Global Supply-Chain Energy Efficiency in Small and Medium Sized Enterprises

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Rising energy prices, new governmental regulations and incentives, increases in corporate environmental responsibility and customers’ increasing ecological awareness have pushed energy efficient manufacturing and production into the spotlight. Industrial energy plays an important role in a government’s national emissions or a company’s supply chain emissions and thus both governments and companies are striving to identify the most effective measures to increase industrial energy efficiency. The industrial sector is one of the main consumers of energy as well as one of the largest emitters of CO2, consuming nearly one third of total global primary energy supply and causing 36% of energy-related CO2 emissions [1]. In addition to its size, opportunities for improved efficiencies are substantial. It is estimated that potential primary energy savings in the industry sector, through the adoption of available best practice commercial technologies, is 18-26% of industrial consumption or 5.4-8.0% of total global energy consumption [2].

From an individual firm perspective, these energy efficiency investments are often a no or low cost proposition. Particularly in the industrial and commercial sectors, many energy efficiency projects carry the promise of substantial financial returns within only a few years. In addition, incentive programs to increase adoption of energy efficiency practices are numerous, most of which are government funded or run by utilities in the context of demand side management. Yet these tools have not provided sufficient incentive for companies to take action on energy efficiency investments at a seemingly justifiable scale. It is estimated that energy use can vary by a factor of 2 to 3 between the most and least energy efficient firms in a sector [3] and that the average firm implements less than two thirds of recommended and economic projects [4], [5]. Although $43 billion was spent on energy efficiency improvements in the United States alone in 2004, amounting to 1.7 quads of energy savings [6], the market potential is much larger according to analysts. Energy cost savings could amount to $900 billion by the year 2020, with investment opportunities on the order of $170 billion annually [7]. Therefore, much of the literature on energy efficiency has sought to understand decision-making, and at the risk of oversimplification, identify the degree to which market and behavioral failures lead to suboptimal adoption rates or where policy interventions might correct for them [8].

While this body of work has done much to illuminate what has come to be known as the “energy efficiency gap,” scant research is currently available addressing the inter-organizational supply chain responsible for a “saved kilowatt hour” or the emerging role of creative financial and operational approaches to bundle and commoditize global energy efficiency assets across small to medium sized enterprises (SMEs). Only recently have management and policy scholars begun to evaluate the role of private sector companies in delivering cost effective energy savings to end users across the supply chain [9]. As such, energy service companies (ESCO) are devising innovative methods to deliver complete packages of technologies, operational support and financing to clients. Financial institutions, in search of new markets, are beginning to explore financial mechanisms targeting energy efficiency. Large manufacturing and retail brand owners (Walmart, Ikea, Tesco, Herman Miller, Pepsi, etc.) are investing in supply chain energy efficiency programs both within their own operations and in upstream suppliers to address corporate-level sustainability

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NGOs (EDF, WRI, CDP, etc.) and transnational organizations (UN, World Bank, IFC, etc.) are increasingly engaging industrial energy efficiency implementation and finance among smaller, less sophisticated and less capitalized enterprises. And, governments are focusing new energy efficiency policies at SMEs. Achieving national or corporate environmental and energy targets must include SMEs and large, enlightened, supply chain actors might be an effective lever toward motivating and scaling SME energy efficiency projects.

While the size of the problem and the importance of reaching further upstream into industrial supply chains has sparked countless pilot projects and experimental programs, little evidence of successful outcomes has been found to exist – leaving companies, governments and NGOs with little knowledge toward effective strategies or policies for supply chain energy efficiency targeting SMEs. A recent Institute for Industrial Productivity (IIP) report summarizes the on-the-ground energy efficiency landscape in China largely as a interconnected web of barriers: structuring efficiency projects is difficult and unconventional; no generally accepted measurement and verification standard exists for energy savings; energy efficiency projects are often small and scattered; financial institutions do not understand energy-saving technologies or trust savings projections; banks are risk-averse and reluctant to change their existing procedural frameworks for energy efficiency projects, ESCOs are themselves often small with limited technical and credit histories, host enterprises in rapidly growing economies prioritize sales growth over cost/energy efficiency, success has largely been concentrated in a very limited number of credible large clients [10].

