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Return on Investment from Industrial Energy Efficiency: Evidence from Developing Countries

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Summary
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Keywords: Energy Efficiency, Energy Investment, Energy And Development, Industrial Development

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Return on Investment from Industrial Energy Efficiency:

Evidence from Developing Countries

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1. Introduction

Energy efficiency (EE) is a foundation of any good energy policy. The economic, security, and environmental benefits of EE have been recognized for decades. This paper focuses on the economic rationale for industry to invest in EE, and presents results from financial analysis of 119 projects surveyed across nine manufacturing sub-sectors. While, a large EE investment-related literature exists (see e.g., Abadie et al., 2012; DeCanio, 1993; DeCanio, 1998;Gudowska-Nowak et al., 1997; Harris et al., 2000; Hu, 2012; Jackson, 2010; Nair et al., 2010; Sandberg and Söderström, 2003; Sanstad et al., 1995; Scott et al., 2008), the empirical results in this paper focus solely on developing countries.

Among the principal barriers to the full implementation of EE technologies and practices, is access to finance. This financing gap and the associated barriers are well documented. Today there are a suite of understood, targeted and innovative financial policies and measures from which policy makers can draw upon. This paper, unlike the bulk of the literature, focuses on issues surrounding the financing of energy savings projects and ventures[2] in developing countries. Although the incentives vary considerably between sectors and countries, the policy levers and financial mechanisms are often not dissimilar.

The finance sectors in developing countries often are not familiar with the technical details of EE projects, and the scale is usually too small to be handled directly by International Financial Institutions (IFIs). Moreover, the economic return of EE projects is embedded in the cost savings generated – i.e., EE projects often use energy savings as a revenue stream and do not create any collateral for loans (see e.g., Vine, 2003 and Ayers, 2010). Such non-asset based business models appear excessively uncertain and risky to many financial institutions – especially in developing countries. Nonetheless, we provide evidence that returns of EE projects are often higher than other types of investments even in these markets.

This paper first briefly describes the scale of investment in EE technologies and practices and reviews the most common tools used to promote and finance investments in EE in developing countries. It focuses on the profitability of EE investments in surveyed firms, and presents the internal rate of return (IRR) of these investments in order to better assess their profitability, which was originally gauged using simple payback methods. Considerations on the remaining issues and barriers to financing EE in developing contexts conclude the paper.

2. Financing precedents

In 2009, estimates by SEFI (2011) show that new investment in EE technologies amounted to US$5 Billion; a 17% increase from the previous year. Investment data shows a clear positive trend of new investment in EE, with an average growth rate of 28% in the 2004-2009 period. Farrell et al. (2008) estimate that the global investment potential to abate energy demand growth from increased energy productivity is roughly US$170 Billion a year. Almost half of it is accounted for by the global industrial sector (US$83 Billion annually).

The barriers to this investment are complex and range from behavioral to structural and technical – they are also widely documented (see e.g., Rohdin et al., 2007; Weber, 1997; DeCanio, 1993; UNIDO, 2011). The lack of available financial resources for EE projects is often not only due to a shortage of funds. Rather, the core of the problem is to be found in the intricate mix of high risk perception, high transaction costs and “difficulties in structuring workable contracts for preparing, financing, and implementing EE investments (Taylor et al., 2008)”. In developing countries, the problem is often not a general shortage of funds, but the lack of available funds at the local level (ESMAP, 2006).

A wide range of financial and economic mechanisms have been developed by both public and private sector to ease investments in EE. These mechanisms and tools address the specific gaps along the finance continuum (see e.g., MacLean et al., 2008; UNEP, 2006) in three main areas: technology innovation, EE ventures and EE projects (Makinson, 2006). UNECE (2010), Makinson (2006), MacLean et al. (2008) and Gielen (2009), among others, provide overviews of the key financing mechanisms for EE projects and technologies. Some of the most common issues that typically affect the application of these mechanisms in developing countries are briefly addressed in the remainder of this Section.

[2]We do not distinguish between manufacturing firms and service sector firms.

Although many EE projects pay for themselves through the generated savings, financing is usually needed to cover energy audits, energy advisory services, new energy efficient equipment, installation and monitoring (Makinson, 2006; ESMAP, 2006; UNIDO, 2011). Publicly or privately-backed risk sharing mechanisms can support financial institution lending for sustainable energy projects. Credit enhancement mechanisms (guarantees, partial credit, partial risk guarantees and loan loss reserve funds, among others) in both developed and developing countries have leveraged private resources and facilitated access to capital (Kadison, 2010; Mostert et al., 2010).

The lack of liquidity of local financial institutions associated with EE investments can be, *inter alia*, addressed by way of concessional credit lines for senior and subordinated debt, or interest rate subsidies. These are usually facilitated by national and international development finance institutions to fill the financing gap in new, immature markets[3]. In developing countries, this lending might be required to finance relatively low-cost measures such as the implementation of Energy Management Systems (EnMS) or those resulting from the improvement of operational practices (McKane et al., 2007; Taylor et al., 2008; UNIDO, 2011).

