Module 17

Industrial energy efficiency and systems optimization

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1 Module overview

This module builds on the information contained in the previous module concerning industrial energy efficiency. The module contains a brief recap of selected concepts and presents them in terms of firstly creating policies and regulations that will foster sustainable industrial energy efficiency programmes that will be widely supported by industry and hence will have a greater degree of sustainability and success. Secondly, the module will introduce the process of industrial systems optimization and the very significant financial benefits that can be realized by industries and national economies as a whole through the process of optimizing industrial systems.

The opportunities for improving the efficiency of industrial facilities are substantial, even in markets with mature industries that are relatively open to competition. The barriers that prevent industrial facilities from becoming more energy efficient will be described in greater detail later in this module.

Industrial energy use globally accounts for 40 per cent of electricity use, 77 per cent of coal and coal products use, and 37 per cent of natural gas use and is a major contributor to CO_2 emissions.[1] In developing countries, the portion of the energy supply (excluding transport) required for industry is frequently in excess of 50 per cent and can create tension between economic development goals and a constrained energy supply. Further, developing countries with emerging and expanding industrial infrastructure have a particular opportunity to increase their competitiveness by applying energy efficient best practices from the outset in new industrial facilities, rather than following the slower path to implementation that occurs in existing industrial facilities in more developed countries.

According to estimates using the Intergovernmental Panel on Climate Change (IPCC) baseline greenhouse gas (GHG) emissions scenarios published in 2000, the projected average annual growth rate for primary energy consumption in sub-Saharan African industry for 2000-2030 is 7.3 per cent under the A1 scenario and 5.1 per cent under the B2 scenario.[2] The corresponding projected growth in CO_2 emissions is 7.2 per cent and 4.2 per cent, respectively. Average annual growth rates for Middle East/N. Africa are just slightly lower.[3]

---

[1]International Energy Agency (IEA) Statistics Division and IEA 7 July 2006 Industrial motor system energy efficiency: Toward a plan of action.

[2]Special Report on Emissions Scenarios: Report of Working Group III of the Intergovernmental Panel on Climate Change, 2000, Nakicenovic, N., Alcamo, J., et.al.

[3]Lawrence Berkeley National Laboratory, 24 July 2006, Sectoral Trends in Global Energy Use and Greenhouse Gas Emissions, Lynn Price, Stephane de la Rue du Can, et al.

This module presents a practical approach to building effective industrial energy efficiency policy through a focus on energy management, industrial system optimization, and measurement and documentation to support continuous improvement. Examples will be provided from Nigeria, the United States, Europe, and China to illustrate the benefits of industrial energy efficiency. This approach is not targeted to the use of energy efficient technologies in any specific sector; instead, it addresses the opportunities for improving energy efficiency that are common across all industrial sectors.

This module will also address issues concerning programme design, developing enabling partnerships, and building a national and regional market for energy efficiency services. An overview will be provided of a range of financing mechanisms that can be employed to encourage investment in energy efficient projects.

Finally, an introduction will also be given to the Industrial Standards Framework, an integrated approach to industrial energy efficiency under development globally, including a description of additional policy mechanisms such as voluntary agreements and recognition programmes. This approach, while compatible with new technologies, does not depend on them. Rather, it relies on the application of proven management and engineering practices and existing technology to attain greater energy efficiency. Additional references will be provided from the peer-reviewed literature and from public websites to provide greater depth for interested policy makers.

1.2. Module aims

The aims of the present module are to:

- Introduce the concept and benefits of industrial energy efficiency to government officials, policy makers and regulators;
- Provide an overview of policy measures that promote industrial energy efficiency;
- Describe how to develop an industrial energy efficiency programme based on these policy measures that is sustainable and has market support;
- Introduce a broader international framework for industrial energy efficiency.

1.3 Module learning outcomes

This module attemps to achieve the following learning outcomes:

- To be able to describe the benefits and barriers of industrial energy efficiency;

- To be able to describe the policy mechanisms that can contribute to industrial energy efficiency;
- To understand the fundamental goals of energy management and industrial system optimization;
- To be able to describe the process of designing an effective industrial energy efficiency programme;
- To be aware of the international context for undertaking an industrial energy efficiency programme.

2. INTRODUCTION

This module covers industrial energy efficiency as it applies to any industrial sector, including industries that are very energy intensive (i.e. petroleum refining, chemicals), as well as those that are less intensive (i.e. textiles, general manufacturing), or seasonal (i.e. food and beverage processing). Industrial energy use globally is extremely important, accounting for 40 per cent of global electrical usage, 77 per cent of coal and coal products use, and 37 per cent of natural gas use and is a substantial contributor to CO_2 emissions that contribute to global warming. Industrial motor systems alone are responsible for 7 per cent of global electrical usage.[4]

Energy use in industry differs from energy use in the commercial and residential sectors in several important ways. First, there is the scale of use—industrial facilities are very large individual users of energy relative to commercial or residential customers. These facilities are typically among an energy provider's largest customers and use their purchasing power to get the lowest available price for delivered energy supply. Second, industrial facilities may have onsite waste (i.e. bagasse, wood scraps or fibre) that can be used for onsite generation to replace some or most of purchased energy. The high level of use tends to reinforce attention to price and availability of supply; with only so much staff time available for non-production issues, there may be little time to attend to energy efficiency.

Third, energy use in industry is much more related to operational practices than in the commercial and residential sectors. If energy efficient lighting or appliances are installed in a commercial or residential building, those devices supply the same level of service at a reduced energy use without any further intervention from the user. If a building is well insulated and favourably oriented to benefit from solar exposure, then those benefits will accrue for the life of the building unless extraordinary measures are taken to negate them.

By way of contrast, an industrial facility may change production volumes or schedules and/or the type of product manufactured many times during the useful life of the factory. The energy-using systems designed to support these production practices may be relatively energy efficient under an initial production scenario but are typically significantly less so under other production scenarios. The presence of energy-efficient components, while important, provides no assurance that an industrial system will be energy-efficient. In fact, the misapplication

[4]Communication with Stephane de la Rue du Can, Lawrence Berkeley National Laboratory, and IEA 7 July 2006 Industrial motor systems energy efficiency: Toward a plan of action.

of energy-efficient equipment in industrial systems is common. The disappointing results from these misapplications can provide a serious disincentive for any subsequent effort toward system optimization.

The principal business of an industrial facility is production, not energy efficiency. Traditional approaches to industrial system design and operation emphasize reliability rather than energy efficiency. As long as these systems continue to support production, however inefficiently, there is little awareness of the benefits of a more energy efficient approach.

The key to industrial energy efficiency is to establish broad policy goals, such as energy management standards, build awareness of how energy efficiency can benefit industry without increasing risk, and then work with both users and suppliers of industrial systems to develop the technical skills and tools required to transform the industrial market toward more energy efficient practices. While this will take time to fully implement, immediate benefits can be realized within less than two years and the long-term effects will contribute substantially to economic growth and sustainability.

Box 1. Industrial energy efficiency in the United States

- In the United States, industry is the largest energy-using sector, accounting for 37 per cent of national natural gas demand, 29 per cent of electricity demand, and 30 per cent of greenhouse gas emissions. The U.S. Department of Energy (USDOE) estimates that a potential energy savings of 7 per cent of industrial energy consumption remains to be achieved through the application of best available practices alone.
- From 1993-2004, the industrial energy savings identified by US DOE's BestPractices programme from the application of industrial energy management best practices totalled 255 trillion Btu per year, or $US 1.4 billion in annual energy cost savings, equivalent to the energy used in 1.55 million homes

Source: United States Department of Energy presentation to the International Energy Agency, May 2006.

3. WHY INDUSTRIAL ENERGY EFFICIENCY?

As previously discussed, industries use a great deal of energy, often inefficiently, and are major contributors to CO_2 emissions. Industries are also a major contributor to economic growth. There is no inherent conflict between industrial energy efficiency and economic growth—indeed, industrial facilities that are well managed for energy efficiency are typically well managed generally, more sustainable, and therefore more competitive in global markets. In addition, the optimization of industrial systems frequently results in greater reliability and higher productivity.

Managers of industrial facilities always seek pathways to more cost-effective and reliable production. Materials utilization, labour costs, production quality and waste reduction are all subject to regular management scrutiny to increase efficiency and streamline practice. The purchase of energy from outside sources at the lowest possible price that preserves reliability of service has also become a central concern in this era of high prices and constrained supply. However, energy efficiency, particularly as it pertains to systems, is typically not a factor in this decision-making equation.

