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Trade in Services Related to Climate Change

AN EXPLORATORY ANALYSIS

Ronald Steenblik, Massimo Geloso Grosso

JEL Classification: F18, L84, L86, N50, Q42, Q56

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Abstract

TRADE IN SERVICES RELATED TO CLIMATE CHANGE: AN EXPLORATORY ANALYSIS

by

Ronald Steenblik and Massimo Geloso Grosso

The deployment of technologies for the mitigation of greenhouse-gases (GHGs) is dependent on a wide range of services, including those that are imported. Business services, telecommunications services, and construction and related engineering services figure prominently. This paper aims to develop a better understanding of the specific roles that these services play in helping to mitigate GHG emissions, and to identify the major suppliers and consumers. It presents examples and mini-case studies that explore how particular services complement the deployment of GHG mitigating technologies. With respect to the four modes of services trade, instances of mode 1 (cross-border trade) trade taking place over the Internet appear to be more commonplace, often complementing movement of personnel. Examples of mode 2 trade (consumption abroad) typically involve training of a client's personnel. Mode 3 trade (commercial presence) is critical for the provision of services that entail construction and operation of production facilities. The temporary movement of natural persons (mode 4) is also common, especially where expert judgement or supervision is required for a short period of time.

***JEL classification*:** F18, L84, L86, N50, Q42, Q56.

Keywords: climate change, business services, environmental services, environmental goods, trade and environment, trade policy.

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Table of contents

Tables

Figure

Boxes

EXECUTIVE SUMMARY

This paper aims to develop a better understanding of the role that trade in services plays in helping to mitigate greenhouse gas (GHG) emissions. Based on a review of literature on companies that provide services to reduce or avoid emissions of GHG in the atmosphere, supplemented in a few cases by interviews with managers, it presents examples and mini-case studies of trade in services used in the deployment of GHG-mitigation technologies and for the mitigation of GHG emissions in general.

The sample of case studies researched for this report suggests that the deployment of GHG-mitigation technologies is dependent on the availability of a wide range of services, including those that are imported. Business services, telecommunications services, and construction and related engineering services figure prominently. In certain countries and regions, financial services also play an important role, particularly for the implementation of climate-policy instruments (e.g. emissions trading schemes), and training is another component of the services that are sometimes provided as part of GHG-mitigation projects.

Expertise and capacity in GHG-mitigation technologies vary across nations. Several countries have little or no domestic capacity to design projects based on low-carbon power sources, such as wind turbines, geothermal energy or concentrated solar power. For example, according to interviews with wind-power project developers conducted for this study, the services needed to develop a wind farm often must be imported because firms with the necessary expertise do not exist in the host country. Even for projects to improve energy efficiency, energy engineers with relevant expertise simply are not sufficiently available in many countries, and therefore such projects are often carried out with imported services.

With respect to the four modes of services trade, instances of mode 1 (cross-border trade) trade taking place over the Internet appear to be coming more commonplace, often complementing movement of personnel. Examples of mode 2 (consumption abroad) trade typically involve training of a client's personnel. Mode 3 (commercial presence) is critical for the provision of services related to climate change. As many of these services entail construction and operation of production facilities, establishing a commercial presence in the foreign country is often a necessity for trade to take place. The temporary movement of natural persons (mode 4) is also very common, especially where expert judgement or supervision is required for a short period of time.

Finally, it is noteworthy that a wide range of products and technologies are connected with the provision of services related to climate change. Across the spectrum of examples and case studies discussed in this paper, respondents indicated that for projects in most developing countries, a great deal of technologically sophisticated equipment (e.g. turbines for power projects and centrifugal blowers for methane capture projects), must be imported, while many construction materials can be procured locally.

Introduction

This study aims at developing a better understanding of the role of services trade in helping to mitigate greenhouse gas (GHG) emissions. Building on previous work on liberalising trade in environmental goods and services in the context of the OECD Joint Working Party on Trade and the Environment (JWPTE), the paper provides an exploratory analysis aimed at enhancing understanding of the characteristics of services related to the reduction of GHG emissions and of international trade in these services.

Work recently released by academics and international institutions has highlighted the potential contribution that trade liberalisation could make to the mitigation of GHG emissions, particularly by facilitating the adoption of energy-efficient and low-carbon technologies. In this context, a successful outcome of ongoing Doha Development Round negotiations in the area of environmental goods and services could complement national efforts aimed at improving access to clean technologies (Stern, 2006; IPCC, 2007; WTO and UNEP, 2009; and OECD JWPTE studies). Improving access to clean technologies and services is also likely to yield co-benefits, including enhanced economic opportunities.

The literature has so far focused on investigating the impact of easing tariffs and non-tariff barriers to international trade in goods relevant to GHG-mitigation (Steenblik, 2005; Steenblik *et al.,* 2006; World Bank, 2007; and ICTSD, 2008). However, analysis of renewable energy sectors highlights the importance of a wide range of services to effectively deploy GHG-mitigating technologies (USITC, 2005). Furthermore, surveys targeted at industries closely related to GHG mitigation suggest that barriers to trade in services have often hampered trade in related technologies as well (Steenblik and Kim, 2009; Steenblik *et al*., 2009).

Against this background, this paper aims to make a contribution to the debate by examining the importance of trade in services in the deployment of GHG-mitigating technologies and for the mitigation of GHG emissions in general. Through a series of examples and mini-case studies based on a review of the literature and interviews with firm representatives, the analysis identifies and describes the following:

- The services used by individuals, corporations and government entities in order to reduce or avoid GHG emissions, grouping (or clustering) them according to the broader service categories to which they belong and the types of mitigating actions with which they are associated;
- The importance of the public sector as a driver of demand for these services, and their market structure, including the role of small and medium-size enterprises (SMEs) in their provision;
- Services related to climate change that are traded internationally and the modes of service provision through which this trade takes place (according to the General Agreement on Trade in Services [GATS]);
- The selected goods connected to these services, noting those that are typically locally procured and those that are imported.

The next section of the report sets out the methodology and definitions broadly used in the study and describes the scope of the review. Sections III and IV then present the examples and case studies with the main elements of the analysis as discussed above, and Section V summarises the emerging findings. The final section concludes with suggestions for further research into services related to climate change.

Method and scope

The study first provides examples of prominent activities related to GHG mitigation, with a detailed description of the characteristics of associated services (and goods). This is followed by a series of mini-case studies on projects in some of these mitigating activities. For some of the examples, interviews were undertaken with managers in firms that provide services to reduce or avoid emissions of GHG in the atmosphere – nine of which are headquartered in Europe, three in the United States, two in Canada, one in Uruguay and one in New Zealand. Additionally, one manager for a Central American electric power utility was interviewed. Just under half of the firms interviewed are SMEs with fewer than 250 employees and less than EUR 50 million in annual turnover. Interviews also helped identify relevant publications to further document selected examples, including project documentation under the Kyoto Protocol Clean Development Mechanism (CDM)[1] and published research reports on demonstration projects. Additional data were collected from company websites. Additional information drew from interviews conducted for previous OECD studies around trade issues and market conditions for geothermal power, concentrating solar power and wind power.

In some cases, the individuals and their employers are not named, a policy that allowed these companies to discuss proprietary and sensitive details of their operations and to comment freely on the policies of foreign governments.[2] Of these firms, one US. firm provided interviews with project managers based in three countries: the United States, Brazil and the United Kingdom.

This study adopts a cluster approach as a framework for identifying and analysing the range of services related to GHG mitigation. The basic rationale for such an approach is that it allows for the recognition of intersectoral linkages in services sectors without requiring a reorganisation of existing classifications. Cluster approaches have been proposed to address specific classification issues and also to group commercially related services, or to foster market opening of an activity which does not constitute a sector but involves the supply of several services. The latter case is particularly suited for this study, since such a cluster could allow for the promotion of the variety of services related to the reduction of GHG emissions.

An example of a cluster approach used in the context of trade discussions is a document submitted to the World Trade Organization (WTO) in December 2007 and co-sponsored by Australia, Canada, the European Communities, Iceland, Japan, Korea, Norway, Kingdom of Saudi Arabia, Singapore, The Separate Customs Territory of Taiwan, Penghu, Kinmen and Matsu, and the United States [JOB(07)/208]. This document proposes a guide for scheduling commitments in energy services, drawing on services classified under ten separate groups. Such a cluster approach could be used as a guide to identifying relevant services sub-sectors for possible liberalisation in the interest of promoting improved quality and more competitive pricing of services needed for GHG mitigation.

1. Under the Kyoto Protocol, CDM allows developed countries (Annex 1 countries) with emission caps to undertake greenhouse gas emission reduction (or removal) projects in developing countries in exchange for emissions credits.

2. An important caveat of any opinions obtained from such interviews is that they reflect only the perceptions of those individuals, and have not been confirmed or refuted by the governments concerned.

Figure 1 presents the indicative cluster approach to services related to climate change used here to illustrate the wide-range of services involved. These services go well beyond those deemed "environmental" and include services that although not uniquely provided to environmental projects, are nonetheless frequently drawn upon in connection with GHG mitigation. As is frequently pointed out in the literature, a project to mitigate emissions of GHG typically involves in the first phases consultancy services, research and development (R&D) services, engineering, architectural or design services. R&D services are particularly important for industries breaking into new areas, and can reduce uncertainty when investments are made. If a facility, such as a wastewater-treatment plant is built, additional services become involved, particularly construction. But a range of other services can also be relevant. Financial services, for example, can be relevant particularly for the application of climate policy instruments (e.g. emissions trading schemes).

Business services are particularly important in the provision of other services related to climate change, such as environmental and energy services (which in the case of services incidental to energy distribution are classified under business services in W/120), because they have environmental or energy end-uses (e.g. environmental engineering and R&D). In addition, services in some of these categories can overlap, e.g. services relating to measurement and verification of performance could, depending on what is to be measured, fall under technical testing and analysis services or some environmental services (e.g. air pollution monitoring and control). Services in connection with "smart grids", which optimise the delivery of electricity using digital technology, thus saving energy, may involve both telecommunications and energy-distribution services.

Figure 1. Indicative cluster of services related to climate change

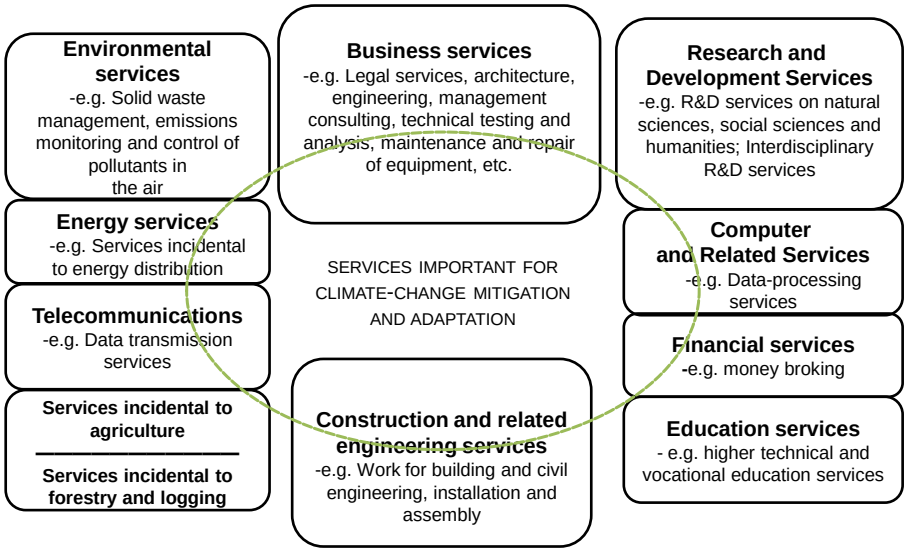

Table 1 provides examples of the different services related to climate change and maps them to their associated environmental actions. According to IPCC (2007), activities to mitigate emissions of GHG into the atmosphere relate to enhancing energy efficiency, increasing reliance on renewable energy, deploying carbon-dioxide capture and storage (CCS), taking forest-related actions, and undertaking specific solutions needed to mitigate emissions of non-CO_2 GHGs.