We now consider the profitability of EE investments, by reviewing the existing literature and providing the evidence from a survey we conducted in selected developing countries.

3. Profitability

Profitability remains the biggest driver for any investment in industry; EE technologies and projects are no exception. Luckily, the economics of investments aimed at improving EE are attractive. Still, in most case such potential remains largely untapped in both OECD and developing countries (see e.g., Worrell et al., 2001b; Taylor et al., 2008; UNIDO, 2011).

In the United States, Nelson (1989), Nelson and Rosenberg (1993), USDOE (2010), Tonn and Peretz (2007) and UNIDO (2011) provide strong evidence of the profitability of EE projects at firm level, with typical payback periods of one to two years, an average return on investment of around 200%, and yearly savings of up to US$100 Million, average energy savings of 30% and positive impact on job creation. Studies on the European experience lead to similar conclusions (see e.g., Worrell et al., 2001b; Jochem and Gruber, 2007; and UNIDO, 2011). Worrell et al. (2001b) review the case of 70 manufacturing companies in six OECD countries.[4] Their findings indicate longer average economic payback periods (4.2 years) and combined net savings of around US$28.5 Million.

The evidence from developing countries is considerably less documented. Taylor et al. (2008) found that more than four fifths of 455 World Bank–financed projects in 11 developing countries had payback periods of less than 30 months. Farrell and Remes (2009) estimate that lower-income economies could slow the annual growth of their energy demand from 3.4% to 1.4% by 2020. Moreover, about two thirds of the "available profitable EE opportunities are located in developing countries" (Farrell and Remes, 2009).

4. The UNIDO industrial EE survey

UNIDO (2011) conducted a survey of 357 manufacturing companies across several sectors in 25 developing countries inquiring about their EE practices and investments[5]. A central selection criterion for the survey was for firms to have invested in at least one project with the aim to reduce the use or costs of energy. The surveyed firms had approved 119 of such projects. The typical project size was below US$100,000[6]. Investments were in the areas of direct equipment replacement (36%), waste reuse (14%), residual temperature reuse (14%), pipes and insulation improvements (13%), improved use of infrastructure (12%), and fuel optimization (11%).

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[3]For a review of credit lines and soft loans successfully put in place in developing countries (see e.g., Salazar, 2004; ECLAC, 2010 for Latin America; Makinson, 2006 for Eastern Europe; Van den Akker, 2008; APERC, 2010; Lefevre, 2009; Levine and Liu, 1990; Liu et al., 1994; Sinton and Levine, 1994; Worrell et al., 2001a for Asia; and the cases of South Africa and Tunisia in Africa).

[4]The sample includes firms from different industries: food manufacturing, building materials, steel manufacturing, paper manufacturing, chemicals manufacturing and textile manufacturing.

[5]Follow-up phone and face-to-face interviews were conducted with selected firms to deepen the understanding of their investment decision-making and EE operations.

[6] Investments in energy-efficiency projects totaled US$613.7 million, and individual investments ranged from US$100 to US$73 million (UNIDO, 2011).

The survey found that the EE investment decision making process is driven by a traditional payback approach: more than 90% of surveyed firms in developing economies used simple payback rules to assess the financial viability of EE projects, with an average payback period of 23 months. The survey found that more in-depth financial assessments, such as internal rate of return calculations, were performed only for larger projects. Although the use of simple payback methods to justify EE investment decisions is common practice also in developed economies, it is often inadequate to accurately assess the real costs and benefits of investments, and to compare alternative projects (Brealey et al., 2008; Lefley, 1996; Remer and Nieto, 1995; Prindle, 2010; UNIDO, 2011).

We analyzed the sample to calculate IRR of EE investments recorded in the survey (Gordon, 1955; Holland and Watson, 1976; Lefley, 1996; Newnan, 1969; Sarnat and Levy, 1969). We assumed no resale value and conducted sensitivities on the useful life of projects to determine IRRs comparable across project types. Three-year projects reported an estimated mean IRR of 25%. As expected, the estimated rate rose with longer life-spans: 37% for the 4 year case, 43% for 5 years, and 50% for 10 years. These rates show higher profitability for EE projects in comparison with average returns in capital markets over similar timeframes. In addition, the profitability of financial investments in countries with high interest rates tends to be eroded by typically higher inflation, which supports the case for investing in EE, especially over longer periods. Estimated IRRs varied considerably across sectors. The sample displayed lower rates of return in projects in process sectors, such as chemicals and cement, than in the case of product sectors, such as equipment manufacturing and automotive (Table 1).

