesters in rural China is expected to increase significantly.*** The 2003-2010 National Rural Biogas Construction Plan is to have 40 million biogas plants operating in China, reaching in the vicinity of 20 percent of rural households (Yu et al., 2008). By 2020, this figure is projected to increase to 98.6 million, resulting in GHG emission reductions of up to 18,961 and 46,794.9 Gt CO₂e in 2010 and 2020, respectively.

32. ***Given the variability in climate, agricultural practices and landscape across China, a number of differentiated programs have been established to promote the use of biogas digesters in different regions of the country.*** For example, biogas digesters do not operate in temperatures below 10 degrees Celsius, and agricultural production is also reduced through the colder months in Northern China. In that region, the ‘four-in-one’ model of biogas digesters has therefore been implemented that incorporates:

- The provision of a greenhouse (utilization of fertilizer from digester and increased food production);
- A shed for pigs (ensure growth during winter and collection of fuel stock for the digester);
- A digester located underneath the pig shed (to maintain appropriate operational temperature); and
- A toilet adjoining the greenhouse (for additional fuel stock and human waste management).

33. ***In contrast, in Southern China, where the weather is more temperate, a five-in-one approach has been implemented that relies on (Kangmin and Ho, 2006):***

- Pig farming (providing fuel stock for the digester);
- A digester (providing gas and fertilizer);
- Fruit orchards (utilizing the fertilizer from the digesters in place of GHG intense nitrogen based fertilizers);
- Fish ponds (further utilization of fertilizer and by products from production of biogas as fish feed); and
- Light traps (powered by the biogas) to attract and kill pests and insects, and to provide additional fish feed).

5.2 Indonesia

34. ***This section focuses on how wind and solar power are used to electrify remote communities in Indonesia that are not connected to the grid, as well as on clean coal technologies required to limit emissions from Indonesia’s abundant lignite coal resources.*** This section also comments briefly on the scope for geothermal and biofuel technologies, although less information is available here. As of February 2009, 24 CDM projects were registered in Indonesia, with the majority focusing on biomass and methane avoidance projects.

5.2.1 Comparative Advantages and Disadvantages

35. ***Indonesia has introduced a number of reforms to increase the attractiveness of inbound investment of the country, although investment restrictions remain.*** Indonesia’s energy policy encourages both the installation of renewables as well as fossil fuelled generation, reflecting a sometimes

conflicting mix of environmental and self reliance objectives. Specifically, the National Energy Law has also sought to put in place specific targets for an optimal energy mix. Additional steps taken to achieve these targets include international cooperative efforts and financial support for consumers.

36. ***During the past two decades, the economic and investment climate in Indonesia was adversely affected as a result of:***

- Political turmoil, which was triggered by the ousting of the then President Suharto after a 32-year reign following widespread accusation of public fund embezzlement;
- The Asian Currency Crisis, which resulted in the significant devaluation of the Rupiah. Although the crisis did not originate from Indonesia, the Indonesian currency was the hardest hit over the ensuing months and years, and Indonesia is still working towards the leveling its purchasing power parity (IEA, 2008d); and
- Social unrest, caused by the widening of the socio-economic, racial and religious rifts.

37. ***Indonesia was considered the eighth most attractive location for FDI in the period 2008-2010 (UNCTAD, 2008a), despite experiencing the Asian Currency Crisis and various socio-political challenges over the past two decades.*** Indonesia's Law on Investment and the Law on Income Tax Facilities include generous incentives offered to new and existing investors that satisfy one of the many requirements set out in Chapter 4. Some of the requirements specifically support the development of CFTs in Indonesia. However, the relatively lax condition of fulfilling any one of the general requirements may impair the effectiveness of the policy in specifically promoting CFT development.

38. ***At the same time, and in addition to the political and policy instability described above, Indonesia has a number of impediments to the take-up of CFTs remaining:***

- Affordability – Rural (low-income) households cannot afford the full price of CFT products installed on a micro-level. Therefore, the successful large-scale micro-level adoption of new CFTs in Indonesia requires significant financial aid by the government and other agencies, such as the World Bank and the ADB.
- Unsustainable financial support system – A significant proportion of the required investment outlay (sometimes 100 percent) for micro-level CFT adoption in Indonesia is government subsidized. The success of large-scale adoption of new CFTs on a micro-level significantly depends on the availability of public funding. As seen in the case of solar PV technology implementation in Indonesia, the project scope significantly shrank when funding fell short.
- Challenging geographical setting and population dispersion – Indonesia is an archipelago of over 17,000 islands and its population generally is found in a large number of small and highly dispersed communities, consisting of uniformly poor households located in difficult-to-access terrain. This challenging geographical setting and high population dispersion act as impediments to the diffusion of CFTs in Indonesia.
- Lack of consumer support – In practice, households taking up new CFT products in Indonesia have faced issues concerning a lack of quality control, warranties, after-sales service and spare parts. These factors have tended to undermine the acceptance of these new technologies.
- Lack of information – The adoption of CFTs on a macro- and micro-level requires public acceptance and participation. A lack of public education on a number of levels – including among technicians, government officials and the general public – on the economic benefits and costs of CFTs has also resulted in public resistance to adopting new CFTs.
- Lack of expertise to quantify renewable energy (RE) potential – Expert studies have only been conducted for some of the renewable energy resources in Indonesia and their scope is normally limited to determining the theoretical potential. Further investigations are still required to

investigate and measure technical potential. Due to the complexity of these measurements and the lack of domestic R&D expertise and funding, however, there is a lack of a general consensus on the technical potential of most RE sources.

5.2.2 Technology-Specific Issues in the Development of CFTs

39. ***The following sections briefly set out the potential for different CFTs in Indonesia.*** Much of this technology is applied to provide electricity to remote communities, which can pose a number of difficult challenges.

5.2.2.1 Potential for Clean Coal Technologies

40. ***Significant coal resource availability in Indonesia and promotion through the ‘National Energy Management’ Presidential Decree No 5/2006 provides a clear impetus for increasing the role of coal in the Indonesian energy supply.*** Current projections suggest that the contribution of coal to the final energy mix will increase from 14 percent to 30 percent by 2020 (PEACE, 2007). Resolving issues and opportunities with respect to advancing CCS technologies, as well as increased efficiencies in coal fired power stations will be essential to ensuring that this policy does not result in increased GHG emissions.

41. ***Indonesia has announced a National Coal Policy that is directed at increasing the role of coal fired power plants in the future energy supply, including the use of clean coal technologies (CCT).*** Over the period 2003-2020, the National Coal Policy will aim to (APEC Energy Working Group, 2008a):

- Implement sustainable exploration and use of coal resources;
- Increase competency in coal utilization technology;
- Develop capacity to utilize low grade coal, or lignite;
- Utilize clean coal technologies;
- Establish a clean coal technology centre; and
- Define national coal legislation.

42. ***The application of CCT has considerable potential to reduce GHG emissions in Indonesia, since 60 percent of Indonesia’s proven recoverable reserves consists of low cost but highly polluting lignite coal (IEA, 2008d).*** A number of clean coal technologies are considered suitable for domestic adoption in Indonesia, and Indonesia has invested in a number of demonstration initiatives including:

- Upgraded brown coal (UBC) – A UBC demonstration plant has been in operation since November 2008 in Satui of South Kalimantan. As of 2009, the future program to develop and commercialize this demonstration plant includes an optimization test, a feasibility study and the engineering design.
- Coal liquefaction/Coal-to-liquid (CTL) – Indonesia is in the process of establishing a coal liquefaction demonstration plant in collaboration with the Japanese government.
- Coal gasification technology – Among the three main coal gasification technologies of interest in Indonesia, the ‘Tigar’ coal gasification technology is considered to be the most advantageous for Indonesia, in terms of its suitability for Indonesian coal.
- Coal Water Mixture (CWM) – CWM activities in Indonesia began in 1992, and the further development of this technology has continued since then. Since 2003, Indonesia has commenced CWM preparation and combustion test using upgraded coal by UBC process.

43. ***While it is unclear whether these demonstration projects have been completed successfully, CCT involves complex, multi-billion US\$ long-term investments, and these investments face many obstacles.*** As such, one obstacle to investment in and the application of this technology relate to the lack of long-term certainty within the broader policy framework in Indonesia. The types of issues that have been identified include (IEA, 2008d):

- A lack of clarity in the legal framework – In addition to the investor uncertainty brought about by political, economic and social unrest, foreign investment into the coal sector of Indonesia face legal uncertainty. A 2002 law, passed by the government to strengthen regulatory guidance in the power sector and promoting new investment was annulled by the Constitutional Court, which also required that electricity should be provided by a state-owned enterprise. At this stage, the details of new proposed laws and their implementing regulations are unclear.
- Slow investment approval, co-ordination and implementation – Indonesia's Investment Law increases the authority of Indonesia's Investment Coordinating Board (BKPM) in both implementing and proposing investment policy. Difficulties have arisen as a result of the slow implementation of government policy and regulations due to poor co-ordination across government.
- Temptation for policymakers to take quick energy supply fixes, at the expense of the environment in the long term – Policymakers in Indonesia are faced with a considerable energy supply deficiency. It is often tempting to opt for the relatively quick and easy solution, which is to support further development of existing coal technologies. However, this short-term solution is considered to not be efficient in the long term as it compromises environmental considerations.

44. ***Some of these concerns are being addressed (IEA, 2008d).*** Improvements have been noted in the area of government communications, where the Ministry of Energy and Mineral Resources has made some effort to improve communication between government and investors to improve investor certainty. Furthermore, and while corruption remains a serious problem, measures taken by the government to combat corruption appear to have had some positive results.

5.2.2.2 Potential for Solar PV

45. ***Along with micro-hydro, photovoltaic (PV) technology is considered to be a preferred option to increase electrification for a significant part of the population (estimated to be more than 70 million Indonesians in 2005) that is currently not connected to the electricity grid (Indonesian National Committee of the IEC, 2007).*** The advantage of PV systems in off-grid electrification is that this technology can function virtually anywhere (World Bank, 2008). PV systems are modular and rugged and require little maintenance (although arrangements must be made to obtain spare parts and repair services).

46. ***The Government of Indonesia has made available a budget of US\$ 12 million to install another 30,000 SHS systems under its Rural Electrification Program (IEA, 2008d).*** However, expansion has been limited, with many institutional, financial and technical hurdles that need to be overcome for most rural areas to gain access to PV power (Retnanestri et al., 2005, 2008).

47. ***Nonetheless, past experience suggests that the widespread application of PV technology poses some challenges (IEA, 2007).*** The Indonesian Solar Home Systems consisted of two major components – a credit component comprising a World Bank IBRD loan and a GEF grant, to enable purchase of SHS by rural households and commercial establishments on an installment plan basis, and technical assistance, including support of detailed monitoring and evaluation activities during project implementation. However, the economic situation following the Asian Financial crisis limited the success of the project and the project is being continued on a much smaller scale with the GEF grant only (IEA, 2007).

48. ***In spite of the challenges facing donor programs, PV technology services appear to be thriving in Indonesia (Retnanestri et al., 2005; Retnanestri et al., 2008).*** Dealers purchase systems or components from manufacturers under a dealer sales model, and sell them directly to households, usually as an installed system, and sometimes on credit. Apart from the solar module, PV equipment is produced domestically, with many PV distributors also assembling imported PV modules and manufacturing the balance of system components. PV distributors have set up outlets to market PV equipment, primarily as a result of governmental projects. PV systems are delivered from the distributor to the end-users through a chain of area sales, outlet, senior canvasser, and canvasser at the local level. In addition, there is a second-hand market, with local entrepreneurs selling used PV systems.

49. ***Although the technology is widely available, the evidence suggests that technological and human capital obstacles to its widespread implementation remain due to a range of factors (Retnanestri et al., 2005; Retnanestri et al., 2008).*** The more common factors include:

- PV installations have generally had inadequate warranties.
- There has been a shortage of trained technicians to install and maintain renewable energy technology.
- After-sales services have been lacking.
- There has been a failure to adapt PV technology to local conditions.
- There has been a lack of availability of spare parts.

50. ***In addition to these challenges, defects in the quality and reliability of the installations have wider ramifications.*** Customer satisfaction drops significantly if there are frequent instances where quality is low. The resulting non-payments and reputational risks tend to discredit the technology and the projects.

51. ***A complex institutional framework also tends to limit the success of PV technology applications.*** Rural PV projects in Indonesia involve many institutional stakeholders, including government agencies (cooperatives, transmigration, technology development, planning, energy, and banking), sponsoring bodies/donors, and local communities. The interaction of multiple parties is complex and time-consuming, and raises questions about institutional capacity.

