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Technology transfer in the Clean Development Mechanism

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Technology transfer is often mentioned as an ancillary benefit of the Kyoto Protocol's Clean Development Mechanism (CDM), but this claim has hardly been researched or substantiated. The question of technology transfer is important, both for developing countries in need for new technology and knowledge and for industrialized countries, as it provides export potential for climate-friendly technologies. To determine what technology transfer means, whether it is occurring through the CDM, and what the value of the associated capital flows is, this article examines technology transfer in the 63 CDM projects that were registered up until 1 January 2006. Technology hardware originates from outside the host country in almost 50% of the evaluated projects, particularly in non-CO_2 greenhouse gas projects, wind energy projects, and a substantial share of the hydropower projects. Bioenergy and projects in the agricultural sector mainly use local technology. The investment value associated with the CDM projects that transferred technology is estimated to be around €470 million, with about €390 million coming from the EU. As the non-CO_2 greenhouse gas projects had very low capital costs, the investment value was highest in the more capital-intensive wind energy and hydropower projects. We also found substantial soft technology transfer, but uncertainties for this finding are greater.

Keywords: Clean Development Mechanism; climate-friendly investment; financial mechanism; technology transfer

Le transfert de technologie est souvent évoqué en tant qu'avantage complémentaire au mécanisme pour un développement propre du protocole de Kyoto, mais cette assertion n'a pas été documentée ou substantivée. Le transfert de technologie est une question importante aussi bien pour les pays en développement ayant besoin de nouvelles technologies et connaissances, que pour les pays industrialisés dont le potentiel d'exportation de technologies pour la protection du climat se trouve ainsi augmenté. Dans le but d'établir ce qu'est le transfert de technologie, s'il se produit par le biais du MDP, et quelle est la valeur des flux de capitaux concernés, cet article examine le transfert de technologie dans les 63 projets du MDP enregistrés avant le 1er janvier 2006. La technologie est d'origine étrangère dans presque 50% des projets visés. La plupart des projets de bioénergie et du secteur agricole utilisent des technologies d'origine locale. Les technologies utilisées dans des projets de GES autres que le CO_2, projets éoliens, et une part importante des projets hydro, sont d'origine étrangère. La valeur de l'investissement associé aux projets MDP ayant donné lieu à un transfert de technologie est estimée à environ €470 million, dont €390 million environ sont en provenance de l'UE. Etant donné le très faible coût de financement des projets de GES autres que le CO_2, la valeur de l'investissement était la plus élevée pour les projets éoliens et hydro, où les flux de capitaux sont plus élevés.

Mots clés: investissement pour la protection du climat; mécanisme financier; mécanisme pour un développement propre; transfert de technologie

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1. Introduction

The Clean Development Mechanism (CDM) is one of the flexible mechanisms of the Kyoto Protocol and has two purposes: to allow Annex B countries to comply with their Kyoto obligations through emission reductions generated in non-Annex B countries, and to assist non-Annex B countries in achieving sustainable development (UNFCCC, 1997). The CDM Executive Board ensures that the emission reductions are real and measurable, while the Designated National Authorities in the host countries are responsible for the fulfilment of the sustainable development criterion. Numerous evaluations have been conducted to establish whether the CDM lives up to the expectations, whereby the sustainable development contribution of the CDM, in particular, was questioned (see, e.g., Ellis et al., 2007), as the additionality of the greenhouse gas emission reductions is thought to be sufficiently guaranteed through the stringent mechanism for registration with the UNFCCC. The flexibility in applying the sustainable development definition and the prerogative of the host country to determine whether it takes place have led to ambiguity and a lack of transparency on how the sustainable development criterion is handled (Cosbey et al., 2005).

Although not an explicit policy goal of the CDM, the mechanism is often associated with the transfer of technologies from industrialized to developing countries. Much has been written about how technology transfer under the CDM might be enhanced, pointing at, for instance, the strategies of credit-purchasing governments (Aslam, 2001) or at mobilizing synergies between private-sector involvement and capacity-building (Davidson, 2001). As the number of projects under the CDM is now on the rise, it is possible to go beyond the speculation on future improvements and empirically evaluate the level of technology transfer taking place in the current CDM project portfolio.