Table 1: Project returns by sector and lifespan

Sector	Number of Projects	Investment (US$)	Payback Years	IRR 3 Years	IRR 4 Years	IRR 5 Years	IRR 10 Years
Automotive/Autoparts	4	98.250	1,93	26%	37%	43%	51%
Cement/Ceramics	15	43.702.213	2,19	18%	29%	36%	45%
Chemicals	14	26.370.874	2,90	2%	14%	21%	32%
Equipment manufacturing	16	9.538.587	2,10	20%	32%	38%	47%
Food & Beverages	9	2.684.000	1,10	74%	83%	87%	91%
Metal	14	4.882.517	1,50	45%	55%	60%	66%
Paper	12	6.249.000	0,90	96%	105%	108%	111%
Textile	22	3.204.540	2,20	17%	29%	36%	44%
Others	13	23.602.000	2,40	12%	24%	31%	40%
All Cases	**119**	**120.332.181**	**1,95**	**25%**	**37%**	**43%**	**50%**

Note: The estimated IRRs are mean values for each respective lifespan.

Analysis of the returns yielded by different types of projects indicates a strong case for systems optimization: improvements in the use of infrastructure, sealing pipes and improving insulation yielded considerably higher IRRs than direct equipment replacement (Table 2). At the same time, relatively smaller (less than US$10,000) projects involving process reorganization were highly profitable. Many projects of this type were reported in paper, food and beverages, and textile firms. By contrast, US$100,000 investments or higher, entailing equipment replacement yielded far lower IRRs and were economically justified only with a 5 year timeframe or longer.

Table 2: Project returns by type of investment and lifespan

Type of Investment	Number of Projects	Investment (US$)	Payback Years	IRR 3 Years	IRR 4 Years	IRR 5 Years	IRR 10 Years
Better Use of Infrastructure	14	458.132	1,20	65%	74%	79%	83%
Direct Equipment Replacement	42	36.455.746	2,70	5%	18%	25%	35%
Fuel Optimizing	12	1.467.156	1,50	45%	55%	60%	66%
Pipes and Insulation Improvements	19	10.373.757	1,30	57%	67%	72%	77%
Residual Temperature Re-Use	20	49.835.719	2,20	17%	29%	36%	44%
Waste Re-Use	12	21.741.671	1,60	39%	50%	56%	62%
All Cases	**119**	**120.332.181**	**1,95**	**25%**	**37%**	**43%**	**50%**

Note: The estimated IRRs are mean values for each respective lifespan.

The findings of the survey confirm the profitability of industrial EE projects. We also separated projects by the type of re-engineering undertaken (process of technology), see Table 3.

Table 3: Projects by type of change

Type of Change	Number of Projects	Investment (US$)	Payback Years	IRR 3 Years	IRR 4 Years	IRR 5 Years	IRR 10 Years
Process Reengineering	20	27.886.630	1,65	37%	48%	53%	60%
Technology Reengineering	99	92.445.552	2,00	23%	35%	41%	49%
All Cases	**119**	**120.332.181**	**1,95**	**25%**	**37%**	**43%**	**50%**

Note: The estimated IRRs are mean values for each respective lifespan.

The analysis indicates a wide range of profitable opportunities to improve EE in all manufacturing sectors. As a general trend, the data show that the higher the organizational and technical complexity of a project, the lower is its profitability. Nevertheless, many of these opportunities remain untapped, partly due to firms' lack of awareness, especially in developing countries. At the same time, with current energy prices, and indeed until environmental externalities are properly priced, many EE technologies remain unprofitable.

5. Econometric evidence

Does the relationship between investment in industrial EE and profitability also hold for a wider, representative sample of firms? To address this UNIDO (2011) conducted a study using the World Bank's Enterprise Surveys database, which provides detailed information on energy use and profits at firm level[7] (Cantore 2011; Cantore and Cali 2011)[8]. The study investigates the relationship between profitability and energy intensity (ratio of energy consumed to total sales), a proxy for EE, using a large sample of firms from 29 developing countries. The majority of surveys took place between 2002 and 2004 (the entire survey period was between 2000 and 2005) with some of the questions referring to each of the previous three years, making it possible to construct a panel dataset spanning the three years preceding the survey year.

[7]Profitability is in the study proxied by a standard measure of price-cost margin, defined as value added net of labor costs over total production.

[8]World Bank's Enterprise Surveys are conducted regularly in a large number of developing countries. Details of the database are available at www.enterprisesurveys.org/.

Realizing that other factors might influence the relationship between investment in energy intensity and profitability, the study introduces a mix of industry and individual firm level variables[9] to the regression. While the former would capture impacts on profitability stemming from differences in industry structures, the latter captures potential firm level determinants. For example, the ability of the firm's management or the business culture of the foreign ownership could influence the readiness of the firm to adopt energy savings technologies while at the same time affect its profitability. The performance of firms is dependent on tangible assets, such as financial and physical factors of production, and intangible assets, such as technology and accumulated knowledge (Teece, 1981; Barney, 2001). Moreover, fixed effects are introduced to encounter for the fact that industry and country level dynamics affecting profitability could vary over time. That being said, the short time-span of just three years greatly reduces the likelihood of large changes in unobservable firms' characteristics over time.

