CHAPTER V

Baseline determination for greenhouse gas abatement by the Clean Development Mechanism and Joint Implementation under the Kyoto Protocol

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CONTENTS

Introduction

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) adopted two project-based mechanisms, the “clean development mechanism” (CDM, Article 12) and the informally called “joint implementation” (JI, Article 6). CDM is designed for cooperative activities between “Annex I” developed country Parties to the UNFCCC and “non-Annex I” country Parties with a two-fold purpose, namely:

- to assist the developing country Parties in achieving sustainable development and contributing to the ultimate objective of the Convention; and
- to assist the developed country Parties in achieving compliance with their quantified emissions limitation and reduction commitments (QELRC) under the Kyoto Protocol.

JI is designed for cooperative activities between different Annex I country Parties. These two mechanisms, however, are only roughly defined in the Kyoto Protocol provisions. There is little guidance on how to implement such (presumed) mutually beneficial instruments in practice. Notable in this regard is the absence of methodological guidelines, especially to the determination of project baselines.

In this paper, Section 1 reviews the provisions in the Kyoto Protocol relating to issues of baseline determination in CDM and JI. Section 2 is a literature review, in which we try to reflect balanced opinions from both developed countries and developing countries. Section 3 concerns conceptual issues of baseline setting. In section 4, we describe practical issues raised in baseline setting, using examples from projects under the pilot phase of the Activities Implemented Jointly (AIJ) program under the UNFCCC, greenhouse mitigation projects of the Global Environment Facility (GEF), as well as case studies conducted by the Harvard-Tsinghua Joint Working Group on CDM. Key issues for the Conference of the Parties to the UNFCCC and Meeting of the Parties to the Kyoto Protocol (COP/MOP) are also included in this section. By comparing different baseline setting approaches, we summarize the problems encountered in practice. Following this, there is a summary and some concluding remarks.

1. Review of Kyoto Protocol

Key ingredients of the baseline setting

In the Kyoto Protocol, related provisions describe three general but important concerns in baseline setting. First is the environmental benefit, requiring CDM and JI project activities to bring about "real, measurable and long term benefits related to mitigation of climate change" [Article 12.5 (b)]. Second is the "additionality" criterion as stressed in Article 12.5 (c) and Article 6.1 (b), requiring that reduction in emissions (or enhancement of removals by sinks under JI) should be additional to any that would have occurred in the absence of the CDM or JI project activity. For baseline determination, there are also important provisions on auditing, verification, and reporting [Article 6.2, Article 12.9]. A last concern relates to sinks projects in JI (which are not mentioned in the Article 12 CDM provisions), and what special needs may be required for setting baselines in such projects [Article 3.3, 3.4]. The relevant text of Articles 3, 6, and 12 are attached in Appendix 1.

The Buenos Aires Plan of Action agreed at the Fourth Conference of the Parties (COP-4) sets out 50 separate items for future consideration of CDM implementation, two of which are explicitly baseline-related, namely, "criteria for project baseline" and "environmental additionality and baselines" [UNFCCC, 1998].

The challenges in baseline determination are in most respects identical in the closely related CDM and JI mechanisms. This paper will focus on CDM baseline applications except for where there are important distinctions for JI, given the authors' own expertise and the Asian geographical focus of this inquiry. (JI is limited to activities between the industrialized and transitional economies of Annex B, of which only Japan and the Russian Federation are Asian).

2. Literature Review

Baseline approaches

Baselines are described in the literature as the amount of greenhouse gas (GHG) emissions (or sequestration) which might occur in a given time and place in absence of CDM/JI project, against which the emission reduction (or GHG sink) benefits achieved by the project would be measured [Wiener, 1997]. The main analytical challenge is that the baseline is generally hypothetical in nature—that which would have occurred in the absence of a project that one assumes is going forward—and some uncertainty is unavoidable. There is a swiftly expanding literature on CDM and JI, but the vast majority are broad surveys of a range of issues with little inquiry into the detailed practicalities of baseline setting [e.g., Goldemberg, 1998, Toman and Cazorla, 1998, CSDA/FIELD/WRI, 1998].

While CDM investments will take the form of projects (or sets of projects), the baselines against which their emission reductions will be measured can be determined on an individual project basis or on a variety of other levels. The literature describes three primary baseline determination approaches for CDM and JI projects: a project-specific approach, a technology-based approach, and a top-down normative approach, each with advantages and disadvantages [Jepma, van der Gaast, and Woerdman, 1998].

The project-by-project approach

This approach develops a baseline limited to a particular project context. The easiest case to conceptualize (with one of the most reliable baselines) would be a retrofit project, which would have an existing emissions record to compare against as the baseline [Parson and Fisher-Vanden 1996]. In many cases, project-specific baselines will also need to be informed by specific national technological circumstances, to project the likelihood and timing of upgrading the target facility that might occur in the absence of the CDM intervention, due to such factors as normal economic modernization. This approach usually provides a comparatively certain estimate of the emissions abated due to the investment, as it is based on relatively precise site information. One drawback is the greatly increased transactions costs to the investing and host entities, as baselines would have to be determined for each individual project instead of an entire technology type or sector. It is in response to this and the non-uniform results of project-specific baseline setting that many analysts argue for standardization, usually by employing one or more of the two following alternative baseline approaches [Jepma, 1999].

Technology-based approach

An alternative is to set baselines at the technology level. Gaining much attention recently in the literature is the idea of benchmarks, which proposes the setting of baselines based on weighted average emissions rates for a mix of technologies in a given sector or subsector [Friedman 1999; Kelly 1999]. These weighted averages could be based either on projected trends or historical data. The emissions benefits of many possible CDM projects would then be measured against the same baseline. As a result, it is argued that the baseline could increase uniformity, predictability, and fairness. It would decrease the transactions costs to prospective project participants, who could take the baseline as a given and make a CDM investment decision with less uncertainty. This approach would encourage projects; and in addition, might ease the use of dynamic baselines (see section 2.2.3. below) by averaging the collective behavior of many cases, changing over time due to technological improvement [Hamwey, 1998].

Technology-level baselines are often proposed to be developed across both geographical regions such as countries or regions—to reflect differences in economic or industrial development—and across categories of technologies (or subsectors). The result would be a country-by-category or region-by-category emissions baseline matrix that could be used for a larger range of prospective CDM projects. An example might be a matrix covering a variety of chemical manufacturing processes across a number of industrially disparate host countries.

A permutation of the technology benchmark approach was proposed earlier, to predefine an individual default technology as a baseline technology for a given subsector [Hargrave et al, 1999]. This, in fact, would be a special case of a benchmark, in that instead of a weighted emissions average of a *set* of technologies for the subsector, the emission level of a single technology, in effect, comprises the set. Most of the literature on technology matrices is based on the default technology idea, but such matrices might as well be constructed of benchmarks representing technology mixes.

There are three approaches for determining the technology benchmark baseline. [Lazarus, et al, 1999]

(i) History based benchmarks are past “typical performance,” i.e., an averaged median value over measurements of past performance of existing facilities, with future performance trend as a static extrapolation of past behavior.

(ii) Projection-based benchmarks are future “typical performance”, regarding projected future behavior in light of emerging and expected changes in the economy, markets, technology, institutional restructuring, environmental policies, etc. Projection-based benchmarks may be drawn from existing plans, scenarios, forecasting exercises, and expert opinions to show “what would otherwise occur” in the absence of the CDM/JI project.

(iii) Normative benchmarks do not presume to represent the “typical performance” for an aggregated category of technology in a given sector in the absence of a CDM activity. Rather, they impose standard performance requirements by incorporating policies with strategic objectives, with the intent of providing incentives to certain types of projects or technologies and/or disincentives to others. Thus a normative benchmarks baseline may explicitly deviate from and be stricter than average or median behavior. This approach may be desirable in the case that driven by particular planning, technical standards and/or environmental policy considerations, a normative baseline project would be expected to be built in the absence of the CDM/JI project.

Differentiating categories of technologies

It should be pointed out that technology categories may be distinguished by different production processes for the same products, for example coke wet quenching, and cke dry quenching (CDQ) for coke making; or by different technology types for the same kind of equipment, such as Pulverized Coal Fired boiler (PCFB), and Bubbling Bed Combustion boiler (BBCB); or by different scale/capacity of generation units for the same product, such as 50MW and 300MW coal fired electric power generation units.

Considering the diverse technological conditions in different countries, it has been proposed that the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UNFCCC may develop a standardized matrix, such as a technology benchmark baseline table, with two dimensions, i.e., technology category, and country or regions. However, this appears difficult to do, and would need significant inputs of technical expertise and resources.

Possible disadvantages of technology-level approaches include the following:

- The transactions costs of the analytical exercises to devise acceptable technology categories and matrices could be large. This would be especially true for the default technology approach, requiring an accredited expert panel to set predefined technologies. Partly for this reason, gaming over baseline determination may simply be raised from the project level to the sector or subsector level.
- Approval of individual baselines or matrices by host governments as well as the COP/MOP could be contentious. Considering the possible range and scales of investment options and varied site conditions, moreover, it may be more difficult than anticipated to match a specific project to a baseline context.

It would be politically difficult for developing country governments to allocate emissions reductions across sectors

Top-down normative approach

The top-down normative baselines would be derived from aggregate national emission levels, targets, or projections. A first top-down approach would take an agreed-upon aggregate emission trajectory (or even national cap), and typically allocate the limits to emissions by economic sector, forming a baseline for each sector [Baumert 1998]. In this case, the national government of the host country allocates its required emission reductions among economic sectors or subsectors, thereby establishing a quantitative basis of a baseline. This is comparably amenable to JI projects between Annex I nations, i.e. in which the host country already faces a binding emission commitment. Some have suggested that this approach might still be applied for CDM projects should a non-Annex I host country agree to set theoretical quantified emission targets for the purpose of baseline calculation [Hargrave et al, 1999; Jepma, 1999b]. We expect most non-Annex I governments to consider this approach an unacceptable political wedge, however, since setting theoretical national limits could be seen as the first step to binding national emission commitments, which such nations typically oppose adamantly for the foreseeable future.

A second top-down approach proposes translating national data into a baseline set by the "national emissions factor" or "carbonization index," defined as carbon emissions divided by energy consumption [Hamwey and Szekely, 1998; Mielnik and Goldemberg 1999]. This would provide a standard methodological basis for setting top-down baselines cognizant of the disparate carbon intensities of energy use of developing and industrialized countries.

The project-based approach to the baseline is micro-based and focuses on what most likely *would* have happened without this CDM and JI project. The technology-based approaches are meso-based and focused on what *could* have happened (to an acceptable approximation) without the project. The top-down approach to the baseline is macro-based and focused on what *should* have happened without the project [Jepma, van der Gaast, and Woerdman, 1998].

Challenges

Calculating baselines, even on the most bounded, project-level basis, is hardly a straightforward task, nor one likely to yield strictly accurate estimates. The challenges described in the literature include the following.

Financial and environmental additionality

Under Articles 12.5 (c) and 6.1 (b), emission reductions are intended to be "additional" to those that would occur—in the entire economy—in the absence of the project [Chayes 1998]. This has led to the coining of the noun "additionality," qualified in a number of ways to have varied meanings. "Financial additionality" derived from AIJ Pilot Phase and "Emissions additionality" or "Environmental additionality" are the usual comprehensive terms, used to capture the general aim described earlier.