52. ***Additionally, like many other renewable technologies, PV capacity is characterized by high upfront costs.*** To overcome the barrier for householders of the high upfront capital cost of SHS, the approach taken by the government is to purchase the systems from private companies through a bidding process and then provide the systems to the households for free. In general, this approach is not sustainable, as reflected in frequent system break-downs because of a lack of after-sales service and a limited (sometimes zero) financial commitment on the part of the households.

5.2.2.3 Potential for Wind

53. ***Across Indonesia, the estimated technical capacity for wind power is approximately 9GW (compared to an installed capacity around 0.5MW to 1MW).*** Since 1970s, universities and research organizations (such as ITB and LAPAN) have conducted R&D on wind energy in Indonesia through projects of small and laboratory scale (1kW to 10kW) and for demonstration and educational purposes.

54. ***The CDM has the potential to strongly benefit wind power in Indonesia.*** As of February 2009, there were no registered CDM projects for wind energy electricity generation in Indonesia. Since wind power is considered one of the most effective CFTs for technology transfer through the CDM, there is much potential in exploiting the mechanism to facilitate future diffusion of this technology.

55. ***There is potential Indonesia to import wind technologies from countries further along the development path, such as China and India, indicative of South-South trade.*** In addition, there is further potential in CFT transfer through North-South trade, such as from the USA, Germany and Spain.

5.2.2.4 Potential for Gas Technologies

56. ***Indonesia's membership of the Global Gas Flaring Reduction Public-Private Partnership has promoted the use of technologies to reduce the practice of gas flaring and harness this additional energy source.*** A study of options to utilize flare gas in Indonesia noted that approximately 62.7 tCO₂e per million standard cubic foot of gas could be mitigated through the utilization of flared gas to displace the use of fossil fuels from alternate sources (World Bank/GGFR, 2006).

57. ***The main technologies to utilize flared gas are power generation, transport via pipeline, natural gas compression (CNG), compression into liquefied natural gas (LNG), and compression into liquefied petroleum gas (LPG).*** LPG was only assessed in conjunction with one of the four other options due to the lower proportion of LPG in the total gas stream. Indonesia, together with Malaysia, is already meeting 40 to 50 percent of the region's demand for LNG, and is among the top two suppliers of LNG in the region. LNG production and trade is likely to continue and expand due to the remoteness of many of the EAP region's gas reserves and the subsequent challenges to gas pipeline connection (World Bank, 2010c).

58. ***Flared gas utilization depends strongly on gas prices.*** For lower gas price scenarios, flared gas utilization in power generation was the preferred option in Indonesia. Given the large distances between the decentralized sources of flared gas, and consumption points, electricity production on site and transfer as electricity is preferable to piping gas for power generation closer to load centers. Under higher gas price scenarios, pipeline and power generation are preferable options for use in Indonesian flared gas projects. The relativity of pipeline and power generation is highly dependent on the distance between the source and consumption point of that gas.

5.2.2.5 Potential for Using Geothermal Energy

59. ***Indonesia is reported to have the world's largest potential for geothermal energy production due to its positioning on the 'South East Asian Ring of Fire', although geothermal energy has a number of unique challenges to its development.*** Up to 27 GW of potential geothermal energy has been identified in Indonesia; however, to date only 1,052MW of capacity, or 4 percent, has been developed. The challenges of geothermal energy development are:

- Commercial development of geothermal energy requires onsite electrical power plant development. Consequently, this requirement may limit the resource to a small local market or one not well connected to a larger load centre.
- Development requires high initial capital costs, including initial exploration and the commitment to purchase a large portion of the eventual fuel supply at start-up in the form of development wells. Long term operating costs, however, are quite low. Thus, geothermal contracts require base load status and long term price security in order to justify development.

60. ***In December 2008, the Government of Indonesia announced plans to increase the capacity of Indonesia's geothermal energy production by approximately 4,700 MW by 2014, thereby essentially quadrupling current capacity and avoiding substantial CO₂ emissions.*** The Indonesian market for developing geothermal energy is considered to be highly attractive, with international power companies expressing considerable interest in investment. The domestic company Pertamina Geothermal Energy is currently assessing applications for investment from companies including: Reykjavic Energy Invest (Iceland, where 72 percent of electricity is geothermal), Suez International Energy, Chevron and Star Energy. It is estimated that, in terms of GHG emissions, such an expansion of geothermal capacity would

avoid up to 82 million tonnes of CO₂ emissions by avoiding the burning of up to 13.5 million tonnes of coal reserves.

5.2.2.6 Potential for Biofuels

61. ***The Indonesian government has proposed the development of the Indonesian Domestic Biogas Program (IDBP) that will be co-funded by the Dutch government.*** The ultimate goal of the program is to facilitate the development and eventual autonomous functioning of a domestic market for biogas plants. The aim for the product is to have developed and sold up to 8,000 units by 2012 (SenterNovem, 2010).

62. ***Other government policies directed at biofuels production in Indonesia include directives promoting minimum levels of biofuel fuel mix by 2010 (2 percent), 2015 (3 percent) and 2025 (5 percent), and the establishment of the National Team for Biofuel Development, tasked with coordinating industry expansion (Indonesia, 2008).*** Near term growth in the domestic market for biofuels will rely to a large extent on government programs. Interest rate subsidies have been announced by the Indonesian government in 2007 directed at farmers growing biofuel such as jatropha, oil palm, cassava and sugar cane.

5.3 Thailand

63. ***Thailand faces many of the same challenges as Indonesia in the implementation of CFTs, including large rural populations, insufficient funding for new technologies, and, to a lesser degree, political instability.*** The focus in this section is also on wind and solar technology used to provide electricity to rural communities. 18 CDM projects are registered in Thailand, the majority of which for methane avoidance and biomass energy projects.

5.3.1 Comparative Advantages and Disadvantages

64. ***Thailand's investment and energy policies are broadly directed at encouraging investment in particular zones, renewable energy development, and the promotion of energy security.*** Thailand has set an energy target aimed at increasing the share of renewable energy, as well as targets for the use of bioethanol, biodiesel and natural gas in the transport industry. As part of its energy source diversification effort, Thailand has placed a cap on natural gas at 70 percent of power generation.

65. ***Nonetheless, a number of obstacles to the further application of CFTs in Thailand remain.*** A major obstacle is a lack of funding. Thai government estimates for the cumulative total private funding required in the renewable energy sector to 2022 in Thailand are USD11.542bn. The largest cost component is biomass, accounting for approximately 40 percent of the total, followed by solar with 17 percent, wind with 15 percent, and ethanol with 10 percent of the total. In particular low-income households are unable to pay the full price of CFT products that are to be installed on a micro-level. Therefore, successful large-scale adoption of new CFTs requires significant funding support by the government and any other possible external sources such as World Bank and ADB.

66. ***Government policies have correspondingly focused on attracting private sector investment into the renewable sector, for instance, using directives that provide tax incentives and import duty exemptions.*** However, the effectiveness of these incentive arrangements is limited because of policy inconsistencies and institutional overlap. Prasertsan and Sajjakulnukit (2005) highlight the existence of several energy agencies with overlapping roles, functions and responsibilities as a drawback - agencies coordinating CFT policies report to multiple ministries, whose interests may not be aligned. The establishment of the Energy Ministry in October 2002 has not addressed these issues.

67. ***Although the Thai government has put in place several investment and energy policies to attract private funding of CFT development, investor confidence has been severely hampered by the***

political and economic unrest in the last decade. A key factor has been political unrest – Thailand has seen a string of political riots and coups for most of the last decade. Abrupt changes in policies relating to overseas investment in the Thai economy have also undermined investor confidence. On 19 December 2006, the Bank of Thailand placed a new currency-control measure, requiring financial institutions to hold 30 percent of any foreign-currency inflows, except those related to exports, for one year. This abrupt change in investment policy wreaked havoc in the financial markets in Thailand, Asia and the rest of the world. The Stock Exchange of Thailand (SET) Index recorded its biggest one-day fall in its history, plunging 14.84 percent on the day.

68. ***Policy inconsistencies also arise because of Thailand's subsidy policy, which offers incentives for liquefied petroleum gas (LPG), but not for biomass technologies (Prasertsan and Sajjakulnukit, 2005).*** This hinders the growth of biomass technologies, especially in cottage and small-scale industries, an example of which is the unsubsidized biomass producer gas, which consequently is unable to compete with the subsidized LPG. Again, co-ordination and alignment of the relevant ministries are needed to remove this barrier of entry.

69. ***Another barrier to the development of CFTs is the bidding process involved in the application for funds.*** The process is seen to be biased in favor of large-scale and low cost small power producers, and discourages ventures into developing smaller scale or higher cost biofuel sources that may need time and scale to be efficient. Corporate tax exemptions for investment in all three investment zones in Thailand only benefit operations with total capital investment in excess of 10m Baht. New and small-scale ventures naturally face more difficulty in obtaining private funding from banks and private investors.

70. ***More generally, Thailand faces similar problems to other middle-income APEC economies in terms of:***

- Widespread problems with quality assurance of renewable energy systems and equipment imported into Thailand.
- A general lack of information that prevents the widespread adoption of biofuel technology.

5.3.2 Technology-Specific Issues in the Development of CFTS

71. ***This section will discuss the two key focus areas for CFTs identified by the Thai government relate to investment in solar and wind energy, as well biofuels.*** Although relatively little information is currently available on biofuels initiatives, it has the potential to play an important role in the future. Reductions in excise tax apply to cars using at least 20 percent fuel ethanol from January 2008 (APEC Energy Working Group, 2008c). Additional policy measures to promote ethanol production and use include reduced prices for gasohol (E5-E25) by 2-2.5 baht/litre compared to gasoline, waived excise tax for ethanol blended gasohol and Bank of Investment privileges for the development of ethanol plants.

5.3.2.1 Potential for Solar PV

72. ***The 2009 national Renewable Energy Plan for Thailand gives solar energy the highest national potential among all renewable energy sources (Renewable Energy Magazine, 2010), and projects the installation of an additional 500MW of installed capacity by 2022 under the 15-year master plan to 2022 (Deboonme, 2009).*** Given the recent inception of the plan, it is not possible to judge the success of this initiative. According to the government, there is intense investor interest, with 2GW of PV solar proposals having been submitted. The government has announced a number of measures to provide financial incentives to investors in renewable energy, including solar. Approved new solar projects will receive a guaranteed FIT, as well as subsidies for solar power of around US\$24 per kWh, with an additional US\$ 0.5 per kWh if solar power replaces diesel generation and/or if the facility is installed in

the most southern provinces (Ministry of Energy, 2009). These add-ons will apply for a period of 10 years. In addition, import duties will be waived on solar equipment, and corporate income taxes will be reduced.

5.3.2.2 Potential for Wind Energy

73. ***The Thai government plans to generate 115MW of electricity from wind power by 2011, although there is currently relatively little installed capacity for wind energy generation, and no registered CDM projects for wind energy electricity generation as of February 2009.*** There are challenges to the government's plans. More than 92.6 percent of the land area in Thailand has poor average wind speeds of below 6m/s, and is thus incapable of wind energy generation. The areas identified as having sufficiently high wind speeds for practical electricity power generation are mostly inland areas, presenting a mismatch of energy requirement and difficulty in access to the national grid (Major et al., 2008). To some extent this issue can be overcome by using low speed wind turbines.

74. ***Partnerships with the European Union are also facilitating knowledge transfer within Thailand (Asian Institute of Technology, 2006).*** The European Union initiative is focused on providing technical, financial, and institutional support to increase the contribution of wind energy in Thailand's generation mix. The program is accordingly focused on information and dissemination workshops, seminars and capacity building training sessions. This will be combined with a background study on the status of wind energy in Thailand and the European Union, and any identified barriers to trade. The program intends to:

- Increase awareness among the potential stakeholder in Thailand regarding wind energy technology, cost, and potential.
- Disseminating the latest developments in applied research in the wind energy sector carried out in European Union.
- Capacity building through training workshop in aspects of wind from local and international experts.
- Disseminating wind energy information to potential stakeholders and the general public.

75. ***It is currently unclear whether wind power is a cost-effective option for Thailand.*** According to Thai Government estimates, the cost of wind-generated energy is among the cheapest options, and comparable to various types of biomass-generated energy. Elsewhere, however, the economic and physical feasibility of developing wind power in Thailand have been questioned. In a review of a wide range of literature on the potential of wind-power generated electricity in Thailand, Major et al. (2008) demonstrated that wind power is unlikely to be economically competitive where grid-connected electricity is available in Thailand. The study concluded that over the foreseeable future, the benefits of wind power electricity generation will probably be confined to small remote isolated installations that rely on traditional applications.