When controlling for firm's fixed effects and further firms' characteristics, the study finds a negative relationship between energy intensity and profitability for 27 out of 29 developing countries (see Appendix, Table A1). However, the relationship is only negative at a statistically significant level (at a 5% level[10]) in 13 countries. For the rest of the countries, the relationship is either insignificant or positive. Although these results suggest that EE may increase firms' profitability in many circumstances, due to heterogeneity they provide only partial support for the hypothesis that lower energy intensity in a firm, i.e., higher EE, is associated with higher profitability.

Cantore (2011) offers several explanations for the observed heterogeneity. First, as the results capture different energy intensity levels but not the actual timing of EE investment, a project is likely to display a mismatch between an EE investment and the benefits achieved. Secondly, different energy intensity investments are associated with different payback periods and rate of returns (UNIDO, 2011). Thirdly, different costs will cause differing impacts of EE on profitability (e.g., costs differ with specific technologies and rise with the stage of EE improvement). Finally, the readiness to adopt new energy savings technologies may be distorted due to, "policy-driven EE interventions which require payback periods for investments that are not consistent with market conditions" (Cantore, 2011).

Similar conclusions can be made when exploring the relationship between profitability and energy intensity across manufacturing sectors (see Appendix, Table A2). Sector specific regressions conducted for 24 manufacturing sectors show the same negative relationship between energy intensity and profitability. The overall negative and significant correlation is confirmed in 9 out of 15 sectors. The largest and most significant effects are found in a number of dominating sectors in developing countries, such as textiles, food, beverages, wood and furniture, but also in sectors such as chemicals and pharmaceuticals and IT services. However, heterogeneity is again present as the effect from energy intensity to profits is insignificant in agro-industry and construction, two important sectors for developing countries.

Although the study finds a clear relationship between energy intensity and profitability in several developing countries, caution is required if taking these results as general evidence that investment in EE in developing countries boosts firm profitability[11]. Indeed, stronger evidence of the negative energy intensity-profit relation is found on the manufacturing sector level, indicating that sectoral factors might be at play. As fodder for further research, the determinants of the proven heterogeneity should be investigated further by focusing on some of the country and industry characteristics that help EE boost profitability.

6. Conclusions

EE is widely recognized as the foundation of a low-carbon path for industrial production. Accelerating EE investments needs requires a better understanding of the economic, environmental and social benefits for manufacturing and financial firms of energy saving technologies and practices in developing countries. Decades of implementation of EE projects and ventures have shaped a set of financial mechanisms to foster investments in

[9] Firm level variables included age, number of workers, value of investment in equipment, ownership (foreign or domestic) and whether the company exported or had ISO90000 certification for good management practices (Cantore and Cali, 2011).

[10] A significance level of 5% is accepted as the highest level where the null hypothesis is still rejected.

[11] Cantore and Cali (2011) takes this as evidence of a no-trade off relationship between the adoption of energy saving technologies and profitability irrespective of the country's average adoption rate of energy saving techniques in firms. A comprehensive debate on the optimal timing of the adoption of new technologies exists in the economic literature (see e.g., Choi, 1994; Farrell and Saloner, 1986; Koski and Nijkamp, 2000).

energy savings technologies and practices. However, the investment delivery mechanisms need "localization" in order to be effective in developing countries. Improvement of EE financing mechanisms necessarily implies sustained efforts to create enabling institutional, financial and industrial settings.

As an example, good regulation is essential to the success of stimulating EE investment. In certain situations, regulation *is* the market for EE[12], as in the case of mandatory EE obligations for utilities (Waide and Buchner, 2008; UNECE, 2010). Utility DSM programs work best in countries where the utility industry is relatively responsive to public sector mandates, and where EE efforts are combined with power factor correction or load management efforts that are in the interests of the utility (Banerjee, 2005; Ellingson and Hunter, 2010).

Although not implemented to its full potential, many types of energy savings projects are technically sound and profitable today in developing economies. While more econometric research may be warranted, we have provided further evidence in support of the case for the profitability of EE investments. It is likely, however, that many firms, especially in developing countries, are still unaware of these opportunities.

[12]See e.g., World Bank, 2004 and SOTUGAR, 2008 for the Tunisian case; CNI, 2009 for Brazil.

References

Abadie, L.M., Ortiz, R.A. and Galarraga, I., 2012. Determinants of Energy Efficiency Investments in the US. *Energy Policy,* In Press.

APERC (Asia Pacific Energy Research Centre), 2010. *Compendium of Energy Efficiency Policies of APEC Economies*. Tokyo. Available at: <www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf>.

Ayers, R.U., 2010. *If Energy Efficiency Pays, Why Is It Not Happening?* Background paper prepared for the UNIDO 2011 *Industrial Development Report.* Vienna: United Nations Development Organization.

Banerjee, R., 2005. *Energy Efficiency and Demand Side Management (DSM) in India.* Background paper submitted to Integrated Energy Policy Committee, Government of India 2005.

Barney, J.B., 2001. Resource-Based Theories of Competitive Advantage: A Ten Year Retrospective of the Resource-Based View. *Journal of Management,* 27(6), pp. 643-650.