Financial additionality requires that sources of funding CDM activities provided by participating Annex I Parties, be additional to its existing financial obligations and mechanism under the GEF and the official development assistance (ODA) [He, 1997], if public funding sources are used.

On the other hand, there are three criteria suggested in the literature, which could be applied to assess the environmental additionality for a JI or CDM project in three aspects, i.e., investment, program, and technology additionality.

A CDM project in a non-Annex I country needs both private and public sources, like the local government, that are additional to those in the baseline case, to invest financial, intellectual, or technological resources to ensure additional environmental benefits relating to GHG emission mitigation. Investments and plans that would still take place in the absence of the mechanism, on *normal business or policy grounds*, should not be allowed a windfall of a carbon abatement credit by relabeling as CDM. Therefore, one needs to distinguish between additional investments and plans in CDM which seek CERs as return, and those in baseline cases that seek commercial return. Proving "investment" or "program" additionality will be difficult, particularly regarding long-run plans and incentives for firms to mischaracterize their investment expectations will be powerful. Even more difficult is accounting for the income effects of economic growth on the demand in non-Annex I countries for policies to ensure cleaner environment, which typically rise as a nation develops [Ho, 1997].

Some non-Annex I representatives view environmental additionality further as a guarantee that technology or equipment delivered for a CDM activity must be beyond the best available domestically, as employed in setting the relevant baseline. Sometimes termed "technology additionality," this is seen as one criterion for accepting CDM as achieving sustainable development and contributing to the ultimate objective of the convention for non-Annex I Parties.

Indirect effects of CDM project on GHG emissions: leakage

In the case that environmental additionality of a CDM project is proven, a primary challenge under the environmental additionality requirement is to consider to which extent the emissions reductions accrued by CDM project activities are intended to be "additional".

To answer the question, one should consider the indirect emission effects of a specific CDM and JI investment, i.e. those occurring outside and separate from the direct effects of the process targeted in the project. This is often termed emissions "leakage," in which a successful reduction via an investment leads to an increase (or possibly a decline) in emissions outside the project purview. In one simple form of leakage, a project that displaces a high-emitting technology with a low-emitting one might then result in the transfer of retired (and cheap) technology to another locale which otherwise would have used cleaner technology.

Emission leakage is a much broader concern, however, notably with regard to general equilibrium effects of investment. For example, how could one account for the effect of a rise in electricity prices resulting from a CDM project[1] that also raises the variable costs of power generation? Higher electricity prices would lower demand, lower the amount of fuel used, and thus lower emissions [Fisher-Vanden, 1997]. Alternatively, a project that reduces the fuel needs of one major consumer, a project participant, could conceivably lower local prices sufficiently to elicit new demand of other consumers, with uncertain net emission effects [Chomitz, 1999]. The incentives for Parties to a CDM project to ignore or conceal any such leakage may be strong. Large-scale inflow of CDM and JI proceeds could even raise domestic investment levels and therefore economic growth, or raise demand for a given commodity by improving its attributes, both of which would arguably increase GHG emissions.[2]

Difficulties in accounting for indirect effects

While the greatest concerns are negative indirect effects that would undermine the abatement objectives of a CDM project, one must also consider the possibility of positive, spillover effects. For instance, the emissions reductions of a CDM project may be amplified if it also results in the diffusion of a low-emitting technology to other, non-project facilities [Chomitz, 1999]. Alternatively, producing higher quality outputs can improve emissions of downstream processes [e.g., Guo, 1999a].

All these indirect effects, either leakage or spillover at various aggregate levels, are outside the CDM project system boundary, and usually are hard to measure due to market diversity and uncertainty. However, they might have impacts on the net GHG emissions reduction benefits of the JI or CDM project to different extents, and therefore on the extent of its environmental additionality. The challenge is raised by the thought that, if one tries to account for these indirect effects, one would have to establish baselines for each one of them, against which the indirect effects on GHG emissions could be measured. However, it is equivalent to extending the system boundary of the project to the whole of its upstream and downstream processes, or to the whole interrelated economic sectors, where the indirect effects occur. This makes baseline determination rather complicated in practice.

Dynamic, static, and ex-post correction of baselines

Dynamic, rather than static, baselines are typically required in CDM projects. This is because, in most circumstances, non-GHG related technological change would likely have improved the carbon emissions efficiency of a technological installation had the CDM/JI investment not been made [Liu et al. 1998]. For this reason, the emission reductions gained from CDM/JI investments usually should diminish over time. A primary analytical challenge is thus to develop an estimated dynamic baseline that projects such change *ex ante*, often by extrapolating trends or comparing to similar technological situations [Michaelowa, 1998].

A complementary proposition is for the project partners to agree to revise a baseline *ex post*, after the project has been implemented and additional hard data becomes available [Jepma, 1999b]. As discussed later in Section 4.6, some argue that this introduces too much risk into the investment decision, since such soft baselines could drastically reduce or even eliminate the emissions credits that enticed the investor in the first place.

An alternative use in the literature of the terms "dynamic" and "static" refers to the following: a static baseline is set for the life of the project from the outset, while a dynamic one is agreed to be corrected at some time after the project begins.

Non-hypothetical dynamic baselines

This approach is taken to a complex if compelling extreme by Hamwey in his proposition of an "observable baseline framework," especially for investments in sectors with certain amenable data characteristics such as electric power [Hamwey, 1998]. He argues for using an interactively updated baseline by which a CDM/JI project is measured against the averaged emission characteristics of its sector (or subsector), i.e., a technology benchmark, in the preceding year. Thus the baseline is not hypothetical but formed by actual, observed performance. Even if each Party can agree on this framework, however, it depends critically on regular compilation of accurate emission inventories, a task whose difficulty should not be underestimated. Further, if there is large-scale penetration of CDM/JI in a sector, say in electric power, the benchmark emission baseline would itself be affected, and may no longer credibly approximate what otherwise would have occurred in the sector.

The major factors that may influence baseline changes over time are the following:

- Technological improvement: For example, during the CDM/JI project lifetime, the old equipment of the baseline case would have often been phased out and replaced by domestic new equipment with improved energy efficiency anyway (i.e. in the absence of the CDM/JI intervention).
- Energy conservation plans: Due to economic incentives to save fuel in energy intensive industrial sectors, the existing energy-intensive physical plant often would have undergone technological retrofitting anyway.
- Products structure change: Due to market competition and demand changes, the products structure may have changed, often resulting in an increase in the share of new, higher value-added products that may be less energy and emissions intensive.
- Fuel switching: Due to regulations targeting local environmental problems or other policy objectives, fuels may well have been switched, e.g., switching industrial and space heating boilers in the urban area from coal to fuel oil or natural gas.

In general, all "most likely" changes in a given technological category and sector in the absence of CDM/JI projects need to be taken into account in a dynamic baseline. In particular, once the dynamic baseline falls to the CDM/JI project level, then GHG emission mitigation effects will no longer be generated and the CDM/JI life cycle is ended, even though its economic life cycle may continue. It should be noted that major uncertainties exist in determination of the dynamic nature of baselines. Though this may be closer to objective reality, it is often analytically difficult.

Monitoring, evaluation, reporting, and verification

Real, measurable, and long-term benefits related to the mitigation of climate change is one of the basic eligibility criteria of CDM projects. In general there will be incentives for both Parties to promote baselines that overestimate mitigation benefits. An independent certification process is intended to prevent this. Article 12 of the Protocol requires the COP/MOP to elaborate modalities and procedures (for the CDM) with the objective of ensuring transparency, efficiency and accountability, through independent auditing and verification of project activities [Article 12.7]. The technical challenges like those outlined above and incentives to influence CDM certification and verification heighten the need for carefully designed and credible mechanisms; and baselines for monitoring and verification of projects, presumably by international bodies. This alone may raise sovereignty concerns and hence political resistance to an aggressive CDM program in non-Annex I countries [Chayes and Kim, 1998].

Related literature has all recognized that baseline setting is perhaps the most technically difficult issue in CDM/JI. Besides the most critical issue of emissions additionality, how to handle the issue of uncertainty by setting methods for various parameters are also challenging in baseline setting. Michaelowa summarized some possible baseline determination methodologies and compared the cost, depiction of reality, and emission reduction indicated. His study supported a common view that a standard methodology is far away [Michaelowa, 1998]. Case studies conducted for the Harvard-Tsinghua collaborative program also suggest that calculating baselines, even on the most bounded, project-level basis, is almost never simple.

Conflicting opinions

Many experts from the developing world generally hold that at the current stage only the project-by-project approach is a feasible way in defining baselines for CDM/JI project activities, as this approach is based on the least hypothetical data. Meanwhile, analysts are evaluating how or whether the technology benchmark or top-down baseline methods can be simplified or standardized. As of now, the trade-off of rigor and cost-effectiveness is preventing any consensus in a single method, and most analysts are acknowledging the necessity of a "learning-by-doing" approach and flexibility as more experience is gathered [Matsuo, 1999; Jepma, 1999].

There is a great range of opinions in developed countries about CDM and JI, with implications for baseline issues. For instance, those that favor international GHG emissions trading (ET, Article 17), currently limited to Annex B nations, seem to hope that such mechanisms as CDM and JI will ultimately be experience-gathering steps toward the ET approach. One might expect many in them to favor meso- or macro-scale baselines, as they are more consistent with what is hoped to eventually be a global cap-and-trade approach to GHG abatement. Others are more skeptical about ET and even the flexibility mechanisms in general, seeking to limit the proportion of Annex B commitments that can be achieved by such transnational arrangements under the rubric of supplementarity (see section 4.8.5). Some developed nations likewise approach CDM (as AIJ before it) on a more conventional project-basis, viewing it as akin to normal overseas development assistance or GEF activities that employ public, rather than private capital. They may be more amenable to project-by-project baselines as a result.

3. Conceptual Issues

A baseline can be better defined as a reference case of the techno-economic characteristics and the GHG emissions level that would be most likely to occur, in the absence of such CDM/JI activities, based on domestic circumstances in the host country. Using the baseline as a reference case, the net GHG emission reduction, additionality, and incremental cost of emission reduction caused by the CDM/JI project would be calculated, assessed, measured, and verified.

Determination of baseline is a key issue in the methodologies relating to the climate change mitigation policies and measures. Actually when the baseline issues are addressed, we face the following analytical challenges, due to the nature of the baseline concept:

- Generally speaking, the baseline is a kind of hypothetical or counterfactual reference case, since it does not exist with CDM/JI project simultaneously.
- Determination of baseline is always accompanied with uncertainty, since it is most likely (but not certain) to occur in the host country in absence of a CDM/JI project activity.
- Baseline need to be carefully identified and elaborated as well as distinguished from the CDM/JI project in order to meet the emissions reduction additionality requirement.

We refer mainly in this section to energy-related activities. Based on this definition of baselines, conceptual issues can be categorized as following.

The content of a baseline

Components of baselines in energy sector projects

The elements of the baseline to be determined for an individual CDM/JI project will depend on the generic type of technology involved in the project. For most energy-related projects in energy efficiency, renewable energy, fuel switching, etc., the baseline consists of three major elements: (i) the energy flow characterized by its energy intensity; (ii) the carbon dioxide (CO_2) emission flow with corresponding emission intensity; and (iii) the financial flow with the cost per unit of product or service. Thus the emissions abatement of CDM/JI project activities against their baselines can be evaluated according to the steps indicated in Figure 1.