Table 1. Climate actions and related services

General	— Management consulting services — Technical testing and analysis services — Related scientific and technical consulting services — Geographic information system services — Interdisciplinary research and experimental development services
Industry	— R&D and engineering services for heat and power recovery; material recycling and substitution; and process-specific technologies — Life-cycle analysis and eco-product design with a focus on energy efficiency and low carbon emissions — Energy performance contracting applied to industrial plants (*e.g.* design and modification of systems to generate additional power, heating or cooling from an existing fuel stream, or to convert to combined heat and power) — Maintenance and repair of equipment, — Wholesale trade services, — Services incidental to manufacturing, retailing services
Buildings (energy performing contracting)	— Energy performance contracting applied to commercial buildings — Energy performance contracting applied to residential buildings — Architectural and engineering services for design and construction of "greenbuildings", "passive solar buildings" and "zero-emissions buildings" — Building renovation services (*e.g.* retrofitting of insulation)
Transport (eco-travelling and eco-logisitcs)	— Transport services based on modal shifts from road transport to public transport, on non-motorised transport, or using low carbon vehicles — Distribution and transportation services
Infrastructure	— Telecoms services used in connection with "smart grids" (*e.g.* improved supply and distribution efficiency and fuel switching to low carbon energy sources) — *Energy management services* applied to infrastructure management such as water infrastructure (*e.g.* valves, pumps, treatment plants) — Integrated engineering and project management — Real-time data analysis and monitoring — Turn-key projects
Electric-power Generation	— Services to improve the efficiency of power generation at existing facilities — Services incidental to energy distribution
Renewable energy[1]	— R&D services playing a key role in the current period of development of energy generated from naturally replenished resources — Financing — Design and engineering of production facilities — Construction of facilities and installation of equipment — Operations and maintenance of facilities — Training of personnel
Carbon capture and storage (CCS)	— Design, building and operation of facilities — R&D services playing a key role in the current period of development of CCS solutions
Agriculture	— R&D, studies, consulting and training (*e.g.* focusing on improved crop and grazing land management to increase soil carbon storage) — Services incidental to agriculture — Research and experimental development services on chemistry and biology — Urban planning and landscape architectural services
Forest management	— Services incidental to forestry and logging — R&D, studies, consulting and training on tree species improvement (to increase biomass productivity and carbon sequestration) — improved remote sensing technologies for analysis of vegetation/soil carbon sequestration potential, mapping land-use change

Table 1. Climate actions and related services (***cont***.)

Mitigating of non-CO2 GHG emissions (gas recovery from landfill waste)[2]	— R&D, industrial process engineering, *product life-cycle analysis*, with a focus on non-CO_2 GHG emission reduction — R&D, studies, consulting and training in agriculture (*e.g.* improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertiliser application techniques to reduce N_2O emissions)
All mitigating actions (carbon market services)	— Measurement and evaluation of emissions using dedicated methodologies — Carbon trading services, carbon register management

1. Covers biomass and biofuels; geothermal energy (high temperature and low temperature geothermal energy); hydroelectricity (including small hydroelectricity); solar energy (including solar energy heating and cooling applications and solar powered electrical generation); marine energy (tidal and wave energy); and wind power.

2. Includes emissions of methane and nitrogen oxide.

The range of services relevant to GHG mitigation can be traded through the four modes of supply as defined in the GATS. Box 1 below provides examples of how trade in these services could take place in each mode of delivery.

Box 1. Examples of trade by mode of delivery in services related to climate change

Mode 1 – Cross-border trade

Carbon emissions modelling and logistics route optimisation provided from a consulting office in the host country to clients overseas via the Internet. Remote, cross-border monitoring services to manage wind farm and gas-fired power plant operations.

Mode 2 – Consumption abroad

Engineers travelling overseas to receive training in energy performance contracting; eco-travelling services (*e.g.* hotels and alternative transport services purchased in a foreign country).

Mode 3 – Commercial presence

Operation of eco-logistics services may be provided by a local subsidiary of an international corporation; a company engaged in biogas recovery from landfill waste operates in a foreign country through a local subsidiary.

Mode 4 – Movement of natural persons

Professionals travel overseas to temporarily provide services associated with carbon capture and storage. Repair service teams are deployed to wind farms that require repair.

Source: Examples drawn from the case studies developed in this report.

Examples of prominent services related to GHG mitigation and adaptation

Services associated with renewable-energy-based electricity

Electricity can be generated by harnessing a wide range of energy fluxes that generally fall under the heading of "renewable" – solar light, solar heat, the wind, falling or running river water, ocean tides, ocean thermal gradients, and geothermal heat. Electricity, and often heat at the same time, can also be generated from the combustion of plant-derived solids, liquids or gases, and other organic matter (e.g. dung, sewage sludge). Public policies over the last several decades have tried to stimulate the expansion of renewable-energy-based electric power sources, both to increase the share of energy

produced domestically, and to reduce pollution and the emissions of greenhouse gases, through the avoidance of electricity produced from combusting fossil fuels.

Services associated with the production of electricity from renewable energy include:

- Site selection and pre-construction surveys.
- Design and engineering of the energy-producing facility.
- Construction of the facility.
- Upgrading, operation or maintenance of the facility over the contract period (e.g. 10 to 15 years).
- Sales of carbon credits on certified emission reduction (CER) markets.

A typical utility-scale, renewable-energy-based electricity generating facility comprises the generating unit itself (an array of photovoltaic modules, one or more wind turbines, a geothermal steam turbine and generator, etc.) plus associated electrical transformers and switchgear.

Consumers of services associated with renewable-energy-based electricity include private landowners (especially in the case of wind turbines), industrial producers of electricity, private and public electric utilities, and local governments of settlements not currently connected to an electricity grid.

Suppliers of internationally traded services run the full gamut, from small and medium-sized suppliers of equipment to large electric companies and multinational service suppliers of all sizes. Many of the suppliers specialise in the particular technologies, such as wind or geothermal energy. The larger companies typically operate through local subsidiaries so the predominant mode of supply is mode 3, with accompanying mode 4 (professionals temporarily working abroad). Mode 1 supply is also possible (e.g. monitoring services provided cross-border to foreign clients), and mode 2 is relevant for training associated with operation of the facilities (e.g. engineers travelling abroad to receive training).

The share of the equipment and products used in renewable-energy-based electricity generating facilities varies considerably by technology. Much of the materials used in hydroelectric plants can often be purchased locally. By contrast, solar-photovoltaic cells and much of the equipment used in wind turbines are typically imported, especially in projects carried out in least-developed countries. Instrumentation and software are also often imported.

Example: GE Measurement & Control Solutions

The General Electric Company (GE), with a global installed base of 14 500 wind turbines, offers a wide range of flexible service solutions tailored to the maintenance and operation needs of each wind power plant, ranging from technical advisory services to on-site operations support. Among these are remote wind-turbine monitoring services, delivered primarily through mode 1. Remote monitoring services have shown that they can boost the overall reliability and capacity factor of wind farms, through increasing equipment availability and reducing downtime. Operating and maintenance costs of wind turbines are also thereby reduced. These benefits translate into greater output of the wind farm – thus reducing the need to generate electricity from fossil-fuel-fired plants – and higher return on investment for the wind-farm owner. Every kilowatt-hour of additional

wind power that can be generated by a wind turbine thus translates into reduced GHG emissions.

GE's monitoring approach typically involves connecting a supervisory control and data acquisition (SCADA) system to a turbine-generator's control system. This SCADA system, in turn, is linked to a customer support centre, which constantly tracks specific operating parameters, relaying the information to specialists. Automated algorithms detect abnormal conditions at the wind turbines. If an abnormal condition is detected, GE specialists are automatically notified and provided with information on the event. Once the event information is analysed, GE may recommend a course of action or refer the event to engineers for more in-depth analysis.

GE monitors and diagnoses some 6 000 wind turbines 24 hours a day, seven days a week at its Remote Operations Centers located in Schenectady, New York (for wind turbines installed in Canada, Central America, South America, and the United States) and Salzbergen, Germany (for Europe and Asia).

In 2009, GE entered into an agreement with a company that owns a wind farm in Nova Scotia to service its 34 GE 1.5-MW wind turbines. During its first winter, the wind farm was struck by a severe ice storm. When GE personnel monitoring the facility from Schenectady, New York noticed sharp output reductions as a result of ice accumulating on the wind turbines, it contacted the wind-farm owner. Within 72 hours, GE implemented a solution that involved upgrading their turbine software remotely with a GE "Winter Ice Operations Mode" package. This software package changed the wind turbines' operating algorithms to better account for ice accumulation, increasing annual energy production by approximately 0.5%-2%. The remote upgrade also lowered the customer's annual maintenance costs and downtime, leading to even greater production of renewable energy and reduced GHG emissions. Every kilowatt-hour of additional wind power that can be generated by a wind turbine thus translates into reduced GHG emissions.

Example: National electric company for a Central American country

This organisation (or its antecedents) has contracted with foreign design, engineering and construction firms for hydroelectric power development for more than 50 years, and it is still highly dependent on imported services because national firms lack the capacity to design, engineer and build large hydropower facilities.

According to the respondent, the company seeks bids for new hydropower projects, rehabilitation of existing projects and other large-scale projects through internationally publicised tenders, as required by national law and the policies of its lenders. It usually issues a first tender for a feasibility study, including site evaluation, basic design and engineering; it then issues a second tender for engineering, procurement and construction (EPC).

For the EPC phase, the company has traditionally divided the project into multiple tenders, as advised by its major lender, the World Bank. The project segments include civil works, provision and installation of transformers, generators, control systems, etc., and an engineering consultant to oversee the process. For its most recent project, the company issued and received bids for turnkey EPC services. In all cases, the service providers have been foreign firms.

Ninety to 95% of the goods for hydropower projects have been acquired from foreign companies because of a lack of domestic manufacturers. Materials such as concrete and stone and some commodity items like attachment hardware are procured domestically.

Services for hydropower projects have been delivered in all four GATS modes, with modes 1, 3 and 4 being the predominant modes.

Typically, engineers will visit the country for a month or two of evaluation and study, then return to their home office to prepare design and engineering documents. During this latter period, there may be service delivery in the form of communication between the consultants and clients via phone, email, fax and videoconference. Later, the foreign company personnel will return to the country to complete the EPC work.

Several foreign consultants have established a commercial presence in the country, generally offices with one resident engineer and a small staff. Foreign contractors will typically open a local office if they plan to have personnel in the country for six months or more.