The carbon and local emissions reductions associated with overcoming these obstacles in the very near term are tremendous. In China alone, the energy efficiency investment to meet new policies implemented under the 12th FYP (2011-2016) is estimated at nearly US$189 billion, with corresponding savings of 400 Mtce [10] – roughly the total electricity consumption of California and New York, combined. At current trajectories, this opportunity will likely be squandered. To alter this path, new concerted efforts to develop critical data infrastructure on supply chain energy efficiency across projects, facilities, material/product supply chains and industrial sectors is paramount. Platforms for increased coordination, rapid prototyping and information sharing across demonstration projects are needed to dramatically increase the speed and quality of deployment. Parallel assessment, evaluative, analytical and modeling approaches to research are imperative to describing and understanding the agents of change, their implications on the unfolding transformation of socio-technical energy systems and developing policies and strategies to meet future challenges.

The symposium on Global Supply Chain Coordination and Industrial Energy Efficiency in SMEs at Wingspread will specifically address the development of these vital enablers for future development, bringing to light expert assessment of current theory and practice across the industrial energy efficiency program-project continuum and the globe. This short document summarizes a select subset of the energy efficiency literature in an effort to motivate discussions. Rather than attempting to cover the totality of the debate across advocates and critics, we present a stylized “straw-person” argument to stimulate thinking and conversation. We propose a working hypothesis that the world of industrial energy efficiency has changed with the entrance of: (1) large downstream customer firms formalizing energy management and carbon reduction incentives, and (2) the global manufacturing power of China and its explicit mandate for energy efficiency to extend much deeper into supply chains. As such, we suspect that a more comprehensive view of current and potential efforts targeting supply chain energy efficiency may illuminate very different paths forward from the largely facility-level adoption or sector-level energy savings opportunity studies so pervasive in the literature. We argue that the field is ripe for reopening dialogue and approaches to program/policy design, project demonstration, data infrastructure, and research.
Energy Efficiency in Small and Medium Sized Enterprise

The idea of governments incentivizing energy efficiency is not new. Subsidies and funding schemes are widely used across the globe. Many, though not all, of these programs target SMEs and are typically used to pay for technical actions such as audits, energy management, equipment investment and R&D [11]. One of the most documented programs is the US Department of Energy’s Industrial Assessment Centers (IAC) program, which has been providing no cost energy audits to small and medium-sized manufacturers since 1976. A review of nearly 40,000 individual projects across over 9,000 US facilities participating in the program concluded mixed results, in terms of energy efficiency adoption [4]. Although more than half of recommended projects were adopted, only the lowest hanging opportunities were pursued – projects with average investments of less than $5,000 and simple paybacks of 1.02 years. The same study suggests that SMEs are about 40% more responsive to investment costs than to energy savings, suggesting that policies to reduce implementation costs may be somewhat more effective than various mechanisms that raise energy prices [4].

While programs like IAC are important efforts to reduce informational barriers to energy efficiency adoption (i.e. reducing the high up-front transaction costs of gathering, assessing and applying information about energy saving potentials and relevant technologies), significant informational, financial and organizational barriers continue to challenge SMEs – and these challenges vary significantly across sector, region and organizational size. Major barriers include: lack of time, other priorities for capital investments, lack of access to capital, lack of budget funding, cost of production disruption and inconvenience, technical risk of future production disruptions, and difficulty of obtaining information on the energy use of purchased equipment [12–15].

Particularly in the industrial sector and among SMEs, the vast majority of literature has suggested public and private energy efficiency initiatives be targeted at increasing the financial attractiveness of projects (e.g., subsidized loan programs, loan guarantees, tax breaks/subsidies for implementation, energy/carbon taxes, etc.). Financing barriers often span well beyond access to capital. Issues of information asymmetries, transaction costs, perceptions of risk and limited capacity and knowledge of financial markets by small ESCOs or industrial process efficiencies by loan officers and risk managers (Figure 1).

