Graduate School of Development Studies

Blue Water, Green Energy, and Red China:
Do China's Hydro-Electric CDM Funded Projects Deliver Sustainable Development?

A Research Paper presented by:

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in partial fulfillment of the requirements for obtaining the degree of

MASTERS OF ARTS IN DEVELOPMENT STUDIES

Specialization:

Economics of Development

(ECD)

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November, 2010

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List of Acronyms

MCA	Multi-criteria Analysis
CBA	Cost Benefit Analysis
CDM	Clean Development Mechanism
CER	Certified Emission Reduction (credits)
DC	Developing Countries
DNA	Designated National Authority
DOE	Designated Operational Entity
GHG	Green House Gas
IRR	Internal Rate of Return
SD	Sustainable Development

Abstract

This paper will examine the process of project approval of a large segment of of the Clean Development Mechanism program, namely large-scale hydro-electric power projects in China. This grouping represents the largest single subgroup of projects both by funding and by emissions mitigation postulation. As such it is necessary to critically examine the methodology used for project evaluation. Currently projects are primarily evaluated on the basis of Carbon Emission Reductions (CER) and Internal Rate of Return (IRR). Despite the requirement for each project to be certified as "Sustainable Development", the lack of clear guidance on the measurement along this dimension has meant that nearly any effort to assert SD characteristics is taken as adequate for certification.

Thus, while the primary goals of CDM may in fact be met, that of emission reduction and resource transfer, it is possible that the secondary goal of sustainable development may not best be served. For one part, this means that resources will be inefficiently allocated, achieving less development, less sustainability, and less emissions reduction per investment. Additionally, it means that national priorities which perhaps are not in alignment with some dimensions of SD may be funded at the expense of more holistically effective programs.

To test this hypothesis, this paper will construct an alternative framework for project evaluation based on additional dimensions of SD. It will examine the large-scale hydro-electric projects which have been certified in China in light of this framework. It will then compare the results of this analysis to the results of other certified projects in China focusing on other technologies. The resulting differential will suggest the opportunity for more effective and efficient programs in the future when the successor to the CDM project is enacted in 2012.

Relevance to Development Studies

Living in a world of scarcity means that resources must be used with maximum efficiency to achieve maximum results. Nowhere is this more true than in the intersecting areas of the environment and economic development in the poorer parts of the globe. By examining the traditional means by which projects are evaluated and proposing an alternative, the false dichotomy between these two areas can be eliminated and more good can be done for more people, in shorter time, with fewer resources.

Chapter 1

Introduction

1.1 The Goal of This Work

The world continues to struggle with the twin issues of environmental degredation and poverty. There have have innumerable projects designed to deal with these problems either singly or in combination. One of the more recent and interesting is the Clean Development Mechanism, which promises to generate 'sustainable development' funding as well as greenhouse gas reductions in one market based program.

The intent of this paper is to investigate the proposition that CDM is efficiently delivering sustainable development at the same time it is reducing greenhouse gasses. To accomplish this task, a segment of CDM projects was selected, large-scale hydro-electric power plants in China. This selection represents the largest single slice of project type by country in the CDM portfolio and a very significant proportion of the total funds which are generated by the CDM for development.

Before an assessment of SD can be made, a working understanding of SD must be developed. Once this is accomplished, a methodology for analysis must be developed. Once the parameters and framework for analysis are established, projects will be evaluated individually and as a group as to their SD suitability. Finally, to give context to these findings, a small sample of alternative investment options in the same country and of the same scale will be introduced using the same framework.

Research Question: Do hydroelectric CDM projects in China deliver SD?

1) **What is Sustainable Development?**
2) **How can it be measured?**
3) **Once measured, how do these projects rate?**
4) **What are potential alternatives?**

1.2 Background

The negotiation of the Kyoto Treaty Protocol in 1997 in many ways signalled a new era of environmental protection (Lecocq and Ambrosi 2007). It represented the formal institutional recognition of the danger of greenhouse gas (GHG) emissions and was an attempt to create tangible structures to deal with them. Much attention was given to the failure of the United States to ratify the treaty, which many felt made the future of the Treaty a moot point. At the same time many observers predicted, correctly, that the lack of enforcement would make the targets unmet. But less attention was given to the portions of the treaty which were enacted. While pundits argued about the inadequacy of the goals, or the failure to achieve even these, far less attention was paid by the public to at least one substantively realized initiative, the Clean Development Mechanism (CDM).

One of the more controversial aspects of the treaty was not only the debate about how much emission reduction to achieve, but the more complex issue of how that reduction would be achieved (Ott 1998). While it was difficult to get agreement on the overall target of reduction, even given that in general the consensus existed that reductions needed to occur, the task of creating a framework to implement those reductions became a Sisyphean labor. The various constituencies, which shifted and morphed depending on the specific issue being addressed, fractured along several lines, poor vs. rich, industrial vs. natural resource focus, forest product producers vs. forest product users, etc (Boyd, Corbera, and Estrada 2008).

One of the primary sticking points revolved around the contention on who would bear the cost of mitigation, both in real terms and in foregone development. The argument hinged on the fact that the wealthy industrial nations are the primary drivers of carbon emissions, either through direct output or product demand (Streck 2004). It was therefore recognized that meaningful reductions in emissions would have to come from the industrialised world. Of course, high emissions were a result of the fact that their economies were highly reliant on carbon emitting processes. This in turn meant that radical reductions could carry the potential of economic dislocation or at least high cost. The industrial nations, in particular the United States, wanted flexibility built into the system to ensure that industry could achieve reductions in the least painful possible way (Grubb 2000). This was thought to be acceptable for two reasons, first the impact of emissions were global and there is no real difference in climate impact from emissions from one area or another. Secondly, a flexible mechanism would allow for greater efficiency opportunities, vis a vis cost per unit of reduction (Anger, Bohringer, and Moslener n.d.). By allowing low cost reductions to take place in preference to higher cost reductions, and allowing them to take place in any location, the hope was that reductions could take place with a minimum of economic cost and dislocation.

For these reasons many industrial countries favoured the creation of some form of carbon market. This was to be a market where emission credits could be bought and sold. Because emitters that had low cost abatement opportunities would be able to bring their emission allocation credits to market, it was believed that a lower equilibrium cost of emissions abatement could be reached (Caplan 2003). At the time of ratification, it had been estimated that to achieve the reduction targets without some flexible trade mechanism would cost between $100-$200 per ton of reduction. With some trade mechanism in place it was believed that that some reductions could be had for $50/ton (Repetto 2001).

At the same time, there was significant concern on the part of developing world (Gupta 2008). Among most of these countries it was hypothesized that economic development depended to some degree on environmental degradation (the left hand side of the Environmental Kuznets Curve). At the very least, any effort to pursue an industrial growth policy would mean that the economy would have to be able to produce more GHG emission unless more expensive 'green energy' technologies were introduced (Grubb 2000). This implies that an attempt to curb industrial effluvia would imply a curb on economic development. In other words, the industrial world had benefited from an era of unrestrained pollution, and now was attempting to deny the potential benefits of industrialization to the less developed world by insisting on "clean" development.

The challenge was to find a mechanism that would deliver both CER, allow enough flexibility to achieve efficiency and reduce the dampening of Annex I growth, and at the same time provide some development support for poorer countries.

1.3 Clean Development Mechanism

Article 12 of the Kyoto Treaty specifies the inception of the "Clean Development Mechanism" and is defined thusly:

2. The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

The nations of the world were divided into two general categories, the Annex I/II countries which are the industrial and transition economies (of which there are 39 and the EU); and the countries of the developing world. Annex I countries made specific commitments to reduce GHG emissions to a level that was 5.2% lower than the 1990 benchmark year (UNFCCC 1997). At the same time, developing countries, while they made a general commitment to GHG reduction, did not have specific targets enumerated. It was recognized at the same time that growth was a major priority for the developing world, and therefore it was left open as how these reductions would be achieved or even if the reductions were in real terms or in terms of projected assumptions of 'business as usual' emissions (Grubb and Energy and Environmental Programme, 1999).

This differentiation hinges on the understanding of GHG emissions as almost a proxy for an economic 'good'. Conceptually, the idea is that mitigation is an additional cost and represents a drain on productive capacity (Caplan 2003). This understanding of the mitigation process drove the negotiating point of the "Developing Countries" party to the treaty. Because the limiting of emissions was also understood to be a limit to industrialization, any attempt to limit DCs emissions was an attack on their ability to develop. They therefore wanted compensation for the potential benefit that emissions would have brought.

One of the primary features that the industrial nations demanded in a mitigation mechanism was *flexibility* (Goldemberg and United Nations Development Programme. 1998). This meant that reductions should occur where they are the least costly. Because each unit of GHG is indistinguishable from any similar unit, no matter what the emission source is, it each unit is universally substitutable. Just as it would not matter to the global environmental system if a ton of CO2 emission is avoided by a car or a factory, so to it should not matter if the car or factory is located in Europe or China (Solomon and Intergovernmental Panel on Climate Change, 2007). Therefore, it should be possible to achieve market efficiency by allowing the low cost reducers to create the emissions reduction without regard to where they were located in the world.

This set the stage for the exchange rational. It was possible to have the mitigation anywhere in the world, including the developing world, where the low cost gains could be realized. The exchange could allow the higher cost producers to compensate them until some equilibrium is established. Because the market would also mean that the low cost mitigators could also receive compensation for their efforts, the loss of emissions based economic development could be offset. In practical terms this means that Annex I (comprising the industrialized and transition economies) economies can meet some of their carbon emission reduction obligation through purchase of emissions reduction in developing countries. Not only would this ease the burden of industrial economies from severe and potentially economically painful reductions, it would provide additional funding for projects in poorer nations (Goldemberg and United Nations Development Programme. 1998). In this way the imperatives of the two main camps negotiating the Kyoto Treaty would be satisfied, emission reduction could be achieved in a way which did not inflict too much pain on industrial countries and at the same time less developed nations could raise capital to fund development projects. Thus was created the Clean Development Mechanism.

A key component of this process leading to meaningful results is known as the principal of 'additionality' (ibid). This means that if the emissions credits are for avoided emissions rather than actual reduction, they must be shown to be in addition to what would have occurred in the absence of CDM. In other words, the project would have to demonstrate that without CDM, more emissions will occur, the 'business as usual' scenario. The number of CER credits (referred to hereafter simply as CERs) would depend on the amount of GHG which is NOT released as a result of this project. This of course is an enormously challenging technical task, projecting the probable events in a contra-factual future which is not taken (Repetto 2001).