Equipment manufacturers have improved the performance of individual system components (such as motors, steam boilers, pumps and compressors) to a high degree but these components only provide a service to the users' production process when operating as part of a system. Industrial electric motor and steam systems consume huge amounts of energy and can be very inefficient.

Electric motor and steam systems offer one of the largest opportunities for energy savings, a potential that has remained largely unrealized worldwide. Both markets and policy makers tend to focus exclusively on individual system components, with an improvement potential of 2-5 per cent per component versus 20-50 per cent for complete systems, as documented by programme experiences in China, the United Kingdom and the United States.

Improved energy systems' efficiency can contribute to an industrial facility's bottom line at the same time when improving the reliability and control of these systems. Increased production through better utilization of equipment assets is frequently a collateral benefit. Maintenance costs may decline because better matching of equipment to demand needs results in less cycling of equipment operation, thus reducing wear. Optimizing the efficiency of steam systems may result in excess steam capacity that can be used for cogeneration applications. Payback periods for system optimization projects are typically short—from a few months to three years—and involve commercially available products and accepted engineering practices.

With all of these benefits, one would expect system optimization to be standard operating procedure for most industrial facilities. However, most industrial managers are unaware of both the existing inefficiency of these systems or the benefits that could be derived from optimising them for efficient operation. Inefficient energy use does not leave a toxic spill on the floor or a pile of waste material on the back lot—it is invisible. Even when it is audible, as is the case with a leaking compressed air system, plant personnel frequently accept this situation as "normal" because they have no other point of reference.

Box 2. Nigerian petroleum jelly plant doubles production with additional steam traps

In 1998, additional steam traps were installed on the drum oven at a petroleum jelly production facility at an Exxon Mobile plant in Apapa, Nigeria. The steam traps improved heat transfer and reduced the amount of time required to adequately heat the drum oven. As a result, the plant was able to double production of petroleum jelly, which led to a $US 52,500 increase in annual revenue. Total project costs were $US 6,000.

Source: www1.eere.energy.gov/industry/bestpractices/pdfs/nigeria.pdf

Box 3. Soda-ash facility recovers cost from improved coal boiler controls in six weeks

In 2002, FMC Chemicals Corporation improved the efficiency of two large coal-fired boilers at its soda ash mine in Green River, Wyoming by upgrading the burner management system (BMS). Before the upgrade, a continuous supply of natural gas was required to maintain the appropriate flame conditions required by the flame detection system of the BMS. After performing a system-level evaluation, plant personnel realized that upgrading the BMS would allow them to discontinue the natural gas supply without compromising boiler operation. The BMS upgrade project is yielding annual energy savings of $US 899,000 and 250,000 MMBtu. In addition, the components within the improved BMS require less servicing, saving $US 12,000 per year in maintenance costs. Also, a smaller inventory of spare parts is needed, and boiler reliability and plant safety are better. With total annual project savings of $US 911,000 and total project costs of $US 110,000, the simple payback was just over six weeks.

Source: www1.eere.energy.gov/industry/bestpractices/pdfs/bp_cs_fmc_chemicals.pdf

4. WHAT MOTIVATES INDUSTRY TO BECOME MORE ENERGY EFFICIENT?

Industry is motivated to become more energy efficient for a variety of reasons, including, but not limited to:

- Cost reduction;
- Improved operational reliability and control;
- Ability to increase production without requiring additional, and possibly constrained, energy supply;
- Avoidance of capital expenditures through greater utilization of existing equipment assets;
- Recognition as a "green company";
- Access to investor capital through demonstration of effective management practices.

Box 4. In their own words—why Frito-Lay, a United States food processor, manages energy

"Frito-Lay spends about $US 110 million a year for its energy needs. This includes natural gas (everything we operate is natural-gas fueled), electricity, water and waste water. While this is well under 5 per cent of our manufacturing cost, it is a substantial outlay. Saving any fraction of that cost is worthwhile, and energy-cost improvement projects turn out to be fairly reliable investments compared to other investments. For example, we spend a lot of money developing new products and concepts. Some products do very well while others don't do well at all".

"Product investments are unreliable in the sense that we can't be sure what return we will get—or if we will get any return at all. But our resource conservation portfolio consistently returns 30 per cent on investment. For example, if we spend $US 100,000 on improving, say, a steam system, and we expect to get $US 30,000 in savings per year out of it, we can rely on getting those $US 30,000 savings year in and year out. There is a community-relations aspect as well. In the communities where we operate, we are one of the larger energy consumers. When a curtailment happens, such as fuel shortages in cold winters or electricity curtailments

Box 4. *(continued)*

in hot summers, it is critical for us to be able to show that we are making significant strides to reduce our consumption. We need to be seen as doing our best to alleviate the situation rather than exacerbating it".

Source: "Energy Management Path-finding: Understanding Manufacturers' Ability and Desire to Implement Energy Efficiency," by C. Russell; presented during "National Manufacturing Week" in Chicago, Illinois, March 2005.

However, unless an industrial facility is made aware of the potential for energy efficiency, none of these factors have significance. Often facility managers have no knowledge of these opportunities.

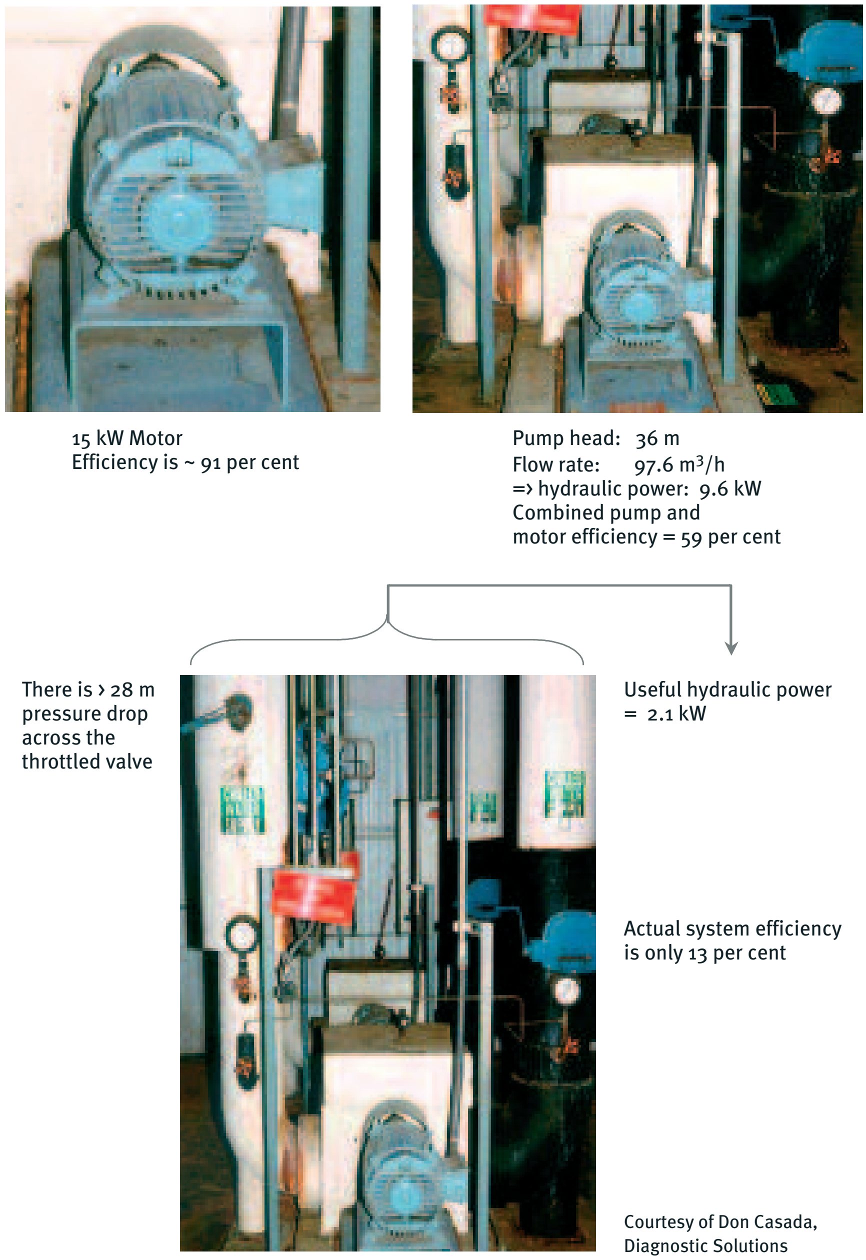
4.1. Opportunities and barriers

If system optimization is so beneficial, why isn't industry already doing it? There are several factors that contribute to a widespread failure to recognize the opportunity that systems optimization presents. This lack of awareness is a global phenomenon—including the EU, the United States, Canada, China, and Australia. Contributing factors include the complexity of these systems and the institutional structures within which they operate. Industrial systems (motor-driven and steam systems) are ubiquitous in the manufacturing environment, but their applications are highly varied. They are supporting systems, so facility engineers are typically responsible for their operation, but production practices on the plant floor (over which the facility engineer has little influence) can have a significant impact on their operational efficiency.

