Why is a hardware financing policy mechanism like the CDM inadequate to facilitate low carbon technology transfer to many developing countries?

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1.0 Introduction

Many developing countries are in the early stages of unprecedented economic growth (MacKerron, et al., 2008; Linares and Pueyo, 2012). Consequently, there is mounting concern that future growth in energy demand and the accompanying increase in carbon dioxide emissions will be dominated by the largest, fast growing economies, such as Brazil, China and India (OECD, 2002; Garcia, et al., 2011; IEA, 2012; Pueyo, 2013). Reducing greenhouse gas (GHG) emissions in developing countries has therefore become one of the cornerstones towards a future international climate change agreement under the United Nations Framework Convention for Climate Change (UNFCCC). However, imposing caps to developing countries’ GHG emissions has met strong resistance in the current negotiations as caps are perceived as a constraint to future growth prospects (Garcia, et al., 2011).

It is now widely recognised that one of the key ways in which future emissions can be avoided is through the development and use of low-carbon technologies (Urban and Yu, 2009; Mallett and Ockwell, 2012; Lema and Lema, 2013). The development, transfer and use of such technologies have more positive connotations than caps to emissions, and are more widely accepted among developing countries as a way to achieve sustained growth without compromising the climate (Hoffmann, et al., 2008; Garcia, et al., 2011). To date, the UNFCCC has attempted to promote technology transfer through several means: an Expert Group on Technology Transfers (EGTT), Technology Needs Assessments (TNA), and two financial mechanisms: the Global Environment Facility (GEF) and the Clean Development Mechanism (CDM). However, these processes have been largely criticized by a growing body of literature that seeks to assess the degree to which technology transfer has either failed or materialized under these strategies (Pueyo, 2007; Haites and Seres, 2008; Dechezleprêtre, et al. 2009; Wang, 2010; Garcia, et al., 2011; Bynre, et al., 2011a; Mallet and Ockwell, 2012; Lema and Lema, 2013).

It is against this backdrop that this paper seeks to explore the extent to which financial mechanisms such as the CDM are adequate in facilitating technology transfer and fostering technological change and innovation within developing countries. To inform this discussion, this paper will first engage with the broader literature on technology transfer in order to dissect the complexities and variations in defining and measuring this concept, before highlighting the importance of technological change/ innovation and its nexus with sustainable development.

This paper in particular is guided by the notion that technological change and capacity building are critical elements of the technology transfer process, as well as indicators of sustainable development. Given that the twin goals of the CDM are to achieve emission reductions while at the same time promote sustainable development, this therefore implies that the mechanism should encourage technological development and innovation in its intended context.

It is within this analytical framework that the remainder of this paper will set out to examine the nature in which technology transfer has occurred in CDM projects, and whether the current approach contributes or diverges from the wider insights suggested by literature on technology transfer and low-carbon innovation. In light of the fact that the current literature on low-carbon technology transfer has focused predominantly on the fast growing economies commonly called BRIC, (Brazil, Russia, India and China), while neglecting smaller emerging developing economies (Pueyo, 2013), the arguments and ideas presented in this paper will therefore rely upon empirical evidence emerging mostly, though not exclusively from the BRICs.

Ultimately, this paper will argue that the adequacy of the CDM in facilitating technology transfer is a measure of its commitment towards encouraging self-directed development and technological innovation within developing countries. Based on the balance of evidence in support of this claim, this paper will culminate in determining the degree to which the CDM has been adequate in promoting sustainable pro-poor development pathways through technology transfer in developing countries.

2.0 Technology Transfer: A Need for Innovation?

Technology transfer is a highly contested and multi-dimensional concept. While no precise definition currently exists, various attempts across a wide range of disciplines have been made in conceptualising and measuring this term. Within the climate change discourse, the most frequently quoted definition is the one adopted by the Intergovernmental Panel on Climate Change (IPCC) (Das, 2011; Lumbreras, et al., 2012). The IPCC defines technology transfer as '*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, non-governmental organizations, and research or education institutions*' (IPCC, 2000, p.3).