![Figure 1. Financing Barriers to Industrial Energy Efficiency [16]](image)

National governments and programs facilitated by transnational organizations have increasingly implemented programs addressing energy efficiency finance. Germany’s Special Fund for Energy Efficiency in SMEs provides SMEs with low interest loans for investment in energy conservation measures. In Japan, a government-affiliated financial institution provides low interest loans for funding for the introduction of energy conservation systems. In the UK, the Carbon Trust runs an interest-free loan scheme for energy efficiency investment of SMEs, with loans ranging from £5,000-400,000, depending on technology and region. In France, a loan guarantee fund with a budget of approximately €18 million for energy efficiency investment of SMEs (FOGIME) was created with the ability to guarantee up to €244 million in loans to the
private sector. In the US, the mandate provided by Title XVII of the Energy Policy Act of 2005 allowed the Department of Energy (DOE) to invite pre-applications for up to $2 billions in loan guarantees. A comprehensive analysis of global energy efficiency policies (Table 2) can be found at [11].

China’s 12th Five Year Plan (2011-2015) builds directly on previous efforts targeting large (predominantly state-owned) enterprises, extending the scope of the Top-1,000 Energy-Consuming Enterprises program to a Top-10,000 program. The plan sets a new national target to reduce energy intensity by an additional 16 percent by 2015 and requires enterprises to invest in energy efficiency improving measures, develop energy reporting and auditing systems and report results quarterly to the National Bureau of Statistics. This policy environment, paired with the scale of China’s manufacturing sector, has resulted in an explosion in the ESCO industry, supported by NGO and transnational organizational programs. IFC’s China Utility-Based Energy Efficiency Finance Program (CHUEE) program, which started in 2006, is aimed at stimulating energy efficiency investments in China through two main instruments: bank guarantees for energy efficiency loans and technical assistance to market players, including utilities, equipment vendors, and energy service companies, to help implement energy efficiency projects. As of end-2011, the CHUEE program’s participating banks have provided loans totaling close to $700 million, far exceeding the target of around $500 million. CHUEE is currently setting up a $558 million risk-sharing facility with partner Chinese banks that is specifically dedicated to supporting small and medium enterprises, as most of the program’s beneficiaries have been large companies [17]. The original expectation was that 60 percent of the guaranteed loans would be small (about $0.2 million). However, by mid 2009, the average loan size was $5.7 million, and loans of $0.2 million or less constituted less than 10 percent of the actual portfolio. Moving down market to smaller companies with sufficient scale to generate meaningful CO2 reduction remains a key challenge.

Implementing Global Energy Efficiency Finance

While many mechanisms exist for implementing energy efficiency (utility-based programs, rebate programs, labeling schemes, etc.), the bulk of energy efficiency finance is in one form or another dependent on performance-based contracts. Energy performance-based contracts can be generally classified into three types: shared savings contracts; guaranteed energy savings contracts; and outsourced contracts [18]. In Shared Savings Contracts, assets created by the project are generally owned by the ESCO, with the contract specifying payments to the ESCO based on an agreed percentage share of an estimated minimum cost savings scenario at normal asset operation. With Guaranteed Energy Savings Contracts, assets typically belong to the client, but designed and implemented by the ESCO under financial guarantees for performance. Finally, Outsourcing Contracts allow for the direct sale of heat, electricity and energy services from assets owned or acquired by an ESCO over an extended period of time. While useful for discussion purposes, it is important to note that great variation exist making it difficult to compare types across countries, and a variety of hybrid approaches have been developed. In nearly all cases, an energy service company (ESCO) establishes the overall project design, manages most project implementation aspects, and guarantees energy savings performance, but, financing, contract, asset ownership and risk-sharing arrangements vary. Of course, where clients have specific needs or concerns, ESCOs often will vary contractual arrangements. However, if ESCOs are looking to banks or other financial institutions for project loan financing, it is important for project payment regimes to be as fixed and predictable as possible.