Brealey, R.A., Myers, S.C. and Allen, F., 2008. *Principles of Corporate Finance.* 9th edition. New York: McGraw Hill/Irwin.

Cantore, N., 2011. *Synthesis: Energy Efficiency in Developing Countries for the Manufacturing Sector. WP 15/2011*. Vienna: United Nations Industrial Development Organization.

Cantore, N. and Cali, M., 2011. Profitability and Energy Efficiency: A Firms Fixed Effect Approach. In *Synthesis: Energy Efficiency in Developing Countries for the Manufacturing Sector,* ed. Cantore, N. WP 15/2011. Vienna: United Nations Industrial Development Organization.

Choi, J.P., 1994. Irreversible Choice of Uncertain Technologies with Network Externalities. *RAND Journal of Economics*, 25(3), pp. 382-401.

CNI (Confederação Nacional da Indústria), 2009. *Achievements in Brazil, Cost Reductions Opportunities and the International Experience*. São Paulo. Available at: <www.cni.org.br/portal/data/files/FF8080812727C7C601272AB85A85600C/Industrial%20energy%20efficiency%20-%20august%202009.pdf>.

Decanio, S.J., 1993. Barriers Within Firms to Energy-Efficient Investments. *Energy Policy,* 21(9)**,** pp. 906-914.

Decanio, S.J., 1998. The Efficiency Paradox: Bureaucratic and Organizational Barriers to Profitable Energy-Saving Investments. *Energy Policy,* 26(5)**,** pp. 441-454.

ECLAC (Economic Commission for Latin America and the Caribbean), 2010. *Energy Efficiency in Latin America and the Caribbean: Situation and Outlook*. Santiago.

Ellingson M. and Hunter, L., 2010. *Compendium of Best Practices: Sharing Local and State Successes in Energy Efficiency and Renewable Energy from the United States*. Vienna: Renewable Energy and Energy Efficiency Partnership; Washington, DC: Alliance to Save Energy; Washington, DC: American Council On Renewable Energy.

ESMAP (Energy Sector Management Assistance Program), 2006. *The Energy Efficiency Investment Forum: Scaling Up Financing in the Developing World.* Workshop Proceedings Series 005/06. Washington, DC.

Farrell, D. and Remes, J., 2009. Promoting Energy Efficiency in the Developing World. *McKinsey Quarterly Economic Studies*, February.

Farrell, D., Remes, J., Bressand, F., Laabs, M. and Sundaram, A., 2008. *The Case for Investing in Energy Productivity*. New York: McKinsey Global Institute.

Farrell, J. and Saloner, G., 1986. Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation. *American Economic Review*, 76(5), pp. 940-955.

Gielen, D., 2009. *Design of a Financing Instrument for Energy Efficiency and Renewables in Indian SMEs*. Vienna: United Nations Industrial Development Organization.

Gordon, M.J., 1955. The Payoff Period and the Rate of Profit. *The Journal of Business*, 28(4), pp. 253–260.

Gudowska-Nowak, E., Papp, G., Brickmann, J. and Thompson, P.B., 1997. Evaluating Energy Efficiency Investments: Accounting for Risk in the Discounting Process. *Energy Policy,* 25(12)**,** pp. 989-996.

Harris, J., Anderson, J. and Shafron, W., 2000. Investment in Energy Efficiency: A Survey of Australian Firms. *Energy Policy,* 28(12)**,** pp. 867-876.

Hu, Y., 2012. Energy Conservation Assessment of Fixed-Asset Investment Projects: An Attempt to Improve Energy Efficiency in China. *Energy Policy,* 43**,** pp. 327-334.

Holland, F.A. and Watson, F.A., 1976. Payback Period, Discounted Cash Flow Rate of Return and Added Value for Manufacturing Processes. *Engineering and Process Economics,* 1(4), pp. 293–299.

IEA (International Energy Agency), 2008. *Energy Efficiency Policy Recommendations.* Paris

IEA (International Energy Agency), 2009. *World Energy Outlook 2009*. Paris.

Jackson, J., 2010. Promoting Energy Efficiency Investments with Risk Management Decision Tools. *Energy Policy*, 38(8)**,** pp. 3865-3873.

Jochem, E. and Gruber, E., 2007. *Local Learning-Networks on Energy Efficiency in Industry - Successful Initiative in Germany*. Amsterdam: Elsevier.

Kadison, B., 2010. *Harnessing the Power of Energy Efficiency Financing: A Sustainable Mechanism for Creating Jobs, Reducing Energy Costs and Strengthening Energy Security*. Washington, DC: US. Department of Energy.

Koski, H. and Nijkamp, P., 2000. Optimal Timing of Adoption of Network Technologies. *Ricerca Operativa*, 29(90), pp. 3-38.

Laan, T., Beaton C. and Presta B., 2010. *Strategies for Reforming Fossil-Fuel Subsidies: Practical Lessons from Ghana, France and Senegal*. Manitoba: International Institute for Sustainable Development. Available at: <www.iisd.org/gsi/sites/default/files/strategies_ffs.pdfv>.