Reflecting upon this definition, it becomes apparent that the scope of technology transfer is not confined to 'equipment' or the hardware element of a technology only, but in fact, it also constitutes a systemic and qualitative nature encompassing software elements like 'know-how' and 'experience', i.e. the knowledge dimension of a technology (Das, 2011; Mallett and Ockwell, 2012). As posited by Lumbreras, et al. (2012), these additional attributes could provide recipient countries with the capacities to install, maintain, and repair imported technologies, replicate and produce lower-cost versions, as well as learn how to adapt and/ or integrate them with local circumstances and indigenous technologies. In other words, the view of technology transcends beyond simply hardware; and its transfer process does not involve a one-time transaction or deployment, but rather, one that privileges technological learning for capacity-building following capital investments (IPCC, 2000; Mallett and Ockwell, 2012).

Although the holistic definition afforded by the IPCC does not appear to exclude any of the aspects desired from a technology transfer process, Zinecker (2011) contends that the current interpretation remains elusive as to what exactly is being transferred. To this end, several authors have distinguished three different flows of transferred technological content involved within international technology transfer, which may provide an indication of 'what' is being transferred (Linares and Pueyo, 2012). According to Bell (1990), the first flow (Flow 'A') encompasses capital goods and equipment, as well as the engineering and managerial services required to set up a system. However, this flow as largely criticized, does not enable the recipient country to utilize imported facilities efficiently, neither generates technological change. The second flow (Flow 'B'), emphasizes the provision of information (know-how) and skills needed to operate and maintain the equipment, but like Flow 'A', does little or nothing for developing innovation capacity; i.e. the skills and knowledge necessary to generate new technology. The third flow (Flow 'C') however, appears to satisfy most if not all of the critical insights underpinning the broader interpretation of technology transfer. In effect, this flow not only embodies knowledge and expertise, but it also promotes active independent learning, creation and innovation, all of which are essential for inducing technological change within the recipient country. Moreover, the characteristics implicit within these three flows (A, B and C) are also described more succinctly by Wang (2010) as: the basic level (know-how), intermediate level (know-what), and advanced or innovative level (know-why) respectively.

It is important to note that while the majority of low-carbon innovation and technology transfer literatures tend to underscore the need for achieving capacities embedded within Flow ‘C’ Mallett and Ockwell (2012) have cogently pointed out that radical innovations are not absolutely necessary in all given contexts. Instead, they argue that the ability of developing countries to create incremental and even adaptive innovations is perhaps more important in facilitating their ‘catching-up’ with other technological frontiers. In this regard, the capacity to innovate, be it, incremental or radical, can be treated as a lynchpin for achieving technological development.

In a similar vein, the insights suggested by innovation studies also have paramount importance to developing countries particularly from the standpoint of climate change mitigation (Pueyo, 2007). As noted by Egelyng, et al. (2009), while the contribution of global emissions from many least developed countries (LDCs) is relatively insignificant at present, in the longer term, should these countries pursue their business-as-usual trajectories, this trend will undoubtedly change. Moreover, despite the fact that these countries and like-minded fast-growing economies including China and India possess the ambition to develop low-carbon pathways, they nevertheless lack adequate financial capacity to upgrade their energy sectors for the sake of GHG reductions (Wang, 2010). As such, internationally assisted technology transfer is therefore critical to help these countries realize their role in shaping global climate change mitigation outcomes. However, as argued by many authors, the acquisition of low-carbon technologies, while necessary, is not sufficient for a sustained impact on the carbon intensity of economic activities within developing countries. In particular, from a developing country’s perspective, it is critical that the firms and companies in their country own these technologies, as well as acquire the skills and expertise needed to develop indigenous low-carbon innovation (MacKerron, et al., 2008; MacKerron, et al., 2009; Urban and Yu, 2009; Byrne, et al., 2010; Pueyo, 2013). In other words, the transfer of low-carbon technologies needs to facilitate the broader process of technological change, since it is technological capacity and innovation that are necessary for sustained economic development and energy security (Ockwell, 2009; Byrne, et al., 2011a; Zinecker, 2011).

