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Technology Transfer under the Clean Development Mechanism

A case study of conflict and cooperation between Germany and China in wind energy

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Zusammenfassung

Diese Studie untersucht, ob deutsche Hersteller von Windturbinen ihre Technologie im Rahmen des *Clean Development Mechanisms* nach China transferieren würden. Die Studie gibt als erstes eine Einführung zum Clean Development Mechanism. Anschließend werden die Interessen und Ziele der am Transferprozess zwischen Deutschland und China beteiligten Akteure diskutiert. Um die Komplexität des Themas Technologietransfer zu reduzieren und die relevanten Aspekte zu unterstreichen, wird ein Modell für Technologietransfer auf Grundlage der Neo-Schumpeterianischen Einsichten über die Rolle von Technologie bei wirtschaftlicher Entwicklung entwickelt. Nach der empirischen Untersuchung der Neigung deutscher Firmen zum Transfer von Technologie nach China, kommt die Studie zu folgenden Aussagen.

- Deutsche Hersteller von Windturbinen sind bereit, ihre Technologietransfer Aktivitäten auszuweiten, warden aber immer Schlüsseltechnologien für sich behalten
- Zentral für den Transfer weiterer Technologie ist nach Ansicht der deutschen Firmen eine verbesserte Finanzierung und eine bessere politische Unterstützung von Windenergie ind China
- Das Konfliktpotential innerhalb des Technologietransfer-Prozesses ist höher als in der politischen Rhetorik um den Clean Development Mechanism angegeben
- Ein Kompromiss zwischen allen Beteiligten Akteuren hat vermutlich einen Trade-off zwischen ökonomischen und Umweltzielen zur Folge.

Abstract

This study investigates the willingness of German wind turbine manufactures to transfer their technology to China within the frame work of the *Clean Development Mechanism*. In order to so, the study undertakes the following steps: It gives an introductory explanation of the Clean Development Mechanism. It then discusses the goals and interests of the four main actor groups of a technology transfer project between Germany and China. To better understand the dimensions and issues at stake within technology transfer, a theoretical model of technology transfer based on Neo-Schumpeterian insights about the role of technology in economic development is evoked.

After assessing the German firms' willingness to undertake technology transfer to China via an empirical case study, the study concludes the following:

- German wind turbine manufactures are willing to extend their technology transfer activities, but they will always keep key technology
- Essential for further transfer are in the view of the German firms more finance and a better political support structure for wind energy in China
- The potential for conflict in technology transfer is higher the in the political rhetoric around the Clean Development Mechanism acknowledged
- Finding a compromise between all actors will most likely entail a trade off between economic and environmental goals

Der Autor

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1 Introduction

With the increase of greenhouse gases (GHG) resulting from human activity in the atmosphere, the threat of climate change arises. Since the Kyoto Protocol was adopted in 1997, industrialised countries have engaged in legally binding obligations to reduce their emission on GHG via domestic action or, with the help so called flexibility mechanisms, through international collaboration. One of the three, the Clean Development Mechanism (CDM), is deemed for the reduction of GHG and to provide clean technology for countries which are on their way to industrialisation. The mechanism allows industrialised countries to invest in climate protection projects in developing countries. Those efforts will be credited on their emission allowance if they are willing to share the necessary technology for future use. Developing countries shall this way not only be integrated into climate protection, but are in theory also offered easy access to new technologies, more energy efficient, cheaper production methods and the modernisation of their energy supply systems. Technology transfer, if the CDM is going to be taken seriously, will therefore become a central aspect of CDM projects.

Since most environmentally sound technology is embodied in firms, private actors are an indispensable part of CDM projects and commercial viability is one of the overall aims of the projects. As Forsyth points out, the inclusion of private investors creates opportunities but also entails a conceptual gap. While the public sector understands and defines technology transfer within the context of climate change in terms environmental and social development, private companies define technology transfer in terms of joint ventures, licensing, and contracting, which indicates the commercial nature of technology sharing between different companies (Forsyth 1999). This difference opens up the potential for conflict stemming from differing interests and irreconcilable goals.

The success of CDM projects depends partly on overcoming the conflicts based on the differing interests of participating actors. If managed well, the CDM becomes a channel for emission reductions and technological advancement of less developed countries. If managed badly, the CDM becomes a means of collecting paper credits with neither environmental nor social benefits. The identification and resolution of conflicts is therefore critical.

This study explores the potential conflicts within a Clean Development Mechanism project between the supplier and the recipient firm of a technology. The CDM was designed to be mutually beneficial for all parties and projects have been labelled win-win situations. The transfer of technology involves various stakeholders with considerably differing interests and it is not clear from the outset that those opposing interests might suddenly turn into common interests within the framework of the CDM. The main research question is therefore: Will firms transfer green technology within a CDM project? And if so, will technology transfer be sustainable and in accord with the goal outlined within the Kyoto Protocol? The research proposition is that the process of technology transfer bears more potential for conflict than the political rhetoric surrounding the CDM acknowledges. Having identified and evaluated the firm's willingness (or non-willingness), the overall aim of the research is two-fold. It firstly seeks to discuss the aspect of technology transfer within the CDM in a differentiated way to better evaluate the likelihood of achieving its double goal of environmental protection and social development. It secondly seeks to discuss opportunities to minimise conflicts within a CDM project.

In order to answer the research question, a case study was conducted investigating the willingness of German wind turbine manufactures to transfer their technology to China. Therefore, a number of semi-structured interviews were conducted with representatives of German wind turbine manufacturers. Choosing a case study based on one industry sector and the co-operation between two countries is of course of limited valued to speak for other industrial sectors and other countries. However, some generic problems can be illustrated to inform further study. Also, wind energy technology is, as will be discussed later, is a key technology within CDM projects and therefore an important area of study in relation to climate change.

To disentangle the complexity of CDM projects, as a first step the main actors of a CDM project between Germany and China in the field of wind energy technology were singled out and their main interests and motivations to engage in a CDM project described. Interviews were conducted with relevant policy makers to gain first hand insight into the current status and future plans of German CDM policy. To further assist the analysis of the CDM, a theoretical model of technology transfer based on Neo-Schumpeterian insights about the role of technology in economic development was evoked to understand the sources of conflict within the process. Also, the practice of European firms transferring technology to China was highlighted. To empirically verify the theoretically suggested conflicts, interviews were conducted with representatives of the German wind turbine manufacturing industry.

2 Political relevance of study

CDM policy and project development are at an intermediate stage of development in Germany. However, there are a number of reasons to investigate the potential for conflict and the feasibility for the transfer of technology within the CDM now. It, first of all, does make sense to identify potential problems at an early stage of institutional and project development. The existing CDM framework is still flexible enough to undergo changes if based on reasonable criticism. Secondly, the opportunities associated with the CDM have so far been mostly measured on a purely quantitative basis[1]. More qualitative aspects like the nature of technology transfer have been neglected. Thirdly, some attempts are currently made to evaluate recent development projects in the climate sector with respect to how the experience gained in these projects can be used in developing rules and guidelines for future CDM projects (Beuermann et. al 2000). While these attempts are based on historical experience, this study places itself in an opposite but complementary angle to these efforts by researching the present expectations and interests of relevant CDM project participants for the future. Furthermore, a number of national CDM capacity building projects in China have just been finished. These projects have however focussed on the exploration of CDM opportunities and Chinese needs to successfully implement CDM projects (Zhang 2004). These projects also neglect the process of technology transfer as such.

Renewable energy sources hold a considerable potential for reducing CO2 emissions. Since nuclear power was ruled out in the Marrakech accords as a means to account for emission reductions through the CDM, and the controversial character of large hydro projects cannot be overlooked anymore, the increase of renewable energy sources remains the most promising way to abate CO2 in the long term. Opposite to fuel switching or energy efficiency measures, which also hold a big potential for reducing CO2, renewable energies have the advantage of fully replacing the emission source. The potential for wind energy is huge. Various estimations conclude that it can contribute up to 10 per cent of energy generation world wide (AWEA 2002: 8).

It is therefore evident that wind energy should rank high on the CDM policy agenda. Also, the German wind energy industry must find new markets abroad if its growth rates shall continue and wind energy prices shall become more competitive in relation to other energy sources. China seems to be one of the most important partners in that respect since its potential for wind energy is estimated to be vast and Chinese authorities have repeatedly stated their interest in the corresponding technology. Despite the Chinese interest, wind energy business is still very difficult in China and extra finance could be a measure of keeping the operations of European firms going.

2.1 The potential for wind energy in China

Wind resources in China are considered high, especially in the north and along the south east coast line. The total available wind energy in China has been estimated at 3.2 TW. The Ministry of Electric Power estimates the exploitable electric potential (at 10 m tower height) to be 253 GW. The potential could double with a tower height of 50 m to 500 GW (Lew 2000: 273).[2] Wind energy technology can be divided into large and small-scale applications, which differ through the size of the turbine and the amount of electricity generate. Typical large-scale wind turbines generate between 250 KW and 1, 8 MW. They are used to set up wind parks serving the power needs for industrialised and industrialising

[1] Those measures consist of project inventories, cost estimations and market evaluations. See for e.g. GTZ (2001, 2000, 1995)

[2] For a detailed map see Appendix. The potential for wind power could match all presently installed electricity generation capacities which are at around 300 MW.

countries and are an alternative to central power generation. Small-scale applications usually generate between 100 and 300 W and serve the purpose of rural electrification. In China, both types of wind turbines find application. In China, 72 Million people live in rural areas with no access to electricity (Lew 2000: 272) and small wind turbines are one means to find relief for this situation. Small turbines are used successfully especially in the region of Inner Mongolia, although by far not all people in need are catered for. About 40 local manufactures currently produce small wind turbines in China more, which also export other Asian countries (Lew 2000: 274).

As for large-scale wind farms, most of the technology is produced within a few European joint ventures. The Chinese government wants to expand the domestic manufacturing capacities and cooperation projects have existed since the mid-eighties. A more detailed overview of the technology transfer activities will be given in the chapter about technology transfer.

2.2 Factors determining power generation from wind

The further development and spread of wind energy technology must be seen in two different contexts: national and international. Within a nation possessing the technological capabilities to manufacture wind turbines and to operate wind parks, the increase of the percentage of wind energy to the overall energy production is defined by interacting political, environmental, technological and economical factors. Political factors for example consist of the policy measures to support wind energy and other energy sources. Environmental factors include for example wind speeds and the existence of adequate sites for wind parks. Technological factors include the existence and the conditions of national production facilities and their abilities to advance wind technology through the various forms of innovation. Economic factors include the price for power generated from wind in relation to other energy sources.

If a country does not posses the capabilities to manufacture and to operate a wind park or only to a limited extend but wants to build those up, the issue of international technology transfer determines the development of wind energy on top of the national factors. Those will be dealt with in this study.

3 The Clean Development Mechanism as part of the Kyoto Protocol

The Clean Development Mechanism (CDM) is one of the three flexibility mechanisms within the Kyoto protocol. Under the framework of the Kyoto Protocol, adopted in December 1997, more than 150 countries, among them most industrialised nations, have committed themselves to reduce their greenhouse gas emissions. The average goal is to reduce GHG by 5.2 per cent below 1990 emissions by the period of 2008 – 2012[3].

Already during the preliminary negotiations for the preceding Convention on Climate Change, Norway introduced the idea that states could achieve their reduction goals not only within their own country but also abroad and in cooperation with other countries. The main economic argument for emission reduction abroad is that cost differences between different abatement opportunities could be exploited leading in theory to cheaper emission reductions (Michaelowa / Greiner / Dutschke 2001: 2). While economic efficiency is surely important to reach the aim of the Kyoto Protocol and was important to keep the negotiations going, Begg et al. stress that the superficially attractive idea of joint action to prevent climate change with cheaper means covers the multi-objective character and inherent goal conflicts of climate policy. Economic efficiency has to be achieved within the constraining goals of environmental protection. On top of that, a number of other goals, like equity, and international pressures (trade liberalisation policies, other environmental goals, technology transfer imperatives, etc.) inform climate policy. Also, a reasonable measure of practicality is necessary to make the agreements work out. Begg et al. therefore underline that not all objectives can be fulfilled and trade-offs have to be made. (Begg et. al. 2001: 4)

The environmental justification for joint action is that in principle it does not matter where GHGs are abated since they are a global problem. Although this argument diminishes the fact that climate adverse emissions stem for the most part from industrialised countries and that less developed countries will suffer the most from future climate change[4], it was seen as a means to overcome resistance of some governments, most notably the US, Japan and Australia.

Under the Kyoto protocol the idea of joint action was extended and resulted in three different, so called flexibility mechanisms, which are designed to help industrialised countries to achieve their national reduction goals in co-operation abroad. An overview is given in the following table:

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[3] They are listed in Annex I of the protocol and usually referred to as Annex I countries. The list includes industrialised and transition economies.

[4] Due to their heightened exposure to negative effects of climate change and their limited resources to combat those.

