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Risk Management for Energy Efficiency Projects in Developing Countries

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[1] Paper prepared for the UNIDO Project *"If industrial energy efficiency pays, why is it not happening?"*

Risk Management for Energy Efficiency Projects in Developing Countries

Abstract/Summary

The present paper addresses risk management fundamentals for energy efficiency (EE) projects in developing countries. The starting point for this paper is that there are many profitable EE projects in nearly every industrial enterprise that are simply not implemented. Four problems are often identified as the culprits for failing to harvest such projects: 1) lack of a rational and feasible approach to finance these projects; 2) lack of a rational internal management approach in the enterprise to package these projects in such a manner that they can be identified and implemented while the "plant is running"; 3) the high perceived risk of these projects; and 4) the fact that management is often simply unaware of the existence of EE projects of value. This paper is primarily focused on the third of these failure factors, risk, but touches also on the fourth factor since reducing project risk is predicated on understanding and measurement of EE benefits. The paper begins with a simple framework that emphasizes two dimensions of the organizational and contractual environment of EE projects. The first dimension is the energy intensity (measured, say, in terms of the ratio of energy costs to the total cost of goods sold) for the focal company initiating an EE project--the higher the energy intensity, the larger the potential payoff from EE, and the greater the ease of focusing management attention on EE. The second dimension is the level of organizational and contractual complexity of a project. Generally, the larger the number of external parties involved in a project (both financial and technical), the greater the complexity of assuring the ability to satisfy constraints necessary for successful project completion and the greater the transactions costs of contracting. After elaborating this framework and providing examples to illustrate required risk management, the paper discusses best practices for EE project risk management with illustrative case studies. Thereafter behavioral and other impediments to effective risk management are described, together with methods for overcoming these impediments. The paper then considers the role of carbon offsets as a possible source of co-financing of EE projects, and the risks associated with obtaining such carbon offsets under the CDM process. Finally, the paper considers the role of Energy Service Companies (ESCOs) in identifying profitable EE projects, in managing these projects and in reducing their risks. The paper concludes with recommendations for both companies executing EE projects as well as for international organizations like UNIDO attempting to promote EE in industry in emerging economies.

1. Introduction

This report considers the role of risk management in promoting profitable energy efficiency (EE) projects in industrial enterprises in developing countries. The paper focuses on developing countries in the middle range of development (e.g., with per capita income greater than $2,000 per annum) where there is a significant industrial sector, although many of the issues here would apply to other countries, both above and below this level of development.[4] The key question posed here is how to improve the payoff in economic and environmental terms from cost-effective energy efficiency projects and initiatives.

The starting point for this report is the maxim, by now well known in the development literature and is the banner for this entire report, that there are many profitable EE projects in nearly every industrial enterprise that are simply not implemented. Four problems are often identified as the culprits for failing to harvest such projects: 1) lack of a rational and feasible approach to finance these projects; 2) lack of a rational internal management approach in the enterprise to package these projects in such a manner that they can be identified and implemented while the "plant is running"; 3) the high perceived risk of these projects; and 4) the fact that management is often simply unaware of the existence of EE projects of value.[5] This paper is primarily focused on the third of these failure factors, risk, but it will be evident in my discussion of effective risk management approaches that the other three factors noted have an important role to play in understanding and managing the risks of such projects. Indeed, without a proper understanding of available financing options and without a viable strategic plan within the enterprise for identifying and implementing EE projects, discussions of risk management for projects would lack the requisite foundation for attracting management attention in the first place and for ultimate success in implementation.

In order to understand risk management for industrial EE projects, it is important to have in mind the typical context of these projects in developing countries. A number of factors affect the risk

[4] Many studies have been undertaken in the past few years on EE in developed countries. For a review of some of the best practices research arising from this, see Itron (2008). These best practices apply broadly across sectors and countries and are the basis for this study as well. In particular, the principles outlined in this paper are applicable beyond the manufacturing sector from which most of my examples and discussion are drawn. For instance, the same philosophy could allow for breakthroughs in EE in energy dependent service sectors such as tourism, building services, after sales technical support centers and information services.

[5] Such basic things as changing incandescent lights that operate 24 hours a day in a hotel or warehouse to high efficiency lighting are often not done despite the payback being accomplished in a matter of weeks. A major role of UNDP in EE has been to field energy auditors (particularly for government facilities where waste is exceptionally high) to identify areas where EE measures are indeed profitable. However, as noted below, there are many reasons why, in the end, even projects that are of recognized value are not implemented.

of such projects for industry decision makers in developing countries. The principal factors impeding implementation of EE projects are the following.[6]

Key Problems in implementing Energy Efficiency Projects in Developing Countries

- Lack of information
- Uncertainty in Energy Prices
- Uncertainty in exchange rates
- Regulatory and contract risks
- Enforcing contracts
- Access to capital
- Credit and budget constraints, which also imply short-term payback requirements
- Reliability and availability of energy

- Lack of information on technical issues and on available technical support, including uncertainties about the performance and reliability of energy saving technologies
- Uncertainty in energy prices and subsidized energy prices that undermine incentives for EE projects
- Exchange rate risks related to the project, especially for equipment sold in international markets, but also affecting the price of carbon credits and the benefits of increased productivity (and output) for manufactured goods
- Regulatory, governance and contract uncertainties with equipment suppliers, contractors and third parties who may be necessary to implement projects
- Related to these contract uncertainties in developing countries are the transactions costs of enforcing contracts, including promises from governments, service providers and energy companies
- Limited access to capital/credit, which often pushes a very short-term payback approach to EE project evaluation
- The mismatch of investment costs and energy savings costs, budget and credit constraints and the opportunity costs of exhausting one's credit limits on energy efficiency rather than on increasing sales
- Availability of energy is a critical issue: even when manufacturing firms are willing to assume a high unit cost per kWh, energy supply is often not only insufficient but unreliable, giving rise in many companies (e.g., smelting and energy dependent continuous chemical processes) to costly backup and self-generation.

Perhaps the biggest problem with EE projects is the fact that these projects are often not seen as being directly aligned with the most important problems a business faces in a developing country on a day-to-day basis. Growing the business by obtaining new customers or new contracts is often seen as far more important than internal efficiency, even for energy intensive sectors. When coupled with the transactions costs and sheer uncertainty of the results from changing industrial processes, or even lighting and building energy, company management will normally turn their attention to the "main game" which is satisfying their current customers and growing sales, while staying within tight budget constraints. Overcoming this natural tendency of managers to focus on sales in the here and now rather than jointly harvesting the longer term and continuing benefits of EE is a central challenge of implementing EE in developing countries.

[6] For a brief background on these factors, and case studies illustrating the importance of these issues, see Taylor et al. (2008) and GEF (2009).

For reasons that will be clear to anyone with experience in developing countries, the problems noted above are more acute there than in industries in the developed world. Nonetheless, this particular problem is manifest in all but the most energy efficient industries in the developed world as well (as I will point out using a case study on a European company's EE initiative). Clearly, there is still much to be learned and shared across all industries on this point. I believe a future orientation, based on solid risk management principles, can be an important element in solving the puzzle of why so many profitable EE projects remain on the shelf. Any workable approach to this matter must provide convincing answers to the following questions in order for the management of an industrial enterprise to consider, let alone pursue with vigor, a program to improve EE:

1. Perceived importance: Why is EE a potential source of profits for this company? A good proxy for companies that should be interested in EE would be energy costs as a percentage of total cost of goods sold.

2. Clarity and concreteness: What are the most important EE projects that could be undertaken in this company and what results can be expected from these projects if they are properly implemented? A common problem is the verification of savings, particularly for relatively small but fast payback actions such as illumination upgrading. The savings in such projects can easily get lost in the "noise" of the normal variability of the energy bills and management cannot easily verify that the savings promised are in fact being delivered.

3. Feasibility: What means are there for financing and implementing these projects without jeopardizing revenue generation and without disrupting on-going operations? Does the firm have the skills or can the firm access the skills to implement EE projects at an acceptable cost?

4. Customer perception: Do customers give the firm a "premium" or "discount" for having EE objectives and accomplishments? Increasing customer awareness and customer integration of EE of suppliers in their buying criteria can be an important factor in promoting EE solutions. This is particularly true for manufacturing products with a large buyer such as government or a major international company that could help to promote EE standards.

5. Technological reliability: Closely linked to feasibility, yet distinct, is the issue of technological reliability. In a high risk environment within the difficult operating context of most developing countries, firms are less likely to adopt technologies that

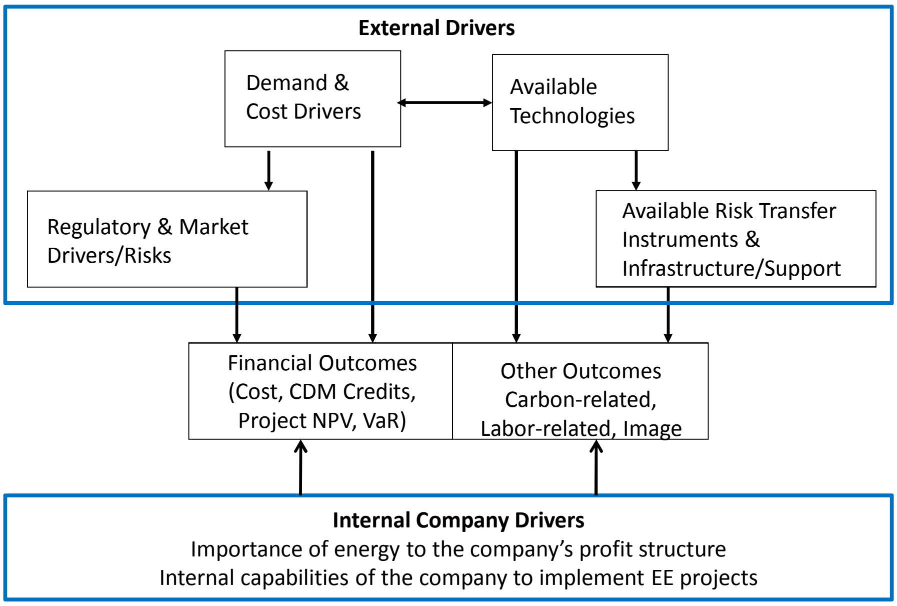
Necessary Preconditions for EE projects to be identified and implemented.

- Perceived importance of EE for profits
- Clarity and Concreteness
- Feasibility of EE without undue disruptions or risks
- Customer acceptance
- Technological reliability and availability of convincing prototypes

are not perceived to be tested and stable, especially in an environment where the suppliers of such technologies may be thousands of miles away.

Many of these concerns can be addressed and mitigated by better information, validated prototype projects and by better approaches to project risk management. The standard approach to energy project valuation is sketched in the Figure 1. This approach encompasses demand estimates, regulatory and market scenarios, as well as trends in components contributing to capital costs, operating costs, and carbon offset revenues (if applicable). The objective is to understand and value the financial returns and eco-efficiency of a given project, or set of projects, and to provide a multi-year comparison of project returns and risks relative to a well-defined benchmark case (typically the status quo). We will explore in this report how risk management can be integrated with this general approach and the special problems that arise in doing so for industrial EE projects in developing countries.

Figure 1: Valuation & Risk Drivers for Energy Efficiency (EE) Projects



It is worth noting that Figure 1 (and this report) takes the specific viewpoint of a focal company in planning and executing EE initiatives. It should be clear, however, that EE projects typically involve external suppliers of technology and capital, and a central aspect of risk management for most EE projects is structuring contracts and project execution so as to satisfy the focal firm while also assuring to these essential partners a reasonable level of profits. Failure to do so will just as surely be fatal for a project as failing to assure reasonable answers to the above questions for the focal firm. Larger firms or MNCs and international organizations like UNIDO can be instrumental in speeding EE in developing countries as sophisticated buyers, suppliers and information suppliers that can work with local SMEs to speed adoption of EE through transfer of technical skills, prescription of new technology and financing options. This is often done by identifying "clusters" of industrial activity (such as lighting in office buildings, waste heat capture in mining, etc.) in a particular sector, such that a number of similar projects can be implemented using the same approach and technology, and often packaged by an Energy Service Company (ESCO) that both implements the project as well as providing access to the necessary capital or credit to finance EE projects.

To understand these matters more concretely, let us begin with a simple framework for classifying EE projects, followed with some examples to illustrate the barriers and key success factors affecting the profitability of such projects.

2. A simple framework and some examples

There are essentially two sets of underlying factors affecting the success of EE projects: 1) factors related to the focal company and the organizational complexity of the project (the capabilities and internal transactions cost side of the project); and 2) the external institutional context within the market and country in question. Figure 2 illustrates the range of projects and risk drivers associated with these two factors.