5.4 Vietnam

76. ***Vietnam is gradually moving from a centrally planned economy to a more open system in which laws have been enacted to facilitate foreign investment in the country, and has considerable potential to develop a range of clean energy sources, including solar, wind, hydropower, geothermal, and biomass energy.*** At the same time, Vietnam is working to reduce its reliance on imported oil supplies (discussed in earlier chapters). Of the various technologies, proposals for electricity generation from hydroelectric, solar and biomass sources are the most developed (ADB, 2009b).

5.4.1 Comparative Advantages and Disadvantages

77. ***Vietnam's moves from a centrally planned economy to one that is more diversified and market-oriented, has helped the country's ability to develop and diffuse CFTs.*** Vietnam has increasingly opened its economy to international trade by progressively removing restrictions on international capital flows. This has reversed a declining trend in FDI, such that Vietnam was considered to be one of the top ten FDI destinations in the period 2008-10 (UNCTAD, 2008). Further, Vietnam's recent membership in international economic communities facilitates inbound and outbound trade of CFT products.

78. ***A number of other factors support Vietnam's potential in CFTs.*** The legislative framework supports FDI generally - recent legislation includes the Law on Technology Transfer (2006), Law on Investment (2005), Law on Enterprises (2005), Law on Intellectual Property (2005) and Law on Competition (2004). In addition, recent legislation is supportive of renewable energy projects. Relevant legislation supporting the development of renewable energy and rural electrification includes the Vietnam Power Sector Development Strategy (2004) and the National Energy Strategy Development (2007).

79. ***While the legislative context for development of CFTs is promising overall, questions remain about the potential scope of these technologies.*** External expert studies have been conducted for some of renewable energy resources in Vietnam, but their scope has normally been limited to determining their theoretical potential. Additional investigations are still required to assess and measure the actual technical potential. Due to the complexity of these measurements and the lack of domestic R&D expertise and funding, there is no general consensus on the technical potential of most RE sources.

80. ***Other factors that have impeded development and take-up of CFTs relate to the lack of specific price signals (such as FITs) to encourage renewable energy and support investment in CFTs and a general lack of education about CFTs.*** Electricity prices in Vietnam are low, non-transparent and generally not cost-reflective. However, Vietnam is now taking steps to achieve more cost-reflective energy prices (see below). In addition, and as is the case in a number of the countries discussed in this report, a lack of public education on the economic benefits and costs of CFTs has in part led to public resistance to adopting new CFTs.

5.4.2 Technology-Specific Issues in the Development of CFTs

81. ***The following sections set out the experience with and potential for the greater utilization of biomass, hydroelectric, and solar technologies in Vietnam.*** While these initiatives are currently only at the inception stage, discussions are also underway with the German Organization for Technical Cooperation (GTZ) to establish a legal and technical framework to support wind power in Vietnam (GTZ, 2010). The focus of the project rests on establishing the legal instruments for the promotion of wind energy, including the guarantee of a feed-in tariff, prioritized access to the electrical grid, and a purchasing commitment for energy generated in this fashion. In addition, the project will contribute to the implementation of ecologically-sound planning processes for wind power projects.

5.4.2.1 Biomass Energy

82. ***Vietnam possesses abundant biomass resources, including wood residues, municipal wastes, and crop residues, and it is expected that around 500MW of renewable energy generation could come from biomass resources by 2025.*** The ADB (2009b) estimates a total biomass potential for Vietnam to be more than 60 million tons produced annually, including from rice husks (7-7.5 million tons), bagasse (4-4.5 million tons), rice straw (35-37 million tons), wood and wood wastes (10-15 million tons), and other sources, such as coffee husks and coconuts (1-1.5 million tons). The range of potential applications for biomass varies widely:

- Biomass for heat is used in rural households for cooking, and in rural, small scale industry for activities such as brick making, ceramic burning, and food processing; however, these

applications (in particular cooking stoves) are considered to be highly inefficient and account for the depletion of local biomass resources in rural areas;

- While currently around 150MW of biomass fired cogeneration capacity exists in 42 sugar mills, additional biomass for energy generation is projected to be applied in sugar mills (with a potential of 250MW), in rice husk fired power plants (potentially 200MW), and for wood processing purposes (potentially 50MW);
- Biogas energy is currently applied in around 100,000 households where biogas digesters have been put in place; and
- The prospects for biofuel (ethanol and diesel) are good with abundant raw material for ethanol (from sugar cane and sugar related products, starch plants such as cassava, sweet potatoes, corns, and cereal) and for bio-diesel (coconuts). Accordingly, Decision No. 177/2007/QĐ-TTg promotes the production of biofuels, including ethanol and bio-diesel production of 250,000 tons by 2015, and of 1.8 million tons by 2025.

83. ***Until recently, a key obstacle to Vietnam's ability to invest in and make better use of renewable energy sources, including electricity generated from biomass, arose from historical distortions in the electricity sector (ERAV, 2009).*** Biomass and biomass energy have not been commercial, since electricity prices were highly subsidized and not cost-reflective. Low prices therefore made investment unattractive. In addition, the vertically integrated structure of the sector could not assure third party investors of fair and non discriminatory access to the grid.

84. ***As of March 2009, Vietnam has instituted fundamental reform to enable private sector investment in the electricity sector, including the creation of:***

- An electricity trading 'pool' to increase competition, discover market prices and improve pricing transparency;
- Capacity payments that are paid to all investors to recover the fixed costs of generating plant; and
- Long term power purchase agreements that are paid to investors for their output.

85. ***A number of recent pricing reforms may facilitate the wider uptake of renewable generation technologies, including from biogas.*** Under the tariff reforms instituted in 2009, average tariff levels were increased to be more cost-reflective, and a number of mechanisms were put in place to reduce existing cross-subsidies, in particular cross-subsidies from industrial and commercial to residential users. However, it is likely that further steps will need to be taken to improve the uptake of CFTs, including putting in place a revised framework for investment in the energy sector, which is currently heavily regulated, and separate incentive payments for energy generated from renewable energy projects.

86. ***A second key obstacle to the wider application of biomass technologies is a lack of research and technical expertise, including on suitable technologies.*** However, Vietnam is pursuing a number of initiatives to foster international collaboration in the research and development of biomass technologies (Thien and Son, 2006; USAID, 2007b), including, among others:

- The Dutch funded 'Biogas Program' operated by SNV Vietnam, which is now in its second phase with a target of constructing 15,000 biogas tanks in rural and peri-urban settings;
- The "Biomass and waste for renewable energy" project, carried out jointly with four universities (in Vietnam, Germany, the UK, and Thailand), with the objective of developing training courses in biomass utilization; and
- A pre-feasibility study for the scope for biomass power generation in cooperation with Italian National Agency for new technology, energy and environment.

87. ***A number of other obstacles to the widespread take-up of biomass technologies remain (USAID, 2007b):***

- The diffuse nature of the supply of biomass fuel, which makes collection costs high when it is used as feedstock for power generation or other commercial and industrial uses.
- The absence of a local technical capability to maintain networks of small specialized renewable energy plants.
- A lack of finance, in particular for advanced technologies of biomass energy applications with high upfront costs, including the absence of contractual vehicles to facilitate project financing and implementation.
- A lack of scale, for instance, because of the absence of large-scale poultry or pig farms, which could be used for biogas applications.
- The absence of a dedicated or specialized agency or ministry charged with looking after early development of a renewable energy industry.
- The lack of a commercial and industrial capability, since few renewable energy businesses operate in Vietnam.
- Quality concerns, since there are often quality disparities between certain key components, such as controls and turbines, manufactured domestically versus those that are imported.
- More generally, an improved government policy and planning capacity, including improved resource maps and resource assessment techniques, and improved and standardized procedures for pre-feasibility and feasibility studies.

5.4.2.2 Potential for Hydroelectric Generation

88. ***The total technical capacity of hydropower resources in Vietnam have been estimated at approximately 20,000MW (APEC, 2009).*** Vietnam has significant water resources, and the technical potential for small hydropower units in Vietnam is estimated to be above 4,000MW, corresponding to 12,000-14,000GWh.

89. ***Current policies within Vietnam promoting the development of domestic renewable resources include the National Energy Development Strategy, announced in December 2007, and the Vietnam Power Sector Development Strategy, announced in 2004.*** Incorporated within these policies is a goal to achieve up to 13-15,000MW of additional installed hydropower capacity by 2020. Current projects promoting hydropower development include Electricity of Vietnam's (EVN's) investment of USD194.7m in 37 small scale hydropower stations in the Northern Provinces along the Chinese border. Approximately 10-13 stations are set to be constructed by 2010, providing up to 5MW of capacity each.

90. ***It is unclear, however, whether resources for hydroelectric power can be used to their full potential (ADB, 2009b) and hydropower has a gradually diminishing role in Vietnam's Master Plan VI for energy supply.*** Some potential sites are located far from customer loads, and their economic feasibility is expected to be low. In addition, the Vietnam Union of Science and Technology Associations (VUSTA) has identified a number of other impediments to the development of hydropower in Vietnam (VUSTA, 2007):

- Seasonal volatility of resource supply – Significant new large hydro plants, especially in the North of the country would not be able to operate at full capacity during droughts. According to the National Regulation Center of Vietnam, between 2001 and 2005, a shortfall of hundreds of MW and millions of kWh occurred every year during peak hours in the dry season due to a lack of water inflows to hydro plants. VUSTA suggests commissioning additional coal-and gas-fuelled

plant to mitigate this risk, implying that additional large hydro plant in Vietnam would require other complementary energy infrastructure.

- Risk from equipment supply, engineering and capital – Due to the current limited capability of the mechanical sector in Vietnam, most hydro equipment is imported. In the past, a delay in supply of equipment has been a major cause for construction delays of hydro power stations. Further, the financial risk of hydropower projects is considerable and is compounded by the delays in equipment supply. The delays also strain the capital budget of the hydropower projects, and additional funding is difficult to access given the high financial risk.
- Unfavorable impact on natural and social environments – Although proponents of hydropower have put forth some potential positive impacts of hydropower potential, VUSTA considers that the negative impacts outweigh the benefits for the natural and social environments.

91. ***Some of the negative impacts outlined by VUSTA (2007) include:***

- Small sized hydroelectric projects that combine flows of water from various basins can exhaust water resources.
- The construction of hydro dams generally changes the ecosystem and reduces biodiversity.
- Water flows cause erosion and sedimentation downstream.
- Many projects cause downstream rivers to dry up, thus causing adverse impacts on agricultural cultivation and households' use in these areas.
- The construction of large reservoirs is often associated with unwelcome resettlement. The resettling people are often faced with difficult living standards, and thus require significant resettling aid.

5.4.2.3 Potential for Solar PV

92. ***PV technology is considered to be the most suitable option to provide electricity to the population living in isolated rural, mountainous, and island areas, although there are several obstacles hindering its uptake.*** Vietnam is considered to be rich in solar energy potential with 4.5kWh/m²/day of annual average sunshine nationwide, especially in central and central-southern provinces, where solar radiation is stable and high throughout the year. Under the current National Strategy of Energy Development until 2020, PV capacity is therefore expected to expand to 4-6 MW by 2025. The demand for solar water heaters is also expected to increase rapidly in the next few years - under current government plans, more than 30,000 solar water heaters will be installed by 2013 (to reduce GHG emissions by 23,541 tons per annum) (Do, 2009; Thanh-Binh, 2009). There are several obstacles hindering the uptake of PV solar technology (Thanh-Binh, 2009):

- Lack of technical capabilities – A lack of local, technically trained staff to install, operate and maintain equipment is a significant obstacle. PV solar systems are often located in remote rural areas, where it is particularly difficult to recruit skilled staff. Poor quality control and system failures are therefore a frequent problem, undermining confidence in the technology. In addition, a general lack of supporting infrastructure has led to shortages in spare parts.
- Inappropriate application of technologies – A related complaint is that PV technology is installed in a manner that is not sufficiently attuned to local conditions. This could mean a failure to take into account such factors as the appropriate size for a given household, but also the requirements of different geographical locations, for instance in proximity to a corrosive marine environment or fast growing vegetation.
- Lack of information – There is also often a lack of accurate information on the potential for solar technology on the part of communities and businesses. Since the technology is poorly

understood, there is also little demand for it. Additionally, given the relative inexperience of the general population, potential purchasers lack the knowledge distinguish between good and bad equipment or, more generally, to make the best choice to suit their circumstances.