Again, on the global stage, China is emerging as an important arena in the development of energy efficiency implementation and finance. With energy performance contracting investment in 2010 totaling more than US$ 4.24 billion, the business volumes of China’s industry are now on par with those of the ESCO industry in the United States (Figure 2). China’s energy performance contracting business has grown remarkably fast over the past decade, developing contractual practices, business models and market approaches that are
distinctly adapted to the Chinese market where almost three-quarters of energy performance contracting investment occurs in industrial sector projects.

Figure 2. Energy Performance Contracting Investment in China 2003-2010 (million US$)

The Role of the Material and Energy Supply Chain Coordination

For much of the past three decades, the imperatives of cost efficiency and customer responsiveness have resulted in the pervasive pursuit of two basic business strategies, globalization and time-based competition [19]. Globalization – motivated by cost minimization, access to new markets, economies of scale, etc. – has led to the emergence of borderless organizations with globally located suppliers and production/distribution facilities. Time-based competition, by contrast, has been driven by more exacting customers, demanding a wide variety of products with minimal lead-time. However, significant increases in risk and complexity of the supply chain function have come along with the benefits that companies have realized as a result of globalization and just-in-time manufacturing.

Recent research has identified major risks that emerge in global supply chains optimized for speed – supply chain disruption and discontinuity [20], inconsistent or inadequate product quality [21], unpredictable delivery times [22], and substantial, unanticipated additional costs stemming from reputational to natural hazards [23], [24]. Many of these risks are exacerbated by the increasing geographical scope of firms’ supply chains that expose supply chains to a variety of cultural, legal, administrative, linguistic, and political issues [25], [26]. Thus, from a supply chain resiliency perspective, the wisdom of adopting a number of publicly-proclaimed “best practices” comes into question – including supply base reduction, global and supply cluster sourcing, and the broad implementation of lean production systems (i.e. reduce inventory, shipment sizes, production batches; frequent just-in-time delivery; rapid-response logistics; central warehousing, mass customization, etc.). This has fueled interest in green supply chain management and many organizations are recognizing the need to influence operations that fall outside the direct control of a single business unit or manufacturing facility, and taking a full life cycle approach to improve the environmental impact of their products and services. In the case of greenhouse gases, companies seeking
to reduce policy or reputational risks associated with these emissions often find that their direct emissions are dwarfed by the emissions in their supply chains [27]. In fact, across industries, companies’ direct emissions average only 14% of their supply chain cradle to gate emissions [28].

By far the most documented case of corporate efforts to reduce environmental impacts in its supply chain, is Walmart [29]. Walmart is widely cited in the academic and popular press as profiting from its actions to reduce greenhouse gas emissions (and increasingly water use), in its own operations and its supply chain. Walmart has been successful in capturing cost reductions (energy efficiency being a central strategy), new sources of revenue, improved employee motivation, enhanced public relations, and increased voice with policy makers through this strategy [27]. Efforts to manage upstream energy and carbon impact are not, however, restricted to Walmart. Dell, Ford, Unilever, Pepsi, Best Buy and countless others, often times in conjunction with NGO partners such as the Carbon Disclosure Product, Environmental Defense Fund, World Resources Institute, etc., have put in place reduction targets and initiatives focused on upstream and downstream supply chain impacts.

These pressures drive firms and governments to increasingly include SMEs in the environmental improvement process of entire supply chains. A supply chain base, as well as a country’s industrial base, primarily consists of SMEs. For example, 93.5 percent of the suppliers in the Korean automobile industry are SMEs [30], and China’s 2.4 million SMEs make up 99% of all enterprises in that country, accounting for more than half of all of China’s emissions and pollutants [31]. Achieving national or corporate environmental targets must include SME suppliers [32].