More problematically, this leads to a peculiar situation in which companies are buying not a good or service, but the lack of one. And even more paradoxically, they are not buying even the absolute absence of a good which would be the case with say a measureable decrease in emissions. But rather they are purchasing the absence of a non-existent, non-specific good. Consider the example of a hydro-electric dam that is proposed to replace the energy that would be produced by an as-yet-unbuilt coal plant. Because it is replacing only a notional emitter, what would stop a CDM country from later building 'another' coal plant after getting funds for the dam? Because the CDM credits are not tied to a specific forgone emitter, the 'second' thermal plant is perfectly legitimate. If the Kyoto Protocol was an attempt to seriously address the dangers of increased GHGs in the atmosphere, it is uncertain the degree to which CDM will contribute to reduction rather than just mitigation (ibid).

Despite this and many other questions, the program was implemented and began taking projects for evaluation in 2005. The UNFCC was designated as the administering agency and was responsible for creating the analytical procedures which are used to evaluate the various projects. To allow for the varied needs of Developing Countries, each nation would have a National Accrediting Agency which would be responsible for vetting and approving projects on the national level. Projects which passed the national process would then be passed to the UNFCC for final approval.

The project process of a CDM project is as follows (cdmrulebook.org 2010)

1) Conception: typically a project would be conceived with a local and an Annex I partner.

2) Quantification of GHG mitigation: The investors must, using approved guidelines, establish the amount of GHG that will be avoided by the implementation of the program.

3) Program Design Document creation: the project leaders must put together a document that includes financial, environmental, and social impacts.

4) National Approval: each country must have a Designated National Authority (DNA) responsible for approving CDM projects according to local and international standards.

5) Validation: projects must be vetted by a private, third party evaluation team from among those approved by the CDM Executive Board.

6) Registration: projects must be approved by the CDM Executive Board, a function of the UNFCCC.

In this system, the impetus for projects would come from the local/national level, and would be conceptualized to fit within the development goals of the local or national authority (as opposed to the international community). To ensure that the projects were being properly vetted for GHG reduction, the third party validators would be used. And to ensure that the spirit of the treaty was being followed, the international community in the form of the UNFCCC had final say in the formation of CDM projects.

In the years since the program has been functioning, it has issued more than 453 million CERs. Although the price of CERs have been extremely volatile, seeing trading on the European Union Emissions Trading Scheme running from a low of .1 euro/ton in Sept 2007 to a high of 30 euro/ton in April 2006 (Great Britain. 2008). Because of this volatility, project planners typically use a figure of 10 euro/ton for planning purposes. Which means that CDM has generated more than 4.5 billion worth of sustainable development funds in its lifetime to date and is projected to run to approximately 16 billion USD by the end of the program in 2012 (from UNFCCC website statistics on projected CER)

The purpose of this analysis is to look at these projects using the internal logic of the CDM institution. There are many and important criticisms of the CDM as an endeavour, such as the logic of a market for the environment. There is also much justified scepticism about the formulation of the CDM process, notably the exclusion of reforestation and problems around 'additionality'. These issues are important and must be addressed going forward, but for this paper, the underlying assumptions of the CDM will be taken as in operation, namely that emission reductions can be measured and have a financial value, and that the value of these CERs should be used to fund sustainable development.

Chapter 2 Operational Concepts

Having described the genesis of the projects to be examined, it is important more fully understand the implications of the stated goal of the CDM project (ie sustainable development) and to create a framework suitable to evaluate the effectiveness of a given project toward that end, in this case multicriteria analysis. These two concepts, SD and MCA form the foundation of the later analysis in Chapter 4.

2.1 Sustainable Development

While CDM was designed to function as a means of simultaneously offsetting carbon emissions and providing funds transfer for development projects, it was also specifically conceived to carry out these functions in the context of 'Sustainable Development' (Goldemberg and United Nations Development Programme. 1998). Article 12 specifically mandates this approach. However, it does not provide guidance on the meaning of 'sustainable development' or of either of the constituent components, 'sustainable' or 'development'. The lack of specificity on this score has allowed, on one hand, a great deal of flexibility for project planners to put forward a variety of proposals (Victor 2006). On the other hand, while they perhaps represent economically viable projects, some of them compromise on other aspects of the sustainable development concept. It is therefore vital understand what the intent of sustainable development is and then to develop a working definition of SD against which proposed projects can be measured.

2.1.1 Definition

There have been many attempts to find a general definition of SD, and none has found universal acceptance (Castro 2004) . The first formal institutional attempt to develop a working definition of sustainable development was the Bruntland Report. It summarized its vision of sustainable development in Section I, paragraph 15

15. In essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.

Like most committee reports, this is a definition which offends no one and means little when attempts are made to operationalize it. This has left it open to distortion and being co-opted by a wide variety of political agendas (Victor 2006). This means that within the rubric of 'sustainable development' many national agendas can be pursued which may not be in accord with more general notions. This is particularly true when the concept is translated from the industrial to the industrializing nations (ibid). The flexibility of the definition has prevented the development of robust and generally accepted measurement mechanisms that allow for determining if a project is 'sustainable development' and if so, how much so. However, it has formed the basis of the United Nations' Agenda 21, and has served as the starting point for many further attempts to operationalize a definition.

What it does do however, is explicitly introduce the temporal dimension of sustainability. While it may seem implicit from the word 'sustainable' (which only makes sense in a temporal context), this is sometimes lacking in subsequent definitions. This also suggests that just as future value of resources must be taken into account, the future cost of today's exploitation must be as well. A process which generates environmental damage must have not only the present cost of the damage included in the analysis, but also the cost to future generations (van den Bergh 1991). This is particularly important for future generations which may not be even reaping any direct benefits from the project. An example would be nuclear power plants, which generate harmful by-product that bears a cost to future generations for several millennia. Another would be river damming projects which cause significant sedimentation build-up behind the dam. This represents a significant clean-up cost at some future point in time (between 75-125 years) (Russo 1995) which will be paid despite the fact that at that point the dam will not be producing power.

This definition also seems to focus on the economic context of 'development' quite strongly, not addressing 'soft' factors. By introducing resources as the object of exploitation, and not addressing the social or especially environmental aspects in the use of these resources, the definition lacks complexity. It gives the impression that it is possible to achieve a maximization state for resource use and capital substitution based on their future expected value. The view that resources are fundamentally a form of productive capital, and therefore are expressible in economic terms is an underlying concept of most environmental economics approaches to project analysis (for review of the literature see (Atkinson and Mourato 2008)).

Later authors have attempted to hone this conceptual definition into something more complete. Barbier (1987) made an early definition as the attempt

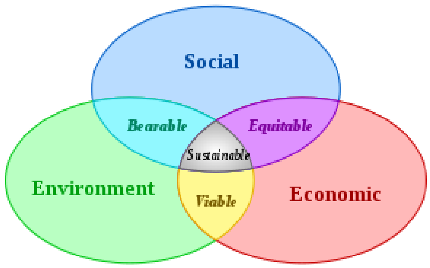
"To maximize simultaneously the biological systems goals (genetic diversity, resilience, biological productivity), economic systems goals (satisfaction of basic needs, enhancement of equity, increasing useful goods and services), and social systems goals (cultural diversity, institutional sustainability, social justice, participation)."

This highlights the many competing imperatives inherent to any attempt to realize sustainable development. It is often quite impossible to maximize any two of these dimensions let alone three. There are often incommensurable differences with the processes inherent to each of these factors. For example, economic development usually implies some use of natural resources. Natural resource protection will have an impact on the human communities which use them for productive purposes.

An additional problematic facet is that these various arenas often have valuation systems which are not commensurable (Munda 1995). While there have been attempts to monetize the value of natural resources, these are usually derived through their productive value to human systems. However, the resources which are extracted may have a value in the biological system which is not related to human economic production and is therefore not easy to measure in financial terms. Additionally, the environment in pristine condition may have social value, either through ethical attachment to pristine nature or an aesthetic value, which likewise is difficult to measure financially (Abaza and United Nations Environment Programme. 2002). It is an even more intractable problem when one considers the variety of value systems which can come into play. Some cultures value human diversity at this point in time, although that is not a trait that exists across all time. Actions which destroy the ability of ethnic groups to live as recognizable entities would then represent a great cost, but only to those who value diversity. The problem of deriving a monetary value for this diversity is nearly insurmountable.

While the Barbier definition specifically lacks the temporal aspect, it does make more explicit the non-economic factors that comprise SD. By including ecological and social aspects in a way separate from their economic value, a more balanced and complex version comes into focus. This has become the '3 Pillars' of sustainability concept (Kates, Parris, and Leiserowitz 2005). This illustrates that sustainability is contingent on harmonizing, not necessarily maximizing, the social, environmental, and economic factors of the human sphere (ibid).

Figure 1 The Three Pillars of Sustainable Development



Sustainable Development. Author: Johann Dréo, 2006. From Wikimedia.

Currently the UN uses the Agenda 21 outline for its conceptualization of sustainable development and implements it through the United Nations Division for Sustainable Development. While it does not provide a succinct definition of SD, it does encompass the areas which the UN considers important for consideration, including land use, community and ethnicity preservation, as well as biodiversity and environmental systems protection (United Nations Conference on Environment and Development 1993). The UNDSD has been active in formulating indicators for the measurement of sustainability, although there is no universally accepted method for assessing either these indicators or 'sustainability' itself.

2.1.1 Problems Defining Sustainable Development

Criticisms of attempts at a definition, including the above, have been many and varied, but revolved around a few key areas.

Who decides what/how much the future will need?

To suggest that current sustainable development must not impinge on future generations' ability to provide for themselves in a sustainable manner, it is necessary for the current generation to decide what and how much the future will demand (Abaza and United Nations Environment Programme. 2002). This can be somewhat problematic, especially if one takes the 'future generations' to stretch into a distant time horizon. Just as it would have been impossible for planners of even 150 years ago to predict what and how much the current generation would demand, so too is it an impossible task for current planners to do the same for the future.