While commercial presence is not required in bidding, a local office can put the company in a better position for customer service and business development. It also can give the foreign company more access to legal and other services that may be necessary, including those that may be required to secure the return of a portion of taxes that have been withheld from its fees.

For carbon-market consulting services, the company issued an international bid tender, then contracted with a consultant from another Central American country to prepare its application to the Clean Development Mechanism Executive Board. For this service, a domestic consultant was also considered, but given the importance of securing CDM designation to the financing of the project, the company chose a more experienced foreign consultant. Foreign engineers from other Latin American countries are contracted frequently for maintenance and repair services. These firms do not have commercial presence in the country.

The company has policies to encourage local procurement of services, and in order to encourage the growth of the capacity of local service providers, it has encouraged them to seek partnerships with competent foreign service providers. In addition to a desire to promote national economic development, the availability of local service providers would reduce project costs because foreign consultants are significantly more expensive than domestic ones.

Example: Canadian consulting engineering firm

This firm provides services internationally for wind power, landfill-gas-to-energy, geothermal and hydropower projects, including site selection, resource evaluation, environmental assessments and permitting. It also conducts greenhouse-gas inventories for firms and advises them in developing mitigation strategies. Additionally, the firm has an energy efficiency division with expertise in many industrial processes. While it does not perform EPC contracts, it identifies the types of equipment required for GHG-mitigation projects.

The firm provides very little service delivery via mode 1, as its initial evaluation work must be done with a physical presence at the client's site. Occasionally it performs a short-term desktop study in its home country for delivery to a foreign client, but these instances are rare.

The respondent estimated that 70% of the firm's international work in GHG-mitigation technologies is done through mode 4 travel of company employees to destination markets. For larger projects, the firm will establish a commercial presence, in addition to a large number of offices it already has around the world. Through this network, a client in northwest Africa can for example be served conveniently by personnel from its South Africa office.

Mode 2 service delivery is also very rare or non-existent, and the interviewee could not recall any instance in which his firm had used that mode for services related to GHG-mitigation projects.

Example: Spanish consulting engineering firm

After developing a track record of solar-photovoltaic (PV) energy projects in Spain, this engineering firm began marketing its EPC services to clients in France, Bulgaria and the Czech Republic. It builds PV arrays of between 250 kW and 4 MW for investment groups seeking to benefit from favourable renewable energy feed-in tariffs.

The firm designs the projects, buys all structural equipment, modules, invertors, cables and other goods, and installs the system. It procures all equipment from Spanish and Swedish manufacturers because of the high quality of the equipment from providers in those countries and because of long-term commercial relationships.

The firm delivers services through modes 3 and 4, and it has established a commercial presence in France justified by the maturity of its project pipeline and its long-term prospects in that country. Such commercial presence in a fellow European Union member nation presented no difficulties. Like other trans-European companies working in renewable energy, this firm says its growth would be facilitated by harmonisation of national renewable energy laws across Europe.

Example: Non-governmental affiliate of a US renewable-energy finance firm

A US firm that develops and markets renewable-energy credits has established a non-governmental organisation (NGO) affiliate to assist rural residents of Uganda, Tanzania, Rwanda, Ethiopia, the Democratic Republic of Congo, Sudan and Kenya deploy PV systems for local electricity supply in regions without grid electricity service. The firm and its affiliate have installed 180 kW of PV power capacity in 2 500 installations ranging from systems of 10 W to 1300 W. All systems are off-grid with batteries for electricity storage.

The firm uses a combination of its own staff and local staff and contractors to design and build the arrays. As it expands its operations in a particular country, it seeks to encourage the development of local PV installer capacity by establishing commercial relationships with a network of providers.

Batteries, wiring and switchgear are often procured locally, while PV modules are imported from the United States. The firm reports that there has been an increase in the capacity of goods suppliers in Tanzania and Kenya, its most mature markets.

A great deal of services are delivered through mode 1, with the firm's principals providing specifications and engineering documents from PV manufacturers to its local contractors and partner NGOs via email or other means of communication. It has conducted no mode 2 or mode 3 delivery due to lack of funding, although its mature

contractor relationships verge on commercial presence by providing in-country representation for the firm.

Aside from travel by the firm's principals, the NGO organises volunteers to travel to the destination markets, participate in trainings also attended by local contractors, and assist in building PV arrays.

Example: New Zealand consulting engineering firm

While this firm does not perform EPC contracting, its personnel manage all phases of renewable-energy project development from conceptual studies through project design and environmental permitting to overseeing construction as the owner's engineer or lender's engineer. It is active primarily in developing countries in Asia and Latin America with wind power, hydropower and geothermal power.

The goods sourced for its projects include a mix of locally procured items and imported ones. Specialised generation equipment almost always is imported, while goods associated with civil works can be procured locally.

The company has established commercial presence (mode 3) in many of its destination markets. It frequently directs its staff to travel between countries for training and, occasionally, it conducts mode 2 trade with a client that requests the firm train some of its staff in one of the firm's offices outside the client's country.

Mode 4 service delivery is the most common mode. The firm prefers to minimise the risk of losses inherent in establishing a commercial presence in a foreign market, so it takes a conservative approach, waiting until its pipeline of work and its prospects are very strong before opening an office in a foreign country.

The decision is also driven by the tax laws in the foreign market and whether those laws are favourable for inter-country travel of employees.

Services associated with fossil-fuelled electricity production

Despite the recent rapid growth in renewable-energy-based electric-power plants, some 41% of the world's electric-power is generated by the combustion of coal or lignite. Except under the most optimistic scenarios, this share is expected to decline only gradually over the next 25 years (IEA, 2010). Moreover, while the thermal efficiency of new coal-fired power plants continues to improve, through the use of super-critical and ultra-super-critical steam cycles, the thermal efficiency of all coal-fired power plants tends to decline gradually over time. Nonetheless, it is possible to recover a power plant's original thermal efficiency and maintain it with improvements in operations and maintenance. For example, it has been estimated that by improving or avoiding the degradation of thermal efficiency of coal-fired power plants around the world by at least one percentage point, some several hundred million tonnes of CO_2 emissions could be avoided each year.

Services associated with the improvement or maintenance of thermal efficiency at coal-fired power plants include:

- Design and engineering services;
- Analytical services;
- Maintenance services;
- Sales of carbon credits on CER markets.

Consumers of services related to improving or maintaining the thermal efficiency of coal-fired power plants include operators of coal-fired cogeneration plants, private and public electric utilities. Service suppliers run the full gamut, from small and medium-sized engineering firms to major energy-service firms. Many of the equipment suppliers specialise in particular technologies, such as heat exchangers or steam generators. The larger companies typically operate through local subsidiaries so the predominant mode of supply is mode 3, with accompanying mode 4 (professionals temporarily working abroad). Mode 1 supply is also possible (*e.g.* monitoring services provided cross-border to foreign clients), and mode 2 is relevant for training associated with operation of the facilities (e.g. engineers travelling abroad to receive training).

Example: The Asia-Pacific Partnership on Clean Development and Climate

For several years now, the Asia-Pacific Partnership on Clean Development and Climate (APP) (Box 2) has been conducting peer reviews under the auspices of its Power Generation & Transmission Task Force. These peer reviews involve site visits to coal-fired power plants by power-plant engineers. Through the peer-review process, the participants receive information on the operational circumstance of the coal-fired power plant to be visited, and the problems it is encountering. Each site visit includes follow-up reports to document the demonstrated practices and technology. The site visits, workshops and capacity building assist Partner countries' power generators in improving their overall coal-fired power plant thermal efficiency, resulting in significant mitigation of greenhouse gases and air pollutants.

Box 2. The Asia-Pacific Partnership on Clean Development and Climate

The APP is an international partnership formed in July 2005 to address problems stemming from the increase in energy demand, environmental pollution, energy security, climatic variation and the like in the Asia Pacific region. By 2007, seven countries were participating in the APP: Australia, Canada, China, India, Japan, Korea and the United States. These seven countries accounted for approximately 55% of global CO_2 emissions. By comparison, the Kyoto Protocol obliges only a subset of countries – those that collectively account for just 28% of global CO_2 emissions – to reduce their global CO_2 emissions.

The APP aims to promote improvements in energy efficiency and to develop, diffuse and transfer technology world-wide through co-operation between the public and private sectors. The APP's activities are undertaken by eight task forces: 1) Power Generation and Transmission, 2) Cleaner Fossil Energy, 3) Renewable Energy and Distributed Energy, 4) Aluminium, 5) Steel, 6) Cement, 7) Building and Appliances, and 8) Coal Mining. Some of these activities include the movement of natural persons as their key elements, providing a good illustration for potential mode 4 services trades.

The APP is a unique forum for co-operation between governments and the private sector, and encourages public-private partnerships. Currently, some of the activities of the APP are provided *pro bono*. Follow-on activities stimulated by the APP peer reviews could in the future develop these into ones involving compensation.

The first peer review, which took place in Japan in April 2007, involved approximately 50 individuals, including private-sector power-plant engineers from six different countries. The second peer review, conducted in February 2008, examined two coal-fired power plants in India. During this review, it was proposed that recommendations for improving the operation and efficiency of the power plants be based on "The Green Handbook for Peer Review" and the "Checklist and review sheet for efficiency", which was designed by the Federation of Electric Power Companies of Japan; the Handbook and Checklist then became the official tools for undertaking peer

reviews, especially receiving high praise from the Chinese and Indian electric-power authorities. They continue to be used to diagnose opportunities for efficiency improvements at power plants elsewhere.

Subsequent evaluations that were carried out in the United States (April and May 2008), Australia (June 2008), Korea (July 2009), confirmed the significant potential to reduce CO_2 emissions from coal-fired power plants through improvements in their thermal efficiency. The peer review process has since developed into a regional concept based on "model efficiency-upgrade plants" and "centres of excellence" to illustrate how the upgrades should be identified and transfer lessons learned on an even broader basis. It has been estimated that by continuing to conduct such peer reviews, and thereby improving or avoiding the degradation of thermal efficiency by at least one percentage point, some 120 million tonnes of CO_2 emissions from APP partner-country coal-fired power plants could be avoided each year.

Services associated with steel production

The steel industry is a big consumer of energy and the leading industrial source of CO_2 emissions, generating over 2.0 billion tonnes of CO_2 in 2006 – an increase of 600 million tonnes from the 1990 level. About half of the steel industry's CO_2 emissions is emitted in China, whose production represents only one-third of the world's total output. Global CO_2 emissions per tonne of steel produced have fallen only slightly since 1990, when 1.8 tonnes of CO_2 were emitted for every tonne of steel produced, compared with 1.7 tonnes in 2006 (World Steel Association, 2008).

A number of technologies have been invented that can improve energy efficiency and hence CO_2 emissions per tonne of steel produced, and put into practice by steel companies in many countries. Some of the key inventions include coke-dry quenching (CDQ) technology, continuous casting of crude steel, and recovery and effective use of coke oven, blast furnace and basic oxygen furnace gases. Typically, installation of these technologies has also been combined with improvements of plant configurations and operational improvements through, for example, upgrading the training of plant engineers and workers, leading to additional improvements in energy efficiency at plants. On average, about 0.3 tonnes of CO_2 emissions per tonne of steel produced could be mitigated if best available technologies were applied in steel making, according to the IEA (2008b).