- Cost of renewable technologies – Given income levels in Vietnam, SHS is a relatively expensive technological option. Particularly in remote areas, households with irregular income patterns may find it difficult to make regular monthly payments, and there are generally no micro-financing packages available. Potential investors often do not have an understanding of investment profiles and life cycle costs for renewable energy systems, and the trade-off between high up-front cost and longer term low costs. SHS also tend not to attract investors, since these are not large and profitable enough. Vietnam also charges high duty and VAT on imported SHS components (up to 30-40 percent in some cases), which compares to zero import duty on conventional grid electrification technology.

6. ISSUES AND POLICY REFORMS

1. ***This chapter lists the main issues identified in relation to the increased uptake of CFTs identified in this report, as well as broad policy mechanisms to overcome these.*** The recommendations are necessarily relatively high level – the social, institutional, and policy contexts in each of the middle-income APEC economies discussed in this report differ, so that the implementation of these recommendations has to be tailored to the circumstances on the ground. Broadly, the factors that need to be considered to facilitate investment and uptake of CFTs include a structured policy environment, investment in human and physical capital, clear property rights frameworks, and caution in energy subsidy and self-sufficiency programs.

2. ***This chapter also highlights the CFT trade potential for the middle-income APEC economies identified in this report, and illustrates how these countries vary in the types of CFTs traded, their trade status, and their position in the North-South divide.*** China is a major trading partner and the dominant exporter of most CFTs that have been considered in this study. China's success in the development of CFTs thus far defines its role in the future development and diffusion of CFTs for middle-income APEC economies. It also has direct and indirect impacts on the development of CFTs on the other countries considered. China is a potentially critical trading partner for Indonesia in a number of respects, such as trade in the wind technology that Indonesia has potential for. As the relative cost of export-oriented businesses in China increases, foreign investment into Southeast Asian countries, such as Thailand is also becoming more attractive. Thailand has several competitive advantages such as having the right to own land (versus just leasing), additional personnel benefits, and more attractive taxes. Thailand has also been active in attracting FDI through joint ventures. While not identified as a major importer/exporter in this report, Vietnam has also established itself in a niche becoming a top trader among developing countries of certain specific CFT technologies and components, such as wind energy technology and components.

6.1 Identified Impediments

3. ***The following section summarizes the broad practical issues identified in Section 5 and potential remedies that could be adopted to address these.*** The factors that facilitate investment in and the uptake of CFT technologies are diverse and reflect the best practice principles and the range of factors:

- A well-structured and consistent overall policy framework, including one that provides as much space as possible for market pricing and allocation.
- Flexibility in how policy objectives are achieved to take into account local conditions.
- Investment in physical and human capital.
- A clear property rights framework.
- Adopting a very cautious and targeted approach towards energy subsidies, using them only when other measures cannot be implemented to correct externalities, achieve social objectives, and share risk in the demonstration of pioneer CFTs.
- Similarly, adopting a cautious approach toward increasing energy self-sufficiency in order to mitigate risks of costs that dominate any potential benefits.

6.1.1 Planning for CFTs

4. ***A number of the case studies discussed in the previous section identified issues preventing the uptake of CFTs that arise at the planning level, such as for wind energy in Thailand and Vietnam.*** These issues, common to most CFTs, include: (i) Insufficient data being available on energy potential in

individual APEC economies; (ii) A low operational capacity of these technologies in spite of a high theoretical capacity; and (iii) a mismatch between geographical distribution of resource and country's power load profile.

5. ***Some approaches to addressing these issues could be:*** (i) to overcome information shortcomings and risks of mistargeted investment, undertake a structured 'inventory' of potential and technical capacity, and engaging expertise for a formal resource assessment to evaluate the theoretical and technical capacity of renewable resources where knowledge gaps are identified; (ii) consider the potential role of CFTs at early stages of planning activities; and, more broadly; (iii) undertake the planning of urban and rural developments so as to accommodate, as much as possible, a higher technical capacity for renewable energy; and (iv) conversely, the application of CFTs should match the existing geographical/planning context. A focus on matching the technological capability of context-appropriate CFTs could, for instance, be achieved by introducing decentralized energy technologies, which can be attached to individual homes and buildings. Ultimately, subject policies seeking to expand CFT use to balanced and realistic assessment of benefits and costs to ensure that apparent gains are as substantial as they seem and can be realized.

6. ***In addition to inadequate planning and upstream evaluation, a lack of infrastructure can also prevent the uptake of CFTs.*** These shortcomings in infrastructure include a lack of ports and roads, preventing large scale technologies from being deployed in remote areas; and weak transmission capacity, which may render larger projects unfeasible.

6.1.2 CFT Inputs

7. ***There is competition for biomass input from pharmaceutical, food and beverage industries in biofuels production in China, Indonesia, Thailand and Vietnam, although steps can be taken to reduce the impact of this competition.*** There is thus a risk that reliance on these technologies damages other industries, including food-producing industries. Recommended approaches to address these risks include:

- Where cost-effective, the introduction of inedible biomass sources such as *jatropha curcas*¹⁸ seeds through domestic cultivation, provided there is sufficient (surplus) land available for these crops;
- The economic importation of biomass materials from nearby countries with excess supply of inedible sources;
- The development of technologies that are complementary to the requirements of existing industries, such as the development of technologies to utilize cellulosic biomass sources; or
- Disallowing further development of grain producing biofuel plants, for instance as done in China.

8. ***Other difficulties arise because of the seasonal and daily volatility of renewable resource supplies.*** This is the case for wind and solar energy in China and Thailand, and hydroelectric energy in Vietnam. The consequences of such volatility are unreliable energy supplies. Some approaches to address unreliable energy sources are:

- The use of alternative technological options, such as more advanced wind turbines that operate at lower cut-in speeds or are sized at smaller capacity increments.
- The use of coordinated energy supply from potentially complementary renewable energy sources, such as wind and hydro power to extract synergies.
- Commissioning thermal generation to compensate for supply shortfalls (for instance, for hydroelectric power in Vietnam). While such measures will clearly improve supply reliability in

¹⁸ *Jatropha* has several features that make it advantageous over currently-used biodiesel feedstocks, including that it grows in poor soil and dry conditions where food production is generally not possible.

circumstances where the CFT cannot operate, however, it is clear that this type of measure would come at a significant additional capital cost. Consequently, the benefits and costs of the overall package of CFT and thermal resource need to be carefully compared to other alternatives.

6.1.3 Technical/Human Resource Issues

9. ***Technical and training issues arise in many instances where the installation and maintenance of CFTs requires some degree of technological support and expertise.*** Issues that are frequently highlighted include insufficient after-sale support, in terms of maintenance and spare part replacement, and a lack of technical expertise in the installation and maintenance of CFTs. This is the case of solar PV in Indonesia, Thailand, and Vietnam.

10. ***The challenge of insufficient after-sale support can be addressed by requiring the suppliers of CFT to provide a complete package, rather than simply the installation of the CFT.*** For instance, the central defined objective for energy service companies that are awarded concessions should be the desired service outcome for end users – as defined in terms of quality and reliability.

11. ***Strengthening government and private sector training programs as they relate to CFTs would also help with additional adoption.*** Examples of such programs are:

- Training programs for industry and technicians whose role is to install and maintain the technology through technical education providers. Additionally, installers and maintenance technicians should be given regular training to maintain their skills, including enabling them to assist when systems get older and more sophisticated diagnostics and maintenance skills are required. The private sector increasingly should be looked to as the provider of these services, where they are the ones that will reap the benefits;
- Training for government staff, who may require capacity building from basic technical aspects to electrification planning;
- Small private companies, who may already have technical expertise, may benefit from instruction in business and financial management, marketing, and project procedures;
- Community-based providers may need basic training in equipment operation and business; and
- Consumers requiring guidance in system selection and operation and choosing the service level best suited to their needs. Specifically where technologies are applied to households, the CFT needs to be easily maintainable by field technicians or householders. This might include basic maintenance skills, such as, for SHS, keeping panels free from shading by vegetation, cleaning panels regularly, checking and topping up batteries.

12. ***These initiatives can be further strengthened by raising community awareness and interest in the implementation of CFTs in local institutions, rural communities, schools, and clinics.*** For example, training on SHS could be extended to local schools, by showing PV demonstration units in schools as a promotional measure.

6.1.4 Limited Uptake of CFTs

13. ***There are many recurring reasons why government programs to encourage the uptake of CFTs have not been successful in practice.*** These include:

- A lack of public information about CFTs so that the technology is not well understood;
- Complex institutional arrangements that create obstacles to the uptake of CFTs;
- Unreliable quality of CFTs and service has limited consumer interest; or

- Once installed, the effectiveness of CFTs is reduced due to a lack of follow-up.
- Public policy recommendations to improve CFT uptake should target the various sources of the observed difficulties:

14. ***Where public information is a constraint, recommendations are to:***

- Improve public education on technologies across all levels in the education system.
- Encourage R&D on CFTs by funding a variety of technical and training institutions.
- Raise public awareness through aligned and enhanced marketing of CFTs, as well as provide public information on CFTs through government websites and industry forums.
- Where the uptake of CFTs is hindered by complex institutional arrangements, for instance, those requiring the approval of multiple agencies, the introduction of a more decentralized approach may better take account of user needs and simplify the approval and allocation process.
- Poor quality outcomes can be managed by putting in place standards and specification for CFT products and services (for instance, through Government or a technical agency) and ensuring that these are enforced. In this context, prescriptive specifications focus on the requirements for each component in terms of size and rating, while performance requirements focus on the output or service that must be provided by the system.
- Realistic provisions should be made to enforce warranties in order to protect consumers.
- Quality assurance procedures should address all links in the chain of designing, specifying and supplying a PV system to the end-user. This includes quality in manufacturing, component purchase, system assembly, testing and installation.

15. ***A number of institutional models have been established to ensure better longer term outcomes, in terms of the ongoing effectiveness of CFTs.*** An example is the creation of an Energy Service Company (ESCO) (a public utility or government-contracted company) to operate small, isolated microgrids. Typically, tariffs are regulated (e.g., set at a level equivalent to the lifeline tariff of rural grid customers). The utility or ESCO operator is provided a subsidy from a cross-subsidy fund or other public source of capital and perhaps a portion of operation-and-maintenance costs. This model is now being applied in China to operate more than 700 centralized, PV microgrids, each with a 10–150 kW capacity. Another example is the establishment of a Medium Term Service Contract (MSC) to focus on service quality outcomes. This model adds mandatory local-market development and 2–5 years of operation-and-maintenance services to the dealer-model requirements for participating companies.

6.1.5 Financing of CFTs

16. ***There are several recommendations to develop financially sustainable funding approaches at the household level include the use of targeted subsidies and complemented with other financing measures.*** These subsidies must focus on the most economic interventions, target those for whom the subsidy is intended without unnecessarily benefitting others, and create incentives for efficient responses, in particular by inducing efficient investment decisions and risk-sharing. Subsidies can be complemented by facilitating increase access to traditional or micro finance, which can increase affordability by lowering the cost of capital and spreading first costs over several years. In some instances, it may also be possible to apply more affordable technical options, for instance, smaller, lower-power systems that offer a lower quantity of service (e.g., reduced hours of lighting), without compromising quality¹⁹.

¹⁹ For example, a solar lantern costing US\$50-75 can provide 3–4 hours of lighting daily. A 50-WP SHS costing US\$600 can operate four lights for 3–4 hours and power a radio or television for a few hours daily. Under the Renewable Energy Development Project (REDP) in China, where consumers had limited financial capability and lacked access to financing, most

17. ***To a greater or lesser extent, issues related to funding and project risks associated with investment are an impediment to the uptake of CFTs in all middle-income APEC economies.*** The key issues include:

- Indiscriminate ventures into CFT production that have increased project risks and limited private sector financing.
- Uncertainty about the size or duration of investment incentives for CFT development, including carbon finance.
- Difficulty in obtaining private funding by small sized and start-up ventures.
- A lack of funding for certain purposes, for instance, to improve the energy efficiency of existing installations (as for CHP technologies in China).

