International Energy Technology Transfers for Climate Change Mitigation

What, who, how, why, when, where, how much …
and the Implications for International Institutional Architecture

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Abstract

The goal of the paper is to expand and refine the international technology transfer negotiating and analytic agendas and to reframe the issues. The paper presents concepts, indicators, illustrations and data that identify and measure international transfers of energy technologies that can be used to mitigate climate change. Among the questions on that agenda are *how much* technology transfer there has been to date, and *how much* will be needed in the future, especially to assist non-Annex I developing countries in their efforts to mitigate climate change. Before the *how much* questions can be answered, however, there are several prior questions, and hence the many other elements of the subtitle of the paper: *what, who, how, why, when, where*. These aspects of international technology transfer vary significantly among three existing institutional settings and among the associated analytic paradigms: North-South Official Development Assistance, Global Private International Investment and Trade, and International Public-Private Cooperation Agreements. The principal sections of the paper focus on features of international technology transfers in these institutional settings and on illustrations drawn from the biodiesel industry, especially the use of jatropha tree as the source of the feedstock. The conclusions are summarized as follows: (i) Technologies include intangible know-how and services, as well as tangible goods in the form of production process equipment and finished products. (ii) International transfers of some types of technology are much easier to measure than others. (iii) International technology transfers are highly industry-specific. (iv) Even for individual industries, it is necessary to use multiple indicators of technology transfers. (v) Patterns in the types of technology and methods of transfer vary across the three institutional settings examined in the paper. (vi) All three of the institutional arrangements are probably under-performing and inadequate to the urgent need to address climate change mitigation more effectively. (vii) There are no agreed criteria or procedures for determining how much would be enough. (viii) An issue that needs more thorough analysis is the extent to which international public-private cooperation arrangements could perhaps actually inhibit international technology transfer. (ix) Another issue warranting more scrutiny is the role of international joint ventures versus wholly-owned subsidiaries in facilitating technology transfer.

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I am indebted to Jacob Werksman, who suggested as a commenter on a previous paper that there is a paradigm of technology development and diffusion based on public-private partnerships, a suggestion that is reflected in this paper in the international public-private technology cooperation paradigm. I am also indebted to John Barton, whose work on international technology transfer, particularly in regard to the global trade and investment paradigm and intellectual property rights, has been highly instructive. Finally, I am indebted to Amitabh Gupta, who assisted in the research for the materials on biodiesel industry. An empirical analysis of trade patterns using gravity models is in progress by Selen Guerin, Head of Trade Policy Unit, Centre for European Policy Studies (CEPS).

1. Context and Purpose

International technology transfer has long been widely regarded as an important element of attempts to mitigate climate change. The prominence of technology transfer has been evident in many formal statements by international climate change meetings, including the Bali Action Plan of COP-13.[1] The importance of technology transfer has also been evident in EU and many national government pronouncements (see, for instance, Euractive, 2008a, 2008b, 2008c). Discussions, however, have often been marked by perplexity and frustration about the relatively low levels of perceived flows, compared with the urgent need to address climate change more seriously; these sentiments have been especially pervasive about flows from Annex I developed countries to non-Annex I developing countries. Such concerns have led to increased interest in more empirically-oriented analyses and thus increased interest in measuring the technology flows.[2]

In order to answer questions about *how much*, though, it is necessary to answer a series of other questions, as indicated by the subtitle of the paper: *what, who, how, why, when, where.* Within this context, the purpose of the paper is to expand and refine the analytic and negotiating agendas of the FCCC and other deliberative processes that are concerned with the role of international technology transfer in addressing climate change mitigation and to reframe the issues.

The paper draws upon and supplements recent papers and publications. The paper reflects additional work beyond two forthcoming publications (Brewer, 2008a and 2008b), which focus on the presentation of two alternative, but complementary, paradigms of international technology flows to address climate change issues. The present paper introduces a third paradigm and discusses measurement issues more explicitly and in greater detail. Barton (2007a and 2007b) discusses changes in international technology transfer, especially in relation to energy and climate change issues. Cantwell (2001) provides a useful survey of the literature on international technology transfers more generally, with an emphasis on the role of multinational firms. Mytelka (2007) emphasizes the role of recipient countries' absortive capacities in the technology transfer process. A report by the IPCC (2000) is an important survey about technologies and technology transfers in the context of climate change mitigation and adaptation issues. A conference paper by the Centre for International Trade

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[1] The Bali Action Plan includes the following provisions about technology: "The Conference of the Parties …1. *Decides* to launch a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012, in order to reach an agreed outcome and adopt a decision at its fifteenth session, by addressing, inter alia: … (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; …. "(www.unfccc.int, accessed on 29 March 2008).

[2] These sentiments were evident in three international conferences of experts from many countries in June 2008 that were focused on issues at the intersection of climate change and international trade-investment-technology transfer: in Copenhagen at a conference sponsored by the Danish government and the German Marshall Fund of the United States; at a conference in Geneva sponsored by the International Centre for Trade and Sustainable Development and the Commonwealth; and in Washington, DC, at a conference sponsored by The Brookings Institution. I am indebted to many participants in those conferences for their thoughts on the subject.

and Sustainable Development (2008) addresses issues about the role of intellectual property rights in climate friendly technology transfers. An article by deConinck, Haake and van der Linden (2007) focuses on technology transfer issues associated with Clean Development Mechanism (CDM) projects. Ueno (2006) analyses existing international technology cooperation agreements. Gallagher (2007) examines the role of host government policies in China as facilitators or constraints on foreign investment in the automotive industry.

These recent papers and publications, as well as the present one, are based on a notion of technology that is more expansive than the traditional focus on hardware. In fact, over time, the literature on international technology transfers has progressed from a relatively narrow definition of technology as codified “scientific and engineering knowledge …[resulting] from R&D” to include a second notion as well, namely technology as tacit knowledge that is embedded in firms’ procedures and personnel (Cantwell, 2001; 434). While the first conceptualization leads to an analytic focus on explicit knowledge concerning specific products and their associated production processes, the second conceptualization leads to a focus on the capabilities and processes of firms, including the tacit knowledge that is embedded in them. Technology is therefore often broadly defined as know-how or applied knowledge. An encompassing notion of technology thus includes both “soft” and “hard” technologies - a distinction that is explicit the analysis of CDM projects in deConinck, Haake and van der Linden (2007).[3]

In these and other items in the literature, three key dimensions of technology are evident; they are based on distinctions as follows: (1) product vs. production process, (2) tangible vs. intangible, and (3) explicit vs. tacit. If these are treated as dichotomous attributes, there are eight types of technology (2x2x2). For instance, manufactured finished goods represent tangible product technology, the international transfer of which can be measure by the volume of trade in goods. Equipment used in the production process of a good represents tangible process technology. Knowledge about the manufacturing process represents intangible technology. Know-how about how to establish and operate a production process is intangible explicit and tacit technology, where explicit technology is manifest in operating manuals and tacit technology is manifest in the knowledge of the production process that is embedded in undocumented organizational procedures. Service products are intangible. See Table 1 for a list of the types with examples.