Having discussed the inherent difficulties in conceptualising technology transfer, it is important to note that measuring the outcome of this process is equally complex since technology in its broader sense has no measurable physical presence or well-defined price (IPCC, 2000). As a result, the majority of economic literature have opted to use indirect techniques of measurement such as total factor productivity (TFP), or indexes that emphasize inputs into technological achievement such as education levels, numbers of scientists and engineers, expenditures on research and development, or the number of patents granted (Lumbreras, et al., 2012). Furthermore, in light of the critical insights suggested thus far, the following section will analyse the approach of technology transfer implemented by the CDM with the hope of determining whether this financing mechanism is adequate in facilitating technology transfer in its broader sense.

2.1 The Clean Development Mechanism: A Vehicle for Technological Development or Deployment?

The Clean Development Mechanism (CDM) was developed by the Kyoto Protocol with the intention of reducing the compliance costs for industrialised countries by financing projects that reduce GHG emissions in developing countries (Linares and Pueyo, 2012). Although this financing mechanism is not explicitly mandated to contribute to technology transfer, it nevertheless performs this function indirectly by financing emission reduction projects that utiltise environmentally sound technologies not currently available within recipient countries; thus encouraging sustainable development (Mallett and Ockwell, 2012). In effect, the CDM as a financing mechanism has a two-fold objective which sets out to bridge the issues of climate change mitigation with that of sustainable development. However, the CDM as a vehicle for facilitating technological change has been widely criticized as inadequate within innovation studies and low-carbon technology transfer literature (Pueyo, 2007; Haites and Seres, 2008; Dechezleprêtre, et al. 2009; Wang, 2010; Garcia, et al., 2011; Bynre, et al., 2011a; Mallet and Ockwell, 2012; Lema and Lema, 2013).

Among the most pressing arguments in support of this critique is that the CDM appears to privilege specific pathways over others, thereby reinforcing static comparative advantage. As pointed out by both Mallett and Ockwell (2012) and Silayan (2005), the investments generated from the CDM reflect an obvious cluster and bias towards a selected group of large developing countries, namely China, Brazil and India. In fact, current trends reveal that China holds the highest concentration of CDM projects, distantly followed by Brazil and

India. Collectively, as of June, 2010, these three nations represented 72 % of all registered CDM projects, and 77 % of the associated GHG emission reduction.

Coincidentally, these countries also possess high levels of absorptive and technological capacities to host low-carbon energy projects, and the projects themselves are often large-scale in nature, and restricted to a narrow range of technologies that are already relatively mature to guarantee a profitable generation of certified emission reductions (CERs) (Hoffmann, et al., 2008; Dechezleprêtre, et al. 2009; Mallett and Ockwell, 2012). In effect, the CDM tends to favour particular countries which offer the highest emission reduction opportunities and have national industries or supporting policies which complement the selected technologies currently financed. In other words, the CDM only encourages investments in specific technologies (e.g. hydro, wind, methane avoidance, biomass energy and land fill gas) that coincidentally fit well within certain settings that represent lower technical, political and economic risks. As a result, this financial mechanism reinforces static comparative advantage, thus marginalizing the poorer countries especially the LDCs which cannot replicate the favourable conditions of the BRICs (Karani, 2002; Pueyo, et al., 2011; Zinecker, 2011; Mallet and Ockwell, 2012). As cogently pointed out by Byrne, et al. (2012), the reason for this inability to replicate, and more importantly, the CDMs inadequate contribution to technology transfer in the LDCs relates to the fact that the innovation systems of many poorer countries are presently underdeveloped, which in turn, makes the process of developing and strengthening innovation systems challenging. In effect, given the skewed distribution of CDM investments, the countries which actually desire access to low-carbon technologies are not the ones that actually derive this benefit. Hence, the CDM may be considered inadequate since it fails to facilitate technology transfer in the contexts where is it mostly needed. Moreover, as cautioned by many authors, since this particular pathway that the CDM privileges does not enable self-directed development or improved energy access to poorer countries, many developing countries may therefore become locked into carbon-intensive development trajectories (Byrne, et al., 2011a; Mallett and Ockwell, 2012).