Mechanism	Mode	Parties	Transferred Emission Units
Emission Trading Art. 117	Trade of emission rights between industrialised countries	Annex I States	Assigned Amount Units (AAU)
Joint Implementation Art. 6	Credit for emission reduction in other industrialised countries	Annex I States (States committed to GHG reductions)	Emission Reduction Units (ERU)
Clean Development Mechanism Art. 12	Credits for emission reduction from projects in developing countries, retrospectively from 2000 (Credit for national reduction goal or tradable).	Annex I and non-Annex I States	Certifies Emissions Reductions (CER)

Table 1 Overview Flexible Mechanisms **Source: Michaelowa et al.**

The establishment of the flexibility mechanisms effectively created a global market for GHG emission reduction which is estimated to be worth of several 10 Billion US $ (Janssen 2002: 1)[5]. The demand within that market is driven by the governments' commitment to emission reduction. Since their first discussion, the flexible mechanisms have been criticized as simple ways for industrialised countries to avoid their obligations and prevent the changes in lifestyle, production and consumption patterns necessary to reduce GHG emissions on a long term basis. The EU and developing countries therefore plead for a restriction in the usage of flexible mechanisms in the different negotiation rounds while USA and non-European OECD members strictly object to limited applications of flexible mechanisms. At the negations in Marrakech in November 2001, the parties agreed on not legally limiting the application of flexible mechanisms. In the optimistic interpretation of Ott however, the wording of the decision might leave some room for political pressure in case an industrialised country solely relies on the use of the Kyoto mechanisms to reduce its GHG emissions (Ott 2002: 3). It is on the other hand realised that a Kyoto Protocol without flexible mechanisms or too many tight rules discouraging investors and industry might not have any effect on GHG emissions at all. To put in the words of Sugiyama / Michaelowa the: "The Kyoto regime desperately needs flexibility to reconcile its ambitious target with difficulties in implementing domestic policies and measures" (Sugiyama / Michaelowa 2001: 76)

5 With the withdrawal of the United States from the Kyoto Protocol, the market might turn out to be much smaller and much more competitive then expected.

3.1 The Clean Development Mechanism

The CDM is a project based instrument which is regulated in article 12 of the Kyoto Protocol. Article 12 paragraph 2 reads that the CDM shall assist developing countries

> "in achieving sustainable development and in contributing to the ultimate objective of the convention" and "assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3."

Article 13 Paragraph 3 (a) reads that developing countries will

> "benefit from project activities".

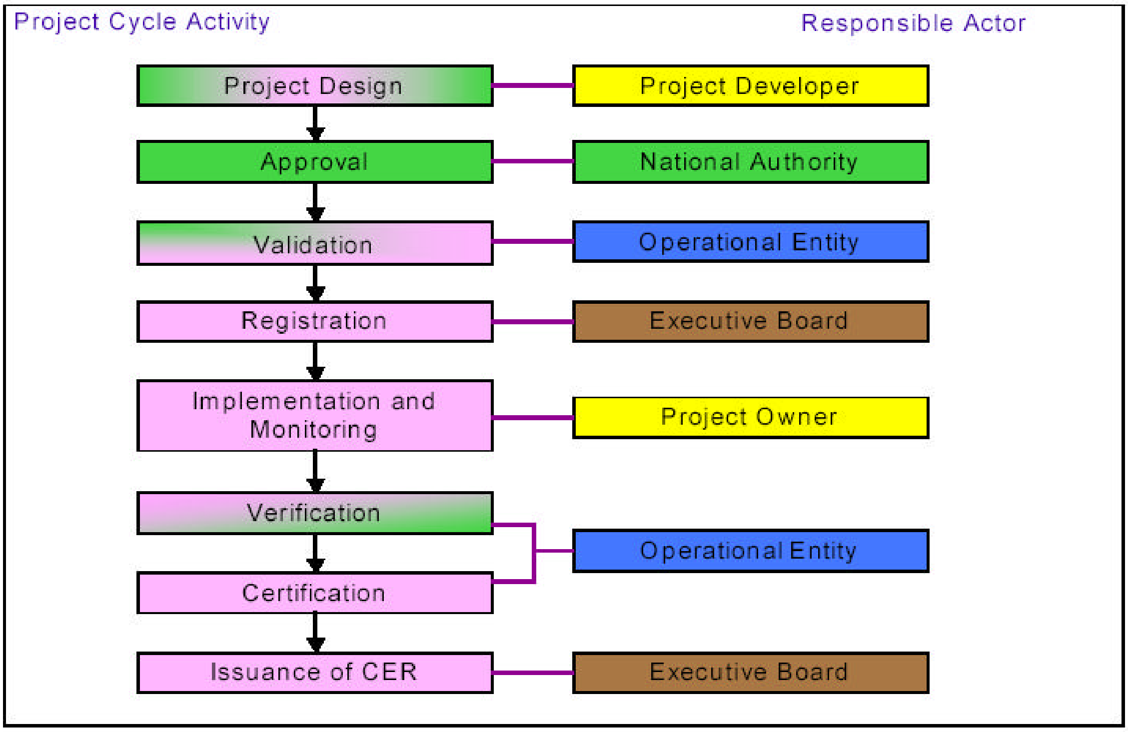
The design of the CDM is the result of the intense debate between developed and developing countries during the Protocol negotiations. The debate centred on the issue of emission reduction versus development. Developing countries are concerned with sustainable development, equity, common but differentiated responsibilities, technology transfer, and financial assistance. The priorities of developed countries are emission reduction, emission trading, credits, private sector participation, and compliance (Jin / Liu 2000).

Article 12 allows industrialised and transformation economies (Annex I States) to reach their emissions reduction goals by preventing emissions in developing countries (countries with no emission reductions goal or Non-Annex I states) through investing in emission reducing or preventing projects. Investors receive credit for the resulting emissions reductions. Developed countries can then apply this credit against their GHG reduction targets. Implemented projects generate "Certified emission reductions" (CER) which can be credited for the national GHG emission reduction goal or they can be publicly traded.

Generally, CER shall assist the investor to reap economic benefits by overcoming financial barriers which would have otherwise prevented the project. Credits in form of CER from CDM project implementation can go either to the investor country or to the host country, in case the host country wants to save credits for future GHG emissions or trade CER on a world market which yet has to be established. It is however not clear from the outset that abatement projects in a less developed host country are necessarily cheaper then in the industrialised home country. CDM projects might be burdened by more administrative regulations and procedures such as validation, verification and certification, thus involving higher transaction costs eventually higher then in industrialised countries. In addition, from the perspective of potential investors, CDM projects, being located in developing countries, are associated with higher political and country risks. According to the Marrakech agreements, the CDM has a "prompt start", which means projects already started in 2000 may be credited if the fulfil the corresponding requirements. Parts of the project revenues (a share of proceeds) have to be used to cover administration cost and will go into a fund for financing adaptation measures of the poorest countries.

Three types of projects are envisioned under the CDM: bilateral, multilateral and unilateral. Bilateral projects are based on agreements between two states. Projects based on multilateral agreements can be based on funds, to which various developed countries contribute financially while other countries bid for the contributed money by presenting projects. With unilateral projects, the host country does not need a foreign investor. It organises and finances a CDM project by itself and sells the CER after project has been successfully implemented (ISI 2000).

For this study, it was assumed that CDM co-operation between Germany and China will be on a bilateral basis, since China has strongly emphasised its intention to carry out projects in such a manner (Cavard / Menateau 2001: 28). Within bilateral projects, modalities and proceeds (finance, project selection, credit sharing) are worked out between the participants (governments, developers and investors) on a project by project basis. Bilateral projects resemble most closely to conventional FDI projects (Baumert et. al. 2000: 3). The project flow is represented schematically below in graph 1. The highest authority within the project is Conference of Parties (COP) which will set up a CDM *Executive Board* to supervise all CDM activities. This *Executive Board* will then nominate a number of *Operational Entities,* which are responsible for project validation, verification and certification. Each developing country wishing to participate in CDM projects has to establish a corresponding *National Authority* responsible for setting up national CDM goals and project approval.



Graph 1 Schematic Project Flow CDM **Source: GTZ**

3.2 CDM project criteria

CDM projects have to fulfil a certain number of criteria, to be recognised by the corresponding authorities as proper CDM projects: Additionality, sustainability, voluntariness and the more formal UNFCC requirements.

Article 12 of the Kyoto Protocol states that, in order to be creditable, emissions reduction projects within the CDM must be "additional to any that would occur in the absence of the certified project activity." To make sure that credits are not given to projects which would have been realised without the economic contribution from carbon credits, CDM projects must prove their economic additionality. This means that they are not result of "business as usual" and would not have taken place without the support framework of the CDM. Non-additional projects might grant greenhouse gas credits to any ordinary foreign direct investment (FDI) that uses more efficient technology than the one existing in the host country. This includes that CDM projects shall be additional to regular overseas development aid. Since the rate of return on investment is what most matters to CDM investors, some commentators have remarked that this criteria could be the biggest stumbling block of the CDM. Projects might either require a high carbon credit price to obtain the needed finance or, if the do not, might have problems demonstrating their additionality (Jung et al 2001). Voluntariness means that parties have to enter CDM projects on their free will.

Article 12 also declares that CDM projects should lead to sustainable development within less developed countries. Sustainability, however, is not listed by all commentators as a criterion for projects to be approved as CDM projects. The notion of sustainability will, however, be of importance when designing and negotiating CDM projects.

3.3 Problems of the CDM

A number of general problems have been associated with the Clean Development Mechanism. They will not be dealt with within this piece of research, but are mentioned to give a balanced idea of the mechanism. Firstly, there is the problem of “lowest hanging fruit”. Investors might only support CER projects, which are easy to finance and to carry out, leaving difficult, high cost projects for later stages or to be excluded entirely. Also, less environmentally sound technologies could be irreversibly chosen over more effective ones for financial reasons within a certain project. Some aspects of the problem of the ‘lowest hanging fruit’ might be counterbalanced by rising prices for CER making more difficult and expensive projects with some time lag also attractive. Secondly, there is the ever-present public policy problem of free riding: Investors are getting carbon credits for business-as-usual activities due to insufficient monitoring or flawed baseline calculations. Additionality is seen as the key concept to discern whether a project is legitimate or a free rider. If free riders are not singled out, the technology change will not be accelerated as envisaged. Also, emissions will only be reduced or avoided to an extent to which it would have happened without of the Kyoto Protocol. A third general problem is that CDM projects will be located where location advantages are offered. Promising markets, infrastructure facilitating business operations, transparent legal system and political stability favour certain regions of the world. (Jung et. al 2001: 40):.

3.4 The role of wind power within the CDM

Energy generated from wind power is one of the fastest growing renewable energy sources worldwide. Installed capacity in Europe went up from 4000 MW in 1997 to almost 18.000 MW in 2001 (IWR 2002). Worldwide, installed capacity rose from 8.000 MW in 1997 to 24.000 in 2001 (AWEA 2002). Since the price for wind energy is in every country still higher then for energy from conventional sources and finance for wind energy is scarce in many less developed countries, it is a potential candidate to fulfil the additionality criteria and projects might be eligible for funding via CER. Energy systems have a long life cycle and the choices made now will have a lasting influence on the mode of energy generation in the future. Within the Chinese energy system, still lacking enough infrastructures to meet future power demands, certain leverage in technology choice exists. Worldwide CO2 emissions result to 30 per cent from the electricity sector and are projected to increase annually by 2.7 per cent between 1995 and 2020 and reducing emissions there is currently much easier achieved then in transportation, the other big source. (Jung 2001: 49). The constraints of increasing wind energy will be discussed in detail in chapter three.

3.5 Technology Transfer within the CDM

Projects within the CDM explicitly combine two goals: the reduction of GHG and the sustainable development of less developed countries (Michaelowa / Greiner / Dutschke 2001: 4). The corresponding paragraphs of the Kyoto Protocol however do not make any direct reference to technology transfer. But if the Kyoto protocol is taken seriously and the joint projects shall help developing countries to achieve sustainable growth, technology transfer becomes an indispensable part of projects. Also, the Marrakech Declaration underlines in relation to the CDM that 'project activities should lead to the transfer of environmentally safe and sound technology and know-how' (UNFCC 2002). The modalities of each transfer project depend on the criteria agreed by the corresponding authorities and the negotiations of the participating parties (ISI 2002: 5). Successful technology transfer pre-supposes to a certain degree of matching interests of all participating parties. In the following section we will investigate whether this holds true for the participants of a CDM project between Germany and China in the field of wind energy. We will therefore investigate interests and aims of the relevant actors.

4 Actors in a CDM technology transfer

For this study, an investigation of a possible CDM project between Germany and China in the field of wind energy technology was conducted. Four groups of main actors would be involved in such a project: The German government, the Chinese government, German wind energy technology manufacturers and firms of the corresponding industry in China. For a 'real' project, a much greater number of participants like financial institutions or the Kyoto protocol authorities would of course be necessary to overcome all project steps and hurdles. Especially the operational entities and the CDM executive board might be of major importance since they have to approve whether a project fulfils all CDM criteria.

4.1 The governments

Despite the uncertainties about the exact scale and the effects of climate change, governments all over the world have taken action by adopting the UN *Framework Convention on Climate Change* (FCCC). The UNFCCC required governments to commit themselves to emission reductions and draw up programmes of how to achieve them. Since GHG emissions are the result of a wide range of socio-economic activity, effective climate change policy must include environmental concerns in a wide range of other policy fields. The main culprit for the climate threat is the fast rising amount of CO2 emissions within the atmosphere resulting from fossil fuel use. Energy production and energy use based on fossil fuels are essential constituents of economic activity in the industrialised world. For the European Union, 31 per cent of all CO2 emissions stem from electricity generation, 20 per cent from domestic energy use, 23 per cent from industrial energy use and 23 per cent come from the transport sector (Collier / Löfstedt 1997: 6). Since emissions are almost exclusively due to energy and transport activities, markets and government policies others then environmental ones fundamentally influence them. Putting it the other way round, CDM policies or CDM instruments and their effect can only be understood when placed in relation to other policy areas. In the case of CDM policy in Germany and China the relating policy framework would consist of energy policy, wind energy policy, climate policy, environmental policy and economic policy.

Although the policy frameworks of the two countries touch similar policy fields, the general attitude towards the CDM is fundamentally different. Developing countries do not necessarily see the need for action regarding emission reduction since their economic activities are not the main cause for climate change. Their main concern is still socio-economic development rather then GHG abatement (Jin / Liu

2000: 17). This fundamental difference in attitude and the corresponding difference in priorities must be taken into account when trying to understand the rationale of both governments.