From this, one line of argument develops along the lines of unknown needs (Kates, Parris, and Leiserowitz 2005). There are many resources in existence today that perhaps have unknown uses for tomorrow. Take for example that many species of both plants and animals have use in bio-medical research. Any loss of species could perhaps be denying the future not just of the enjoyment of the experience of those species, but also the potential benefit those species may provide. Given the huge reliance the pharmaceutical industry has on organic compounds which occur in nature, and the rate at which these uses are being discovered, it can be argued that species loss constitutes the potential to deny the future treatments for diseases or maladies which have not been recognized or even emerged (Garrity and Huntercevera 1999).

Similarly, the transformation of land use could be understood under the same rubric. The decision to use some area of productive land for a purpose which precludes several others represents a decision to prioritize the needs of the current generation before the needs of the next. This comes into particular focus when one considers the transformation of land area that occurs when a hydroelectric power project is implemented. While it is true that, unlike with fossil fuels, the energy generated is essentially infinitely renewable, it is not without cost to the environment as experienced by future generations. The area behind the dam, and in many cases below the dam as well, becomes transformed from whatever previous use into lake (Russo 1995). In some cases this means that vibrant natural ecosystems are destroyed and sometimes fertile agricultural area is inundated. In either case, the ability of future generations to benefit from the pre-existing environment is destroyed.

How to account for diversity of priorities

The Barbier definition in particular highlights the multiplicity of imperatives which can factor into the notion of SD. But given that these can be prioritized differently by different stakeholders, it is unclear from the definition how these incompatible values can be accommodated. For example, for people who depend on a river for livelihood will have a different interpretation of the impact of a hydroelectric dam project on their river than will agriculturalists who depend on irrigation. While the aquaculturalists may see an interruption of the rivers natural flow as a threat to their economic conditions, the agriculturalists may see the flood prevention and irrigation opportunities as imperative for their economic development. When the cost of 'development' may be the viability of whole communities or indeed cultures, it may not be satisfying to simply apply a financial valuation of the products of the different stakeholders and fall back on a utilitarian ranking system.

The inability to reconcile these differences or even to find a common unit of measurement to begin to compare them is called social (or value) incommensurability (Munda 1995). This refers to the situation in which there are various social actors with various valuation methods, all of which are equally valid but which do not directly correspond to each other. The valuation by each party is based on certain assumptions about reality, norms, and goals. Traditional CBA reduces decisions and outcomes to a comparable unit, a monetary one. But for many facets of SD, this reductionalist methodology does not capture the input from various stakeholders, whose understanding of the issue can be expressed in highly incommensurate ways (ibid). A framework to analyze the sustainability of a project must be flexible enough to handle incommensurate inputs from a wide spectrum of stakeholders.

The stakeholder unit of analysis adds a layer of complication as well (Munda 2004). When speaking of environmental issues, they are by their very nature transregional. To what degree should the interests of people perhaps far removed but impacted by any given project be considered? In the case of China, very large urban populations are demanding more energy, and providing it at a reasonable cost is seen as a prerequisite for China's continued growth. But the urban population lives far from the immediate environmental impacts of any dam project. How can one evaluation system balance the direct vs the indirect costs and benefits? Perhaps more complexly, the entire world is impacted by GHG emissions for example, how much consideration should the desire for lower emissions in the developed world be incorporated into the calculus as opposed to the desire for economic growth in the developing world.

The Oxymoron of Sustainable Development

Much of the debate that led to the creation of the CDM and related programs is the belief that resource use, particularly energy, is a requirement for economic growth (Goldemberg and United Nations Development Programme. 1998). Because at this point fossil fuels are the primary source of large scale energy generation, less developed countries argue that the attempts to limit energy use are attempts to limit their growth. This seems to be true for economies that are seeking an industrialize path to growth, the processes of which are quite energy intensive.

However, in a context of population growth, economic growth generally uses a greater quantity of resources than the baseline scenario. In other words, even allowing for increased productivity as a driver of growth, if the population is growing, an increase in the aggregate economy implies an increase in resource use. Because the world is a closed system, the implication is that economic growth, given static or increasing population cannot truly be sustainable. More resources must be used to drive growth, eventually running into the limit of their availability.

Even processes which are internally renewable do not meet the conditions for sustainability under all definitions. Agriculture can be seen as a renewable economic sector, but a given parcel of land cannot simultaneously serve as agricultural land and pristine wilderness. If the natural world is considered as an equal stakeholder in the analysis of sustainability, it is impossible to reconcile these two positions. A given resource cannot serve a human productive purpose and at the same time serve its function to the 'non-human' ecosystem in the form it would have in the absence of humans.

What issues highlight is the lack of a definitive standard of 'sustainable' for any human activity. A given project or process can be 'more' or 'less' sustainable than another. It is only possible to evaluate them hierarchically and relatively. To label something as 'SD' must always be understood to imply 'relative to this other alternative'. At the same time, the move away from an economics based evaluation approach allows for widely divergent needs and imperatives to be incorporated into the concept, but it adds confusion as to the way in which these aspects are to be evaluated. Many of these facets have valuations that are contingent on social and individual perception, moral framework, or taste. This means they are not amenable to traditional cost/benefit analysis for the purposes of comparison.

2.2 Multicriteria Analysis

2.2.1 Definition

One of the major difficulties of sustainable development is that, lacking a very concrete definition, it becomes a challenge to evaluate programs or projects for sustainability in a practical setting. In a world of scarce resources, and assuming that efficiency and effectiveness are goals, project evaluation is a necessary and beneficial process (Munda 1995). But while the traditional methodology which focuses on financial cost/benefit analysis is quite well understood, the process becomes much more complex when issues of environment and society are included. There have been many attempts, but none totally satisfactory, to quantify concepts such as bio-diversity, ecosystem sustainability, social cohesion, or equity (Munier 2006).

But these very qualities are fundamental to the concept of sustainable development. A method must, therefore, be implemented allows for intrinsically unquantifiable concepts to integrated into an evaluation process. This method must respond to at least two aspects of sustainable development projects which are less prevalent with more traditional projects (Munda 1995).

1) It is impossible to optimize all the imperatives simultaneously. This is particularly true of SD projects which must balance environmental, economic, and social goals which may be completely incompatible.

2) There is no action which is clearly preferable in relation to every other action for each of these competing criteria. With multidimensional analytical structures, an action which is better vis a vis one criteria may be worse according to a different criteria when compared to action b.

While the first point has been discussed in the context of SD, the second must also be considered. This more than the 'second best' scenario of economics. It can be said that these projects fall into the realm of "fuzzy logic" (Munda 1995). Fuzzy logic is the space where quantifiable qualities take on an element of qualitative description. For instance, a person's age is quantifiable, but to qualify that number as 'old' or 'young' is a qualitative act. The qualitative measurement can only be taken in relation to another element of the set. A person is only 'old' or 'young' compared to something or someone (Stanford Encyclopaedia of Philosophy).

For many aspects of SD projects, this has several implications. Firstly, it is difficult to say something is 'environmental' or 'sustainable' in any absolute sense (Munier 2006). As has been discussed above, these concepts can only be understood in relative terms. A plan may be more environmentally sensitive than some other action, but the fact of taking action implies some change to the environment. Secondly, when assessing the impact of SD actions, assumptions about the future state must be made. For instance, to evaluate the social impact of some action, assumptions must be made about what the future social state will be. But complex systems such as society and the environment do not lend themselves to accurate prognostication this way.

Most social and environmental systems are highly correlated with other systems and highly stochastic (Munda 1995). This means that the effects of any given action interact so highly with other factors, and then become themselves a cause of further, even less predictable effects, that the result is impossible to predict definitely. In this context this means that rather than specific outcomes, any analysis must incorporate probabilistic outcomes. MCA is powerful in this context in that it allows for relative ranking that does not depend on accurate numerical valuation. It explicitly allows for the probability of outcomes and gives space for the evaluators to incorporate risk aversion/seeking in a more transparent way.

An example would be a social impact analysis of a project with two possible methods of completion. Both methods may be economically similar, but one may have some small but non-zero chance of large social disruption, perhaps through land-use changes. For MCA, it is not necessarily imperative that those changes are quantified, nor even that the probability is computed accurately. It is enough to know the relative likelihood and scale of the impact. The evaluator then has to make their preference visible in the weighting of the probability and scope of the impact.

Another strength of this methodology is that it allows for multidisciplinary input in a way which makes sense to each of the individual approaches (Munier 2006). This is in contrast to the traditional CBA which takes input from various disciplines, such as ecology or sociology, and attempts to express them in terms of economics via a financial valuation.

It must be pointed out that MCA is not a method that allows evaluators to transcend bias or value judgement. It still requires that criteria are picked, a method to evaluate those criteria is agreed upon, and the relative weights of the different criteria are set. In this sense, it is not inherently more objective than the more traditional CBA, although it allows inclusion of a wider variety of inputs. But what it does do is make more transparent the assumptions and bias in the valuation process. For example, when determining the weighting factors of each indicator, the evaluator is expressing their assumptions about the relative importance of each category in a way which becomes more noticeable, and therefore challengeable. It does not allow one to avoid arbitrariness, but makes the arbitrary decisions explicit.

MCA analysis has been shown to be a robust system of analysis for social and environmental issues (Qureshi, Harrison, and Wegener 1999). It has been used by a variety of governmental and non-governmental agencies including the Dutch government when evaluating the SD impact of their own CDM investment (Gupta 2008). It is therefore the key tool of analysis that this paper will undertake to use to measure the relative sustainable development value of the chosen CDM projects.

2.2.2 Implementing MCA in the CDM Context

Currently, there is no unified standard method to assess the 'sustainable development' of a CDM project. What is required is that a proposal demonstrates that it is "sustainable" in that it does no additional damage to the environment, and "developmental" in that it produces a positive IRR. There are proposed evaluation guidelines, such as the Gold Standard (see http://www.cdmgoldstandard.org) and SouthSouthNorth (http://www.southsouthnorth.org) but none of them represent official standards. Even the UN Division of Sustainable Development, which has done considerable work on developing indicators for SD, does not have a mandate to impose them formally as criteria for project evaluation. Instead the 'do no harm' principal is used as a minimum standard and it is left to the DNA, subject to approval by the DOE, to further elaborate what SD means and how it is best measured.

In practice this means that SD is incorporated as a binary viable, a project is or is not 'sustainable' and does or does not create some 'development' benefit. For many stakeholders this is adequate, demonstration of at least neutrality (ie the project does not damage prospects for sustainability or development) is sufficient given that the outcome of project realization is also a positive.