Figure 2: Internal & External Factors Affecting EE Project Risk

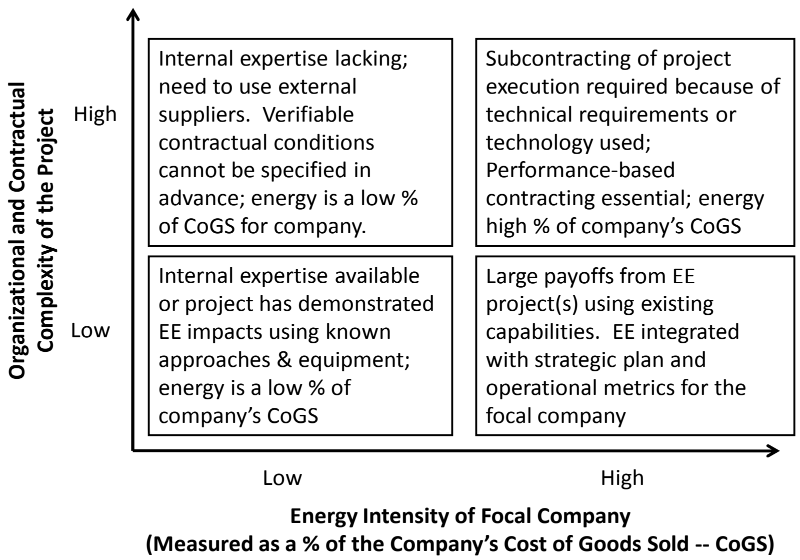


Figure 2 shows four different environments for projects on two dimensions. The first dimension (the horizontal axis in Figure 2) indicates the energy intensity (measured, say, in terms of the ratio of energy costs to the total cost of goods sold) for the focal company of a potential EE project. The higher the energy intensity, the larger the potential payoffs from EE, and the greater the ease of focusing management attention on EE. The second dimension (the vertical dimension in Figure 2) indicates the level of organizational and contractual complexity of the specific project. Some projects may require special expertise or equipment available only from external specialist companies, even when the focal company is energy intensive. In other instances, e.g. in energy-intensive sectors like cement and metals refining, the most important EE projects will be directly aligned with company operations and there will already exist significant project-relevant expertise internal to the focal company. Generally, the larger the number of external parties involved in a project (both financial and technical), the greater the complexity of assuring the ability to satisfy participation constraints and the greater the transactions costs of contracting.[7] Let us consider some concrete examples of each of these environments to illustrate the very different challenges from a risk perspective associated with them.

First, consider some general comments on the nature of the EE projects one might expect in each of the quadrants in Figure 2.

<u>Low Intensity-Low Complexity</u>: The Low-Low quadrant of Figure 2 will feature simple and transparent applications such as lighting, with proven technologies and (in line with the low energy intensity of companies implementing these) low cost. These would typically be implemented by ESCOs (Energy Service Companies), or by the local utility under DSM (demand-side management programs). This quadrant would also include the no-cost and low-cost operations and maintenance (O&M) measures that could be implemented internally by companies. They could just involve better metering to allow the focal company to monitor its energy use better. Larger companies, such as those in the pharmaceutical and commercial real estate area, can empower their engineering division and facility maintenance groups to develop portfolios of EE projects as part of company or facility cost and energy targets. Smaller companies in the discrete manufacturing sector can do the same. The central impediment in these cases is often not risk, but the fact that energy is not sufficiently important as an overall cost driver to receive management attention.

<u>Low Intensity-High Complexity</u>: The Low-High quadrant of Figure 2 will normally be empty as high transactions costs undermine the interest of companies with low energy intensity to make the necessary investments in time and money to reap the modest rewards associated with these projects. An exception could be the bundling together of many small projects of similar technology by an outside partner, an example of which is given below.

<u>High Intensity-Low Complexity</u>: The High-Low quadrant of Figure 2 will feature projects in companies in energy-intensive sectors using internal capabilities to implement proven technologies, such as using new sources of fuel in cement or electric power. To the extent that these projects are for very specific modular purposes, use existing technology, and are provided by suppliers with a good track record, they are low in complexity and risk. For example, while using municipal waste or stressed cooking oils was considered an innovation in such industries 20 years ago, this is by now a proven technology with relatively low risk.[8] Other examples of projects in this quadrant are one-on-one deals with major suppliers selling demonstrated solutions, with in-built risk mitigation and financial guarantees.

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[7] A great deal of ink has been spilt already in the theoretical and empirical literature on the subject of contractual complexity and its consequences for project feasibility. See, e.g., Laffont and Tirole (1993) and Williamson (1985). I will note here only that these matters are of central importance in projects in developing countries where adjudicating contract disputes and other elements of contracting infrastructure are often quite unsatisfactory. See, e.g., the on-going work by the World Bank (2009) on determinants of contractual reliability and other elements of "doing business" in the world.

[8] The largest risk for such technologies based on these "new fuels" is assuring a continuing and reliable supply.

High Intensity-High Complexity: The High-High quadrant of Figure 2 encompasses projects in energy-intensive companies that entail multiple organizational providers and large projects that require sophisticated contracting and guarantees to finance. Examples of such projects would include investments in new kiln technologies in cement or pulp & paper manufacturing or reinforcing grid operations in an electric utility company to allow reliable integration of significant amounts of wind and other renewables. EE projects are to be distinguished from major investments in infrastructure, although the latter provide interesting insights on risk mitigation and management for any large project. What makes large EE projects more difficult than new infrastructure projects and power plants is that the latter are often guaranteed by the government or by major private operators (through build, own, operate and transfer contracts), together with the greater difficulty of measuring ex ante benefits for EE projects and of contracting against these benefits with capital providers.

Let us now consider 4 illustrative projects corresponding to each of the 4 quadrants in Figure 2. The basic point I wish to make is that as organizational and contracting complexity become greater, the scope of risk management increases to include guarantees related to assuring proper performance of cooperating financial and technical partners necessary for project initiation and success.

2.1: Low Intensity-Low Complexity: Sri Lanka DSM Program for Improved Lighting Efficiency[9]

This program was launched in 1994 by the Ceylon Electricity Board (CEB) and the privately owned Lanka Distribution Company in order to avoid costly new capacity additions to its electric power network, and to shave load from the already stressed peak evening hours. The program was directed at all consumers, and was based on the following innovative contracting idea. Customers would agree to replace high-energy incandescent lamps with more energy efficiency bulbs. They would do so with no upfront costs, but with costs for the bulbs collected over the following year in 12 monthly installments. Once a customer signed a contract to participate, they were given a voucher to collect the bulbs free of charge from a certified dealer. The dealer was then paid by the CEB for any bulbs distributed. The bulbs were guaranteed for a two-year period and associated promotion literature showed that the cost of bulbs (collected as a part of the customer's bill) would normally pay for itself from energy savings within the 12-month period following installation. Disconnection due to non-payment of loan installments was illegal, so customers faced very little risk from participation. The results were impressive. In the first six years of the program, an average of 110 GWh per year of energy savings were achieved, with the system load factor improving from 57% to 60% during this period. Here was a win-win project that was bottled, sold and delivered, primarily on the basis of the innovative way of collecting repayments from participating customers. The problem of default risk by customers for the Lanka Distribution Company was further mitigated by collecting first for the "loan" on the DSM contract from any payments made, and applying any remaining funds paid to the electricity bill. As is so often the case, "necessity was the Mother of invention" in this case, as the Ceylon

[9] See Taylor et al. (2008, pp. 233-245)

Electricity Board truly faced a difficult peak load problem, which it was able to solve together with providing significant energy savings opportunities to its customers, packaged in a manner that was essentially risk-free for these customers.

2.2: Low Intensity-High Complexity: SELCO and Rural Solar Solutions in India[10]

SELCO Solar Pvt Ltd is a social enterprise company based in the state of Karnataka, currently providing solar lighting solutions to more than 100,000 rural customers in the states of Karnataka and Gujarat. The company started in 1995 with the basic vision of providing poor people with light in rural areas through solar lighting systems. SELCO can be thought of as a successful ESCO-type company serving both households and small businesses. All these customers have low energy intensity, and almost all of them are severely budget constrained. Any investment requiring multi-period payback would require credit. Together with the technical demands of anything but the simplest solar systems, this would place investments in solar beyond the reach of this group, leading instead to the use of much less sustainable energy sources.

SELCO is a successful for-profit company, featured in *Business Week* and other investment publications as having solid performance and positive growth prospects as a company promoting both energy security and energy efficiency. The key factors which enabled SELCO's success were its "customer-centric products", its financing scheme and its culture of honesty and technical competence in its dealings. On the product side, SELCO realised that its rural customers required different types of solar lighting systems, depending on their needs. For example a street vendor may require a two-light system while a basket-weaver may require a portable lighting system of a different wattage. By designing lighting systems centred on their customer needs, SELCO was able to influence its rural customers' willingness to pay and created demand for its products. SELCO also realised that its rural customers would not be able to afford their lighting systems by paying for them upfront, hence they focussed on designing a financing scheme which would be both feasible and sustainable. As part of the financing scheme SELCO focussed around establishing connections with state-owned rural banks and convincing them to make loans to the rural poor. It also worked in conjunction with the bank in creating feasible loan payment schedules for the rural customers by matching repayments based on their weekly cash flow. In its initial years of operation SELCO tracked sympathetic loan officers in the rural bank networks and planned its business expansion to other rural areas based on their postings in order to replicate the same financing scheme. Eventually by maintaining a strong relationship with both the bank and the end-user and ensuring that payments were collected on time from the rural community, they were able to build credibility with their financing scheme and apply it over a wider customer base. A final point of crucial importance to SELCO's success was maintaining honesty and technical competence. SELCO treated its rural customers with honesty, informing them of the true cost of the solar solution and providing them with ready support through the life of the

[10] This case is based on research by Raka Basu of INSEAD. See also http://www.selco-india.com/ Note that solar implementation is usually not included with discussions focused on energy efficiency. However, the institutional concept of the SELCO project is useful in illustrating the role of a project developer/ESCO for EE efforts.

product, by ensuring that it had customer service branches to serve its customers in every rural area. By developing a trained and competent pool of staff who invested time in understanding the customer's needs, ensuring smooth installation of products and providing satisfactory after-sales support, SELCO developed an installed base of rural customers and relied on them for repeat purchase as well as word of mouth advertising. What is evidently central to SELCO's success is effectively integrating the technical, financial and customer-centric product development functions in its operations. Starting its operations in the resourceful southern states of India, where social and cultural factors were more conducive to spreading of renewable energy ideas, was also likely an important factor in their success.

2.3: High Intensity-Low Complexity: Dongying Shengdong EMC Waste Gas Projects in China[11]

The Dongying Shengdong Energy Management Company (DSEMC) installs power generators for industrial clients. Their original projects were with Chinese steel plants and coal mines. These projects contribute to energy efficiency by using waste gas from these operations (that would otherwise be simply flared or released to the atmosphere) to operate electric power generators. The electric power generated helps to meet the energy needs of the focal company providing the waste gas, and generates additional revenues by selling excess electric power into the network. What qualifies this as a low-complexity solution from the point of view of the focal companies (which are themselves energy-intensive companies) is that they enjoy one-stop shopping with DSEMC. DSEMC installs the generator, negotiates contracts with the local electricity supplier, and operates the generator on the premises of the focal company. DSMEC then sells the electric power generated with the waste gas to the focal company at marked down prices, relative to normal grid purchases, selling any excess to the grid. What makes this an interesting proposition for the focal company is what also makes it a win-win EE project, namely the conversion of otherwise wasted energy into a valued energy stream. For energy-intensive companies in the metals and mining sectors, where energy is a significant fraction of total cost of production, the relatively painless process of allowing DSMEC to set up their self-generation operations on site is well worth the money.

DSEMC's model has proven to be very profitable, for both DSEMC and their customers. All the customers need to do is to provide the space for the generator (sized between 10 KW and 2.5 MW capacity range) and access to waste gas. The rest is accomplished by DSEMC. By 2004, DSEMC had installed 25 separate such power stations. In the past 5 years, its mother company Shandong Shengdon Power Machinery Sales has expanded its operations globally, with expanded operations to include biomass and biogas units, but with the same general approach of the early DSEMC projects. Namely, find energy-intensive companies or facilities in need of self-generation to burn waste gas, or to burn locally available biogas or biomass. Bring efficient small generation units into play with financing for these units provided by the revenues generated

[11] Data for this case is available in World Bank (2009, pp. 246-249). See also the mother company website Shandong Shengdon Power Machinery Sales Ltd. http://sdxsgs.en.alibaba.com/aboutus.html

from the self-generation projects.[12] In the projects in China, the key selling points have been the technical knowledge and reliability of DSEMC and the fact that their services are manifestly value creating. DSMEC not only owns the generation unit (and therefore has every incentive to operate it properly), but they also provide a guaranteed savings contract (the standard is a 10-year contract) to the focal company for any energy generated with the DSEMC on-site power station, relative to what the company could obtain from the grid. These clear benefits, backed up by documented success stories with existing customers, have been very convincing and have led to a highly profitable company and to significant energy savings.