4.2 The German government

Germany is one of the biggest CO2 emitters world wide contributing 5 per cent to global and 30 per cent to European Union emissions (Huber 1997: 66). The German government committed itself to a reduction of 25 per cent of CO2 emissions by 2005. The long term plan is to reduce CO2 exhausts for 40 per cent by 2020. The German target for over all GHG reductions is 21 per cent by 2008 – 2012. The present German government claims that overall GHG emissions fell for 18 per cent from 1990 to 2000, which seems to imply that Germany is well on its way to fulfil its emission targets. The high percentage is partly due to the breakdown of the industries in the former German Democratic Republic and the related slow down of economic growth. These 'falling of the wall benefits' were responsible for about 50 per cent of the overall reductions. Taking this benefit into account, overall GHG emissions fell by 9 per cent. This result is due to a number of policy measures on the national and regional level. Schleich et al. suggest that this trend will continue and Germany will reach an overall drop in GHG emissions by 18 per cent in 2010. CO2 emissions fell for roughly 15 per cent, but if the wall-fall bonus is excluded emissions have only been reduced by 7 per cent. (Schleich e. al. 2001). From that perspective, Germany is well on its way to fulfil its Kyoto protocol commitment but far from reaching its national CO2 goal.

The previous development very much informs overall CDM policy. Although many critics pointed out that Germany will not find it easy to fulfil its reduction commitment within the country due to strong resistance of the powerful industry (Boeckem 2000) or the inability of the government to reduce CO2 emissions in the transport sector (Huber 1997), the overall ambition of the relevant policy maker is to fulfil them by national action (Forth 2002). National CDM policy is at a very early planning stage and ranks low in the policy agenda. The German government has established one full time post for three years for CDM policy at the Ministry for Environment (BMU), which is the lead ministry in designing CDM policy, and a scientific advisory panel. According to the BMU representative, current activity is relatively low. The BMU is co-ordinating research projects and considering various project proposals with other German research institutions, most notably the Institut für Klimaforschung in Wuppertal. The main focus of all current activities is to evaluate whether existing international energy projects would fulfil the criteria for CDM.

The fact that CDM policy ranks rather low as a part of German Climate policy is the result of a number of reasons. The most important reason being, which all interviewed persons stated, that the predominant goal of German climate policy is to achieve the German climate goal within the country. And since Germany is doing relatively well in that respect, it is difficult to draw more attention to the subject of flexible mechanisms. As one person interviewed put it: "The German position has always been that climate commitments must be fulfilled nationally. Then the US came with the idea of flexible mechanisms. Now, the US has left Kyoto and we have to get used to the flexible mechanisms". Another reason for the low priority of CDM is that the main focus regarding the flexible mechanisms is on emission trading. The overall aim of the present government, however, is to "implement the Marrakech accords 1 to 1", as one interviewee put it. That means, CDM projects will be supported, but not within the next year or two. Forth estimates, that the German government will allocate about 50 million Euro for CDM in the near future and that it will be difficult "to convince the finance department for more money if Germany continues to do so well in abating greenhouse gases on a national level". He estimates that CDM will reach its full potential after 2010, when the leverage for national measures is considerably smaller then now and the goal of reducing CO2 emissions for 40 per cent by 2020 draws closer. It was also noted that economic goals in form of using the CDM as a means of export promotion would sooner or later gain in prominence and the Germany of course had a very strong interest in selling his green technology.

4.3 The Chinese government

4.3.1 Economic and Energy Policy

The Chinese government wants the national economy to grow rapidly. This wish is expressed in the goal to double the gross national product by 2010. The economic aspirations entail strong incentives to build more commercial energy sources. The bulk of it would use, if current trends continue, carbon based fossil fuels as an energy source. China has abundant resources in coal, which currently make up for 75 per cent for primary energy consumption and 75-80 per cent of total power generation in China (Ni / Sze, 1998).

The Chinese Ministry of Electric Power planned to expand electricity generation capacity from currently about 280 GW to 530 GW in 2010 and 800 GW in 2020 (Michaelowa et al. 2000). The electricity production rose enormously over the past decades as can be seen by the table underneath. Renewable energies play with an production output of 0.3 TWh a rather insignificant role.

Electricity production (TWh)

	1981	1986	1991	1992	1993	1994	1995	1996	1997	1998
Thermal	243.7	355.2	552.7	622.9	685.7	760.9	807.4	878.1	912.6	929
Hydro	65.6	94.4	124.7	131.2	150.6	167.0	186.3	186.7	184.7	195
Nuclear	-	-	-	-	-	-	13.0	12.8	14.1	14.1
Renewable	n.a.	n.a	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3
Total	309.3	449.6	677.5	754.2	836.4	927.9	1006.9	1079.4	1117.6	1140

Table 2 Electricity Production in China Source: Michaelowa et al.

Since most of the future energy demand is planned to be met by coal and large hydro, the most ambitious and environmentally contentious project being the 18 GW *Three Gorges Dam* on the Changjiang river, the contribution of renewable energy will not dramatically change in the near future. Renewable energies were indirectly supported by the government's decision to reduce coal subsidies from 37 per cent in 1984 to 29 per cent in 1995 and fully abolish them in 1997. Petroleum subsidies were from 55 per cent in 1990 to 2 per cent in 1995. Nevertheless, delivered heat and residential fuels continue to be heavily subsidised and coal and oil prices fell by 15 per cent after their partial liberalisation in 1998 (Michaelowa et. al. 2000: 13).

4.3.2 Wind Energy Policy

The Chinese government has, however, recognised the importance of renewable energies for the future development of the energy sector since the mid eighties. Wind power received special attention by the government since a study by the World Bank concluded that wind power holds the biggest potential to supply power at economic conditions. Starting from the eighties to 1995, several small scale demonstration and research wind farms were established with government help and ODA, totalling an installed capacity of 35, 5 MW. In 1996, the Chinese state planning commission launched the “Ride the wind programme” with the goal of creating local manufacturing capabilities for 250 to 600 KW wind turbines. German and Dutch government institutions provided finance and firms of the countries provided technology to set up various wind farms under this program (Junfeng 1999). The installed capacity reached 345 MW by the end of 2000 and shall reach 1, 5 GW by 2005 according to the tenth five-year plan (2001 – 2005) (Lew / Logan 2001:1).

In the Industrial Development Plan for Renewable Energy (2000–2015) enacted by the State Economic and Trade Commission (SETC), a long-term target is that 7000 MW of wind turbines are to be installed by 2015. Industrialization and commercialisation of wind power will be the focus of future development and a large-scale expansion. In the industrial development plan, wind power is considered a major energy technology being used to reach the target of 2 per cent (3.6 per cent if including small hydropower) of the total commercial energy consumption through renewable energy sources by 2015. This is far less ambitious than the European Union objective of 12 per cent by 2010 (Liu / Gan / Zangh 2002: 755).

It is also the aim of the government to further build and grow a domestic wind turbine industry in cooperation with foreign firms. The political leadership stresses the role of domestic production facilities to bring down the price for energy generated from wind[6], and it is evident though not publicly mentioned that a domestic industry is considered a valuable driver for economic growth and shall expand to a profitable business (Gu / Liu Undated: 7). The domestic industry is very small. By 1996, out of the 56 MW of installed wind turbines nationwide, only 950 kW of the generating capacity came from domestically made wind turbines. It accounted for only 1.7per cent of the total installed capacity (Gan 1998: 18).

Lacking manufacturing skills are by far not the only reason for the slow development of wind energy in China. Lew points out that the absence of a national policy framework for wind power sales is a major barrier to further development of wind energy. Every power purchase must be negotiated individually with a local grid operator. Apart from that, Lew points to the general lack of fiscal incentives for investors and problems for project developers caused by bureaucratic incompetence on the Chinese side (Lew 2000: 283).

Some policy initiatives to support wind energy have taken place or were at least announced, but still suffer from implementation problems. In 1999, SDPC and the Ministry of Science and Technology (MOST) issued a circular to support renewable energy (RE). RE should be favoured when trying to obtain finance from Chinese banks and grid administrators were forced to buy electricity generated from RE. Lew / Logan however report that local and regional grids often argue about who has to allow for a connection of wind energy to the grid (and then having to pay the high price for wind energy). They also report that prices vary between regional grids making it difficult in some regions to maintain wind parks, and that utilities still simply refuse to buy power from wind energy because the consider it too expensive. Local utilities have still no incentive to buy power from wind because they have to pay a higher price for wind energy and are neither compensated for that nor mandated to do so by a national law. The tenth five year plan also proposed to establishment of a mandated market share for RE, but the implementation has not yet proceeded (Lew / Logan 2001).

Liu et al. remark that investment in wind energy in China is still risky for foreign investors, since no co-

[6] Wind energy development in China is restrained by relatively high investment costs and relatively high kWh prices. For an overview see Appendix.

ordinated investment policy exists. Also, a mandated market share or a law determining a fixed price paid for wind energy when delivered to the grid would reduce the financial uncertainty for investors. Either of the policy measures would create a market, which might facilitate the building up of a domestic manufacturing industry. Liu et al. also point out, that various tax incentive mechanisms like exempting wind farms from income tax to reduce the price of wind energy are not fully used by the government (Liu et. al. 2002: 763).

4.3.3 Environmental and Climate Policy

Apart from CO2 emissions contributing to climate change, the reliance on fossil fuels and Carbon in particular, will increase regional and local environmental problems. The average level of particulates in major Chinese cities is, for example, three times higher then recommended by the World Health Organisation. Also, The sulphur dioxide emissions associated with the burning of coal causes acid rain in southern and eastern China and neighbouring Japan. (Austin e. al. 1999: 5). China's main policy to combat air pollution is a set of levies on a number of pollutants. Fees are charged to the extent to which the discharges by an industrial complex exceed a certain standard. The levy system has been criticised for not being high enough to stimulate investment in clean-up equipment or to operate this equipment once installed. Although fees were increased in subsequent modifications after its first introduction in 1982, some doubts remain about the effectiveness of the system. One main point of concern is that proper enforcement on a local government level is not guaranteed (Watson et. al. 2002: 10). The lax enforcement stems amongst other reasons from a constant conflict between economic and ecological goals. Austin et al. report that environmental regulations are relaxed for political reasons and many political decisions show a clear preference of economic over environmental goals (Austin et. al. 1999: 6).

China is preparing to ratify the Kyoto Protocol, which would make the country eligible for CDM projects (Vidaillet 2002). In relation to the Kyoto protocol, the Chinese government understands China as a developing country which has to benefit economically from the measures undertaken to mitigate climate change. This stands in contrast to the CO2 emission of China, which were between 9 and 14 per cent (depending on estimation) per cent of the global total in 1999 and is estimated to rise to 25 per cent by 2020, turning China into the largest emitter world wide (Johnston 1998: 555). The country's officials acknowledge that in the future China has to share its burden in GHG abatement in accord with future economic growth, but currently China sees itself as a low-income country with limited abilities to combat climate change (Wei 2000: 6, Jin /Liu 2000: 10). Hence, China has not committed itself to a reduction of its GHG emissions under the Kyoto Protocol and is not willing to do so until its per capita income rises to the level of a 'middle income country'. The prevalence of economic over environmental goals is quite openly admitted in China's Agenda 21 which reads that in order to improve living standards the country must take "the path of rapid economic growth and gradual improvement of the quality of the development" (State Council 1996).

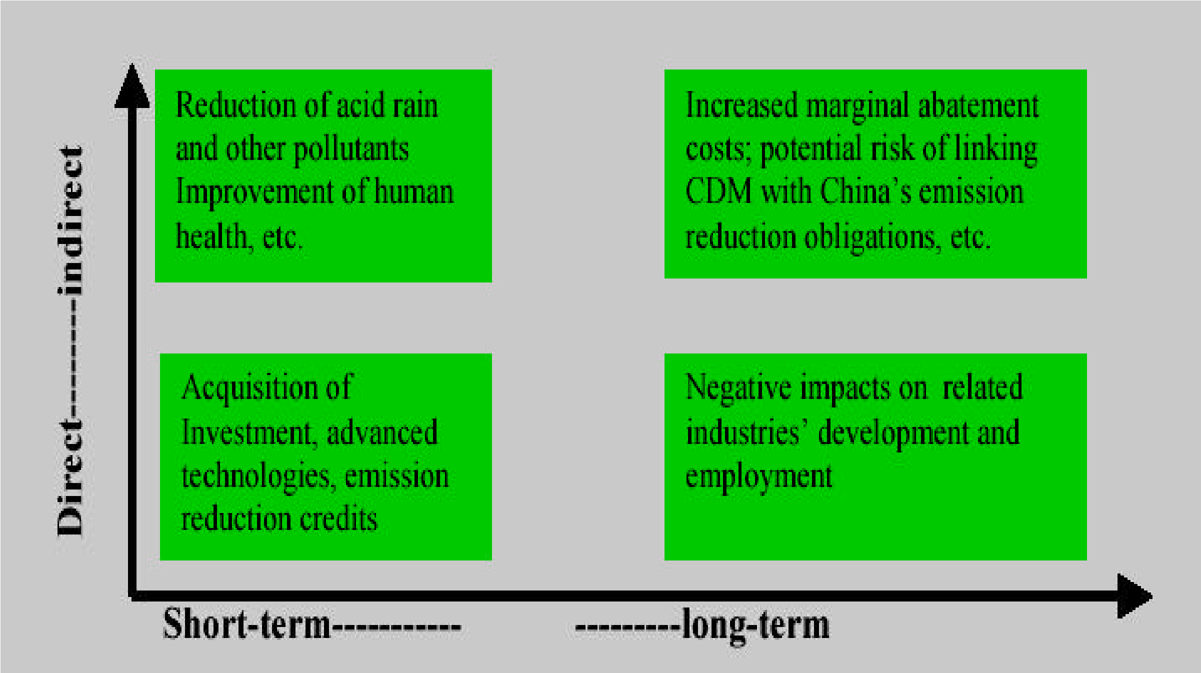
Michaelowa et al. report that GHG reduction is at present only of interest for Chinese officials if it entails direct or indirect reduction of pollutants. A long term transformation of the energy sector taking into account climate change is envisioned by the Chinese government for the time from 2020-30 to 2050, when the coal use shall be down to 35 per cent, natural gas and oil accounting for 40-50 per cent, and nuclear and RE accounting for 10 per cent (Michaelowa et. al 2000: 20). Dielen / Changhong go so far in this context to say that in order to convince China to participate in GHG abatement measure one should not promote GHG reduction efforts with positive side effects like reduction of air pollution but put cleaner air for China first on the agenda and then calculate the CO2 or SOx benefit (Gielen / Changhong 2001: 258).