In addition, this paper posits that the above-mentioned argument is closely linked to the fact that the CDM is guided by an inadequate and flawed conception of technology transfer as merely hardware deployment; rather than the broader processes encompassing technological accumulation (Byrne, et al., 2011a; Mallett and Ockwell, 2012). Furthermore, some argue that this current notion of technology transfer as a 'hardware-finance' framing is inherently due to the lack of adoption of a precise definition of technology transfer by the UNFCCC. Consequently, the CDM tends to analyse technology transfer largely on the basis of vague statements enshrined within individual project design documents (PDDs). These PDDs universally interpret technology transfer as simply the use of equipment and basic-level technological capacity (know-how) not previously available within a host country. As such, this narrow-minded view of technology transfer clearly neglects the delivery of the software elements e.g. tacit knowledge, needed for improving productive capacities, and ensuring a successful and sustainable transfer process. In other words, as suggested by Haites and Seres (2008), the CDM only focuses on rapid diffusion of equipment and basic knowledge needed to implement a project, rather than the recipient country's capacity to manufacture or develop the technology, hence, the general conclusion of the CDM's inadequacy in facilitating technology transfer.

Furthermore, this paper has recognised that the CDMs inadequacy to facilitate technology transfer in a more holistic sense is not only driven by its narrow understanding of what technology transfer is, but perhaps more importantly, by the influence of political and economic interests to uphold this vague interpretation. As the old proverbial saying goes "*give a man a fish and you feed him for a day; teach a man to fish and you feed him for a lifetime*" (Ritchie, 1885). This paper opines that this simple proverb has a significant analogy to the current discourse on technology transfer, and therefore, it lends itself usefully. As stated previously, it is the industrialized nations that mainly develop and remain in control of low-carbon technologies (in effect, they own the '*fish*'). However, as implied from the growing body of literature on technology transfer, should these countries, who are coincidentally the key actors driving the CDM agenda, provide developing countries with the sort of tacit knowledge needed for innovation (*teach them how to fish*), this will place them at an economic disadvantage (Ockwell, 2009). To this end, this paper argues that the developed world remains fixated upon the inadequate and flawed conception of technology transfer as merely hardware deployment (*access to the fish only*) because this interpretation maintains their static competitive advantage over other countries that are rapidly becoming their competitors. In this regard, one can therefore conclude that the approach of the CDM is inadequate in facilitating technological accumulation within recipient countries, and at the same time, it undermines its sustainable development commitments (Linares and Pueyo, 2012). In effect, the developing world remains perpetually dependent upon *'access to the fish'* from the more developed countries, rather than the ability to '*fish on their own*'.

Despite the inadequate conception of technology transfer implicit within PDDs, various studies have frequently relied upon these documents as a methodology for analysing technology transfer claims under the CDM. While the findings from such studies do not explicitly demonstrate the development outcomes of

CDM projects in practice, they nevertheless indicate the scope of hardware deployment and operational knowledge transferred across specific contexts. For instance, Haites and Seres (2008) analysed technology transfer claims made within the PDDs of 3296 projects in the CDM pipeline as of June, 2008. The findings from this study revealed that approximately 36% of registered projects (accounting for 59% of estimated emission reductions) claimed to involve some form of technology transfer. Moreover, 53% of the projects claimed to involve transfers of both equipment and knowledge, while 32% relied on only imports of equipment, and 15% claimed the transfer of knowledge only. Similar findings were also revealed by an earlier study conducted by Pueyo (2007) who analysed technology transfer in a sample of 15 CDM host countries: using 938 PDDs, which represented 60 % of the CDM pipeline in April 2007. The analysis of this study also showed that only around 35% of the CDM projects claimed to involve technology transfer at that time. However, more recently, a study conducted by Das (2011) suggested that the contribution of the CDM to technology transfer was minimal. After analyzing 1000 projects, Das (2011) noted that only 265 claimed to involve technology transfer. Among these, the majority (259 projects) qualified for technology transfer in which technological learning and capability building were restricted to the level of operation and maintenance of the imported equipment, whereas, the remaining 6 projects involved technology transfer in which the recipient country either collaborated with a foreign entity in developing a technology, or utilized in-country technological capacities to improve upon the imported equipment.