2.4: High Intensity-High Complexity: Highveld Steel & Vanadium Corporation (South Africa)[13]

The Transalloys Manganese Alloy Smelter Energy Efficiency Project of Highveld Corporation is a good example of a high-complexity project in a high-energy intensive company in South Africa. The manganese smeltering process is centered on the electricity-fired furnaces that give rise to silicomanganese (SiMn) alloy, which is a key ingredient in high-quality steel. The EE project of interest is simple enough to describe, namely to retrofit Transalloys' five furnaces with new electric arc furnaces, including related control and peripheral systems. The consequence of this EE project were seen as reducing the amount of electricity consumed per ton of alloy produced, with savings from reductions in the consumption of electricity as well as further CO2 emissions savings, since most of South Africa's electric power is generated from coal-fired plants. Notwithstanding the straightforward nature of the project, a number of factors made this a high-risk project.

First, and foremost, straight NPV analysis at the Company's internal cost of capital yielded a negative NPV in traditional terms, so that it was in fact not initially thought to be financially viable. Moreover, the project NPV remained negative under a variety of sensitivity analyses on relevant parameters related to energy savings and realistic productivity increases that might accompany the furnace retrofitting. Some of the complicating risk factors that led to this negative NPV were the following:

Low electricity prices in South Africa: SA is one of the four cheapest electricity producers in the world (IEA Statistics, 2008). Incentives for saving electric power are therefore very weak in SA.

High investment cost: The total initial investment cost for all five furnaces to be retrofit was around $17.5 million. Total annual savings from electricity and O&M costs were predicted at $2.4 million/yr. Even assuming all went well, and such savings in energy and maintenance costs

[12] Basically, the same self-financing model is used by the Brazilian company Ecogen (formerly Iqara Energy Services, a subsidiary of British Gas) a subsidiary of Geribá Investimentos.. Ecogen focuses on cogeneration applications for industrial facilities and shopping centers. Cogeneration provides both heat and electric power for such facilities through the combined cycle generation process. In addition, absorption cooling can be added to this system to provide summer cooling for administrative offices or shopping centers, an important consideration for Brazil, which also contributes to smoothing the utilization of the system between summer and winter. For details on the early Iqara model, see World Bank (2009; pp. 250-256).

[13] For details on this project, see the detailed description of the project under the CDM register of the United Nations at http://cdm.unfccc.int/Projects/DB/DNV-CUK1174913531.12

continued, this project clearly was not a good investment at normal internal rates of return (of say 10%).

Uncertainty in market prices and exchange rates: One objective of the retrofitting project was to increase availability of the furnace and therefore output of the smelting process. Whether this would pay dividends depended on the market price for the SiMn alloy produced, which was sold into a global market at $-based prices. Given the large upfront investment cost for the project, the uncertainty of these variable returns was an unsettling prospect for the project.

Uncertainty on yields, technical conditions and maintenance costs: Any project that goes to the heart of a company's production process, as furnaces are to manganese alloy production, is confronted with additional uncertainties in retrofitting to other equipment in the process. (A greenfield approach was also evaluated but was considered even less viable financially than retrofitting.)

If this project had a clear, positive NPV, it would have been a high-intensity, medium-complexity project that would have been financed readily from internal funds of its internationally based mother company Highveld. However, the above factors taken together led Highveld to seek additional funding through the CDM mechanism.[14] The ensuing project evaluation led to a conservative estimate of projected savings of over 500,000 tons of CO2 over the life-time of the project (saving approximately 50,000 tons a year over a 10-year horizon of the CDM certification). When valued at the low end of expected CO2 prices in the EU market (namely around 15 Euros per CER credit), these annual carbon revenues would amount to another $0.6 to $1.0 million/year, and were enough to drive this project solidly into the black. Highveld decided to undertake the project, even before being granted registration for CDM credits, which they eventually were given in 2008, nearly three years after filing the project for CDM approval.

The combination of exchange risk, subsidized energy prices, production yield risk and CDM credit price uncertainty in this project, together with the centrality of energy in manganese alloy production, made this project a high-intensity, high-complexity project. Because of the financial backing of the mother company, Highveld, these risks could be managed in this case, and the project was successfully launched.

3. Risk Management Fundamentals

Risk analysis in industrial contexts consists of four integrated processes: (i) identifying underlying sources of risk, (ii) determining the pathways and triggers by which such risks can materialize, (iii) estimating the potential consequences of these risks under various scenarios, and (iv) providing the means for mitigating and coping with these consequences. Specific risks, once identified, are usually characterized by the probability of their occurrence and the magnitude of their consequences, but many other attributes of risks may be of interest to a company implementing

[14] I discuss the CDM process and associated risk problems in more detail in section 6 below, including some further discussion of the Transalloys case.

EE projects. Risks can have both positive and negative outcomes though normally it is the downside risks that are significant for EE project execution and these will be the primary focus of our discussion here. With an eye on Figure 1, these risks can occur in any domain of a company's internal operations, from engineering to finance, as well as in relations with external partners, regulators and energy markets. A great deal of work in corporate finance and insurance has gone into the design of efficient risk management instruments for risks that can be monetized (e.g., Doherty, 1999), and to the extent that the consequences of these risks are borne by the owners of an enterprise, there are incentives for owners and managers to make efficient choices in balancing risks and returns.[15] Given the transactions costs of negotiating and implementing EE projects, however, the risks and returns of such projects are often overlooked, especially for low energy-intensive companies.

3.1: Project Management and Risk Management for EE Projects

Many useful tools and industrial applications of risk analysis have been developed over the past half century. A good survey of these is available in Haimes (1998) for general risk management, and with Rocky Mountain Institute[16] for EE project risk mapping and execution. Applying this framework to the area of EE project risks gives rise to the following steps in applying risk management to EE projects:

1. Establish Strategic Objectives and Perform Baseline Assessment: Obtain senior management and owner/investor approval for EE and set up organizational responsibility for EE. Identify company energy flows and costs and develop objectives against this baseline for potential EE projects. Existing prototypes and test projects with demonstrated results are often important precursors for EE projects. For companies with modular processes or multiple facilities, sequential implementation and diffusion of internal best practices and results is usually a guiding principle for EE planning.

2. Identify sources of risk: Begin with a complete chart of the proposed project (with major activities, timing and resources identified) and its expected financial and energy consequences using standard project management techniques. For each phase of project execution, and each key actor or process involved in the project, identify areas of potential concern or potential failure and qualitatively prioritize these in terms of their consequences for the project (from minor annoyance to fatal).

3. Risk Assessment: Determine what triggers and pathways associated with the various risk drivers, including key events and scenarios that might trigger these. To the extent possible, quantify the median and worst case consequences associated with these.

4. Risk Mitigation and Hedging: Considering especially those risk factors that would imply damage to the enterprise mission (e.g., in the form of financial distress or loss of key customers' business), identify ways of avoiding or reducing risks to acceptable levels. Risk mitigation can

[15] An exception occurs in the energy area when carbon or other air pollutants are not priced, so that their impacts may be borne by the eco-system and by uninvolved third parties including future generations. For such risks, market forces are not sufficient to motivate a profit-oriented company to operate efficiently. We revisit this matter below in discussing the impact of carbon taxes and cap and trade system policies on EE projects.

[16] See the resources available from Rocky Mountain Institute at http://www.rmi.org/rmi/.

also involved hedging of cash flows, e.g. connected to energy costs or carbon credits, as discussed later in this report.

5. Project Initiation and On-going Control: Determine conditions under which the benefits from the project (or a portfolio of projects) clearly outweigh residual risks, and set up contractual and management systems to remain within these bounds of acceptable risk. For larger projects, this will also entail contingent responses to financial surprises as well as insurance provisions for serious disruptions to project operations.

Companies can rely on a variety of tools and methodologies to assist them (Haimes, 1998). For general project risks, the most important ingredients are the first three steps, including a proper project management system itself. Poor measurement of baseline conditions and a sloppy or incomplete project management framework are often the most critical missing factors for projects that are actually launched and fail.[17] A second critical set of tools for EE projects is provided by industrial ecology (IE).[18] The tools of IE in mapping material and energy flows (e.g., Ayres and Ayres (2001)) are essential diagnostic tools to indicate the current energy and carbon footprint and costs of key processes. A general model and mapping of energy use in the company is a critical first step to understanding the payoff from EE projects and the potential process and enterprise risks accompanying such projects.

> Poor measurement of baseline conditions and a sloppy or incomplete project management framework are often the most critical missing factors for projects that fail.

When these processes and tools are applied, the results achieved can be remarkable. In line with the findings of the effects of quality management programs, these results are in two key areas. First, is the structuring of a strong management system for companies that links their strategy process and their operations to a legitimate, science-based framework to identify, assess and manage their Energy Efficiency (and where appropriate their carbon footprint as well). Second, is an organic structure of shared knowledge that allows all stakeholders in a company's operations to understand the potential effects of these operations on overall energy inputs and outputs in terms of useful work and costs.

The extent to which EE is integrated into general management concerns and priorities will, of course, depend on how important energy is in the company cost structure (thus, the importance of the horizontal axis in Figure 2). Nonetheless, bearing in mind that what is not managed will not happen, and what is not measured cannot be managed, the most central aspect of effective risk management for EE projects is to develop an internal framework, with measurement and management responsibility, that will assure continuing oversight of EE projects. Whether this

[17] See, e.g., the work of Marcie Tyre and Oscar Hauptman (1992) on challenges in implementing industrial projects. This work and research at the Project Management Institute (PMI) suggests that simple project planning methods, such as the Critical Path Method, now widely supported by user-friendly software tools, are more honored in the breach than in practice, with the result that even easy to avoid risks are often the source of either complete project failure or of a project's failing to attain anywhere near its potential payoff. For an introduction to appropriate project management techniques, see the resources at PMI http://www.pmi.org/Pages/default.aspx.

[18] See Ayres and Ayres (2001).

responsibility resides with senior management, as it should for high energy-intensive companies, or with plant engineering and maintenance personnel, as it will likely in the case of low energy-intensive companies, getting energy onto the slate of key metrics for continuous improvement of operations is the starting point for energy awareness and efficiency. We discuss further below some of the best practices emerging in this important area of metrics and management for EE.

3.2: A Simple Example to Illustrate Risk-Management Impediments for EE Projects

This section considers a simple example of a standard EE problem, namely replacement of lighting fixtures in a manufacturing facility or office building to illustrate key issues in risk management stated earlier. This example is purposefully simplified in order to highlight the essential elements of risk present in EE projects in developing countries.

Lighting is a very basic EE investment problem that derives its value from the lifetime savings associated with changing one form of light bulb (and its fixtures) for another more energy efficient form. In its simplest form, no additional wiring or control equipment is needed (this would be the case for the Sri Lankan DSM example described in section 2.1 above). In the analysis presented below, I allow also for some additional investment in control systems and wiring. To avoid needless complexities, I assume that one set of light bulbs is changed for another, possibly with more reflective fixtures, and that the new bulbs/fixtures assure the same or greater level of luminescence as the old bulbs/fixtures.

The following are the basic parameters of interest from the perspective of computing expected annual savings from investing in more efficient lighting.

I = initial cost, including labor, for replacement of bulbs, fixtures and wiring

N = Number of bulbs/fixtures involved in the project

e_o = Energy consumption per period (e.g., per month) in kWh of each "old bulb"

e_n = Energy consumption per period (e.g., per month) in kWh of each "new bulb"

P_e = Energy cost per kWh

L_o = Expected lifetime (in months) of old bulbs[19]

L_n = Expected lifetime (in months) of new bulbs

R_o = Replacement cost per unit for old bulbs

[19] My objectives here are modest, to illustrate even in this simple setting basic drivers of risk. I am not going to get into details of alternative failure rate distributions, statistical properties of aggregates of these across a population of bulbs, the impact of the initial distributions of age of bulbs at the start of the project and other such details. I also am focused entirely on energy savings here. As the Sri Lankan example described earlier notes, there are potential savings also for the utility in peak load shaving, and these can lead to ultimate deferral of investments in new power plants. Depending on the size of the installation base, and the other parameters of the problem, these more technical issues could be important in practice.