Transfer of technology has several aspects: the transfer of hardware, in terms of the actual installations and equipment; and 'soft' technology transfer, in the form of knowledge transfer and capacity-building. This article first generally assesses technology transfer as a whole, including soft technology, and determines whether technology transfer took place according to the definition adopted in Section 2. Next, it focuses on two aspects of 'hard' technology transfer: it first assesses in detail the origin of technology of the 63 CDM projects that were registered with the UNFCCC on 1 January 2006, and in addition provides a rough analysis of the volume of exports from industrialized countries to the CDM host countries.

The latter question is relevant for two purposes. Firstly, the outcome gives an indication of the investments in cleaner, foreign technologies that CDM generates. Secondly, it provides an additional ground for the development of cleaner technologies in industrialized countries, and for gaining experience with these technologies, in order to be able to export to countries that have not been willing or able to develop them.

Section 2 of this article explains the methodology that is used in the analysis. Section 3 provides results for the overall technology transfer analysis, and Section 4 for the hardware and investment analysis. Section 5, finally, discusses the conclusions that can be drawn.

2. Approach for the technology transfer analysis

There is surprisingly little consensus on what technology transfer comprises. The literature offers a broad array of definitions (Wilkins, 2002; Kline et al., 2004). In this article, we adopt the broad definition of the IPCC (2000):

> A broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions.

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Projects looking at technology transfer often focus not so much on the question *whether* technology transfer took place, but on the *effectiveness* of the technology transfer. In the context of climate change, for instance, criteria include 'whether emissions are reduced' or 'whether the local community is involved in the activity' (IPCC, 2000). As these criteria are already inherently positive for the CDM, given its requirements for emission reduction, additionality, public comment procedures, and sustainable development, we have not used them.

Given the IPCC definition, in the context of this article we will evaluate a number of criteria that can be applied to registered CDM projects and that cover all relevant aspects of technology transfer:

1. Whether technologies deployed in CDM originate from outside the host country.
2. Whether the technologies that are implemented in CDM are indeed new or improved and do not represent business-as-usual in the host country of the project.
3. Whether the knowledge and capacity to implement the technology in the project originates from outside the host country.

The evaluated CDM project portfolio consists of all CDM projects registered by 1 January 2006. The total number of projects is 63, situated in 20 different countries. The project design documents (PDDs) (UNFCCC, 2006) were used to obtain a detailed description of the project activity, including, in some cases, an assessment of whether technology transfer had taken place. Sometimes the PDDs gave sufficient information on the technology origin, but in other cases the project developer was contacted by e-mail to obtain the missing information. This resulted in an overall, high-level evaluation of hard and soft technology transfer.

After evaluating all projects, the second step entailed further analysis of the projects that comply with the first criterion (Criterion 1 – i.e. projects that show hard technology transfer), evaluating the countries that export the various technologies and the capital costs of the installations used in the projects. The sum of the total capital costs of projects that show technology transfer equalled the value of the exports that companies from Annex B countries have been able to make as a consequence of the CDM.

Although the approach outlined above fits the purpose of evaluating technology transfer in the CDM, it has a number of limitations. First of all, we do not show the full, real technology transfer according to the definition of the IPCC (2000), as we do not evaluate technology transfer inside a country, e.g. from one region to another, or from urban to rural areas. The fact that domestic technology transfer may be a significant flow is illustrated by investment numbers – the lion's share of all investment in most developing countries is represented by domestic investments (Ellis et al., 2007). As we disregard a potentially large amount of technology transfer, the resulting numbers may be an underestimate.

Another limitation is data availability, particularly for the second and third criteria. In the case of the question whether the technology is 'new or improved', there is much room for interpretation, and information on the state-of-the-art or 'average' technology in specific countries is often hard to obtain. This is the main reason why we focus on hard technology transfer in Section 4.