Lefevre, T., 2009. *Opportunities for Sustainable Energy Technology and CDM Development in Thailand*. Sustainable Energy Technology at Work – SETatWork. Bright Green, Copenhagen 12-13 December 2009.

Lefley, F., 1996. The Payback Method of Investment Appraisal: A Review and Synthesis. *International Journal of Production Economics*, 44(3), pp. 207–224.

Levine, M. D., Price, L., Zhou, N., Fridley, D., Aden, N., Lu, H., McNeil, M., Zheng, N. and Yining, Q., 2010. *Assessment of China's Energy-Saving and Emission-Reduction Accomplishments and Opportunities during the 11th Five Year Plan*. Berkeley, CA: Lawrence Berkeley National Laboratory.

Levine, M.D. and Liu, X., 1990. *Energy Conservation Programs in the People's Republic of China*. Berkeley, CA: Lawrence Berkeley National Laboratory.

Liu, Z., Sinton, J.E., Yang, F., Levine, M.D. and Ting, M., 1994. *Industrial Sector Energy Conservation Programs in the People's Republic of China during the Seventh Five-Year Plan (1986-1990)*. Berkeley, CA: Lawrence Berkeley National Laboratory.

MacLean, J., Tan, J., Tirpak, D., Sonntag-O'Brien, V. and Usher, E., 2008. *Public Finance Mechanisms to Mobilise Investment in Climate Change mitigation: An Overview of Mechanisms Being Used Today to Help Scale Up the Climate Mitigation Markets, With a Particular Focus on the Clean Energy Sector*. Nairobi: United Nations Environment Programme, Sustainable Energy Finance Initiative.

Makinson, S., 2006. *Public Finance Mechanisms to Increase Investment in Energy Efficiency*. Basel: United Nations Environment Programme, Basel Agency for Sustainable Energy.

McGilligan, C., Sunikka-Blank, M. and Natarajan, S., 2009. Subsidy as an Agent to Enhance the Effectiveness of the Energy Performance Certificate. *Energy Policy*, 38(3), pp. 1272-1287.

McKane, A., Price, L. and de la Rue du Can, S., 2007. *Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies*. Background Paper for the UNIDO Side Event on Sustainable Industrial Development on 8 May 2007 at the Commission for Sustainable Development (CSD-15). Vienna: United Nations Industrial Development Organization.

Mostert, W., Johnson, K. and MacLean, J., 2010. *Publicly Backed Guarantees as Policy Instruments to Promote Clean Energy*. New York: United Nations Environment Programme, SEF Alliance.

Nair, G., Gustavsson, L. and Mahapatra, K., 2010. Factors Influencing Energy Efficiency Investments in Existing Swedish Residential Buildings. *Energy Policy*, 38(6)**,** pp. 2956-2963.

Nelson, K.E., 1989. Are There Any Energy Savings Left? *Chemical Processing*, January.

Nelson, R.R. and Rosenberg, N., 1993. *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press.

Newnan, D.G., 1969. Determining Rate of Return by Means of Payback Period and Useful Life in the Engineering Economist. *A Journal Devoted to the Problems of Capital Investment*, 15(1), pp. 29–39.

Parthan, B. and Bachhiesl, U., 2007. *Barriers to energy efficiency under the clean development mechanism*. REEEP, Vienna. IEE, Graz University of Technology, Graz. Background paper for the Global Forum on Sustainable Energy - 7, Energy Efficiency in Developing Countries - Strong Policies and New Technologies. 21-23 November 2007, Vienna, Austria. Available at: <www.gfse.at/fileadmin/dam/gfse/gfse7/REEEP-IEE-GFSE07.pdf>.

Prindle, W.R., 2010. *From Shop Floor to Top Floor: Best Business Practices in Energy Efficiency*. Arlington, VA: PEW Center on Global Climate Change.

Remer, D.S. and Nieto, A.P., 1995. A Compendium and Comparison of 25 Project Evaluation Techniques. Part 2: Ratio, Payback, and Accounting Methods. *International Journal of Production Economics*, 42(2), pp. 101–129.

Rohdin, P., Thollander, P. and Solding, P., 2007. Barriers to and Drivers for Energy Efficiency in the Swedish Foundry Industry. *Energy Policy*, 35(1), pp. 672-677.

Salazar, J., 2004. *El Desarrollo de las Finanzas Ambientales en el Perú*. Lima: APOYO.

Sarnat, M. and Levy, H. 1969. The Relationship of Rules of Thumb to the Internal Rate of Return: A Restatement and Generalization. *The Journal of Finance,* 24(3), pp. 479–490.

Sandberg, P. and Söderström, M., 2003. Industrial Energy Efficiency: The Need for Investment Decision Support from a Manager Perspective. *Energy Policy,* 31(15)**,** pp. 1623-1634.

Sanstad, A.H., Blumstein, C. and Stoft, S.E., 1995. How High are Option Values in Energy-Efficiency Investments? *Energy Policy,* 23**,** pp. 739-743.