R_n = Replacement cost per unit for new bulbs

The expected monthly savings S in switching from old to new bulbs are then given by:

$$S = N\left[\left(\frac{R_o}{L_o} - \frac{R_n}{L_n}\right) + P_e(e_o - e_n)\right]$$

Assuming that energy and other costs are paid at the end of each month, the discounted net present value (NPV) of future savings from switching to the new bulbs would then be given by the standard annuity valuation formula

$$NPV(S) = \frac{\delta S}{(1-\delta)} = \delta S + \delta^2 S + \delta^3 S + \ldots$$

The usual financial decision rule would then be to invest in the project if the initial investment cost is less than discounted savings (i.e., if $I < NPV(S)$). A number of risk issues are easily identified that might prevent projects from implementation that would, in principle, fulfill this standard financial criterion for investment.

This simple lighting example illustrates several risk factors that undermine good NPV-based investment choices for cost-effective EE projects?

- Lack of assured knowledge or trust in the factors driving EE
- Technological and organizational credibility of suppliers
- Exchange rate risks
- Credit and budget constraints
- More pressing priorities of company owners and managers

Lack of assured knowledge of the savings parameters: Some or all of the key parameters for the problem may be uncertain, at least for the decision maker. If, as is usual for lighting application, $R_n > R_o$ and $e_o > e_n$ (so most of the action is in energy savings for the new bulbs), then a major question (beyond the decision maker's credible knowledge of R_o, R_n, e_o, e_n) is the price of energy going forward. Obviously, if energy price P_e is subsidized, then energy savings would have to be very significant indeed to warrant investment.

Technological and organizational credibility of suppliers: The party selling the new bulbs/fixtures and the specific quality of the services offered may not be known or credible to the decision maker. In the case of lighting replacement, this credibility would apply to the initial investment "I" as well as to the on-going cost of bulb replacements. Generally, the presence and reliability of key suppliers over the life time of a project should be a central element of project valuation (which may not be so important for light bulbs, but is usually very important for EE projects in general). Depending on the nature of the retrofitting required, reverting to the older bulbs in case the new bulbs do not perform adequately can be undertaken, but would result in the loss of at least the initial investment.

Exchange rate risk: If replacement bulbs are manufactured outside the country in which the project is undertaken, there may be perceived or actual risk going forward in exchange rates and the therefore in replacement costs, where these might not be the case for the old bulbs if they are manufactured domestically.

Credit and budget constraints and implicit high discounting of savings: As we explore in section 5 below (which considers behavioral issues related to risk), the decision maker might face significant credit or budget constraints, which would have the effect of driving up the perceived or actual cost of borrowing, if this were required to finance this project. These constraints would, in turn, be exhibited in high implicit discount rates or in low required payback periods from assured project savings.[20] Indeed, the normal approach to risk and uncertainty of any of the above forms is to add estimate savings more conservatively and to require that initial investment be recouped in a shorter payback period.

Busy decision makers, small potatoes and more pressing priorities: Added to the above list of risk factors is the fact that decision makers, especially in SME's, do not have the time to go through a lengthy due diligence process for EE projects. If they are not clear winners, then any of the above risk factors push the project off the table, given other pressing priorities. This point itself raises the fundamental question to which I now turn as to how an enterprise can gain sufficient focus for EE projects to ensure that at least that larger and more cost-effective projects have a chance of surviving in the face of the above types of risk factors.

4. Organizing the Enterprise for Effective Risk Management of EE Projects[21]

The above reflections underline the importance for identifying and implementing profitable EE projects that these be undertaken within a framework that connects these projects to the strategy and profits of the company. With an eye on Figure 2, this is especially true of companies with high energy intensive operations. For such companies, EE is a strategic concern and should be tracked as part of any effective operations management system. However, even companies with low energy intensity must establish standard procedures for identifying and valuing EE projects or they will leave many cost-effective projects fallow. For low energy intensity companies large enough to have an engineering or facilities maintenance group, this is the obvious address to locate responsibility for EE projects (although, as noted below, there needs to be a strong connection to the finance function of the company to assure proper monitoring of risk and profitability). In companies too small to have the requisite technical manpower to identify and track EE projects, the only solution is external service providers (ESCOs and DSM programs from the local utility).

In what follows, I consider the question of organizing for effective risk management under the assumption that there are technically qualified individuals in the company who already have responsibility for maintenance and operational readiness of the company's plant and facilities. I will refer to this group as the CEMG (Company Engineering and Maintenance

[20] In the present context, the payback period in its simple non-discounted form would be the number of months at which saving S would be required in order to pay back the initial investment I, which would be the smallest number M such that $MS \geq I$.

[21] I am indebted to Sam Aflaki at INSEAD for valuable insights on this section and for his work on the Pfizer Corporation case discussed here (see Aflaki and Kleindorfer, 2010).

Group). I address the question here of what appropriate management system would be simple enough for a very busy CEMG in a developing country in a focal company that may be in a business of low energy intensity, but in which nonetheless there may be significant EE payoff potential. I will assume that the company has only a single facility or manufacturing process, which I will refer to as the "Facility". I will discuss at the end of this section a case example from a major pharmaceutical company with multi-plant operations in both developed and developing countries. Suffice it to say that EE projects may be replicable, but they are also site specific and the real work in implementing these occurs at the level of individual manufacturing facilities.

Organizational responsibility and accountability: The first and most important element in any effective management system is recognition of the responsibility and accountability for EE results. Such recognition needs to be further formalized in an Energy Master Plan. The Master Plan can include also other resources such as water and air pollutants[22] such as CO2, but it must be clear as to the system boundaries for EE projects, the objectives of EE within the company, and responsibility for monitoring and reporting. The first and foremost element of any such plan is a credible measurement of the status quo of energy use and energy costs for internal operations, later possibly to be extended to supply chain partners and customers (though I neglect these broader EE issues here).

Identification and valuation of potential EE projects (the EE portfolio): Armed with initial measurements of energy consumption for specific uses, CEMG need to work with site process owners at the Facility as well as external service providers to form a set of alternative options for the Facility energy needs (both heating, cooling, lighting, and manufacturing) in order to increase energy and carbon efficiency. A good EE identification and valuation process is grounded on four basic principles:

- integration of all projects into a transparent value-based Energy Master Plan to show progress over time, to identify synergies across projects and to show systemic interactions of these projects;
- objective measurement of energy inputs and useful work accomplished with energy for the Facility as a whole as well as for individual processes at the site;
- working with process owners at the Facility in a participative way to identify opportunities for improving energy efficiency and to implement projects with the highest combined energy and cost impact;
- developing a transparent process for reporting and valuing the cash flows, risks and energy consequences of identified projects.

The CEMG, bearing overall responsibility for implementing EE, must be responsible for the measurement side. Various mapping tools based on Industrial Ecology and Life Cycle Analysis (LCA) are available to determine inputs and outputs of individual processes throughout the facility.[23] On-going discussions with process owners, with the results of

[22] I return in Section 6 below to a discussion of the special problems of risk management related to carbon emissions.

[23] See, e.g., the resources available through the Rocky Mountain Institute: http://www.rmi.org/rmi/About+RMI. See also the general approach to integrating with sustainability strategy in Orsato (2009) and the case studies noted in Rouer and Gouyon (2007) of BeCitizen.

measurement and historical trends in hand, should lead to joint decisions on potential projects. Further work to value these in a uniform manner, and to coordinate with objectives in the Energy Master Plan, then should lead to predictions and milestones for decreased energy efficiency and related profit metrics. Depending on how accounting is accomplished at the Facility, recognition might be immediate by process owners (e.g. if they are cost centers and are held responsible for overall process costs, including energy). If accounting and process ownership are not aligned, then other means need to be found to share the "glory" for improved results achieved. Results on energy and cost need to carefully monitored and fed back into the measurement process, so that a cycle of accurate measurements, predicted benefits, monitored results and verified improvements is achieved. Communicating results of Facility performance to all employees can further enhance the importance of EE for the company, and for the broader community (the latter in terms of carbon and other polluting emissions avoided by EE improvements).

What is described here is effectively the EE version of continuous improvement which has been such an important part of manufacturing excellence and the quality movement since the worldwide recognition of kaizen principles transformed manufacturing in the 1980s.[24] Integrating EE (and perhaps other key resources such as water and logistics) in a culture of continuous improvement is the primary means of identifying promising EE projects and having the cooperation of participating process owners in the implementation of such projects. The same culture can transform an underperforming, low-quality Facility onto a path of long-term profitability. While it is often claimed that "things are different in developing countries", this is often just an excuse for what Eric Kakou characterizes in his work as a flawed mindset.[25] In fact, it is the mental models of people that drive the actions they take that in turn shape the context in which they live and eventually the world. This reality is as true for EE project as it is for other domains. In the case of EE, it is important to identify some of the preconceived notions that are at play. These include: EE solutions are too expensive to implement; EE solutions are not proven and are therefore high risk; the skills required to make EE solutions a reality are not available in developing countries. It is important to see how creating the right incentives and the right information, as illustrated in the case studies above can help customers suspend their disbelief long enough to try a solution and be convinced. In industrial settings, the culture of kaizen described here captures some universal attributes of respect for people, fact-based management and the shared benefits of participating in a profitable, well-run enterprise. In this sense, kaizen-driven EE can be a portal to broader quality and cost efficiencies in the enterprise as a whole.

4.1: Case Example: An Example of a Well-Organized Approach[26]

The Freiburg Facility is an important manufacturing facility of the Pfizer Corporation, a global pharmaceutical company. Freiburg is located in Germany, which explains in part the commitment of Pfizer Freiburg's management to EE, given the strong "green" movement that has existed for many years in Germany. However, profits for Big Pharma derive primarily from R&D and marketing, and EE has not been high on the agenda of importance of any major company in Big Pharma until relatively recently. Indeed, globally only 2-3% of the cost of goods

[24] See the newly translated classic by Zhigeo Shingo (2007).
[25] Eric Kakou, personal communication.
[26] The discussion here is based on Aflaki and Kleindorfer (2010). .

sold results from energy expenses for the pharmaceutical industry. Not surprisingly, therefore, the management of Pfizer Freiburg (for which energy is a major expenditure) did not find an initial warm reception for its plans to launch a major EE initiative. Nonetheless, the head of engineering at the Facility decided that EE was something that needed to be done in order to move the Facility to a more sustainable energy future.

With the support of the Facility Manager, a program similar to that described just above was launched in 2005 by the Pfizer Freiburg's CEMG. The initial form of the program was an Energy Master Plan that was based on a Facility-wide measurement system. The Master Plan consisted of some 50+ projects in various areas. These included larger projects such as geothermal heating and cooling, the installation of biomass (wood pellet) boiler and adiabatic cooling in the Facilities manufacturing and laboratory processes. However, a host of smaller projects were also included, from weekend shutdown to better building controls to behavioral programs. All of these projects were accompanied by an assessment of projected energy savings, carbon savings, and cost savings. They were also clearly identified with some process owner, with capital expenditure requirements and expected payback periods. Four general sources of profit for projects in the Energy Master Plan were identified and valued for each project:

a) Reduction in operational and maintenance costs relative to business as usual
b) Reductions in greenhouse gas (GHG) emissions by using more eco friendly technologies; for the larger projects these emissions savings were certified in the Joint Implementation market for GHG emissions, with resulting revenues from the CO2 emission credits
c) Governmental incentives (tax reductions and feed-in tariffs for excess electric energy resold to the grid[27])
d) Further benefits in aligning operations with corporate environmental goals and Pfizer's corporate social responsibility objectives.

Some of the projects such as insulation and smart air-conditioning systems are "no brainers", with low upfront investments, relative certainty of the direct benefits of the project, and short payback periods (group 1), while others required significant capital expenditures and entailed operational risks or uncertainty in profitability (group 2). Representative group 2 projects included the installation of geothermal heating and cooling system and a biomass boiler fired by wood-pellets .[28]

[27] Feed-in tariffs provide incentives to adopt renewal energy resources. For example, in Germany, according to the Renewable Energy Law passed in 2008 and coming into force in 2009, companies generating electricity from renewable energy sources such as hydro, solar, biomass or wind receive a guaranteed payment per kWh of excess electricity fed into/resold to the grid. For electricity generated from biomass, for example, this payment amounted to 8.4 to 11.5 Euro Cents/kwh, depending on the size of the installation, with these guaranteed prices decreasing annually from 2010 on. This means that if a Company installed a cogeneration unit burning wood pellets, for example, it could generate both electricity as well as process heat for its own operations. It could thereby both displace energy purchases from the gas or electricity grid as well as generate additional revenues from feed-in tariffs by selling excess electric power from its co-generation unit to the grid. This is similar in spirit to the Dongying Shengdong EMC case described above.