18. ***These issues can be addressed by a range of different approaches.*** To address concerns about project risks, one possibility would be to focus initially on demonstration projects until the commercial capacity of the technology has been better ascertained (Cannady, 2009). Pilot projects can be set up with commercial producers supported by government in sharing the cost and reducing the risk of initial investments. A key step is ensuring that government support does not undercut efficiency. For example, a direct capital cost subsidy will have greater attraction for weaker and more poorly capitalized firms. Simple price and purchase guarantees reduce incentives for holding down costs of production. Another possibility would be to put a policy framework in place that would mitigate against avoidable systemic risks in order to provide investors with a greater degree of certainty by, for instance, by developing broad guidelines and clarifying the time horizon of government incentives (Cannady, 2009). Avoiding temporary rules and exceptions would more likely build confidence among potential domestic and foreign manufacturers and investors.

19. ***A number of mechanisms have been proposed to assist smaller and start-up ventures to attract funding.*** These include the government managing special funds to support ventures into new CFTs, so that some portion of the investment risk is managed and assumed by the government; and extending loan periods to finance investments in cooperation with commercial banks.

20. ***Mechanisms to facilitate the financing of energy efficiency measures include targeted financing opportunities and developing project-specific financing mechanisms.*** The creation by government of targeted financing opportunities – perhaps working with ESCOs or via indirect financing through the CDM – to advance retrofit projects that are designed to improve the efficiency of existing installations. Encouraging third parties to finance projects can be a new specific financing mechanism for projects, as has been the case in China in the commercial building energy conservation arena.

21. ***A common theme limiting the take up of CFTs is the existence of economic and pricing barriers that affects the ability of investors to fund CFTs.*** In all middle-income countries that are the focus of this report, the private sector provision of CFTs is weakened by historical regulated pricing structures. Recommended approaches include broader energy price reform so that energy prices better reflect market values, rather than historically set tariffs; and access to the grid so that developers of CFTs are able to sell excess output into the grid.

22. ***The World Bank (2007) considers that the second approach – the creation of FITs to enable small power producers to sell power to the grid – has been one of the most important reforms, and accounts for the strong take-up of these technologies in developed countries.*** For example, to promote private investment in renewable energy, the Thai government has used feed-in tariffs and a price adder on top of the average power purchase price for small-scale (less than 90 MW) power producers. These measures provide additional tariffs above the base tariff of 8.3 cents/kWh from power generated from

purchased low-cost 10- and 20-WP SHSs (US\$80-160) initially and larger 45-Wp systems (US\$400) after their incomes increased.

conventional energy. There is thus an incentive to improve commercial viability of renewable energy projects. Thailand's biomass capacity has thus grown from nearly 0 to 1.6 GW in the past decade (World Bank, 2010c). Other fiscal incentives to encourage the use of CFTs are (World Bank, 2007):

- Income tax exemptions/reductions/credits offering preferential income tax treatment for renewable energy investments.
- Accelerated depreciation permitting rapid write-off of capital investments in renewable energy equipment.
- Sales tax, VAT, and/or customs duty exemption to reduce the cost of renewable energy investments.

6.1.6 Policy and Legal Framework

23. ***Many of the government energy policies discussed in this study are directed at increasing the share of CFTs in a particular economy.*** Nonetheless, there are number of circumstances under which government policies have tended to undermine investment in and uptake of CFTs. These circumstances include:

- Unclear specification of energy policies leading to public circumvention, such as for wind energy in China.
- Poorly articulated targets that reduce the efficiency/usefulness of installations.
- Multiple government agencies pursuing different policy objectives.

24. ***One example of inconsistent government policies that tend to impede the uptake of CFTs are taxation policies that may oppose wider government policies in relation to the greater use of renewables.*** While all middle-income economies of interest here are trying to increase the share of energy from these technologies, tariffs on CFTs in middle-income APEC economies are high, and in some instances higher than average industrial tariffs in these countries.

25. ***Greater clarity of objectives and responsibilities for policy makers in a five distinct areas.*** These areas are in (i) energy policy, (ii) technological capabilities, (iii) certainty in legal frameworks, (iv) improving international cooperation, and (v) intellectual property rights.

26. ***First, energy policies must focus on utilized capacity instead of installed capacity.*** The objective of this recommendation is to prevent energy suppliers from circumventing the intention of the policy by building CFTs that are not physically capable of being adequately utilized.

27. ***Second, specific technological capabilities need to be strengthened.*** These areas of improvement include:

- To collect data,
- Perform technical analysis;
- Design financial support mechanisms and monitor performance in order to limit financial support to only projects operating efficiently;
- Define medium-term and long-term development plans, including the creation of targeted financial incentives;
- Establish coordinating bodies to align the policies of different related governmental departments.

28. ***Third, an uncertain legal framework, poor government communication and lengthy processes, as well as corruption have had a negative impact on investors contemplating significant long-term investments in advanced technologies in some countries.*** This has been the case in Indonesia. To

improve the broader policy climate to facilitate investment the IEA (2008d) has suggested that for new laws being considered, the underlying policy and detail of proposed laws and regulations should be provided to the public and stakeholders to enable a widespread canvassing of the impact of the proposed laws. Tender and approval procedures and the composition of policy bodies are also important.

29. *Policy bodies need to include members from industry to advise on mechanisms to improve the investment climate.* These measures should include:

- Empowering relevant government bodies to review impediments to investment through periodic consultations with investors according to transparent processes and timetables.
- Strengthening government efforts to expose corruption in all its forms and to promote these efforts before the domestic and international investor communities.
- Encouraging officials in their active communication with investors while maintaining their high code of ethics.

30. ***Fourth, international cooperation must be strengthened.*** Given that, with the exception of China, developed countries generally have an advantage in the deployment of CFTs, there is considerable room to strengthen international cooperative efforts in this regard. Examples include strengthening bilateral cooperation for specific CFT implementations, such as the Sino-US Cooperation Proposal by China to the US for IGCC/CCS integration, or for general CFT implementation, agreements such as the BECIN between Indonesia and the Netherlands.

31. ***Fifth, a lack of confidence in security of intellectual property rights in particular countries, including licensing and royalty arrangements, tends to deter R&D efforts and funding (e.g. for large-scale wind energy in China).*** As discussed in earlier chapters, the ability to register and enforce patents for CFTs is likely to be of crucial importance in this respect.

6.2 Summary of CFT Trade Potential for Middle-Income APEC Economies

32. ***This section draws on analysis undertaken in previous chapters of this report on trade in CFTs and the production capabilities of selected middle-income APEC economies.*** For each of the middle-income APEC economies, the countries' respective capabilities to be importers and/or exporters of CFTs, and the associated potential for South-South, North-South or South-North trade are assessed.

6.2.1 A New Trade Paradigm

33. ***The traditional view of trade flows focused on North-South flows, whereby developing countries were importers of new technologies from the North.*** In contrast, the new paradigm views technology flows as being embedded in global trade and FDI flows (Brewer, 2009). This new paradigm focuses on firms as facilitators of international technology flows, particularly through good and services trade and FDI. Firms are viewed as the principal sources of technological innovation and diffusion, which occurs through international trade and investment. In particular, firms in developing countries are increasingly seen as important leaders in technological innovation. Two factors account for this (ICTSD, 2007):

- Developing nations, in particular middle-income countries, have become far more sophisticated; and
- World trade has become global, and in many industries economies of scale favor production facilities that serve more than one nation.

34. ***The result has been increasing specialization and trade, both in components and finished products that may have origins in a number of different nations.*** Production chains are now often spread over a number of countries. These developments have changed the incentives and barriers for

developing global firms. These firms must face global competition, and may have to find a place in an elaborate international production structure. Moreover, not every nation can have firms leading in every area of technology — for many areas of technology, there can be only a few centers of excellence in the world at any one point in time.

35. ***Governments continue to have a central role to play even though private sector firms are increasingly viewed as key stakeholders in facilitating trade and the diffusion of new technologies, including CFTs. First and foremost***, governments are vital in terms of their role in establishing a broader policy framework that supports trade in CFTs and technology transfer. As earlier chapters have discussed government trade and investment policies can facilitate, but can also constrain technology transfer. Trade policies that either limit inbound trade and investment or weaken the capability of domestic firms to compete internationally are examples of such constraints. Liberalizing trade, in combination with other policy measures to encourage investment in human and technical capital remains the central mechanism for facilitating trade in CFTs and technological transfer.

36. ***Governments can also act to reinforce the role of firms as facilitators of technology transfers. Firms and governments can cooperate to overcome under-investment in CFTs via business-government partnerships.*** There is a range of collaborative mechanisms of this type that can assist in the transition of new technologies from the demonstration phase to the commercialization stage.

37. ***Governments must also actively pursue international cooperative efforts, be they bilateral or multilateral, as they facilitate the transfer of prerequisite technology, human capital and investment capital, such as the CDM.*** Moving forward, middle-income APEC economies should place greater emphasis on capitalizing on the CDM, which has been proven to be an effective mechanism for the diffusion of a number of CFTs in the countries of interest in this study. In this context, it is relevant that the successful CDM projects have certain features²⁰ (Sato, 2009):

- The existence of a committed project champion, either the project proponent company or the ministry, or, in the absence of sufficient technical capability, from external technical assistance.
- Strong project design and planning at start, in terms of project feasibility, financial arrangements, assessments of the methodology, and monitoring requirements.
- Strong underlying financials, in the sense that the project must make financial – as well as technical sense.

38. ***The CDM has a clear potential to reduce emissions, and there is a strong incentive to develop the capacity to make further use of this financing mechanism.*** This financing mechanism can achieve this because projects that can result in large volumes of GHG reductions relative to their baseline will be more attractive to investors and carbon buyers. Also the possibility of earning significant amounts of carbon revenues through certified emission reductions incentivizes project performance over time and projects with larger emission reductions volume better absorb CDM transaction costs. These characteristics of successful CDM projects suggest that there is considerable value in investing in the know-how required at the level of government to identify suitable projects, analyze their likely effectiveness (including, in terms of their attendant scope for GHG reductions and financing options), identify sponsors, and oversee the structured design and implementation.

6.2.2 A Framework for Assessing CFT Trade Potential

39. ***All of the countries reviewed in this report are characterized by their unique circumstances, based on socio-economic structures, development history, natural resource availability, government policy framework and many other characteristics.*** However, it is possible to identify a portfolio of key

²⁰ Although these features may be true for successful projects more generally.

factors to be considered when evaluating the potential for CFT inbound and outbound trade in the middle-income APEC economies.

40. ***At its simplest, the potential for and direction of trade between one country and another depends on the relative prices of CFTs.*** The costs of CFT imports, for instance, depend on such key factors as the cost of labor and capital in the exporting country, as well as transportation costs between the exporting and the importing country. While capital costs tend not to vary across countries (Ng, 2004), there is significant variation in international labor costs. This differential is most significant across the North-South divide, with countries in the North being regarded to have persistently higher labor costs historically. Since middle-income APEC economies, by definition, are countries in the South, this implies that they have an edge in the production of CFTs, when labor costs are taken into consideration. This strengthens the potential for outbound trade (South-North, South-South) in middle-income APEC economies. The relative cost advantage is further strengthened for South-South trade given the generally shorter distance for transportation of trade between middle-income APEC economies, which are generally within closer geographical proximity.

41. ***Beyond the direct costs of traded goods and services, government policies play a key role.*** Directly or indirectly, import tariffs or non-tariff barriers, such as restrictive investment and trade policies add to the costs of imports and hinder trade. No significant trade barriers currently exist between middle-income APEC economies that could significantly hinder South-South trade.

42. ***Price is not the only criterion for identifying attractive trading partners.*** Other things equal, countries are more likely to source CFT imports from other countries that have achieved international certification in terms of quality. More generally, countries are more likely to import CFTs where products are compatible with a particular country's requirements. This is a further support to South-South trade of CFTs since these countries often have similar technological requirements. For instance, a crosscutting issue faced by all middle-income APEC economies is the need to electrify communities living in rural and remote locations. Meeting this objective requires the installation of small-scale, low-cost technologies that can be adapted to local circumstances. This is an area where middle-income APEC economies are increasingly developing expertise, so that there is some potential for South-South trade.

43. ***A further consideration for inbound trade potential of CFTs is the extent of domestic technological know-how and human capital.*** This presents a more complex picture, however. During the 1970s and 80s, many developing countries embraced complex new technologies with the aim of 'leapfrogging' intermediate stages of development and investment. In circumstances, where countries did not have the physical infrastructure or the human capital to successfully apply these technologies, projects of this type tended to fail. At the same time, international trade and FDI are key mechanisms that facilitate the transfer of technologies and technical know-how. In general, these considerations also point to the importance of South-South trade, where individual middle-income APEC economies may have a comparative advantage in the production and application of suitable CFT technologies.