Scott, M.J., Roop, J.M., Schultz, R.W., Anderson, D.M. and Cort, K.A., 2008. The Impact of DOE Building Technology Energy Efficiency Programs on U.S. Employment, Income, and Investment. *Energy Economics,* 30(5)**,** pp. 2283-2301.

SEFI (Sustainable Energy Finance Initiative), 2011. *Global Trends in Sustainable Energy Investment 2010*. Nairobi: United Nations Environment Programme, Sustainable Energy Finance Initiative; London: Bloomberg New Energy Finance.

Sinton, J.E. and Levine, M.D., 1994. Changing Energy Intensity in Chinese Industry: The Relative Importance of Structural Shift and Intensity Change. *Energy Policy*, 22(3), pp. 239-255.

SOTUGAR (Société Tunisienne de Garantie), 2008. *Rapport Annuel 2007*. Tunis. Available at: <www.sotugar.com.tn/Rapport_annuel_2007.pdf>.

Taylor, R.P., Govindarajalu, C., Levin, J., Meyer, A.S. and Ward, W. A., 2008. *Financing Energy Efficiency: Lessons from Brazil, China, India, and Beyond*. Washington, DC: World Bank.

Teece, D., 1981. Internal Organization and Economic Performance: An Empirical Analysis of the Profitability of Principal Firms. *Journal of Industrial Economics*, 30(2), pp. 173-199.

Tonn, B. and Peretz, J.H., 2007. State-Level Benefits of Energy Efficiency. *Energy Policy,* 35(7), pp. 3665–3674.

UNECE (United Nations Economic Commission for Europe), 2010. *Financing Global Climate Change Mitigation*. Geneva.

UNEP (United Nations Environment Programme), 2006. *Improving Energy Efficiency in Industry in Asia: A Review of Financial Mechanisms*. Nairobi.

UNIDO (United Nations Industrial Development Organization), 2010. *Motor Systems Efficiency Supply Curves*. Vienna.

UNIDO (United Nations Industrial Development Organization), 2011. *Industrial Development Report 2011. Industrial Energy Efficiency for Sustainable Wealth Creation: Capturing Environmental, Economic and Social Dividends*. Vienna.

USDOE (United States Department of Energy), 2010. *Industrial Technologies Program*. Washington, DC. Available at: <www1.eere.energy.gov/industry>.

Van den Akker, J., 2008. *Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP): Final Evaluation*. Kuala Lumpur: Government of Malaysia; New York: United Nations Development Programme; Washington, DC: Global Environment Facility.

Vine, E.L., 2003. *An International Survey of the Energy Service Company (ESCO) Industry*. Berkely, CA: Lawrence Berkeley National Laboratory.

Violette, D., 2006. *Demand-Side Management: Future Role in Energy Markets*. Presented at the 2007 Energy Futures Speaker Series: Panel Discussion on Consumer Response to High Energy Prices, Meetings of the National Energy Board, 21 April, Calgary. Available at: <www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/cnslttnrnd1/pnldscssn-eng.html#s3_5>.

Waide, P. and Buchner, B., 2008. Utility Energy Efficiency Schemes: Savings Obligations and Trading. *Energy Efficiency*, 1(4), pp. 297-311.

Weber, L., 1997. Some Reflections on Barriers to the Efficient Use of Energy. *Energy Policy*, 25(10), pp. 833-835.

World Bank, 2004. *World Bank GEF Energy Efficiency Portfolio Review and Practitioners' Handbook*. Thematic Discussion Paper. Environment Department Climate Change Team. Washington, DC.

Worrell, E., Laitner, J.A., Ruth, M. and Finman, H., 2001a. *Productivity Benefits of Industrial Energy Efficiency*. Berkeley, CA: Lawrence Berkeley National Laboratory.

Worrell, E., van Berkel, R., Fengqi, Z., Menke, C., Schaeffer, R. and Williams, R., 2001b. Technology Transfer of Energy Efficient Technologies in Industry: A Review of Trends and Policy Issues. *Energy Policy,* 29(1), pp. 29-43.