[28] The boiler itself was of standard industrial type, a closed vessel in which water (or other fluids) are heated and used to generate heat and steam for building heat and production. Wood pellets are a type of bio fuel that are produced from the biomass harvested from sustainably managed forests and from waste products of sawmills. High density and low humidity make wood pellets an efficient combustion fuel option. Wood pellets have significantly lower GHG emissions in their production life cycle since if the excess wood from which they are

Geothermal heating and cooling was the first major project implemented in the Energy Master Plan. It had a significant ecological and economic impact on the site. After careful test drills and geological studies had established the safety and feasibility of the project, access shafts around the facility were drilled reaching 130 meters into the ground. These provided access for closed loop piping that brought circulating water into contact with the underground water at a nearly constant year-round temperature of 12-14^{o}C. Water in the closed loop system that was pumped through this aquifer came out at this temperature. Since the resulting temperature of 12-14^{o}C was considerably lower than the ambient temperature in the summer (around 25^{o}C) and considerably higher than the a through the ambient temperature in the winter, circulating the water from the geothermal closed loop system through a network of piping embedded in the walls of the facility results in cooling of the ambient air in the summer and heating in the winter. Of course, additional cooling and heating are also required to maintain temperatures within the comfort range, but the geothermal wells and pumping system went a long way to achieve heating and cooling efficiencies. The system became operational in the summer of 2008. With a payback period of less than 2 years, the geothermal project was immediately hailed as a success for the Facility's vision of sustainable energy. The project yielded considerable savings in annual energy costs, reducing gas and fuel by 3325 megawatt hours (MWh) and reducing CO_2 emissions by 1,200 metric tons per annum. Harvesting the benefits of the geothermal project underlined the importance of having a comprehensive Master Energy Plan. The geothermal installation was an essential part of that plan, but its full benefits could only be harvested in connection with other projects in the Master Energy Plan. The entire process was driven by the vision of a low-energy consuming manufacturing site designed and constructed using the latest energy and resource conservation principles.

The next major step was the installation of a biomass boiler (BMB), which was considered to be one of the major projects in the Facility Energy Master Plan, with large benefits in both environmental and cost terms, and which would allow the Facility ultimately to generate all of its energy needs from locally available renewable energy sources. The BMB project consisted of the replacement of boilers #1 and #2 with a single efficient boiler fired by wood pellets. The initial cost of the replacement boiler was higher than an alternative gas boiler, but the payback period on that additional investment was easily less than two years. The installation of the boiler was done with the technical assistance of a large ESCO specializing in biomass.[29] The ESCO was also contracted as the initial provider of wood pellets to fire the boiler.

The CO2 emissions from wood pellets are 0 tonnes per MWh (based on Kyoto regulations), while oil and natural gas produce 0.25 and 0.19 tons CO2 per MWh, respectively, of equivalent energy use. The reduced emissions from the BMB project were in excess of 5,000 tons/annum. These reductions will not only contribute to achieving Pfizer's objective of reducing its overall carbon footprint, but these reductions will be certified and the credits obtained will be sold in the European Emissions Trading System (ETS). While pharmaceutical companies and their facilities are not regulated directly on their GHG emissions, companies in the EU can obtain credits under

made is left to simply decay naturally, it will yield basically the same GHG emissions as if it were burned as wood pellets. Biomass is therefore considered a near-zero net GHG emission source for energy.

[29] The ESCO in question is the Heidelberg-based subsidiary EC Bioenergie GmbH of the Dutch energy giant SHV Holdings N.V. See http://www.ec-bioenergie.de/ for information on the innovative contracting and services provided by EC Bioenergie.

the so-called Joint Implementation (JI) process. JI is essentially identical to the Clean Development Mechanism (CDM) of the Kyoto Protocol, but for Annex I countries. JI allows certification agencies to verify emission reductions from energy efficiency projects, leading to credits (in terms of tonnes of CO2 equivalent emission reductions), which can be traded in the cap and trade system at the going market price. The current price in December of 2008 for such credits in the ETS market was just under 15 Euros/teCO2. Even at this price (depressed because of the lower level of economic activity associated with the 2007-8 economic crisis), the resulting revenues from 5,000 tons of CO2e saved by the BMB project would add 75,000 Euros/annum to the already positive NPV of the project.

A standard cash flow and risk analysis was to be integrated with managerial and strategic considerations for a comprehensive value assessment. This assessment indicated that the project was very profitable. Given the ready local supply of biomass and wood pellets, and the financial guarantees provided by the supplier, little risk was envisaged from disruptions. Moreover, some of the existing boiler capacity (fired by oil and gas) was kept as standby in case additional energy was required or there were a disruption in the BMB operations.

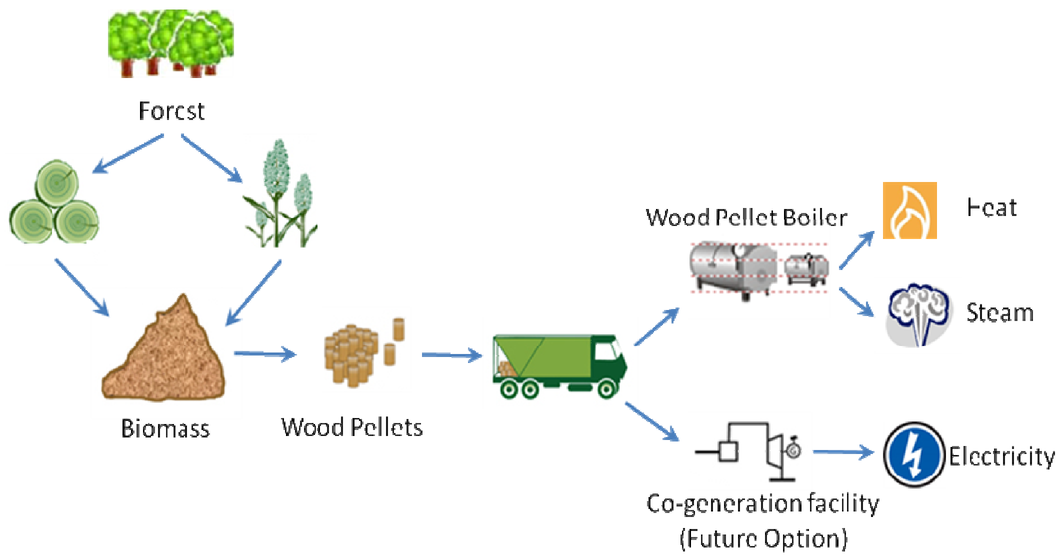

Figure 3: A schematic model of the Biomass Boiler (BMB) project

The CEMG team at the Pfizer Freiburg Facility envisaged a three-phase process for the BMB project (see Figure 3). In phase 1, the Facility would contract with the ESCO supplier to install the boiler and supply wood pellets for the coming ten years. The supplier had sufficient long-term contracts itself that it was prepared to offer a ten-year supply contract to the Facility indexed by a market index of wood-pellet prices (an index of the cost of wood pellets sold in the region) and capped at 70% of the heat equivalent market cost of oil. The savings potential from the BMB project relative to business as usual was therefore manifest and credible.

Phase 2 of the BMB project was planned as the installation of an absorption cooling system that would use some of the steam generated in the BMB as input to an absorption cooler. This was viewed as an important complement to the cooling already provided by the geothermal system, and had the additional benefit of assuring a more seasonally balanced use of the thermal energy generated by the BMB.

Phase 3 of the BMB project foresaw the installation of a co-generation[30] unit. The electric power generated from the co-generation unit would be used for lighting and production, and the heat would be captured for building and process heat. The electricity produced would be used by the Facility or re-sold to the grid. With the completion of Phase 3, the Facility would supply 100% of its own energy needs from biomass obtained within 50 kilometres of its Facility, as well as producing and supplying additional renewable energy (with zero carbon net emissions) to the local grid.

Phase I of the project was implemented in 2008-2009 and it has fulfilled all expectations. If phases 2-3 of the Energy and Resource Master Plan are as successful as hoped, Pfizer could capture these as best practices and disseminate them and the management and measurement systems on which they were based to other sites around the world as part of their sustainability strategy. This sort of dissemination of best practices, both in terms of technology as well as management systems, is a form on internal benchmarking. It is very credible, inasmuch as it manifestly fits with company culture, accounting systems and management practices. Thus, the usual resistance to change is somewhat mitigated when successful projects of a transferable nature are implemented in the same company at another site. Thus, to the extent that the EE technologies are transferable, the EE results achieved can cascade from any Facility to any other within the company.

The most important lessons from this case study for risk management derive from two reinforcing ideas. First is the fundamental importance of measurement as a foundation for identifying and valuing EE projects. Second is the key role of having a responsible group, with the necessary expertise, charged with the responsibility to deliver on EE. On the first point, the ability to value any EE project relies on both precise internal knowledge of energy flows, uses and costs, as well as external knowledge on the prices of existing and alternative energy. While specialized knowledge in this case on carbon markets was provided by the ESCO involved (EC Bioenergie), the CEMG at the Freiburg Facility was clearly in control and had a full understanding of projected carbon reduction impacts from their projects. The continuing process of measurement, prediction, control and feedback in the Facility's approach to EE has not only paid off in profit terms. It has led to a deeper understanding of the nature of the production processes at the Facility and that most important element of risk management, namely the development of internal competencies and knowledge that allow a rationale and reliable response to external contingencies. In the case of Pfizer's Freiburg Facility, the engineering division was able to integrate EE with its normal slate of responsibilities, and with the added precision of underlying energy use and cost measurement they were able to obtain a much better understanding of other engineering drivers of cost and performance. Just as in the quality movement of the 1980s, where cycle time was a fundamental lever to discovering where quality problems lie, so in this case the analysis of EE is proving to be a means of discovering inefficiencies that go well beyond wasted energy.

[30] Co-generation refers to the process of generating both electricity and heat from the same electric generator.

5. Barriers and Enablers for Effective Risk Management

This section considers a few of the important barriers to choice under uncertainty and what might be done to improve these in the context of promoting effective risk management of EE projects. As examined in the Decision Sciences literature over the past several decades,[31] human decision makers have greater problems with choice under uncertainty when these involve complexity, ambiguity and intertemporal effects. Many EE problems have all three of these characteristics. From the perspective of the Decision Sciences, it is therefore not surprising that many apparently profitable EE projects are not implemented. Let us consider some of the details.

5.1: Financial and Behavioural Aspects of Decision Making for EE

I will structure the discussion in terms of a number of observed phenomena related to project selection and execution that suggest departures from rational choice (which in this context means overlooking cost-effective EE projects). I will note also some "debiasing techniques" that have been proposed for the indicated biases. The discussion here is intended to be general, and not specific to the context of developing countries. However, as will become apparent in the discussion, many of the problems noted are likely to be exacerbated in developing countries. Thus, I suggest some conclusions at the end of this section to connect strategies and policies that might be helpful in moving toward more efficient choices and better risk management for EE projects in developing countries.

Myopia: There is a clear tendency to undervalue continuing payoffs from multi-period EE projects. The consequence is that many EE projects that should pass reasonable hurdle tests do not. A typical example of myopia is the following.

Suppose a project decision maker (DM for short) is "risk neutral" and the rate of interest (or cost of capital) is r = 0.1 ($/$/yr). Consider the following "project". Will the DM find it desirable (or not) to pay $100 at time 0 (think of this as the beginning of period 1) if the DM receives $80 for each of the next 5 years (assume DM receives the savings of $80 at the end of years 1 through 5) and then nothing thereafter? The standard calculation for this would compare the status quo vector of payouts $(x_0, x_1, \ldots, x_5)$

$$x = (0, 0, 0, 0, 0, 0)$$

with the vector of payouts if the project is undertaken, namely:

$$y = (-100, 80, 80, 80, 80, 80)$$

This leads to the comparison:

$$\text{NPV}(x) = \sum_{t=0}^{5} \delta^t x_t < \text{NPV}(y) = \sum_{t=0}^{5} \delta^t y_t, \text{where } \delta = \frac{1}{1+r} = .909$$

[31] See, e.g., Kleindorfer, Kunreuther and Schoemaker (1993) for a summary of the literature on heuristics and biases in decision making under uncertainty.

For the given data, NPV(x) = 0 and NPV(y) = \$203.26. Clearly, the project is worth undertaking from an NPV perspective. However, suppose the DM considers in his evaluation only payouts through the end of year 1. Then the evaluation would be between status quo vector x = (0, 0) and y = (-100, 80), with the resulting NPV comparison yielding NPV(x) = 0 and NPV(y) = -\$9.1. In the case of a myopic DM, the apparently cost-effective project described above would not be undertaken.