How to find a baseline

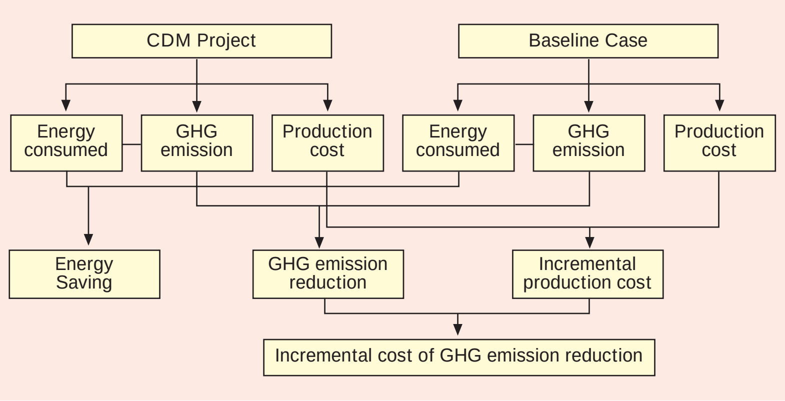
What is most likely to occur in the host country in absence of a CDM/JI project activity? "Most likely to occur" means that a baseline case should be technologically, politically, economically, and financially realistic as well as commercially available in the domestic market, based on the real circumstances in the host country. It helps to reference two primary types of CDM/JI activities: (i) energy-saving retrofit projects in existing plants, in which the baseline refers to the existing facilities (e.g. boilers, kilns, pumps, motors, etc.); (ii) new capital investment projects, in which the baseline refers to "most likely to be adopted" facilities based on the local circumstances and domestic technical policies, standards, and regulations in the host country.

How to measure GHG emission abatement against the baseline

The GHG emissions of a CDM/JI project need to be compared with those in the baseline case under the condition that both the baseline case and CDM/JI project meet the same level of production and/or service, either in the sense of unit product/service or in the sense of total scale of products/service.

For instance, for a CDM/JI project with co-generation (combined heat and power [CHP]), may supply district

Figure 1: **Steps for calculating the incremental cost of GHG emission reduction**



Examples of baseline setting

heating to replacing existing small industrial boilers for process heating and residential coal fired stoves for space heating in the area covered by the heating pipeline system, and electricity for local industrial users who would otherwise use the electricity from the grid otherwise. All of these form baseline cases, which provide industrial and residential heat and electricity as their service purposes. In this case the baseline cases could be easily determined by calculating how much their services will be replaced by the CDM/JI project. Under the same service level, the GHG abatement could be measured by comparing the energy efficiency of the CHP against those in the baseline cases.

In another case, i.e., energy conservation retrofitting in a petrochemical refinery as CDM/JI project, however, baseline setting is more complex. The project will gain multiple benefits of not only energy efficiency improvement, but also increase in product output, by retrofitting the old production process and facilities, including electric motors that form the baseline case. In this case the service purpose of the CDM/JI project and its baseline case will refer not to energy supply, but the petrochemical production. Because there will not be the same level of production in the CDM/JI project and the baseline case, the GHG abatement should not be measured by simply comparing the annual heat and electricity energy consumption between the CDM/JI project and the baseline case, but by comparing the heat and electricity intensity per unit of the output before and after the retrofitting.

How baselines could meet CDM/JI technological and investment additionality

Since CDM projects will yield GHG abatement in non-Annex I country Parties with no emissions caps under the Kyoto Protocol, it is essential for such projects, while meeting the environmental additionality condition to also demonstrate technological and financial additionality. This CDM projects would require technologies that are not commercially available in the baseline case and/or are not financially competitive with the baseline case. The receipts from CERs of the project transferred to Annex B Parties would be expected to make the CDM project at least financially competitive with the baseline case. Therefore the baselines of CDM projects need to be well elaborated to reflect what kinds of domestic technologies are commercially available in the domestic market.

For JI, which may be implemented between Annex B Parties that have both been assigned a target cap of GHG emissions, such additionality does not seem so essential, although it is required by Article 6 of the Protocol. In fact, unlike CDM projects, for JI projects any emissions reduction against a reasonably set baseline, no matter whether it meets additionality requirements or not, will be subtracted from the assigned target cap in the transferring Party and will be added to the assigned amount in the acquiring Party, according to the Article 3.11 of the Kyoto Protocol. However, on the other hand, undermining additionality requirements for JI projects would bring about "poor quality" emission reduction units from unqualified emission reduction sources at low cost. Thus it might provide aberrant price signals to the carbon trade market.

Baseline approaches

Project-by-project approach in concept

The emissions baseline could be determined relatively precisely at the project level, based on the technical specification, standards, local resources, and/or existing operation records of the facilities through an on-site survey, as well as the future development perspectives of the given activity in the baseline case. This is the most practical and direct approach. Since CDM is a project-based mechanism between developed and developing countries, at the beginning phase of CDM, in which experience needs to be built through learning by doing, project-specific baselines should be adopted on project-by-project basis.

On the other hand, determination of project specific baselines need to identify specific details in technical processing, energy efficiency and financial performance for individual projects, which require time and effort, and may thus result in high transactions costs.

Technology-based approach in concept

A technology-based benchmark baseline is one aggregated at technology level featuring benchmark emissions intensity rather than looking at individual projects. By using weighted averaged median benchmark baseline as a common reference case for those CDM projects of similar technology category within a given sector, it offers an economy of scale that may reduce transaction costs ultimately. In addition, when a dynamic baseline is considered, the technology-based baseline could be taken into account since the dynamic baseline would be an averaged collective behavior of many cases, changing over time due to technological improvement.

Top-down approach in concept

The top-down approach might be the one of choice for JI projects. According to the Annex B emissions commitments, specified by Article 3.7 of the Kyoto Protocol, the targeted national emissions in the given year could be divided and assigned as baseline emissions by sector, region, etc., in a top-down manner. It seems that the global emissions reduction benefits accrued by a JI program at sector or regional level could be ensured with less GHG leakage and less transaction costs. On the other hand, this approach is politically sensitive for non-Annex I country Parties. If the top-down baseline is applied in CDM projects, then it might imply that the host country must take an obligation to maintain the top-down baseline without exceeding it in order to guarantee the emissions reduction benefits specified by the CDM contract. This would risk a kind of commitment of an emissions cap on the host country, and therefore be inconsistent with the criterion of the Kyoto Protocol against “introducing any new commitments for Parties not included in Annex I.” For this reason, the top-down baseline will generally be unacceptable to developing countries for CDM projects.

On the other hand, considering strategic feasibility studies of CDM, baselines at the sector, region, and even national levels may be used to assess GHG emissions reduction potentials and identifying priority areas and sectors. Such study results, in the eyes of many, however, could never be officially applied to CDM/JI projects for the reason above.

Dynamic baselines in concept

The definition of a baseline refers to a reference case that would most likely occur in the absence of a CDM/JI project. This must not only refer to the current situation but also to the future situations that would most likely occur during the lifetime of the CDM/JI project. Technological advance would often drive a dynamic change in the baseline over time, approaching the emissions level of the CDM/JI project rather than remaining static. This implies less emissions reduction in the entire lifetime of the CDM/JI project than when a less realistic static baseline is applied.

Intermittent and continuous technology change

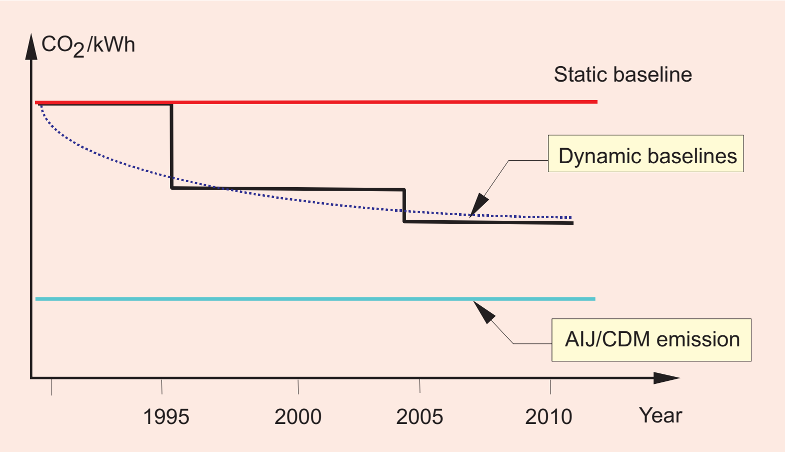
In Figure 2, the dynamic baseline marked in bold looks like a staircase, representing the effect of technological policy interventions, for instance, the phase out of backward technologies at fixed times. Alternatively, a dynamic baseline can look like a smoothly declining curve, representing gradual market penetration of energy efficient technologies, as suggested by the dotted line.

System boundary and avoidance of leakage

To avoid leakage and ensure GHG emissions reduction performance, one should precede the CDM/JI project design by identifying a reasonable system boundary. All direct GHG emissions in both the CDM/JI and baseline cases should be covered in the system boundary. The term “leakage” here refers to the possibility that implementation of a CDM project may generate indirect effects on GHG emissions outside of the system boundary, which are not taken into account in the total emissions reduction estimated for the CDM investment. The indirect effects may be positive in terms of the Kyoto objectives, i.e. resulting in indirect emissions reductions above and beyond the anticipated ones, like spillover from a cup. They may also be negative, i.e. resulting in indirect emissions increases, like leakage from a bubble, and resulting in less than the anticipated reductions.

Let us take an energy-efficient building as an example of a CDM project. If the baseline case assumes use of energy-intensive building materials like brick, cement, and glass, and the CDM project uses less energy-intensive and

Figure 2: **The dynamic baseline in a CDM/JI project (electricity)**



heat-isolating new materials to generate direct CO_2 emissions reductions, indirect reductions may also result from the better production process of those new materials than in the baseline case (this is called "upstream" leakage). As a contrary example, a CDM project might produce direct energy savings by improving a production process in a way that also improves the product, perhaps by CDQ or manufacturing Amorphous Metal Distribution Transformers (AMDTs). However, the improved products may also lead to indirect emissions reductions on the product user side (called "downstream" leakage), as CDQ coke has a higher energy content and AMDTs are more efficient than conventional transformers.

Defining system boundaries

More broadly, the indirect effects on the GHG emissions may not only be caused by such technological processes as those mentioned above, but also by economic factors such as increased economic growth in the sector and resulting price and foreign exchange changes. It may even be caused by changes in human behavior. Theoretically, the indirect effects may spread across projects, sectors, the national economy, and even across countries. Observers worry about leakage because it could undermine the carbon balance. Therefore theoretically it is essential to define the system boundary large enough to form a GHG "bubble" system, so that all upstream and downstream indirect effects on GHG emissions are covered in the system boundary in both the CDM project and baseline cases.

Such exercises are, however, often not feasible in practice, especially in project-specific cases affected by microeconomic pressures and possibly having macroeconomic effects. In fact upstream and downstream leakage is hard to trace and often unmeasurable, due to market diversity, contributing to uncertainty.

In practice, the system boundary will usually be defined as the physical site of both the CDM/JI project and its baseline in a project-specific manner. In some cases, when the CDM/JI project activities are associated with mutually connected energy networks or pipeline systems, like electric power grids and natural gas distribution systems, the CDM/JI project system boundary should be extended to them, in order to avoid easily definable leakage. However, many kinds of leakage outside of system boundaries, with no direct physical or financial dependence on the CDM/JI project, cannot realistically be taken into account in the sense of Article 12.5 (b) of the Kyoto Protocol.