The technologies of special interest for this paper are energy technologies that can mitigate climate change. Energy technologies dominate lists for climate change mitigation - for instance, the lists reported by the UNFCCC, IEA and European Commission as presented in Tables 2, 3 and 4, respectively. Major sources of data about energy technologies, sources, and uses - with an emphasis on investment patterns and trends - are IEA (2008), UNEP, SEFI and New Energy Finance (2008) and World Bank (2007).

2. Institutional Settings and Paradigms

Analyses and negotiations about international energy technology transfers for climate change mitigation tend to assume – or occur within – three distinctive institutional settings. The

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[3] International technology flows occur at the level of individuals, products (goods and service) and projects. These micro-level flows are often aggregated at the industry or country levels. Although balance of trade and payments data are helpful in identifying patterns and trends in these aggregated industry-level and country-level data, they can also be misleading. For such aggregated data do not capture the full scope - nor therefore the richness - of the multidimensional flows that are occurring at the micro-level.

focus of attention varies among them in terms of several features of the technology flows. As the comparative summaries in Table 5 indicate, these three paradigms reflect different notions of key features of the technology transfer process, including what is transferred, who transfers it, and how, why, when and where it is transferred.

North-South Technology and Financial Flows

Paradigm I, which is typically employed within the context of UNFCCC venues, is focused on unidirectional technology transfers from developed Annex I countries to developing non-Annex I countries and on official international financial transfers to fund the technology flows. The levels and patterns in bilateral and multilateral official development assistance (ODA) programs are thus key determinants of the levels and composition of technology transfers. The data of Table 6 and Box 1 are indicative of levels of total bilateral and multilateral ODA funding for climate related-related purposes, which have been on the order of a few hundred million dollars per year (Table 6) but may increase to a few billion dollars per year with the advent of the Climate Investment Funds (Box 1).

Table 7 presents findings from a recent study (deConnick, Haake, and van der Linden, 2007) of technology transfers associated with Clean Development Mechanism (CDM) projects.[4] CDMs were not originally envisioned to be technology transfer projects (Bohringer, Klaassen, and Moslener, 2007); rather, they were - and are - one of the Kyoto Protocol ‘flexibility mechanisms’ for international emissions trading. In any case, their effectiveness as channels of technology transfer from Annex I to non Annex I countries has become a issue in negotiations on the post 2012 international climate regime. The data in Table 7 indicate that there international technology transfers in 29 of the 63 projects investigated, with such traqnsfers being especially common in hydropower and landfill gas projects.

Global Technology, Trade and Investment Flows

Paradigm II, which is commonly used to frame issues in international trade and investment policy venues, focuses on firms, especially multinational firms, as facilitators - and sometimes inhibitors – of international technology flows, particularly through trade and foreign direct investment in goods and services. Government trade and investment policies are thus important as constraints and facilitators of technology transfer (Brewer 2008b). These are reflected in the World Trade Organization (WTO) and the large number of bilateral and regional trade and/or investment agreements, including the more than a thousand bilateral investment treaties (see Brewer, 2004; Brewer and Young, 2000 and 2001 [revised edition forthcoming in 2008). Paradigm II incorporates the changing international geography of technology transfer based on the increasing importance of developing countries as sources of technologies.

Figure 1 indicates total world new investment of more than $150 billion in renewable energy in 2007, approximately double the amount in 2006 (though about 6 percent of the numerical increase was the result of foreign exchange rate changes, i.e. the declining dollar). Wind energy projects received 38 percent of the total in 2006 and 43 percent in 2007. Biofuels’

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[4] CDM projects involve features of all three of the paradigms presented in the paper. They were initially conceived as a way to facilitate transfers of funds from Annex I to non Annex I countries and thus have Paradigm I features. However, they also have features of Paradigm III, as many of them involve government participation, especially on the donor/source side; until 2007 all JI projects were government funded. Less than half and a declining portion of CDM projects are government funded.

share, meanwhile, declined from 26 percent to 17 percent, though still increasing in absolute dollar amounts. Solar increased from 16 percent to 24 percent.

About three-fourths of these investments in renewable energy were in the EU and the US – 42 per cent in the EU and 34 percent in the US in 2007. The absolute amounts invested in China and India, as well as many other developing countries, increased, though their shares of the total declined slightly (see Table 8 and Figure 3). In short, global investments are on the order of a hundred billion dollars or more, with about one-fourth being in developing countries.

One of the issues about such investments – particularly in the context of the WTO – is the extent to which they are in goods or services. For, as Table 9 indicates, the coverage of WTO rules is greater for services than for goods. Table 10 indicates the kinds of services that are at issue. Table 11 identifies the energy-related services included in a US GATS offer.

International Public-Private Cooperation Agreements

Paradigm III focuses on international cooperation agreements that involve both public sector and private sector entities that are engaged in specific projects (Justus and Philibert, 2005; Ueno, 2006). Such arrangements are developed to overcome the market failures associated with public sector investments in long-term infrastructure and to overcome obstacles to international knowledge diffusion.

Table 12 indicates that the EU has bilateral agreements with China and India and that it participates in several plurilateral arrangements based on specific technologies (carbon sequestration, hydrogen, nuclear and thermonuclear). As Table 13 indicates, the US also participates in these latter technology-specific arrangements, and in addition the Asia Pacific Partnership (APP) on Clean Development and Climate. The APP includes firms and industry associations as well as the governments of seven countries: Australia, Canada, China, India, Japan, the Republic of Korea, and the United States. It has developed a work program in the following sectors: cleaner fossil energy; renewable energy and distributed generation; power generation and transmission; steel; aluminum; cement; coal mining; and buildings and appliances (see especially Fujiwara, 2007). Box 2 lists some of the ‘flagship’ projects, in particular those focused on energy efficiency and/or renewable energy sources.

It is easy to be dismissive of many of these APP international cooperation arrangements for a variety of reasons. First, some of them were created at the instigation of the US administration at a time when it was under domestic and international pressure to show evidence of activity in addressing climate change, and the sheer number of agreements, countries, committees and projects may have created the impression of active engagement. In fact, the US Congress initially refused to fund the APP because it was widely considered a diversion from more serious issues. On the other hand, the Japanese government and industry have apparently taken a leadership role on several of the sector specific activities of the APP, and so it may become a more fecund forum for international technology transfer than the US administration envisioned.

Finally, there are numerous international energy collaborations under the auspices of the IEA (1980: 192-196).

One should be careful not to be too cynical about the role of such arrangements in international technology transfer. In fact, technology is transferred internationally through the myriad meetings and projects and informal networking that are engendered. Measuring those transfers, however, is not easy and has not yet been done to the best of my knowledge.