However, this 'just over the goal-line' approach opens significant scope for national agencies to prioritize projects that best reflect parochial agendas rather than global environmental or development ones. This has the effect that efficiency of the CDM program as a whole may be impaired. Given limited funding resources and finite CER availability, it is imperative to maximize the efficiency of each potential SD project, not only with respect to GHG reductions and IRR, but also for the more difficult to measure environmental and social aspects of sustainability. The difficulty lies in finding an evaluation tool that is both robust enough to handle the multifactor input and the indeterminate nature of much of the data on outcomes.

Because of the various positions of stakeholders and the fuzzy outcomes inherent to any environmental project, it may not be possible to generate a definitive 'Sustainable Development' ranking. It may be possible, and indeed desirable, to develop a methodology which can establish a ranking of projects relative to one another. This could function to ensure that scare resources are being directed to the most effective projects. It would also improve transparency of the certification process and remove some of the potential for 'gaming the system' (Munda 1995).

In this respect, multi-criteria analysis proves to be a suitable tool for the reasons outlined above. It has the advantage of incorporating, conceptually, inputs from a large spectrum of stakeholders with varying needs and conceptions of sustainability. Additionally it allows for a methodology for ranking projects vis a vis other potential destinations for funding (G Munda 2004). For the purposes of this paper, we will build on the Multi-Attributive Assessment of CDM (MATA-CDM) model proposed by Sutter (2003). It is important to keep in mind that is not an official assessment tool used by either the UNFCC or any of the NCAs.

The outline of the model is

Figure 2 Multicriteria Equation

$$U(P) = \sum_{i=1}^{n} w_i \, u_i[c_i(P)]$$

Where

P = CDM Project

W_i = Weight of criterion i

c_i = Sustainability criterion i

U = Overall Utility

u_i = Utility of criterion i

From (Sutter, 2003)

This is just a generic form of a formula which asserts that the sustainable utility of any given project is the sum of the utilities of each criteria multiplied by a weighting coefficient which represents relative importance in the decision making process. In this form it resembles strongly the traditional CBA formula. However, in this case, the values of u are not directly commensurable in their raw form across categories. In other words, the value of u when considering 'ecosystems impact' may be a '1' which is derived differently than the '1' when considering the 'community empowerment' category (ibid).

The weighting coefficient allows the evaluators to make explicit their perception of relative value for each category (Munda 2004). It is entirely possible that in some contexts, the value of a particular variable, for example 'biodiversity' may be considered less important in the evaluation process than 'economic return'. These value judgements are inherent in any and all evaluation processes, but this system forces them to be transparent. Because the system also allows for a multiplicity of inputs, not just financial ones, or ones that can be expressed financially, it opens greater space for discussion about which variables are or are not included. By implementing a framework which does not require a dollar value for its inputs, a wider variety of stakeholders can be formally included in the process. Or, if they are excluded, the exclusion becomes more noticeable, less justifiable, and therefore open to negotiation (Abaza and United Nations Environment Programme. 2002).

But opening the space for a wide variety of inputs begs the question, which variables to choose and how to rank them. In most cases, when building an evaluation matrix using MCA, an analysis of the position of various stakeholders would be conducted, which would compile the relevant categories and establish areas which were subject to friction and/or trade-offs (United Nations. 2007). For example, if a planner was evaluating various proposals for a water use plan, the various stakeholders (users of the water, government, environmental, or other groups) would be polled to determine what the relevant factors were.

Then a ranking system must be established such that attributes can be compared within categories and ranking can be compared across category. This usually takes the form of a simple '1,2,3..' or 'A, B, C...' ranking system (Munda 1995) This could either mean that an option is 'the best' in a category meaning relative to other studied options, or that it is 'good' relative to some standard. While this system adds considerable flexibility to the evaluation process, it is incumbent on the evaluators to make clear the standards by which the rankings will be given.

Chapter 3 Hydro-Electric Power

Having established the general framework within which the evaluation process will take place, this paper will turn to an examination of the specific projects under examination in order to meaningfully establish a set of criteria and ratings.

In many ways, hydro-electric power has enormous potential as a source of 'green energy'. Because it does not directly release GHG in the electricity production process, and where it is available it is amenable to large-scale production, it is often presented as an important solution to growing energy demand (Russo 1995). Indeed, with approximately 45,000 large dam projects in the world, some contend that they represent an important future for energy generation systems that may not contribute to GHG levels to the degree that thermal energy production methods do (ibid).

While these projects are promising when examining the GHG dimension, there should be a large degree of caution when positing these projects as 'sustainable'. Many projects have shown themselves to be environmentally damaging and socially dislocating (World Commission on Dams. 2000). Because of the growing scepticism about large dam projects, development aid has moved away from these types of projects at the same time fewer dam projects are being initiated in the industrial world (ibid). To develop a framework for analysis using MCA, it is important to first understand the challenges that hydro-electric power posses in the SD context.

3.1 The Dam Problem

The analysis of large scale dams from the SD perspective must encompass environmental, social, as well as economic factors. Because of their large footprint, both geographically and environmentally, they impact their local areas significantly (UNEP Dams and Development Project. 2007). This is not to suggest that they do not have enormous potential as a source of renewable energy. But it must be understood that, like any human activity, it impacts its environment, both ecological and social. These impacts can be positive or negative depending on one's perspective, but they must be accounted for in any comprehensive analysis of these projects.

It is also important to differential between the concept of 'renewable' and 'sustainable', although many times the popular literature does not seem to. Hydroelectric power is for all practical purposes infinitely 'renewable' as it converts the gravitational potential energy of flowing water into electricity. Because this energy originates from the sun via the hydrologic cycle, it is for all practical purposes inexhaustible. But using the UN conception of 'sustainable' in which the resource use impact of a process must be considered, the credentials of hydroelectric power are less pristine (United Nations Conference on Environment and Development 1993). There are several areas in which it can be demonstrated that this form of energy generation has problematic impacts.

Environment – Dams by their very nature change the flow of water in a river ecosystem. This means there is some impact on the potentially fragile and highly inter-related flora and fauna which depend on the river.

Water flow – one of the most important aspects of a dam is that it modifies the flow of water along the river system. This has consequences for sediment accumulation, seasonal flooding, and habitat (McCully 1996). For some stakeholders this can be a positive impact, such as the control of flooding or the increased availability of irrigation supplies. For others it can be a negative, such as any environmental process which is dependent on the dynamic forces of flooding or delta sediment deposits (World Commission on Dams. 2000)

Ecosystem fragmentation - by dividing the river ecosystem with a man-made barrier, the interwoven elements such as upper, mid, lower, and estuary ecosystems lose continuity. Because many species move through these various reaches and important physical processes may be impacted such as sedimentation, salting, and vegetation loss ((World Commission on Dams. 2000).

Temporal Ecological Distribution – A major problem with dams is the problem of sediment build-up. While this problem is slow to develop, it is serious. In China, large scale dams lose approximately 2% of their reservoir capacity each year to sediment build-up (McCully 1996). While this means a loss of efficiency, it also means that at some point in the future the dam will become inoperable without significant intervention. This has the effect of passing a potentially difficult environmental problem onto future generations. The river flow, even in the moderated, dammed state, may be severely impaired. Additionally, the sediment build-up is susceptible to heavy metal accumulation and can pose a disposal challenge (ibid).

Land-Use change - Dam reservoirs submerge land. Whether the land submerged was agricultural or wilderness, or even urban, the change is disruptive to the ecosystem. The change of a large area into a lake has implications for the local flora as well as fauna. Just as land-use change in other contexts has implications for the green house gas levels, so too does it in this context. Not only does the submerged flora no longer function to sequester carbon, the dead vegetation releases its carbon. In fact, because much of this gas is released in the form of methane (with a much higher greenhouse warming potential of approximately 72 times that of CO_2 in the first 20 years in the atmosphere). The total carbon release is highly dependent on location and environmental circumstances, but in some instances is believed to be on the same order as some thermal energy production techniques (World Commission on Dams. 2000).

Social – Because rivers are often an important feature in the life and livelihood of communities located on or near their course, any change in their flow will impact those communities in a variety of ways.

Land-Use change - **The** reservoirs behind dams convert land of some kind into lake. This area often has some function in the life of the communities in the area. This can include farmland or even actual settlements but also includes the changes in availability of natural flora and fauna which some communities rely upon. It also can mean changes in recreational opportunities or uses, with more or fewer people using the area in question (World Commission on Dams. 2000).

Dislocation **–** Often, especially in heavily populated countries, a river system represents a widely utilized habitation zone. When large areas behind dams are converted to lakes, significant populations can be forced to relocate. In the 3 Gorges project in China, 1.6 million people have been or will be relocated either as a result of the reservoir or for environmental reasons (Heming, Waley, and Rees 2001). This of course is disruptive of the specific community, but also potentially with the larger social context. There are other cases in which sites of historical, religious, or cultural importance to specific ethnic groups have been inundated. These impacts can be exacerbated in poor rural communities where alternatives for livelihood and coping resources are quite limited (Cernea 1988). Given that the World Commision on Dams report estimates of the displacement of people due to dam projects to be between 40 and 80 million people in the post-war era (World Commission on Dams. 2000), hydroelectric power globally serves as a major disruptive factor in the social fabric of many communities.

It is a practical impossibility for a dam project to have no impact on its surroundings, both social and environmental. These impacts are differently distributed and evaluated by various stakeholder groups, and defy simple attempts to quantify them. It is just such a realm that a practical use of MCA can best be put to use.

3.2 Hydroelectric power in China

Despite the potential problems, and unlike most of the OECD countries, China has remained committed to the expansion of hydro power in their energy portfolio. Already nearly two thirds of the large scale dams are located in China, and this figure is expected to increase . In 2008, China's demand for electricity was approximately 2529 billion kilowatt hours. This figure has grown and is projected to continue to grow at around 12% per year for the next several years (Adams and Shachmurove 2008). This growth is fueled by two related trends, economic growth and increased discretionary income.

China's GDP continues to exhibit very strong gowth on the basis of increased production. At the same time, the energy efficiency (the amount of energy used to produce a unit of GDP) has remained at a very low level compared to the advanced industrial countries. While the US economy uses 8x the total energy as the Chinese, the Chinese economy is only 25% as efficient in energy usage as function of GDP (ibid). What this means is that the increase in aggregate economy that China is experiencing is creating an even greater, proportionally, energy demand than is witness in other industrial countries.