Verification

All information used and methodologies adopted in baseline determination are needed along with those in the CDM/JI project for verification and certification, as well as reporting, by the designated independent operational entity.

Meeting the requirements of the Kyoto Protocol Article 12.5 (b)

Article 12.5 (b) of the Kyoto Protocol requires "real, measurable, and long term" environmental benefits of any CDM emissions mitigation. Conceptually, this implies the following:

- The "real" and "measurable" requirement implies that the benefits shall be real GHG emissions reductions against a credible and probable baseline scenario, and should be technically measurable within a reasonable degree of certainty. In ideal circumstances, such as in CDM project with technical renovation, baselines may be directly measurable before the CDM project is implemented. For such non-measurable baseline cases seeking to meet the criterion of "most likely to occur," one needs to find a credible approach and sufficient statistical data to establish the baseline with reasonable certainty.
- The "long term" requirement implies that a CDM project must maintain sustainable environmental performance related to the GHG emissions reduction during the lifetime of the project. Here the lifetime refers to either the technical or economic lifetime or the GHG emissions reduction lifetime against the baseline case.

For reforestation-type projects, which might be potential options for CDM in future, the lifetime of the project is not only until the growth stops, but extends beyond that. How "long term" lifetime of the LULUCF type project will depend on the nature of the project. But in any case the selected timber should not be burnt in order to keep the carbon stock for a long period.

There are additional requirements of accuracy, transparency, compatibility, and accountability. The baseline emissions of a CDM project should be evaluated by Operational Entities according to agreed procedures and the baseline methodology should be verified according to guidelines and rules to be adopted by the COP/MOP or SBSTA. They should also be reported to the UNFCCC Secretariat and Executive Board in a uniform format.

4. Baseline Determination in Practice

Practical experience

The methodological concepts of baseline definition discussed in Section 3 can be illustrated by practical experiences from both real and simulated projects. The former includes pilot projects under the AIJ pilot phase, which number 122 activities by July of 1999 [UNFCCC, 1999a], and GHG mitigation projects established by the GEF. A list of AIJ projects, sorted by category, is attached as Appendix 2.

Of the available AIJ and GEF reference cases, however, only a few projects describe baseline setting in detail. The rest simply mention the baseline with little insight of how they were determined. Many derived only rudimentary baselines, and some even left the baseline setting for future study.

Project-by-project approach in practice

Diversity of baselines

Most AIJ pilot projects employ baseline scenarios determined by project-specific methods. The baseline emissions (or sequestration) that would have occurred in the absence of the AIJ project were based not only on a wide variety of local circumstances differing in complexity and the coverage of externalities, but also on a variety of parameterized assumptions reflecting "most likely" conditions.

Unfortunately, a thorough study of project-specific cases indicates that setting such baselines is not straightforward, even in the most bounded cases. First, AIJ projects are highly site-dependent, even for the same type of projects. For example, for the most popular type of AIJ projects—fuel switching in heating boilers, which make up 50 of the total 122 AIJ projects—the typical technical measures are to replace old heating boilers, installing or upgrading auxiliary equipment at existing facilities. Typical baselines listed in the uniform AIJ reports are compared with each other in Table 1 by the following factors: (i) the lifetime of the baseline; (ii) whether fuel-switching was considered possible in absence of the AIJ projects and when; and (iii) whether a static or dynamic emission baseline was employed. One sees a varying baseline setting due to site-specific project information as well as the different methodologies used, which are not standardized.

The diversity in project-specific baselines shown in Table 1 raises contending arguments. One is that project-specific baseline setting is necessary to ensure credible environmental effects, due to much diversity even in similar projects. The other is that the resulting higher transactions costs for the baseline setting on a project-by-project basis may cause the CDM to be impractical and unattractive, and therefore argues for standardization of baseline approaches. Later we will discuss alternative approaches responding to these concerns.

Project specific baselines may lead to higher costs

Retrofit, new, and capacity expansion projects

More than half of the AIJ pilot projects are technical retrofits. Their baseline setting is generally easier than newly built projects, as mentioned in Section 3. Many AIJ retrofit projects simply use the status quo emissions as the baseline case. While simple to calculate, one may question how well this reflects the dynamic changes that would have occurred. A number of the AIJ projects did adopt dynamic baselines and gave some reasonable explanation for their assumptions, to be discussed in section 4.2.4.

Table 1: **Diversity of Baselines for AIJ and GEF District Heating Projects**

Projects/Country	Baseline Assumptions	AIJ Life Time (Year)	Static or Dynamic	Fuel Switching in Baseline Case
Järcakandi district heating in Estonia	(1) Project specific: status quo; (2) Topdown: emission decline over time	1	(1) static; (2) dynamic	No
Türi district heating in Estonia	Status quo	15	Static	No
Jochy in Slovakia	Old boilers retrofitted, but with energy efficiency increasing only from 60% to 70%	30	Dynamic	Yes, 100% to N.G in 2008
Lucenec in Slovakia	Energy demand increase by 25% from 2001. Partially fuel-switching to biomass	30	Dynamic	Yes, partially to biomass
GEF Podhale project in Poland	Substantial switching from coal and coke to gas and oil during the next decade	10	Dynamic	Yes, to gas in 2001

Sources: UNFCCC and GEF web sites.

Examples of project-based baselines

For newly built projects, the question is how to choose a baseline of what was most likely to occur in the absence of the AIJ project. An example is an AIJ project on grid-connected photovoltaic (PV) power supply in Fiji, financed by Australia [UNFCCC, 1999b]. The current electricity supply on the island is a hydropower/diesel generation mix, with diesel used for peak load, which occurs in the daylight hours. The project uses diesel-generated power as the baseline, asserting that the PV power is expected to largely displace this power supply since it will also be generated in daylight. Other examples are the AIJ projects on wind power in Costa Rica under the U.S. Initiative on Joint Implementation (USIJI) program, which assume that they will displace electricity that otherwise would have been generated by existing thermal power plants [UNFCCC, 1999c]. A third example, a horticulture project in Russia funded by the Netherlands, demonstrates the range of baseline assumptions that might occur [UNFCCC, 1999d]. This project employs advanced western greenhouse technologies to improve energy efficiency in production of tomatoes and other vegetables. The project considered five separate baseline calculations, reflecting different possible means of generating heat and power that may have been otherwise adopted in the greenhouse, including both cogeneration and noncogeneration supply, and both natural gas and fuel oil. According to the five baselines, the project would result in annual CO_2 emission abatement ranging from 293 to 696 kg CO_2/m^2. Ideally in this case, the final CO_2 emission abatement might be a weighted sum of the five baselines, depending on their relative likelihood. In the actual project, however, no single baseline was selected or summing conducted.

Almost all of the renewable energy projects such as solar power, wind power, and hydropower report similar baseline setting problems. In project-based circumstances, the general method is to seek the best scenario by answering the question of what is the most likely alternative plan to meet this demand for the specific site. Critics of the nonuniform results of project specific baseline setting suggest a broader approach, such as using the "observable" sector average emissions rates mentioned above [Hamwey, 1998], though these in general require ongoing and imposing data support.

Capacity expansion projects are typically a combination of retrofitting and newly built projects. A typical example is the AIJ project modernizing a cement factory in Czech Republic, funded by France [UNFCCC 1999e]. The current plant in Cizcovice produces about 600,000 tons of cement per year, while the modernization project would expand its capacity to 900,000 tons per year. In this case, the baseline includes two parts: i) a baseline for the current capacity; and ii) a baseline for the expanded capacity. For the former, the current on-site data as well as projected non-AIJ technological changes were used in the baseline setting. For the latter, the best cement works in Cizcovice were adopted as a technology reference case for the expanded capacity. Thus a capacity expansion project may present a doubled baseline task, with each baseline posing challenges such as those described above.

System boundary and indirect effects

In CDM and JI project design, including baseline setting, a key issue to be addressed is the system boundary. As discussed in Section 3.7, it is the premise for CDM and JI projects to identify suitable system boundaries within which all direct GHG emissions both in the CDM project and baseline case should be covered, and direct leakage avoided. Indirect effects on the GHG emissions outside the system boundary may be caused at micro level relating to technological process linkages, or at *meso* and macro- level relating to sector and the whole economy linkage. Generally the indirect effects cannot be taken into account in the system boundary of an individual CDM and JI project, except in cases like connected electric power grid, heat supply and natural gas pipeline systems. The AIJ pilot phase provides us with a good opportunity of learning- by-doing exercises, to distinguish and identify the direct and indirect effects on GHG emissions and how to design the system boundary, as shown in example 1 (below).

On the other hand, there may be common components both in the CDM/JI project and its baseline case that may not be CDM/JI-related, with no net effect in their direct emissions. Therefore excluding such non-CDM/JI components from the system boundary can reduce unnecessary analytical work. For this reason, the mathematical principle of the "least common multiple" can be employed, in order to form a minimum system boundary. This strategy is used in the AIJ pilot project on cogenerated heat and power for a public network in Poland [UNFCCC 1999g] and the AIJ pilot project on energy-saving buildings in Saldus, Latvia, funded by Sweden [UNFCCC 1999h]. Generally speaking, the determination of the system boundary in a specific issue needs careful investigation and analysis. The following two examples of AIJ projects in the People's Republic of China (PRC) illustrate the definition of an appropriate system boundary. A third example is given in Appendix 3.

Example 1: Coke Dry Quenching (CDQ) AIJ pilot project at the Capital Iron and Steel Group Company in Beijing (Guo, 1999).

The system boundary of the CDQ AIJ project, jointly funded by Japan and PRC, is illustrated in Figure 3. In brief, the CO_2 emission reductions result from recovery by the CDQ process of waste steam heat, supplanting the same amount of steam originally generated by a thermal power boiler fueled with blast furnace gas in the coke wet quenching (CWQ) baseline case. The saved blast furnace gas is then burned as fuel in a self-owned power plant, generating electricity that will substitute that which is otherwise purchased from the local electric power grid (in the baseline case). Meanwhile more electricity is used in the CDQ process for inert gas loop cycling than in the CWQ baseline case, and less CDQ coke is used in the blast furnace for iron making than CWQ coke in baseline case. Thus the system boundary should cover at least four processes: (i) coke quenching, (ii) steam generation, (iii) electricity generation, and (iv) coke consumption in iron making process.

It should be noted that the CDQ is the direct process in the AIJ project, while those processes such as steam, electricity generation and coke utilization as raw material in iron making are all subject to the indirect process. However, their emissions are explicitly regarded as the direct effects on the emissions mitigation benefits for the AIJ project concerned. In particular, coke is directly used in the subsequent iron-making process in the blast furnace. The higher quality of CDQ coke than CWQ coke can lead to a lower coke-iron ratio and less coke induced CO_2 emissions per unit of iron output. Accordingly lower CO_2 emissions are due to steam recovery, blast furnace gas fired electricity generation, and by CDQ coke utilization. These direct effects bring about real, measurable and long term environmental benefits. Therefore, among others, the iron-making process in the blast furnace as shown in a dotted rectangle in Figure 3, should be covered in the system boundary, although there are some uncertainties and inadequate experience in estimation of the coke-iron ratio. This problem could be improved through monitoring and verification in the implementation of the CDQ AIJ project.[3]

On the other hand, the CDQ coke utilization maybe regarded as an indirect effect in another case, where (all or part of) the CDQ coke is produced for sale in the market. Such a case is identified in Example 3 (in Appendix 3).