Services associated with the improvement or maintenance of steel plants include:

- Design and engineering services;
- Analytical services;
- Maintenance services;
- Sales of carbon credits on CER markets.

Consumers of services related to improving the energy-efficiency of iron and steel making include mainly steel companies. The service suppliers range from specialist engineering firms to other steel-making companies.

Example: The steel sector's "Voluntary Sectoral Approach"[3]

The Voluntary Sectoral Approach (henceforth, VSA) in the steel sector is a transnational co-operation of steel companies that aims to diffuse cleaner and more energy-efficient steel-making technologies through the voluntary actions of companies. These actions involve the development of guidelines, and the sharing of technical information, especially methods to improve the environmental performance and energy efficiency of steel plants. Examples include the bilateral partnership between Japan and China, the seven-country partnership under the APP,[4] and the 55-country partnership under the World Steel Association (worldsteel) (Table 2).

Table 2. Results of the APP Power Generation and Transmission Task Force peer reviews

Review	Host country	Power plants	Date	Number of participants	Results
1	Japan	Takasago, Hitachinaka	April 2007	50	Shared the significance and the effects of the peer review; exchanged opinions and shared experiences among participants regarding operational management and equipment in these coal-fired power plants.
2	India	Kota, Dadri	February 2008	80	Japan proposed ideas for improvements in the power-plants' operation and recommended new equipment.
3	United States	Edgewater, Columbia	April-May 2008	80	Confirmed that each plant is capable of improving its thermal efficiency by 1.0-1.5%, and reducing its annual CO_2 emissions by about 90,000 tonnes per unit.
4	Australia	Loy Yang	June 2008	50	Confirmed that the power plant is capable of improving its thermal efficiency by 0.5% and reducing its annual CO_2 emissions by about 24 000 tonnes.
5	South Korea	Yong-Hung	July 2009	100	Confirmed that the plant is capable of improving its thermal efficiency by 0.6% and reducing its annual CO_2 emissions by about 58 000 tonnes per unit.

The VSA encourages the exchange of information and opinions, both between steel-making companies and in international workshops. This exchange of information has led to the development of a comprehensive State-Of-the-Art Clean Technology (SOACT) Handbook for the steel sector.[5] The handbook fills an important gap in the literature by

3. This case study is based on a contribution by Mr Teruo Okazakai, General Manager, Global Environment Affairs Department, Nippon Steel Corporation and Co-operative Research Fellow, the University of Tokyo.

4. The seven member countries are Australia, Canada, China, India, Japan, South Korea and the United States. These countries accounted for 55% of global CO_2 emissions in 2007. The steel industry is one of the APP's task forces.

5. www.asiapacificpartnership.org/pdf/Projects/Steel/SOACT-1-7-08.pdf.

furnishing information on energy-saving technologies and practices in the iron and steel industry in different parts of the world. Of course, any decision to upgrade an existing installation, or invest in new equipment, requires a careful assessment by the company of the expected costs and benefits of using alternative technologies. Participants in the VSAs can seek advice from experienced steel-industry executives that have had to take similar investment decisions themselves. Often, an advisor will visit the steel plant in question, in order to perform a diagnoses of the energy consumption and environmental-protection opportunities at the facility, recommend appropriate improvement strategies, and answer questions from local engineers. This performance diagnosis helps local engineers gain confidence in their final decision, and is highly appreciated by government officials and steel industries in developing countries.

The VSA in the steel sector has successfully contributed to the diffusion of several energy-efficient technologies, including coke dry quenching (CDQ). The number of installed CDQ units operating in China has grown to more than 130 (a saturation of around 50%), thanks in no small part to the bilateral partnership between Japan and China (Table 3). The rapid diffusion of CDQ in the 2000s was also aided by feasibility studies supported by Japan's New Energy and Industrial Technology Development Organization (NEDO), and the emphasis put on CDQ in China's 10^{th} (2001-05) and 11^{th} (2006-10) Five-Year Plans. Continuing efforts under VSAs to diffuse knowledge on energy-efficient technologies is expected to further reduce CO_2 emissions.

Table 3. The estimated numbers of CDQ installations in China and Japan (as of January 2009)

Decade	Japan	China (by country supplying the equipment)				
		Japan	Russia	JV[1]	China	Total
1970	6	0	0	0	0	0
1980	19	4	0	0	0	4
1990	13	10	2	0	0	12
2000 est.	4	6	0	21	90	117
Total	**42**	**20**	**2**	**21**	**90**	**133**

1. Joint venture of a Japanese and Chinese company.

Source: Government of Japan.

Technologies covered by patents account for a low share of the total investment in a modern steel plant. For this reason, intellectual property rights are not generally major barriers to investment in energy-efficient steel-making technologies. Moreover, training in how to operate the equipment is often included in the equipment-installation contract. Purchasers value this kind of information, and are willing to pay a fee for it. Of course, there is always a risk that such "know-how" will leak out to non-contracted persons. Thus, in order to ensure that technology transfer occurs in an orderly manner, buyers are usually required to sign documents promising that they will not divulge privileged

information to third parties.[6] Through these activities, more cases of technology transfer in the steel industry are taking place.[7]

Nowadays, the APP's VSA for steel involves all the APP's members. The APP's Steel Task Force is currently working on three major projects: sharing energy-efficient technologies; identifying concrete quantitative indicators related to energy efficiency and environmental improvement (normally expressed in basic units of energy or a saturation level); and diffusing technology. The Steel Task Force has also led expert diagnostic projects in China and India to identify cleaner energy technologies that would save energy, reduce energy intensity, and lower emissions of NO_X, SO_X, and CO_2. In addition, the International Organization for Standardization (ISO) has already started to standardise a method for measuring CO_2 emissions and establishing the boundary conditions of the analysis. Once the ISO method is established and a database has been completed, VSAs are expected to spread more widely, not just among the APP member countries.

Although the services are at present being provided without compensation, similar services could be traded in the future. Despite the free provision of these services so far, however, the VSA activity has already encountered several impediments, particularly ones relating to the movements of natural persons, such as onerous visa requirements, which often impose burdensome administrative processes and cause long delays for experts trying to enter a country. Other impediments include the need to establish mutual trust among participants before submitting an assessment or advice; the need to hire interpreters and guides; problems with miscommunication; and differences in natural and institutional circumstances.

Finding leaks in natural-gas pipelines

Generic description of the service

Most of the natural gas – a fossil fuel – produced in the world is transported in large steel pipelines before it reaches the point of final consumption. Corrosion and cracking are common problems for the operators of these pipelines. Not only can these defects threaten the operational integrity of pipelines, increasing the chance of a dangerous pipeline failure, but they also lead to fugitive emissions of methane – a greenhouse gas 56 times more potent than carbon dioxide.[8] Some estimates place the global leakage of methane at some 3.2% of global natural-gas production, or some 85 billion cubic metres a year – the global warming potential of the annual CO_2 emissions from over half the coal-fired power plants in the United States (Revkin and Krauss, 2009). Of these emissions, at least one-third emanate from leaks from pipelines and storage facilities (Harrison *et al.*, 1997). Controlling fugitive methane leaks is clearly a priority activity for addressing

6. The term *technology transfer*, as used here, is incorporated by the Japanese steel industry into its business model, but does not imply the transfer of information free of charge.

7. For example, the installation of desulphurisation equipment to clean up waste gas from the sintering process has been expanding in China as a result of consultations among Chinese and Japanese engineers.

8. Averaged over 20 years, according to the UNFCCC (http://unfccc.int/ghg_data/items/3825.php). Because methane in the atmosphere oxidises over time (on average within eight to nine years) into carbon dioxide (CO2) and water (H2O), its global warming potential falls when averaged over longer periods. For example, it is 21 times that of CO2 when averaged over a period of 100 years.

greenhouse gases, particularly as existing pipelines age and global production of natural gas continues to increase.

In-line inspection and monitoring services have emerged to help pipeline operators detect corrosion and cracks before they develop into an environmental and safety hazard. These use specialised in-line self-powered inspection devices (known variously as "intelligent pigs" or "smart pigs") that travel down the pipeline gathering data. These data are then analysed by engineers and technicians to determine and report on the condition of the line. Information provided by the pigs can also include co-ordinates for precise mapping. Early detection of cracks and corrosion thus allows timely intervention to repair the pipeline, minimising disruption of service, increasing the asset value of the pipeline, and avoiding (in extreme circumstances) the cost and disruption of line replacement. And, also important, it reduces fugitive leaks of methane.

The main clients of in-line inspection and monitoring services are the operators of natural-gas pipelines, which number in the hundreds world-wide. Many of these are state-owned enterprises. Globally there are several million kilometres of pipelines of a diameter of 10 cm or greater – the minimum size that can fit an in-line inspection device.

Service suppliers are dominated by companies domiciled in North America and Europe, but also include several in China and Russia.[9] A few, such as Baker Hughes Pipeline Management Group, Halliburton's Pipeline & Process Services (PPS) department, and PII Pipeline Solutions are subsidiaries or joint ventures of large, multinational engineering-services companies. A number of others, however, are companies specialising in pipeline-related services.

Most international trade takes place through mode 4 (e.g. staff from the parent firm temporarily working overseas). Technicians typically spend one to five days in the field when conducting an inspection. A few of the larger companies have also established subsidiaries abroad (mode 3).

Example: PII Pipeline Solutions

PII Pipeline Solutions is a joint venture formed between GE Oil & Gas (a division of the General Electric company) and Al Shaheen Energy Services (a subsidiary of Qatar Petroleum), that brings together specialised skills, advanced technologies and field experience to help pipeline operators assess the present and future condition of their pipelines.

Of the several inspection services provided by PII Pipeline Solutions to pipeline owners and operators, one involves using intelligent pigs to assess the condition of steel pipelines. As the pig travels through a pipeline and mechanically checks for corrosion and cracks using ultrasonic and magnetic technology (Box 3), it sends data to GE personnel on areas in the pipeline that are either already leaking or close to failure. GE technicians, along with the pigging technology, are deployed wherever the gas pipelines are located, in over 100 countries.

Beyond defect detection, PII Pipeline Solutions also offer proactive risk assessment and threat management through off-site monitoring, delivered through mode 1. Once the monitoring device is installed in the natural-gas pipeline system, the condition of the

9. See, for example, the directory of members of the Pigging Products & Services Association (www.ppsa-online.com/directory-of-members.php).

pipeline is monitored continuously from one of two locations: Houston, Texas or Florence, Italy. Pipelines outside the United States that are monitored by GE are currently located in Belgium and France, and the service is expanding to new regions.

PII Pipeline Solutions were recently contracted by a customer operating in a foreign country. GE technicians ran a state-of-the-art pig through the underground pipeline, where it detected multiple, thin stress cracks. Given the relatively small size of the defect, these cracks would likely have been undetectable by other measures. On GE's advice, the customer unearthed the pipeline and repaired the defective sections. Not only did GE's services reduce emissions as the result of an undetected gas leak; they also prevented a potentially catastrophic event from occurring at a nearby farmhouse as a result of gas release and build-up.