6.3 Country Analyses

6.3.1 China's Potential Role

44. ***China is currently a major trading partner, developer and the main exporter of most CFTs that have been featured in this study.*** China's success in the development of CFTs thus far defines its role in the future development and diffusion of CFTs for middle-income APEC economies. Its main potential is to be a key regional trading partner for South-South trade, given that it is a relatively cheap source for CFT inputs due to its low labor costs, relatively low exchange rate, and close proximity to other middle-income APEC economies (Chun, 2005). China's current dominance in the export of the some CFTs to Asian countries, further facilitates outbound trade diffusion, given that it has in place established trade routes and infrastructure.

45. ***In many respects, the rapid emergence of China as a key exporter of CFT products justifies that some lessons be drawn from the systems and governance processes that have contributed to the success. China has taken a gradual approach to liberalizing trade by region and developing ventures into fledgling CFTs.*** Although there are some drawbacks to this centralized approach, it has also enabled a more systematic implementation of CFT production and the management of national investment risk. In this way, China has invested in and mastered the application of CFTs and is now in a position to export its know-how internationally.

46. ***China has been actively pursuing international and bilateral cooperative efforts to develop CFTs.*** In particular, China has significantly capitalized on the CDM, as seen by the substantial amount of CDM projects and issued CERs that have been secured across a large range of CFT project types. Bilateral cooperative efforts have also been consistently pursued with advanced predecessor countries to further research and develop on the existing CFTs in place, such as the Sino-US R&D Cooperative Proposal for IGCC/CCS technology. Given that China has successfully adopted and diffused a wide range of CFT products, its future potential can be maximized through further pursuit of international collaboration with predecessor producers of new CFTs.

6.3.2 Indonesia's Potential Role

47. ***Indonesia has proven itself capable of producing and taking on a significant role in the export markets of certain CFTs such as CFLs and forestry products.*** More generally, Indonesia's comparative advantage lies in the country's natural energy resource abundance, including coal, oil and gas, as well as forestry and other products. As such, Indonesia should work on streamlining its existing systems and processes and expand on its infrastructure needs so as to further strengthen its relative advantages.

48. ***Looking forward, China is an increasingly important trading partner for Indonesia in a number of respects.*** Like Indonesia, China is rich in coal, has significant future energy requirements, and is in the process of exploring the potential role of CCTs, so that there is potential for trade and technology transfer between the two countries. As the world's largest archipelago with a highly dispersed and non-electrified population, Indonesia also intends to place far greater reliance on wind energy in future. Another potential area of trade between the two countries is in the wind (and other renewable) technology required by Indonesia, where China is a key low cost and proximate producer and exporter.

49. ***Indonesia has actively pursued international collaborative efforts in the development of a number of existing CFTs.*** These have ranged from general bilateral cooperation, such as BECIN, to technology-specific collaborative research and development projects, such as those for CCT development. The pursuit of such international cooperation is an effective mechanism for transferring the prerequisite technology, human capital and foreign capital. In addition, Indonesia has taken advantage of the CDM mechanism by securing CDM projects and issued CERs across a range of CFTs as shown earlier. This has significantly facilitated the diffusion of CFTs into Indonesia. Moving forward, Indonesia could look into pursuing further bilateral cooperation with more middle-income APEC economies, especially with China, where their energy supply and demand criteria are overlapping and where their research and development needs are complementary.

6.3.3 Thailand's Potential Role

50. ***Like China, Thailand has also applied and developed specific CFTs in which it has become a major international trading partner.*** Thailand is a major exporter of CFLs, of hydroelectric technologies, solar PV and solar thermal technologies, wind technologies, and others.

51. ***As the relative cost of export-oriented businesses in China increase, foreign investment into Southeast Asian countries, such as Thailand is becoming more attractive.*** In a study comparing the competitiveness of export manufacturing of Vietnam, China, Thailand, Cambodia and Laos, Thailand is viewed as being highly competitive, and is generally a lower cost option than China and even Vietnam,

which oftentimes is thought of as a low-cost option for some operations (Runckel and Associates, 2008). Specifically, Thailand's identified competitive advantage lies in factors such as the right to own (as opposed to just leasing) land, mandated additional personnel benefits, tax incentives and quality of life for company executives sent to manage operations.

52. ***Thailand has also been active in attracting foreign investment through joint ventures with different international business stakeholders***²¹. The success of these efforts was apparent in the development of FFC technologies where Thai authorities had put in place incentives that successfully attracted seven major global automobile producers into setting up domestic manufacturing plants for eco-cars in 2007 (Economic Intelligence Unit, 2008).

53. ***Thailand's weaknesses as a trading partner and investment destination relate to policy uncertainty, for instance as a result of sudden government policy reversals, which have caused significant confusion amongst existing and potential foreign investors and business stakeholders.*** The factors contributing to the uncertainty surrounding investment and trade policies have often been identified as socio-political instability over the past decade.

54. ***As of 2009, CDM projects in Thailand had only been in place for biomass energy, landfill gas, methane avoidance and nitrogen peroxide management.*** A relatively large number of CERs have been issued for methane avoidance and biomass energy thus far, but there is significant room for securing more CDM projects and CERs for other CFTs.

6.3.4 Vietnam's Potential Role

55. ***Vietnam's movement from a centrally planned economy to one that is more diversified and market-oriented has generally helped in the diffusion and development of CFTs.*** This is especially so for inbound and outbound trade. Furthermore, the removal of international capital flows restrictions has attracted FDI into the economy.

56. ***Vietnam does not feature on the list of major importers/exporters in this report, but it has nonetheless carved out a niche for itself in trade in a number of CFTs.*** Among developing countries, Vietnam features in the list of the top 20 exporters/importers of wind energy technologies and components, solar PV cell manufacturing, as well as biomass-related, hydroelectric and geothermal technologies and components.

57. ***The greatest potential for Vietnam moving forward lies in its ability to set itself up as a top export-oriented low-cost production base.*** In a recent study comparing the competitiveness of export manufacturing of Vietnam, China, Thailand, Cambodia and Lao PDR, Vietnam was viewed as the top location of choice for export-oriented businesses for reasons such as the work ethic of its people, the relatively low labor and other costs in general, highly attractive government incentives and an improving legal and business environment. However, identified impediments include its relatively high land cost and difficulty in foreign land ownership, as it only allows for leasing (Runckel and Associates, 2008).

58. ***There were only 6 CDM projects registered in Vietnam as of July 2009.*** These projects only cover across, fugitive emissions, hydropower, landfill gas usage, reforestation and wind power. Even then, the only project that has issued CERs was the one for fugitive emissions. This suggests plenty of potential for Vietnam in securing more CDM projects to further facilitate trade and development of CFTs.

²¹ A stand-out example is the development of eco-car production, where Thai authorities put in place incentives that successfully attracted seven major global automobile producers into setting up manufacturing plants in 2007.

BIBLIOGRAPHY

- APEC (2007) How Can Environmental Regulations Promote Clean Coal Technology Adoption in APEC Developing Economies? Asia-Pacific Economic Cooperation, Singapore
- APEC (2009) APEC Energy Review 2008. Asia-Pacific Economic Cooperation, Singapore.
- APEC (2010) Industrial Science & Technology Internationalization Database. Available: <http://www.apec-isti.org/isti/abridge/cic/cicrdo02.htm> (Accessed on 16 February 2010)
- APEC Energy Working Group (2008a). Technology Status and Project Development Risks of Advanced Coal Power Generation Technologies in APEC Developing Economies. Asia-Pacific Economic Cooperation, Singapore.
- APEC Energy Working Group (2008b). “The Future of Liquid Biofuels in APEC Economies. Asia-Pacific Economic Cooperation, Singapore
- APEC Energy Working Group (2008c) The Future of Liquid Biofuels for APEC Economies, May, Asia-Pacific Economic Cooperation, Singapore.
- Asian Development Bank (2009a) The Economics of Climate Change in South East Asia: A Regional Review, Asian Development Bank, Manila.
- Asian Development Bank (2009b) Country Report Energy and Climate Change in Vietnam, Workshop on Climate Change and Energy, 26-27 March, Asian Development Bank, Manila.
- Asian Development Bank (2009c) Strengthening Adaptation and Mitigation in Asia and the Pacific. Climate Change ADB Programs, Asian Development Bank, Manila.
- Asian Institute of Technology (2006) Study Report on Identification of Barriers on EU-Thai Trade Policy on Wind Energy.
- Australian Greenhouse Office (2006) International CFL Review: A Study of Seven Asia-Pacific Economies, August.
- Badinger, H. and P. Egger (2008) “Intra- and Inter-Industry Productivity Spillovers in OECD Manufacturing: A Spatial Econometric Perspective,” CESifo Working Paper No. 2181, CESifo, Munich.
- Balce, G.R., T.S. Tjaroko, and C. Zamora (n.d.) “Overview of biomass for power generation in Southeast Asia,” ASEAN Centre for Energy. Available: http://www.ec-asean-greenippnetwork.net/documents/tobedownloaded/knowledgemaps/KM_overview_biomass_power_SEA.pdf (Accessed: October 5, 2010)
- Bai, J. and L. Walet (2009) Update 3: China offers big solar subsidy, shares up. Reuters article July 21 2009. <http://www.reuters.com/article/companyNews/idUSPEK12570920090721> accessed on 14/08/09.
- Beckman, C. and J. Jiang (2009) China Biofuels Annual. USDA Foreign Agricultural Service, Washington DC.
- Benítez-Ponce, P.C., I. McCallum, M. Obersteiner, and Y. Yamagata. (2007) “Global Potential for Carbon Sequestration: Geographical Distribution, Country Risk and Policy Implications” *Ecological Economics*, 60, (572-583).

- BKPM (2009) Statistic of direct investment realisation, 1990-December 31, 2008
http://www.bkpm.go.id/file_uploaded/Tabel-1.pdf accessed on 12/08/09.
- Brewer, T.L. (2008) Climate Change Technology Transfer: A New Paradigm and Policy Agenda. *Climate Policy*. Volume 8, Number 5, 2008 , pp. 516-526 (11)
- Brewer, T.L. (2009) *Technology Transfers and Climate Change: International Flow, Barriers and Frameworks*. Washington, DC: The Brookings Institute.
- Cannady, C. (2009) Access to Climate Change Technology by Developing Countries: A Practical Strategy. ICTSD's Programme on IPRs and Sustainable Development (25).
- Chun, L. (2005) *The Chinese Model of Modern Development*. UK: Routledge.
- Claro, E., M. Lucas, M. Sugathan, M. Marconini, M., and E. Lendo (2007) Trade in Environmental Goods and Services and Sustainable Development: Domestic Considerations and Strategies for WTO Negotiations. ICTSD Environmental Goods and Services Series.
- CoalTrans (2009) Shenhua to launch China's first CCS project, 9 April 2009, at:
<http://www.coaltransinternational.com/htm/w20090409.474526.htm> (Accessed on 1 March 2010).
- COGEN3 (2010) "About The COGEN Programme", Available:
http://www.eetasia.com/ART_8800572017_765245_NT_e6bbc213.HTM (Accessed on 1 March 2010).
- Dechezleprêtre, A, M. Glachant, I. Hascic, N. Johnstone, and Y. Ménière (2008) "Invention and transfer of climate change mitigation technologies on a global scale: a study drawing on patent data", CERN
- Deboonme, A. (2009) "Alternative-Energy Goal: Huge Interest Shown, Especially in Solar Power," *The Nation*, December 14, 2009.
- DNV (2010) "Jaroensompong Corporation Rachathewa Landfill Gas to Energy Project", Available at:
http://www.dnv.com/focus/climate_change/projects/projectdetails.asp?ProjectId=941 (Accessed on 1 March 2010).
- Do, T.S.D. (2009) Solar Energy in Vietnam – A Change Needed,
<http://www.frost.com/prod/servlet/market-insight-top.pag?Src=RSS&docid=159785047>.
 (Accessed: October 5, 2010)
- Economic Intelligence Unit (2008) All is not well with Thailand's ambitious eco-car scheme, *Thailand Fuels: Thai Indecision*.
- Electric Power Research Institute (EPRI) (2008) *Advanced Coal Power Systems*, Palo Alto, California.
- Electricity Regulatory Authority of Vietnam (2009) "Restructuring and Tariff Reform of the Power Sector in Vietnam", 17 November.
- ENTTRANS (2008) The State of Play with the CDM, ENTTRANS: EU Sixth Framework Programme, November 2008
- Environmental Resources Group (2010) "Global Hydropower Scenario", at:
http://www.erg.com.np/hydropower_global.php, accessed on 15 February 2010.