China will most likely be the country benefiting the most from the CDM world wide. Studies suggest that over half of all financial flows resulting from CDM activity will go to China (Austin et. al. 1999: 11). As for CDM policy, the Chinese government sees potential for CO2 abatement in the following areas and welcomes the corresponding projects:

Abatement Options	**Abatement Potential** (Mt-C)	**Abatement Cost** (US$/t-C, at 1990 prices)
Technical renovation of motors for general use	27.1	-99
Cutting the ratio of iron/steel in steel & iron industry	2.6	-88
Renovation of kilns for wet cement production	3.6	-47
Energy-saving lighting	10.8	-32
Comprehensive process renovation of synthetic ammonia	3.1	-28
Renovation of industrial boilers	21	-14
Continuous casting of steel making	2.1	-14
Renovation and reconstruction of conventional thermal power plant	13.1	16
Nuclear power	30.7	25
Hydro power	54.3	73
IGCC and other advanced thermal power technologies	2.2	117
Biogas and other biomass energy	2.5	129
Wind power	1.3	216
Solar thermal	1.5	366

Table 3 CO2 Abatement options in China **Source: Wei**

As we can learn from the table above, wind energy is considered by the Chinese to hold a rather small potential for CO2 abatement, most likely because of the high abatement cost. As we will see later on, the estimation of the potential is not purely a result of the natural, exploitable resources of wind, but of a combination of political decisions and Chinese industrial capabilities. Wei however states that it is considered the most important opportunity together with energy efficiency by the government (Wei 2000). It is important to notice that there are not only positive effects for China if engaging in CDM. Jin / Liu underline that general conclusions cannot be drawn and decisions must be made project by the project, especially because many rules regarding the CDM are still not made. Also, estimations about markets, prices and cost are very uncertain and benefits co-depend on the negotiating skills of the parties. They also note, that a beneficial involvement of China in CDM projects depends on the size of the market and the market share that China will gain. Both are only estimated and estimations vary considerably. A summary of the main pro's and con's in graph 2. Jin / Liu distinguish between direct and indirect effects as well as short term and long term effects of CDM projects on China.



Graph 2: Effects of CDM projects on China **Source: Jin / Liu**

Despite the doubts, China is getting prepared for the CDM on an institutional level. The *National Co-ordination Group on Climate Change* was founded in 1990. The group hosts members from 13 different ministries and state agencies including Ministry of Foreign Affairs, the State Development Planning Commission, the State Economic and Trade Commission, the Ministry of Science and Technology, the State Environmental Protection Administration and the Ministry of Finance. The powerful *State Development Planning Commission* (SDPC) has recently made stronger efforts to carry out the Chinese government's program for the future implementation of the Kyoto Protocol. Apart from that, the SDPC has joined forces with foreign donor organisations to carry out feasibility studies and assistance programs in relation to the Marrakech accords and the CDM (Watson et. al. 2002: 22).

4.3.4 Summary: Position of China

Although favouring economic growth over present climate commitments in general, the Chinese government has indicated an interest in international technology transfer to enhance their technological capabilities and to reduce their domestic air pollution. The government is aware of possible negative consequences of foreign technology import. The interest in wind energy technology is large, which is also demonstrated by the relatively long history of co-operation with foreign partners in the field. The still lacking national policy framework for wind energy however stands in contrast to the government's ambition to increase the share of wind energy. Also, renewable energy is not the only preference of the government for CDM projects. The finance generated by the CDM however is a chance to overcome the economic disadvantage of wind energy.

4.4 The firms

The private sector is explicitly asked to participate in CDM projects. Firms are the essential part in technology transfer projects since they are the carriers of technology and knowledge. In the following, the position of German and Chinese firms in their markets and their interest in a potential CDM projects are outlined. The reason for doing so is to evaluate the likelihood and the interest of German and Chinese firms to participate in an eventual CDM project. Due to the scope of the study, the emphasis is on German firms. For Chinese firms, it can only be assumed that they have an interest in upgrading their technological capabilities and expanding in China as expressed by the Chinese government.

4.5 German wind technology manufacturers

The German domestic market is still showing the strongest growth rates world wide. In 2001, 2.600 MW of capacity were installed (BTM Consult 2002). German and Danish firms dominate the German market.

Vestas (DK)	10,54%
Enercon (D)	46,11%
NEG Micon (DK)	3,68%
Bonus (DK)	6,84%
GE Wind (US)	14,40%
Fuhrländer (D)	1,47%
Nordex (DK-D)	10,50%
DEWind (D)	4,44%
REPOWER (D)	6,17%
Others	0,48%

Table 4: Market shares wind turbine manufactures in Germany Source: Energy Economist

Of the five German firms, all are active in markets abroad, but only four of them were or are active in the Chinese market. German firms dominate the domestic market, though Danish firms have a strong presence. Internationally, German firms had a market share of around 16 per cent internationally, while Denmark has 50 (BTM Consult 2000: 16). German-Dutch manufacturer Nordex held 48 per cent of the Chinese market in 2001 (BT Consult 2001: 47). In theory, all firms have an interest in engaging with the Chinese market. This is due to increasing domestic and international competition as well as the large potential for wind energy in China. The attitude of German firms will be discussed more extensively in the empirical part of the study.

4.6 The Chinese wind energy technology manufacturing industry

As stated before, a Chinese large-scale wind energy manufacturing industry is virtually non-existent, although some firms produce in licence or through joint venture. Their market share is however so small, that it is not mentioned by commercial market studies (BTM Consult 2002: 47). An in depth assessment of existing firms and their technological capabilities is beyond the scope of this study. Therefore, it is assumed that Chinese firms and related industries will have an interest in acquiring the capabilities related to wind energy manufacturing from foreign firms

4.7 Colliding interests

From what we have learned so far, one of the central questions is whether the development plans of the Chinese government collide with the objectives of the German wind-industry[7]. As McElroy puts it:

[7] As a tribute to the limited space of this study, the interest of the Chinese firms must be conflated into that of the Chinese government. There are however a number of reasons other then space which justify this conflation. Firstly, China is by far not yet a market economy despite the huge changes and efforts during the last 20 years. It is still a transition economy and the state plays a much stronger role in economic activities then most other countries. Foreign wind turbine manufacturer

> China faces a daunting choice. It can opt to pursue an independent path seeking essentially one goal, the most rapid possible economic growth, risking serious long term, potentially irreparable damage to her environment in the interest of short-term returns. Or, it can learn from the historical experience of other countries – that it is less costly in the long run to avoid present environmental damage. …To pursue the second, wiser course in an expeditious manner will require a major investment of capital and expertise from developed nations. To the extent that the essential resources are held not by governments but by private industries, China must accept these companies' needs to achieve a satisfactory return on their investment (McElroy 1998:263).

Begg stresses in this context that CDM projects must find a balance between multiple objectives (Begg et. al 2000). That refers on the one hand to the different objectives of the participating actors but also to the different objectives laid down in the protocol. The guiding motto "common but different responsibilities" assigned different roles and obligations to industrialised and developing countries. Industrialised countries have committed themselves to certain emission reduction goals. Less developed countries have because of their low economic development and corresponding low contribution to GHG emissions not made reduction commitments. Developing countries have however in many cases realised that they might have to cut their emissions in the future or are expected to do so by other countries. The integration of larger developing countries, like China or India, into efforts to cut global emissions is urgent because of the sheer size of the country. China is for example a low-income country and the emissions per capita are very low, but due to the enormous population, it is the second biggest emitter of GHG after the US in absolute terms. Not trying to cut back their emissions as soon as possible might threaten the success of the whole climate convention.

Developing countries however face currently a trade-off in the achievement of environmental and economic goals. The achievement of one additional amount of social product (GDP) is linked with an increase in GHG emissions. This link is determined by technical parameters. In the field of power generation the emission increase per unit of social product is determined by e.g. energy efficiency or the power source. So there is usually a trade off between either achieving economic growth or cutting emissions. Developing countries usually do not posses the financial resources and / or the political will to invest in both, economic growth and emission reduction (Ipsen et. al. 2001: 317). A way out of this dilemma is co-operation between industrialised and developing countries. This rationale fits perfectly with the idea of the Clean Development Mechanism and China has realised the potential benefit from co-operation. Industrialised countries invest in less developed countries to fulfil parts of their GHG commitments and developing countries benefit from the broadened range of technology choices which facilitate economic growth with reduced GHG emissions.

However, co-operation is not automatic, although the interests of the participating parties do not seem to exclude each other at a superficial level. In economic terms, the start of co-operation between an industrialised investor and a developing country is purely a matter of cost. The industrialised country invests in the developing country if it is cheaper then abating at home. The developing country accepts the investment if it saves him cost to extend his technology choices (Ipsen et. al. 2001: 322). Hence, Ipsen et al. point out that for co-operation to happen only the right institutions must be in place: "Fundamentally, this is a question of creating institutions which are supportive to the cooperative case. There will be no demand for joint implementation projects from the industrialised countries if there are no well-defined pollution rights and no allocation of them to specific actors within an industrialised country. Only a pollution tax or the establishment of an emission trade market allows for a compensation of pollution credits from abroad against domestic obligations" (Ipsen et. al. 2001: 322). The same,

e.g. cannot choose their Chinese joint venture partner but must cooperate with a firm designated by the government. Secondly, CDM projects are in the first step state driven. Thirdly, the small existing Chinese wind turbine manufacturing industry depends on government subsidies.

Ipsen et al. claim, holds true for the developing countries: “As long as environmental policy is only of symbolic value, we may expect the supply of joint implementation projects to be low. Thus creating an institutional capacity for a national environmental policy is an important precondition for cooperation” (Ipsen et. al. 2001: 323).

Cost and institutions are of course the basic foundations to initiate cooperation for international GHG abatement. This study however, wants to go beyond the economic discussion of co-operation. Co-operation is not automatically successful if the institutions are in place and financially efficient technology investment opportunities in a developing country have been identified. Rather, it is argued that there is an inherent potential for conflict around the modalities of the investment within a co-operation project with has only partly to do with cost and institutions. In order to do so, the next chapter will give a theoretical base for technology transfer and its importance to economic development.

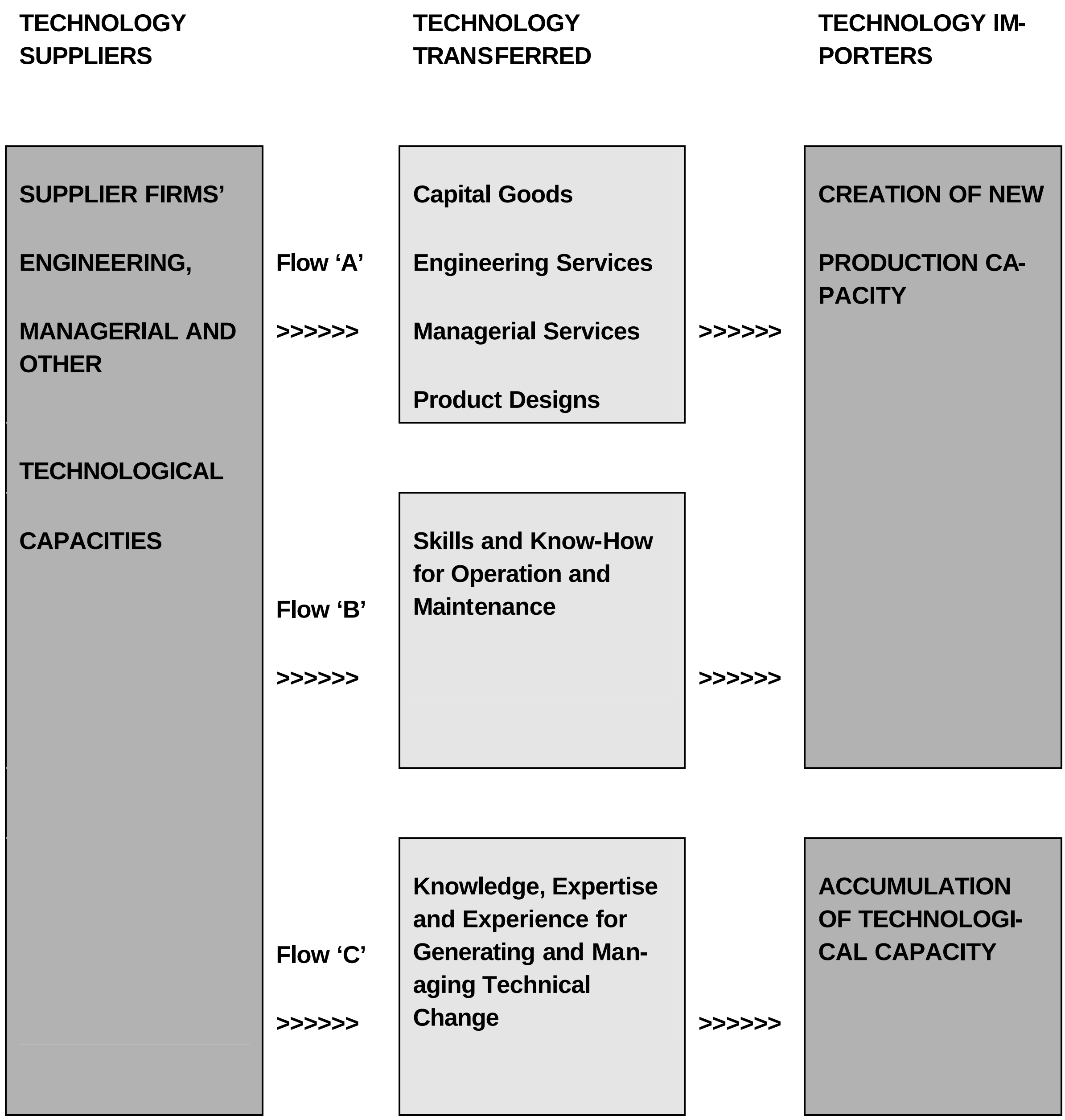
5 The Dynamics of Technology Transfer

As stated before, the most important means of the CDM to reach its environmental goals is technology transfer. There are two basic meanings of the term. The first meaning of the notion refers to the transfer of knowledge, devices and artefacts from source of initial invention of a new technology, for example a scientific laboratory, to some form of application, for example in the industry. The second meaning of the notion refers to the transmission of technologies and its application across national boundaries, in many cases from a developed to less developed country. It is in the second meaning, that the term for the following elaborations is understood.