3. Industry Illustration: Biodiesel Using Jatropha as a Feedstock

This section further illustrates the diversity of the various forms of technology – in particular those that are involved in the use of the berries from jatropha trees as a source of biodiesel fuel. Although jaropha-based biodiesel is not yet widely available in Europe or elsewhere, it has several features that make it advantageous over currently-used feedstocks. In particular, because jatropha grows in many parts of the world (Asia, Central and South America, Sub-saharan Africa) in poor soil and dry conditions, where food production is generally not possible, it does not pose the same food-fuel land-use conflicts as other feedstocks. See Methane Institute and International Fuel Quality Center (2006) for an introduction to jatropha-based biodiesel.

A recent forecast by the FAO and OECD (2008) is that world wide biodiesel production will increase to about 24 billion litres by 2017, more than double the 11 billion produced in 2007.[5] Jatropha-based biodiesel is likely to be commercially viable in about five years. To date, India has been the center of interest in growing jatropha trees and refining the oil from their berries into biodiesel. However, interest has spread to many other developing countries, including China and several countries in South American and Africa.[6]

The Industry in India

In India, there has been some interest shown by the government-owned railways, regional public transport corporations, and the petroleum industry. In the state of Haryana, the state-run Haryana roadways successfully tested its buses on biodiesel. Indian Railways has been very enthusiastically promoting the use of biodiesel. India's Minister of Railways was recently talking about the prospect of railways promoting biodiesel to earn the carbon credits. A pilot plant put up by the Railway produces about 300-500 litres of biodiesel fuel a day. Indian Railways has been planting jatropha on its vacant land, and it has been using biodiesel to run trains on a pilot basis in two of its zones - Northern Railways and Southern Railways.

There has been a favorable response from the industries that are the major users of diesel - including the automobile industry. For instance, Mahindra and Mahindra (M&M) an automobile major of India has recently announced plans to launch vehicles that can be run on biodiesel; in fact, the company is keen on promoting its biodiesel initiative globally.[7] The German auto firm Daimler has been showing active interest in the jatropha based biodiesel in India. In 2003, Daimler launched a project with the Central Salt and Marine Chemicals Research Institute (CSMCRI), a constituent of Council for Scientific and Industrial Research (CSIR) in the Indian state of Gujarat and the German University of Hohenheim as partners. Under the project, farmers are being encouraged to cultivate jatropha in wastelands and semi-arid areas under the wasteland reclamation program to optimize the value-chain of biodiesel

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[5] Biodiesel production still lags far behind ethanol, which the FAO-OECD report forecasts will be 125 billion liters in 2017, compared with an estimate of 24 billion for bioethanol.

[6] Countries' comparative advantages in producing jatropha vary considerably, but jatropha trees tend to flourish in hot dry climates and in poor soil.

[7] http://www.blonnet.com/2007/10/07/stories/2007100751260200.htm

creation through best practices and models for community participation and emphasize on finding innovative utilization of by-products.[8]

Components and International Transfers in the Industry

In order to understand the technologies and technology transfer processes involved in the jatropha-based biodiesel industry, it is helpful to have a brief overview of the components of the industry. The principal value-adding elements of the biodiesel industry generally (feedstocks, processing facilities, and transportation-storage infrastructure) are represented in Table 14. In sum, there are numerous and diverse technologies that are essential to this relatively new and narrowly defined industry segment.

How are these technologies transferred internationally? To date, there has been virtually no international trade in the finished biodiesel products,[9] but there has been a long-history of international technology transfer through international investment and international licensing. And there is international trade in jatropha seeds and seedlings and in equipment used for planting, harvesting, transporting, storing and refining. In fact there are a wide variety of on-going international technology transfers. Table 15 decribes several examples of South-South transfers. Box 3 describes the activities of the Centre for Jatropha Promotion in India. Box 4 describes the activities of the D1 Oil firm in the UK.

How much of what?

It is apparent that there is no single measure that can capture the broad range of types of international technology transfers, even in the relatively small and still emerging jatropha-based biodiesel industry. For instance, one could use millions of jatropha tree seedlings exported/imported; or refinery capacity increases from inward foreign direct investments; or international joint ventures in integrated plantation-refinery projects; or of course liters of biodiesel fuel exported/imported. These and other possible measures are listed in Table 16.

Of course, it is possible to aggregate them all into a monetary numeraire, but that hardly captures the richness and interdependencies of the different types of flows. There is, finally, the question of how the absolute amounts are put into perspective, by expressing them as relative to some base.

4. Conclusions

The conclusions of the analysis can be summarized in the following points:

(1) Technologies include *intangible know-how and services, as well as tangible goods* in the form of production process equipment and finished products. They even include largely tacit knowledge, which is often embedded in the managerial processes of firms.

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[8] http://www.blonnet.com/2006/12/06/stories/2006120605260300.htm

[9] A high-profile exception is the practice of some US-based firms of importing biodiesel from Southeast Asia, then mixing it into a blend that is 99 percent biodiesel and one percent petro-diesel, collecting a US domestic biodiesel subsidy for each gallon of biodiesel they blend, and dthen exporting it to Europe, where there are additional subsidies available. The practice has caused much consternation in the European biodiesel industry, especially in Germany, and much stress in EU-US trade relations.

(2) International transfers of some types of technology are much *easier to measure than others*. For instance, trade in final goods can be measured relatively easily with widely available data; but transfers of tacit knowledge through interpersonal international contacts are a much greater challenge to measure.

(3) International technology transfers are highly *industry-specific*, and attempts to measure them must take this into account. Strong industry patterns are revealed in the study of international technology transfers for CDM projects. The analysis in the present paper of the jatropha-based biodiesel industry also reveals idiosyncratic industry technologies.

(4) Even for individual industries, it is necessary to use *multiple indicators* of technology transfers. In the case of the jatrophas-based biodiesel industry, there are distinctive agricultural technologies concerning the planting, growing and harvesting of jatropha plantations, and distinctive mechanical and chemical technologies concerning refining processes. Diverse technologies in the motor vehicle, airline, maritime shipping and other industries which are users of biodiesel fuel must also be taken into account in order to gain a full understanding of the technology transfer issues.

(5) Patterns in the types of technology and methods of transfer *vary across the three institutional settings* examined in the paper. ODA-related transfers are often related to donor-country industry and political interests; private trade and investment-based transfers are driven more by the markets and/or factors of production, including technology, in the importing/recipient countries; public-private cooperation arrangements are driven by governments' desires to overcome the market failures associated with large-scale, long term investments in infrastructure and firms' desires to keep abreast of international technology developments of special interest in their industries.

(6) All three of the institutional arrangements are probably *under-performing and inadequate* to the urgent need to address climate change mitigation more effectively. The levels of bilateral and multilateral ODA to fund international technology transfers appear low to most observors. The barriers to transfers of technology through government international trade and investment policies remain high in many countries and for many key technologies. The commitments of human and financial resources to international cooperation activies remain inadequate.

(7) Yet, it is also true that there are *no agreed criteria* or procedures for determining how much would be enough. Furthermore, any evaluations would need to vary across the three institutional arrangements because they are intended to serve different purposes.