System optimization cannot be achieved through simplistic "one size fits all" approaches. Both industrial markets and policy makers tend to focus on equipment components (motors and drives, compressors, pumps, boilers), which can be seen, touched, and rated rather than systems, which require engineering and measurement. As previously stated, the presence of energy-efficient components, while important, provides no assurance that an industrial system will be energy-efficient. Misapplication of energy-efficient equipment (such as variable speed drives) in these systems is common. System optimization requires taking a step back to determine what work (process temperature maintained, production task performed, etc) needs to be performed. Only when these objectives have been identified can analysis be conducted to determine how best to achieve them in the most energy-efficient and cost-effective manner

An illustration of how energy efficient components can fail to result in an energy efficient *system* in shown in figure 1.

Figure I. Optimizing a motor system



Courtesy of Don Casada, Diagnostic Solutions

Since the efficiency of the system (motor + pump + throttle valve) is only 13 per cent, replacing the existing motor in this system with a more energy efficient one would accomplish little.

A typical example may help to illustrate the opportunities that can be derived from the application of system optimization techniques using commercially available technology, see box 5 below.

Box 5. Textile mill lowers costs and increases production after compressed air system improvement

In 1997, a compressed air system improvement project was implemented at the Peerless Division of Thomaston Mills in Thomaston, Georgia, United States. The compressed air system project was undertaken in conjunction with an effort aimed at modernizing some of the mill's production equipment. Once they were both completed, the mill was able to increase production by 2 per cent per year while reducing annual compressed air energy costs by 4 per cent ($US109,000) and maintenance costs by 35 per cent ($US 76,000). The project also improved the compressed air system's performance, resulting in a 90 per cent reduction in compressor downtime and better product quality. The project's total cost was $US 528,000 and the annual savings are $US185,000 per year, the simple payback is 2.9 years. The mill also avoided $US 55,000 in costs by installing a more optimal arrangement of compressors.

Source: www1.eere.energy.gov/industry/bestpractices/pdfs/thomastonmill.pdf

The goal to increase production and lower production costs for the mill at the same time as production changed to a new type of loom requiring more, and better controlled, compressed air triggered an opportunity to conduct an assessment of the mill's compressed air system. During the system assessment, a problem with *unstable* air pressure was identified (note that this is commonly misdiagnosed as *inadequate* pressure). Instead of increasing the pressure to compensate, thus using more energy, the plant installed storage and controls, properly configured the compressors, and reduced the amount of leakage from piping and drains. As a result, pressure was stabilized, fewer compressors were required to serve increased production, production suffered many fewer work stoppages, and energy use declined.

Without the application of system optimization techniques, the typical outcome would be treatment of the *symptom* (problems maintaining the pressure required for production equipment) rather than the *root cause* (the compressed air supply could not respond adequately to variations in the plant's compressed air requirements). Understanding how such practices occur and how they can be addressed through effective public policy and programmes is a major focus of this module.

First, existing systems were typically not designed with operational efficiency in mind. Optimizing systems for energy efficiency is not taught to engineers and designers at university—it is learned through experience. Systems are often designed to maintain reliability at the lowest first cost investment. As a result, basic design factors such as pipe size may be too small to optimize performance, and too expensive to retrofit—requiring a work-around approach to do the best optimization project possible. Unless the load to be served is constant and unlikely to change, the preferred approach to new systems is to design for efficient operation in response to variations in load

Second, once the importance of optimizing a system and identifying system optimization projects is understood, plant engineering and operations staff frequently experience difficulty in achieving management support. The reasons for this are many, but central among them are two: *(a)* a management focus on production as the core activity, not energy efficiency and *(b)* lack of management understanding of operational costs and equipment life cycle cost (which are often 80 per cent or more of the life cycle cost of the equipment). This situation is further exacerbated by the existence of a budgetary disconnect in industrial facility management between capital projects (incl. equipment purchases) and operating expenses.

Third, as a further complication, experience has shown that most optimized systems lose their initial efficiency gains over time due to personnel and production changes. Since system optimization knowledge typically resides with an individual who has received training, detailed operating instructions are not integrated with quality control and production management systems.

Since production is the core function of most industrial facilities, it follows that the most sophisticated management strategies would be applied to these highly complex processes. Successful production processes are consistent, adaptable, resource efficient, and continually improving the very qualities that would support industrial system optimization. Because production processes have the attention of upper management, the budgetary disconnect between capital and operating budgets is less evident. Unfortunately, efficient use of energy is typically not addressed in these management systems in the same way as other resources such as labour and materials. An answer lies in fully integrating energy efficiency into these existing management systems through the application of energy management standards.

5. PROMOTING INDUSTRIAL ENERGY EFFICIENCY

Returning to the question, “What motivates industry to become more energy efficient?”, one needs to look below the surface to the organizational culture. Simply defined, companies can either become energy efficient because they have to, or bad things will happen or because they want to, because there is a competitive advantage to be gained. In the first instance, companies are concerned with negative factors such as taxes, fines, damage to the company’s public image and loss of revenue and/or market share. Companies with this operating mode will typically only meet the minimum requirements; there is no integration of efficient practices. By way of contrast, companies seeking a competitive advantage are looking to energy efficiency as a strategy to achieve market distinction, low-cost positive publicity, lower operating costs, less waste, and access to financing or rebates. Companies with this operating mode tend to treat energy efficiency as continuously improving.

Effective public policy for industrial energy efficiency leverages a company’s desire to improve and to become more competitive and attractive to customers and investors alike. While judicious use of mandatory requirements (such as appliance standards) may help push some markets rapidly forward by removing the worst performing equipment or “bottom feeders”, industrial markets require a different policy/programme mix.

Recalling that the application of industrial energy efficiency best practices is largely operational, it follows that industrial energy efficiency policy and programmes must seek to change traditional operational practices and to integrate these practices into the institutional culture of the company. This is the underlying challenge of industrial energy efficiency—it requires a new way of looking at systems and corresponding changes in the behaviour of those that supply and manage them. If well-structured and delivered, an industrial energy efficiency programme can have a substantial and lasting positive impact on a country or region’s energy use that far exceeds many other opportunities. Without an effective structure and supportive delivery mechanism, policies and programmes can fall well short of this potential. The most effective tool available in developing industrial programmes and policies is the participation by industry (both manufacturing facilities and the companies that supply them) early and consistently during the planning process, while carefully avoiding the dual and unforgivable offences of wasting their time or giving the appearance of product bias.

The section that follows will present the elements of effective industrial policy making: energy management standards, enabling policies, training in energy management and system optimization and tools.

5.1. Energy management

If, as previously stated, the answer to industrial energy efficiency lies in fully integrating it into existing management systems—how is this accomplished? If, as previously discussed, plant engineers with an awareness of the benefits of system optimization still face significant barriers to achieving it, how is this overcome? If, as experience has shown, most optimized systems lose their initial efficiency gains over time, how is this avoided? Energy management standards, system optimization training, and tools to assist companies in documenting and sustaining their improvements are essential elements of an effective programme response. Other enabling policies can include recognition programmes, favourable tax policies and sectoral targets.

Since production is the core function of most industrial facilities, it follows that the most sophisticated management strategies would be applied to these highly complex processes. With the advent of quality control and production management systems such as International Organization for Standardization (ISO) 9000/14000, Total Quality Management, and Six Sigma, companies have instituted well-documented programmes to contain the cost of production and reduce waste. To date, most companies have not integrated energy use and efficiency into these management systems, even though there are obvious links to reducing operating costs and waste.