Technology transfer can take place in many different settings and arrangements. Key actors are policy makers, regulatory bodies, development agencies, financiers, utilities, private firms, NGOs, academic institutions, the recipients, and the users of the technology. Not all actors are involved in every transfer project and the modalities vary. Transfer can happen through joint ventures, foreign direct investment, government assistance programmes, direct purchase of products, joint R&D programmes, franchising, education, training and sale of turn-key plants. The International Panel on Climate Change underlines that each mode of technology transfer has its own strengths and weaknesses. Selection should therefore be project specific and determined by the negotiating parties (IPCC 2000).

5.1 A Model of Technology Transfer

A common understanding of the term technology transfer does not exist and meanings differ in relation to the academic and political context they are used in. A useful model to shed more light on the existing qualitative differences between technology transfer projects is developed by Martin Bell. He distinguishes between three different types of technology flows from technology supplier to technology recipient.



Graph 3 A Model of Technology Transfer **Source: M Bell**

Flow A comprises the capital goods and services needed to create the physical facilities of a new production system. This includes the production machinery and equipment as well as the managerial / technological services to carry out the installation of the production machinery.

Flow B refers to the skills and know-how needed to operate and maintain the newly installed production facility. Some of the skills might be found in the host country, but usually, as Bell states, if transfer projects involve elements of flow A, at least some elements of the whole transfer process fall into the category of B. B-type flows can be broken down into codified knowledge or information and tacit knowledge. The former is embodied and transferred in manuals, schedules etc. The latter is embodied within persons and their knowledge and experience and can be transferred to a certain extent through training, advice and instruction.

Flow C refers to the skills and knowledge necessary to generate technical change. Those include the capabilities to adapt the technology to local, changing needs, to replicate it, to enhance it and eventually create a new product. And although, as Bell points out, there is no sharp distinction between C- and B-type flows, C-type flows are significantly different and additional to the knowledge needed to operate a production facility (Bell 1989: 5). C-type flows also lead to an augmentation of the host country's technological capacity, while A and B flows lead to creation of new production capacity. It is important to underline that the pure installation of production capacities does not automatically lead to technical change in the host country. Additional knowledge and deeper understanding beyond operating and maintaining the technology are necessary to alter and modify it productively.

To successfully capitalize on imported technology, the foreign knowledge flow to generate technical change must be accompanied by the investment in technological capabilities in form of education, R&D, financial institutions, academic training and firm support within the recipient state (Bell / Pavitt 1993: 14). The building up of local technological capabilities within the recipient country could be called D flow. Local capabilities are in many cases the prerequisite for increased benefits from A and B type flows. Without them, no reverse engineering or other forms of knowledge extraction from transferred hardware are possible. However, if a certain amount of technological capacity exists and new C-type knowledge flows enter a firm via technology transfer, the conditions for technical change are in place.

5.2 The importance of C type flows for recipient countries and recipient firms

The importance of type C flows for a host country derives from a Schumpeterian understanding of the role of technology and innovation for economic growth. For Schumpeter, innovation incorporating technical change is the most important source for quasi-monopolistic profits (Schumpeter 1961). New or modified products or processes are the source for these profits, which derive from the various sources of technical change (R&D, customer feedback, incremental product improvement on the production site, learning by doing, etc.). Generation of new knowledge embodied in new products and processes and its diffusion is, from this perspective, the main source of economic growth and accumulation of technological capacities its basic requirement. They have to complement the imported technology during the adaptation phase and, in the second step to change and improve the adapted technology (Radosevic 1999: 3).

The importance of type C flows for a recipient firm derives from the importance of the capability to innovate for sustaining long-term competitiveness. The knowledge required to innovate can either be generated in-house or acquired outside the firm. For the recipient firm of a certain technology after having mastered to use a new production system, C-type flows of information are the most essential to create a competitive advantage over other firms having received similar technology by being able to alter and improve the technology. As Watson points out, the negotiations over C-type knowledge flows within transfer projects hold the biggest potential for conflict between the participants of a technology transfer project. It might be needed by the recipient firm built up technological capacities and in that way in the long run eventually contribute to the development of the host country economy. But technology suppliers might be hesitant to transfer it out of fear they might lose their own competitive advantage (Watson 2001: 71).

5.3 Conflict within technology transfer

Technology transfer has been understood a process with a 'built in' conflict by Kaplinsky. In Kaplinky's understanding conflict is an essential component of technology transfer since the technology transferred is essential to create surplus in either profit or growth on a firm level, although resulting conflicts can be resolved in relation to the distribution of power between the firms and the legal frameworks surrounding the technology transfer. Firms enter foreign markets via the various forms of technology transfer because of the competition they face in established markets or because they are approached by the government or firms of the recipient state because they hold technologies of strategic interest. The interest of the recipient firm stands, according to Kaplinsky, in sharp contrast to the interest of the supplier firm. Since the main motive of the recipient firm is also either to grow or make profit, it has a strong interest in gaining over as much control as possible (Kaplinsky 1974: 11).

Conflicts over the "monopoly" of the transferred technology seem to be unavoidable and the supplier firm maintains control over technology by either by concentrating innovative processes in the country of the head office of the supplier firm or the level of the transferred skills in its majority operational. The supplier firm hence controls technical change (Kaplinsky 1974: 23). The outlined conflict is usually resolved via power which is expressed in the different forms of control over equity ownership, the various business functions and legal arrangements which determine the technology / knowledge flows.

In practice, however, the recipient end of the technology transfer process is usually a dynamic system of local actors (firms, technological institutions, academia, etc.) with again diverging and competing interests. Furthermore, it is also possible that no conflict arises because recipient firms have no interest in the core technology of the donor firm. Kaplinky's model is therefore drawn a bit starkly but it reminds us that the ultimate intention of every firm is to benefit as much as possible from its owned technology and will only share it if it sees a potential benefit from sharing or is forced to do so. That technology transfer in practice differs from Kaplinky's model will be shown a bit further down. The distribution of power between the participating parties depends on a number of factors and differs from project to project as well and it is obvious that conflict about the quality of technology transfer might arise within the CDM projects.

5.4 Trends in technology transfer

To better judge the CDM as an instrument for technology transfer, one must place it in relation to the current international framework for technology transfer. Radosevic analyses the current shifts in the international policy setting for technology transfer. According to him, governments have lost in influence over technology transfer during the last 40 years. This is mainly due to increased global trade liberalisation and the changing nature of technology. The WTO governed global economy of the 80s and 90s has led to a specific interaction of trade and financial liberalisation with new production and technology networks which also shaped the modes of technology transfer. According to Radosevic, two distinct but interrelated phenomena economic mark globalisation: scope and integration (Radosevic 1999: 44). The scope of economic activity is increased due to the multilateral lowering of tariffs and on-tariff barriers to trade, which also entailed the expansion of international financial markets. From a national point of view, liberalisation has diminished the influence of the state on good and capital flows. Hence, developing countries might have problems to direct inward investment to technology sectors they consider of crucial importance.

Trade liberalisation has however not directly affected a states ability to support localised knowledge. The WTO agreements do not inhibit state subsidies for R&D capabilities of firms. Forbidden under the world trade agreements are export subsidies and content subsidies, which favour local products over imports. Building localised D-Flows can be supported by the state which then indirectly helps to exploit transferred technology (WTO 2002)

At the same time, liberalisation enabled the deeper, although geographically unbalanced integration of local firms in international production networks. Integration is driven by trans-national corporations and their distribution of production tasks across national borders through sourcing, mergers and acquisitions as well as their relation to other production networks in form of subcontracting, licensing, consortia, strategic alliances, etc.. The integration of production networks is also facilitated by the liberalisation of the international framework governing technology flows (merger and acquisitions legislation, joint-venture rules, local-content regulation, technology transfer controls). Technology transfer therefore in its majority facilitated trough inter firm linkages rather then government lending or development programmes.

The decrease of public sector involvement has far reaching consequences for the recipient states since the agendas of public and private actors often differ. Projects driven by the public sector are usually driven by political and social goals while projects driven by the private sector are driven by commercial goals (IPCC 2000)[8]. The decrease of public sector involvement also entails that governments of developing countries are much less able to influence the relations of trade, finance and production, which set the context for technology transfer (Radosevic 1995: 63). The extension of trade and the stronger integration of production networks might lead to technology transfer and technological accumulation in a host country but it is not a necessary result. A strong government influence on technology transfer is however seen crucial for the successful appropriation of technology beyond mere installation of production capacity, which will eventually lead to economic growth. It is now more dependent on the state's effort to invest in local technological capabilities which might attract investment and the resulting technology transfer and support the fruitful exploitation of the transferred technology.

Considering the trends outlined by Radosevic, the CDM could strengthen the position of the host governments. Finance is provided in form of CER and the national authorities and the CDM executive board control the direction and quality of technology flows ultimately. It is them who have to approve the projects and this way might be able to balance technology flows. Stronger claims by host governments however could be a disincentive for firms in developed countries to participate. In relation to a potential wind energy co-operation between Germany and China, a worst case scenario would be the following: The German government is trying to start a transfer project, but the German technology suppliers are not willing to participate because the Chinese authorities demand in accord with local firms a form of transfer which the German suppliers perceive as to threatening to their business interest. At the same time, the Chinese authorities are not willing to make concessions or cannot make concessions because they fear that the independent surveillance bodies will not approve the project as a CDM project if compromises are made.

5.5 What do multilateral institutions say about technology transfer?

In order to better understand what kind of technology flows are envisaged within CDM projects one

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8 Some commentators however claim that also the development aims of industrialised governments were a pretext to create markets for the country's industrial products leading therefore to unsuccessful or inadequate technology transfer (Forsyth 1999)

has to analyse the relating official documents. The Kyoto protocol gives no definition of technology transfer. Its affiliated multilateral institutions and international organisations from the energy / development field give only vague definitions. The International Energy Agency e.g. states about technology transfer in relation to the CDM that it "is *not* simply about the supply and shipment of hardware across international borders. It is about the complex process of sharing knowledge and adapting technology to meet local conditions. It strengthens human and technological capacity in developing countries. It promotes commercial markets for climate-friendly technology" (IEA 2001:8). Similarly, the Intergovernmental Panel on Climate Change (IPCC) states that technology "comprises the process of learning to understand, utilise and replicate the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies" (IPCC 2000: 4).

Both bodies underline that technology transfer must strengthen the technological capacity of the host country, but remain opaque about the actual meaning of the term or how transfer projects could fulfil this criterion or differ from another. The emphasis on the contribution of technology transfer to local capacities however sounds like a vague plead for including C-type flows into projects.

5.6 Technology transfer and sustainable development

That the quality of the technology transfer undertaken within the CDM might resemble Bell`s C flows seems to be reinforced with the criterion of "sustainability" which CDM investment project have to fulfil if they want to be approved as a CDM project. The notion of sustainability has however not been precisely defined within the Kyoto protocol and might be an equally contested term as technology transfer in the future negotiations over CDM projects. In the literature relating to the CDM, sustainability of the project or sustainable development as a result of the project is often mentioned, but rarely defined and even less problematised.

The UN's World Commission on Environment and Development (WCED) tried to define sustainable development in its report *Our Common Future* as the ability "to meet the needs of the present without compromising the ability of future generations to meet their own needs". The concept emphasized in particular "the essential needs of the world's poor, to which overriding priority should be given," but also "the environment's ability to meet present and future needs"(WCED 1987: 43). The idea behind the concept is to facilitate economic growth without threatening the natural resources of future generations.[9] It recognizes the limited capacities of the biosphere to withstand the consequences of human activity and the need to end poverty and underdevelopment where it exists. Consequently, technology and social organisation should be organised in such a way, that both environmental protection and economic development could be improved at the same time. Green technology transfer is an essential component of sustainable development since the technology helps less developed countries to manage their natural resources according to their needs.

Some commentators claim that sustainable development does not mean the continuation of existing economic growth patterns with more environmentally friendly technologies but also an emphasis on resource conservation including the change of consumption patterns in the developed world and poverty alleviation in less developed countries as well as greater equality in the access to natural resources. This includes for less developed countries gaining the means to end poverty, which is identified as one of the biggest reasons of environmental degradation. The re-distribution of some wealth

[9] There is still considerable debate over the possibility of achieving sustainable development in principle. Some say that achieving growth and environmental resources protection are mutually exclusive goals, other say the term secures northern predominance over the south. In the words of Muchie, there is also "not yet conclusive empirical proof that a trajectory that combines economic development with environmental concerns" can override present patterns of industrial-economic evolution (Muchie 2000: 202)

from the rich to the poor is a pre-requisite for all of these aims (Blowers / Glasbergen 1995: 170).