(8) An issue that needs more thorough analysis is the extent to which *international public-private cooperation arrangements* may actually inhibit international technology transfer. Public-private partnerships could perhaps be vehicles for government-business collusion and regulatory capture as well as technology sharing.

(9) Finally, another issue warranting more scrutiny is the *role of international joint ventures versus wholly-owned subsidiaries in facilitating technology transfer*. For joint ventures between foreign investing firms and local firms are often established under pressure (or explicit legal requirements) of host governments, who want to increase the transfer of technology into the local economy. At the same time, foreign firms instinctively want to protect their technology by internalizing it within the firm, even as it is transferred

internationally among home and foreign entities of the firm. A firm may decide not to enter a country if a joint venture with a local firm is required by the local government. The mixture conflicts between the interests of firms and governments along with the common interests that bring them into agreement on foreign investment projects has of course been at the heart of multinational corporation-host government relations for decades.

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Table 1. Typology of Key Features of Technology, with Energy Efficiency and Renewable Energy (EERE) Examples

	Product - Production Process	**Tangible - Intangible**	**Explicit Tacit**	**Example**
1	Product	Tangible	Explicit	Wind turbines, hybrid autos, CFLs
2	Product	Tangible	Tacit	[?]
3	Product	Intangible	Explicit	Global Positioning System services for more direct aircraft routing patterns
4	Product	Intangible	Tacit	[?]
5	Process	Tangible	Explicit	Computer-aided manufacturing processes for EERE products
6	Process	Tangible	Tacit	[?]
7	Process	Intangible	Explicit	Wind turbine design – engineering drawings
8	Process	Intangible	Tacit	On-site construction process for wind towers, or other EERE facilities

Table 2. Energy Technologies for Reducing GHG Emissions – FCCC List

Reducing emissions from energy supply and infrastructure

Low emission, fossil-based power and fuels
- Zero-emission power, hydrogen, and other value-added products
- High-efficiency coal/solid feedstock
- High-efficiency gas fuel cell/hybrid power systems

Hydrogen
- Hydrogen production from nuclear fission and fusion
- Integrated hydrogen energy systems
- Hydrogen production
- Hydrogen storage and distribution
- Hydrogen use
- Hydrogen infrastructure safety

Renewable Energy Fuels
- Wind Energy
- Solar photovoltaic power
- Solar buildings
- Concentrating solar power
- Biochemical conversion of biomass
- Thermochemical conversion of biomass
- Biomass residues
- Energy crops
- Photoconversion
- Advanced hydropower
- Geothermal energy

Nuclear
- Existing plant research and development
- Next-generation fission energy systems
- Near-term nuclear power plant systems
- Advanced nuclear fuel cycle processes
- Nuclear fusion

Energy infrastructure
- High-temperature superconductivity
- Transmission and distribution technologies
- Distributed generation and combined heat and power
- Energy storage
- Sensors, controls and communications
- Power electronics

Reducing emissions from energy use

Transportation
- Light vehicles-hybrids, electric, and fuel cell vehicles
- Alternative-fuelled vehicles
- Intelligent transportation systems infrastructure
- Aviation
- Transit buses-urban duty-cycle

Buildings
- Building equipment, appliances and fighting
- Building envelope (insulation, walls, roof)
- Intelligent building systems
- Urban heat island technologies

Industry
- Energy conversion and utilization
  - Resource recovery and utilization
  - Industrial process efficiency

- Enabling technologies for industrial processes

Enhancing capabilities to measure and monitor emissions

- Hierarchical measuring and monitoring systems
  - For energy efficiency
  - For geologic carbon sequestration
  - For terrestrial carbon sequestration
  - For ocean carbon sequestration
  - For other greenhouse gas

Reducing the climate effect of non-carbon-dioxide greenhouse gas

Methane emissions from energy and waste

- Anaerobic and aerobic bioreactor landfills
- Conversion of landfill gas to alternative uses
- Electricity generation technologies for landfill gas
- Advances in coal mine ventilation air systems
- Advances in coal mine methane recovery systems
- Measurement and monitoring technology for natural gas systems

Methane and nitrous oxide emissions from agriculture

- Advanced agriculture systems for nitrous oxide emission reduction
- Methane reduction options for manure management
- Advanced agriculture systems for enteric emissions reduction

Emissions of high global-warming potential gasses

- Semiconductor industry; abasement technologies
- Semiconductor industry: substitute for processes producing gases with high global warming potential
- Semiconductor and magnesium: recovery and recycle
- Aluminum industry: perfluocarbon emissions
- Electric power systems and magnesium: substitute for SF_e
- Supermarket refrigeration: hydrofluorocarbon emissions

Nitrous oxide emissions from combustion and industrial sources

- Nitrous oxide abatement technologies from nitric acid production
- Nitrous oxide abatement technologies for transportation

Emissions of troposheric ozone precursors and black carbon

- Abatement technologies for emissions for tropospheric ozone precursors and black carbon

Source: UNFCCC (2000: 63)

Table 3. Technologies in the IEA Roadmap

Supply Side	**Demand Side**
CCS fossil-fuel power generation	Energy efficiency in buildings and appliances
Nuclear power plants	Heat pumps
Onshore and offshore wind	Solar space and water heating
Biomass integrated-gasification combined-cycle and co-combustion	Energy efficiency in transport
Photovoltaic systems	Electric and plug-in vehicles
Concentrating solar power	Hydrogen fuel cell vehicles
Coal: integrated-gasification combined-cycle	CCS in industry, hydrogen and fuel transformation
Coal: ultra-supercritical	Industrial motor systems
Second generation biofuels	

Source: IEA (2008: ES-46)

Table 4: Technologies for the Reduction of Greenhouse Gases – EU List

	Energy Supply	Energy demand-households + services	Energy demand industry	Transport	Agriculture	Waste
Energy efficiency	-Advanced macro CHP -Micro CHP -Coal bed methane -Ultra high efficiency combined cycle gas turbines -High efficient clean coal technology	-Building fabric -Integrated building design -Controls & building energy management systems -Heating & cooling & ventilation equipment - Energy efficiency equipment-office and domestic equipment -Lighting	-Alternative equipment -Combustion technologies -Low temperature processing materials -Process control -Separation technologies -Waste heat recovery	-Improvement internal combustion engine (diesel & gasoline) -Hybrid vehicles -Aeronautic technology -Traffic management systems	-Diet composition for reduced enteric fermentation	-Waste treatment technologies -Recycling/recovery (including eco-design)
Low carbon-technologies **Renewables**	Including -Direct solar (Photovoltaic, Solar thermal power stations) -Wind onshore/offshore -Biomass-electricity generation -Geothermal -Tidal wave -Small hydro	-Biomass-local heat generation -Passive solar systems	-Biomass-process heat	-Bio-fuels-transport	-Production of biomass	-Capture of bio-gas
Low carbon technologies-CO2 sequestration	-CO2 capture and storage (various options)				-Biological carbon sequestration	
Hydrogen & fuel cells	-Production of hydrogen from renewable energy sources (including options such as photo electrolysis), fossil fuels with CO2 sequestration	-Fuel cells-domestic CHP	-Fuel cells-industrial	-Hydrogen internal combustion engine -Fuel cells-transport -Hydrogen storage - Hydrogen infrastructure	-Production of biomass for hydrogen productions	