The main point to note here is that these three independent studies clearly showed that the CDMs approach towards technology transfer is one that is confined to the deployment of equipment and basic/ operational knowledge, which are not originally available within target locations. It is for this reason that the authors of these studies have concluded that the CDM as a vehicle for technological change is grossly inadequate since the current transfer process does not equip recipient countries with the level of capacity (beyond basic/ operational knowledge) needed for facilitating technological innovation and self-directed low-carbon development. Furthermore, although few studies (Doranova, 2009 and Disch, 2010) have extended beyond the scope of PDDs in analyzing technology transfer, the general conclusion drawn from such studies is that little is still known about the development outcomes from the transfer process under the CDM. However, for the most part, these studies all posit with great certainty that the priority of the CDM remains focused on economically efficient emission reductions, whilst sustainability goals and technology transfer are treated as secondary benefits; restricted to the acquisition and financing of hardware.

In light of the above-mentioned insights, this paper has recognised that the implications of the 'hardware-finance' framing of technology transfer by the CDM are far-reaching especially in the context of China. According to Wang (2010), while the CDM has helped to increase investments in low-carbon projects in China, the nature of technology transfer (introduction of foreign equipment and training in operational skills alone) promoted under this mechanism has failed to coincide with the country's current policy priorities. Over the years, the government of China have formulated comprehensive legislations and policies specifically aligned towards facilitating technological development at the intermediate (know-what) and advanced or innovative levels (know-why) within the country. Bearing in mind that the country already possesses high absorptive capacity in comparison to other developing nations, the desire for more advanced technological capacities that can facilitate radical innovations should not be surprising. In other words, since China already has the supporting operational knowledge for most matured low-carbon technologies, as well as access to local substitute technologies, any technology transfer mechanism designed to provide simply access to foreign equipment and basic knowledge would not encourage the form of innovation-building expected within China. Unfortunately, as echoed throughout most of this paper, technology transfer under the CDM only delivers low-level (basic knowledge/ know-how) capacity which in effect, would not contribute towards realizing China's vision, and hence, the country's low-carbon innovation is hindered.

Despite the fact that the current approach of technology transfer employed by the CDM does not foster a transformation in local contexts by facilitating innovation-building, Wang (2010) has nevertheless shown that the rate of technology transfer in the narrow sense of 'equipment deployment' has still contributed meaningfully in specific sectors of China where local substitute technologies did not previously exist. In fact, the findings which emerged from Wang's study clearly demonstrated that the projects dealing with the decomposition of the industrial gases: nitrous oxide (N_2O) and hydroflurorcarbon-23 (HFC-23) represented the highest rates (91% and 100 % respectively) of technology transfer involving foreign equipment deployment and training in operational know-how. However, for other sectors such as coal mine methane, wind power and central waste heat recovery (CWHR), the transfer rates were much lower, accounting for 26.7%, 28.7 % and 6.7% respectively (Wang, 2010).

In light of the lower rates of technology transfer noted in the latter sectors mentioned above, this has raised yet another contentious issue within the current discourse. Notably, some authors have reported that technology transfer rates in general, have been steeply declining overtime among the BRICs (Achanta, et al., 2012). Within the current literature on technology transfer, this declining rate is said to be based upon the common assumption that earlier CDM projects would have contributed towards seeding local innovation (knowledge, skills and experiences) within recipient countries, through which later projects would rely upon, hence, reducing the need for additional foreign technology and operational knowledge to be deployed (Haites and Seres, 2008). As a result of this assumption, the CDM tends to be praised for creating the original capacities among the BRICs (for specific technologies), and therefore, the declining rates of technology transfer are misinterpreted as an indicator of innovation driven by the CDM. However, as many critics have strongly argued, this assumption is largely misleading since in their opinion, the CDM did not play an instrumental role in developing the original capacities observed among the BRICs, particularly, China and India (Lema and Lema, 2013). This conclusion was drawn mainly from the analyses of various CDM projects engaged within the wind turbine industry; one of the more matured technologies within the spectrum of low-carbon technologies currently financed under the CDM.