For the third criterion, the question of whether knowledge transfer or 'soft' technology transfer has taken place is surrounded by even greater uncertainties. Not only is the criterion itself rather subjective (e.g. in an extreme case, knowledge transfer could even occur by sending a user a manual of an installation), the source of information is problematic, as we have to rely on the PDD alone for this. Many PDDs do not mention 'soft technology transfer', and the ones that do use it to demonstrate additionality or

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ancillary benefits. Because the claim of knowledge transfer or capacity-building cannot be evaluated independently and the project approval partly depends on it, the writer of the PDD has an incentive to exaggerate the level of knowledge transfer or capacity-building associated with his project. The reliability of the assessment of Criterion 3, in particular, is therefore reduced significantly.

3. Results of the broad technology transfer analysis

The 63 CDM projects that were registered up until 1 January 2006 were evaluated based on the criteria listed in Section 2. The projects in the portfolio involved the sectors of electricity, waste, industry, agriculture, thermal energy, and the residential sector.

The technologies of the registered projects were biogas, bioenergy, hydropower, wind energy, fuel switching and energy efficiency, all of which reduce CO_2, methane capture from swine manure and landfill gas capture (reducing CH_4), N_2O avoidance and HFC-23 destruction. The host countries were Argentina, Armenia, Bangladesh, Bhutan, Bolivia, Chile, China, Costa Rica, Fiji, Guatemala, Honduras, India, Mexico, Morocco, Nepal, Panama, Peru, Republic of Korea, South Africa and Sri Lanka (UNEP/Risoe, 2006). The project development and financing arrangement varied significantly across the project portfolio. While some of the projects were initiated unilaterally, others were heavily financed by development agencies, were helped by World Bank funding, or had contracted buyers via national tender constructions before registration with the CDM Executive Board. The emissions reductions per technology are summarized in Table 1. As has been noted on many occasions (see, e.g., Capoor and Ambrosi, 2006), the share of renewable energy projects in the total number of projects is significant in this snapshot of the CDM project portfolio, but it is small in the market share of Certified Emission Reductions (CERs) compared with the large-scale non-CO_2 greenhouse gas emission reduction projects. In particular, N_2O and HFC-23 destruction dominate the CER portfolio, as well as landfill gas projects. Normally, a lower level of desirability and sustainable

TABLE 1 Summary of emission reductions by technology in the 63 registered CDM projects by 1 January 2006

Technology	Number of projects	Share of number of projects	Annual emission reduction (tCO_2eq)	Share of total emission reduction
Biogas	6	10%	387,591	1.4%
Biomass	10	16%	302,735	1.1%
Energy efficiency	1	2%	6,580	0.0%
Fuel switching	1	2%	19,438	0.1%
HFC-23 destruction	3	5%	8,233,566	28.9%
Hydropower	22	35%	775,471	2.7%
Landfill gas	10	16%	2,712,395	9.5%
Methane capture	3	5%	410,378	1.4%
N_2O destruction	2	3%	15,111,165	53.0%
Wind energy	5	8%	573,013	2.0%
Total	63		28,532,332	

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development contribution is associated with CDM projects that favour large-scale, industrial, non-energy-sector emission reductions. Specifically, the low cost of HFC-23 projects (IPCC, 2005), the associated windfall profits on CERs, and the perverse incentives that such HFC projects provide for the production of ozone-depleting HCFC-22 have generated much concern.

A large proportion of the projects in the portfolio use technologies that originate from the host country and therefore do not generate technology transfer as defined in Criterion 1 (see Table 2). In those cases where the technology originates from outside the host country, it comes mainly from the European Union, although a small number use technology from the USA, Japan or Switzerland.

Moreover, in almost 60% of the projects, we could confirm that new or improved technology was used (Criterion 2). The projects in the group that use new or improved technology included all projects that met Criterion 1 with respect to the use of foreign technology. The technologies that were new or improved but also supplied from inside the host country involved, for instance, swine manure methane capture projects in Chile, and biomass projects in India.

In addition, according to the PDDs, almost half of the projects involved some degree of capacity-building or knowledge transfer (Criterion 3). This mostly involved the employment of local workers, who required training and courses in order to operate the technology.

The summary of the evaluation of the criteria is presented in Table 2 and Figure 1.