It does not take a lot to see that the sustainability goals of the CDM are in accord with the aims of the WCED at least on a superficial level. And although sustainability is nowhere exactly defined within the Kyoto protocol (Kolhsus et al. 2001: 9), there are however, indicators in the discussion around CDM which reveal that host countries could interpret the sustainability criterion in such a way that it would justify an insistence on C- type technology flows. This is not to say that C –type technology flows generate automatically sustainable development. But the transfer of C– type knowledge flows can be seen as fundamental, although not sufficient, for sustainable development since it gives the recipient wider and especially lasting control over the technology.

A study on the transfer of clean technology from Japan to China by Orshita / Ortolano underlines that the maintenance and successful diffusion of transferred technology within a commercial environment depends certainly also on C-type knowledge flows. In their study on 16 coal preparation facilities, coal power plants and sites of industrial coal usage, they remark that only three facilities could continue to operate the imported equipment after the end of the project although operation was assured during the project. Operation after the end of the project however is crucial for the wider diffusion of the technologies. The reasons for little continuing operations were manifold: "In the three cases where project operation continued past the trial period, enterprises had the capabilities and finances to satisfy project demand. They also experienced a strong market demand for their products and project operation was encouraged by environmental requirements" (Orshita / Ortolano 2002: 73). Although most of the mentioned success factors are beyond the influence of technology transfer, the mentioned "capabilities to satisfy project demand" deserve more attention. What is meant by that are the technical capabilities to install, adapt and change the imported technology and management skills to meet the organisational requirements of the new technology. The capacities for local adaptation, local engineering, and cumulative learning about the technology by using it for eventual local improvement are necessary to operate a transferred technology without foreign help. If we interpret sustainability with an emphasis on a lasting impact of the technology, C- type flows within the process are essential.

Translating these results to our example of wind turbines, a local Chinese industry is only sustainable if it can accumulate local competitive capabilities deriving from the capabilities to improve and change the imported technology. Mere production capacities will soon put an end to production if world wide competition improves products while Chinese improvement is lacking. However, no definition of sustainability emerging around the CDM takes the aspects of sustainability just discussed into account.

Austin and Faeth claim that the Kyoto protocol is based on the underlying assumption that "that projects which are good for carbon abatement must also be good for sustainable development in developing countries" (Austin / Faeth 2000:2), which of course will not automatically come true. For Kolhus et al. sustainability in relation to CDM means that transfer projects must have "positive side effect" like cleaner air, increased employment opportunities or increased biodiversity apart from the installation of the technology (Kolhus et. al. 2001: 10). A similar stance is taken by Mathy et al.. They state that CDM projects must create positive local externalities or that economic co-benefits must "go beyond local technical upgrading" (Mathy et al. 2001).

What sounds clear in the above-mentioned definitions turns out to be more problematic on closer examination. Positive side effects of CDM projects are also called 'double dividends'. They are more problematic in relation to the notion of sustainable development then the authors above admit because the effects of projects are never straightforward and many involve trade offs. Chadwick et al. stress that although the language surrounding the Kyoto protocol is full of references to double dividends, neither section in the protocol imposes any requirements or gives guidance towards appropriate environmental and social assessment other then the principal goal of achieving sustainability (Chadwick et. al. 2001: 80). Reviewing a case of the conversion of a district heating system from a heavy-fuel oil heating system to biomass combustion they for example report that the SO2 emissions decreased while the CO2 emissions increased. The comments on sustainability reviewed before lack the caution of Chadwick et al..

Take for example the Kolhus et al's claim that CDM projects must lead to increased employment effects. Apart from the fact that that absolute numbers are hard to calculate since new jobs in say the wind industry will take away jobs in coal mining, there is the problem of defining when increased employment is reached. When a few new wind turbines are installed by foreign engineers and operated by local technicians, which would require only A and B type flows of technology? Or when local factories for gearboxes are set up which in the future will be able to operate and produce without German input, which will obviously require C type flows of knowledge? Just claiming that technology transfer must have any effect apart from CO2 abatement gives no guidance about how to design technology transfer and leaves ample space for conflict over A, B, and C type flows. In other words, because the term *Sustainability* is fuzzy, its application as a CDM project criterion does not clarify at all what kinds of technology flows have to be managed within a CDM project.

Having said that, it must be underlined again that it is not the aim to solve the discussion about what technology transfer and sustainability mean in relation to CDM. The intention here is rather to point to some neglected issues, which might be hurdles on the way to a successful CDM project. The decisions on the relevant meanings of both terms are in the end made by the negotiating parties. But if the sustainability criteria will include some ideas of social justice and long-term environmental concerns instead of short-term green benefits, technology flows will significantly differ. It has to be pointed to the fact that the fuzzy definitions of sustainability and technology transfer in the existing agreements and the surrounding discussions will be a potential site of conflict if the negotiating parties appropriate differing understandings of the term. The UN ad-hoc working group on the CDM cautiously anticipated that kind of conflict by underlining those sustainability criteria should be in accord with the host nation's priorities but are to be negotiated between the participating parties (UN 1999: 47). The claim is that if dramatic differences exist and those differences are not properly or early enough taken into account, they will threaten the success of the CDM.

In the next paragraph, some of the technology transfer which already has happened to China is reviewed to confront Kaplinky's model with business practice.

5.7 Recent technology transfer to China

In practice, firm strategies and aims in relation to technology transfer differ from Kaplinky's model. Although conflict will always exist due to the competitive nature of the existing capitalist regime, firms from industrialised countries do transfer C- type technology flows to less developed countries. Benett et al. for example report in their study on the technology transfer strategy of 20 major European firms in advanced technology industry fields regarding China, that the firms considered 30 per cent of all technology transferred to China as able to provide a "lead over competitors" and 20 per cent related to an own recent innovation[10]. 74 per cent of the transferred technology went to producers in the same sector, which entails the risk that local firms might become competitors in the future.

However, 75 per cent of all companies stated that the retained key parts of their technology especially since they feared that local firm could develop threatening technological capabilities. Similarly, 75 per

[10] Benett defines as „advanced technologies" all industry sectors in which the R&D spending is in relation to sales at least twice as high as in the overall industry sector average.

cent of all firms had not transferred R&D facilities to China. In order to maintain their lead over Chinese competition 90 per cent mentioned R&D, 50 per cent close co-operation and 50 per cent mentioned restricted technology transfer (Bennett et. al. 2000: 17-24). Bennett et al. conclude from their study that European firms are well aware of the risk of technology loss but take it because they need technology transfer mostly as a means to market access. Other reasons include cost considerations, globalisation strategies, and Chinese sourcing and technology transfer policy. At the same time, most firms trust in their development capacities to stay ahead of Chinese competitors. Translated to our context the findings of Bennett et al. indicate that firms do perceive technology transfer as a risk even though technology transfer of key technology happens. Although it is impossible to judge whether the "key technologies" transferred fulfil the criteria of C-type flows in terms of its local effects or have the dimension to generate technical change, it is important to acknowledge that firms are willing to transfer crucial technology and therefore avoid conflict with their Chinese partners.

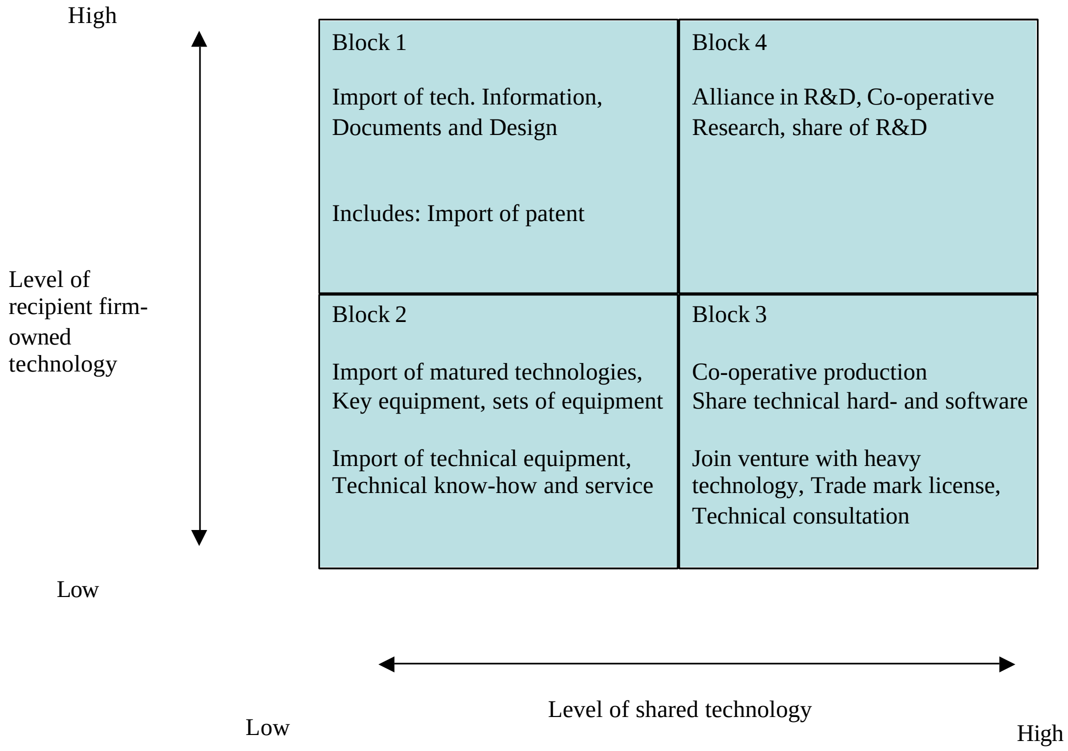
Transferring C-type flows seems to be however a more recent exception within technology transfer to China. The overwhelming majority of market led technology transfer via foreign direct investment lead to low technology production concentrated in the textile, toys, plastic and the electronics sector (Thoburn / Holwell 1999: 174). This observation is also confirmed by a study of Chen / Sun about technology transfer in the mechanical industries. They conclude that, although the scope of technology import between China and foreign partners increased during the last decade, most imports consisted of "hardware" (meaning machinery and equipment) while "software" (meaning knowledge beyond maintenance and operation) was missing (Chen / Sun 2000: 361).

In the field of energy technology, international technology transfer also focussed on capital goods and equipment in form of bilateral or multilateral aid. The following table summarises the support received between 1988 and 1997 in US$:

	Bilateral Aid	Multilateral Aid	Total
Coal-fired Power Plants	1,9990m	3,507m	5,497m
Hydro Power Plants	924m	1,735m	3,660m
Oil & Gas	321m	522m	843m
Renewables	59m	-	59m
Energy Efficiency Projects	220m	544m	764m
Clean Coal Projects	331m	203m	534m
Total	**3,845m**	**6,511m**	**10,356m**

Table 5 International Aid to China for Energy Projects **Source: Watson et al.**

Chen / Sun develop a useful graphical map of possible technical co-operation for technology transfer on which both supplier and recipient firms can be placed in order to detect differing notions of technology transfer and potential conflict. The map is based on the assumption that the level and the nature of technical co-operation depends on the in-house technological capacities of the recipient firm and the willingness of the supplier firm to share technology. Accordingly, the Y axis represents the recipient firm's technological capabilities and the X axis the level of shared technology.



Graph 4 Levels of technology transfer co-operation **Source: Chen / Sun**

What the table of cannot represent is the dynamics which are set in motion when transfer happens. Therefore, the map can be used in two ways. First, it can be used as a mapping out of the state of a current co-operation. The map can secondly display where both firms want to move during the co-operation. The map will be useful to visualise the strategies of the interviews German firms. It will be more difficult to evaluate the recipient side, since no interviews were conducted in China.

5.8 Chinese government ambition

To further promote localized manufacturing, the State development planning commission (SDPC) has required that all new wind farms have at least 40 percent local components before they are approved for construction. Furthermore, the State Economic and Trade Commission (SETC) has set up the National Debt program, which provides favourable loans for wind farms that have locally manufactured components (Lew / Logan 2001).

5.9 Wind energy technology transfer to China

The very first imports of wind energy technology import into China were made an in the mid-eighties by Danish firms with the help of the Danish government and a few years later by Belgium, Swedish and American firms in form of demonstration and research projects. The initiation of industrialisation started in the beginning of the nineties with the establishment of the first wind parks

In 1996, the State Development and Planning Commission initiated the “Riding the Wind” support program and the Spanish and Austrian manufactures entered the market. This program aimed to develop local manufacturing capability by supporting sales of 190 MW of foreign wind turbines in exchange for technology transfer. German-Danish wind turbine manufacturer Nordex-Balcke Dhürr transferred their knowledge and technology to build up a turbine manufacturing site in China. China First Tractor and Construction Machinery Corporation and Xian Aviation Company are the two local companies, which have been selected by SDPC to receive the technology (Lew 2000: 228).

Xinjiang Wind Energy Company (XWEC) was the first Chinese company to commercially manufacture large-scale wind turbines with mostly Chinese components. The company bought a license from the German manufacturer Jacobs to build a 600 kW turbine, and began manufacturing in mid-1998 with successively larger fractions of local components. Ten turbines have been successfully operating for the last four years, the newest of which has 92 percent locally manufactured components (Jacobs 2002).

The strategy of localization of technology carried out by XJWEC was as follows: Import the design and manufacturing technology of the model 43/600kW wind turbine; understand the philosophy of turbine design; partial local manufacturing; full local manufacturing; and finally, innovation.

Chinese experts, including engineers from component manufacturers, visited Jacobs and other component suppliers in Germany received training. Jacobs’ experts also visited China for supervision and training. The first prototype machine with 38 per cent of Chinese components was erected in June 1998, and the ninth, with 70 per cent of locally manufactured parts was installed in November 1999. The operating record of these turbines showed, according to Lew, good performance, equivalent to imported turbines (Lew 2002).