Increased discretionary income has led to a boom in demand for consumer goods in China. Many of these are energy intensive items, such as televisions, computers, even electric lights. The goal of moving large numbers of chinese out of poverty is indirectly the goal of increasing the net energy demand in China.

Currently, most of this energy demand is being met by fossil fuels, specifically coal which accounts for approximately 78% of total energy demand (Brown, Magee, and Xu 2008). China is now the worlds largest total CO2 emitter, and is projected by the International Energy Agency to be the source of 40% of the total GHG emissions over the next 25 years.

It should also be noted that the majority of the increased income, and hence energy demand, experienced in China over the last 20 years has been in coastal provinces, not the inland provinces in which the majority of the hydroelectric projects are located or planned (Zhang 2004). While the benefits of electricity can be available to people from all points of the economic spectrum, inasmuch as electricity demand tracks with income, it is important to hold in mind that the stakeholders who benefit most from the lower energy costs are not the same stakeholders who will bear the direct social and environmental costs of these dams.

In recognition of the problems of reliance on coal, China has been aggressively developing its hydroelectric potential and already generates 16% of its total from this source (Zhang 2004). The China Electrical Council has targeted 12 river systems for simultanious development which they claim represent 214 thousand MW of potential energy. Most of this comes in the form of large-scale dam projects on these 12 river systems. However projects of all sizes are going forward on many dams all over China, with plans to triple its energy output by 2020.

3.2.1 Hydro-electric CDM projects in China

Because of the controversial nature of the very large scale projects, the Chinese government has not proposed these as CDM projects to the international community. However smaller, less controversial projects have come to dominate CDM funding. China is the largest single player in this phenominum, with large amounts of money moving toward these projects.

Because of the scope and scale of the CDM investment in hydro-electric power in China, it is important to examine the process of decision-making for funding. These projects represent not only a significant amount of renewable energy investment, but also a significant source of development aid. While it is true that these projects do represent significant reductions in carbon emission, it is possible that they do not represent the most efficient destination for development funds.

As of 4 September 2010, hydroelectric projects either approved or in the pipeline under the CDM amounted to:

	Number (% of total)	Energy Production
total projects	2504	
of which dams	1525 (60%)	63,176 MW
of which in China	971 (38%)	39,911 MW (63%)
of which large scale	590 (24%)	38,727 MW (61%)

From the above it is clear that hydroelectric power projects represent a substantial and important component of the CDM program. Specifically, large scale dams in China, the object of this paper, represent nearly one quarter of the total CDM portfolio of projects. they also account for 61% of the total energy production capacity which falls under CDM. As such, it is proper to examine the effectiveness of the resource allocation process. For this examination, we will analyse the projects as a class. In other words, we will attempt to qualify 'large scale hydro-electric power' as a category as a subject of comparison with other categories of investment.

3.3 The Evaluation Process

As part of the evaluation process, the proposal must include analysis of alternative methods to provide the energy that the prospective CDM wil generate. These are:

Alternative I: the same project but without CDM funding

Alternative II: A thermal plant with the same capacity

Alternative III: Same level of output but from alternative energy sources supplied on the same grid

Alternative IV (not always included): Same output created generically by the same grid, in practical terms identical to AII

Alternative I is designed to demonstrate the importance of the CER to the financial viability of the project. 100% of projects examined demonstrated that the only way they would pass the 'viability' threshhold (usually 8% IRR) would be with income from CERs. While it may be true that the IRR would drop below the state suggested level, the fact that none of the projects which were rejected (and also asserted that CERs were vital) were in fact cancelled makes the analysis somewhat suspect.

Alternative II is the business as usual scenario. Thermal plants in this case refers to coal plants. Chinese law prohibits construction of coal power plants of less than 135 MW capacity in regions covered by large scale grids and severly limit those elsewhere of less than 100MW (The Management Provisional Regulation on the Construction of Small Fuel fired Generators). This means in practice that Alternative II is very rarely deemed to be viable because so few dam projects under this proposal are of that scale.

Alternative III is a comparison with alternative (non-coal generally) energy sources which the same grid could theoretically use. This is the scenario in which other renewable or sustainable energy sources are compared, and in 100% of the cases examined, found to be non-competative on IRR alone. For this category, which is mandated in the CDM process, only the economic aspect of alternative sources is considered. This represents the major weakness, from the sustainable development perspective, of the CDM process. Because sustainability is not considered as a variable of comparison among prospective projects, but rather a threshold variable derived independantly of other projects, alternative possibilities of power generation are exluded from consideration because of purported 'non-competative' IRR.

It should be noted that there are two measurements for IRR, with and without CERs. Because CERs represent additional income for the project, they significantly alter the IRR calculation. In fact, this is one of the necessary attributes for a project to accepted into the

CDM program. Each program must show that Alternative I (without CDM funding) is not an economically viable investment. The implications of this are that these projects would not (or should not) occur in the absence of CDM funding. This makes the requirement for effective evaluation of projects even more critical, because mis-allocation may mean that more effective programs will lack access to investment funds and thereby not see the light of day.

Once these alternatives have been shown to be impractical, the sustainability of a project must be demonstrated. This involves an environmental impact assessment and a stakeholder survey. There are however, serious questions as to how some countries, such as China, conduct these inquiries project can be cleared by the accrediting agency. This process does not include more the more complex dimensions of SD, nor does it allow for a comparative evaluation of SD with regard to other potential investment opportunities.

3.3.1 Measuring Sustainability

To attempt to measure the comparative effectiveness of these projects we first must establish the criteria which will be the source of comparison. Given the lack of consensus on what constitutes SD, it is not surprising that there is little consensus on indicators. However, the UN Division for Sustainable Development has made it a major component of its work to develop guidelines for indicators (United Nations. 2007). Of course not all of these are applicable, and several authors have chosen to use different ones ((Sutter and Parreño 2007). One glaring omission from the UNDSD guidelines is the lack of reference to cultural or ethnic identity factors as well as social cohesion factors. This despite the fact that even agencies such as the World Bank recognize the potential for disruption of development projects (Cernea 1988).

Despite this omission this paper will take this factor into account as it has been shown in studies of similar dam projects in China (Heming, Waley, and Rees 2001) and in other places in the world (Rothman 2001) show that these impacts are significant and important to many local stakeholders.

The goal then of this chapter has been to establish the areas in which hydro-electric projects are problematic from a SD perspective and lay the groundwork for a simple rating system to be applied to this category of projects generically, from which base-line individual projects can be evaluated.

Chapter 4 Application

For purposes of this paper, we will address 6 different criterions which will reflect the environmental, social, and economic aspect of these projects. While it would be preferable to have a more complete basket of indicators, due to data limitations we are constrained to select a small sample. These are enough to catch some of the complexity of the trade-offs each of these projects makes in the various aspects of SD. They have been selected to be in general alignment with indicators developed by both the UNDSD (United Nations. 2007) and the Gold Standard CER rating system (Ecofys 2009)

4.1 Rating System

The relevance of MCA for this project is clear when specific attempts are made to apply specific ratings to any category of SD indicators. It is difficult to derive some meaningful, commensurable numeric for comparison across categories or even within category across project type. For this reason, a simple method of "good", "bad", and "indifferent" is used. This is based on the system devised by the SouthSouthNorth non-profit organization but simplified. They use a -2 to 2 system; this paper will use a -1 to 1 ranking. Because of the nature of the data-gathering process, ie reliance on published reports and lacking specific project research, it was felt that less extreme results would give more credible rankings.

1 = generally positive or better than average

0 = neutral or average

-1 = negative or worse than average

It is immediately apparent that this scale is 1) extremely simple, and 2) highly relative. As such it is used in two ways. Within project categories, it serves to highlight specific projects which in some differ from an assumed generic norm of impact. In this way, a systematic approach to impact mitigation can be recognized. For instance, while it is assumed that dams have on balance a negative impact on ecosystems (a -1 rating) significant efforts to counter these impacts by a specific project will garner it a rating of 0. Thus we can infer an overall approach to impact mitigation for the category within the country in question. What this means is that it allows for the possibility that a country would generally devote more effort to impact mitigation and thereby 'exceed the mean' with regards to the generic rating.

When comparing across categories, this is an ordinal ranking. It shows the *relative* impact of these projects on the indicators in question. The point of comparison is the other project options, and these ratings serve to highlight best choice projects in the array. This rating is generated by comparing the previous, intra-category scores across project types.

Once this process is completed, and the various project options have been rated in the selected indicators, then the relative weight of each category must be determined and a final 'score' is computed.

The indicators used are as follows:

Economic

Internal rate of return - this is the standard measure of economic viability for any project. It is simply a measure of the value of product of the project as a fraction of the cost over some period (usually a year). While there are many ways to interpret this number, if the IRR is significantly lower than other investment options (including non-energy ones), the opportunity cost of the project will be too high to attract investment. The standard thresh-hold that project proposals use for this sector is 8%, below which they feel the investment is not attractive.

For the purposes of this ranking, the IRR with CER is considered, as these are accepted projects and will be generating CER. An IRR of 10% or greater will be given a 1, from 8% to 10% a zero, and less than 8% a -1. Because the minimum threshold for viability according to Chinese authorities is 8% anything less than that would be considered a negative investment opportunity. Over 10% would represent a positive investment opportunity (10% is the 40 year S&P500 average return).

Local Economic Development – The net change in employment or income possibilities for the local population. Each project will have positive employment impact as people are hired in the construction and then the operations phase. Additionally, some projects may have a specific focus on local economic development, for instance rural electrification. However, this is usually reported in isolation, without considering the loss of jobs implied by land-use change or relocation. Because all dam projects in China feed the electricity produced into regional grids, there is no direct impact on the economic capabilities of the local community. It is assumed that job creation in the operations phase (after construction) is relatively small for non-specialized workers and unless a program is specifically mentioned to train local people in specialized operations skills, the net impact is presumed to be small. Because all dams in China which involve relocation are required to have a compensation plan in place, it is assumed that this will offset the economic loss a community may have. Unless there is some indication to warrant a rating to the contrary (either positive or negative), all dam projects are given a score of zero (neither good nor bad) in this category

Social

Distribution of Benefits - this refers to the distribution of economic benefits of the project. A key component of sustainable development is that the benefits of a project should be distributed over a large section of society, or at least not localized in economic/political elites (Sutter and Parreño 2007). To contribute to social development, some proportion of the profits must be directed into the communities which support the project. For the purposes of this analysis, we will assume that this must represent some form of ownership/stakeholder share, not merely an outflow of operating costs in the form of employment. While employment is a benefit to the community, the larger concept of equity demands that the community have an established, non-arbitrary right to the proceeds of use of their resources. This is particularly the case when, as in the case of regional hydroelectric projects in which the benefits are generated for a widely distributed population but the negative impacts are felt only by the local community. Because of the disparity of costs with regard to geography, without some specified mechanism for distribution of benefits or local ownership these projects are assigned a -1.