- ERI – National Development and Reform Commission. (2004). China National Energy Strategy and Policy to 2020: Scenario Analysis on Energy Demand.
- FAO (2010) “Fuel-efficient stoves”, Food and Agriculture Organization, Rome. Available: http://www.fao.org/sd/teca/tools/1st/LSTP26_en.html, accessed on 15 February 2010.
- Folkmanis, J. and D. Nguyen (2009) Vietnam Opens Refinery, Overcoming Foreign Criticism (Update1), Bloomberg report, 22 February 2009. Available: http://www.bloomberg.com/apps/news?pid=20601087&sid=ao32X_VDkbAo&refer=home (Accessed on 18/08/09).
- General Electric (2007) GE Energy IGCC Plant With Carbon Capture & Sequestration IGCC Plant - Bituminous Coal, General Electric
- Gielen, D. (2003) The Future Role of CO₂ Capture and Storage: Results of the IEA-ETP Model, Paris
- Global American Technology Alliance (2008) Investor Briefing on Southeast Asia’s New Expanded Special Economic Zone (Riau Islands & Indonesia), 11 November. Available at: <http://intlalliances.wordpress.com/2008/11/11/investor-briefing-on-southeast-asias-new-expanded-special-economic-zone-riau-islands-indonesia/> (Accessed on 1 March 2010).
- Godrey, M. (2009) A global hydropower, China International Business, March 6, 2009. Available: http://www.cibmagazine.com.cn/Features/Trend.asp?id=854&a_global_hydro_power.html (Accessed 15/02/2010).
- GTZ (2010) “Establishment of a Legal Framework and Improvement of Technical Capacities for Grid - connected Wind Power Development in Viet Nam”, Deutsche Gesellschaft für Internationale Zusammenarbeit, Eschborn, Germany. Available at: <http://www.gtz.de/en/weltweit/asien-pazifik/vietnam/26929.htm> (Accessed on 1 March 2010).
- Hakura, D. and F. Jaumotte (1999) “The Role of Inter- and Intra-industry Trade in Technology Diffusion,” IMF Working Papers 99/58, International Monetary Fund, Washington DC.
- Hall, D., M. Levi, W. Pizer and T. Ueno (2008) “Policies for Developing Country Engagement”, Harvard Project on International Climate Agreements Discussion Paper No. 2008-15, Cambridge, Massachusetts.
- Hoekman, B., K.E. Maskus, and S. Kamal (2004) “Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options”, World Bank Policy Research Working Paper No. 3332, World Bank, Washington DC.
- Huang, H. and Z. Yan (2009) “Present Situation and Future Prospect of Hydropower in China,” Renewable and Sustainable Energy Reviews, 13, 1652-1656.
- ICTSD (2007) New Trends in Technology Transfer and their implications for national and international policy, International Centre for Trade and Sustainable Development, Geneva.
- ICTSD (2008), Trade in Climate-Friendly technologies, Bridge/News, International Centre for Trade and Sustainable Development, Geneva.
- Index Mundi (2010) “Indonesia Hydroelectric Power Production by Year”, Available at: <http://www.indexmundi.com/energy.aspx?country=id&product=hydro&graph=production> (Accessed on 20 April 2010).

- Indonesia, Republic of (2008) “National Energy Policy and Recent Development In Indonesia”, Ministry of Energy and Mineral Resources, Director for New Renewable Energy and Energy Conservation. (2008). Available: http://www.senternovem.nl/mmfiles/National%20energy%20policy%20Indonesia_tcm24-288054.pdf (Accessed on 1 March 2010).
- Indonesian National Committee of the IEC. (2007). Rural electrification in Indonesia: Progress and challenges. Presentation to the 71st IEC General Meeting.
- International Atomic Energy Agency (2006) Climate change and nuclear power 2008, International Atomic Energy Agency, Vienna.
- International Atomic Energy Agency (2008c) Energy, electricity and nuclear power estimates for the period up to 2030. Reference data series no.1, International Atomic Energy Agency, Vienna.
- International Energy Agency (2003) Clean Coal Centre, International Energy Agency, Paris.
- International Energy Agency. (2006a). Energy technology perspectives, International Energy Agency, Paris.
- International Energy Agency. (2006b). Compared assessment of selected environmental indicators of photovoltaic electricity in OECD cities, International Energy Agency, Paris.
- International Energy Agency. (2007). CHP and DHC in China: An assessment of market and policy potential, International Energy Agency, Paris.
- International Energy Agency (2008a) Combined heat and power: evaluating the benefits of greater global investment, IEA/OECD, , International Energy Agency, Paris.
- International Energy Agency (2008b) Key World Energy Statistics, International Energy Agency, Paris.
- International Energy Agency (2008c) How Much Renewable Energy Do We Use? Energy in Brief, International Energy Agency, Paris.
- International Energy Agency (2008d) Energy Policy Review of Indonesia, International Energy Agency, Paris.
- International Energy Agency (2009). Cogeneration and district energy: Sustainable technologies for today and tomorrow, International Energy Agency, Paris.
- International Energy Agency/Organisation of Economic Co-operation and Development. (2006) Light’s Labours’ Lost: Policies for Energy-Efficient Lighting, International Energy Agency, Paris.
- International Energy Agency/Organisation of Economic Co-operation and Development. (2009). Key Cross-cutting Issues 2007/2008. In: IEA (ed.) Lessons Learned from the Energy Policies of IEA Countries, International Energy Agency, Paris.
- IPCC (2005) Carbon Dioxide Capture and Storage. A Special report of Working Group III of the Intergovernmental Panel on Climate Change.
- IPCC (2007) Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
- Jaroensompong Corporation (2007) CDM Project Design Document Form, Project 1413.

- Junfeng, L., S. Jinli and M. Lingjuan (2005) China: prospect for renewable energy development. Prepared for the Stern Review.
- Kangmin, L. and M-W Ho (2006) Biogas China, ISIS report, 02/10/06.
- Kessides, I.N. (2010) "Nuclear Power and Sustainable Energy Policy: Promises and Perils," World Bank Research Observer, 25 (2): 323-362.
- KMDK Vietnam Co. Ltd (2006) CDM Project Design Document Form, Project 1910.
- Kwok, V. (2009) Weaknesses in Chinese Wind Power, forbes.com article, 20/07/09. Available: <http://www.forbes.com/2009/07/20/china-wind-power-business-energy-china.html> (Accessed on 14/08/09).
- Lenzen, M. (2008) Life cycle energy and greenhouse gas emissions of nuclear energy: A review. Energy Conversion and Management 49, 2178-2199.
- Li, J., G. Hu, S. Pengfei, S. Jingli, M. Lingjuan, Q. Haiyan, and S. Yanqin (2007) China Wind Power Report 2007, China Environmental Science Press, Beijing. Available: <http://www.greenpeace.org/raw/content/eastasia/press/reports/wind-power-report.pdf> (Accessed on June 1, 2011).
- Major, S., T. Commins, A. Noppharatana (2008) Potential of Wind Power for Thailand: An Assessment. Review Article.
- Matysek, A., M. Ford, G. Jakeman, R. Curtotti, K. Schneider, H. Ahammad and B.S. Fisher (2005) "Near zero emissions technologies", ABARE eReport 05.1 Prepared for the Department of Industry, Tourism and Resources, Canberra, January.
- Meyer-Ohlendorf, N. and C. Gerstetter (2009) Trade and Climate Change: Triggers or barriers for Climate Friendly Technology Transfer and Development? Dialogue on Globalization Occasional Papers No. 41, Berlin: Friedrich-Ebert-Stiftung.
- Ministry of Industry (2009a) BOI meets JFCCT to reassure confidence among investors – One start one stop services to be launched for better investment facilitation, Press release, No 90/2009, June 22 2009, Thailand.
- Ministry of Industry. (2009b). BOI raises special investment promotion measures to greater support investment in the Southern (sic) of Thailand, Press release, No112/2009, July 16 2009, Thailand.
- National Energy Technology Laboratory (2008) The cost of carbon dioxide capture and storage in geologic formations, US Department of Energy. Available: <http://www.netl.doe.gov/energy-analyses/refshelf/Default.aspx> (Accessed: October 5, 2010).
- New Energy Finance (2009) New Energy Finance Summit - The book 2009, Bloomberg New Energy Finance, Available: bnf.com/WhitePapers/download/22 (Accessed on June 1, 2011).
- New York Times (2010) Gains in Global Wind Capacity Reported, February 15, 2010. Available: <http://green.blogs.nytimes.com/2010/02/15/gains-in-global-wind-capacity-reported/> (Accessed on June 1, 2011)
- Newell, R.G. (2008) "International Climate Technology Strategies", The Harvard Project on International Climate Agreements, Harvard Kennedy School Discussion Paper 08-12, Boston.

- Ng, D. (2004) The international CAPM when expected returns are time-varying. *Journal of International Money and Finance*, 23, 189.
- Nicholson, M. (2002) "Intellectual Property Rights, Internalization, and Technology Transfer", FTC Bureau of Economics Working Paper No. 250. DOI:10.2139/ssrn.393661
- OECD (2008) China: Encouraging responsible business conduct, OECD Investment Policy Reviews, Organisation of Economic Co-operation and Development, Paris.
- PEACE (Pelangi Energi Abadi Citra Enviro) (2007) Indonesia and Climate Change: Current Status and Policies. 90 pp. Available: http://siteresources.worldbank.org/INTINDONESIA/Resources/Environment/ClimateChange_Full_EN.pdf (Accessed on June 1, 2011)
- Phuangpornpitaka, N. and S. Kumar (2007) "PV hybrid systems for rural electrification in Thailand," *Renewable and Sustainable Energy Reviews*, 11 (7) September 2007, Pp. 1530-154.3
- Pirker, O. (2007) Climate change and hydropower: Consequences and challenges, presentation at Symposium on Climate Change and the European water dimension 12-14 February 2007.
- Practical Action (2010) "Reducing of greenhouse gas emissions through the dissemination of cook stoves in Bangladesh," Available: http://www.practicalaction.org/?id=bangladesh_stoves (Accessed on 1 March 2010).
- Prasertsan, S. and B. Sajjakulnukit (2005) "Biomass and Biogas Energy in Thailand: Potential, Opportunity and Barriers," *Renewable Energy*, 31, 599-610.
- PT Gikoko Kogyo (2009) CDM Project Design Document Form, Project 2509.
- PT Navigat Organic Energy Indonesia (2006) CDM Project Design Document Form, Project 0938.
- PVResources.com. (2010) "Large-scale photovoltaic power plants located in Thailand," Available: http://www.pvresources.com/en/top50_thailand.php (Accessed on June 1, 2011).
- Renewable Energy Magazine (2010) "Good news for the solar industry," January 28, 2010. Available: <http://www.renewableenergymagazine.com/paginas/Contenidosecciones.asp?ID=15&Cod=4794&T ipo=&Nombre=PV%20Solar%20News> (Accessed: October 5, 2010).
- REN21 (2009) Renewables 2009 Global Status Report, Renewable Energy Policy Network for the 21st Century.
- Retnanestri, M., H. Outhred, S. Healy (2005) Off-grid Photovoltaic Applications in Indonesia: An Assessment of Current Experience, Proc. ANZSES Annual Conference, Dunedin, NZ, 28-30 November, ISBN 0-473-10937-9.
- Retnanestri, M., H. Outhred, Tugino, B. Astuti, A. Rezavidi, A. Prastawa, (2008) "An Adra Research Project to Overcome Barriers to Renewable Energy in Rural Indonesia by Community Capacity Building Using the I3a Framework", ISES-AP - 3rd International Solar Energy Society Conference – Asia Pacific Region (ISES-AP-08), Incorporating the 46th ANZSES Conference, 25-28 November 2008 Sydney Convention & Exhibition Centre
- Richards, K. and C. Stokes (2004) "A review of forest carbon sequestration cost studies: A dozen years of research," *Climatic Change*, 63, pp 1-48.
- Romm, J. (2006) "The car and fuel of the future," *Energy Policy*, 34, pp 2609-2614.