Source: European Commission (2003: 12-13)

Table 5. Summary Comparisons of Three Paradigms/Institutional Settings

	I North-South ODA	II Global Private FDI & Trade	III International Public-Private Cooperation Agreements
Who	Donor countries and IFIs; recipient countries	Firms, incl. large MNEs and SMEs	Governments & firms & industry associations
What flows		Goods, services, know-how	
How	Financial assistance	Trade, investment, licensing	Demonstration projects & meetings
Why	Political & ethical consideration; tied trade	Firms seeking markets &/or access to factors of production, incl. technology	To overcome market failures in infrastructure investments & obstacles to international

Table 6. Sources of Global Investment in Gross Fixed Capital Formation, 2000

A. Total

Sectors	FDI Flows %	International Borrowing %	Bilateral ODA %	Multilateral ODA %	Domestic %	Total GFCF USD bil
Electricity, gas, water	12.2	16.4	1.7	0.9	68.8	257
Transport, storage, com	16.7	16.8	0.5	0.4	65.5	889

B. In Annex I Countries

Sectors	FDI Flows %	International Borrowing %	Bilateral ODA %	Multilateral ODA %	Domestic %	Total GFCF USD bil
Electricity, gas, water	0.0	18.5	0.0	0.0	81.4	186
Transport, storage, com	0.3	22.2	0.0	0.0	77.5	630

C. In Non-Annex I Countries

Sectors	FDI Flows %	International Borrowing %	Bilateral ODA %	Multilateral ODA %	Domestic %	Total GFCF USD bil
Electricity, gas, water	12.6	5.8	0.6	3.3	77.7	67
Transport, storage, com	8.9	1.5	1.7	1.4	86.43	248

Source: Computed by the author from UNFCCC (2007: Tables 35.1-31.7)

Table 7. Technology Transfers in CDM Projects

Technology	Number of Projects	Number of Projects with Technology from Outside Country	Country Origins of Technology
Biogass	6	0	China, India
Biomass	10	0	India
Energy efficiency	1	0	South Africa
Fuel switching	1	1	Germany, USA
HFC-23	3	2	Germany, Japan, UK
Hydropower	22	12	China, Australia, France,India, Japan. Panama, Brazil, Peru, Spain, Sri Lanka, Switzerland, USA
Landfill gas	10	8	Belgium, Netherlands, Japan, France, Brazil, USA
Methane capture	3	0	Chile
Nitrous oxide destruction	2	2	France
Wind energy	5	4	Spain, Denmark
Totals	**63**	**29**	

Source: deConnick, Haake, van der Linden (2007: Table 3)

Table 8a. Worldwide Investment in Renewable Energy by Technology (2006, 2007) Percentages of Total

	2006	**2007**
Biofuels	26%	17%
Biomass and waste	10	9
Solar	16	24
Wind	38	43
Other renewable	4	3
Energy Efficiency	6	2
Other low carbon	(included in above)	2

Source: Derived by the author from UNEP, SEFI and New Energy Finance (2007: Fig. 5; 2008: Fig. 4)

Table 8b. Worldwide Investment in Renewable Energy by Region/Country (2006, 2007) Percentages of Total

	2006	**2007**
US	31.7%	33.9%
EU 27	38.2	42.0
Other OECD	8.9	8.1
China	8.6	6.7
India	5.2	1.9
Brazil	na	4.1
Africa	0.2	0.7
Latin America	3.7	na
Other Developing/Other non-OECD	3.4	2.6

Source: Derived by the author from UNEP, SEFI and New Energy Finance (2007: Fig. 9; 2008: Fig., 10)

Table 9. Methods of International Technology Transfer, Climate Friendly Technology Examples, and Coverage in WTO

Methods	Goods	Services
Production in exporting country/consumption in importing country	GATT: tariffs and non-tariff barriers	GATS: “consumption abroad”
Foreign direct investment, including joint ventures	GATT/TRIMs only	GATS: “commercial presence” (i.e. FDI)
Temporary relocation of employees	Not covered	WTO/GATS: “movement of natural persons”
International migration of skilled people	Not covered	Not covered
Licensing	TRIPs	TRIPs

Table 10. WTO/GATS Industry Sectors and Subsectors of Special Relevance to International Energy Technology Transfers

	SECTORS AND SUB-SECTORS	CORRESPONDING CPC NUMBER
	BUSINESS SERVICES	Section B
A.	Professional Services	
d.	Architectural services	8671
e.	Engineering services	8672 *
f.	Integrated engineering services	8673
g.	Urban planning and landscape architectural services	8674
C.	Research and Development Services	
a.	R&D services on natural sciences	851
b.	R&D services on social sciences and humanities	852
c.	Interdisciplinary R&D services	853
F.	Other Business Services	
c.	Management consulting service	865
d.	Services related to man. consulting	866
e.	Technical testing and analysis serv.	8676
f.	Services incidental to agriculture, hunting and forestry	881
g.	Services incidental to fishing	882
h.	Services incidental to mining	883+5115
i.	Services incidental to manufacturing	884+885
j.	Services incidental to energy distribution	887
m.	Related scientific and technical consulting services	8675
n.	Maintenance and repair of equipment (not including maritime vessels, aircraft or other transport equipment)	633+ 8861-8866
	CONSTRUCTION AND RELATED ENGINEERING SERVICES	
A.	General construction work for buildings	512
B.	General construction work for civil engineering	513
C.	Installation and assembly work	514+516
D.	Building completion and finishing work	517
E.	Other	
	EDUCATIONAL SERVICES	
C.	Higher education services	923
D.	Adult education	924
E.	Other education services	929
	ENVIRONMENTAL SERVICES	
A.	Sewage services	9401
B.	Refuse disposal services	9402
C.	Sanitation and similar services	9403
D.	Other	
	TRANSPORT SERVICES	
A.	Maritime Transport Services	

a.	Passenger transportation	7211
b.	Freight transportation	7212
c.	Rental of vessels with crew	7213
d.	Maintenance and repair of vessels	8868**
e.	Pushing and towing services	7214
f.	Supporting services for maritime transport	745**
B.	Internal Waterways Transport	
a.	Passenger transportation	7221
b.	Freight transportation	7222
c.	Rental of vessels with crew	7223
d.	Maintenance and repair of vessels	8868**
e.	Pushing and towing services	7224
f.	Supporting services for internal waterway transport	745**
C.	Air Transport Services	
a.	Passenger transportation	731
b.	Freight transportation	732
c.	Rental of aircraft with crew	734
d.	Maintenance and repair of aircraft	8868**
e.	Supporting services for air transport	746
E.	Rail Transport Services	
a.	Passenger transportation	7111
b.	Freight transportation	7112
c.	Pushing and towing services	7113
d.	Maintenance and repair of rail transport equipment	8868**
e.	Supporting services for rail transport services	743
F.	Road Transport Services	
a.	Passenger transportation	7121+7122
b.	Freight transportation	7123
c.	Rental of commercial vehicles with operator	7124
d.	Maintenance and repair of road transport equipment	6112+8867
e.	Supporting services for road transport services	744
G.	Pipeline Transport	
a.	Transportation of fuels	7131
b.	Transportation of other goods	7139
H.	Services auxiliary to all modes of transport	
a.	Cargo-handling services	741
b.	Storage and warehouse services	742
c.	Freight transport agency services	748
d.	Other	
I.	Other Transport Services	
	OTHER SERVICES NOT INCLUDED ELSEWHERE	95+97+98+99