The objective is a permanent change in corporate culture using the structure, language and accountability of the existing ISO management system. The operation of industrial steam and motor systems can have a significant environmental impact on an organization. Inefficient systems not only use up to twice the energy required of optimized systems, but are also responsible for off-quality products, waste and scrap. Organizations do not normally recognize this impact. When they do, they usually think only of the initial energy impact, which is significant. The rework of off-quality products resulting from improperly operating systems can double the energy input of a product and produce additional waste. Products that cannot be reworked result in increases in the amount of scrap requiring disposal. Properly operating systems not only have reduced energy input requirements, but in many cases, reduce other energy inputs in the tools and equipment being operated by the system.

Most energy audits of such systems result in recommendations that apply to the current factory production levels. In cases where future expansion is anticipated at the time of the audit, the expansion is commonly included in the recommendations. After the recommendations have been implemented and the auditor is gone, there is no procedure in place to ensure continued proper operation of the system. Often, improvements in systems are made but changes to production levels and/or personnel negate the improvements over time. In other cases, operating personnel simply go back to doing things the way they were doing them, again negating the improvements.

Linkage to ISO

Of the management systems currently used by industrial facilities across most sectors to maintain and improve production quality, ISO is recommended as the management system of choice because it has been widely adopted in many countries, is used internationally as a trade facilitation mechanism, is already accepted as a principal source for standards related to the performance of energy-consuming industrial equipment, and has a well established system of independent auditors to assure compliance and maintain certification. For the purpose of this discussion, ISO includes both the quality management programme (ISO 9001:2000) and the environmental management programme (ISO 14001:2004), which can share a single auditing system.

A link is proposed between ISO 9000/14000 quality and environmental management systems and industrial system optimization, which has at its core an energy management standard. Since ISO currently has no explicit programme for energy efficiency, use of an ISO-compatible energy management standard, especially in combination with ISO-friendly documentation (see Documentation for Sustainability), will effectively build energy efficiency into the ISO continuous improvement programme. The objective is a permanent change in corporate culture using the structure, language, and accountability of the existing ISO management structure.

Formal integration of energy efficiency into the ISO programme certification structure (most likely as part of the ISO 14000 series), while desirable for the explicit recognition of energy efficiency as an integral part of continuous improvement, would be a resource- and time-intensive undertaking. Since the current ISO programme structure creates no specific barriers to the inclusion of energy efficiency projects, immediate programme integration is not a high priority, but could occur over time as the user community for the standard grows.

Energy management standards

The American National Standards Institute (ANSI) has adopted the Management System for Energy (MSE) developed by Georgia Institute of Technology as ANSI/MSE 2000:2005. This standard was developed by individuals with extensive experience with ISO certification and is suited for future consideration as an ISO standard. It is also compatible with Energy Star Guidelines for Energy

Management and is easily added to an ISO 14001 Environmental Management System:

> ANSI/MSE 2000:2005 . . . is a documented standard that establishes the order and consistency necessary for organizations to proactively manage their energy resources. [In this standard] personnel evaluate the processes and procedures they use to manage energy issues and incorporate strong operational controls and energy roles and responsibilities into existing job descriptions and work instructions . . . MSE 2000:2005 integrates energy into everyday business operations, and energy management becomes part of the daily responsibility for employees across the entire organization (Georgia Tech, 2005).

Figure II. ANSI/MSE 2000:2005

Source: Georgia Institute of Technology 2006.

In addition to ANSI/MSE 2000:2005, several European countries have developed energy management standards, including: Denmark, Ireland and Sweden. Additional work is underway by UNIDO to facilitate international cooperation on the development of energy management standards. Typical features of an energy management standard include:

- A strategic plan that requires measurement, management and documentation for continuous improvement for energy efficiency;
- A cross-divisional management team led by an energy coordinator who reports directly to management and is responsible for overseeing the implementation of the strategic plan;
- Policies and procedures to address all aspects of energy purchase, use and disposal;
- Projects to demonstrate continuous improvement in energy efficiency;
- Creation of an energy manual, a living document that evolves over time as additional energy saving projects and policies are undertaken and documented;
- Identification of key performance indicators, unique to the company, that are tracked to measure progress;
- Periodic reporting of progress to management based on these measurements.

Additional information concerning energy management standards is included in the reference section of this chapter.

5.2. System optimization

What do we mean by system optimization? System optimization seeks to design and operate industrial systems (i.e. motor/drive, pumping, compressed air, fan and steam systems) to provide excellent support to production processes using the least amount of energy that can be cost-effectively achieved. The process of optimizing existing systems includes:

- Evaluating work requirements;
- Matching system supply to these requirements;
- Eliminating or reconfiguring inefficient uses and practices (throttling, open blowing, etc);
- Changing out or supplementing existing equipment (motors, fans, pumps, compressors) to better match work requirements and increase operating efficiency;

- Applying sophisticated control strategies and variable speed drives that allow greater flexibility to match supply with demand;
- Identifying and correcting maintenance problems;
- Upgrading ongoing maintenance practices.

Please note that a system that is optimized to both energy efficiency and cost effectiveness may not use the absolute least amount of energy that is technically possible. The focus is on achieving a balance between cost and use that applies energy resources as efficiently as possible.

Figure III. What is a system

Courtesy of Don Casada, Diagnostic Solutions and United States Department of Energy.

An industrial system encompasses everything from the supply of energy into the system to the production end uses. A pump house, compressor room, or boiler room is not an industrial system because it only covers the supply side, not the distribution and end use. The mismatch between supply and end use is the most fertile ground for improving energy efficiency.

Opportunities overview

The skills required to optimize systems are readily transferable to any individual with existing knowledge of basic engineering principles and industrial operations. Training and educational programmes in the United States and the United Kingdom have successfully transferred system optimization skills since the early-1990s.

Examples of system optimization benefits:

- After system optimization training, a Chinese engineer connects two compressed air lines in a polyester fibre plant, saving 1 million RMB annually (about $US 127,000);[5]
- A United States system optimization expert conducts a plant assessment and directs operations staff to close a valve serving an abandoned steam line, saving nearly $US 1 million annually;
- A United Kingdom facility experiencing difficulty with excess delivery pressure, pump cavitation and water hammer identifies an opportunity to reduce the system head. After trimming the pump impeller for a cost of £377, the plant realizes energy savings of £12,905 and maintenance savings of £4,350 for a simple project payback of eight days.

While these examples have been selected for their impact, it is important to understand that the inefficient situations that produced these opportunities occur frequently. The primary cause is quite simple—the employees at industrial facilities rarely have either the training or the time to recognize the opportunities, to take the "step back" to see the big picture.

Building technical capacity

Since system optimization is not taught in universities or technical colleges, UNIDO has worked with a team of international experts to develop and pilot in China a training curriculum specifically designed to build the necessary technical capacity.

A carefully organized training programme can have a significant impact. As a result of the United Nations Industrial Development (UNIDO) China Motor System Energy Conservation Programme, 22 engineers were trained in system optimization techniques in Jiangsu and Shanghai provinces. The trainees were a mix of plant and consulting engineers. Within two years after completing training, these experts conducted 38 industrial plant assessments and identified nearly 40 million kWh in energy savings.

[5] 1 RMB = $0.127146, Exchange Rate 10 November 2006.

Table 1. Energy savings from system improvements (China pilot programme)

System/facility	Total cost ($US)	Energy savings (kWh/year)	Payback period
Compressed air/forge plant	18,600	150,000	1.5 years
Compressed air/machinery plant	32,400	310,800	1.3 years
Compressed air/tobacco industry	23,900	150,000	2 years
Pump system/hospital	18,600	77,000	2 years
Pump system/pharmaceuticals	150,000	1.05 million	1.8 years
Motor systems/petrochemicals (an extremely large facility)	393,000	14.1 million	0.5 years

UNIDO 2005

The goal of capacity-building training is to create a cadre of highly skilled system optimization experts. Careful selection is needed of individuals with prior training in mechanical or electrical engineering, who have an interest and the opportunity to apply their training to develop projects. This training is intensive and system-specific. Experts may come from a variety of backgrounds, including, but not limited to: government sponsored energy centres, factories, consulting companies, equipment manufacturers and engineering services companies. Experts in pumping systems, compressed air systems, ventilating systems, motors and steam systems should be used to develop local experts through an extensive training programme. Training should include both classroom and hands-on measurement and system assessment instruction and include at least a year of access to follow-up technical assistance from the instructors to assist the trainees in developing their first few projects. The resulting system experts are prepared to evaluate and optimize one or more industrial motor-driven systems or steam systems

Ideally, the completion of the intensive training programme is coupled with recognition for the competency of the trained local experts through a certificate. Testing of skills through the successful completion of at least one system optimization assessment and preparation of a written report with recommendations that demonstrates the ability to apply system optimization skills should be a prerequisite for any recognition.