4. Origin of technology and international capital flows

Zooming in from broad technology transfer to transfer of 'hardware', it is observed that the origin of specific technologies is very widespread. The technology for landfill gas comes mainly from the Netherlands although some is of host-country origin, technology for N_2O reduction comes mainly from France (for some: no data found), and technology for HFC-23 destruction originates from Japan, the UK and Germany. Methane capture from swine manure in Chile is a locally developed technology.

TABLE 2 Summary of results of the technology transfer criteria analysis

Criterion	Result indicator	Number of projects meeting criterion	Share of projects meeting criterion
1. Origin of technology used	European Union	23	37%
	Host country	26	41%
	Other (mainly Japan, USA)	7	11%
	No data	7	11%
2. New or improved technology, new in the country	Technology transfer	37	59%
	No technology transfer	22	35%
	Unclear	3	5%
	No data	1	2%
3. Capacity-building or knowledge transfer required	Capacity-building	29	46%
	No capacity-building	33	52%
	Unclear	1	2%
	No data	0	0%

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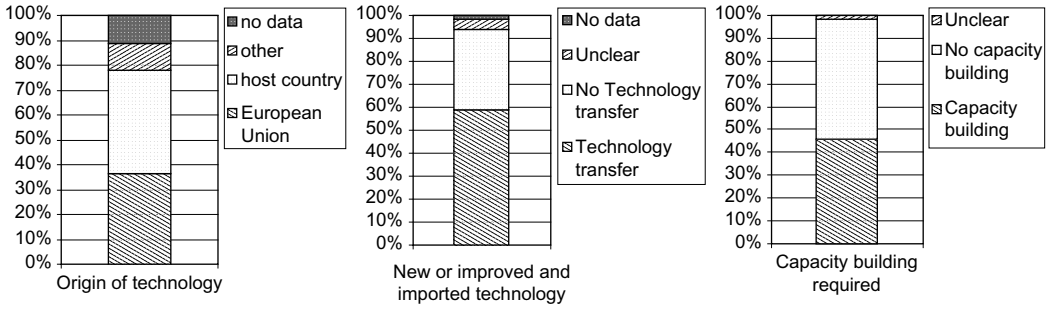


FIGURE 1 Summary of results of the technology transfer criteria analysis in share of the projects

In the power sector, hydropower technology is partly imported from the EU (Spain and France), Japan, Switzerland and the USA, and partly supplied by the host country (India, Peru, Sri Lanka). Wind energy technology originates from Spain and Denmark. Bioenergy for electricity generation originates without exception from the host country.

As for thermal energy, the biogas installations are in some cases from the host country, and in other cases the data are unavailable. With regard to the single efficiency project, its technology originates from the host country, i.e. South Africa. The project that involves fuel switching in industry uses technology from Germany. The technology transfer results per technology are summarized in Table 3.

It is remarkable that many of the projects that might be able to comply with 'sustainability quality brands', such as the CDM Gold Standard (Ecofys, 2005), do not feature technology transfer. The small projects in terms of greenhouse gas emission reductions, energy efficiency, fuel switching in industry, biogas and small-scale biomass-based energy use host country technology, whereas the large-scale projects, especially in the non-CO_2 greenhouse gases, use technology from the European Union or Japan. The power sector shows a more mixed picture: with respect to wind energy, all projects of which the technology origin could be determined show technology originating from the European Union, whereas hydropower technology comes from all over the world. The origin of technology per country is shown in Figure 2.

Even when the greenhouse gas reduction and the technology are known, the size of the investment is not necessarily obvious. For capital costs, the size of the installation is relevant, as opposed to the reduction in tonnes CO_2eq. For wind energy, for instance, the capital costs are expressed in installed capacity (€/MW) but the emission reductions on the produced electricity are expressed in tCO_2/kWh. These units are not readily convertible, as a wind energy project with a load factor of 20% produces less electricity, and therefore reduces less emissions than a project with a load factor of 30%, which may be the case in good wind locations. One needs a significantly higher investment to reach the same GWh electricity production for a less favourable wind location. Similarly, run-of-river hydropower plants have a very different load factor than dam-based hydropower plants. For non-power projects, the investment costs have to be expressed in other units; per tonne of HFC-23 or N_2O destroyed, or per tCO_2 in the case of fuel switching.