Box 3. Detection methods used in in-line inspection of pipelines

The main methods used for in-line inspection of natural-gas pipelines are magnetic flux leakage (MFL) and ultrasonics. MFL is an inferred method that works by inducing a strong magnetic flux into the pipeline wall. Internal loss of material in the line — e.g. through corrosion or erosion — will cause flux leakage detectable by sensors. The flux patterns are then compared with catalogues of defects, which are built up to distinguish one defect from another.

Ultrasonic inspection is a direct method for measuring the thickness of a pipe wall that uses a transducer to emit a pulse of ultrasonic sound. Since this sound travels at a known speed, the time taken for the echo to return to the sensor correlates with the thickness of the pipe wall.

Source: Pigging Products & Services Association, "Frequently asked questions", www.ppsa-online.com/frequently-asked-questions.php.

Biogas production

Biogas is a mixture of gases produced through the microbial digestion of organic substances in the absence of oxygen. Typically it consists of 50-70% methane and 30-50% carbon dioxide, with trace amounts of nitrogen, ammonia and hydrogen sulphide. Numerous agricultural substances are suitable to produce biogas, particularly crop residues with low amounts of lignin (woody structured materials), and solid and liquid manure. In recent years, biogas has been promoted as a way to deal simultaneously with the waste-disposal problems of large dairy farms, while producing a clean, combustible gas and a high-quality agricultural fertiliser.

A typical biogas installation feeds manure mixed with straw and other residues into a digester – a covered tank with some kind of mixing device to keep the slurry in suspension. Some systems include a second, post-digester tank. The odourless residue ("digestate") left over from the digestion process is then usually stored in a separate tank, for distribution as a fertiliser. The biogas itself is extracted from the top of these tanks and may be then used in a boiler, in a small (up to 500 kWe) combined heat and power plant (CHP), or compressed for a vehicle fuel. Turning biogas into electricity and heat directly at a biogas plant may not always be optimal, however, because of insufficient demand for heat in the vicinity of the plant. For this reason, some facilities upgrade the gas to be compatible with the natural gas network, often using an amine solution to scrub out the excess carbon dioxide.

Clients of services related to biogas production are typically livestock (especially dairy) farmers, food-processing companies, and owners and operators of sewage-treatment plants, which include both public authorities and private companies. The number of biogas projects from waste dumps is rapidly increasing worldwide; in the German Land of Bavaria there were already over 1 300 biogas systems in place as of April 2007. A number of biogas projects have been built in recent years in countries involved in Appendix 2 of the Kyoto Protocol (i.e. developing countries). Such projects often qualify under the CDM. Efforts by a number of governments to improve the separation of organic household waste from waste streams, for the purpose of composting or biogas production, are likely to increase the demand for biogas-related goods and services in the coming years.

Service suppliers from Europe and North America are leaders in the international market. These include independent SMEs and subsidiaries of large waste-management corporations. Many suppliers of equipment provide integrated design, installation services and, in some cases, help with procurement of planning permission. Some independent SMEs or subsidiaries of large groups also provide biogas upgrading technology, as well as connected engineering and installation services.

Most trade takes place through mode 3 (*e.g.* via a subsidiary established abroad) and mode 4 (*e.g.* staff of the subsidiary includes executives from the parent firm temporarily working overseas). Some mode 1 trade is involved in cases where monitoring of operations is conducted across borders, such as via the Internet, and where laboratory tests are conducted of the biogas substrate.

Example: MT-Energie[10]

MT-Energie is a full-service biogas company with 350 employees that was formed in Germany a little more than a decade ago. In 2006, the company sold its first biogas facilities outside of Germany, and in 2007, it established its first foreign offices. As of 2010, it had subsidiaries in nine countries, including the United States.

MT-Energie both furnishes the technologies used to produce the biogas, which it has designed to be able to be shipped in containers, and offers a wide range of services (Table 4). Because each biogas must be optimised to the specific biological and chemical properties of the feedstock to be used, MT-Energie employs experts at the planning phase who produce a feasibility analysis of the profitability and liquidity of a biogas project. This phase also normally involves on-site inspection. Architects, technical draughtsmen and civil engineers compile the documents needed to secure local planning permissions. The company can also provide clients with advice and support on securing financing.

Clients can chose among different levels of service during the plant's construction phase, from construction only to provision of a turn-key system including all occurring ancillary work. MT-Energie also offers intensive support during initial commissioning phases. For customers whose biogas systems are approaching completion, the company also offers operator training courses, which consist of both theory and practice.

After-sales services are of two types: biological process support and maintenance and service. The basic prerequisite for optimum operation of a biogas system is a stable

10. The material here is a synopsis of information provided on the company's website, http://en.mt-energie.com/.

digestion process. Technicians in MT-Energie's laboratory can detect the possible problems at an early stage in the process, and suggest specific intervention. In addition, on-going biological process support makes a contribution to clear improvements in gas yield and thus also in the profitability the client's biogas system. After a plant has been successfully commissioned, the company typically maintains close contact with the operators. It employs service who are available around the clock via a telephone hotline and who can also personally visit the site. Some plants are now being equipped with systems that allow remote (*i.e.* cross-border) monitoring of operations by MT-Energie staff.

Table 4. Biogas-related services provided by MT-Energie

Project development **Project planning**	**Profitability analysis** • Biological input analysis • Plant rating (tank size, input system, plant output) • Financial aspects • Profitability analysis (liquidity/profitability) **Technical analysis** • Site planning with a view to possible expansion • Support with permit planning • Support with planning gas and electricity feed aspects
Project implementation	**Construction phase** • Construction and installation **Initial commissioning** • Technical and biological commissioning of the plant • Operator training
MT-After-sales-Service	**Biological process support** • Digestion sample analysis • Feed recommendations • Monitoring process stability • Advise when introducing new input substances **Technical service** • Provision of maintenance work • Remote monitoring • 24h hotline • Evaluation **Operations management (optional)**

Source: http://en.mt-energie.com/turn-key-systems/turn-key-systems.htm.

Landfill-gas recovery and treatment

Municipal solid waste deposited in landfills produces various gases,[11] mostly methane (40-60%), as a result of waste fermentation. Methane is 56 times more potent as a GHG than carbon dioxide. Gas recovery from landfills reduces GHG emissions either by flaring the methane on-site (which transforms it into CO_2) or using it as a fuel for electricity production.

Services associated with gas recovery from landfill waste include:

- The complete design of the landfill-gas extraction scheme and gas-recovery modelling.
- Construction of the facility and its operation over the contract period (*e.g.* 10 to 15 years).
- Sales of carbon credits on CER markets.

A landfill-gas extraction facility comprises wells that are dug into the waste and connected to a system of pipes. Recovered landfill gas is either flared or upgraded and used as a local energy source. Pipes, and drilling equipment to install pipes in the landfill, can often be purchased locally.

Depending on what is done with the gas, more sophisticated landfill-gas cleaning and upgrading equipment may have to be imported. As an example, methane within landfill gas can be concentrated via a gas upgrader to the same standards as fossil natural gas. If the local gas network allows for this, the producer of the landfill gas may supply the local gas-distribution networks. If concentrated and compressed, landfill gas can also be used to power vehicles.

Clients of services related to landfill-gas collection are typically owners and operators of sanitary landfills, which include both public authorities and private companies. The number of landfill-gas recovery projects from waste dumps is rapidly increasing worldwide. Large new projects have appeared in countries involved in Appendix 2 of the Kyoto Protocol. Such projects often qualify under the CDM. Developers indicate that they offer a 24 hours, seven days per week production. They claim that the volume of certified carbon-reduction credits generated by an installation for a given amount of power generation is ten times greater than that of wind or solar installations.

Service suppliers from Europe and North America are leaders in the international market. Most are either independent SMEs (e.g. Bionersis, France) or subsidiaries of large waste-management corporations (e.g. BFI Gas Recovery Systems, Laidlaw Gas Resource Systems). These suppliers provide integrated design, installation and operation services and, in some cases, sales of carbon credits. Some independent SMEs or subsidiaries of large groups also provide biogas upgrading technology, as well as connected engineering and installation services.

11. Landfill gas also contains varying amounts of carbon dioxide, nitrogen, oxygen, water vapour, sulphur and numerous other contaminants, most of which are known as "non-methane organic compounds" (NMOCs). NMOCs include toxic chemicals like benzene, toluene, chloroform, vinyl chloride, carbon tetrachloride, and 1,1,1 trichloroethane. Inorganic contaminants, including mercury, are also sometimes present in landfill gas. Even radioactive contaminants, such as tritium (radioactive hydrogen), have been found in landfill gas.

Most trade takes place through mode 3 (e.g. via a subsidiary established abroad) and mode 4 (*e.g.* staff of the subsidiary includes executives from the parent firm temporarily working overseas).

Example: Kamphaeng Saen Landfill

The Kamphaeng Saen landfill site is located near Bangkok, Thailand. It is an anaerobic managed landfill, opened in 1991 and closed in 2005. It is estimated to hold approximately 10 million tonnes of waste. In 2010, the Bangkok Metropolitan Administration signed a 10-year contract with Bionersis to recover landfill gas from the site. Bionersis is a French company founded in 2005 and listed on the Paris stock-exchange, that specialises in the energetic valorisation of gases from landfills. Bionersis already operates eight facilities in Latin America and Asia. The contract involves building, operating and maintaining a landfill-gas collection and flaring system. Possible uses for the collected landfill gas include the generation of electricity, which may be used at the landfill site or supplied to the local grid. More specifically the project involves:

- Constructing a gas-collection network with vertical gas wells and mixed-gas-leachate wells;
- Installing a high-temperature enclosed flare;
- Installing and operating monitoring and control systems to measure the actual flow and composition of the landfill gas;
- Constructing associated civil works.

Bionersis designed the project, prepared the project design document for CDM recognition under the Kyoto Protocol and will build and operate the facility. E.On Climate and Renewable (EC&R), a subsidiary of E.On (a German Power and Gas Company), financed the investments – amounting to around EUR 5 million – and will purchase carbon credits generated by the project.

The gas-recovery facility is expected to avoid emissions of 1.2 million tonnes of CO_2-equivalent over its 10 years of operation. The carbon credits generated over that period are expected to be worth EUR 2 million.

Example: US and Brazilian divisions of a US environmental consulting firm

This firm designs and constructs methane-capture systems for landfills, including projects that simply flare the gas and those that combust it to generate power. It has worked on projects in Brazil and Mexico, and is currently doing feasibility studies for projects in China and Morocco.

The project cycle usually starts with initial feasibility studies to determine the size of the project, its revenue potential in terms of marketing carbon credits and the main factors that will influence the recovery or control of the methane emissions. The firm then conducts field investigations to verify its modelling assumptions before designing and in some cases building the systems. In other cases, its role is limited to preparing the project design documents for verification and CDM registration of the projects.

Most of the equipment for these projects is procured locally with the exceptions of centrifugal blowers, for which the firm always specifies cast aluminium versions for

safety reasons, and gas analysers which are critical to validating a project's emission reductions and also important for safety.

Services are delivered through modes 1, 3 and 4. In one of its foreign markets, it established a commercial presence through acquisition of a locally based firm.

Energy performance contracting for buildings

Generic description of the service

EPC is a turn-key service from the initial building energy audit through long-term monitoring and verification of project savings.[12] It involves a comprehensive set of measures to improve the energy performance of buildings, including the following:

- building envelope improvements (e.g. insulation, roofs, windows);
- heating, air conditioning and ventilation;
- lighting;
- domestic hot water systems;
- control systems;
- demand response; and
- renewable energy.