- Runckel and Associates (2008) Table of Investment Cost Comparison for Vietnam, China, Thailand, Cambodia and Laos, Business in Asia. Available: <http://www.business-in-asia.com> (Accessed on June 1, 2011).
- Sathaye, J.A., W. Makundi, L. Dale, P. Chan and K. Andrasko (2007) "GHG mitigation potential, costs and benefits in global forests: A dynamic partial equilibrium approach," Energy Journal, Special Issue 3, pp. 127-172.
- Sato, K. (2009) "Clean Development Mechanism (CDM): How it Works and New Carbon Finance Instruments", Carbon Finance Unit, The World Bank, March 3.
- SenterNovem (2009). Mini/Micro Hydro Power, Available: http://www.senternovem.nl/becin/projects/hydro_power.asp (Accessed on 1 March 2010).
- SenterNovem (2010). "Bilateral Energy Cooperation Indonesia Netherlands (BECIN)", Available: <http://www.senternovem.nl/becin/projects/biogas.asp> (Accessed on 1 March 2010).
- Sohngen, B. and R. Sedjo. (2006) "Carbon sequestration costs in global forests," Energy Journal, Special Issue, pp. 109-126.
- Stanway, D. (2010) China Skeptical As Foreign Firms Push Carbon Capture [Online], Tianjin. Available: <http://in.reuters.com/article/worldNews/idINIndia-45818020100201> (Accessed 11/02/2010).
- Statesman, N. (2010) ADB Approves \$135m Loan for IGCC Power Plant In China [Online], Tianjin. (Accessed: November 2, 2009).
- Stern, N. (2006) The Economics of Climate Change: The Stern Review. Cambridge, UK: Cambridge University Press.
- Thailand Board of Investment. (2006) Thailand's Energy Policy and Development Plan.
- Thanh-Binh, N.T. (2009) "Evaluation of Franchising Business Model Applied to Solar Energy Market in Vietnam", Faculty of Business Studies Master Programme in International Business Management Master's Thesis, Autumn 2009. Available: https://publications.theseus.fi/bitstream/handle/10024/6800/Nguyen_Thanh.pdf?sequence=1 (Accessed: October 5, 2010)
- Thien, N.Q. and N.H. Son (2006) Biomass in Vietnam: Case Study, Workshop on Utilization of Biomass for Renewable Energy. Kathmandu, Nepal. Available: http://www.apo-tokyo.org/biomassboiler/D1_downloads/presentations/Nepal_Program_DEC2006/Country_Papers/Vietnam/Vietnam_CP.doc. (Accessed: October 5, 2010)
- UNCTAD (2008a) World Investment Report 2008, United Nations Conference on Trade and Development, New York and Geneva.
- UNCTAD (2008b) Investment Policy Review: Viet Nam, United Nations Conference on Trade and Development, New York and Geneva.
- UNEP (2009a) Global trends in sustainable energy investment 2009, United Nations Environment Programme, Nairobi.
- UNEP (2009b) The Global Financial Crisis and its Impact on Renewable Energy Finance, United Nations Environment Programme, Nairobi.

- UNEP (2010) “CDM/JI Pipeline Analysis and Database”, United Nations Environment Programme, Nairobi. Available: <http://www.cdmpipeline.org/> (Accessed on 15 February 2010).
- UNFCCC (2007) Investment and financial flows relevant to the development of an effective and appropriate international response to Climate Change, United Nations Framework Convention on Climate Change, Bonn.
- UNFCCC (2009) Second synthesis report on technology needs identified by Parties not included in Annex I to the Convention. Subsidiary body for scientific and technological advice, United Nations Framework Convention on Climate Change, Bonn.
- Unibros. (2010) “Wind power industry in Vietnam”, Available: http://www.unibros.com/en/news.php/wind_power_industry_in_vietnam/id=12389/cid=4 (Accessed on 20 April 2010).
- USAID (2007a) Confidence in quality: Harmonization of CFLs to help Asia address climate change, United States Agency for International Development, Washington DC.
- USAID (2007b) “Annex 6”, Vietnam Country Report, United States Agency for International Development, Washington DC.
- US Department of State (2008) Investment Climate Statement – Indonesia, Washington DC.
- USDA (2006) Bio-fuels: an alternative future for agriculture. GAIN Report, United States Department of Agriculture, Washington DC.
- VUSTA (2007) Assessment of Vietnam Power Development Plan, Vietnam Union of Science and Technology Associations (VUSTA).
- Vuuren, D. V., M. den Elzen, P. Lucas, B. Eickhout, B. Strengers, B van Ruijven, S. Wonink, and R. van Houdt, (2007) “Stabilizing greenhouse gas concentrations at low levels: an assessment of reduction strategies and costs,” *Climatic Change*, 81 (2) pp. 119-159.
- Watts, J. (2009) “China's new faith in solar energy projects is hailed by environmentalists as a milestone”, *The Guardian*, 26 May.
- Weyerhaeuser, H. (2007) Biofuels in China: An Analysis of the Opportunities and Challenges of *Jatropha Curcas* in Southwest China. ICRAF China.
- Whittington, R. (2007) “Hydro and the CDM”, *Refocus*, Volume 8, Issue 1, January 2007, Pages 54-56.
- Williams, P. (1993) “Dam Safety Analysis”, Chapter 10 in M. Barber and G. Ryder (ed) (1993) *Damming The Three Gorges*, Probe International, Earthscan Publications.
- World Bank (2007) Warming up to trade? Harnessing International Trade to Support Climate Change Objectives, World Bank, Washington DC.
- World Bank. (2008) International trade and climate change: Economic, legal and institutional perspectives, World Bank, Washington DC.
- World Bank/GGFR. (2006) Indonesia Associated Gas Survey – Screening and Economic Analysis Report, prepared by PA Consulting Group, World Bank, Washington DC.

- World Bank (2010a) World Development Report 2010: Development and Climate Change, World Bank, Washington DC.
- World Bank (2010b) Climate Impacts on Energy Systems: Key Issues for Energy Sector Adaptation, World Bank, Washington DC.
- World Bank (2010c) Winds of Change: East Asia's Sustainable Energy Future, World Bank, Washington DC.
- World Bank (2010d) "Climate Change and Fiscal Policy: A Report for APEC," Climate Change and Economic Policies in APEC series, Report 2, World Bank, Washington DC.
- World Business Council for Sustainable Development (2004) Mobility 2030: Meeting the challenges to sustainability.
- World Economic Forum (2009) Green Investing: Towards a Clean Energy Infrastructure, World Economic Forum, Cologny, Switzerland.
- World Energy Council (2007) Survey of Energy Resources, Available:
http://www.worldenergy.org/publications/survey_of_energy_resources_2007/wave_energy/763.asp
 (Accessed on 15 February 2010).
- World Energy Council (2008) Survey of Energy Resources Interim Update 2009
http://www.worldenergy.org/documents/hydro_7_1_1.pdf, accessed on 15 February 2010.
- World Resources Institute (2009) Climate Analysis Indicators Tool (CAIT) Version 6.0 Washington.
- Xiao, Y. (2009) "The Development of IGCC, co-production and CCS in China", Presented at 2009 U.S.-China Coal Conversion and Carbon Management Workshop West Virginia University Morgantown West Virginia, USA, December 3-4, 2009.
- Xinhua (2008) China's Coal Liquefaction Craze Cools Off, China Daily. Available:
http://www.chinadaily.com.cn/bizchina/2008-09/19/content_7043240.htm [Accessed 11/02/2010].
- Yotam, A. (2009) "Incentives, Falling Cost and Rising Demand in China's PV Market", 3 November. Available: <http://www.renewableenergyworld.com/rea/news/article/2009/11/incentives-falling-cost-and-rising-demand-in-chinas-pv-market> (Accessed on 16 February 2010).
- Yu, L., K. Yaoqiu, H. Ningsheng, W. Zhifeng, and X. Lianzhong (2008) "Popularising household-scale biogas digesters for rural sustainable energy development and greenhouse gas mitigation," Renewable energy 33, 2007-2035.

APPENDIX A: HARMONIZED SYSTEM CLASSIFICATION OF CLIMATE FRIENDLY TECHNOLOGIES

CFT Category	HS-6	CFT Product
Advanced Fossil Fuel Power	840410	Auxiliary plant for use with boilers of heading 84
	840420	Condensers for steam or other vapor power units
	840490	Parts
	840510	Producer gas or water gas generators, with or with
	840681	(1996-) Of an output exceeding 40 MW
	840682	(1996-) Of an output not exceeding 40 MW
	840690	Parts
	841181	Of a power not exceeding 5,000 kW
	841182	Of a power exceeding 5,000 kW
	841199	Other
	841410	Vacuum pumps
	842139	Other
	851410	Resistance heated furnaces and ovens
	851420	Furnaces and ovens functioning by induction or die
	851430	Other furnaces and ovens
	851440	Other equipment for the heat treatment of material
	851490	Parts
Wind Power	730820	Towers and lattice masts
	841320	Hand pumps, other than those of subheading 8413.11
	841350	Other reciprocating positive displacement pumps
	841360	Other rotary positive displacement pumps
	841370	Other centrifugal pumps
	841381	Pumps
	841382	Liquid elevators
	841391	Of pumps
	841392	Of liquid elevators
	848340	Gears and gearing, other than toothed wheels,
	848360	Clutches and shaft couplings (including universal
	850231	(1996-) Wind powered
	850300	Parts suitable for use solely or principally with
Biogas	730410	(-2006) Line pipe of a kind used for oil or gas pi
	730511	Longitudinally submerged arc welded
	730512	Other, longitudinally welded
	730519	Other
	730610	(-2006) Line pipe of a kind used for oil or gas pi
	840219	Other vapor generating boilers, including hybrid
	840290	Parts
	840410	Auxiliary plant for use with boilers of heading 84
	841940	Distilling or rectifying plant
Biofuels	841989	Other
	271011	(2002-) Light oils and preparations
	271019	(2002-) Other
	271111	Natural gas
	271112	Propane
	271113	Butanes
	271121	Natural gas
	290511	Methanol (methyl alcohol)
	382490	(1996-) Other
Waste Heat/ Gas Recovery	391721	Of polymers of ethylene

CFT Category	HS-6	CFT Product
	391722	Of polymers of propylene
	391723	Of polymers of vinyl chloride
	392010	Of polymers of ethylene
	560314	(1996-) Weighing more than 150 g/m²
	840790	Other engines
	847982	Mixing, kneading, crushing, grinding, screening, s
	847989	Other
	850110	Motors of an output not exceeding 37.5 W
	850120	Universal AC/DC motors of an output exceeding 37.5
	850131	Of an output not exceeding 750 W
	850161	Of an output not exceeding 75 kVA
	850162	Of an output exceeding 75 kVA but not exceeding 37
	850163	Of an output exceeding 375 kVA but not exceeding 7
	850164	Of an output exceeding 750 kVA
	851410	Resistance heated furnaces and ovens
	851420	Furnaces and ovens functioning by induction or die
	851430	Other furnaces and ovens
	851440	Other equipment for the heat treatment of material
	851490	Parts
	902810	Gas meters
Hydro Power	841011	Of a power not exceeding 1,000 kW
	841012	Of a power exceeding 1,000 kW but not exceeding 10
	841013	Of a power exceeding 10,000 kW
	841090	Parts, including regulators
Photovoltaic Solar	850440	Static converters
	850720	Other lead acid accumulators
	853710	For a voltage not exceeding 1,000 V
	854140	Photosensitive semiconductor devices, including ph
	900190	Other
	900290	Other
Solar Thermal	392510	Reservoirs, tanks, vats and similar containers, of
	761100	Aluminum reservoirs, tanks, vats and similar cont
	841919	Other
	841950	Heat exchange units
Fuel Cells	850680	(1996-) Other primary cells and primary batteries
Agriculture	392010	Of polymers of ethylene
	392020	Of polymers of propylene
	392030	Of polymers of styrene
	392051	Of poly(methyl methacrylate)
	392059	Other
	392061	Of polycarbonates
	392062	Of poly(ethylene terephthalate)
	392063	Of unsaturated polyesters
	392069	Of other polyesters
	392071	Of regenerated cellulose
	392072	(-2006) Of vulcanized fiber
	392073	Of cellulose acetate
	392079	Of other cellulose derivatives
	392094	Of phenolic resins
	392099	Of other plastics
Water Resources	392290	Other

CFT Category	HS-6	CFT Product
	392330	Carboys, bottles, flasks and similar articles
	691010	Of porcelain or china
	732490	Other, including parts
	761100	Aluminum reservoirs, tanks, vats and similar cont
Combined Heat and Power	850213	Of an output exceeding 375 kVA
	850239	(1996-) Other
Building	700800	Multiple walled insulating units of glass.
	701932	Thin sheets (voiles)
	701939	Other
Hybrid Vehicles	870290	Other
	870322	Of a cylinder capacity exceeding 1,000 cc but not
	870390	Other
Energy Efficient Light Globes	853931	Fluorescent, hot cathode