The investment costs in this analysis are technology-specific but have not been made location-specific. This is a serious limitation, but general assumptions had to be made of projects that function under fairly diverse conditions. The investment costs are calculated based on the size of the project and the greenhouse gas emission reduction, and on generalized assumptions on

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TABLE 3 Summary of technology transfer and origin of hardware per technology

Technology	Number of projects with technology outside host country of total projects	Percentage of projects technology outside host country	Origin of technology
Biogas	0 of 6	0%	China, India
Biomass	0 of 10	0%	India
Energy efficiency	0 of 1	0%	South Africa
Fuel switching	1 of 1	100%	Germany, USA
HFC-23	2 of 3	67%	Germany, Japan, UK
Hydropower	12 of 22	55%	China, Australia, France, India, Japan, Panama, Brazil, Peru, Spain, Sri Lanka, Switzerland, USA
Landfill gas	8 of 10	80%	Belgium, Netherlands, Japan, France, Brazil, USA
Methane capture	0 of 3	0%	Chile
N_2O destruction	2 of 2	100%	France
Wind energy	4 of 5	80%	Spain/Denmark

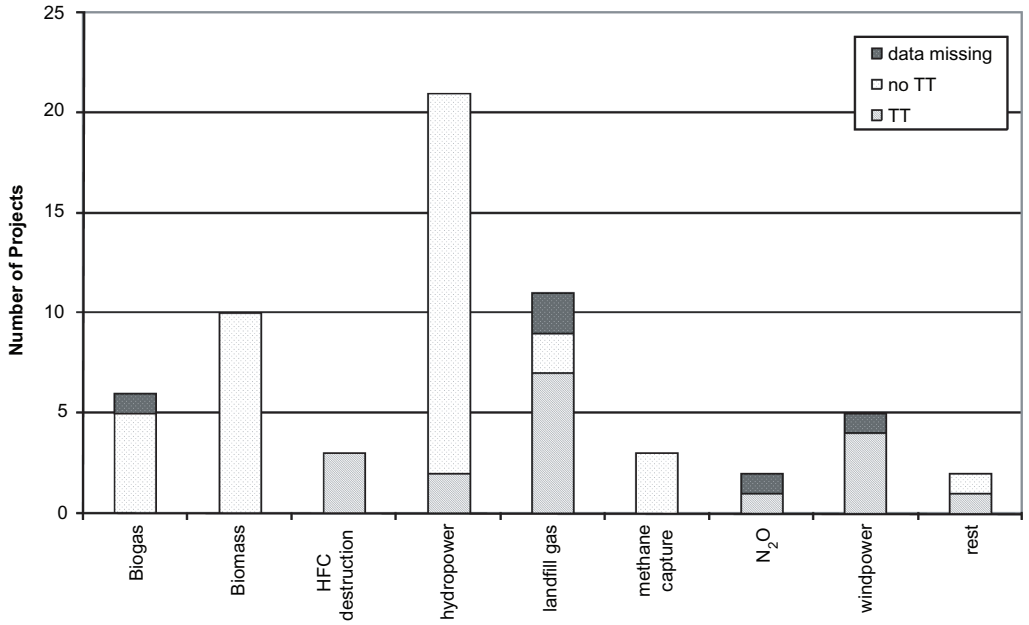


FIGURE 2 Overview of technology transfer per technology (Haake, 2006). For biogas, biomass, hydropower and methane capture, most of the projects use technology from the host country. For HFC and N_2O destruction, landfill gas, and wind energy, most of the projects use technology from the European Union or Japan

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investment costs per unit size. The numbers do not include costs for any soft technology transfer. Table 4 shows the investment costs that are used for different technologies that were transferred. A pragmatic approach was adopted to evaluate investment costs, which was more often led by data availability than by the question what would be the most suitable metric for the investment costs. The numbers in Table 4 should therefore be regarded with a great deal of caution, and should only be used in a general way. Only the projects that meet Criterion 1 (see Section 2) involve the transboundary movement of technology-transfer-associated capital flows, and therefore only those projects are considered in the investment flow analysis.