More broadly, indirect effects at sector level was discussed in other AIJ projects. As an example, the aforementioned Franco-Czech cement project in Cizcovice shows that modernization of the factory will improve both the productivity and the quality of the cement, increasing efficiency, and reducing electrical power consumption. Since the quality of cement is improved, one may expect a reduction of total cement in the downstream industries like house construction. In this case, the indirect effects were too complex to be evaluated.

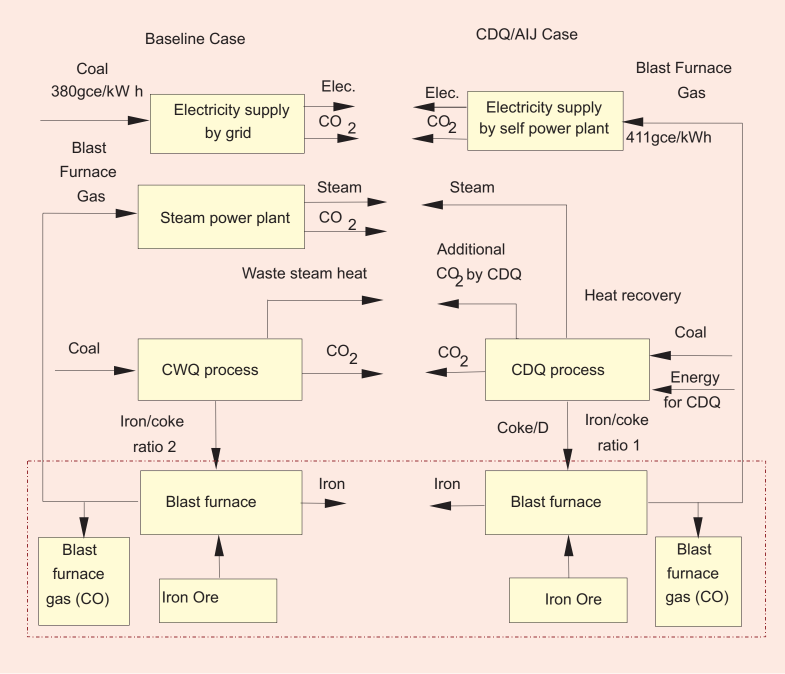
An example of the difficulty in evaluating indirect effects

The CDQ case represents a typical example for setting a project-specific baseline, methodologically similar to many AIJ pilot phase projects. Many energy efficiency projects will use new equipment to replace existing outdated systems, often justifying use of a static baseline by demonstrating the likelihood that the original system would have otherwise continued operating as is [UNFCCC 1999e,h]. In the CDQ case, for instance, the large investment involved and limited local environmental benefits suggested that the original CWQ system would have continued to be used for approximately 20 years. Such retrofit projects with a static baseline may prove the simplest examples of baseline setting.

Example 2: Shangqiu Thermal Power Plant with CFBC/CHP (Liu et al., 1998).

In this AIJ pilot project funded by Norway, a newly built thermal power plant with Circulating Fluidized Bed Combustion/Combined Heat and Power (CFBC/CHP) technologies will replace existing low-efficiency, coal-fired

Figure 3: **Diagram of System Boundary of the Baseline Case and the CDQ/AIJ Project**



small industrial boilers. It will use CFBC boilers with 3x75 t/h capacity and cogeneration units with 2x12 MW capacity to supply electricity to new industrial users. In the absence of the AIJ project, these would purchase electricity from the local grid. Therefore, the system boundary could cover the following processes both for the baseline case and the AIJ Project: (i) electricity generation process, and (ii) industrial process heat supply, as shown in Figure 4.

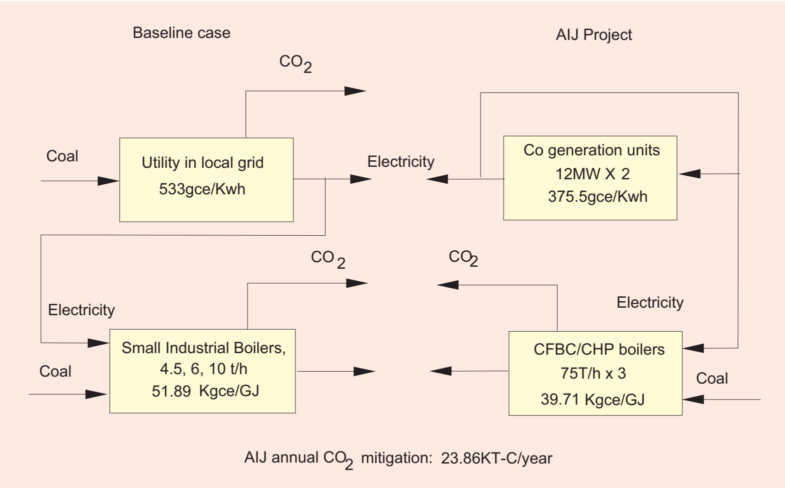
Dynamic versus static baseline

Examples of project-based dynamic baselines

Very few project-specific baselines adopt dynamic baseline scenarios, especially in retrofit projects. In most capital-intensive energy supply cases, static baselines seem reasonable due to the long lifetime of such capital stock and relatively loose pressure of environment regulations to phase out heavy polluting equipment. Nevertheless, situations of rapid technical improvement and innovation as well as more stringent environment regulations raise the likelihood of dynamic changes in baseline cases, although timing is usually unpredictable. Some cases have employed dynamic baselines by using currently available information to make a best estimation of future change. Two AIJ projects supported by Norway provide good examples.

The first is an AIJ project in Slovakia, fuel switching from coal to bioenergy in a heating boiler [UNFCCC 1999i]. There was already significant potential and an intention to convert the boilers from coal to natural gas even without the coal-to-bioenergy AIJ project. Based on a feasibility study by local stakeholders, it appeared that the expansion of a long distance natural gas pipeline grid would be economically competitive, and that 100 percent conversion to natural gas would thereby occur in 2008. Based on this projection, a dynamic baseline reflecting this change was adopted.

Figure 4: **System Boundary of the Shangqiu Thermal Power Plant with CFBC/CHP**



The aforementioned AIJ project on a cogeneration power plant in Shangqiu, PRC, is another example [Liu et al., 1998]. A dynamic baseline was constructed based on heat supplied by small boilers and electricity supplied by the provincial power grid, taking into account national and local policies on technical renovation and development plans. This dynamic baseline is shown in Figures 5 and 6, along with a comparison with a static baseline.

Although some uncertainties exist in determination of dynamic baselines that are often hard to handle, they are more reflective of objective reality. Considering the uncertainties and difficulty of dynamic baseline setting, an AIJ project on renewable energy in a Bhutanese village supported by the Netherlands adopted a static baseline based on an *ex ante* measurement of current energy use [UNFCCC 1999j]. To validate the baseline, however, this project also selected a control village with similar conditions but no AIJ investment, to evaluate the dynamic changes that might have otherwise occurred.

Emissions reduction additionality

Emission reduction additionality is perhaps the most difficult analytical challenge in this area. In the project-by-project approach, additionality is determined by simulating the project investment decision. Key questions are: what would the sponsor have undertaken in the absence of funding related to CDM/JI?; and would the project have been undertaken by the host country itself? To prove additionality, one needs perfect site information as well as accurate local and national policies. Therefore even for a specific case, related information about the technology, sector, policies, and regulations of the government, including projections and development plans of the region may all be required. For example, in an ongoing Tsinghua-Harvard simulation case on fuel switching from coal to natural gas in Beijing district heating, the evidence described in Box 1 was gathered to support the conclusion that this fuel switching project would meet additionality criteria.

GEF climate change projects use a method involving incremental costs to prove additionality. If positive incremental costs exist, this is taken to mean the host would not undertake the project by itself without additional assistance. This is equivalent to the "simulation of investment approach" mentioned above.[4]

A common difficulty in judging additionality is the enforcement of law and regulations. For some host countries, although there are regulations on environment and technology improvement, one cannot assume full or even partial enforcement. Under these circumstances there is much debate whether a specific project can meet additionality criteria. Assuming legal enforcement may preclude crediting a project as CDM/JI, while reality suggests that the host country probably will not implement such a project in the near future.

The technology approach in practice

The technology-based approach employs either benchmarks, weighted average emissions rates for a mix of technologies, or individual default technologies to set emissions baselines for given categories of, for example, industrial processes. Among other justifications, such predefined technology baselines are suggested to decrease uncertainty and therefore risk to potential CDM/JI project investors, encouraging projects. Large transactions costs of another sort would arise, however, such as the expense of establishing an accredited expert panel to investigate and define appropriate benchmark categories, or to determine specific default technologies. In developing a matrix of benchmarks or default technologies, moreover, the expert panel would have to make such determinations along second and possibly third dimensions of the matrix, i.e., regions and time.

Given these substantial analytical requirements, it is not a surprise that we did not find a practical example of a full technology-based matrix baseline in the literature. Of interest, however, are three analyses upon which benchmark baselines either are being or could easily be constructed for a target sector. These examples happen to

Figure 5: **Dynamic Baseline for Heat Supply in the Shangqiu CHP Power Plant**

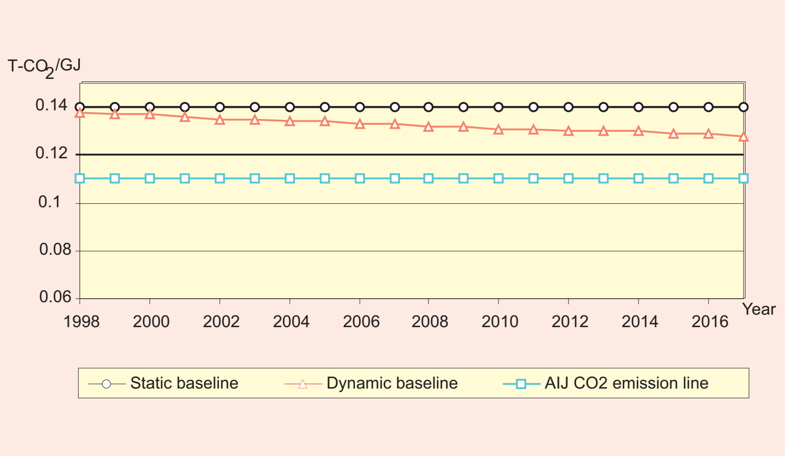
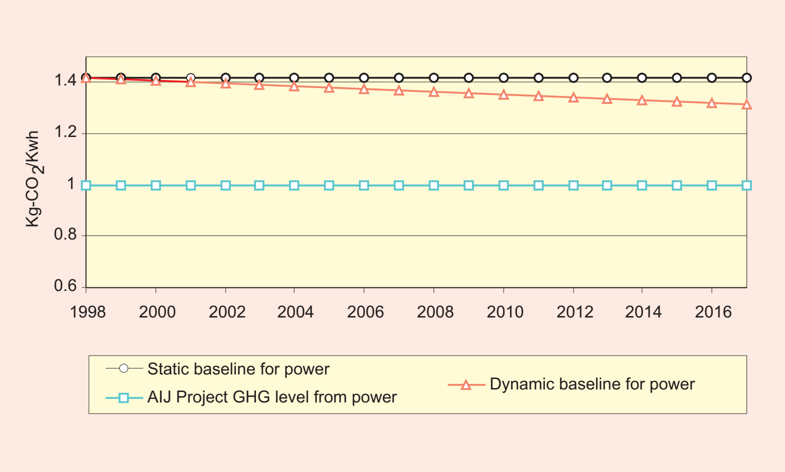


Figure 6: **Dynamic Baseline for Electricity Supply for the Shangqiu CHP Power Plant**



Box 1: **Additionality of Fuel Switching in Beijing District Heating [Guo 1999b]**

The following reasons suggest why natural gas is not favorable to the users outside of the regulated area:

- Outside of the urban planning area within the Second Ring Road, land prices fall from more than 10,000 yuan per square meter to less than 4,000 yuan per square meter. Thus, the rank of preferred heating technologies will be different. Based on sensitivity analysis, coal-fired central boilers will be the cheapest option compared with natural gas-fired central boilers under the current fuel and land prices.
- The current natural gas price is just a temporary price set by government to give incentives to users. It is less than the supply cost. In the future, this price will probably be raised by 0.3 yuan per cubic meter. This will make natural gas boilers even more expensive in the future.
- Apart from the capital cost and operational cost considered in economic analysis, natural gas users have to pay a so-called “gas source fee” which is added to the total cost of apartments of 22 yuan per square meter. This will increase building construction costs, dissuading investors from using gas.
- Emission charges on pollutants such as SO_2 are very low and are not likely to be increased in the near future. Therefore, environmental regulation is unlikely to provide sufficient incentives for users to use natural gas.