Protection of local social fabric – for the reasons outlined previously, it is important to examine the degree to which a development project keeps the local social relationships intact. It should be noted that not all dams displace people or damage existing social groups. However those that do are noted and receive a negative score. A factor which is beyond the scope of this paper but which would merit further study is the placement of these projects in areas with large ethnic minority representation. There is some evidence that minority groups are disproportionately displaced by these projects (Brown, Magee, and Xu 2008). Some of these groups are quite small and face destruction in the face of displacement or disruption of traditional ways of living. For the purposes of this study, projects which involve some displacement of persons receive a -1 score, while in the absence of information they receive a 0.

Environmental

Land-use change – this has implications for GHG emissions as well as terrestrial biological systems functions. Because submerged flora decomposes in an anaerobic environment, the release is primarily methane, which has a higher GHG forcing effect than CO2. In fact, there is some evidence that in certain environments, dams produce more GHG effect than comparable size thermal (fossil fuel) generators (World Commission on Dams. 2000). Additionally, the fact of land use change implies a change of the local bio system. While this can have positive consequences for some species, it can also have negative consequences for others. The conversion of land also implies the non-availability of the land to future generations which violates the temporal cost sharing aspect of SD. Because all dams entail land-use change, they are assigned a -1 rating.

Local ecosystem protection – while all human processes impact the other species which share the region, some processes impact them more than others. Dams, because of their very nature, impact aquatic species dramatically. The impact on terrestrial species which depend on the river can also be dramatic. Because the rivers are such an important part of the local ecosystem, any change in their function will have impact on the local ecosystem. For this reason, the default value of a dam was assigned a -1, unless there were specific measures outlined to mitigate the impact on native species, flora and or fauna.

Once the ratings of each project is determined in each category, the sum of the ratings are computed to give a SD score. This number can be used within categories to compare projects. Additionally, the average scores in each category can be taken to give a generic project type score which can be used to compare across project types. This is particularly useful when comparing project types that may have quite different specific parameters which are difficult to compare directly in a quantitative way.

4.2 The Survey

To conduct the survey, a random sample of 64 large-scale hydroelectric projects which had been accepted into the CDM system was drawn. Each project design document was retrieved from the UNFCCC website and vetted for indications of the above 6 indicators (see Annex for listing of projects). This was possible because each project was by regulation required to have 1) an economic feasibility outline, 2) an environmental impact statement, and 3) a survey of local people as to perception of impacts. This meant that the three categories of analysis are present consistently across project type and can form the basis of comparison.

At this point it is necessary to comment on the nature of the data presented in these studies, particularly the social surveys. This paper relies entirely on secondary data, and as such is dependent on the accuracy of the survey data collected in China by government authorities. It is immediately obvious that this presents significant problems. For example, in no case did less than 90% of respondents support the construction of the dam in their local area, even in cases when there would be significant dislocation of people and communities. This is highly suspect and divergent from the results of surveys conducted by independent actors for the 3 Gorges project (Heming, Waley, and Rees 2001). Similarly, there were exactly 0% of environmental impact studies that showed any potential damage to local ecosystems sufficient to call into question the practicality of the project. One report did comment that because of up and down-stream dams, there were no local aquatic species to be impacted! This would seem to suggest that dams do indeed have some effect on species. For this reason, in the absence of specific information to the contrary, dams in this paper are given a 'dam average' rating, which is an indication of their generic impact in a particular area, and it is only with specific information in the project outline that a score will diverge from this.

4.2 Hydro Project Data

A summary of the data follows:

Table 3 Project scope data:

CER/yr (k)			MW			Static invest		
mean	(max)	(min)	mean	(max)	(min)	mean	(max)	(min)
172.736	603.4	50.2	52.0	200.0	15.0	388.5	1823.0	73.2

CER/ yr — the number of Carbon Emission Reduction Credits (in thousands) that a project is expected to produce

MW — Megawatts of electricity generation capacity of the project

Static Invest — the cost of the project, in Million Yuan (1 USD = c. 6.678 yuan)

This table gives a sense of the scope of the projects under discussion. It is immediately obvious that there is a wide range of project sizes under consideration. While these are not used to describe the degree of SD for each project, it gives a sense of the breadth of projects and implies the variety of situations which this category of projects encompasses.

SUSTAINABILITY INDICATORS

Table 4 Economic Indicators

RR w/ CER*	ocal Empower
.4909	.015873

IRR — Internal rate of return, calculated as investment over life of project divided by expected annual net profit, given as both the expected return without income from CERs and with. The standard valuation of CER is $10 / ton

Local Empowerment — The amount of local economic empowerment the project specifically undertakes. Only one hydroelectric project examined specified measures to empower the local community.

The IRR is considered important as a benchmark of economic viability. If projects are shown to be above a certain threshold of return without CERs, then they are not qualified because it is assumed that the project will take place without them. If they are not above a certain threshold with the CERs, the project will not be qualified because it is assumed that it is not viable in any case. Nearly all projects where found to have a non-CER IRR of below 8%, and these projects listed the government determined threshold as 8% according to the Chinese government rules in *Interim Rules on Economic Assessment of Electrical Engineering Retrofit Projects.*

However, for the projects which had a non-CER IRR of greater than 8% (of which there were 7), the *Economic Evaluation Code for Small Hydropower Projects issued* by the Ministry of Water Resources was used which suggested a baseline of 10%. Therefore, according to their project design documents, all the projects were unviable without CERs.

The return with CERs is used to show the importance of the credits in the economic viability of the project. In only one case did the IRR with CERs fail to push the project over the critical investment threshold, the projected return was computed to be 7.7% (*Wengyuan 20MW Hydro Power Project in Guizhou Province China*, #2178). However, in this project the investors indicated that they were prepared to invest in any event, providing the CERs were forthcoming. The question this begs of course is to what degree then are investors willing to invest in projects of less than the 8% (or 10%) threshold, given that 13 of the projects have a projected IRR without CERs of greater than the 7.7%.

It should also be noted that 9 projects did not provide IRR data on either or both the CER or non-CER cases, instead they merely indicated that the CERs were necessary to the feasibility of the project. Ordinarily, this should be automatic grounds for rejection; it is not immediately clear how these projects were allowed to be accepted into the CDM program.

The second column shows the *local empowerment* rating. This gives an indication of the planned distribution of economic benefits of the projects. When determining this coefficient, the assumption was made that in the absence of specific measures, no project had a specific positive impact on local economic development. This was due to the fact that in every case, the power generated was designed to be fed directly into the national grid, and from there be provided at market prices, to local as well as non-local consumers. This would mean that the local community would not derive any additional benefit from the presence of the dam in the form of lower cost energy, except inasmuch as the entire regional market does.

In only one project, the *Shangri-La Langdu River 2nd Level Hydropower Station,* did the project managers specify benefits to the local community in the form of university scholarships and community services? Surprisingly, this was also the only project which offered the community free electricity. This project was given a rating of '1', which brought the project category rating to .016, or barely positive.

What this demonstrates is that these projects demonstrate little if any attempt to serve the local community, which is suffering the impacts of the dam, as a mechanism for local economic empowerment. Without provisions of lower cost energy, or education to take higher skill job positions, there is little scope for local economic empowerment.

However, hydro-electric projects do score well as an economic instrument, with nearly half the proposed dams projecting an IRR of greater than 10%.

Table 5 Social Indicators

Distribution	Social Fabric
mean	mean
-1	-.246

Distribution — The distribution of profit or production to the local community. -1 indicates that local communities do not receive any direct profit or benefit in the design of the project.

Social Fabric — The degree of social fabric strengthening or weakening

Because none of the projects provided any attempt at local ownership or profit sharing, none of the projects scored higher than a -1. In every project examined, the partners involved where a sponsoring government or corporation in the industrial world, and a Chinese government sponsored private development company. The exact ownership structure of these entities is not clear from the Project Design documents, but there was no indication in any of them that local rural peoples were involved in any aspect of ownership.

Because only 18 projects explicitly involved displacement of people, the total value for the protection of social fabric variable was -.321. While each project that will cause displacement is required to have a compensation and resettlement plan, it was unclear that these plans went beyond the form of cash payment or arbitrarily assigned land grants. The stakeholder surveys without exception demonstrated that the majority (never less than 90%) of respondents were 'satisfied' or 'very satisfied' with the resettlement/compensation package. However, in other projects, when independent surveys were taken, the results were not so sanguine (Heming, Waley, and Rees 2001).

Table 6 Environmental Indicators

Fragmentation	Land Use
mean	mean
-1	-1

Fragmentation — The degree of unmitigated ecosystem disruption.

Land Use — The degree of land use change

Every project must include an environmental impact assessment, and must address any potential problems revealed by this document. However, there is no clear guidance on the scope of the environmental impact assessment. What this means in practical terms is that only the immediate area of the project is considered, not the impact down-stream. Nor in any of the impact statements was the impact of change in water-flow investigated. In every case, investigators determined only the presence and potential impact on endangered species. In all cases, it was determined that there were no meaningful environmental impediments to dam construction. This includes the 2 projects which are located in Nature Preserves areas which normal prohibit construction, and one that would result in "serious impact on fish and soil erosion".

The approach to environmental degradation taken by the regulators is demonstrated by two reports in particular. In the assessment for *Guangxi Xiafu Hydropower Project* (#1604) it states "after the reservoir is completed, the natural ecological balance of the river will be destroyed, but the new biotic community will reach a new kind of balance". In project *Tao River Lianlu Cascade II* (#2932) "Since hydropower stations have already been established in both upstream and downstream of this river, aquatic organism is so rare that this station has insignificant ecological impact on aquatic organisms". There is nothing about these projects that make them unusually vulnerable to environmental damage. It is therefore difficult to reconcile the two approaches to ecosystem damage that the evaluators take. On one hand they suggest that there is categorically no meaningful danger to ecosystems. On the other, they suggest that dams are actually massively destructive to ecosystems, but that it doesn't matter. Particularly the second quote should give cause for question, since it seems that the impact of extant dams is the complete eradication of aquatic species. For this reason, the baseline rating of dam projects is set to -1. If extraordinary measures are taken to ensure the continuity of the ecosystem, a rating of 0 is given. Additionally, if there is some reason to believe that the project has a positive impact, such as erosion prevention or flood management, it would theoretically be possible to achieve a rating of 1. However, in this sample no projects addressed ecosystem damage in a comprehensive way and all dams scored a -1.