Conclusions and Next Steps

Increasing sustainability risks to the resiliency of time-sensitive global supply chains, coupled with the need to reach further up and down the supply chain for solutions, are at the heart of energy efficiency implementation growth as we move into the next decade. A complicating and not well understood factor is that while increased coordination of supply chain actors is likely needed for large scale deployment of energy efficiency investments across the industrial sector, at least two distinct yet interacting supply chains require integration. A central focus of our work at Wingspread next week leans on the proposition that improved integration of energy efficiency supply-chain actors (financial institutions, utilities, energy service companies, factory/facility management, brand owners, retail giants, etc.) provide new and potentially fruitful avenues for aggregation and commoditization of energy efficiency assets deployed at SME facilities. These supply chains, necessary for the creation of a “saved kilowatt hour”, must not; however, decrease the robustness or resiliency of the material (or product) supply chains associate with large, enlightened brand owners. Understanding this tension between short-term stress to the material supply chain and long-term resiliency and advantage of less environmentally and socially impactful supply chains is paramount – ultimately changing the optimization function from cost reduction or profit maximization to a multi-criteria approach. Implementing this transition will require an additional set of suppliers external to the material supply chain implementing energy efficiency upgrades and legitimizing carbon reduction strategies; suppliers assembled and coordinated toward identifying, assessing, accrediting, financing, and implementing energy and carbon improvements (Table 1).

We hope that this review provides a starting point for conversation and additional inquiry; it also begs a number of questions for symposium participants: (1) How might the inclusion of SMEs alter approaches taken by governments and companies working toward energy efficiency investments? (2) What additional risks and opportunities of SME energy efficiency exist for governments and supply chains? (3) How might increased supply chain coordination facilitate energy efficiency improvements in SMEs? (4) How does the development and effectiveness of the energy efficiency supply chain impact the stability material/product
supply relationships? (5) Where do leverage points exist in the industrial energy efficiency system if new information from coordinated research, data infrastructure, and demonstration was available?

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<tr>
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<th>Frames of reference for securitization</th>
<th>Potential role in aggregation</th>
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<tbody>
<tr>
<td>Governments</td>
<td>PACE</td>
<td>Governments can match investors and clients for loan programs and provide loan guarantees. They can develop standard contracts.</td>
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<td></td>
<td>Bonds</td>
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<td>Small Business Administration Loan Guarantees</td>
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<tr>
<td>Electric utilities</td>
<td>Energy efficiency performance standards</td>
<td>Utilities can utilize existing relationships with industrial customers and knowledge of their energy use profile; identify those offering the best opportunities for load-shifting. Given the right financial incentives (decoupled rates, time of day pricing, EE performance standards), utilities can bring together similar companies.</td>
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<td></td>
<td>On-bill financing</td>
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<tr>
<td>Insurance industry</td>
<td>Loss prevention insurance</td>
<td>Insurance providers can offer standardized insurance for energy performance contracts. The insurance industry can lower the transaction costs and risk of EE investments by offering loss prevention insurance. They also have a role to play as institutional investors interested in annuity style investments.</td>
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<td>Risk management through insurance securitization</td>
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<tr>
<td>Financial industry</td>
<td>Securitization</td>
<td>The financial industry can build on the experience with securitization of credit card and other assets to develop rules for EE investments. It also can build on the experience with metrics and financial risk indices to develop a yardstick for evaluating EE investments.</td>
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<td></td>
<td>Financial risk indices</td>
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<td></td>
<td>Performance banking</td>
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<tr>
<td>Energy service companies</td>
<td>Performance contracting</td>
<td>ESCO could expand their business into the small business sector and develop methodologies to streamline contracts for firms with similar characteristics.</td>
</tr>
<tr>
<td>Business to business</td>
<td>Supply chain management</td>
<td>Downstream businesses can manage their supply chain to make EE a part of lean manufacturing and performance contracting.</td>
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<td>Lean manufacturing</td>
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Table 1. Frames and potential roles for energy efficiency supply chain coordination [33]

Ultimately, the answers to these questions will only be effective if organized around data, frameworks, models, and tools emanating from both research and practice to help better understand the technical and operational systems addressing energy conservation and management, as well as their interaction within and between policy and market actors. Outcomes of this symposium will inform ongoing research exploring supply chain influence on energy and carbon strategy deployment as well as effort to develop a comprehensive initiative for broad-scale coordination of global energy efficiency data, demonstration and research.
References