Source: WTO (1991)

Table 11. Energy-Related Services included in the U.S. GATS Initial Offer

Descriptions of Services in WTO Classification List	Corresponding UN Central Product Classification Codes
Services incidental to mining	5115, 883
Certain related scientific and technical consulting services	8675
Services incidental to energy distribution	887
Certain professional services, including engineering and integrated engineering services	861, 862, 863, 8672, 8673, 9312, 93191, 932
Distribution services, including commission agents, wholesale trade, and retail trade services that apply to fuels, related products, and brokerage of electricity	6111, 6113, 6121, 621, 622, 631, 632
Maintenance and repair of equipment, except transport-related equipment	633, 8861-8866
Management consulting and related services	865
Construction and related engineering services	511-518
Pipeline transportation of fuels	7131
Storage and warehouse services, particularly bulk storage services of liquids and gases	7422
Technical testing and analysis services	8676

Source: WTO (2003)

Table 12. European International Technology Cooperation Arrangements

Bilateral technology partnerships with major emerging countries:

- the EU-China clean energy partnership, which aims mainly at building a demonstration coal power plant in China using 'zero-emissions' CO2 capture and storage technology

- the India-EU Initiative on Clean Development and Climate Change, which includes stepping up co-operation under the Kyoto Protocol's Clean Development Mechanism (CDM)
- Kyoto Protocol Clean Development Mechanism (CDM) **-** envisages market-based instruments that facilitate technology transfers to developing nations

Others developed outside the framework of the Kyoto Protocol, such as

- the Asia-Pacific Partnership on Clean Development
- the Carbon Sequestration Leadership Forum
- the International Partnership for the Hydrogen Economy
- the Generation IV International Forum (GIF)
- the International Thermonuclear Experimental Reactor (ITER) developed by the EU China, Japan, Russia, South Korea, and the United States. The EU will take on 40% of the project's total cost (€4.57bn) while the host country, France, will pay 10%. The remaining five partners will invest 10% each. No commercially viable result is expected before the end of the century.

Source: Excerpted by the author from Euractive (2005)

Table 13. US 'International Technology Partnerships'

Carbon Sequestration Leadership Forum: 22 members; focused on CO2 capture & storage.
International Partnership for the Hydrogen Economy: 17 members; organizes, coordinates, and leverages hydrogen RD&D programs.

Generation IV International Forum: 10 members; devoted to R&D on next generation of nuclear systems.

ITER: 7 members; project to develop fusion as a commercial energy source.

Methane to Markets: 20 members; recovery and use of methane from landfills, mines, oil & gas systems, and agriculture.

Asia-Pacific Partnership on Clean Development & Climate: 7 members; focuses on accelerating deployment of technologies to address energy security, air pollution, and climate change.

Global Nuclear Energy Partnership: 19 members; seeks consensus on enabling expanded use of nuclear energy using a nuclear fuel cycle that enhances energy security, while promoting non-proliferation.

Source: US DOE (2007)

Table 14. Tangible and Intangible Technologies in the Biodiesel Industry

Element of Industry	Tangible (Goods)	Intangible (Services)
Feedstock production	Plants, seedlings	Horticulture, biochemistry, agriculture: how to plant, grow and harvest jatropha berries
Processing/refining	Oilseed processing and refining facilities	Mechanical and chemical engineering: how to build and operate facilities
Infrastructure	Transportation and storage	Mechanical and chemical engineering: how to build and operate facilities
End use industries	Motor vehicles Electric power plants Space heating	Various engineering fields, e.g. automotive engineering: how to manufacture vehicle fuel systems

Table 15. International Technology Transfer Projects involving Jatropha

Ghana and Other West African Countries with aid from the Indian Government

The Indian government plans to spend $250 mln on the development of biofuels production in 15 West African countries, Ghana's Vice President Alhaji Aliu Mahama recently said. He added that the fund will be set up by the Bank for Investment and Development (EBID) of the Economic Community of West African States. As a first step, EBID is to provide $35 mln for a jatropha biodiesel project in Ghana, in cooperation with the country's commercial banks and financial institutions. December 4, 2006

Indonesia with FDI from South Korea

[An unspecified] South Korean company in cooperation with Jakarta-based PT Tata Harapan Cemerlang plans to invest $100 mln for 30,000-50,000 ha of jatropha plantings in West Sulawesi and Sumba Island in East Nusatenggara.

Logistic services company GKE International has agreed to buy Van der Horst Biodiesel, which plans to set up two jatropha-based biodiesel plants in the country, for SGD13 mln (1$=SGD1.51435). GKE will pay SGD9 mln in cash while the remainder will be financed by issuing 36.36 mln new shares. Van der Horst plans to set up an 100,000 tonne biodiesel plant on Jurong Island by end-2008, which will be expanded to 200,000 tonnes by 2010. Additionally, the company plans to build a 200,000 tonne plant in Johor by 2011. May 09 2007 May 09 2007

Mozambique with FDI from China

Four Chinese companies plan to plant 30,000 ha of jatropha in Narmpuda in northern Mozambique for biodiesel production, Bonifácio Saulose from the Investment Promotion Center said. However, the plan has still to be approved by Mozambique's Council of Ministers, Mr. Saulose said. April 24, 2007

Philippines with FDI from South Korea

Conglomerate Samsung Corp, has stolen a march on Japanese trading rivals with plans to set up a 200,000 tonne jatropha-fuelled biodiesel plant together with a subsidiary of Philippine National Oil Co. (PNOC). October 9, 2006

Sources: Excerpts from various issues of *FO Licht's World Ethanol & Biofuels Report*, as indicated by dates at the ends of the individual items.

Table 16. Illustrative Indicators of International Technology Transfers in the Jatropha Biodiesel Industry

Jatropha tree seedlings – millions exported/imported per year, per country

Jatropha plantations – hectares developed by biodiesel industry multinational firms

Berry crushing machines – capacity exported/imported

Refineries – number built and operated by international joint ventures

Biodiesel fuel exported/imported

Foreign-trained engineers employed in local projects

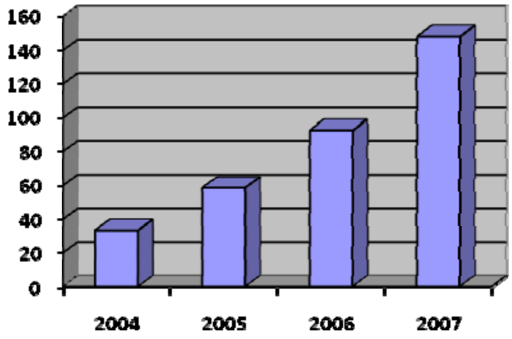
Employees' and/or government officials' participation in international biodiesel industry conferences

International licensing agreements involving local firms

Storage-transport facilities using foreign-made equipment

N.B. This is not intended to be a comprehensive list.