The trained local experts should also be prepared to offer awareness level training to factory operating personnel on how to recognize system optimization opportunities. This awareness training can be used to build interest in and a market for the local experts' system optimization services. In addition, awareness training can provide a basic understanding of system optimization for factory operating personnel to apply in identifying energy efficiency project opportunities.

Documenting for sustainability

In order to ensure persistence for energy efficiency savings from system optimization projects, a method of verifying the on-going energy savings under a variety of operating conditions is required. ISO 9000/14000 Series Standards would require continuously monitoring an organization's adherence to the new energy system-operating paradigm.

The purpose of ISO 14001 is to provide a framework for organizations to achieve and demonstrate their commitment to an environmental management system that minimizes the impact of their activities on the environment (a similar framework for ISO 9001:2000 pertains to quality). The framework does not include any specific requirements, only a means of achieving goals set by the organization. This ISO standard also provides for an audit procedure to verify that established policies of the organization are being followed. To maintain certification, participating companies must maintain a Quality Environmental Management (QEM) Manual.

The environmental management system model for this standard is composed of six elements: *(a)* the establishment of an environmental policy by the organization; *(b)* planning; *(c)* implementation and operation; *(d)* checking and corrective action; *(e)* management review; and, *(f)* continual improvement.

Once top management has defined the organization's environmental policy, the next step is planning. In the ISO 14001-1996 Environmental management systems—Specification with guidance for use, Section 4.3.1 states:

> "The organization shall establish and maintain (a) procedure(s) to identify the environmental aspects of its activities, products or services that it can control and over which it can be expected to have an influence, in order to determine those which have or can have significant impacts on the environment. The organization shall ensure that the aspects related to these significant impacts are considered in setting its environmental objectives".

There are two approaches to establishing and maintaining efficient operation of energy systems. Both approaches involve the "Planning" phase and the "Implementation and operation" phase of ISO 14001. As an alternative for operations that are ISO 9000 certified, but not ISO 14000, these same steps can be incorporated into the ISO 9000 Quality Standards.

First, a set of standards can be developed in the ISO format that can be incorporated in the "Planning" portion of ISO 14001.[6] From those standards, work instructions can be written for the "Implementation and operation" portion. By making these "best practices" standards part of ISO certification, an organization ensures that these best practices will become part of the organization culture through the continuing audit procedure required by ISO. By making these best practices ISO-friendly, organizations can easily incorporate them into existing ISO systems. The number of standards incorporated can be determined by the individual organization. As more goals are reached, new standards can be included, further improving the energy efficiency of the steam and motor systems' operation and making efficiency part of the culture. Second, for organizations that are involved in carbon financing, ISO standards can be developed that are specific to that organization's on-going commitment to energy efficiency and pollution reduction.

A procedure refers to a general description of a process and is incorporated into a company's QEM Manual. The first step is for a company to develop a policy of efficient operation of energy systems within their facility, then develop and implement system procedures that are consistent with that policy.

The company must develop procedures for energy systems. The company must document those procedures and keep the documentation up to date. Each procedure should:

- Specify its purpose and intended scope;
- Describe how an activity is to be performed;
- Describe who is responsible for carrying out the activity;
- Explain why the activity is important to the efficient operation of the system;
- Identify a timetable for the activity;
- Explain what equipment is required to complete the activity;
- Detail the documents and records that need to be kept.

Procedures may also refer to detailed work instructions that explain exactly how the work should be performed.

A project refers to a specific activity designed to contribute to meeting the ISO requirement for continuous improvement. Examples of projects include: initiating a leak management programme or replacing a throttle valve on a pumping sys-

[6]The use of the term "standard" in this context broadly refers to a company-specific operational standard as part of the company's ISO plan, not an energy efficiency standard per se. The inclusion of energy-efficient best practices as part of these operational standards is what is discussed here.

tem with a speed control device. Work instructions are step-by-step information (text, diagrams, photos, specifications, etc) to assist operations staff in maintaining the improvements realized through implementation of a project. Examples include: instructions on how and when to check leaks and repair them or maintenance information to ensure that the pump system speed control device continues to function efficiently. Work instructions are typically posted for or easily accessible to operations staff.

The regular external audit process assures that proper and efficient operation of industrial energy systems is maintained and becomes part of each firm's operating culture, while transferring much of the burden and cost associated with regulatory compliance enforcement to these independent auditors. Linkage to ISO will also provide verification of results for financial backers (including future CDM carbon traders), and provide a clear methodology for recognizing "investment grade" projects, which will help stimulate a significantly higher level of industrial energy efficiency.

To enable firms to comply with the energy management standards and to more easily include energy efficiency projects as part of a company's continuous improvement plan (whether ISO or not), UNIDO and its partners are creating a System Optimization Library. The System Optimization Library consists of an electronic reference document that organizes energy efficiency opportunities by system and includes a series of procedures, projects, and work instructions written in an ISO-compatible format that are designed to facilitate integration of energy efficiency system improvements into ISO 9000/14000 operational and compliance materials.

Other enabling policies

In addition to energy management standards, system optimization training, and tools to assist industrial facilities in documenting and sustaining energy efficiency, other enabling policies that have been effective include: recognition programmes, favourable tax policies and sectoral targets in the form of energy efficiency agreements. This section will provide a brief introduction to energy efficiency agreements. For a more complete discussion of international experience with these policies, see Tax and Fiscal Policies for Promotion of Industrial Energy Efficiency: A Survey of International Experience (Price, Lynn et al, 2006).

Energy efficiency agreements

Energy efficiency agreements, otherwise known as voluntary agreements, have been used by a number of governments as a mechanism for promoting energy efficiency within a specific industrial sector. The Netherlands has the most extensive experience with these types of agreements, but they have also been implemented in a number of other countries, including: Australia, China, Denmark, and the United Kingdom.

An energy efficiency agreement is a written agreement between an industrial company and government (this can be accomplished through an industrial association) that establishes a mutually agreed upon target for energy savings over a long-term period given specified supporting policies. The features of an effective energy efficient agreement include:

- Signed, negotiated agreement with specific targets tied to units of production;
- Long-term outlook (typically 5-10 years);
- Includes an implementation plan for reaching the targets;
- Includes annual monitoring of progress toward the targets;
- Require supporting programmes- technical assistance, recognition to succeed;
- Most effective programmes;
- Are legally binding;
- Set realistic targets;
- Include sufficient government support;
- Include real threat of increased government regulation or energy/GHG taxes if targets are not achieved.

The inclusion of energy efficiency agreements is a useful addition to an industrial energy efficiency policy. This policy instrument is entirely compatible with the promulgation of energy management standards, system optimization training, and documenting for sustainability. An energy efficiency agreement provides a broad, but measurable target while an energy management standard provides an industrial facility with a methodology for meeting the target and system optimization techniques identify projects that help the facility meet both the goals of the standard and the efficiency targets of agreement.

6. GETTING STARTED

6.1. Building a market for industrial energy efficiency services

Role of government

The primary role of government is to develop and issue energy efficiency standards and to support the provision to industry, consultants and suppliers of training and tools to aid in compliance. A further role is to recognize outstanding efforts that exceed compliance requirements.

Standards for corporate energy management provide a framework for companies to integrate an energy efficiency ethic into their management practices. Government-sponsored training would prepare plant engineers and emerging energy service companies with:

- The skills to recognize energy efficiency opportunities, including on-site power generation, via training on system techniques;
- An understanding of standards requirements;
- Knowledge and access to the software tools for use in developing and implementing projects;
- Government-sponsored recognition based on verified energy savings provides industrial plants with the incentive to document and report project savings.

Engineers (plant-based and consulting) will need to be trained in the systems approach. These experts will provide awareness training to encourage plants to undertake system optimization improvements, conduct plant assessments to identify system optimization opportunities, work with plants to finance and develop projects based on these findings, and prepare case studies of successful projects. This cadre of experts will also form the nucleus for future training of additional experts.