Appendix

Table A1: Profitability and energy efficiency

	(1)		(2)	(3)	(4)		(5)
	Coeff	**SE**	**Coeff**	**Coeff**	**Coeff**	**SE**	**Coeff**
Bangladesh	0.59***	(0.14)	0.72***		-0.13	(0.14)	-0.19
Benin	-0.17	(0.17)	-0.10		-0.80	(0.60)	
Brazil	-0.54***	(0.10)	-0.51***	-0.51***	-0.41***	(0.11)	-0.40***
China	0.11	(0.20)	0.12		-0.64***	(0.25)	
El Salvador	0.08	(0.15)	0.15	0.15	0.12	(0.16)	0.11
Eritrea	-1.91**	(0.75)	-2.18**	-2.91***	-3.50***	(1.35)	-2.62
Ethiopia	-0.40**	(0.19)	-0.34*	-0.35*	-0.48	(0.32)	-0.70
Guatemala	-0.15	(0.10)	-0.15	-0.15	-0.77***	(0.21)	-0.83***
Honduras	-0.22*	(0.12)	-0.25*	-0.24*	-0.28**	(0.12)	-0.27**
India (2000)	0.08	(0.10)	0.00		-0.24	(0.27)	0.08
India (2002)	-0.20***	(0.07)	-0.20***		-0.27*	(0.14)	-0.11
Indonesia	-0.00	(0.06)	0.01		-0.43***	(0.13)	
Kenya	0.37***	(0.10)	0.42***		-0.11	(0.09)	
Madagascar	-1.53***	(0.19)	-1.50***	-0.83**	-2.67***	(0.99)	-1.78
Malawi	-0.42**	(0.17)	-0.38**	-0.40**	-0.98**	(0.41)	-0.99**
Mali	-0.22	(0.50)	0.65*		-0.53	(0.60)	
Mauritius	-0.30***	(0.10)	-0.28***	-0.34***	0.02	(0.12)	0.05
Morocco	-0.23**	(0.09)	0.00		-0.51**	(0.21)	-0.43**
Mozambique	-0.25	(0.16)	-0.17		-0.75	(1.19)	
Nicaragua	-0.01	(0.12)	-0.03	-0.04	-1.60***	(0.30)	-1.56***
Pakistan	0.08*	(0.04)	-0.22	-0.14	-0.11***	(0.04)	0.00
Philippines	0.41***	(0.09)	0.44***	0.45***	-0.35*	(0.18)	-0.37*
Senegal	-0.87***	(0.22)	-0.81***		-1.24***	(0.21)	
South Africa	0.19	(0.31)	0.27	0.39	-3.41***	(1.18)	-3.57**
Sri Lanka	-0.35***	(0.11)	-0.38***		-0.51*	(0.29)	
Tanzania	0.27*	(0.16)	0.13	0.51	0.07	(0.08)	-0.02
Thailand	0.31***	(0.07)	0.34***	0.16	-0.26	(0.27)	0.05
Uganda	0.39***	(0.09)	0.40***		-0.01	(0.12)	
Vietnam	0.79***	(0.08)	0.81***	0.84***	-0.14	(0.11)	-0.21
Zambia	0.10	(0.34)	0.02	-0.03	-1.19	(0.74)	-1.15
Age (ln)			0.01***	0.01***			
Workers (ln)			0.01***	-0.00			-0.02
Equipm (ln)				0.01***			-0.01*
Exporter			0.01***	0.02***			
Foreign			0.02***	0.02***			
ISO				0.01			
Work sq (ln)							0.00
Eq. sq. (ln)							0.003*
Fixed eff.							
Industry-year	YES		YES	YES	YES		YES
country-year	YES		YES	YES	YES		YES
Firms	NO		NO	NO	YES		YES
Observations	40781		31635	15296	40781		24523
Adj. R-sq.	0.093		0.101	0.088	0.754		0.749

*Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is value added net of labour costs over total sales value. The value for each country indicates the value of the coefficient of energy intensity in the different specifications.*
Source: Cantore and Cali (2011)

Table A2: Profitability and energy efficiency, regressions by manufacturing sector

	Coeff.	S.E.	Obs	Firms	R-sq.
Textiles	-0.221***	(0.070)	5267	2016	0.023
Leather	-0.229*	(0.125)	1612	621	0.041
Garments	-0.190**	(0.078)	7242	2793	0.029
Agro-industry	-0.042	(0.123)	816	352	0.069
Food	-0.261***	(0.092)	5300	2080	0.042
Beverages	-0.281***	(0.049)	226	105	0.208
Metals and machinery	-0.257	(0.214)	3652	1455	0.082
Electronics	-0.063	(0.105)	3336	1253	0.012
Chemicals and pharmaceutics	-0.294**	(0.139)	3089	1339	0.044
Construction	-0.477	(0.831)	218	92	0.145
Wood and furniture	-0.485**	(0.217)	3603	1454	0.056
Non-metallic & plastic mater.	-0.211*	(0.117)	2228	907	0.074
Paper	-1.206	(0.863)	481	189	0.127
Sport goods	-5.799	(3.788)	129	44	0.224
IT services	-2.164**	(0.917)	301	120	0.099
Other manufacturing	0.053	(0.412)	758	301	0.047
Telecommunications	-0.918	(1.276)	99	35	0.018
Accounting and finance	0.143	(1.278)	64	26	0.162
Advertising and marketing	-0.117	(0.556)	95	39	0.016
Other services	-0.872***	(0.224)	180	64	0.624
Mining and quarrying	-0.194	(0.203)	47	18	0.089
Auto and auto components	-1.011	(0.731)	1950	708	0.042
Other transport equipment	0.028	(1.499)	45	17	0.123
Other industries	0.274	(0.160)	33	11	0.041

*Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is value added net of labour costs over total sales value. All regressions include firms and country-year fixed effects. The coeff.column indicates the value of the energy intensity coefficient of the industry.*
Source: Cantore and Cali (2011).

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