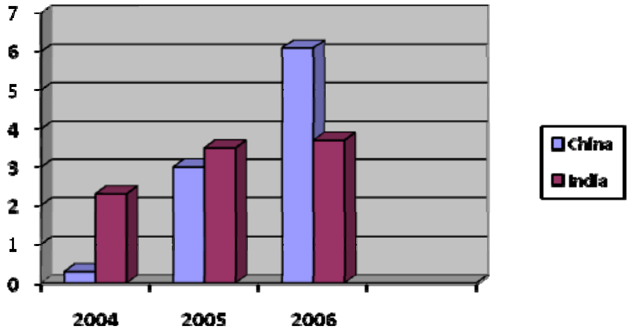
Figure 1. Total World New Investment in Renewable Energy
USD billions*



*Exchange rate movements (and in particular, the weakening dollar) were estimated to account for approximately $3.35 billion of total new investment in 2007, representing 6% of the increase in new investment worldwide between 2006 and 2007, and 2.3% of total new investment in 2007.

Source: Derived by the author from UNEP, SEFI and New Energy Finance (2008: Fig. 1)

Figure 2. Investment in Renewable Energy in China and India (2004-2007)
US Dollars, Billions



Source: compiled by the author from data in UNEP, SEFI and New Energy Finance (2007: Fig. 9)

Box 1. New World Bank Climate Investment Funds

Washington, July 1, 2008 – The World Bank Board of Executive Directors today gave formal approval to the creation of the Climate Investment Funds (CIF), a pair of international investment instruments, designed to provide interim, scaled-up funding to help developing countries in their efforts to mitigate rises in greenhouse gas (GHG) emissions and adapt to climate change.

Two trust funds will be created under the Climate Investment Funds; total investments, based on preliminary indications from donor countries, are targeted to reach US$5 billion.

One of the funds, the Clean Technology Fund, will provide new, large-scale financial resources to invest in projects and programs in developing countries which contribute to the demonstration, deployment, and transfer of low-carbon technologies. The projects or programs must have a significant potential for long-term greenhouse gas savings.

The second fund, the Strategic Climate Fund, will be broader and more flexible in scope and will serve as an overarching fund for various programs to test innovative approaches to climate change. The first such program is aimed at increasing climate resilience in developing countries.

Source: Excerpted from World Bank Press Release No:2009/001/SDN, July 1, 2008

Box 2. APP Flagship Projects (partial list, July 2008)

Buildings and Appliances Task Force

Cooperating to Standardize Energy-Efficient Lighting

Harmonization of Test Procedures for Compact Fluorescent Lamps (CFLs) (BATF-06-01). Many countries have test procedures, standards, and labeling schemes for a wide variety of products. In the majority of cases, these test procedures and resulting performance levels are different, resulting in a worldwide patchwork of testing and performance requirements for manufacturers to meet in order to sell in that market. Harmonized test procedures are fully achievable for many products and would greatly benefit these countries and reduce the burden on manufacturers of complying with the multitude of standards worldwide. This project will focus on the harmonization of test procedures for CFLs (compact fluorescent lamps); it is expected to cost-effectively achieve an average reduction of at least 5% in total residential and commercial energy use in partner countries at the time of peak impact.

Showcasing High-Profile Green Buildings in China

Green Building Flagship in China (Mayors' Training Center, Olympic Village Zero Energy Building, and Center of Excellence in Sustainable Design and Technology at the Agenda 21 Demonstration Energy-Efficiency Office Building) (BATF-06-07) Improvements in building techniques have led to some buildings achieving significantly reduced energy consumption or other clean development climate objectives. Often, these techniques can be incorporated at no additional cost. The sharing of information and the commitment of Partner countries to the introduction of these measures will significantly reduce energy consumption and the associated emissions. In Beijing, several high-performance buildings are being constructed or enhanced, resulting in energy and cost savings, as well as a reduction in greenhouse gas emissions. These include the Mayor's Training Center, which will demonstrate high-performance building technologies to mayors during their semi-annual training meetings; the Olympic Village Zero Energy Building that will house 17,000 athletes during the Olympics; and the Center of Excellence in Sustainable Design and Technology at Agenda 21 Demonstration Energy Efficient Office Building in Beijing, which will sponsor the Center of Excellence in Sustainable Design and Technology on the second floor of the building. These green buildings provide an opportunity to disseminate high-performance building principles throughout China and to other APP countries, and increase trade in materials used to make and service these buildings.

Cement Task Force
Transforming Waste to Fuel for Cement Kilns
Hazardous Wastes – Best Practices for Co-Processing and Management in Cement Kilns (CMT-07-07) This project has four components with a common theme of promoting the safe use of hazardous and other industrial wastes as a reliable alternate, renewable source of energy for clinker production in cement kilns while serving to develop clean and safe destruction technologies for waste management; components include three demonstration projects and a trade expo. Desired outcomes from this Umbrella Project are increased awareness of options for responsible use of alternate fuels; reduced fossil fuel-derived CO2 emissions from cement production and waste incineration; reduced emission intensities for SO2, NOx, particulate matter and other pollutants of interest; and increased trade in clean energy products and service among APP Partners.

Cleaner Fossil Energy Task Force
Accelerating Demonstration of Carbon Capture and Storage Technology for Existing Power Stations
Callide-A Oxy-Fuel Demonstration Project (CFE-06-05) In order to meet future greenhouse constraints, power generators within APP countries will need access to technology that they can retrofit to existing power stations in order to capture and store CO2 emissions. Oxyfuel, a low or zero emissions technology, is one of only two main technologies that can be retrofitted to existing power stations to do this. This project will make a major contribution to reducing the lead times associated with making this technology ready for its commercial deployment within APP countries and globally. As well as directly supporting retrofit options, the Callide A project is contributing to the development oxyfuel technology for new low-emission power stations. The project is well advanced with construction scheduled to commence in 2008 and the unit expected to be operational from mid 2009. The project is being developed by a consortium of eleven Australian and Japanese organizations.