TABLE 4 Assumptions on metric and investment costs for technologies that are transferred under the registered CDM projects as of 1 January 2006

Technology	Unit for investment costs	Investment costs	References and clarification
Landfill gas	€/kW	1,200[a]	Based on Jansen (1992) and SCS Engineers (1994) (US$1.5 million for 1 MW), and the average GHG reduction per MW in the CDM registered projects of UNEP Risoe is 51.
Hydropower	€/kW	1,958	Investment costs for small-scale hydro from van Sambeek et al. (2003) – MEP tariffs – 2004/2005. It is assumed that 55% of the total investment costs of 3560 €/kW are 'technology costs' and are associated with technology transfer.
Wind power	€/kW	1,000	Investment costs for small-scale hydro from van Sambeek et al. (2003) – MEP tariffs – 2004/2005. It is assumed that some 91% of the total investment costs of €1,100/kW are 'technology costs' and are associated with technology transfer.
HFC-23 destruction	€/tHFC-23/year	15,000	Based on 'expert judgement' of €3 million for 200 tHFC-23/year (Harnisch and Hendriks, 2000).
N_2O destruction	€/tN_2O/year	176	Based on the PDD of the Korean CDM project, which claims an offer by Rhodia of France of €6.5 million for 29,500 tN_2O.
Fuel switching (coal to gas)	€/tCO_2eq/year	23	Based on the PDD of the sole coal-to-gas project (for steam production) in the portfolio: US$550,000 for reduction of 19,438 tCO_2eq.

[a] Most of the investment costs are for the turbine, converting the landfill gas into usable electricity. Many projects, however, do not generate electricity and only claim the emission reductions from the methane flaring. In the case of flaring, the investment costs are: 0.35 × 1,200 because the electricity production is 65% of the total investment cost.

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The main uncertainties and assumptions occur in the following steps and data:

- There are uncertainties in the technology transfer database to start with. For instance: the Dutch supplier of landfill gas technology uses turbines from Germany. These secondary earnings are not taken into account.
- The investment metric has been generalized in many respects. For instance: the unit of €/MW for landfill gas projects is not the most appropriate one – per tonne of waste would, in principle, be better.
- The investment costs themselves originate from different data sources, and in many cases are on an aggregate level. Investment costs for hydropower projects, for instance, vary greatly depending on the project circumstances and the technology used.
- No ranges are given, only 'best estimates'.

According to the data in Section 3, transfer of hardware technology took place in 30 of the 63 projects. However, because in several projects the technology originated from more than one country, the total number of entries in our analysis is 34. In any case with more than one country, it is assumed that the investment value is shared equally among the technology-exporting countries.

Table 5 shows the greenhouse gas emission reductions per exporting country and per technology in tCO_2eq per year. The total amounts to 25.4 $MtCO_2eq$ per year, which constitutes 89% of all emission reductions of registered CDM projects as of 1 January 2006. EU Member States supply technology associated with 23.5 $MtCO_2eq$ per year of emission reduction and other countries (mainly Japan) supply the remaining 1.9 $MtCO_2eq$ per year.

TABLE 5 Greenhouse gas emission reductions through the technology of exporting country, and per technology (numbers in $ktCO_2eq/yr$). The numbers between brackets indicate the total number of projects that transfer hardware technology from the country. Columns and rows may not add up correctly because of rounding errors

Technology-exporting country (number of projects)	Landfill gas	Hydro power	Wind energy	Fuel switch	HFC-23 destruction	N_2O destruction	Total GHG reductions in host country through transferred technology
Belgium (2)	87						87
Denmark (1)			26				26
France (8)	70	135				15,111	15,316
Germany (3)		30		10	3,834		3,873
Netherlands (3)	752						752
Spain (7)		48	366				414
UK (1)					3,000		3,000
USA (5)	279	30	26	10			345
Japan (3)	135	0.3			1,400		1,535
Switzerland (1)		30					30
Total (34)	1,323	274	417	19	8,234	15,111	