EPC providers usually guarantee the energy savings and CO_2 emission reductions of their projects, assuming the performance risk over the entire contractual period (typically 3 to 15 years). The International Performance Measurement and Verification Protocol (IPMVP) is a standard method for validating project savings, recognised by major market players.

Energy performance contracts have a dual impact on GHG emissions. First, by reducing overall energy requirements they reduce GHG emissions by an amount up to that which would have been emitted had all the avoided energy been provided by fossil fuels. Second, by substituting renewable energy for fossil fuels, they may achieve additional reductions in GHG emissions.

Consumers of EPC services include owners and operators of public buildings, such as municipalities and other government units, school districts and universities, and public housing authorities. Private owners or managers of residential, commercial or industrial buildings are also clients.

A large and growing number of independent SMEs have emerged to supply EPC services. In some localities, these providers compete with subsidiaries of electric or gas utilities, manufacturers of building equipment or controls, international oil and gas companies, construction firms and large engineering firms. Key players on the international market include Siemens Building Technologies, Schneider Electric, Johnson Controls, ABB Building Technologies, Cofely (GDF-Suez), Dalkia (Veolia Environment). These companies operate through local subsidiaries so the predominant

12. These are often divided into BEAMS (Business Energy Management Systems) and HEMS (Home Energy Management Systems.)

mode of supply is mode 3, with accompanying mode 4 (professionals temporarily working abroad). Mode 1 supply is also possible (e.g. EPC monitoring services provided cross-border to foreign clients), and mode 2 is relevant for training associated with EPC (e.g. engineers travelling abroad to receive training).

Typically, a major share of the equipment and products needed to improve the energy performance of buildings can be purchased locally. More sophisticated items (e.g. instrumentation and energy-automation devices, renewable energy equipment, software packages) may have to be imported.

Example: City of Nyköping contract with TAC Energy Solutions

Recently, the City of Nyköping, Sweden, signed an 11-year energy performance contract with TAC Energy Solutions (a subsidiary of Schneider Electric Group), to provide a comprehensive set of solutions with guaranteed results, in order to reduce the energy consumption and GHG emissions of 123 public buildings with a combined surface of 250 000 m². Buildings covered by the contract are mostly schools and senior people's homes. Solutions implemented to improve energy efficiency and reduce GHG emissions include:

- Installation of a new building management system.
- Installation of heat pumps and solar panels.
- Optimisation of operations procedures.
- Instrumentation, control and automation of lighting, heating, ventilation and air conditioning.

TAC Energy Solutions proposed the technical solutions to be implemented, then implemented these solutions and provided investment financing. TAC technical personnel are available on-site, but Nyköping city-services staff remain in charge of day-to-day operations according to procedures defined in collaboration with the services supplier.

The energy saving potential of the contract is 17% (a 21% reduction was measured after one year of operation). The associated annual reduction in emissions amounts to 4 300 tonnes of CO_2. As well, the City is expected to save EUR 750 000 on its annual heating bills, and EUR 240 000 on its electricity bills.

Example: UK energy-efficiency division of a US environmental consultancy

This US-owned firm performs energy efficiency services worldwide, with approximately 50% of its projects in Europe and 25% in Asian countries, Australia and New Zealand, with a small amount of work in Africa. Its typical client is a large multinational corporation in the hospitality or manufacturing industries with facilities worldwide. The majority of its work is in energy-efficiency retrofits, while it also participates in designing energy-efficient systems for new buildings.

The firm’s energy engineers first audit their client’s facilities using sub-meters and energy monitoring software. Then they design and propose a comprehensive program that includes some hardware upgrades like new lighting or heating, ventilation and air-conditioning (HVAC) systems as well as operational changes like monitoring energy usage more carefully and reducing or shutting down services when space is unoccupied.

The firm does no engineering or construction, but provides clients with project-management services to assure proper execution of the engineering and construction phase. In many developing countries, the project management function is very important because local contractors have limited experience with energy-efficient design features, and in some cases these inexperienced contractors will try to exaggerate their relevant expertise.

Goods associated with these projects include submeters, new chillers for HVAC systems or hot water heaters (boilers). The latter items can often be procured locally in developing countries, but the submeters must always be purchased from developed-country manufacturers to meet necessary quality thresholds.

This company trades services via all four GATS modes, with mode 4, presence of natural persons, being the most common. In the past this firm conducted trainings for clients in the United Kingdom, United States or other country where it had a large commercial presence, but it has reduced this practice for cost and inefficiency reasons.

In terms of mode 3, the firm reported that its decision to establish commercial presence in a foreign market is driven by the volume of business and potential business as well as language considerations: in non-English speaking countries, it tends to expand in the market through commercial relationships with subcontractors rather than establishing its own office.

Data-analysis services

Water is one of the most indispensable and widely-used natural resources and its growing scarcity is cause for concern. Aggravating water scarcity is that, globally, water use has been growing at more than twice the rate of population growth. As the world becomes more developed, per capita demand for water also increases, putting pressure on available water supplies. Climate change will likely further exacerbate supply-demand imbalances. According to the 2030 Water Resources Group (2009), over a third of the world's population will be living in basins with severe water stress. Data-analysis services aimed at mitigation and cost-cutting activities can be expected to play a critical role in meeting these challenges.

It is estimated that nearly half of water mains and pipes in the western world are over 80 years old. Water distribution is a complex network to main, and aging networks are one of the reasons that it is estimated that there are 200 critical main breaks per year per 1 000 km of pipe. As a result, according to the World Bank, global non-revenue water (water that entered the distribution network but was not sold) is 25% of fresh water produced.

Because the extraction, treatment, and distribution of water require considerable energy, which results in GHG emissions, inefficient water management is costly for consumers and creates a twofold issue for the environment. Specifically, treating surface water utilises 58 kWh per megalitre (ML), treating and pumping groundwater utilises 160 kWh/ML, brackish groundwater utilises 1 000-2 600 kWh/ML, and seawater utilises 2 600-4 400 kWh/ML. According to the American Water Works Association (Reekie, 2008), up to 35% of a water utility's operating budget is related to its energy use, and water distribution is considered an energy-hungry activity. With proper water infrastructure monitoring, water network efficiency can be considerably improved, thus conserving water and energy, benefiting both consumers and the environment. Reducing

water loss from the 25-30% range means a corresponding saving of new water sources and energy.

Services associated with water infrastructure monitoring include:

- Tracking water use;
- Monitoring water quality, operations, and inefficient pumping;
- Monitoring and reporting leaks, busts, and other irregularities;
- Planning network upgrades and long-term action;
- Ensuring that all parts of the network can be monitored.

Clients of data-analysis services related to water management are typically large utility companies interested in mitigating water use and energy costs. Service suppliers are comprised of small and medium, independent SMEs. Because utility water monitoring typically involves remote sensors and internet-based communication, international trade typically takes place through mode 1.

Example: TaKaDu

With up to 30% of clean water lost in leaking transportation pipes, Israel-based TaKaDu provides a service to water utility companies that takes all data existing in the network and uses advanced algorithms to detect water loss, inefficient operations and other network anomalies, such as consumption variations. Founded in 2008, its clients already include water utilities operating in Israel, Austria, Australia, the Netherlands, and the UK. In 2010, TaKaDu was awarded the Global Cleantech 100 by the Guardian and Cleantech Group honouring its business and innovation in clean technology. It also won a Sustainability prize for its work with Thames Water, the UK's largest utility, from the International Water Association, was selected to the Artemis 50 and was selected as a 2011 Technology Pioneer from the World Economic Forum. Services provided by TaKaDu include:

- Tracking water use based on season, day of week, and other metrics as well as ensuring regulatory compliance with water quality and supply regulations;
- Monitoring water quality, operations, and pumping;
- Processing online and historical data through the use of technology based on mathematical and statistical algorithms. TaKaDu creates a spatial, real-time model of the water network, which enables it to detect leaks, bursts, and other irregularities that were previously invisible.

TaKaDu's water network management approach involving mode 1 trade requires no network changes, hardware additions, or other field work.

Eco-travelling and eco-logistics services

Generic description of the service

Eco-travelling and eco-logistics can be considered at various geographic scales from local to international. They are based on achieving modal shifts from road transport to rail and public transport systems, non-motorised transport (cycling, walking) and transport using low-carbon vehicles. Services include:

- R&D, consulting and engineering (e.g. for transport network optimisation, freight and travel modelling).
- Training (e.g. changing driving behaviour).
- Operation of transport services using alternative vehicles (e.g. hybrid vehicles, electric delivery vans or tricycles, biofuels powered vehicles, bicycles).
- Information services for green travelling: carbon calculators, car sharing services, "eco-tourism" services, etc.
- Measuring and reporting energy-efficiency improvements and CO_2 emission reductions.

Impacts on GHG emissions comes from various factors such as: reducing travel distances; achieving more efficient vehicle loading; substituting low-carbon transport modes and fuels for conventional fossil fuels; and increasing fuel efficiency. For example, it is estimated that a driver trained in "eco-driving" can reduce his or her CO_2 emissions by some 15%.

Goods connected with eco-travelling and eco-logistics service provision include alternative vehicles, such as electric vehicles, or industrial tricycles. In the United Kingdom, the transport firm TNT uses a 100-strong fleet of electric vehicles manufactured by Smith Electric Vehicles. In China, TNT uses a fleet of electric vans designed, manufactured and assembled by Dong Feng Motor Co., China's largest automaker and manufacturer of electric vehicles.

Service providers may also adapt software packages for clients, such as for database management, and geolocation. Some of these goods may have to be imported. At the current stage of deployment of eco-logistics services, electric vehicles used are often provided by a manufacturer based in the same country.

Eco-travelling service users are primarily individuals. Nevertheless, service users include firms and public authorities. Eco-logistics services users are mainly firms and households.

Services delivered by SMEs include engineering and consulting, car-sharing services, eco-tourism services, and tricycle-based urban-delivery services. Services more typically delivered by multinational corporations include eco-logistics (e.g. by TNT, Green Logistics Consultants Group) and urban transport services (e.g. Veolia, Transdev). Public authorities still provide the majority of urban mass-transport services, and information services to facilitate modal shifts from road transport to urban public transport.

Operation of eco-travelling and eco-logistics services may be provided by local subsidiaries of international corporations. Consulting and engineering services are internationally provided by local affiliates of international groups. Hence, modes 3 and 4 are the most relevant for the provision of these services. Modes 1 and 2 are also possible. For example, carbon emissions modelling and logistics route optimisation are often provided to foreign clients via the Internet. Eco-travelling services such as hotels and alternative transport, to the extent they are purchased in a foreign country, also involve mode 2.

Example: TNT Eco-logistics Services

TNT is a large multinational logistics corporation with an operational fleet of some 14 500 vehicles and an annual turnover of EUR 11 billion. In recent years, TNT has initiated programmes to reduce its carbon footprint. TNT's long-term objective is to

become the first zero-emissions express and mail company. Its intermediate objective is a 45% improvement in CO_2 efficiency by 2020, compared with 2007 levels.