Improving Carbon Capture Technology for Coal-Fired Power Plants
Assessing Post Combustion Capture (PCC) Technology for Emissions From Coal Fired Power Stations (CFE-06-06) The capture of CO2 from power station flue gases and its geological storage is being developed to achieve large scale reductions in greenhouse gas emissions. This project features the use of mobile post combustion capture (PCC) pilot plants that can be moved to different power stations to capture CO2 emissions from flue gases. PCC is applicable to any large stationary combustion device, and is therefore suitable for natural gas turbines, smelters, iron and steelworks and cement kilns. It can be retrofitted to existing power stations, allowing wide application of the technology in APP countries. This project, along with other trials and associated research, will be used to gain a better understanding of the role that PCC technology can play in reducing greenhouse gas emissions from existing coal power stations in China, Australia and other APP countries. Trials will be conducted at existing coal power stations in Australia and China.

Coal Mining Task Force
Capturing and Using Methane as a Clean-Burning Energy Source
Increasing Recovery and Use of Coal Mine Methane (CLM-06-11). This flagship activity contributes to the Coal Mining Task Force's Increasing Recovery and Use of Coal Mine Methane project. It consists of a feasibility study for a coal mine methane recovery and utilization plant in China. The anticipated outcomes of this flagship include environmental, economic, and social benefits, all of which further the goals of both the APP and the Methane to Markets Partnership. China is the world's largest coal producer and the leading emitter of coal mine methane emissions. Capturing and using coal mine methane as a clean-burning energy source can reduce greenhouse gas emissions while bolstering mine productivity and revenues. Increasing recovery and use of coal mine methane can improve mine safety through the use of more effective mine drainage technologies and techniques. The study will involve selection of an appropriate mine, analysis of methane resource data, a market assessment for the produced methane, an evaluation of degasification and methane utilization technologies, a technical analysis with preliminary engineering design work, an estimate of project capital and operating costs, and a full economic and financial analysis with cash flow projections.

Power Generation and Transmission Task Force
Sharing Best Practices in Power Generation
The entire "chain" of power generation best practices peer review workshops and follow-on projects which implement best practices either through operational changes or installations of new hardware and reduce emissions. This project consists of several activities supporting identification and implementation of best practices for power generation, including site visits and related follow-up, workshops, and knowledge capacity building. To promote these activities, power generators are hosting country representatives (mostly plant engineers) at site visits to highlight best practices, as well as areas for improvement that the visiting engineers can utilize at their power plants to improve operating efficiency and environmental performance. Peer review activities are being implemented during the site visits to learn "best-of-kind" operation, maintenance,

and management practices of each Partner countries' same-generation power plants, as well as identification of opportunities for improvement. This activity includes frank discussion by participants, which are consequently being summarized into a set of recommendations; development of a database of reviewed items and a checklist of items that contribute to improved thermal efficiency; sequential peer review visits to power plants in each country; and development of a best practices handbook to collate the outcomes of the peer reviews. The goal is to provide the opportunity for power generators to learn from each other ways to improve generating efficiency and how to control and reduce air pollutants, and implementation of applicable practices, and technologies in their own power plants.

Renewable Energy and Distributed Generation Task Force

Promoting Solar Power Deployment

Building Critical Mass For Ultra High Efficiency Solar Power Strategy (RDG 06-01). An Australian company, Solar Systems, has developed technology to concentrate the sun's energy 500 times and deliver electricity at one-sixth of the cost of conventional solar power. The Australian developed and owned technology concentrates the sun's energy by using mirrors to reflect and focus sunlight into a small area called a solar receiver. Maximum daily sunlight is captured by the additional ability of the mirrors to track the movement of the sun across the sky. The technology's combined use of high efficiency PV (photovoltaic) solar cells, similar to those used to power satellites, with relatively low cost other materials, allows for large-scale affordable electricity. Under this project, Australian Partnership funds will be used to build a 2 megawatt demonstration plant in North West Victoria, and to assist in deployment of the technology throughout the world.

Expanding Use of Innovative Energy Solutions

Feasibility Study and Development of Microgrid Smart Energy Solution (RDG 06-16). This project consists of a feasibility study on integrated systems using different renewable energy and distributed generation technologies in harmony with the existing grid. The study will allow several different distributed generators to be operated as a microgrid that can optimally balance the supply and demand of energy, including electric power and heat, while exchanging information and operating in harmony with the existing utility infrastructure. Initial research will be focused in Japan and Korea and later extended to China. This project will ultimately facilitate the expansion of smart energy solutions in Partner countries.

Steel Task Force

Improving Energy Efficiency in Iron and Steel Plants

Development of Mechanism for Eligible Technology Adaptation based on Expert Diagnoses (STF-06-04 and 06). Partners, especially China and India, welcome ideas that promote energy saving and environmental protection. To facilitate these objectives, experts in these fields will conduct site visits in these and other Partner countries to offer domestic iron and steel plants advice on best practices and clean technologies. Partners will use the performance diagnoses of experts to develop improvement plans to increase energy efficiency and environmental protection opportunities. This project will also identify and explore opportunities for collaborative research and development in the areas of energy efficiency and clean energy technologies. As clean technologies are identified, Partners will develop practical projects to deploy such technologies. Each project will contribute to energy efficiency improvements, greenhouse gas reductions and increased environmental performance in Partners' iron and steel industries.

Source: APP web site, www. app.net, accessed on July 1 2008

Box 3. International Technology Transfer Activties of the Centre for Jatropha Promotion (CJP) in India

CJP ‘provides support/services from “soil to oil” for development and establishment of non-food bio-fuel crops…. [It has] plant science expertise, process engineering and operational expertise to plan, design and create … fuel farms, deploy and commission non-food vegetable oil refining and design and construct biodiesel plants….CJP provides project management and consultancy services, … jatropha curca production technology, support, technical expertise etc. for setting up plantations from ground zero to harvesting stage….’

… CJP has developed Jatropha Agricultural Training package to deliver competencies through qualified trainers with a practical “hands on” approach and has created a successful training division which delivers training to international and national participants by integrating technical and managerial issues….[Its] June 2007 training programme …[was] attended by participants from 18 countries…[Australia, Bangladesh, Costa Rica, Ethiopia, Honduras, India, Indonesia, Kenya, Lao PDR, Malaysia, Nigeria, Portugal, Singapore, Spain, Sri Lanka, Thailand, UK, and USA].’

Source: Excerpted by the author from Centre for Jatropha Promotion (2008)

Box 4. International Technology Transfer Activities of the D1 Oil Corporation of the UK

‘D1 Oils plc is a biofuels technology company. [Its] strategy is to develop new energy crops into sustainable commercial fuels. [It] provides technology and services for the breeding, development, planting and harvesting of new varieties of commercial biofuel crops, focusing on alternative, sustainable feedstocks that are not subject to the same price pressures as food-grade crops. [It has] an established plant seicne and planting programme for *Jatropha curcas*, a robust, tropical oilseed bearing tree. Jatropha produces inedible oil feedstock for biodiesel and is able to make use of land not suitable for arable agriculture.’

In June 2007, D1 established a 50/50 joint venture with BP, called D1-BP Fuel Crops Limited, which has operations in India, southern Africa, and southeast Asia. It has plant science facilities that are co-located with these D1-BP facilities. A goal of D1-BP is to plant a million hectares of jatropha by 2011.

Source: D1 Oils (2008)

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