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TABLE 6 Investment costs per technology and exporting country for the registered CDM projects as of 1 January 2006. Numbers are in €million, and columns and rows may not add up correctly because of rounding errors

Technology-exporting country (no. of projects)	Landfill gas	Hydro power	Wind energy	Fuel switch	HFC-23	N_2O destruction	Total
Belgium (2)	0.7						0.7
Denmark (1)			13				13
France (8)	0.6	83				8.6	92
Germany (3)		29		0.2	4.9		34
Netherlands (3)	9.1						9.1
Spain (7)		23	212				235
UK (1)					3.8		3.8
USA (5)	8.0	29	13	0.2			50
Japan (3)	2.0	0.1			1.8		3.9
Switzerland (1)		29					29
Total (34)	21	194	238	0.4	11	8.6	472
Share in total	4%	41%	50%	0%	2%	2%	

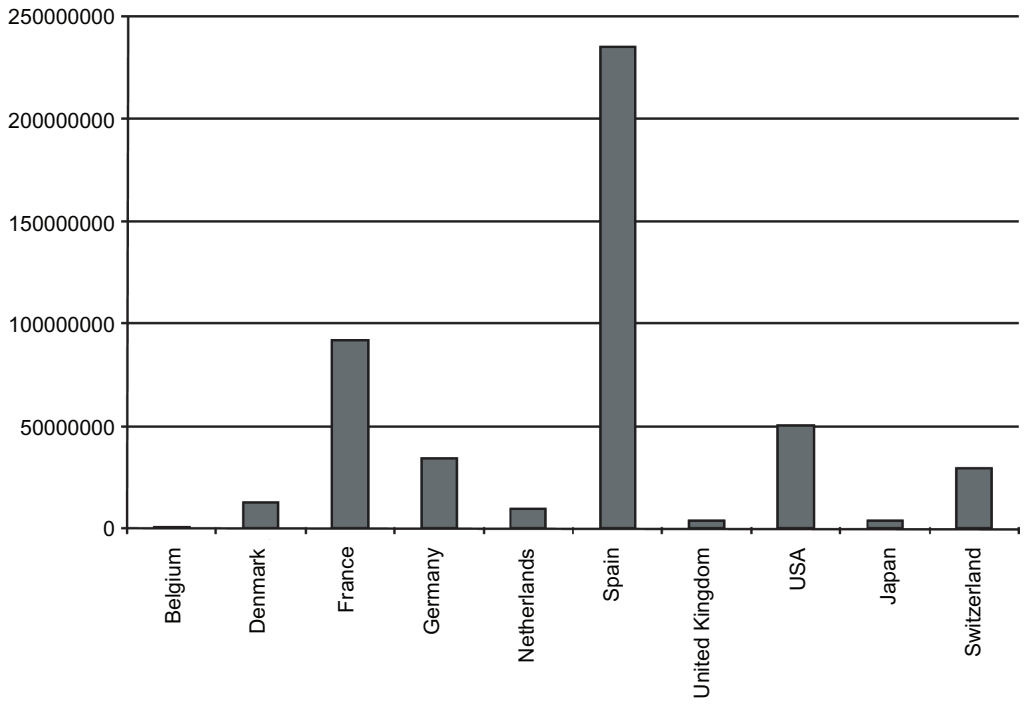


FIGURE 3 Value of exports used for CDM projects (€) per technology-exporting Annex B country

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Based on the above, the detailed project data in our databases and using the investment costs in Table 4, the total investment value per technology and per exporting country can be calculated. The numbers are given in Table 6.

Renewable energy technologies dominate the investment portfolio in the registered CDM projects where hardware technology is transferred. Spain is able to export the highest value of technology, primarily through its supply of wind energy. France also has a high export value, primarily through hydropower. The USA, Germany and Japan also export a substantial value of technology. Denmark, the Netherlands, the UK, Switzerland and Belgium all have small shares. The results per country are given in Figure 3.