In 2008 TNT Australia introduced ten hybrid trucks, following an extensive evaluation between 2004 and 2006. These trucks emit 14% less CO_2 and 50% less NO_X than a conventional diesel truck of equivalent size. With these hybrids, TNT expects that it will reduce its average annual emissions by 1.6 tonnes of CO_2 per vehicle. Also in 2008, TNT UK introduced 50 electric delivery trucks (7.5 tonnes capacity) to its operational fleet. These are expected to reduce emissions by 1 300 tonnes of CO_2 a year.

TNT Netherlands has piloted one electric truck (9 tonnes) and one electrical van (3.5 tonnes) as part of its delivery operations in and around Rotterdam. And TNT China is testing battery-electric delivery vans in Wuhan City.

Besides divisions and direct affiliates of TNT Corporation, the provision of eco-logistics services by TNT involves partnerships with SMEs. In France, TNT engaged in a partnership with Becycle, a start-up launched in 2004 and specialising in urban delivery of goods by tricycle. The service area covers Paris and eight other French towns. In the United Kingdom, TNT entered into an agreement with Lysanda, a provider of vehicle management software established in 2005, to be the approved supplier of on board eco-driving technology to TNT.

Services associated with CO_2 capture and storage

Generic description of the service

Carbon dioxide capture and storage (CCS), also called carbon capture and geological sequestration, involves capturing CO_2 (by separating it from other gases produced, usually in a liquid medium), transporting the captured CO_2 to a suitable storage location, and storing the CO_2 away from the atmosphere for a long period of time, typically in an underground geological formation.

CCS is of great interest to the international community because it holds out the promise of being able to make deep cuts in global CO_2 emissions while still using fossil fuels. Nevertheless, there are still doubts about the commercial and environmental viability of CCS technology (*e.g.* the long-term safety of underground storage sites). For this reason, CCS technology has not yet been approved for Joint Implementation or CDM projects by the United Nations Framework Convention on Climate Change (UNFCCC). To test its viability, numerous demonstration projects have been announced (in Brazil, Canada, China, Europe and the United States) for start-up within the next five years. Some 15 CCS projects were agreed in March 2009 by the European Council as part of the European Economic Recovery Plan.

Services associated with CCS include:

- Feasibility studies, including analysing the geological site's characteristics from the standpoint of its adequacy for injecting compressed CO_2, as well as the project's technical, economic, financial, environmental and institutional feasibility;
- Design, engineering and operation of the complete facility;
- Monitoring performance of the facility.

Goods central to CCS-related service provision include equipment for carbon capture and pressurisation. Such equipment may have to be imported, because only a few industrial groups currently can provide the three main technologies used (post-

combustion, pre-combustion and oxy-fuel combustion). Otherwise, many of the other goods, such as pipes transporting compressed CO_2, and pipes and drilling equipment for CO_2 injection into a geological formation, can usually be purchased locally.

Once CCS becomes commercially viable, potential service clients for CCS-related services include thousands of large CO_2 emitters, such as coal or oil-fired power plant operators, steel and chemicals plan operators, and petroleum refineries. The following groups lead several of the CCS projects currently planned: Transalta, Shell, Chevron, Marathon Oil Sands (Canada), Statoil-Hydro (Norway), RWE, E.On (Germany, United Kingdom, Netherlands), ArcelorMitall, Total (France), Vattenfall (Germany, Poland), GDF-Suez (Netherlands).

Services suppliers include:

- Specialists in geological and environmental studies and modelling. Among them are independent firms, subsidiaries of major oil companies and spin-offs of research centres (e.g. Geogreen);
- Engineering departments of industrial groups mastering key CO_2 capture technologies (*e.g.* Alstom, Air Liquide);
- Engineers and constructors capable of building CO_2 pipelines;
- Experts in long-term monitoring services of underground storage (e.g. Schlumberger).

International trade in CCS-connected services is expected to primarily involve modes 3 and 4, since in most cases the service provider has to be present in the foreign country. Yet, mode 1 may be used as well (*e.g.* analysis and modelling of carbon underground storage data provided cross-border to foreign clients), and mode 2 is relevant in instances where training in CCS is received abroad.

Example: Sleipner CO_2 capture and storage

The Sleipner natural gas field is located in the North Sea, about 250 km west of Stavanger, Norway. In 2000, StatoilHydro, together with its partners Esso Norge, Norsk Hydro, TotalFinaElf Exploration Norge, Statoil Research Centre, established the world's first CCS project, to capture and store carbon dioxide from natural gas produced from offshore platforms. The natural gas produced from Sleipner contains close to 9% carbon dioxide in its natural state, and since the market specification permits a maximum CO_2 content of 2.5%, it is necessary to reduce the carbon content in the gas before it is exported. Some 11 million tonnes of CO_2 have been captured and stored since production started in 1996. This is more carbon dioxide than the total number of cars in Norway emit in two years.

Services have been involved in all the stages of the project, from the design and building of the facility to its operation. The facility uses amine scrubbing technology to separate CO_2 from natural gas. The recovered CO_2 is then injected with powerful pumps into the porous and permeable reservoir rock called the Utsira Sand, some 1 000 metres below the surface of the North Sea. The British Geological Survey is among the organisations involved in monitoring and modelling the distribution of injected CO_2 in the Utsira Sand, which is done remotely by analysing seismic data.

It is estimated that the Utsira Formation is capable of storing up to 600 billion tonnes of CO_2. Some 1 million tonnes of CO_2 are being stored in the sub-surface annually – 3% of Norway's annual GHG emissions. CCS is not cheap, however: the CO_2 treatment

module alone cost EUR 350 million. Had this process not been adopted and the CO_2 produced had been allowed to escape to the atmosphere, however, the licensees of the Sleipner West field would have had to pay EUR 50 million a year in Norwegian CO_2 taxes.

Carbon-market services

The Kyoto Protocol introduced three market-based mechanisms to reduce GHG emissions: emissions trading, the CDM, and Joint Implementation (JI). As noted, CDM involves investment in projects that reduce emissions in developing countries, and has as a primary purpose stimulating transfers of low-carbon technologies to developing countries. JI enables industrialised countries to carry out projects jointly with other developed countries. Emissions trading schemes (ETSs), such the European Union's ETS and regional ETSs in the US, have been established to trade carbon credits. Together, these various institutions constitute the "carbon market".

Various market services have emerged to help implement Kyoto Mechanisms and ETSs. They include:

- Management of registries to record and track the creation and movement of so-called "Reduction Units or "Carbon Credits" generated by GHG-mitigating projects;
- Carbon Trading Services under the various ETSs;
- Services to provide the necessary verification and certification of GHG emission reductions.
- Carbon finance expertise;
- Documentation of CDM and JI projects, as well as projects eligible under other ETSs.

Projects developed under the Kyoto Protocol and emission trading schemes cover a wide range of technological solutions in most economic sectors, including energy, industry, transport, forestry and agriculture. Kyoto mechanisms as well as other ETS are designed to favour the implementation of the most cost-effective of these projects. Carbon-market services contribute to stimulating investments in such projects.

Clients of carbon-market service include businesses, non-governmental s and other legal entities that may participate in the Kyoto mechanisms or other ETS, under the authority of governments. Service suppliers were mostly created over the past ten years, either as independent new companies or as specialised subsidiaries or departments of existing companies. They include:

- Carbon finance Consulting and Advisory firms.
- Developers and Financiers of GHG emission reduction projects (e.g. EcoSecurities, EcoEnergy International).
- Verification and certification companies, including Designated Operational Entities under the UNFCCC (e.g. SGS, DNV).
- Emissions trading firms (e.g. Orbeo).
- Carbon exchange and registry operators (e.g. DEHSt, BlueNext, Caisse des Dépôts, The American Carbon Registry).

Key players on the international market often operate through local subsidiaries and representatives (*e.g.* EcoSecurities has established a network of offices in foreign countries, see below). International trade in services connected to carbon markets thus entails mostly modes 3 and 4. Mode 1 is also a possibility though, *e.g.* data or CDM documents delivered overseas through the Internet.

Example: EcoSecurities' carbon services

Ireland-based EcoSecurities was created in 1997 to provide carbon finance expertise to projects reducing GHG emissions. EcoSecurities floated on the Alternative Investment Market of the London Stock Exchange in December 2005, raising EUR 80 million. This allowed the firm to expand its project portfolio and to create a network of offices and representatives in 20 countries, on five continents. The Carbon Acquisition Company (a wholly-owned indirect subsidiary of J.P. Morgan) acquired the EcoSecurities Group in December 2009.

EcoSecurities' activities include sourcing, developing and trading emission-reduction credits. The company works with both project developers and buyers of emission-reduction credits, offering services such as:

- Participation in drafting national GHG-mitigation programmes;
- Development of approved CDM project methodologies;
- Development of CDM projects registered under the Kyoto Protocol (e.g. the NovaGerar Landfill Project in Brazil was the 1st CDM registered project in 2004).

EcoSecurities has a portfolio of more than 100 registered CDM projects that it manages. Examples include: fuel switching (South Africa), hydroelectricity generation (Honduras), biomass production (Brazil), and geothermal energy (Nicaragua).

Example: Canadian carbon market consulting firm

This small enterprise (with fewer than 30 employees) develops projects for clients seeking to market carbon-offset credits in both the regulated CDM market and the North American carbon market. The primary GHG-mitigation technologies it works with are methane capture, fuel switching from a fossil fuel energy source to a clean, renewable energy source, and recovery of waste energy from fossil-fuel power plants and industrial facilities. The firm has recently become active in the development of forestry projects for sponsors intending to seek carbon credits under the emerging REDD protocols. It has clients in Peru, Brazil, Panama and Bolivia.

The North American market for carbon offsets is frequently referred to as "voluntary", because participation is not mandatory nationwide, as is the case in Europe. But state laws mandate reductions by electric power generators in the Northeast United States, while major greenhouse-gas emitters in California and elsewhere will likely soon face mandatory emissions caps. Hence, the term "voluntary" is rapidly becoming outdated.

The company's consulting services range from searching for project opportunities for clients and conducting initial feasibility studies to contracting for verification services and preparing final documents for CDM registration or validation by a "voluntary" market protocol such as the Voluntary Carbon Standard. In some cases, it performs this entire project cycle, and in others it performs only discreet services.

Most of the technologically sophisticated equipment associated with its projects – such as turbines, heat-recovery steam generators and cooling systems – is imported from the United States or Europe. Only in Brazil does there exist sufficient domestic manufacturing capacity to provide some of the goods.

As the company has recently expanded its commercial presence in its foreign markets, it less frequently conducts cross-border trade (mode 1). Mode 2 trade, in which clients receive services in the firm's home country, never takes place.

The company determines whether it will deliver services through inter-country travel (mode 4) or by establishing commercial presence (mode 3) based on the extent to which its personnel have contacts and relationships in a foreign market. It also considers geographic proximity and whether a foreign market is an air travel hub for other Latin American countries.

Irrigation services

Services to make irrigated agriculture more efficient both help mitigate GHG emissions (by reducing energy requirements for pumping water) and help the agricultural sector adapt to a changing climate. Additionally, improved irrigation techniques reduce soil erosion and thus help preserve soil fertility, reducing pressure to create farmland from forested land. Services associated with irrigated agriculture include:

- Providing agronomic and technical guidance including the design, engineering, and operation of precise and efficient irrigation systems;
- Educating growers in how to best operate advanced irrigation systems and incorporate planning, training, technical, and agronomic field support;
- Monitoring the application of plant nutrients.