There are many experiments and a great deal of literature verifying myopia and relating it to other behavioural phenomena such as loss aversion, risk aversion, budget constraints and information processing limitations of human DMs.[32] The standard approach to debiasing (correcting for) myopia is better information for the DM and the use of guarantees and third-party intermediation. The latter is very important for EE projects and works as follows. A bank or other third party "buys" the project from the DM, providing the upfront investment cost of \$100 to the supplier of the project technology and obtaining the rights to the \$80 in cash flow/savings from the DM for the five year period of the project. Such a third party in this instance could offer the above myopic DM very little upfront in return for a very handsome return on this project over the five-year period, arbitraging the DM's myopia against the true project returns. Of course, the third party would have to have reasonable assurances of being able to collect the returns from the project over the five-year period (however, in this case even two years worth of returns would make the project worthwhile for a third party with cost of capital as indicated).

High Discount Rates: A phenomena related to myopia (and often indistinguishable from it) is the apparent use of high discount factors or different forms of discounting than that implied by the usual constant discount rate model. To understand this, first consider the notion "implicit discount rate" defined as the discount rate that would just equalize a project's NPV to zero at the rate at which a DM is prepared to pay to have the project implemented.[33] For example, consider a project with monthly savings of \$30 to a DM for each of the next six months. If the DM says that he would be prepared to pay \$100 upfront to launch this project, then the implicit discount rate for the project for this DM would be the value of the monthly discount factor δ such that:

$$-100 + 30(\delta + \delta^2 + \delta^3 + \delta^4 + \delta^5 + \delta^6) = 0$$

which leads to the value $\delta = .834$ (with an implied cost of capital per month derived from $\delta = 1/(1+r)$ of r = 0.199 per month!).

There is a large experimental and empirical literature showing that projects, like EE projects, that require upfront investments in return for a series of implied savings give rise to observed implicit discount rates that are wildly out of line with available credit or debt costs in financial markets.[34]

[32] See Kahneman and Tversky (2000) for details, especially chapters 32 and 33. For a recent survey of the intertemporal choice literature, see Andersen et al. (2008).

[33] Of course, this is directly related to the Internal Rate of Return, a.k.a. the effective interest rate, of the project which is the interest rate r and corresponding discount factor $\delta = 1/(1+r)$ which equates project cash flows, including upfront investment costs, to 0. The IRR has some problems, including non-uniqueness when there are negative cash flows after the first period. However, it is an often used benchmark for evaluating projects and determining if they pass specified hurdle rates.

[34] For a review of evidence on implicit discount rates for projects with upfront costs and payoffs over time, see Kleindorfer and Kunreuther (1999).

Of course, these results are computed on an as-if basis, based on observed behaviour, and they do not imply that project DMs are actually using a discounted NPV-type model. In particular, the high implicit discount rates found in laboratory and empirical studies could just be an indication of faulty logic or of very myopic decision making. Other explanations include alternative discounting models (e.g., hyperbolic discounting), risk aversion or ambiguity concerning returns far into the future, and budget constraints.[35] Debiasing remedies for excessively high implicit discount rates are the same as for myopic decision making.

Complexity and Ambiguity: Complexity (in understanding the cause and effect chains that link decisions to outcomes) often translates into ambiguity about returns. Beginning with Frank Knight's work on risk and uncertainty, and continuing through observations by John M. Keynes, Frank Ramsey and the philosophers of the Vienna School in the 1930s, the subject of "ambiguity" has remained an interesting area in the decision sciences.[36] More recently, work on the descriptive side of this question has highlighted the fact that laboratory subjects and decision makers "in the field" behave very differently under conditions of ambiguity than under conditions of well-specified risks. In particular, DMs tend to avoid situations where ambiguity is present. In terms of EE projects, this translates into not undertaking projects which may appear cost effective to external experts but are seen as either too complicated or too ambiguous to invest. Undoubtedly, complexity and ambiguity are central barriers to cost-effective EE investment. The critical debiasing approaches to improve choice for projects that are so affected are information dissemination and technical assistance from trusted sources. Prototype projects by contemporary businesses in the country and sector in which EE is to be stimulated are very central in overcoming perceptions of ambiguity and complexity. In the same vein, a company or government agency that can facilitate technical and financial assistance can play an important role in overcoming this barrier. This is perhaps the reason for the rise of Energy Service Companies (ESCOs), which we will discuss in greater detail below.

5.2: Implications for Improved EE Project Risk Management

Summarizing the above, we can note the following generic strategies for improving risk management and decision making for EE projects.

- Cures for myopia and complexity include 1st party cures in the form of rational valuation process (see sections 3-4 above); 2nd party cures in the form of technical assistance, packaged approaches by ESCOs and informed loan officers with solid EE knowledge; and 3rd party cures in the form of guarantees from credible sources.

- If ambiguity and intertemporal effects are troubling, the most basic approach would be to improve the certainty of EE projects through credible contracting and guarantees. Performance-based contracting through ESCOs is discussed in this regard in section 7.

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[35] For a review and critique of this research, with special attention to the context of decision making by poor people, see Krupka (2008).

[36] The work of Knight (1921) is the most well known in this area. For a review of theoretical and empirical literature on ambiguity and its relevance to project investments and legitimation, see Kleindorfer (2010).

- Knowledge (a.k.a. epistemic) risks can be reduced through better measurement systems and the spread of best practices through benchmarking, promotion of good management practices (see section 4) and easily understood demonstration projects.

In line with the basic question posed in this Report, a central factor identified in many studies on behavioural finance and economics are the impeding factors of myopia and inappropriate discounting of returns. There is by now a rich literature on these factors in economics and a general recognition that upfront investments for risky projects are especially prone to these effects, the consequence of which is typically to delay or disregard entirely profitable investments. Related to these phenomena are also epistemic risks (complexity or knowledge-based risks) which together with risk or ambiguity aversion can also undermine investment incentives. While these effects are not specific to developing countries, they can be expected to be especially pronounced in the developing world where access to capital and guarantees is difficult to begin with, and may be compounded with other behavioural effects. Solutions to these behavioural effects include the usual recipes of correct pricing, better information and financial and technical brokerage activities to arbitrage myopic or inappropriate risk perceptions through aggregation of risks and technical advice across projects.

The multiplicity of risks (capital, regulatory, market, operating and natural hazards) is a central aspect of the difficulty for industrial energy project managers to value and prioritize these risks to assure themselves of reasonable security and positive value from energy conservation projects. As noted in section 3 above, the traditional approach to risk management consists of discovery, assessment, management and (preparation for) disruptions/crisis response, covering the general factors in the figure above. A serious problem for industrial project managers emerges when the first stage of vulnerability discovery (what are the risks facing a project?) is either omitted altogether or undertaken in a haphazard fashion. The result of this is that project risks are not properly identified, and therefore they are neither mitigated nor reserved for in terms of project planning and resources. A full analysis of each of these classes of risk for industrial energy projects is beyond the scope of this report, as each of these depends on the details of the technology in question, as well as on location and market interface issues. Section 4 above notes best practices for indentifying and mitigating the risks that would undermine the implementation of potentially profitable energy efficiency projects in industry. These practices include good measurement, responsive management systems and a causal framework connecting potential vulnerabilities affecting efficiency and cash flows to project parameters. Absent fact-based assessment of the baseline case and energy conservation improvement alternatives, the prospects for the identification of profitable energy efficiency projects and their successful implementation are likely to be bleak.

For very large projects, connecting risk management and insurance is one area where some progress is being made for industrial projects in developing countries.[37] The area of CAT-linked parametric securities both have the potential for dealing with some types of risk (namely those which arise largely through factors not under the direct control of the manager or contractor for an energy project, for example risks from natural hazards and other major calamities). Weather-related derivatives can also provide some protection against losses in larger energy projects, or

[37] A discussion of current prospects and needed improvements in this particular area of risk management in the context of weather-related events connected to climate change is provided in Kleindorfer (2009).

groups of projects in a region, e.g. risks arising from non-storm weather events such as lack of rainfall with its consequences for micro-hydro projects. The scope for using these tools depends on a number of factors such as accurate and robust sensory devices that would allow parametric triggers to be properly defined. Improved data and GIS mapping can also be important for insurance risk modellers in defining and pricing these insurance instruments.

Among economists, the most important signal to promote proper risk management is transparent pricing. In the area of risk management, this begins with an explicit recognition of the risks themselves by the project initiator/owner. What is not understood will certainly not provide the basis for appropriate mitigation or reserving activity. Beyond this elementary point, however, the usual problems of subsidies of energy will surely continue to be a fundamental barrier to the proper valuation of the risks of energy efficiency projects and ultimately to the undertaking of these projects. Thus, a central element from a policy perspective in the context of UNIDO is to continue to press for market-based prices of energy and carbon. Together with mechanisms for improved information, as well as technical and programmatic support for high payoff areas in energy conservation, market-based prices provide the mainstay of identifying and improving energy efficiency in a sustainable manner.

6. Carbon Pricing and CDM Credits

Driven by concerns with the impact of industrial activity on climate change, there has been considerable activity in the past decade directed towards measuring and limiting man-made emissions of the primary greenhouse gases (GHG), CO_2, Methane and N_2O.[38] An index of CO_2 equivalents is used to reflect total GHG emissions. The primary focus for the energy sector has been on CO_2 itself, however, and that will be our focus here. The Kyoto Protocol of 1997, which came into full force in 2005, requires countries in Annex I to the Protocol (the developed countries) to establish measures to limit their annual GHG emissions by on average 5.2% below 1990 levels in the first enforcement period 2008-2012. Extending the Kyoto agreement, defining new targets for 2020 and 2050 and agreeing on the most efficient private sector mechanisms to fight climate change were some of the major agenda items in the 2009 United Nations Climate Change Conference in Copenhagen (COP15). While COP15 did not lead to specific outcomes or targets, the resulting Copenhagen Accord did embody a renewed sense of urgency in keeping overall global surface temperature increases below the $2^{o}C$ level and requires countries to submit to the UN before the end January 2010 a list of their next targets and actions (non-binding) to reduce their GHG emissions. The negotiation process is still very much alive and will most likely lead to more stringent targets to reduce CO2 emissions for the post 2012 period. Thus, even though there is uncertainty about how these new targets will affect the size of the carbon market (today dominated by the European Union Emissions Trading System, EU-ETS), and the demand for carbon allowances, and therefore the carbon price, it seems a safe bet that such pricing will be an essential feature of the economic landscape going forward.

[38] See Munasinghe (2009) for an excellent introduction and overview of the background to the sustainability debate and on the critical role that climate change could play in developing countries. Indeed, as Munasinghe notes, the sustainability framework provides the foundation for the discussion of EE in development.

Implementing targets agreed to under the Kyoto Protocol is left to individual countries that do so through a mix of regulations, taxes, standards and market mechanisms. In particular, the Kyoto Protocol defines three “flexible mechanisms” which are designed to lower the overall costs of achieving Annex 1 emissions targets. . They include 1) International Emissions Trading; 2) The Clean Development Mechanism (CDM - generation of compliance carbon credits from projects in developing countries) and 3) Joint Implementation (JI - generation of compliance carbon credits from projects in other Annex 1 countries). These mechanisms enable developed countries to purchase emissions reductions from other Kyoto signatories where the marginal cost of emission reductions may be less than they are domestically.

Following the success of SO_2 and NO_x markets in the USA, emissions trading (aka ‘cap-and-trade’) has been favored over other emission reduction schemes such as the imposition of a carbon tax, although there is also an agreed place for carbon taxes on the policy agenda, especially in the transport sector and in other retail energy markets where CO2 emission sources are too numerous to bring under a cap and trade system. Under a cap and trade system, a target cap on emissions from covered sectors (typically the most energy-intensive sectors in the economy) is imposed on an annual basis. The implication of this for an electric power company or a cement manufacturer with facilities operating in a Protocol country is that the company must measure its CO_2 emissions throughout the year, subject to audit, and for each calendar year the company must then provide to its Kyoto Regulator (the agency in the country certified to collect and verify emissions data) emissions credits at some defined date after the calendar year has been completed. For example, in the European Union (EU), which is treated as a single country for the purposes of the Protocol, companies’ verified emission data for the previous calendar year must be provided to the Member State registries (which in turn forward it to the Community Independent Transaction Log - CITL) no later than April 15th of the following year. The system is relatively straightforward to understand once the country targets have been established and the covered sectors are defined.