Role of industry

Industrial plants are responsible for compliance with national standards for corporate energy management, which typically require:

- An energy management team led by an energy coordinator with strong management support;
- Policies and procedures to promote energy efficiency;

- Projects to demonstrate continuous improvement in energy efficiency;
- Monitoring and measurement to document achievement of annual energy efficiency goals.

These requirements can be achieved through the application of system optimization techniques (with their own staff or outside experts), to identify energy efficiency opportunities. If the industrial plant is ISO-certified, work instructions, projects and procedures should be integrated into current ISO 9000/14000 programmes. The periodic ISO audit provides independent verification of compliance with written procedures and policies, and energy-efficient operation becomes part of the factory culture.

Role of suppliers

Industrial facilities typically develop very close relationships with their supply chain, including the suppliers of the equipment used in motor-driven and steam systems. Suppliers can have an important role in introducing system optimization concepts through their interactions with customers. Conversely, if suppliers do not identify any benefit or value from an industrial energy efficiency programme or policy, they can have a significant negative impact. Plant personnel are well aware that if they experience an equipment failure or system problem that affects production, they must obtain emergency service from their supplier, and quickly. A government programme that seeks to influence the system supplier/user relationship to promote more energy efficient practices needs to recognize the importance of the relationship to both parties, or expect that the supplier may discourage the plant from adopting any new practices.

Role of energy service companies

Energy Service Companies, or ESCOs, typically provide customers with a range of services to develop energy efficiency projects. These services can include: technical assessments, bid specification development, project development and implementation, and financing arrangements in which the cost of the project is paid from the resulting energy savings. A principal benefit to an industrial facility from using an ESCO is the opportunity to develop capital projects "off-budget"—without any investment of capital funds.

In general, energy service companies (ESCOs) are under-represented in industrial markets worldwide. With a few exceptions, ESCOs have had little impact on the development of energy efficiency projects that involve industrial systems. ESCOs typically enter industrial markets with experience from the commercial sector and tend to concentrate on measures such as lighting and district heating that are found in commercial buildings. Alternatively, ESCOs concentrate on a very narrow portfolio of measures in which they build a specific expertise.

Properly prepared, however, ESCOs can be an important element of an effective industrial energy efficiency programme. For example, several projects developed by experts who participated in the UNIDO system optimization training programme in China have had shared savings arrangements. Please note that before undertaking these projects, the experts completed their training and understood the optimization potential of the systems that they assessed. Please also note that all such work in industry requires close attention to contract details, as changes in production can have a significant impact on anticipated energy savings.

Finally, one relatively recent market development should also be considered. Equipment suppliers well trained in system optimization techniques are becoming increasingly engaged in offering ESCO-type services for their system of specialty, especially compressed air and pumping systems. These services generally include a commitment to manage for energy efficiency and are usually offered by suppliers to industrial customers with whom they hope to continue a long-term relationship. As such, they offer more promise for sustaining energy efficiency than the narrow range of measures from other specialized ESCOs.

6.2. Programme design

The key to an effective industrial energy efficiency policy is to find a balance between consistency and flexibility. Consistency in programme message, goals, target industries and basic programme offerings is critical. When announcing an industrial programme, a policy maker should assume that industry will require at least a year to accept it and another year or more to respond. Most industries require at least 12-18 months for completion of an energy efficiency project after an assessment is done and opportunities have been identified. This is because any planned capital improvements must wait to be included in the following year's budget cycle. Changing organizational behaviour takes time and permanent market change takes even longer. Assume that an industrial energy efficiency programme will take at least five years to fully mature. Small improvements to the programme or "tweaking" during this period can be helpful—especially in response to industry input; but re-branding and major meddling with the programme design are counterproductive and to be avoided. If funds are too limited to consider a full-scale launch, a graduated programme could begin with system optimization training (expert and awareness), followed later by energy management standards and documentation for sustainability.

Training experts and suppliers

A comprehensive training programme would include the following components:

Experts training

The purpose of this training is to prepare a group of experts who will be expected to: *(a)* provide awareness training to encourage plants to undertake system optimization improvements; *(b)* conduct plant assessments to identify system optimization opportunities; *(c)* work with plants to finance and develop projects based on these findings; and, *(d)* prepare case studies of successful projects. A one-to-one, one-to-many, training and implementation scheme has been tested and proven effective. In this approach, international experts are engaged in the initial capacity-building to create a core of highly skilled experts who will become a resource to their country and the region for years to come. To ensure success of the training, selection of the individuals to be trained must be rigorous and based on technical and training capabilities. Successfully negotiating this selection process will require the international team and the country coordinators to develop a shared vision of the project goals, which will vary somewhat from country to country in response to cultural, organizational, and social requirements. This cadre of experts will also form the nucleus for future training of additional experts.

A three-step training programme on optimization of each industrial energy system is recommended, based on UNIDO's execution of similar training in China. According to this model, an international team of experts initiates the training of system optimization experts in close cooperation with country coordinators. The international team is drawn from a pool of the leading experts who either participated in the UNIDO China Motor System Program experts training or otherwise come highly recommended as trainers and system optimization experts. The international team should include at least two experts for each system type (see figure IV):

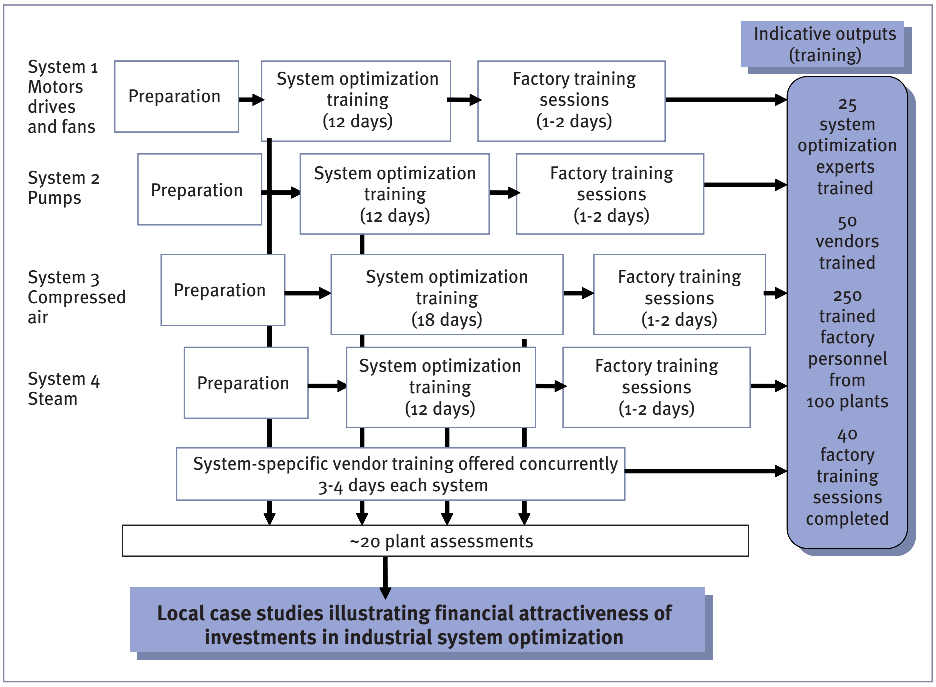
- Preparatory activities are completed over periods of two to three months in advance of each system optimization training session. This involves the compilation of training materials by the international team, the identification of appropriate factories for the in-plant training by the country coordinator with requisite pump/fan/drive/compressor/steam systems, securing approval of site visits, purchase of measurement equipment to perform the in-plant training, acquisition of technical data from host plants pertaining to the systems and components to be evaluated by the teams, identification of classroom facilities, provision of accommodation for trainees, etc.
- During system optimization training, international teams train local energy experts in classroom and plant settings. At each plant the local experts are

trained "on-the-job" in the use of measuring instrumentation, data collection and analysis and the preparation of investment proposals for energy systems improvements, which are subsequently submitted to management of the plants hosting the training. Training covers system design, operation and installation, measurement of fluid flows, pressures, energy consumption, and application of analytical software.

Case studies are developed illustrating financially attractive investments in efficiency improvements. The national experts then employ the case studies in the subsequent factory training.