Clients of services related to irrigated agriculture are typically farmers hoping to install or modernise irrigation methods, including public and private land owners in need of landscape upkeep, mining companies hoping to revegetate disturbed land, operators of golf courses and resorts, and municipalities and private companies in charge of maintaining public green spaces.

Service suppliers range from small and medium, independent SMEs to large, independent, companies operated through local subsidiaries. Many use sophisticated technologies and often provide continuous support after the completion of the initial project.

International trade in irrigated agriculture services can involve all four modes of supply. Mode 4, presence of natural persons, and mode 3, commercial presence, are the most common when operating through local subsidiaries. Additionally, mode 2 is used in instances wherein training is received abroad. A small amount of trade takes place through mode 1 in the case of remote monitoring.

Example: Netafim

Since introducing the world's first drip-irrigation solutions in 1965, Netafim has evolved to become the world's largest provider of "smart drip" and micro-irrigation solutions for the agriculture, landscape, and mining industries. Headquartered in Israel, Netafim has factories and offices in over 110 countries. The majority of its services are divided into three main divisions:

- The Agronomic and Technical Guidance division employs agronomists who help clients to select appropriate irrigation systems depending on company needs and the local environment. The result is enhanced water productivity, fertiliser use efficiency, and land productivity. The department additionally provides guidance on micro-irrigated crops, water, and nutrition management technologies.
- The Projects and Design division provides support throughout the agricultural projects' life-cycle, beginning with a joint agronomic, engineering, and economic feasibility study followed by detailed design, procurement, implementation, and training and project support.
- The Hydrocalc Software division provides downloadable Hydrocalc Irrigation Planning software, which calculates basic hydraulic computations, thereby allowing the designer and end-user to evaluate the performance of micro-irrigation in-field components.

When utilising Netafim's advanced drip-irrigation methods, productivity per unit of soil and water used often increase dramatically. For example, crop productivity from rain-fed plots, typically 1.0-2.0 t/hectare (ha), can increase to 3.0-5.0 t/ha. In the case of strawberries, yields in drip irrigated greenhouses are typically 250 t/ha, compared with 50 t/ha on rain-fed soil.

Most of Netafim's international trade takes place through mode 3 via a subsidiary established abroad, and mode 4 (employees from the parent firm temporarily working overseas). Mode 1 is utilised for software implementation (an important aspect of irrigation monitoring), and mode 2 in contracts involving training received abroad.

Findings

According to the sample of examples and case studies researched for this study, the deployment of GHG-mitigation technologies is often heavily dependent on the availability of specialised quality services, including those imported from other countries. A wide range of services are needed to perform the different mitigating actions, among which business services, construction, environmental and energy services figure prominently. Since technological solutions are often still under development, extensive R&D is needed to develop most of the GHG mitigation activities. Project studies, consulting and engineering services are also important for a wide range of GHG mitigation projects. Services relating to measurement and verification of performance need to be available as well in most of these projects.

Construction and related engineering services are necessary for building facilities and install equipment to carry out low GHG emission activities. Financial services also play an important role since sophisticated new carbon-finance mechanisms are being deployed and financial incentives are needed. In light of the wide array of new technological and organisational solutions to be implemented in all economic sectors, training is another component of the services to be provided in GHG mitigation projects.

The public sector is often an important driver of demand for mitigation projects, for instance in relation to energy performance contracting for buildings and as governments often own and operate sanitary landfills. Coal companies, oil operators and chemical refineries also play a significant role as service users (e.g. for CO_2 capture and storage projects), in light of their large CO_2 emissions. On the supply side, a range of these services from eco-travelling to biogas recovery from landfill waste is performed by SMEs or subsidiaries or large groups such as electric or gas utilities. This is particularly the case

in the initial phase of the project cycle involving conceptual and feasibility studies, project design and engineering, but also with respect to project management services to ensure project execution of the engineering and construction phase.

Expertise and capacity in GHG-mitigation technologies varies across nations. This is especially true in the case of low-carbon power sources based on renewable energy technologies. A recent study by Sterk *et al.* (2007), for example, found that

> *[t]he number of countries where RET [renewable-energy technologies] have seen significant market growth is steadily increasing. However, in most countries of the world, dissemination of new renewable energy technologies is still very limited. A range of barriers – financial, economic, institutional, political and technical – impede implementation. Key barriers include energy markets that are either monopolistic or oligopolistic and distorted by subsidies, lack of awareness of RET potential and benefits, and a lack of technical and institutional capacity and financing means. So far only a few countries have implemented clear policies promoting RET.*

Even in developed countries, where the private sector has ample expertise and capacity to provide the services needed for many mitigation-technology projects, project sponsors will often choose to import services after determining that an international supplier that can meet their needs more effectively or at lower cost.

Utility-scale wind power projects, for example, can only be developed with specialised technical and professional services. According to interviews with wind-power project developers, the services needed to develop a wind farm – from identification of project sites and contracting with power customers through design, engineering, construction, operations and maintenance – often must be imported because firms with the necessary expertise do not exist in the host country. For energy efficiency and methane-capture projects, many services must also be procured from outside a host country's borders in order to design, finance and implement projects effectively.

Even for projects to improve energy efficiency, energy engineers with sufficient expertise for such projects simply do not exist in many countries, according to firm representatives interviewed for this paper, and therefore such projects can only be accomplished with imported services. Engineering services in relation to energy audits, which typically employ sub-meters and energy-monitoring software, are necessary before large-scale energy efficiency projects can be implemented at facilities such as office buildings, industrial plants and hotels. In addition, to allow the facility owner to plan and commit to an energy-efficiency investment, the engineers must design and propose a comprehensive programme, providing information on projected costs and returns.

In responding to requests for ideas and proposals on the Bali Action Plan,[13] numerous developing countries identified the need for capacity-building to support technology transfer (see summary at UNFCCC, 2009). Trade in climate-related services can facilitate such capacity-building. As sectors related to GHG mitigation become more mature in

[13]. Following the 13th Conference of Parties (COP-13) of the United Nations Climate Change Conference on the Indonesia island of Bali in December 2007, the participating nations adopted the Bali Road Map as a two-year process to finalising a binding agreement in 2009 in Copenhagen. The Bali Road Map includes the Bali Action Plan (BAP), adopted by Decision 1/CP.13 of the COP-13. The BAP sets out a comprehensive process to enable the implementation of the Convention through long-term co-operative action through and beyond 2012.

developing countries, the internal capacity to manufacture and market goods and to provide needed services often increases. The remarkable progress of the wind turbine sector in China demonstrates the potential for a country to develop a robust manufacturing base in renewable-energy technologies as its domestic market matures. The same will likely hold true for many categories of services associated with GHG-mitigation technologies. In addition, the analysis here documents the development of initiatives to foster creation of domestic capacity through partnerships with local SMEs. As seen in the above example of eco-logistics, such partnerships are underway in some countries.

With respect to modes of supply, modes 3 and 4 are critical for the provision of services related to climate change. As many of these services entail construction and operation of production facilities, establishing a commercial presence in the foreign country is often a necessity for trade to take place. The temporary movement of people is also very common, both independently to provide the range of relevant business services and to complement trade through commercial presence (mode 3). There are numerous instances of mode 1 trade taking place over the Internet, often complementing prior or subsequent movement of personnel. Mode 2 appears to be largely confined to cases in which training of a client's personnel takes place in the domestic market.

Although the current exercise did not probe deeply into barriers encountered by the service suppliers, ongoing OECD work on barriers to services in general suggest the following could be creating impediments to international trade in services related to climate change:

- **Modes:** Since modes 3 and 4 are the preferred modes of supply, trade barriers are likely to be in the form of investment restrictions (*e.g.* foreign equity limits, legal form, and economic needs tests) and impediments to the temporary movement of service providers (quotas, labour market tests and limitations on the duration of stay for foreign providers). Discriminatory subsidies and taxes might also be important.
- **Inputs:** Many services related to climate change (business services or construction) are likely to be relatively labour-intensive, involving highly-skilled people. Hence, impediments relating to qualification and licensing, such as nationality and residency requirements, can be key.
- **Market structure:** Services related to climate change appear to be largely competitive as indicated by the presence of SMEs in many of the examples and case studies in this paper. At the same time, the international market in some activities such as energy-performance contracting may be mostly dominated by a few large firms and contractors, which typically undertake large-scale projects. Hence, barriers to competition (*e.g.* in relation to public ownership) may be relevant.
- **Government procurement:** Since public procurement is an important driver for demand in a range of services related to climate change, procurement regulation can have a significant impact on trade in these services. In addition to traditional government procurement, public-private partnerships, such as concessions and build-operate-transfer contracts, have also emerged to facilitate private participation in infrastructure and service development. Related practices may affect trade in these services as well.
- **Standards:** The construction sector and related architecture and engineering services are characterised by the importance of building regulations and technical requirements.

In addition, as this study shows, contractors for projects related to climate change are dependent on bringing in technologically sophisticated equipment to the project site from other countries. Therefore, standards affecting the mobility of goods and technologies may be important.

- **Transparency and administrative impediments:** Opaque regulatory regimes increase the cost of compliance and uncertainty of business operations. Since the level of transparency provides a perception of the overall business climate in the host country, it can affect firms' willingness to establish a commercial presence. The number and complexity of administrative procedures can also have a detrimental effect on market entry and operation of contractors.
- **Transaction costs:** In the case of projects that qualify for Certified Emission Reduction credits under the Clean Development Mechanism, transaction costs can be particularly high for small projects as a proportion of total costs. In a study of transaction costs under Finland's CDM and JI pilot programme, for example, Ahonen and Hämekoski (2005) found that the total transaction costs for small-scale CDM and JI projects could be as high as EUR 300 000 per project.

Finally, it is noteworthy that a wide range of products and technologies are connected with the provision of services related to climate change. For example, energy-efficiency programmes often utilise new electronic controls, energy-efficient boilers and HVAC equipment. Across the spectrum of examples and case studies discussed in this paper, respondents indicated that for projects in most developing countries, a great deal of technologically sophisticated equipment – *e.g.* turbines for power projects, centrifugal blowers for methane capture projects, electricity sub-meters for energy-efficiency projects and electronic control equipment for many types of projects – must be imported, while many construction materials are procured locally.

Concluding remarks

The foregoing analysis provides initial insights into the characteristics of services related to climate change and on how international trade takes place in these services. It shows that a wide range of services are being used, across all four modes of delivery. The increasing availability of mode 1 as a supply option also parallels the innovation that is taking place in identifying specific tasks that can be separated from ones previously assumed to be inseparable. Since this is a mode for which many countries have in the past indicated "not applicable" in their specific services commitments, this finding suggests that an updating of commitments in those areas would help increase investor confidence.

The cursory discussion of possible measures that may be creating impediments to international trade in climate-related services (and associated goods) also points to an area of possible future research: an examination of measures actually affecting trade in these services. Such research could involve structured surveys and interviews with companies engaged in supplying internationally traded services to obtain an impression of perceived impediments in those services. Another fruitful avenue of enquiry might be to compare the services identified in the paper with services requests made in the context of current trade negotiations.

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