What is the source of these carbon credits for a given company covered by the cap and trade system? To start with, the government in each country may give out “free allocations” to the company at the beginning of the year, perhaps based on a benchmark such as 80% of emissions levels for some previous year’s demand served and for the mix of technologies used in the focal year by the company or sector. Secondly, some of the total cap target may be auctioned off at the beginning of the year. Thirdly, the company may purchase (or sell if it has excess) credits on the open market. There is now a very active carbon market in Europe.[39] Given the annual accounting for emissions liabilities, the focus is on the end of December futures contract for delivery of credits. However, there is an active options and swap market also developing in Europe. Finally, the company can buy emissions credits from brokers, or directly invest in CDM or JI offset projects. JI and CDM projects themselves might rely for part of project financing from

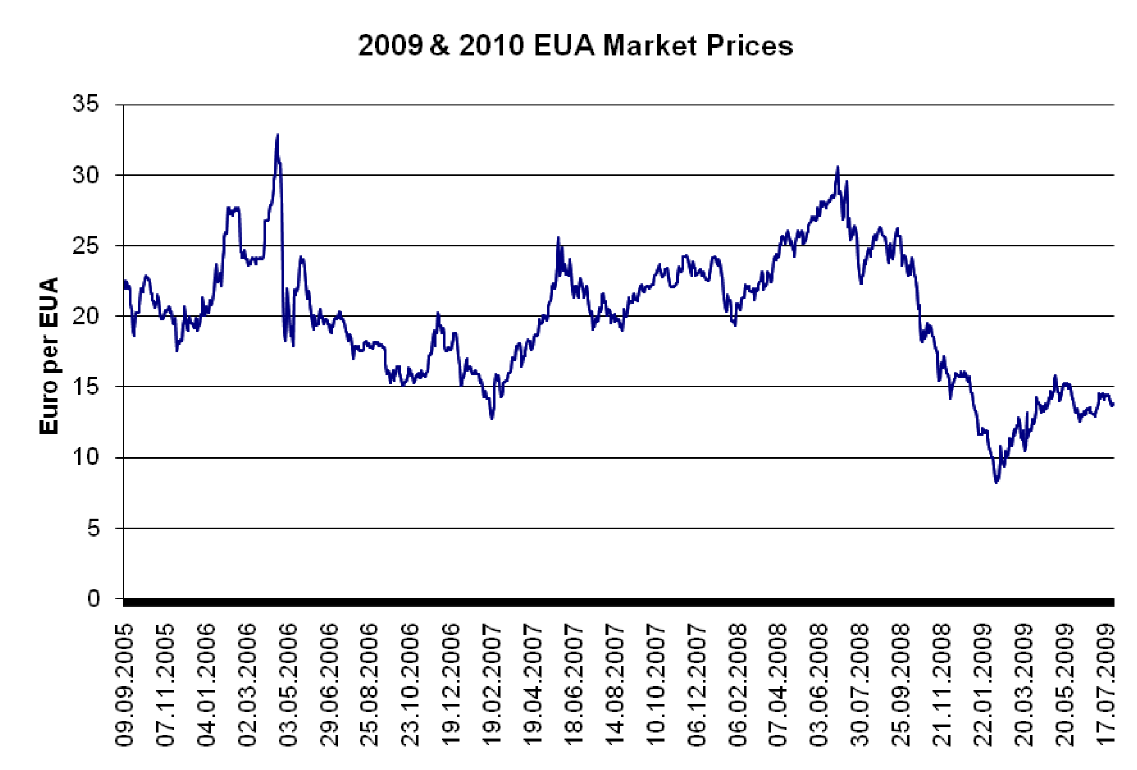
[39] See Mansanet-Bataller and Pardo (2008) for an introduction to the infrastructure of carbon markets in the EU. See also the data on carbon trades and prices at New Carbon Finance, a research and information provider for the market: http://www.newcarbonfinance.com/.

the carbon offsets generated by the project and sold forward on the carbon market. CDM projects (or their JI equivalents) are verified by their country Kyoto-authorized regulators (known as Designed Operating Entities, or DOEs) on the basis of their additionality (generation of emission reductions that would not have occurred under a business as usual scenario). This certification will typically be given for a period of 7-10 years following project completion.[40] The resulting credits for a CDM project are called Certified Emission Reduction Units (CERs), and the resulting credits for JI projects are called Emission Reduction Units (ERUs). Each credit is equal to a carbon allowance (1 tCO2e) and may be used by countries or companies that are required to meet Kyoto targets as part of their portfolio of verified coverage of emission liabilities. What is important for our discussion of project risk management and finance is that carbon credits from EE projects can be certified and the certification itself is worth money, proportional to the CO2e tons of additionality offsets certified.

From a risk management and project finance perspective for a focal company, the key question is how much are such carbon offsets likely to be worth for a given EE project? To answer this question, one needs to understand a bit more about the markets for CERs. I will focus on the EU here, as that is the best developed market thus far for CERs (though the USA is expected to soon have its own cap and trade system and there is already a significant voluntary market for CERs in the USA).

Prices for CERs are quoted in $/ton of CO2 and allow the holder to emit one metric Ton of CO2 (or its equivalent in other GHGs) throughout the period of the contract. Trades are quoted from 5.000t- 50.000t with 5.000t increments on the European Trading Scheme (EU-ETS), the market platform for trading carbon in the EU. CER prices are slightly below EU emission Allowance (or EUA) prices as the EU-ETS has CER import limits. Once obtained by a broker, however, both CERs and ERUs are essentially equivalent to EUAs in that either of them can be used by covered facilities in the applicable time period and going forward (subject to national import limits). Prices for CERs and EUAs have been highly volatile (see Figure 4 below) ranging from 0 to 30€ in the EU-ETS. This volatility has been the result of an early excess of allowances granted to compliance players which flooded the market, and more recently to the recession which lowered the level of economic output and thus GHG emissions.[41] The market has now settled down and can be expected to provide continuing support for CDM projects.

[40] See CDM rulebook: http://cdmrulebook.org.
[41] See Mansanet-Bataller and Pardo (2008) for a discussion of the market behavior in the first three years of its operation. Structure of carbon markets and instruments traded is surveyed in Barclays Capital (2008).



Suppose a focal company in a developing country undertakes an EE project which is expected to reduce emissions by 10,000 tons of CO2e for each of the next three years, and gets its project registered by the UN Executive Board. What additional revenues would such a project generate (above and beyond any basic energy savings it might generate)? The answer is the value of 10,000 CERs in the international CDM market. The focal company would first obtain the certification and the CERs that go with it. It would probably contact one of the many brokers now active in buying these CERs to value and purchase these CERs. This is so because most EE projects are not large enough on their own to warrant a company setting up its own carbon trading operations. Rather, an international broker will have to aggregate a number of these in order to have tradable quantities of CERs. The broker might negotiate a fixed price for delivery of the 10,000 CERs at some fixed date (usually the end of the calendar year) for each of the next three years. Or the broker might negotiate a price benchmarked on the ETS price that obtains at some specific date for CERs deliverable at the end of each of the three years. Each of these would have different risk implications for the focal company. In either case, however, the basic price the focal company should expect (minus brokerage and sales fees) can be obtained by looking at the current price of futures contracts on the EU-ETS for the calendar years in question. The earlier the project is in its development stage, the higher the discount to current market prices will be when selling the credits forward (to reflect project development risk). These prices are market determined and transparent.[42]

[42] Further hedging of the cash flows from CERs can be undertaken using standard hedging techniques. See Kleindorfer and Li (2009) for details on this rather technical matter. It should be noted, however, that once a

Summarizing, the establishment of cap and trade systems in the EU and elsewhere can be expected to provide continuing support for carbon abatement associated with EE projects. However, at least for the near future until the Kyoto Protocol is renewed and new targets are set for GHG reductions, there are likely to be only regional markets, largely separated in operations and even in price, rather than a single global market for carbon. To date, and notwithstanding the transactions costs and uncertainties of registration, pricing of carbon offsets in developing countries has led to an active market[43] for CDM projects and their associated CERs. The resulting credits have been used interchangeably with EUAs in Europe and in voluntary markets elsewhere to indicate for covered facilities in Kyoto signatory countries and for companies pursuing voluntary targets that their emissions are within desired limits. For large projects (say generating 10,000+ tons of CO2e offsets), one-off deals can be set up with international brokers for the project itself. For smaller projects, ESCOs or Utilities will tend to be aggregators of carbon credits and will often bundle the benefits of such revenues into their pricing of individual projects. In either case, the value of such CERs for an EE project will not usually be sufficiently large to be a determining factor of whether or not to undertake the project, but these CER revenues can nonetheless add from 5% to 10% in incremental cash flows to projects which are already at or near desired hurdle rates.

6.1: CDM Credits as Co-financing--the Highveld Steel & Vanadium Corporation

The case of the Transalloys Manganese Alloy Smelter Energy Efficiency Project of Highveld Corporation was introduced in Section 2. This is a good example of a CDM-enabled project in a high-energy intensive company. Let us revisit this case here to understand the role and risks of CDM credits in project finance. Recall from our discussion in Section 2.1.4 that this project was to retrofit Transalloy's arc furnaces to make them more energy efficient.

> The Highveld Transalloys Manganese Alloy Smelter Energy Efficiency Project would almost certainly not have taken place without the prospect of CDM credits as a co-financing mechanism.

Recall also that the initially calculated NPV at the Company's internal cost of capital yielded a negative NPV

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country has adopted a carbon pricing system, such as cap and trade, then carbon-intensive sectors such as cement, steel, pulp & paper, etc, will definitely find it in their interest to establish competencies in measuring, reducing and valuing carbon, including the establishment of carbon trading competencies for hedging carbon liabilities. This is not yet the situation in the developing world.

[43] Total transactions throughout 2008 on the carbon market were worth $118bn, representing 4bn tonnes of carbon allowances changing hands. The dominance of the European Union Allowance (EUA) market continued with EUAs accounting for 70 % of the volume of carbon emissions traded in 2008 and 80 % of the value. Secondary or "guaranteed" Certified Emission Reductions (CERs), the main currency of the Clean Development Mechanism, have steadily increased their market share from 8% in 2007 to 13% by 2008, and in 2008 accounted for transactions worth over $14bn. Credits bought directly from CDM projects - the primary CER market – fell by around 30% in 2008 compared to 2007 from an estimated 551mt ($7.4bn) to 381mt ($5.8bn). .By the end of 2009 New Energy Finance expects the global carbon market to be worth $122bn – a 3% increase on 2008 – and predicts a market of $1.9tr by 2020. Source Press Release, 26 October, New Energy Finance. See http://www.newenergyfinance.com/.

in traditional terms. The total initial investment cost for Transalloys' furnaces to be retrofit was around $17.5 million. Total annual savings from electricity and O&M costs were predicted to be $2.4 million/yr. Even if investment costs or savings could be improved somewhat, the project was not financially viable without the CDM credits that might accrue to the project from CO2 emissions savings against a BAU scenario. However, the ensuing CDM project evaluation led to a conservative estimate of projected savings of over 500,000 tons of CO2 over the life-time of the project (saving approximately 50,000 tons a year over a 10-year horizon of the CDM certification). When valued at the low end of expected CO2 prices in the EU market (of say 12-15 Euros per CER credit), these annual carbon revenues would amount to another $0.6 to $1.0 million/year, and were enough to drive this project solidly into the black. Highveld decided to undertake the project, even before being achieving registration of the project to enable CDM credits.

To obtain the CDM credits, and the associated revenues in the carbon market, Highveld engaged Ecosecurities to prepare their CDM certification papers. This process took more than a year to complete, and the credits were approved only effective July 28, 2008, however with retrospective grants of credits to the project for the first three years of CO2 emissions offsets.[44] The Highveld Transalloys Manganese Alloy Smelter Energy Efficiency Project would almost certainly not have taken place without the prospect of CDM credits as a co-financing mechanism.

At the same time, this project illustrates two significant sources of risk for obtaining such CDM-based co-financing. The first risk apparent here is the risk of the amount and timing of the additionality offsets themselves, i.e. what will be allowed as offsets against a business-as-usual scenario and when will the registration process for the project be completed. Projects offsets are, of course, the fundamental basis for obtaining the CER credits that can then be sold. The second risk apparent in this case is the magnitude of the transactions costs of applying to the UN under the CDM process. While there are standards and rules for the application, there is also considerable judgment required in executing these rules. Together with timing uncertainty associated with the registration process, it is difficult in practice to count on a specific cash inflow for co-financing of EE projects using CDM-based CER credits. Added to this are the uncertainties associated with renewal of the Kyoto Protocol in 2012, and the picture is even cloudier.

7. The Role of ESCOs and Performance-based Contracting in Mitigating Risk

An Energy Service Company (ESCO) is a business that develops, installs, and finances projects designed to improve the energy efficiency of public and private sector organizations.[45] ESCO contracts normally involve some sort of risk sharing or guarantees of performance and often

[44] The time and complexity to file for this project for CDM certification is by no means unusual, as the reader can see by consulting the completed project registry of the CDM UNFCCC at http://cdm.unfccc.int/Projects/. Indeed, the complexity of the filing for CDM credits, and the time and expertise it takes to file these, is one of the standing complaints of the CDM project development community.