To demonstrate the above argument more clearly, it should be noted that the current capacities and innovation within the wind power industry of both China and India were developed following years of experimentation with a diversity of transfer mechanisms involving joint ventures, licensing agreements, foreign direct investments, and even the development of ambitious industrial and energy policies such as the 70% local content requirements, in the case of China (Wang, 2010; Lema and Lema, 2013). As noted by Byrne, et al. (2010), these efforts were instrumental in encouraging foreign technology providers to move their production operations to these countries, thus contributing to the level of domestic innovation evident today. Moreover, it should be noted that in China, wind turbines were imported and assembled in adhoc plants from since the mid-1980s, whereas, the first CDM projects started to generate carbon credits until 2003 (Lema and Lema, 2013). In other words, the wind turbine market in China had already matured long before the introduction of the CDM. Similarly, in the case of India, this country had also experimented with subsidiaries and joint ventures prior to the CDM in establishing its wind turbine industry. The point to note here is that the current CDM wind power projects implemented within India and China are in fact a reflection of pre-existing transfer mechanisms. As such, the assumption that the CDM played a spearheading role in enhancing technological innovation is flawed since most of the advanced skills and capabilities within the wind sector were developed independent of this mechanism. It is on this premise that Lema and Lema (2013) have concluded that technology transfer under the CDM is more or less an effect rather than a primary cause of the domestic capabilities found in India and China. To this end, it is clear that the declining rate of technology transfer under the CDM does not reflect the success of this mechanism, but rather, the pre-existing innovation that was cultivated within these countries independent of the CDM. Such findings therefore justify the inadequacy of the CDM in facilitating technology transfer since the mechanism clearly does not promote technological change or a transformation in local contexts.

Based on the arguments and ideas presented in this paper, it is evident that the CDM's inadequacy in facilitating technology transfer is a result of a multitude of factors driven by political, economic, social, and environmental influences. Furthermore, while the proponents behind this financial mechanism continue to advocate for the need to create enabling policy environments within developing countries (beyond the BRICs) that are conducive for CDM investments, this paper strongly opines that unless a reform of the CDM is made to broaden its understanding of technology transfer (in keeping with the wider insights suggested earlier), any changes at the national level aimed towards achieving technological change through the CDM, would remain futile. In other words, it is crucial that the CDM extends beyond its current, narrow framing of technology transfer in order to contribute more meaningfully towards ensuring self-reinforcing low-carbon development pathways among developing countries.

3.0 Conclusion

This paper sought to examine the extent to which the hardware financing policy mechanism, CDM, facilitates technology transfer in developing countries. Based on the ideas and arguments presented, the CDMs approach in the transfer of low-carbon technology may best be described as inadequate.

This pessimistic outlook was based on a multitude of overlapping factors discussed within this paper. Among the most pressing arguments, included the fact that the CDMs approach in promoting low-carbon development is one which tends to favour specific pathways over others; pathways which encompass countries possessing high absorptive capacities, and large-scale projects limited to a narrow range of relatively matured technologies. As a result, the CDM reinforces static comparative advantage, thus leading to a marginalization of many poorer countries which simply cannot replicate the enabling conditions needed for CDM investment. Hence, these countries do not benefit from improved energy access and are therefore more inclined to follow carbon-intensive pathways.