In summary, except for domestic actions included in the BAU scenario, fuel switching from coal to natural gas, in most cases, should qualify as additional GHG emissions reductions creditable under CDM.

emphasize, moreover, the complex challenges in projecting the influence of public policy and price changes on the future technological choices that must be represented in a credible CDM/JI baseline, benchmark or otherwise.

Example 1: Power Sector Technology Choice in the PRC

A power sector study was recently carried out jointly by Harvard and Tsinghua universities, separate but complementary to our CDM collaboration, funded by the U.S. Department of Energy. It focused on finding the least-cost path of technology and environmental choice in the electric power system of the PRC (Murray and Rogers, 1998; Kokaz, Liu, and Rogers, 1999). This study divided the PRC into 6 regions and examined the optimal technology choices over the period 1995-2020. The choice of technology was conditional upon the constraints on the fuel transportation system, local and regional air pollution constraints, and meeting a pre-specified target for electricity supply in each of the regions. In all, eight coal-based, two oil-based, one gas-based, and geothermal technologies were considered for thermal-based electricity generation. In addition to nuclear power, hydropower, wind, and photovoltaics were non-fossil choices available to the model. The model also allowed the choice of coal washing for six different types of coal in the six regions. The model produced a "least-cost" baseline showing the choices from these 16 technologies and coal washing which best fit the environmental, political, and social constraints acting on the PRC electric power system.

Use of optimization models in determining technology-based baselines

Thus in principle, the technology mixes projected by such an optimization model's business-as-usual (BAU) scenario could yield dynamic benchmarks for the PRC's power sector, if one accepts that a least-cost optimization model is an acceptable predictor of the course of sectoral development. The most likely application would be to determine a coal-fired power technology benchmark, since the model compares eight such technologies (though it may need to be further refined by differences in capacity or other characteristics). The emission factors of each coal-fired technology would be weighted by their respective projected generation share under a realistic BAU, and summed to produce a benchmark for coal-fired power in a given region and time. This could then serve as the baseline for emission crediting of new investments in the same technology category. For instance, a CDM investor might propose an Integrated Gasification Combined Cycle plant (IGCC), an advanced "clean coal" technology that is essentially too costly for the PRC's power market (indeed the model projects it to gain no generation share, as shown in Figure 7). The "additional" emissions savings of such a plant could be calculated and credited for CDM by a straightforward comparison of its emissions rate to the coal-fired benchmark resulting from a realistic BAU projection. What is additionally compelling about the analysis is that because the model automatically disaggregates the PRC into six regions to capture economic and other disparities, no additional analytical effort would be required to produce a region-by-technology benchmark matrix for the PRC.

In a separate vein, researchers discovered in developing the model that what has been defined as the BAU scenario often used in studies of the PRCs electric power system (e.g., BMI/BEEC/ERI 1998)—a scenario without any constraints other than those observed historically—was not realistic when compared with the current PRC policies governing the regulation of fuels, transport, and environment. The results obtained by the study indicated that to meet the current policies and those already on the books for the near future, there is a need for the PRC to move up the technology ladder away from the traditional coal-fired power plants to more expensive and clean technologies. As there are joint effects due to meeting sulfur and particulate emissions of these technologies that potentially reduce the carbon emissions, these projects cannot be claimed as potential CDM projects because they are part of a realistic BAU baseline that takes account of such policy developments.

Figure 7 suggests the dynamic baseline that would arise from using the model to project this realistic BAU, although the results have not yet been translated into any benchmarks or, better, a region-by-technology benchmark matrix. (Producing such a matrix is an aim of current research.) The figure shows the amounts of installed capacity by technology required to meet the demand and the other constraints and policies assumed. The traditional BAU has little change in terms of the types of technologies; it just increases the amounts in place. The "realistic BAU" baseline has a marked shift to higher levels of technologies (and costs). In terms of the implied cost per ton of carbon saved under CDM in the BAU case, it ranges between $5 and $50 per ton of carbon depending upon the magnitude of the CDM trading effect. For the realistic BAU, the costs range between $5 and $450 per ton of carbon depending upon the magnitude of CDM trades.

Thus, in addition to the potential benchmark matrix applications, this case shows the difficulties inherent in setting meaningful dynamic baselines derived from technology choice. In the case of the PRC, for example, we firmly believe that the correct baseline to choose for the electric power system is one that reflects all of the current and committed regulations and policies, difficult through this may be analytically.

Example 2: Residential Space Heating in Beijing.

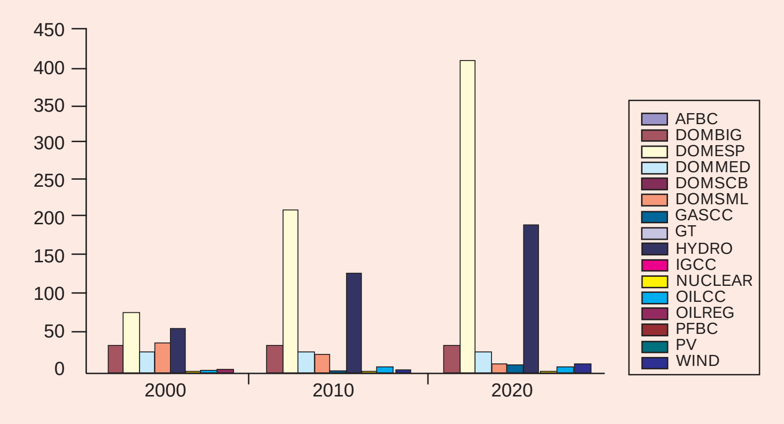
This example, a recently initiated case study of the Harvard-Tsinghua CDM collaboration, concerns residential heating in Beijing [Guo, 1999b]. Analysts suggest that there will be nine primary technology options for residential heating in Beijing in 2010. They include (i) process heat from coal-fired thermal power plants (electric heating itself was deemed too expensive), (ii) coal-fired central boilers, (iii) natural gas-fired central boilers, and (iv) oil-fired central boilers, (v) coal-fired central boilers, (vi) natural gas-fired central boilers, (vii) oil-fired small boilers, (viii) individual household heaters including coal-fired small stoves and natural gas-fired, and (ix) wall-hung heaters.

National and local policies provide guidelines to determination of feasible technology options. The relevant policies include:

- Coal-fired boilers and stoves will be phased out incrementally in urban areas. In 1998, the Beijing government announced that 40 districts with a total area of roughly 105 square kilometers would be "no coal" districts, accounting for 21 percent of the total urban area. According to the regulation, new infrastructure in the city center must use cleaner fuels than coal. Additionally, the regulation dictated that heating in new, large public buildings in the urban planning area outside of the city center must use natural gas, electricity or district heating by cogeneration.
- An aspirational additional policy is that after the natural gas supply satisfies the demand by residents in buildings of two or more stories, fuel switching from coal to natural gas in heating and industrial boilers is "encouraged."

In addition to these policy factors, under the PRC's increasingly market oriented economy, price will be the most important factor affecting heating technology penetration. An economic assessment of the different technologies is shown in Table 2. Economic characteristics of technologies are ranked relative to natural gas-fired central boilers. Given disparities in the importance of the capital investment and fuel and operational costs of different technologies, the net present value of total costs is the basis for comparison.

Figure 7: **Realistic Base Case Capacity for Electric Power Generation Technologies**



Many factors will influence the penetration of different technologies, among which land and fuel prices are the two most salient factors. In the economic analysis, we assume that land price is 5000 yuan per square meter and natural gas costs 1.4 yuan per cubic meter (the current price for residents). The discount rate is 9 percent.

A future technology mix in 2010 under a BAU scenario is projected in Table 3, based on both the above summarized economic comparison and policy analysis. The assumptions of the BAU scenario include:

Table 2: **Comparison of Economic Feasibility of Space Heating Technology Options, Beijing**

No.	Space Heating Technology	Capital Investment Index	Net Present Value Index[a]
1	coal-fired co-generation power plant	1.38	0.90
2	coal-fired central boiler	1.17	0.89
3	natural gas-fired central boiler	1.00	1.00
4	oil-fired central boiler	0.74	1.17
5	coal-fired small boiler	1.14	0.72
6	natural gas-fired small boiler	0.76	0.83
7	oil-fired small boiler	0.52	0.99
8	natural gas-fired wall-hanging heater	0.80	0.75

[a] NPV consists of capital, fuel and operating costs, based on 20 years of lifetime and 9 percent per year discount rate. The land price is 5000 yuan/m^2 and natural gas cost is 1.4 yuan/m^3 (the current price for residents). Source: Guo 1999b.

Table 3: **Projected Technology Mix for Beijing Residential Space Heating in 2010**

Technology	Coal (%)	Natural Gas (%)	Oil (%)
Co-generation power plant	33.5		
Central boiler	25.5	5.0	4.5
Small boiler	22.0	5.0	
Individual heater	4.0	0.5	

Source: Guo, 1999b.

- Most small coal-fired boilers and stoves will be phased out from the city center;
- All excess generating capacity of current thermal power plants will be utilized;
- Natural gas-fired, wall-hung heaters will still be in an experimental stage and will not be a preferred technology;
- Under the BAU scenario, total residential building in the urban planning area in 2010 will reach 165 million square meters. The total heating energy demand is projected to be 3.75 million tons of coal-equivalent (tce) end-use in energy.

Without CDM projects, coal would continue to dominate space heating in Beijing

Table 3 indicates that without CDM activities, even with the availability of natural gas and other clean fuels, coal will still be dominant in heating. Natural gas will provide only 10.5 percent of heating demand, at about 0.47 billion cubic meters. As total natural gas supply in 2010 can reach 4~7 billion cubic meters, it appears that there are strong prospects for CDM activities in this sector.

Weighted by the proportions derived in the projected mix in Table 3, historical data on the average emission efficiency of each kind of technology could be used to devise a residential heating benchmark as the reference baseline case. CDM projects, for example a program to install gas-fired technologies beyond the projected 10.5 percent household penetration, could be credited relevant to this aggregate benchmark emission efficiency. This is the subject of current research.