- Following completion of each system optimization training module, each international team returns to work with their trainees on plant assessment and project development skills. In addition, the international teams prepare and observe trained national experts conducting training of local personnel in "factory training sessions". These factory-training sessions continue to be undertaken by the national experts to build awareness of system optimization services.

Figure IV. System optimization training—expert and vendor



UNIDO 2005.

Vendor training

Concurrent with experts training, it is an excellent idea to conduct training to introduce equipment vendors, manufacturers' representatives, and suppliers to system optimization techniques. Each training session should focus a specific system type and be offering a mix of theory and practical considerations. The purpose of this training is to prepare manufacturers, vendors and suppliers to: *(a)* participate in reinforcing the system optimization message with their customers; and *(b)* assist them in identifying what will be required to reshape their market offerings to reflect a system services approach. Combining the expert training and vendor training is not recommended, as their needs are different and the dynamics of the supplier/customer relationship could distract from the overall learning experience.

Building industrial awareness

A core element of any industrial energy efficiency programme is an information campaign. This campaign should introduce industry to the basic concepts of energy management and industrial system optimization. The message needs to be appropriate to plant managers and needs to make a direct link, through brief examples no more than a couple of sentences long, between industrial energy efficiency and cost savings, improved reliability and greater productivity. If international corporations have already established or plan to establish industrial facilities in the country, they may be important allies in this campaign—see Developing enabling partnerships. Please note that while reference to the environmental benefits of industrial energy efficiency can be helpful, this is an additional benefit for most managers, after the economic benefit.

Once the in-country system optimization experts have been trained, additional awareness messages will be needed to help them build the market for system optimization services. It is important for the government to be active during this early stage of market transformation, for instance, hosting factory awareness training sessions as part of the programme response to the announcement of the energy management standard. A list of the trained experts should be kept and made available to companies seeking system optimization services.

Establishing an energy management standard

The appropriate government agency will be charged with developing and issuing an energy management standard. Even if the agency decides to adopt an existing energy management standard, an advisory committee should be formed to participate in the process. The advisory committee should include representatives from companies with medium and large industrial facilities and from several of the industrial sectors most important to the country's economic growth. The advisory committee should also include respected members of the consulting engineering and supplier community who have extensive experience in industry. To be effective, this group should number no more than 15 persons. The purpose of the advisory committee is to ensure that the standard, as adopted, can be practically applied to the country's industries and to build ownership in use of the standard prior to its announcement. Work is now underway at UNIDO on guidance documents on energy management standards.

In addition to the advisory committee, a public comment period should be held. The length of this period and the number of informational workshops will be determined by the requirements of the implementing country and the effort required to provide access to information about the proposed standard. Again, this public comment period can be used to build ownership of the energy management standard prior to its formal announcement. Industrial companies do not like sudden changes in governance, so providing information well in advance can improve the chances for success of the standard.

An energy management standard should be issued initially as a voluntary standard coupled with a recognition programme for companies who demonstrate that they are applying the standard. The decision to make the standard mandatory is best made well in advance, for instance, the government might announce a voluntary standard with a three to five-year phase-in period to a mandatory energy management standard. Some time will be required for industrial firms to develop the organizational infrastructure needed to effectively implement the standard. This transition period is needed to avoid unnecessary disruptions in industrial operations.

Standards training

Training will be needed to prepare industrial firms to comply with energy management and standards. What is envisioned is a "train the trainer" approach that engages interested system optimization experts and representatives from large companies in understanding and learning how to apply these standards. The programme would recognize experts and representatives from large firms as qualified to offer their services to industrial firms who are developing their compliance programmes. Government representatives and their designees would receive specialized training in standards oversight and enforcement.

6.3. Developing enabling partnerships

For an industrial energy efficiency policy to become effective, government officials will need to form partnerships. These enabling partnerships are needed to:

- Build ownership in the proposed efforts to change existing practices and behaviours for greater energy efficiency;

- Reach many industrial firms with the system optimization message through existing business relationships (such as with suppliers, trade associations, etc);
- Develop credibility within specialized industrial sectors;
- Ensure that proposed policies are practical given the current situation of industry in the country;
- Engage the financial community and assist them in understanding the financial benefits of industrial energy efficiency;
- Recruit the best talent to become trained in system optimization techniques;
- Successfully launch an industrial energy efficiency programme.

The specific organizations that make effective partners will vary from country to country, but generally include: industrial trade associations, professional engineering societies or associations, equipment manufacturers and suppliers and their associations, leading and/or growing industrial companies, power companies, technical universities and commercial lenders.

If well-established multi-national corporations have already, or plan to have, industrial operations in the country, they may be interested in becoming identified with an industrial energy efficiency programme as a way to demonstrate that they are a good corporate citizen in the host country. Most multi-national corporations have sophisticated business management systems in place, such as ISO or Six Sigma, however, they may not yet have an energy management system in place. Plants operated by these companies offer the potential for either case studies on the ongoing benefits of energy management (if such a system is already in place), or as “early adopters” through integration of a new energy management standard into their existing business practices.

6.4. Financing considerations

Although systems optimization projects are typically small ($US 10,000-250,000) and do not require off-balance sheet financing, partnerships with financial institutions or other sophisticated financing measures, the availability of capital varies widely from country to country. An effective industrial energy efficiency programme will need to establish mechanisms designed to enable local banks and financing institutions to support the energy efficiency (systems optimization) efforts of their industrial clients.

As experts have noted, a common barrier to financing of energy efficiency projects is caused by the introduction of a cash-flow based financing model required by third party financing rather than the typical model of asset-based lending directly to an institution. This section does not propose major structural changes in financing practices, but rather to identify meaningful short-term mechanisms that will create incentives for the industrial organizations to initiate and accelerate the process of integrating energy efficiency into their management programmes for continuous improvement.

A comprehensive programme should consider a mix of financing mechanisms developed in consultation with plant personnel, energy efficiency organizations, vendors, utilities, and financial institutions that are identified as needed to accelerate this integration process. All incentives should be carefully evaluated to select only those that do not interfere with developing market support for energy efficiency that continues after the incentive is phased out. These mechanisms could include, but are not limited to:

- Loans—an intermediary loan fund can be used to reduce the cost of capital made available to commercial banks for loans to industrial organizations that undertake improvement projects developed using recognized system optimization methods. The lending product can be either a guaranteed loan or a subsidized interest rate loan; typically backed up by a revolving fund initiated through non-commercial sources. Thailand has experience with a revolving fund for energy conservation.

- Financial incentives—these are typically rebates, dealer incentives, or other mechanisms offered through a utility as part of a peak load management or demand reduction initiative. These incentives need to be very carefully structured to avoid distorting the true market value of energy efficiency improvements—which needs to be recognized in order to persist after the financial incentive is withdrawn.

- Leasing arrangements—sometimes described as leaseback arrangements, which allow an industrial plant to make a monthly payment for energy efficiency improvements from their operating and maintenance budget rather than seeking approval and financing for capital improvements. Some vendors are already offering these arrangements, which could be expanded and strengthened through capacity building to focus on system improvements rather than components. Established vendors have access to commercial credit and are frequently further supported by equipment manufacturers.

- Vendor provision of the desired service rather than equipment. In this arrangement, the vendor retains ownership of the system and contracts with the plant to provide the desired service—pumped fluid, compressed air, etc. This arrangement is also known as “over the fence”, since the system owner is outside of the factory.

- Third party financing—energy service performance contract in which, via shared savings or other mechanisms, a third party finances the improvement. This arrangement differs from a vendor arrangement because the ESCO typically obtains payment from the savings achieved.

7. PULLING IT TOGETHER

7.1. Industrial standards framework

The Industrial Standards Framework proposes a link between ISO 9000/14000 quality and environmental management systems and industrial system. This Industrial Standards Framework includes energy management standards, policies, training and tools that have the net effect of making system optimization for energy efficiency as much a part of typical industrial operating practices as waste reduction and inventory management. The objective is a permanent change in corporate culture using the structure, language and accountability of the existing ISO management structure. The proposed Industrial Standards Framework is equally applicable in industrialized or industrializing countries. See table 2: Industrial standards framework.

The purpose of the framework is to standardize, measure and recognize industrial system optimization efforts, including waste heat recovery and the installation of on-site power generation. The framework builds on existing knowledge of "best practices" using commercially available technologies and well tested engineering principles. The framework seeks to engineer industrial systems for reliability and productivity, as well as energy efficiency. Factories can use the framework to approach system optimization incrementally in a way that maximizes positive results and minimizes risk and downtime.