Additionally, this paper also noted that the CDM's interpretation of technology transfer is based on a flawed conception which neglects the transfer of tacit knowledge needed for innovation-building. Consequently, this mechanism may be considered inadequate since it fails to foster technological change within recipient countries or enable self-directed low-carbon development. This particular argument was largely supported by empirical evidence from the wind power sectors of both China and India. The findings highlighted by various studies clearly demonstrated that although the CDM would have provided access to foreign equipment and operational knowledge within these countries, this mechanism simply did not play an instrumental role in seeding local innovation in either of the contexts examined; thus justifying its inadequacy as a tool for facilitating technology transfer.

Therefore, this paper purports that, unless a reform of the CDM is made to broaden its understanding of technology transfer (beyond its current 'hardware-finance' framing), to facilitate technological change and innovation; its commitment towards promoting sustainable development would remain weak.

4.0 References

Achanta, A., Erickson,P., Fecher, S. R., Haites, E., Lazarus, M., Pahuja, N., Pandey, N., Seres, S., Tewari, R., 2012. Assessing the Impact of the Clean Development Mechanism. Available at: http://www.cdmpolicydialogue.org/research/1030_impact.pdf [Accessed:14/05/2013].

Bell, M., 1990. *Continuing Industrialisation, Climate Change and International Technology Transfer*, Report prepared in Collaboration with the Resource Policy Group, OSLO and Science Policy Research Unit, University of Sussex, Brighton, U.K. December.

Byrne, R., Ockwell, D., Stua, M., Watson, J., 2010. Low Carbon Technology Transfer: Lessons from India and China. Sussex Energy Group Policy Briefing Number 9. Available at: https://www.sussex.ac.uk/webteam/gateway/file.php?name=low-carbon-tech-transfer-briefing---nov-101.pdf&site=264 [Accessed:16/05/2013].

Bynre, R., Ockwell, D., Smith, A., Watson, J., 2011a. Energy Pathways in Low Carbon Development: From Technology Transfer to Socio-Technical Transformation, STEPS Working Paper 46, Brighton: STEPS Centre. Available at: http://steps-centre.org/wpsite/wp-content/uploads/Energy_PathwaysWP1.pdf [Accessed: 14/05/2013].

Bynre, R., Ockwell, D., Stua, M., Watson, J.,2011b. UK-China Collaborative Study on Low Carbon Technology Transfer, Final report. Available at: http://www.tyndall.ac.uk/sites/default/files/uk-china_final_report_-_april_2011_0.pdf [Accessed:14/05/2013].

Byrne, R., de Coninck, H., Gallagher, K., Ockwell, D., Sagar, A., Schoots, K., Watson, J., 2012. Innovation systems in developing countries. Policy Brief. Climate Technology and Development Project. Available at: http://unfccc.int/ttclear/sunsetcms/storage/contents/stored-file-20130422151216227/ECN_EE.pdf [Accessed: 14/05/2013].

Das, K., 2011. Technology Transfer under the Clean Development Mechanism: an empirical study of 1000 CDM projects. The Governance of Clean Development. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1887727 [Accessed: 14/05/2013].

Dechezlepretre, A., Glachant, M ., Meniere, Y., 2009. Technology transfer by CDM projects: A comparison of Brazil, China, India and Mexico. *Energy Policy* 37: 703–711.

Disch, D., 2010. A comparative analysis of the ‘development dividend’ of Clean Development Mechanism projects in six host countries. Centre for Environmental Policy, Imperial College London. Available at: http://www.highbeam.com/doc/1G1-225740706.html [Accessed: 14/05/2013].

Egelyng, H., Fjalland, M., Funder, M., Ravnborg, M. H., 2009. Low Carbon Development and Poverty Alleviation: Options for Development Cooperation in Energy, Agriculture and Forestry. Denmark: Danish Institute for International Studies. Available at:

http://www.diis.dk/graphics/Publications/Reports2009/DIIS_Report_200920_Low_Carbon_Development_and_Poverty_Alleviation.pdf [Accessed: 17/05/2013].

Garcia, R., Mendiluce, M., Morales, D., Pueyo, A., 2011. The role of technology transfer for the development of a local wind component industry in Chile. *Energy Policy* 39: 4274–4283.