Example 3: GEF Project in Four Township and Village Enterprise (TVE) Industries in the PRC

A brief third example, based on a GEF project, considers such PRC township and village industries as brick, cement, and coke production, and metal casting [GEF, 1999]. Using the metal casting industry as example, the energy consumption and the emissions intensity for the TVEs at different technical levels were estimated as shown in Table 4.

Table 4: **Energy Consumption and CO_2 Emission Intensity of Metal Casting TVE**

Technical Level	Output (million ton Casting	Share (%)	Energy Consumption (tce/ton casting)	CO_2 Emission (ton CO_2/ton casting)
Backward	4.32	41	2.05	8.50
Less backward	4.10	39	1.87	7.70
General level	2.10	20	1.50	2.80
Advanced level	0.00	0	1.32	0.20
Total	10.52	100		

Source: GEF, 1999.

From Table 4, an average emissions intensity for metal casting could easily be calculated, to serve as an emission benchmark baseline for clean production processes as CDM investments in this industry. The other three TVE industries could be analyzed analogously.

Pros and cons of the technology benchmark approach

Among the several baseline setting approaches, benchmarking seems to have raised among the highest interest as potentially acceptable to both developing and developed countries. However, application of the benchmark approach is still likely to encounter such challenges as the following.

- *Geographical scope of the benchmark*. For some large countries, technical levels of a given technology category vary greatly among regions. Thus a benchmark for each region may have to be evaluated instead of a unique benchmark for the entire country. This will raise transactions costs.
- *Aggregations of the benchmark in a sector*. Benchmarking seems unsuitable for aggregation at the sector level. For industries with widely heterogeneous products and/or services, such as the chemical industry or transportation sector, benchmarking should be disaggregated by major categories of products or service. Even for industries with homogenous products, such as electricity generation, district heating, and iron- and steel-making, benchmarking needs to be disaggregated by major categories of capacity sizes since different energy efficiencies exist among the different capacity size. Nevertheless the benchmark approach may provide a practical way to reduce some transactions costs.
- *Dynamic benchmarking and uncertainty*. For a static benchmark based on historical data, like the GEF example on TVEs, it appears relatively easy to verify and certify a project. For dynamic benchmark-setting, as shown in the Beijing's space heating case, future trends in technological penetration have to be forecast based on variety of assumptions and information sources. This will again introduce uncertainties. One should be aware that the trade-off between transactions costs and uncertainty in environmental effects must be judged in a reasonable way to ensure transparency, efficiency and accountability.

Top-down approach in practice

So far there appears to have been little effort to apply any top-down baseline approaches. We identified only one brief citing of its application in an AIJ pilot project between Sweden and Estonia, however no information on methodology was cited [UNFCCC I999a]. The following are issues of common concern for top-down baseline setting.

Top-down baselines, if they can be credibly calculated, are likely only to be acceptable under JI, since both participating Parties to JI must fall under Annex B of the Kyoto Protocol, i.e. have already accepted binding emission caps. Compared to other approaches, top-down baselines are derived from the most aggregate level of host country data. This allows them to consider national-level plans for meeting the targets, and potential allocations of the assigned amount of emission targets among sectors. Additional emissions abatement accruing from an individual JI project could, in theory, be measured against this reference allocation, and credited accordingly.

Comparison of different approaches

Assessment of the different approaches

The applicability of different baseline setting approaches are closely related to such aspects as transactions costs, additionality, uncertainty, and potential for "gaming." The advantages and disadvantages of these approaches can be compared accordingly.

Transactions costs of baseline determination. The project-by-project approach will have large transactions costs to the project developers. The technology approaches will reduce the transaction costs per project, especially if there are many participants in the same field. As to the top-down approach, there is no clear conclusion whether it can decrease transactions costs because it depends on unclear, but potentially large initial costs for establishing acceptable national or sectoral emissions projections.

Uncertainty. While each baseline definition approach cannot completely avoid uncertainties, the sources of uncertainty will be different. In the project-by-project approach, the main sources of uncertainty result from assumptions and methods of obtaining data and the prospects of leakage. In the technology-based approaches, the uncertainty of future industry development forecasts, and enforcement of regulations and law will lead to uncertainty. In the top-down approach, the primary uncertainty will result from uncertain macro-economic plans.

As to the uncertainty of enforcement of law and regulations, the project-by-project approach will depend heavily on the perspective of the host firm. As an example, if SO_2 emissions charges exist in the region but are not strictly enforced, the host firm will be reluctant to include compliance in its baseline projection. For other approaches, if such laws and regulations have already been enacted, they are likely to be incorporated into baselines.

On technology choice, the project-by-project approach will try to evaluate the current and most probable future technologies as the baseline, a source of uncertainty. The technology-based approach will adopt either a default prevailing technology for the field or—in the case of benchmarks—a weighted average emissions rate of all the technologies in the field as baseline.

Additionality. In the technology and top-down approaches, determining a baseline to meet additionality requirements will be difficult, Should a baseline prove acceptable, however, determination of a given CDM/JI project's additionality will be easy to judge. In the project-by-project approach, much additional information and effort is required to prove additionality on the project level.

Gaming. Baseline determination not only depends on methodology, but also on the institutions tasked with keeping application of the methodology reasonable and credible. In situations where there are doubts on relative factors for baseline setting, incentives to maximize benefits will encourage the participants to favor that option which will bring them more benefit. Gaming behavior (in its worst manifestation, this can be termed "cheating") in project-by-project baseline approaches will mainly result from very site-specific issues. Generally the cheating potential is not large. In the technology approaches, there is little prospect of project-based gaming because the baseline is predetermined, but there will be pressures for sector level gaming at the baseline determination stage. In the top-down approach, there is a prospect of national-level gaming.

Incentives to cheat in baselines determination may exist in all three approaches

Table 5 is a tentative comparative assessment of the approaches.

All methods of baseline definition have weaknesses. We can only draw the rough conclusion that certain approaches appear better than others for different sectors. Table 6 is a summary of these tentative recommendations.

Ex-post correction of baselines

No matter what approach to baseline setting for a specific project and how thorough the supporting analysis, real project performance is likely to diverge from the estimated baseline. *Ex-post* correction of baselines based on project performance will help, though it will introduce additional investment risk for the project developers (who would prefer to have baselines set *a-priori*). Normal business investment is in most cases foremost an exercise in

Table 5: **Tentative Assessment of the Approaches Based on Key Criteria**

Aspect	Project-specific	Technology	Top-down
Transaction costs	Relatively large, investor level	Relatively large, system level	Uncertain, system level
Uncertainty	Assumption Data obtaining method	System uncertainty	System uncertainty
Additionality	Very difficult to prove, info-dependent	Moderate to difficult to prove	Moderate to prove
Gaming potential	Project level, relatively less	Sector level	National level

Table 6: **Suggested Approaches to Baseline setting by Sector**

	Project specific	Technology
Power plant		•
Heating system		•
Industry with heterogeneous products	•	
Industries with homogenous products		•
Residential		•
Land-use change and forestry	-	-
Transportation	•	

risk assessment, however, and we suggest that firms will develop capability to assess baseline risk. The investment risks of *ex-post* baseline revision alone should not prevent its adoption in appropriate conditions.

Key issues for the COP/MOP and EB on baseline setting

In addition to the methodological issues on baseline setting discussed in the above sections, there are several key issues to be decided by the COP/MOP and Executive Board of CDM before such mechanisms can come into application. Some of these issues are listed below.

Eligibility of sink projects in CDM

So far land use change, forest preservation, and afforestation (LULUCF) are eligible sink projects for AIJ in the pilot phase (Decision 5/CP 1), eligible as domestic actions in Annex I country Parties for compliance with their QELRC targets under the Kyoto Protocol (Article 3.3), and also for JI (Article 6.1). However there is no clear language in Article 12 on whether sinks should qualify for CDM. This is a politically sensitive issue that needs to be resolved by the COP/MOP. Given that there are more serious scientific uncertainties in determining baseline GHG emission removals by sinks for LULUCF than for other project categories, we suggest an emphasis on emission reduction projects in CDM during the first commitment period. After that, experience in LULUCF may result in sufficient understanding to permit defensible baseline determination in sinks. However, these will depend on a number of outstanding political issues to be resolved by the COP/MOP. Pressure to make an early decision on sinks may be counterproductive.[5]

Top-down approach in non-Annex B countries

Whether and how the top-down baseline approach might be employed in non-Annex I countries for CDM is to be determined. As mentioned in Sections 2 and 3, however, this is likely to continue meeting strong developing country opposition. It may be immaterial, moreover, because so far there is little practical evidence from Annex I country Parties to show that the top-down approach can be operational and reliable.

Guidelines on monitoring, evaluation, reporting, and validation

COP/MOP must prepare to establish a set of guidelines on monitoring, verification, certification and reporting for different kind of CDM/JI projects, especially for baseline determination. Special efforts should be made by SBSTA to establish guidelines on the methodology of different baseline approaches that can be credible, transparent and practicable, and compatible with the criteria of the CDM.

Responsibility of different entities

What FCCC entities should take what related responsibilities needs to be clarified to facilitate baseline setting.

- The COP/MOP and SBSTA/SBI may have to develop methodological guidelines for the baseline approaches. These would elaborate modalities, rules and procedures for CDM with the objective of ensuring transparency, efficiency and accountability through independent auditing and verification of project activities.
- Appointed by the Executive Board, an operational entity designated by COP/MOP will likely have to take the responsibility to verify and certify independently CDM project activities, including baselines, according to rules, procedures and methodological guidelines established by COP/MOP.

- The COP/MOP will have to determine the responsibility of project participants to provide accurate, systematic and periodic monitoring of the project.

5. Conclusions

Analysts of CDM, and its related mechanisms AIJ and JI, generally agree that setting project baselines is a fundamental difficulty for practical implementation of such mechanisms. Depending on the unique characteristics of targeted project investments, different approaches are likely to be better for different situations. None are likely to be straightforward, let alone ideal. By comparing the three leading approaches and identifying critical advantages and disadvantages of each, both theoretical and practical, we draw the following conclusions.

First, candidate projects for CDM typically have highly site-specific conditions that ideally should be considered in their emissions baselines. The project-by-project method, the dominant approach in the AIJ pilot phase providing much of the practical information assessed in this study, has an obvious advantage in capturing such site-based particulars. Unfortunately, this method will generally carry high transactions costs by requiring the development and certification of baselines on an individual project basis, and invite project-level baseline gaming. Perhaps more important, because it concerns the theoretical legitimacy of the mechanism itself, is that in most cases this approach is poorly suited to capture all indirect effects, notably emissions leakage, and thereby to meet strictly the additionality requirements of Article 12. The most hopeful project-by-project baseline context for ensuring additionality (within reasonable uncertainty bounds) appears to be retrofit projects.

The technology-based approach of benchmarks and/or default technologies, including matrixes, is a more encouraging option to simplify baseline formulation, at least for some applicable sectors. Benchmarking appears to have potential for acceptance both to developing and developed countries. As for the transactions costs, since a benchmark for each region may have to be conducted considering geographical and economic differences, transactions costs may not be as low as some assume. Matrixes will be suitable for sectors with highly heterogeneous products or processes. Greater participation in technology-based approaches may decrease the transaction costs, however, if considered on a cost-per-project basis. To reach consensus on technology approaches may involve gaming by host government and investors, since uncertainties will remain from different assumptions and methodologies. *Ex-post* correction of technology-based baselines may reduce uncertainties, but carries additional transactions costs itself and is likely to somewhat reduce investor interest.