This year, German firm DeWind sold six turbines to two firms in the province of Zhejiang. The project includes the construction of towers and the local training of engineers (Wind power monthly 2002: 17). The same year, Nordex sold 12 800 KW wind turbines to Liaoning Tianlin Windpower Investment Company (Wind power monthly 2001a). Wind farm developer Windsolar planned a project involving the import of 32 Nordex 600 KW turbines (2001b: 38).

5.10 Summary

As seen, there is an inherent conflict within technology transfer between supplier and recipient firms. The institutions supporting the CDM do not properly acknowledge this conflict. On the contrary, the absence of clear definitions of the terms *technology transfer* and *sustainability* leaves ample room for interpretation and debate about project design. What we can gather however from empirical studies so far is that firms are generally willing to allow for C-type technology flows and that in the case of wind energy, first steps have been made which already lead to C-type flows. Those are positive signs, although they are in relation to the bulk of technology transfer in form of FDI clearly the exception. The next part of the study will present the results of the empirical study undertaken for this research. It aims to better evaluate the potential conflict within technology transfer between China and Germany in the field of wind turbine manufacturing.

6 Wind Technology Transfer from Germany to China

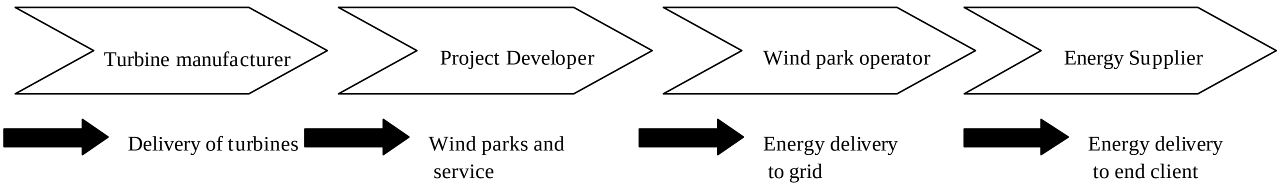
6.1 Background and methodology

The aim of the empirical part was to find evidence for a potential conflict in transferring wind technology from Germany to China within the CDM. Correspondingly, the German wind turbine manufacturing industry was identified as the object for primary research.

Interviews with senior managers of the relevant firms were chosen as the appropriate research method. The reasons for this choice lie in the absence of any scientific research on wind energy technology transfer between Germany and China and the up to date information interviews can give. Semi-structured phone interviews were chosen, though more costly in terms of time and resources, it was felt that they would yield a greater response than an anonymous postal survey.

6.2 German wind turbine manufacturers

Before a discussion of the results, the value chain and the construction of technological competitive advantage within wind turbine manufacturing must briefly be outlined. Otherwise, as we will see later, the different firm strategies for transferring technology to China cannot be understood. The value chain of wind energy can be represented as follows:



Technological advance in wind turbines is expressed in reaching economies of scale by reducing the price through building physically bigger turbines with larger generation capacities. The underlying reasoning is that physically bigger turbines generate more energy with lower cost per turbine. Danish wind turbine manufacturer Vestas for example claims that their 1,5 MW turbine, with a tower height of sixty meters and a rotor blade diameter of 60 meters, produces one k/Wh of electricity for the price of 3.8 US Cents. Their 500 KW model, with a tower height of 39 meter and a rotor blade diameter of 39 meters produces one K/Wh of electricity for the price of 4.4 US Cents (Andersen 1994: 565)[11]. It is however not possible to simply take the knowledge used to build smaller wind turbines and just expand the physical measurements in order to construct bigger ones. New and different engineering knowledge is necessary to deal with heightened strain on the used material by expanding physical measurements and the increased weight of the turbines. The knowledge to build a 600 KW turbine is not sufficient to build a 1,5 MW turbine. Also, new and different control technologies for the positioning of the rotor blades towards the wind are necessary to make turbines reach generation capacities in the

[11] Prices have fallen since 1994 and costs vary more in regard to where a wind turbine is built (easy accessible coast or high mountain), but the figures indicate a general trend.

MW zone. (Nord/LB 2002: 12). Competitive advantage over recipient firms can therefore be kept in two different ways: by guarding key components or by only transferring smaller turbines.

Five German large-scale wind turbine manufactures exist currently. One of them is a German-Danish joint venture. Of those five, four are presently active in the Chinese market. Of those four, two were interviewed while the other two pulled out in the last minute after initially having agreed on participation. To broaden the interview base, the only German small-scale turbine manufactures with experience in China was interviewed as well. The results of this interview however must be treated differently from those conducted with large scale turbine firms because the Chinese industry structure and the transferred technology of small-scale turbines is completely different from large-scale wind turbines. Since almost no literature on the experience of technology transfer exists firms were asked about their past experience as well as about their future plans and their envisioned behaviour within a CDM project. Questions were asked about the following topics:

- General perceptions of Chinese market and how problems could be resolved
- Their past experiences in China
- Their attitude towards technology transfer and the CDM

For the first set of questions, it was hoped to determine what firms require from policy makers and whether their expectations could be accommodated within the CDM framework. It was hoped that answers to the other sets of questions could be related back to the theoretical assumptions and models about technology transfer in order to determine the quality and the conditions of technology flow. It was also hoped to find out how firms planned to behave within a CDM framework, which would alter the conditions for technology transfer considerably.

6.3 Responses

6.3.1 General perceptions of China

All firms described their experiences in China as generally good, although they stated that they encountered tremendous difficulties in getting where they are now. All firms were active in selling wind turbines to Chinese wind parks and operating production sites in form of joint ventures or licence agreements within China. The main obstacles encountered for all firms were problems with the huge and almost un-understandable bureaucracy, which in their view was slow, inefficient and lacking an understanding of the needs of firms which have to make profit. One interviewee found it particularly constraining that his firm could not choose his joint venture partner. The firm had to partner with a firm selected by the Chinese government, which is located 1000 kilometres “away from the nearest wind”. Their Chinese partner firms, on the other hand, were all praised for their capabilities and the well work co-operation.

A second negative experience for all firms was the judicial system, which was in their experience lacking expertise in the whole country apart from the east coast. Complaints about the absence of trained judges and lawyers were common. Also, all firms were concerned about the full disrespect of intellectual property rights. This was not only seen as a problem but also described as a huge obstacle to further business development. Although no interviewee indicated that his firms had experienced any copyright infringement, one reason stated for not delivering key technologies more widely and without joint ventures was that patents were not properly protected in China. However, the market for wind energy was considered huge, though largely unexploited due to too little political support.

As a third obstacle was pointed out that the bureaucracy was lacking an understanding of the necessity for renewable energy or the contribution this energy form could make to protecting the environment.

When asked what could be done about the current problems, the interviewees stated that a better education of the civil servants in regard to renewable energy would be helpful. Also, competencies should be assigned and overall structures within the bureaucratic apparatus more clearly designed. Everyone was however aware that the biggest concern of Chinese officials was covering the country's electricity needs rather then worrying from which source power was generated. All interviewees thought that a nationwide and strictly enforced law regulating the fed-in tariffs for wind energy would be a big step towards the full exploitation of China's potential for wind energy. As one interviewee pointed out, the present fragmentation of the grid was a major obstacle for the promotion of wind energy. The regional grid operators were, in his words, very powerful due to their quasi-monopolistic position and "equally corrupt". For this reason, it was very difficult to negotiate a fed in tariff with them, which would be high enough to support the generation of wind energy. This experience coincides with Lew / Logan's observation introduced earlier that a consistent, national renewable energy policy framework was still lacking.

The expectation towards German policy clearly pointed towards more help for the Chinese government in establishing solid policy measures for supporting wind energy. One interviewee proposed that the German government should invite a number of senior civil servants, managers and politicians to demonstrate how the political support framework for renewable energy is designed and implemented in Germany. Another interviewee felt that more institutions for matching German and Chinese businesses should be established. Generally it was hoped that the status of IPR would change but no one really expected a change in the short term.

6.3.2 Experience within the Chinese market

All three firms are or were engaged in establishing Chinese domestic manufacturing capacities. Small-scale wind turbines are now 100 per cent produced in China. The two large-scale wind turbine manufactures produce 600 KW turbines and the localised content is in both cases over 90 per cent. One of them also produces 250 KW turbines. Also, both firms engage in incremental innovation with their Chinese partners and adapt their turbines to local needs. Both firms are willing to produce also models of higher generation capacity in the future in China. Being asked why the localised production was not 100 per cent, one respondent answered that the Chinese capacities were not able to build certain dynamic parts while the other stated that certain hydraulic parts were still to expensive to produce in China and did not reach sufficient quality.

The technological capabilities of Chinese firms were considered high. All interviewees said they were in retrospect surprised how fast local firms learned, via reverse engineering and German training, to produce wind turbines. They also all mentioned that they were willing to transfer much more technology if the Chinese partners were willing to provide more finance. One has to take care in understanding what is meant by finance here. More finance does not exclusively mean the state raising more money to buy more machines, expertise and training from German firms to strengthen domestic firms. More finance means also creating the political circumstances in which it pays for the German firms to produce more costly turbine technology with their Chinese partners under German control. That would mean e.g. a feed-in law, which would guarantee a certain price for the electricity delivered from wind. Generally, all three underlined that their Chinese partners had a different idea about what technology transfer should cost. They also all stated that their Chinese partners wanted to have all technology transferred from the German firms.

The representatives of the large-scale firms said that they would be happy to develop even 1,5 MW turbines if the Chinese government would procure the necessary money for the transfer of the technology and the conditions to operate a wind park consisting of 1,5 MW wind turbines profitable. As one of them put it:

> "In theory the Chinese are able to built everything via reverse engineering if we give them the product and some training within a pilot project. The problem is that for bigger turbines the whole business environment (reliable suppliers, secure finance, sites for wind parks) and the basic infrastructure (roads, cranes) are not in place to maintain production beyond the pilot phase."

6.3.3 The CDM and technology transfer

Regarding their future technology transfer strategy, the large-scale manufactures and the small scale manufactures said that they would be willing to transfer more technology in the form of joint ventures if finance was provided. This transfer would not only comprise machinery delivery but enlarging the local production capacities including training and instruction of the local work force. However, two said their companies would always try to retain control over some components within each turbine model. The other of the two large scale manufactures said that his firm was willing to fully transfer complete older turbines including R&D units to further develop them for the Chinese market but never the latest, technologically advanced model. This behaviour reflects the two possible strategies of maintaining competitive advantage in wind turbine manufacturing. The establishment of local competition through technology transfer was seen as a normal part of the process.

One firm would not locate R&D units to China because skills of local engineers would not be high enough for research. This statement stands contrary to the praise stated in another part of the interview.

The knowledge of the CDM was low to non-existent within the firms interviewed. All interviewees welcomed the possibility of technology transfer since they first and foremost interpreted it as a way to secure funding for future operations in China. When confronted with the issue of sustainability and technology transfer in order to establish local manufacturing capacities, they said they would be willing to transfer more technology, however always retaining key technologies and only in form of joint ventures. One interviewee saw the danger that Chinese firms could start selling turbine parts or full turbines to other Asian countries. The producer of small scale wind turbines was much better informed about CDM and stated that small systems were not interesting in that respect since not enough CO2 was saved and baseline calculation was too difficult. Therefore, CDM was not a topic for him. He however pointed out that too much money from abroad might prevent the Chinese government from arranging the necessary steps to develop a functioning domestic support for renewable energies. This was at least his experience from wind turbines for rural electrification, where foreign aid enabled short term solutions but prevented the built up of long term domestic finance mechanisms. Also, the German firms saw little need for the Chinese government to enhance the technological capacities of their Chinese partners. Indeed, one can assume that the advantage German firms currently retain was welcomed.

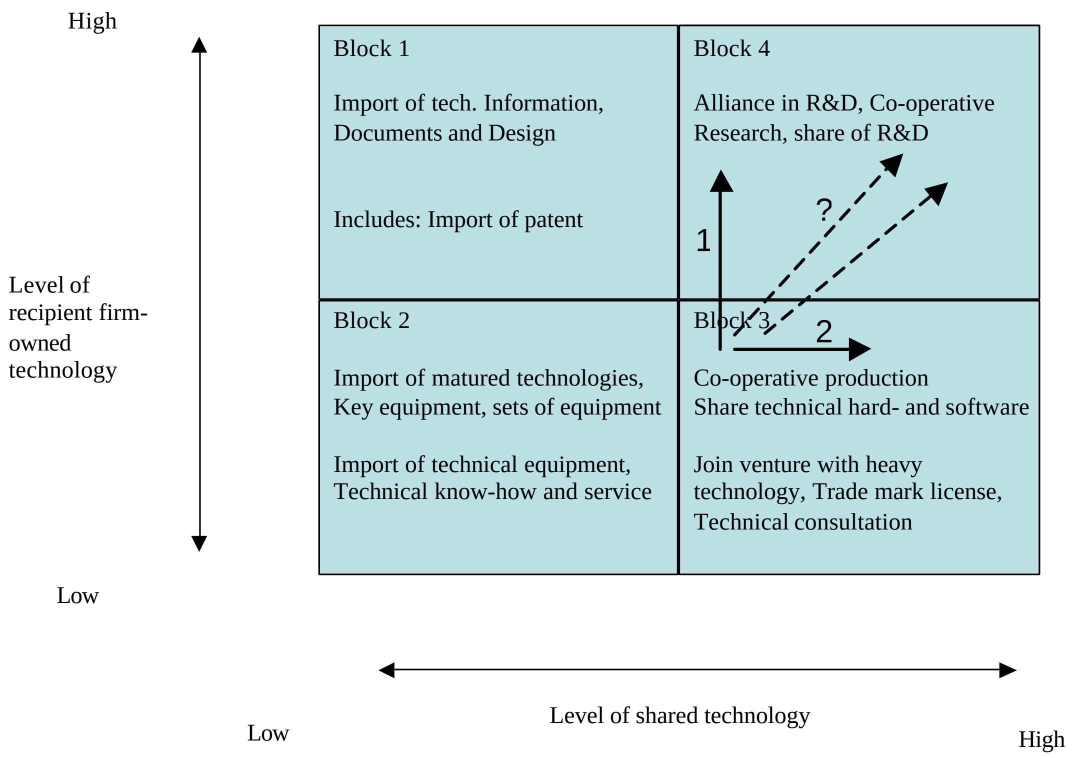
7 Discussion and Conclusion

7.1 Limitations of the study

The object of this empirical study was to evaluate the potential for conflict within CDM technology transfer projects by investigating technology transfer between Germany and China in the sector of wind turbine manufacturing.