Land use change is a facet of hydroelectric projects. This has several environmental implications, both for GHG emissions or loss of sequestration capability, environmental functioning, and the ability of future generations to make choices as to the use of the impacted area. Dams as a category get a -1 rating.

4.3 Aggregate Results

For the final step the result is summed. Because of the nature of the SD ethic, each category will be given the same weight (1). The results are

Table 7 Results

Economic		Social		Environment		
IRR	Empow.	Distribution	Social Fabric	Fragmentation	Land Use	Sustain. Sum
0.491	0.016	-1.000	-0.246	-1.000	-1.000	-2.739

In the final result, the hydroelectric projects garner a -2.814 sustainability score. In fact the only categories they score positively in are the economic ones, and then only weakly as an aggregate. This is an indication of the poor performance of these projects if using a more comprehensive sustainable development definition. A couple caveats must be noted. There is a certain arbitrary nature to the selection of indicators. While efforts have been made to justify them, there are arguments for the inclusion of others or the exclusion of these. As was noted in the explanation of the MCA, the technique does not transcend arbitrary, qualitative decisions, but makes them more transparent. Secondly, these ratings are derived from the specific implementation plans presented to the UNFCCC, and therefore do not represent the best case scenarios that hydroelectric projects can achieve. It is may be possible to have much more robust damage mitigation processes in place which could raise the scores significantly.

However, in a vacuum, this score means nothing, this is itself a 'fuzzy logic' space. Certainly the projects are shown to be net negative from a SD perspective, but because humans are action biases, in other words they will typically chose to act over not acting, it is perhaps more useful to compare these scores with other possible destinations for CDM funds.

4.3 Comparison Cases

For purposes of comparison, two alternative green energy project categories were chosen, bio-mass and on-shore wind. In both cases, approved projects of similar energy production scale in China were selected. However, because both of these groups are composed of a much smaller number of projects, only 5 were randomly selected for each, which also composes approximately 10% of the total projects accepted in China of this scale. They were subjected to the same analysis that the hydroelectric projects were with the following assumptions:

4.3.1 Bio-mass

These projects involve the collection and anaerobic decomposition of organic materials, usually some waste product, for the release of gases, primarily methane, to generate electricity (Hall 1991). The generation method is therefore similar to other thermal processes, but because it uses recently dead biomass, it does not increase the net level of CO2 in the atmosphere in a reasonable time unit. In other words, only the amount of CO2 taken up by the plant or animal during its life is release when the gas is burned.

In these case, although the return without CERs was significantly lower than hydro (on average 4.4% vs 6.9% for hydro), because of the large offset capacity of these projects, they realize very similar IRR scores as the hydro plants when CERs are applied. In fact, this is one of the key findings of this paper. There are projects which are more sensitive to the additional income that CERs represent, and therefore not only represent better investment from a SD perspective, but also are far less likely to come to fruition without CDM funding.

Because of the nature of the bio-mass process, there is a central role for rural agricultural workers (ibid). The projects in this study all were designed to process agricultural waste. This had two impacts for the local community. Firstly, they would be able to gain income through selling agricultural waste. This represents a significant community empowerment dimension, in that an additional revenue stream was actualized without the diversion of existing production or processes. Secondly, the by-product of the digestion process is a high-grade fertilizer (Ahlgren et al. 2010). In all the cases examined, this product was to be available for the local agriculturalists for free or at reduced charge. This represents direct access to the proceeds of the CDM project and scores a 1 for profit distribution. The projects have no impact on the social fabric of the local community as they do not displace production processes or significant amounts of land.

These projects have no significant impact on ecosystem function. In one project, *Henan Luyi Biomass (#0825),* it was stated that the project would have noticeable positive impact on the local ecosystem because of the large amount of agricultural waste that was traditionally left out to rot in the 'business as usual' scenario. The amount of rotting vegetation piled in fields created unhealthy and pestilent conditions. This project was scored a 1 while the others received a zero in both categories.

Table 8 Biomass SD Score

Economic		Social		Environment		
IRR	Empow.	Distribution	Social Fabric	Fragmentation	Land Use	Sustain. Sum
0.400	1.000	1.000	0.000	0.000	0.200	2.600

The final SD score is a 2.6. This would indicate that, according to these criteria, the bio-mass projects are as positive as the hydro-electric ones are negative. This is despite the fact that they are not as good an economic investment as a whole, in fact without CER the highest return projected was a substandard 6.7%. In the non-economic categories, they are only slightly above neutral with a combined score of 1.2 out of 4 possible points. It should again however be remembered that this score is really only understandable in the comparison context with other project alternatives, such as hydro-electric.

4.3.2 On-shore Wind

The projects considered herein are large scale wind-farms which are designed to generate power for a regional grid rather than local use.

Once again, with the use of CERs they have a return similar to hydro projects, and in fact have a return without CERs quite comparable (average 6.34%). Similar to the dam projects, none of these projects addressed the local communities specifically. All the power generated was to be fed to the regional grid and the proceeds were to be collected by the managing firm. However, because of their small footprint, there were not significant negative consequences to be borne by the local community either, which meant a rating of 0 for both the distributive and social cohesion variables (Munksgaard 1998). This small footprint also means that there is negligible impact on the local ecosystem, even the incidents of bird-strikes has been shown to be potentially problematic but not of much more than for other human construction (Anon. 2002) . Similarly, the turbines can be sited in agricultural land if necessary, although all these were located in arid, non-agricultural land. This meant that none of them necessitated a land-use change.

The final tally is a sustainable development score of .4. This is surprising considering the very low impact that wind-power has on the environment. But it is a function of the lack of commitment to use these projects as local development tools. This results in a Social score of 0 as well. Just as with hydro, it is not necessarily the projects but rather the specific implementation of them that results in lower than optimal scores.

Table 9 Wind SD Score

A summary of the scores is as follows

Economic		Social		Environment		
IRR	Empow.	Distribution	Social Fabric	Fragmentation	Land Use	Sustain. Sum
0.400	0.000	0.000	0.000	0.000	0.000	0.400

4.4 Synthesis

Putting these results side by side give us the following

Table 10 Combined Scores

	Economic		Social		Environment		
	IRR	Empow.	Distribution	Social Fabric	Fragmentation	Land Use	Sustain. Sum
Hydro	0.491	0.016	-1.000	-0.246	-1.000	-1.000	-2.739
Bio-mass	0.400	1.000	1.000	0.000	0.000	0.200	2.600
Wind	0.400	0.000	0.000	0.000	0.000	0.000	0.400

This table demonstrates immediately that it is possible to argue that hydro-electric power is not the best vehicle for CDM from the SD perspective. It also demonstrates clearly what the single most important criteria for project planners is, the IRR, given the massive prevalence of dam projects in the Chinese CDM portfolio. It also allows observers to infer the weighting coefficient used by authorities. Given the relatively negative social and environmental consequences of hydro projects, it is clear that these categories are given a vanishingly small weight in the final analysis.

According to the criteria used in this paper to evaluate SD, it is clear that hydro-electric dams represent a poor choice, at least in comparison to two alternative systems. While the bias for dams is primarily driven, it is possible to infer, from the relatively higher economic returns, the poor performance in both social and environmental areas make these projects suspect investments to achieve true sustainability.

The results of the MCA do not give a number which can be quantified as something like 'sustainable efficiency quotient' or 'SD units'. Instead it gives an idea of the relative ranking of the various alternatives with respect to one another. It is not possible to assert that biomass generation is '200% more sustainable' than hydro-electric. But it is possible to assert that, based on these criteria, biomass is positively sustainable, wind power is neutrally sustainable, and dams are not sustainable.

Given the preponderance of dam projects in the CDM portfolio, this is an important consideration. For a program which is specifically supposed to target sustainable development, it is difficult to argue that this goal is being met with these funding priorities.

5. Conclusions

In many occasions, the term 'sustainable development' is used in a 'flavour of the month' way, as a term which is used without real regard to its meaning in a practical way. But if the UN is serious about its Agenda 21 commitments, SD must move from rhetoric to measurable. The efforts of the UNDSD to develop standardized indicators are laudable, but without commitment to include them in project planning in a serious way, they remain just window dressing for business as usual.

The goal of this paper was to demonstrate one potential methodology which could be used to maximize the efficiency, in SD terms, of investment funds flowing to the developing world through the CDM mechanism. Given that the CDM exists because of the belief in the value of market efficiency and flexibility given a set of constraints, it is appropriate to use that logic while challenging the constraints which do not align or are missing to determine is the stated goals are being met.

To achieve this, first the goals and parameters of these goals were determined. By examining the premise of SD and its role in the CDM this paper determined that some specific criteria could be used to measure project performance which are not limited to traditional CBA. Once these parameters are identified, a methodology for assessment was proposed, in this case MCA. This method has been shown to be appropriate for analysis of these types of problems in that it can handle diverse inputs of incommensurate valuations from multiple stakeholders.

The paper then moved on to apply this framework to a specific set of projects which constitute an important segment of the CDM, large-scale hydro-electric plants in China. These projects were rated using the method and criteria developed and it was revealed that under this framework these projects scored poorly in the SD dimension. To properly contextualize these findings, a brief sample of alternative projects was also rated, and it was confirmed that hydro projects represented a poor choice for investment from a sustainable development perspective. It is clear that if the UN is serious about its stated goal of promoting SD through programs such as CDM, more must be done to analyse and evaluate projects both individually and catagorically in multiple dimensions and with multiple inputs.