Haites, E., and Seres, S., 2008. Analysis of Technology Transfer in CDM Projects. Available at: http://cdm.unfccc.int/Reference/Reports/TTreport/TTrep07.pdf Accessed: [14/05/2013].

Hoffmann H. V., Holzer, A., Schneider,M., 2008. Understanding the CDM's contribution to technology transfer. *Energy Policy* 36: 2930– 2938.

IEA., 2012. Energy Technology Perspectives, Paris: International Energy Agency.

IPCC., 2000. Special Report: Summary for Policymakers Methodological and Technological Issues in Technology Transfer Available at: http://www.ipcc.ch/pdf/special-reports/spm/srtt-en.pdf [Accessed:18/05/2013].

Karani, P., 2002. Technology Transfer in Africa: Constraints for CDM Operations. Refocus. Available at: http://www.sciencedirect.com/science/article/pii/S1471084602800373 Accessed: [14/05/2013].

Lema, A., and Lema, R., 2013. Technology transfer in the clean development mechanism: Insights from wind power. *Global Environmental Change* 23: 301–313.

Linares, P., and Pueyo, A., 2012. Renewable Technology Transfer to Developing Countries: One Size Does Not Fit All. Institute of Development Studies. Available at: [Accessed: 14/05/2013].

Lumbreras, J., Mendiluce, M., Naranjo, M., Pueyo, A., 2012. How to increase technology transfers to developing countries: a synthesis of the evidence. *Climate Policy*, 12:3.

MacKerron, G., Ockwell, D., Pal, P., Watson, J., Yamin, F., 2008. Key policy considerations for facilitating low carbon technology transfer to developing countries. *Energy Policy* 36: 4104– 4115.

MacKerron, G., Mallett , A., Ockwell, D., Watson, J., Verbeken, A., 2009. A blueprint for post-2012 technologytransfer to developing countries. Sussex Energy Group Policy Briefing Number 5. Available at: https://www.sussex.ac.uk/webteam/gateway/file.php?name=techo-briefingweb1.pdf&site=264 [Accessed:16/05/2013].

Mallett, A., Ockwell, D., 2012. *Low-Carbon Technology Transfer: From Rhetoric to Reality*. Routledge Publishing, London and New York.

Ockwell, D., 2009. Transferring Clean Technologies to Developing Countries. Institute of Development Studies (IDS). Available at: http://www.youtube.com/watch?v=SlbVnvIQKG0 [Accessed:15/05/2013].

OECD., 2002.EnvironmentDirectorate,Environment Policy Committee, Working Party on Global and Structural Policies, Environmental Benefits of Foreign Direct Investment: a Literature Review. OECD, Paris.

Pueyo, A., 2007. Magazine on the Kyoto Mechanisms, Vol. 13 - No. 3. Paterswolde, the Netherlands. Available at: [Accessed: 14/05/2013].

Pueyo, A., 2013. Enabling frameworks for low-carbon technology transfer to small emerging economies: Analysis of ten case studies in Chile. *Energy Policy* 53: 370–380.

Ritchie, T. A., 1885. *Mrs. Dymond*. Smith, Elder & Company.

Silayan, A., 2005. Equitable Distribution of CDM Projects Among Developing Countries. Hamburgisches Welt-Wirtschafts-Archiv (HWWA) Hamburg Institute of International Economics. Available at: http://ageconsearch.umn.edu/bitstream/26098/1/re050255.pdf [Accessed:14/05/2013].

Urban, F., and Yu, W., 2009. Climate Change, Energy and Low-Carbon Development in the Chinese Context. IDS in Focus Policy Briefing 8.2.

Wang, B., 2010. Can CDM bring technology transfer to China?—An empirical study of technology transfer in China's CDM project. *Energy Policy* 38: 2572–2585.

Zinecker, A., 2011. Low carbon technology transfer to least developed countries: case study of a Senegalese-German renewable energy project for rural electrification. University of Sussex. School of Global Studies.