[45] See Vine (2005), Bertoldi et al. (2006) and Taylor et al. (2008) for surveys of practices related to ESCOs. The theory of ESCOs and performance-based contracting is developed in Aflaki and Kleindorfer (2010).

extend over several years following project completion. A typical ESCO project would be a contract with a business to change lighting fixtures in its administrative offices, yards and access routes to provide the same luminescence for these areas, but at lower energy consumption. A contract to accomplish this might specify that the project developer would, at his own cost, change the lighting fixtures in return for, say, half of the savings against a specified baseline of energy consumption for the building in question for the following two years after project completion. This same model, applied to heating and street lighting and many other applications, has become an important element in the developing business models of ESCOs. As explained in Taylor et al. (2008), and illustrated in the cases earlier in this report, the ESCO model has also been important in driving EE in industry in developing countries. The primary reason for this is that an ESCO packages expertise, implementation capacity and financial channels into one-stop shopping, delivering EE at lower transactions costs than if a business tried to act as its own general contractor for EE project.

Notwithstanding the benefits of financial guarantees or technical knowledge provided by ESCOs, ESCO projects are still complicated. First and foremost, customers often lack knowledge of the factors influencing their current energy consumption and the opportunities for reducing it. Major projects can be disruptive of daily routine, and may involve a relatively large upfront investment and an uncertain payback period. These factors have given rise to a number of different ESCO contract types in the market to attempt to mitigate these risk factors. These contracts are usually performance-based, in which some portion of the ESCO's future earnings from a project depends on the success of the project. Such risk sharing between the ESCO and a focal customer can take several forms. In the guaranteed savings contract (GSC), the ESCO collects a fixed sum from the customer up front, but the fixed sum is set so that (over some agreed period of time) there is a reduction in the customer's expected bill relative to business as usual. In the shared savings contract (SSC), the ESCO and the customer agree on a benchmark performance standard (usually relative to the status quo) and then share in the measured performance difference between the benchmark and achieved performance after project completion. In the pay from savings contract (PSC), the ESCO self-finances the project and may pay an additional lump sum to the customer, essentially 'buying' the project from the customer, but then the ESCO enjoys the full benefits of cost savings going forward. One may think of the PSC project as an outsourcing arrangement from the customer to the ESCO, in which the customer is guaranteed of required energy for a building or industrial facility for some period of time, and in which the ESCO bears the full responsibility for operations and garners any profits generated relative to some specific benchmark scenario.

There are many factors to be considered in choosing the right contracting form, including the nature of energy and carbon price uncertainty, and the degree to which the customer can affect energy savings through changes in their post-contract behaviour. Moreover, the ESCO business model is typically pitched to segments of customers, and not single customers. Thus, marketing and sales stratgegies are important in developing particular technologies and expertise by in the ESCO and in determining service attributes and pricing for relevant market segments.[46]

[46] The examples given in this section are based on discussions with Dr. Ulrich Kaier, CEO of EC BioEnergie GmbH, a Heidelberg-based ESCO specializing in renewable energy and performance-based contracting.

Moral hazard in contracting exists when one of the contracting parties can affect outcomes that have material consequences for the other party under the terms of the contract. A typical example of this in performance-based ESCO contracting would be changes in behaviour on the part of the Customer, after a project has been implemented, that would influence payments between the Customer and the ESCO. In terms of changes in demand, the usual way of handling such potential sources of post-implementation conflict is good measurement and clear benchmarks against which to judge consumption and savings, but available procedures for dispute resolution and respect for contracts per se are important elements of any forms of contracting requiring payments over time. This is just where problems emerge in many development contexts. For example, the case study of Sri Lanka described above is interesting in that there is minimum exposure to the ESCO from light bulbs on credit. Similarly, the case reviewed above of SELCO in India represents a case in which SELCO could repossess solar panels and related batteries in case of customer payment default. For more ambitious projects, credit worthiness and financial guarantees, either to the Customer or to the ESCO are essential to allow the ESCO performance-based contracting to proceed. These issues of risk management, default and guarantees are central barriers in developing countries. They generally emerge as by-products of the ability to "trust" contractual agreements underlying ESCO projects. This trust, in turn, is based on two reinforcing elements that are often missing in developing countries:

(a) Contractual enforceability, the "stick" of business agreements: if contractual clauses cannot be enforced because of mistrust in effectiveness of local justice system, then many other instruments need to be put into place to safeguard project performance requirements. These instruments will naturally affect the boundaries and tone of negotiations over the life of the project.

(b) Tested relationships: Emerging countries create new fast growing players with limited "shared (working) history". This gives rise to limits in sourcing of projects and in the willingness to embark on such schemes with untested partners.

Central Challenges for ESCO-type Performance-based Contracting Arrangements

- Weak contractual enforceability and resulting need to either obtain upfront financing or complex project performance safeguards.
- Weak or untested relationships among the parties necessary to assure the success of a project

Some examples will help to illustrate the types of performance-based contracting that might be used in different types of EE projects, the types of risks associated with these, and the contract terms dictated in part as an attempt to mitigate these risks.

Energy conservation through better building controls, windows and/or insulation of a building are capital intensive projects, ultimately owned by the Customer. Ordinarily an ESCO would be interested in a GSC contract to cover these. Based on experience and on engineering calculations, the ESCO would also offer a short-term (e.g., 3 to 12 months) guarantee, both for workmanship as well as for initial savings. Longer-term guarantees would be risky for a number of reasons and are normally avoided for these types of projects. The reasons include unexpected changes in environmental parameters over time and the difficulty of specifying a longer term benchmark against which to measure savings, as well as enforcing contract terms.[47] Third-party finance (banks or special funds) can be used to provide customers with the required funds to pay for these projects, isolating the ESCO from credit risk on the part of the Customer. Financing may be provided by a separate financial sub-division of the ESCO for larger projects with either good default options or external guarantees provided by the government or trustworthy international lenders.[48]

Lighting projects that provide improved energy performance for given illumination standards for buildings or public spaces including parking lots and entry roads to facilities are a further interesting example. For buildings or spaces with constant and verifiable use patterns (as in city street lighting or office building uses), is possible, subject to clearly articulated illumination standards and usage patterns. A typical example would be the replacement of existing lights and fixtures in a commercial or administrative building with lower wattage light bulbs and reflective surfaces on fixtures, maintaining fixed luminescence output. Measuring the energy savings from such an application is straightforward. If variable usage patterns are involved, then timing total usage is an additional requirement, leading to the calculation of total savings. This type of arrangement is by now very common in lighting applications, and when backed by the local distribution utility (as in the Sri Lanka example described earlier), billing procedures can be modified to provide easy financing mechanisms for customers.

Larger energy projects, including outsourcing arrangements are clearly the most challenging and yet the most impactful EE projects. An example discussed above was the substitution of a biomass boiler for a natural gas or oil-based boiler for heating and process heat for a manufacturing company. Such projects entail significant risks. A company would not engage an ESCO to implement such a project unless they had great confidence that the project would be executed carefully and that the projected savings from the project were real. The SSC form of performance-based contracting is a means of providing assurance to customers of the confidence the ESCO has in results. SSC contracting is typically used where the implementing company continues to own and operate the assets provided by the project (e.g., a replacement boiler or a co-generation facility). However, the PSC is coming into play for outsourcing arrangements. Both contract types have numerous conditions on standards of operating performance, and on non-performance penalties for service interruptions, specified as part of the contract.

A typical SSC in practice would be a quarterly fixed fee paid from the Customer to the ESCO for the period of the contract, plus any operating expenses the ESCO has to incur to provide on-going service to the Customer, plus some share of the savings arising from the project. A typical outsourcing PSC arrangement would engage the ESCO to set up, own and operate a replacement energy system for a company's current system. The ESCO might even pay the customer for the opportunity to operate such a system, with the Customer then paying the ESCO fixed and variable monthly fees over the period of the contract that serve to compensate the ESCO for its upfront investment and for its on-going costs (this is essentially the model used by the Denying Shandong Energy Management Company described earlier in this report). Terms of the

[47] I am indebted to Jean Pasternak, Carbon Strategy and Alliances Director of Schneider Electric (China), for valuable insights on ESCO risks related to contracting in developing countries.
[48] For example, see the description in Taylor et al. (2008, pp. 162-167) of the GEF-supported Loan Guarantee Program launched in 2003 to support ESCO financing in China.

agreement would include energy output and quality standards, maintaining temperature limits for HVAC, providing process steam of specified temperature and pressure and other matters that specify the Customer's needs. The ESCO would bill the company on an on-going basis for operating costs, and typically provide a guarantee of savings relative to the total energy bill or unit energy costs for the preceding baseline time period. Given the complexity of these arrangements, and the size of the financial risks, SSC contracts without third-party guarantees would only be viable between relatively large Customers and ESCOs which were both reliable and credit worthy.

The above three types of projects illustrate the variety of contracting forms seen in practice. One might ask what the actual payoff has been from ESCO projects and whether the ESCO model is an appropriate one for EE projects in developing countries. A survey of existing ESCOs and their performance is provided in Vine (2005), Bartholdi et al. (2006) and Taylor et al. (2008). The recent report Okay and Akman (2009) revisits the data of Vine (2005) and provide additional insights on the likely impact of ESCOs. They conclude that the early data (prior to 2003) suggests that ESCOs are not yet equipped to deal with major industrial applications, focusing instead on lighting and simple building retrofits. However, the recent data is beginning to show larger movements toward sectoral projects of reasonable size, such as cogeneration and large biomass projects. Several large investment funds are being put in place at this time, and major investments in BRIC countries (Brazil, Russia, India and China) are now taking shape that build on the ESCO concept. [49] The jury is still out, however, as to whether ESCOs and performance-based contracting will be able to fill their promise in relieving the fundamental barriers of industrial EE projects in the developing world. ESCOs could well be part of a workable solution going forward, perhaps sponsored by investments from large multinationals like ENEL, GE and Schneider Electric with significant EE expertise. This will depend on whether such companies can foster trust in ESCO activities, and can provide the capital to finance these activities (possibly with additional sponsorship from governmental or international organizations).

8. Summary: Principles for Effective Risk Management for Industrial EE Projects

The above overview of risk management underlines several important principles for project development and implementation of cost-effective EE projects in developing countries. Most importantly, effective risk management of industrial projects includes the following:

- Reliable measurement so that a company understands its baseline energy consumption, including how much of its energy is used to actually provide useful work rather than waste;[50]

[49] Private equity funds are beginning to emerge for BRIC and BASIC countries, where EE is viewed as a foundation for future development. See also the detailed studies on Brazil, China and India in the Three Country Energy Efficiency Project (2006). For a discussion of early ESCO initiatives in Russia, see Efremov et al. (2004).

[50] This basic point is central in the convincing argument made by Ayres and Warr (2009) that a great deal of energy in manufacturing activities in both the developed and developing world does not lead to useful work being done. The exergy framework they develop is central to mapping energy to useful work, but even intuitive frameworks that attempt to map a facility’s total energy onto its activities can begin to produce useful insights on EE.

- Management systems and responsibilities to identify win-win EE projects, including approaches to rational project evaluation and project management;

- Tested and stable technologies to harvest EE and credible demonstration projects that promote trust in their profitability;

- Financial and technical expertise that will provide the necessary competence and resources for project implementation.

The major question, which remains largely unanswered for EE in developing countries, is what factors would cause the above outcomes to occur. That is, what are the leverage points for setting in motion forces and incentives that will give rise to industrial practices reflecting the above outcomes? From UNIDO's perspective, such leverage points might include the following:

- Clustering of applications by sector, including demonstration projects, tools and easily understood examples of EE practices that work;

- Using local and national government initiatives and communication programs to highlight likely areas of high payoff for individual sectors and countries and to communicate available resources for accomplishing these;

- ESCOs and their role as part of private market activity in promoting cost-effective EE, especially in view of the fact that many profitable EE projects go unharvested because of simple lack of awareness of the payoffs from these projects by company management;

- The role of carbon credits and the payoffs from improving the CDM process in terms of timing risks, additionality risks, and project preparation costs;

- Cooperation with international finance organizations, including the World Bank but also NGOs and philanthropic organizations, to help align financial support with effective project practices and results;[51]

- The role of management education in developing countries in promoting effective project management techniques and in highlighting the payoffs from EE.

By emphasizing the role of company managers in the EE process, including their knowledge and the constraints they face, effective risk management provides a valuable framework for identifying and implementing cost-effective EE projects. However, getting the attention of busy managers in industrial enterprises in the developing world and providing proven and profitable recipes in the EE area for them to use remains a central problem. The above leverage points remain to be understood and exploited if we are to harvest the potential of EE projects to create value for the economy and the planet.

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[51] See, e.g., the GiveWell ranking process (at http://GiveWell.org) that has been effective in pointing out "good practices" and cost-effective results for non-profits working on social problems. Rankings of good practice on operational systems and project evaluation can have beneficial effects in generating private philanthropy for organizations that use the funding well.

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