The most obvious limitation is that only half of all German large scale wind turbine manufactures could be interviewed and it is not assured that their strategies regarding technology transfer would be similar with the other half. Including the small-scale turbine manufacturer is helpful to a certain extent because the firm operates within the same market and a similar technology. However, the political support framework, the technology and the manufacturing base in China differ substantially from that of large-scale firms. Therefore, the claims towards technology transfer can be seen used as an insightful comparative, but not to draw assumptions about the behaviour of large scale manufactures. This work is therefore to be considered a pilot study.

7.2 Technology transfer: present, past, future



Graph 5 Technology transfer strategies of German firms and Chinese expectations

If we transfer what we have gathered from the interviews with the firms to the model of Chen / Sun, we can learn the following. The present mode of technology transfer by German firms, indicated by the starting points of the unbroken arrows 1 and 2, is relatively high[12]. Also, German firms are willing to increase technology transfer but pursuing two different strategies, as indicated by the arrows 1 and 2, to retain their competitive advantage. Firm 1 is willing to increase knowledge about older products including joint R&D to increase the intensity of transfer within a certain product. Firm 2 is willing to share knowledge about newer, more competitive products but insists on controlling key parts of the technology. Firm 2 is increasing product range but not the transfer intensity.

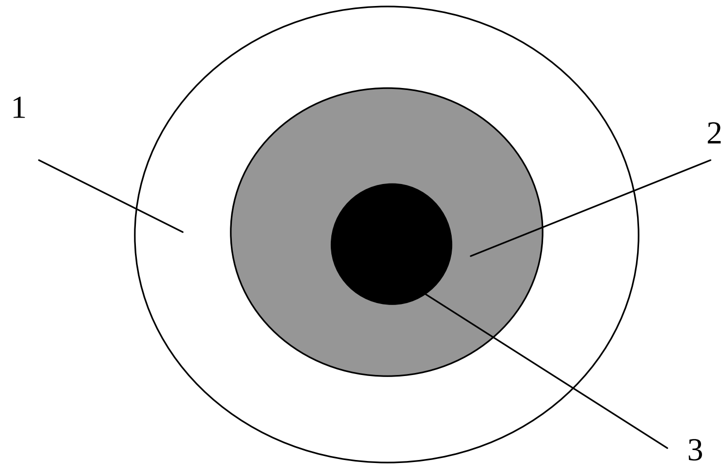
The broken arrows, marked with the question marks stand for the technology transfer envisioned by the Chinese firms and the Chinese government. These cannot properly determined, since no primary research could be conducted within this study. What we know from desktop research about the Chinese government plans is that a working wind turbine manufacturing industry shall be set up. That would require a transfer dynamic which would be somewhere similar as indicated by the broken arrows if all relevant knowledge and technology shall be received from foreign firms. It is also not determinable at this point which 'arrow' it would take to fulfil the sustainability requirements by the Kyoto protocol institutions. Further research would also be necessary to determine how realistic technology transfer along the lines of the broken arrows would be. German firms made obvious that they would not support this degree of transfer.

[12] The distinction between the blocks is of course blurry. One could also argue that the arrows start in box two since 600 kW turbines have to be considered matured technology by now. However, when the first were introduces in the late nineties they were not that mature. Also, block two would miss the aspect of co-operative production as well as joint venture.

7.3 German firms' willingness to supply technology

All firms said they were willing to transfer more technology if more money was provided. One firm they would actively pursue technical change for some of their slightly older turbine models. However, they also said they must keep control over key elements of their technology to keep their competitive advantage, because no properly functioning patent protection exists and because the technological capacities of Chinese recipient firms were not high enough to produce certain items at all or to the same quality. The statements of the technology suppliers stand in slight contradiction to each other and more research on supplier and recipient side would be necessary to disentangle which technologies are exactly meant and why capacities of Chinese firms eventually differ.

To better interpret the German suppliers willingness to share more technology it is useful for invoke a model of technology sharing from Scott-Kemmis / Bell. Scott-Kemmis / Bell find in their cross-industry sector study of technology transfer from the UK to India that supplier firms are quite willing to supply technology beyond the basics that make production sites working, but that this technology gets not transferred for a variety of reasons other than conflicting interest as described by Kaplinsky. Their study starts from the observation that Indian recipient firms of a certain technology almost never set in motion the same innovative process as in England. They also note that their interviews with the British technology suppliers showed that the British firms were willing to supply higher and more detailed knowledge of the transferred technology then just what was needed to get the installed machinery running if their Indian partners would be willing to pay more money (Scott-Kemmis / Bell 1988). The following diagram emerged.



Graph 6 Technology Transfer UK-India schematic **Source: Martin Bell**

Circle 1 stands for the technology necessary to build, run and maintain a productions site and which was transferred in any of the British – Indian co-operation. Circle 2 stands for complementary technology and extra knowledge, which supplements the operating technology and / or deepens the understanding of circle 1 technology to help to exploit and manage it better. It also stands for knowledge important for technological improvement, which the supplier firm had accumulated over time. The technology within this circle is important for setting in motion innovation and was shared sometimes but not in all cases. Circle 3 stands for the core technology firms had no interest in sharing. Scott-

Kemmis / Bell report that the knowledge in circle 2 was only transferred in some case but would have been shared by the British suppliers if the Indian firms would have shown interest and the necessary financial and human resources in much more cases then it actually happened. In other words, the study indicates that there might exist some middle way between just sharing production technology and withholding everything impeding technical change or giving away so much that the business interest of the supplier firm is threatened.[13]

One can learn from the empirical part of this research, that German firms have installed circle 1 technology to produce turbines. Both firms adapt their products on an incremental level to the local, Chinese conditions. One can also learn that German firms seem willing to supply more technology to Chinese firms, if the financial incentives were high enough. This relates to circle 1 technology and circle 2 technology (know-how to build bigger wind turbines). Furthermore, the German firms made quite clear that they will not transfer certain parts of their technology regardless of the circumstances which equals circle three. Also, German firms stated that they wanted to retain control over production.

Linking these findings to our previous thoughts about conflict on a firm level, the following conclusions can be drawn. From a German firm perspective, if parties could agree on circle 2 technology, the CDM could provide the relevant finance and conflict would be relatively small. Circle two flows include a substantial amount of C-type flows since German firms have an interest in developing and adapting turbines for local circumstances. The technology and knowledge base of their Chinese partners would be extended and substantial steps towards a fully Chinese owned manufacturing capacities could be made. Conflict would arise over circle 3 technology and a less tight control by the German side over their products. So from the German side, there seems to be some common ground for mutually beneficial technology transfer. To evaluate the severity and the extent of the conflict is not possible at this stage since further research on the plans of the Chinese side is necessary. Also, it cannot be said from the outset, whether the sustainability criteria as laid down in the Kyoto protocol can be fulfilled. Partly, because one can never fully anticipate or guarantee sustainability and partly, because the term is not properly defined.

But also another set of positive trends emerges from the interviews. At least half of the German large scale wind turbine manufactures are in principal willing to engage in CDM projects and are willing to commit themselves more then just using it as a sales channel for their products. Likewise, half of all German wind turbine manufactures are willing to engage into long-term partnerships with Chinese firms, mostly because of their good experience with their Chinese partners. This should diminish the conflict as lined out by Kaplinky significantly. Whether technology flows also include and to what extent C type knowledge flows cannot be determined at this point. However, the willingness of one supplier to re-locate R&D units is promising in that respect. Also, the cooperation in form of a joint venture is beneficial for Chinese firms, since it allows German and Chinese employees to work together at almost the whole innovation chain – from design to innovation. Joint ventures also hold the potential to build trust and long-term relations between the German and Chinese partners.

It is however not clear whether the plans of the German firms coincide with the plans of the Chinese government or the strategy of Chinese firms and whether they also fulfil the criteria of sustainability as they will be developed by the Kyoto protocol institutions. Further research on the Chinese 'end' of the process could further clarify those issues. A better understanding of all sides before entering any ne-

[13] Looking at the reasons why Indian firms paid in so many cases no attention to transfer of deeper knowledge, Scott-Kemmis / Bell reveal that in many, but not all cases, Indian firms would have liked to engage in a deeper technology flow comprising more detailed knowledge but were restricted by Indian governments policies. The government feared that to much technology import would mean too much export of foreign currencies and prevented domestic technological development (Scott-Kemmis / Bell 1988: 94). Their study in so far smoothes the edges of the conflict pointed out by Kaplinky and points to a different conflict: the divergent interest of the recipient state's government and the recipient firm Due to the limited extend of this study, this conflict could not be further researched and discussed.

gotiations should also avoid conflict, since the mutual acknowledgement of positions allows finding common ground more easily.

7.4 Support of wider framework as basis for technology exploitation

What also emerged from the interviews is that German suppliers are not in conflict with their partner firms but have to battle with the wider context of their business activities. One technology supplier stated that Chinese firms were able to build almost everything within a pilot project but the wider business environment and the infrastructure was not in place to keep the production of bigger (1,5 MW turbines) commercially going. Also, all firms were not disillusioned about the capabilities of their partner firms but with intellectual property right protection and the existing political support of wind energy. This was seen more as an obstacle then fears over arising competitors within China. Strengthening technological capabilities of the recipient firms is an important asset to technology transfer but not enough to maintain sustainable economic growth, the second key word of the CDM, as already pointed out by the study of Orshita / Ortolano cited earlier on. MacDonald concludes that successful technology transfer depends on local demand for new technology, availability of information for users, supporting infrastructure such as transportation and education, economic viability and a lack of dependency on subsidies, sufficient capital for initial investment, and appropriateness of technology for the underlying needs of end users (MacDonald 1992).

Paying attention to the wider social framework in which technology transfer takes place is surely important for a lasting effect on environmental performance in China and beneficial for German firms in the long run. Helping China to produce the latest wind turbines does not make sense if the road network is not good enough to transport the turbines to their wind parks.[14] Conflict about how much and what technology shall be transferred can surely be diminished if the support for building up extra-firm prerequisites to facilitate the effectiveness of technology transfer (like a national feed-in tariff law) became part of CDM projects.

However, two points must be taken into account here. Firstly, more research is necessary to validate the evaluations of German firms. More in depth research on Chinese needs and plans might draw up a different picture. Secondly, strengthening China's extra firm economic environment, means entering the field overseas direct aid, which the CDM is to be separated from. Indeed, strengthening a country's national innovation system and capacity building to facilitate technology transfer are aspects of technology transfer regulated in article 4. 5 of the United Nations Framework Convention on Climate Change where it is said that developed countries "shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention." Undertaking those measures surely facilitates technology transfer via the CDM but it is not yet clear in how far they can be part of CDM projects. However, there might be room for common ground and synergies in concerted project design.

7.5 Conclusion

The transfer of German wind energy technology seems to be a success story in terms of the amount

[14] The weight of the components rises disproportionably with the height of the towers and rotor blade size due to the disproportionably increasing strain on the material. The gondola of the Enercon 1,8 MW E 66 turbine weighs 100 tons. The gondola of the 4,5 MW E-112 turbine will weigh around 400 tons. The rotor blade diameter will only increase from 66 to 122 meters (Nord/LB 2002).

of technology transferred.[15] Localised production with over 90 per cent content produced by the Chinese partners is in place and German firms are willing to transfer much more of their technology if sufficient finance is raised. Also, the German wind turbine manufactures seem to be a prime partner for future CDM projects. But whether the German willingness is enough to fulfil the goals of the Kyoto protocol and Chinese expectations cannot be determined at this point. If the term sustainability is interpreted as continuing production of wind turbines with a growing Chinese work force, the German inclination is sufficient. If sustainability is interpreted as continuing production of wind turbines including key technology and state of the art models in order to foster an independent Chinese manufacturing base as soon as possible, German firms would probably not engage in any project operating under these goals. This slightly exaggerated contrast underlines on the one hand the advantages of the possibility for the parties to negotiate the aim of the CDM and the appropriate technology project by project. On the other hand it shows, if no definition of sustainability is given and enforced, the whole rhetoric around sustainable development seems a bit futile and it becomes even more obvious that there is a trade off between environmental and development goals inherent to CDM projects.

The process of technology transfer is not an easy one and bears more problems then admitted by the rhetoric around the Kyoto Protocol and economists trying to determine the ideal cost curve for joint CO2 abatement. However, as empirical research has shown, it is at least partly possible between two firms because of business interests of supplier and recipient firm can match (though it does not always).

The statements of the German firms also point strongly towards a second field of conflict, which is the conflict between firms and government policy. More research in this direction might further explain why China has made much more effort to acquire technological skills in turbine manufacturing then in implementing a national feed-in law.

The willingness of the German firms to provide more technology to a certain extent is an important step to a successful CDM project, but by far not a guarantee. As seen in Part 3, China has an energy agenda which's main focus is not renewable energy and wind energy competes with a number of other technologies for attention and resources within the CDM. Promoting wind energy as a way to abate CO2 emissions via the CDM can therefore only be part of a broader, concerted plan to establish wind energy in China and as a part of China's overall energy needs.

[15] The amount of turbines produced is still small and business is still very difficult

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