Because there is no emissions cap for developing countries, whether and how the top-down approach—which requires acceptance of at least theoretical national emission projections, and is thus seen as a step toward caps—can be used in CDM is debatable, and likely to be politically sensitive to developing countries. The costs of capacity building to conduct nationwide emissions inventories and projections, which will require central developing country participation, will also be a major impediment to use of this approach.

All methods for setting CDM baselines have considerable weaknesses, and choosing any involves tradeoffs of costs, uncertainty, gaming opportunities, political feasibility, and other criteria. Detailed practical analytical experience (as opposed to theoretical inquiry) is still very rare, and as such there is a need for continued experience gathering in actual project conditions. Assuming eventual progress on entry-into-force of the Kyoto Protocol—a major assumption—we recommend agreement to conduct a small number of *credited* projects within a set time frame, on a provisional basis that will be evaluated in its entirety at the end of the experimental period. Any rush to permanent arrangements on such weak underlying knowledge would be a mistake, technically and politically. Moreover, subjecting such provisional projects to strictly defined standards of proof of additionality will make experience gathering nearly impossible. CDM baselines are invariably going to have at least some element of uncertainty with unanticipated crediting implications for one party or another. What will ultimately be required is agreement of parties to a CDM project (and outside observers) to accept a baseline protocol that *approximates* reality, with all its implications, even should later information demonstrate some divergence from factual truth.

Actual experience in setting baselines for real-world projects will be critical

At such a beginning stage, we recommend continued experience gathering via application of the project-by-project approach, with the most hopeful prospects in technology retrofits. We also suggest focused efforts at benchmark baselines in select sectors, such as power generation, and perhaps narrow technology matrixes in applicable industrial sectors. A commitment of international organizations and governments to build capacity in developing countries in baseline determination is also essential. For CDM to gain broad applicability, assuming its other challenges can be addressed, prospective host countries must have the independent capacity to examine, compare, improve, and ultimately agree to baselines from a position of analytical parity with investor nations. This also will serve the objective of reducing transactions costs and uncertainties, by helping to develop baselines grounded in accurate understanding of conditions in developing countries. Confronting the challenges inherent in baseline setting for CDM should be seen as a long-term task, with agreement to move ahead incrementally the best hope for eventual, broad application, which is nevertheless hardly assured.

Notes

1 Editor's Note: If the CDM/JI project is an electric power plant, given that the host entity would receive at least the marginal abatement cost for transfer of GHG abatement credits as a payment, it is difficult to see that electricity prices would rise. However if the CDM/JI project were a demand side project in which fossil fuel is displaced by electricity of non-fossil origin, e.g., a mass transit system replacing diesel buses, electricity demand, and hence prices may rise.

2 Editor's Note: Financial additionality may have several effects. On the one hand CDM/JI proceeds may increase savings and investment, and therefore economic growth. On the other , it may lead to appreciation of the domestic currency, leading to shrinkage in tradable commodity outputs, and increase in outputs of non-tradeables. In the latter effect ("Dutch disease"), the net effects on the country's GHG emissions may be indeterminate.

3 For facilitating the review process in the AIJ pilot phase, the CDQ related environmental benefit was not included in the total benefits in the uniform format reporting of the AIJ project, but was estimated in an appendix in the report separately.

4 Editor's Note: However, the considerations for determining baselines in GEF financed GHG abatement projects are essentially the same as for CDM/JI projects as described above.

5 Editor's Note: This matter is still unresolved after the 13th Meeting of the Subsidiary Bodies to the UNFCCC at :upm. Framce. 11-15 September 2000.

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Appendix 1

Related Provisions of Kyoto Protocol

Article 3.

3.3 The net changes in greenhouse gas emissions from sources and removals by sinks resulting from direct human-induced land use change and forestry activities, limited to afforestation, reforestation, and deforestation since 1990, measured as verifiable changes in stocks in each commitment period shall be used to meet the commitments in this Article of each Party included in Annex I. The Greenhouse gas emissions from sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8.

3.4 Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide for consideration by the Subsidiary Body for Scientific and Technological Advice data to establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how and which additional human-induced activities related to changes in greenhouse gas emissions and removals in the agricultural soil and land use change and forestry categories, shall be added to, or subtracted from, the assigned amount for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990.

Article 6

6.1 For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy, provided that:

(a) Any such project has the approval of the Parties involved;

(b) Any such project provides a reduction in emissions by sources, or an enhancement of removals by sinks, that is additional to any that would otherwise occur;

(c) It does not acquire any emission reduction units if it is not in compliance with its obligations under Articles 5 and 7; and

(d) The acquisition of emission reduction units shall be supplemental to domestic actions for the purposes of meeting commitments under Article 3.

6.2 The Conference of the Parties serving as the meeting of the Parties to this Protocol may, at its first session or as soon as practicable thereafter, further elaborate guidelines for the implementation of this Article, including for verification and reporting.

Article 12

12.5 Emission reductions resulting from each project activity shall be certified by operational entities to be designated by the Conference of the Parties serving as the meeting of the Parties to this Protocol, on the basis of:

(a) Voluntary participation approved by each Party involved;

(b) Real, measurable, and long-term benefits related to the mitigation of climate change; and

(c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity.

12.9 Participation under the clean development mechanism, including in activities mentioned in paragraph 3(a) above and acquisition of certified emission reductions, may involve private and/or public entities, and is to be subject to whatever guidance may be provided by the executive board of the clean development mechanism.

Appendix 2

Table 7: **Approach by Type of Projects under AIJ**

FCCC Classification		By Sector	
Type	**Number**	**Type**	**Number**
Afforestation	2	LULUCF	16
Agriculture	2	Electricity generation	19
Energy efficiency	50	Heating boiler	56
Forest preservation	12	Other industries	4
Fuel switching	7	Residential	10
Fugitive gas capture	4	Transport	1
Renewable energy	45	Others	16
Total	122	Total	122

Note: As of March of 1999, counting a few additional projects in the PRC that have not been reported yet to FCCC, there were 128 AIJ pilot projects ongoing and planned in the world. Of these, 64.8% of the total are distributed in East Europe and CIS countries, 20.3% are in Latin America, 12.5% are in Asia, and only 2.3% are in Africa. Therefore the geographical distribution of AIJ pilot projects is uneven over the world.
Source: FCCC 1999a.

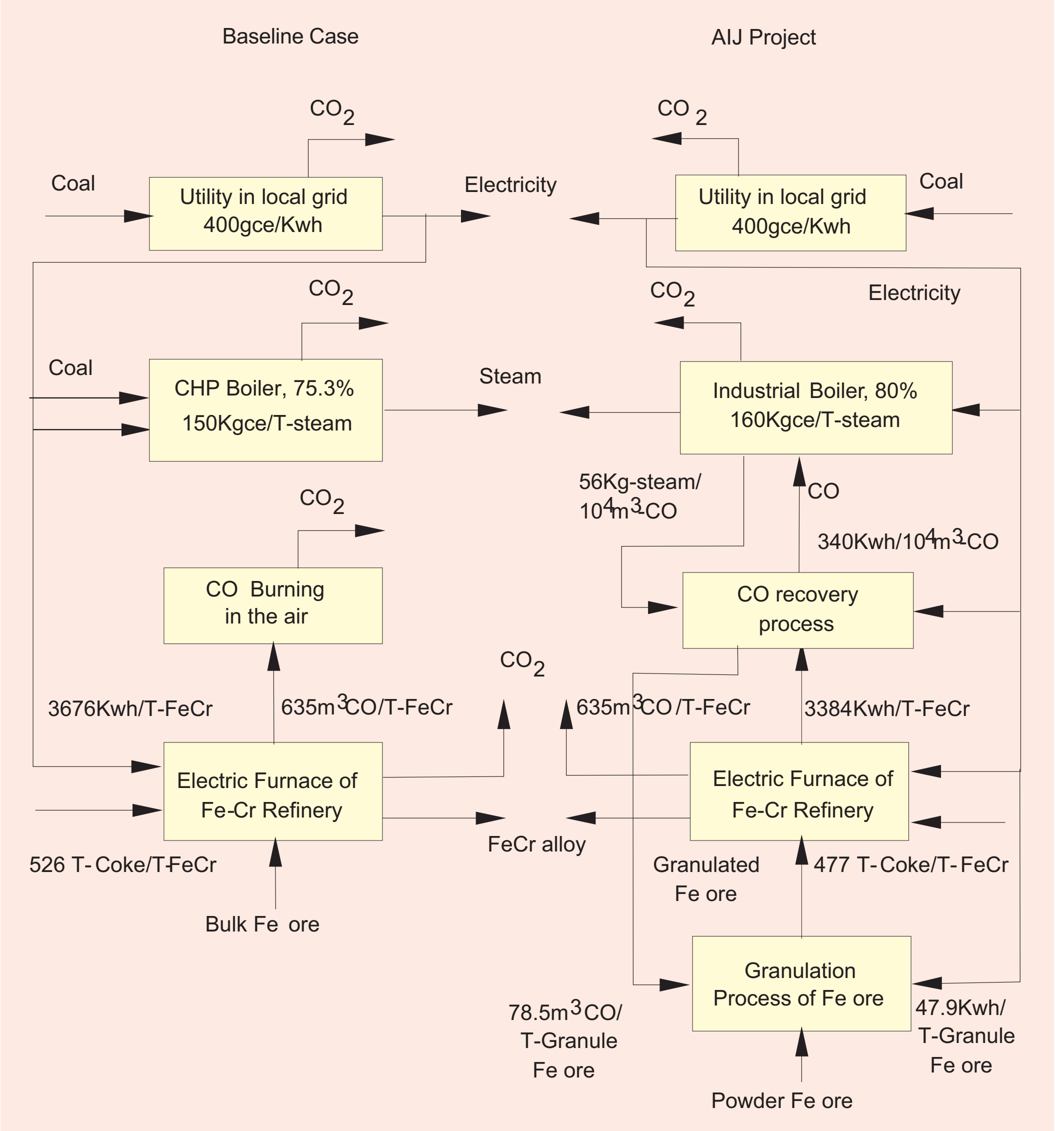
Appendix 3

System Boundary and Indirect Effects (Section 4.2.3).

Example 3: Energy Conservation in Electric Furnace in Ferro-Alloy Refinery of Liao Yang City

In this AIJ project funded by Japan, energy conservation of electricity and coke in the ferro-alloy Fe-Cr refinery process in existing electric furnaces will be achieved by installing a Fe-Cr ore-palletizing facility. The waste carbon monoxide (CO) gas emissions will be recovered by installing a furnace cover system into existing electric furnaces, and the recovered CO will be used as fuel in an industrial boiler to generate industrial heat which would otherwise be purchased from a local cogeneration plant. Meanwhile additional electricity will be used in the Fe-Cr ore-palletizing process and in the CO recovery process to that in the baseline case, where raw powder ore is fed and CO gas is burnt in the air without electricity inputs. Therefore the system boundary is designed to cover those processes with direct emissions both in the AIJ project and its baseline case, as shown in Figure A3-1.

Figure A3-1: **System Boundary of Energy Conservation in Liao Yang Electric Furnace**



Production capacity: 38,300 ton-FeCr/year,
Annual CO_2 emissions reduction: 34,275 T-CO_2/year

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