Appendix CDM Projects Evaluated

Hydro-Electric Projects

				Economic			Social		Environment		
				IRR							
project #	Name	CER/yr (k)	MW	no CER	CER	Local Empoerment	Distr	Social Fabric	Fragmentation	Land Use	Notes
0574	Erlongshan Hydropower Project in Gansu Province	134.811	50.5			0	-1	0	-1	-1	N
0841	Yunnan Whitewaters Hydropower Development Project	274.56	78			0	-1	-1	-1	-1	D
0989	Lianghekou 15MW Small Hydropower Project, Gansu Province +	75.827	15	7.06	11.39	0	-1	0	-1	-1	
1264	Sandaowan Hydropower Project in Gansu Province, P.R. China	313.273	112	6.39		0	-1	0	-1	-1	
1275	Hua'an Xipi Hydropower Project +	139.873	44	6.2	8.7	0	-1	0	-1	-1	
1467	Qinghai Jinshaxia 70 MW Hydropower project	208.345	70	6.89	8.58	0	-1	0	-1	-1	
1478	Fujian Beijin Hydropower Project	144.467	50	6.41	8.95	0	-1	0	-1	-1	
1484	Shaba 30MW Hydro Power Project in Guizhou Province China	85.624	30	7.28	11.07	0	-1	0	-1	-1	
1517	Guizhou Shuicheng Jinshizi Hydropower Station	59.554	20	6.64	10.23	0	-1	0	-1	-1	

1585	Fujian Shouning Liuchai 20MW Hydropower Project	61.534	20	8.4	12.19	0	-1	0	-1	-1	
1590	China Tongwan Hydropower Project	593.389	180	6.32		0	-1	-1	-1	-1	D
1596	Guangxi Bajiangkou Hydropower Project	247.049	90	6.76	9.37	0	-1	0	-1	-1	S
1604	Guangxi Xiafu Hydropower Project	126.581	49.5	6.64	8.97	0	-1	0	-1	-1	1
1633	28 MW Jinkouba Hydropower Project	124.066	28	7.1	9.8	0	-1	0	-1	-1	
1864	Hunan Jinjiagou Small Hydropower Project +	63.358	15	7.89	11.55	0	-1	0	-1	-1	
1872	Hunan Chenxi Dafutan Hydropower Station	567.089	200	6.84	9.07	0	-1	0	-1	-1	D
1966	Sichuan Miyaluo Hydroelectric Station +	64.357	15	7.9	11.53	0	-1	0	-1	-1	
1980	Guangdong Shaoguan Yizhou Hydro Power Station	53.376	20	7.55	10.19	0	-1	0	-1	-1	
2016	Yunnan Yingjiang Xiangbai River Zhina Hydropower Station	74.665	21	8.58		0	-1	0	-1	-1	
2017	Hubei Lichuan Longqiao Hydropower Station	158.687	60	7.12	8.46	0	-1	0	-1	-1	
2039	Jiangxi Taojiang Hydropower Project	65.365	25	8.71	11.42	0	-1	0	-1	-1	

2052	Yunnan Yingjiang Wakuhe Hydropower Station	123.27	36	7.8	8.9	0		-1	0		-1	-1	
2054	Shangri-La Langdu River 2nd Level Hydropower Station	69.049	22.5	6.51	12.83	1		-1	1		-1	-1	O
2065	Guizhou Xingyi Laojiangdi Hydropower Station	307.682	100	6.51	8.32	0		-1	-1		-1	-1	D
2070	Zhuxikou Hydropower Project	253.51	74	6.79	9.71	0		-1	-1		-1	-1	D
2106	Yunnan Lianghe Hulukou Hydropower Station	74.589	20			0		-1	0		-1	-1	
2108	Gansu Datonghe Tiecheng Hydropower Station Project	184.047	51.5	6.38	9.31	0		-1	0		-1	-1	
2131	25MW Liangwan Hydropower Development Project	65.981	25	7.8	10.69	0		-1	0		-1	-1	
2133	Nansha Hydro Power Project inYunnan Province	547.718	150	6.69	10.61	0		-1	-1		-1	-1	D
2142	Longyou 18 MW Hydropower Project in Zhejiang Province	52.222	18	6.98		0		-1	-1		-1	-1	D
2151	Yunnan Leidatan 108MW Hydropower Project	364.736	108	6.83	11.25	0		-1	-1		-1	-1	D
2156	Fujian Shouning Xiadongxi 25MW Hydropower Project	65.356	25	6.25	9.94	0		-1	0		-1	-1	

2178	Wengyuan 20MW Hydro Power Project in Guizhou Province China	50.205	20	5,15	7.7	0		-1	0		-1	-1	2
2192	Tianquan Xiacun Hydro Power Project	92.471	24	4.17	8.84	0		-1	0		-1	-1	
2575	Sichuan Yetang 24MW Hydro Power Project	102.023	24	6.33	10.43	0		-1	0		-1	-1	
2590	Sichuan Xiaolongmen Hydropower Project	182.278	52	6.48	8.64	0		-1	-1		-1	-1	D
2690	Shangri-La Xinglonghe Cascade Hydropower Project	81.953	24	7.2	12.2	0		-1	0		-1	-1	
2702	China Sichuan Province Liuping Hydropower Project	526.707	120	6.48	9.07	0		-1	0		-1	-1	
2737	Sichuan Shimian County Ximagu Hydropower Project	60.416	18	8.21	11.65	0		-1	0		-1	-1	
2837	Weiyuan River 72MW Hydropower Project	207.232	72	7.22	10.75	0		-1	-1		-1	-1	D
2842	Hunan Xiaotan Hydropower Project	74.861	20			0		-1	0		-1	-1	
2844	Gansu Yongchang County Donghewan Cascaded Hydropower Project +	109.438	29.7	6.89	11.13	0		-1	0		-1	-1	
2852	Yunnan Saizhu Hydropower Project	332.571	102	7.1	10.75	0		-1	0		-1	-1	

2932	Tao River Lianlu Cascade II (Xiacheng)	121.42	37.5	6.03	9.41	0	-1	0	-1	-1	3
2955	Guizhou Tongzihe Yuanmanguan Hydropower Proiect +	116.466	40	5.62	8.34	0	-1	0	-1	-1	
2990	Sichuan Xiaohe 48MW Hydropower Project	205.013	48	4.59		0	-1	-1	-1	-1	D
2991	Sichuan Baixi 24MW Hydropower Proiect	101.725	24	6.86	10.71	0	-1	-1	-1	-1	D
3011	Hunan Lengshuijiang Langshitan 36MW Hydropower Proiect	123.86	36	6.61	9.88	0	-1	0	-1	-1	
3030	China Sichuan Province Se'ergu Hydropower Project	603.382	150	6.28	8.62	0	-1	-1	-1	-1	D
3045	65MW Dagushan hydropower Project in China	171.154	65	5.28	8.27	0	-1	0	-1	-1	N
3101	Yunnan Lujichang Hydropower Project	311.117	96	6.03	10.31	0	-1	-1	-1	-1	D
3199	Shilong 70MW Hydropower Project in Jilin Province	130.88	70	6.52	8.13	0	-1	-1	-1	-1	D
3299	LinCang Yun County, XinTangFang Hydropower Station Project	69.155	18	7.5	10.7	0	-1	0	-1	-1	
3385	Heqing County Liuhe 30MW Hydropower Plant	110.642	30			0	-1	-1	-1	-1	D

3402	Guangxi Yizhou Sancha 21MW Hydropower Project	61.367	21	7.72	11.93	0	-1	0	-1	-1	
3529	Sichuan Miyi Chengnan 15MW Hydropower Project	68.832	15	8.42	13.6	0	-1	0	-1	-1	
3590	Zhenkang Quanqiaohe Hydropower Project in Yunnan Province	53.756	16	8.22	12.95	0	-1	0	-1	-1	
2815	Yunnan Yingjiang Binglangjiang Shizishan Hydropower Station Project	102.079	24	8.58	11.82	0	-1	0	-1	-1	
2188	Hubei Yuquan River 25.2MW Hydropower Project	95.437	25.2	6.19	8.99	0	-1	0	-1	-1	
2596	Fujian Pingnan Jinzaoqiao Hydropower Project	137.34	66	6.59	8.41	0	-1	-1	-1	-1	D
2769	China Qinghai 42MW Jiangyuan hydropower project	153.65	42	6.87	9.54	0	-1	0	-1	-1	
1849	Jinji 25.2 MW Hydropower Project in Guangxi Autonomous Region	58.288	25.2	7.1	10.01	0	-1	0	-1	-1	
2789	China Chalinhe Hydropower Project	233.635	54	6.8	9.2	0	-1	-1	-1	-1	D
2868	Sichuan Lushan Dachuan River Cascade Hydropower Bundle Project	444.876	106.4	6.5	11.2	0	-1	0	-1	-1	

2945	Sichuan Baoxing Dongfeng Hydropower Project	189.599	42	6.79	12.15	0	-1	0	-1	-1
	Averages	172.73597	52	6.888	10.152	0.015	-1.000	-0.246	-1.000	-1.000

1 = "after the reservoir is completed, the natural ecological balance of the river will be destroyed, but the new biotic community will reach a new kind of balance"

2 = proposed IRR w/ CER still below 8% but investor willing

3 = "Since hydropower stations have already been established in both upstream and downstream of this river, aquatic organism is so rare that this station has insignificant

D = Displacement of persons

N = In Nature Preserve

S = Serious Soil Erosion

Biomass Projects

				Economic			Social		Environment	
				IRR						
project #	Name	CER/yr (k)	MW	no CER	CER	Empoerment	Distro	Fabric	ion	Land Use
811	Shandong Yuchien	189.55	15	3.5	12.6	1	1	0	0	0
825	Henan Luyi Biomass	185.664	25	5.15	9.5	1	1	0	0	1
819	Zongjieneng Suqian	123.055	12	2.05	8.71	1	1	0	0	0
1293	Heilongjiang Tangyuan	183.69	24	4.99	10.45	1	1	0	0	0
1263	Shandong wudi Biomass	113.433	24	6.36	9.88	1	1	0	0	0
		159.0784	20	4.410	10.228	1.000	1.000	0.000	0.000	0.200

Wind Farm Projects

				Economic			Social		Environment	
				IRR						
project #	Name	CER/yr (k)	MW	no CER	CER	Empoerment	Distro	Fabric	ion	Land Use
	Ningxia Tianjian	57.439	30.9	6.8	8.67	0	0	0	0	0
3079	Hebei Chengde Peifeng	121.89	49.5	6.1	8.7	0	0	0	0	0
3251	Inner Mongolia Zhuozi III	130.372	48	6.22	10.1	0	0	0	0	0
3374	Helanshan Phase V	80.96	40.5	6.57	10.62	0	0	0	0	0
3160	Hebei Leting	107.031	49.5	6.03	8.74	0	0	0	0	
		99.5384	43.68	6.344	9.366	0.000	0.000	0.000	0.000	0.000

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