5. Discussion and conclusions

We analysed the portfolio of registered CDM projects on 1 January 2006 to clarify whether and how much technology transfer takes place in the CDM. We found that a significant proportion of the projects use technology from outside the host country, notably in large-scale non-CO_2 greenhouse gas projects, and in wind energy. The lion's share of the technology used in the projects originates from either the EU or the host country. In most of the projects, new or improved technologies were used, and in many projects knowledge transfer and capacity-building took place, although these numbers are uncertain. The outcomes confirm that many of the projects that resulted in hard technology transfer also involved knowledge transfer and capacity-building associated with the transfer of new technologies.

In terms of hard technology transfer, the EU exported technology in over one-third of the projects registered under the CDM by the beginning of 2006, notably in non-CO_2 greenhouse gases, wind energy and some of the hydropower projects. In bioenergy, thermal/efficiency and some hydropower and landfill gas projects, much of the technology was locally produced. In general, hardware technology transfer takes place to a larger extent in projects that reduce non-CO_2 greenhouse gases than in renewable energy and energy efficiency projects. The exception is wind energy, for which all projects used technology from the EU.

The value of the investment in technologies originating from industrialized countries is estimated at approximately €470 million, of which €390 million comes from the European Union. Most is spent on renewable energy: about half on wind energy, 40% on hydropower, and the contribution of non-CO_2 greenhouse gas reducing projects is very small: 4%, 2% and 2% of the total for landfill gas, HFC-23 and N_2O destruction, respectively. The investment analysis is surrounded by many uncertainties and assumptions. The numbers should therefore be regarded as a mere approximation of the actual benefits for Annex-B-based companies in the CDM.

It can be instructive to compare these numbers to other money flows. Compared to total foreign direct investment in developing countries, for instance, which amounted to approximately €50 billion in 2002 (Ellis et al., 2007), the investments associated with CDM are small.[1]

It is noteworthy that the allegation that CER-buying countries sponsor their own private sector through buying CERs only from projects that use national technology is not supported by the above data. The large buyers of CERs, such as the Netherlands, The United Kingdom, Japan and Italy, are not the countries that export the highest value of technology to the host countries for CDM projects. It should also be noted that the United States, though not a Kyoto Party, has exported technology valued at around €50 million, which constitutes around 10% of the total export value for CDM projects at the time.

What is the potential for extrapolation of these numbers to the more recent CDM portfolio, which throughout 2006 has grown significantly? Several developments have taken place that will

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significantly influence the numbers presented above, both in the direction of more technology transfer and in the direction of less. First of all, the number of projects has increased rapidly, as well as the number of technologies. As we have not elaborately analysed these new technologies, we can only speculate about their origin, but given the rise in technologies that are widely used in Europe and Japan, particularly in the renewable energy and industrial efficiency sectors, it can be expected that the potential for technology transfer (and the export potential for companies in those countries) to developing countries has not been exhausted. Secondly, and contradicting the first point, there is a trend towards the development of high-technology industries particularly in emerging economies, such as wind turbine industries in India and China. Although these industries still need to gain experience, their location gives them an advantage in terms of costs, and this is likely to increase their market share in the CDM. The balance of these developments might be that the amount of exports of climate-friendly CDM-compatible technologies from industrialized countries will increase, but the number of projects without technology transfer or, for that matter, with non-Annex-B to non-Annex-B technology transfer, will also rise. The extent of these increases will depend on the post-2012 regime and the market that it will provide for the CDM.

Although it has become clear from this article that the CDM generates both hard and soft technology transfer, both the broad data on technology transfer and the cost data should be considered carefully, as they suffer from limited data availability and many arguable assumptions. In order to retrieve better data, local visits and more readily available information are essential. A possible way of resolving the question around technology transfer in the CDM (in a better way than this article could do) would be to encourage project developers to let DOEs report on technology transfer during the validation and/or the verification phases of their projects. This reporting should be done voluntarily, as there is currently no mechanism to make such reporting obligatory. Positive results, however, particularly on soft technology transfer, could increase support for the CDM, as its benefits would be portrayed with more emphasis.

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Note

1. The price of €50 billion is based on the sum of the flows of 'direct investment' and 'other private flows' in Figure 1 of Ellis et al. (2007).

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