A key element of the framework is a corporate energy management programme. Since ISO currently has no explicit programme for energy efficiency, the framework builds energy efficiency into an ISO continuous improvement programme (9001:2000 or 14001) through an ISO-compatible energy management programme.

Table 2. Industrial Standards Framework

Element	Category	Purpose	Current status	Importance	Compatibility
Corporate energy management standard	Standard, voluntary or mandatory	Provides organizational guidance for “hardwiring” energy managementinto company management practices	ANSI/MSE 2000 (US); existing standards also in Denmark, Ireland, Sweden; planned for China	Essential for management support; compliance with standard can be met through other elements	Written as possible ISO standard with ISO-friendly documentation and continuous improvement requirements
	Training	Prepares management to implement standard	Existing training through Georgia Tech (US).		
System optimization library	Tool-electronic reference document	Provides factory personnel and experts with guidance on system optimization within the ISO context of procedures, projects, and work instructions	Library samples developed and reviewed; demonstration project planned	Essential—provides an incremental path to continuously improve and maintain system efficiency	Written in ISO language for use in ISO 9000 or 14000 programme; supports corporate energy management goals
	Training	Prepares factory personnel and system optimization experts to use library (Follows system optimization awareness training)	Training to be developed as art of demonstration project		
System optimization training	Training	Expert training prepares a cadre of engineers to conduct factory assessments, train factory personnel, and assist in project development Awareness training alerts factory personnel to system optimization opportunities	Expert and awareness training developed as part of UNIDO Motor System Programme (China)	Essential—provides the technical skills for small group of experts and prepares them to train others	Consistent with the approach used for Motor System Standard, system optimization library

ISO 9001:2000 and/or 14001 certification	Independent certification	Determines whether a factory is meeting ISO objectives for continuous improvement via procedures, projects and work instructions	Global programme with over 770,000 participating companies	Essential for sustaining and improving energy efficiency	Other elements provide path for maintaining certification
Energy efficiency targets by industrial sector	Policy	Provides plant-specific energy efficiency targets based on continuous improvement that is non-prescriptive and developed in cooperation with the industrial sector	Pilot programme developed and demonstrated in Chinese steel industry; based on European experience	Very helpful—engages management in efficiency objectives, leading to other elements	Compatible with all elements
Government recognition of outstanding energy management	Policy	Provides meaningful recognition programme for factories who initiate and sustain continuous improvement for energy efficiency	Proposed	Very helpful for motivating companies to become energy efficient	Recognition based on measurable results from other elements

Source: Aimee McKane, Lawrence Berkeley National Laboratory 2005.

8. CONCLUSION

Industrial energy efficiency is frequently overlooked by policy-makers concerned about energy supply and use. Although designing an industrial energy efficiency programme takes time and must be undertaken with some care, the opportunities for improving the efficiency of industrial facilities are substantial, even in markets with mature industries that are relatively open to competition. Developing countries with emerging and expanding industrial infrastructure have a particular opportunity to increase their competitiveness by applying energy efficient best practices from the outset in new industrial facilities, rather than following the slower path to implementation that occurs in existing industrial facilities in more developed countries.

For a company to achieve a high level of energy-efficiency, maintain it and continuously improve it:

- The company needs an organizational culture that supports continuous improvement;
- The company's management must develop methods to "hardwire" energy-efficiency into existing management practices;
- Energy efficiency needs to become a "key performance indicator" for managers and workers.

The business-as-usual scenario would likely include the continuation of oversized and poorly controlled systems that inadequately match system supply to production demand. The reason is that this is "generally accepted engineering practice" which can only be overcome through a concentrated educational effort.

This missed energy efficiency opportunity from the business-as-usual scenario would apply to both existing systems and new systems. For existing systems, conservative engineering practices would dictate replacing failing or ageing equipment with equipment of similar or larger capacity without first conducting a thorough assessment of actual system needs. For new systems or systems undergoing a major retrofit, this missed opportunity could be even greater, since these systems, once oversized or mismatched to load requirements, are likely to remain so for the life of the equipment, which could be 10-20 years or more.

In the growing economies of the African region, the loss from omitting industry from a country's energy efficiency portfolio would be large and virtually non-recoverable in terms of wasted energy and excessive GHG emissions. While it could be argued that global market pressures will eventually push industries in the region toward greater energy-efficiency, this is a very blunt and long-term instrument that will be overshadowed in the short-term by other production cost advantages, such as labour.

LEARNING RESOURCES

Key points covered

These are the key points covered in the module:

- The concept of industrial energy efficiency has been described along with the economic and developmental reasons why industrial energy efficiency represents an important goal for industries and governments to pursue and how this applies to both developed and developing countries.
- The proven opportunities and the existing barriers to industrial energy efficiency have been detailed and explained.
- The process of industrial systems optimization has been presented and the very significant benefits that can be realized by industries have been demonstrated.
- The available policy and market-based instruments to promote industrial energy efficiency as integral part of industrial corporate management and operation have been presented and described.
- The process for establishing a policy framework and a suitably enabling market environment for industrial energy efficiency services has been described along with the roles of the various relevant parties/stakeholders. The key steps and tools/actions needed for developing and implementing sustainable IEE programmes have been explained and described.

Review questions

1. An equipment supplier has been selling pumps for 20 years. What benefit could the system optimization approach have for his/her business? What are the perceived threats to his/her business? What might you do to encourage his/her participation in system optimization training?
2. A company has factories that are fewer than five years old. What possible benefit could this company gain from *(a)* implementing energy management standards or *(b)* system optimization training?

Exercises

How would you begin to develop an industrial energy efficiency programme in your country? Sketch a diagram of what your programme implementation scheme might look like. Think about each element of the programme (standards development, capacity building, training, documentation and reporting, other enabling policies), what would be required to complete each, who would participate, what you could accomplish.

Presentation/suggested discussion topics

Presentation: ENERGY EFFICIENCY—Module 17: Industrial energy efficiency and systems optimization

Suggested discussion topics:

What do you think are the main challenges to implementing industrial energy efficiency in your country? Consider the types of industries and the industrial growth, the typical size of industries, the growth of management systems such as ISO, the technical capabilities of industry and suppliers, and the current status of interactions between industrial companies and government.

1. Make a list of the greatest challenges.
2. Make a list of organizations that are potential partners and what would motivate them to become involved.

Answers to review questions

Question: An equipment supplier has been selling pumps for 20 years. What benefit could the system optimization approach have for his/her business? What are the perceived threats to his/her business? What might you do to encourage his/her participation in system optimization training?

Answer:

A supplier will typically have experience in equipment components, not systems. In this example, it is likely that the supplier is quite familiar with pumps, seals, valves and other equipment which are selected from the perspective of providing the customer with reliable service. The supplier is much less likely to have experience with the operation of the pumping system from an energy efficiency perspective.

Potential business benefit: expand the market for selling pumping system services and related products, especially for existing systems. Provide market distinction for energy efficient performance. Bring greater technical value to the customer relationship.

Perceived threats: government has an unknown (and potentially negative) influence on customer interest in supplier and supplier's products; providing system services requires an investment of time and money in training that takes away from resources available for today's business with no guarantee of a positive return.

To encourage participation:

Involve major suppliers in developing and offering the vendor training programme. *Note: you must invite all major suppliers to participate in this process to ensure that the resulting training is well balanced and not biased toward any one-product line or business practice.* Explain to participating suppliers that the vendor training is being offered to them to familiarize them with the training that their customers will be receiving. Invite them to develop ways to effectively "sell into" the systems message.

Question: A company has factories that are fewer than five years old. What possible benefit could this company gain from *(a)* implementing energy management standards or *(b)* system optimization training?

As discussed earlier, many new systems are not designed for energy efficiency and could benefit from further optimization. Moreover, a company that does not have a system in place to measure and document system performance over time will not be able to sustain the initial energy efficiency level of those systems. An energy management system addresses all aspects of energy in the facility, from procurement through use to proper disposal. Any plant, however new, would benefit from such an approach.

REFERENCES

Georgia Tech Research Corporation. 2000 & 2005. ANSI/MSE 2000: 2005. Washington, D.C. American National Standards Institute. webstore.ansi.org/ansidocstore/default.asp

Ghislain, Joseph C. and Aimee T. McKane, 2006. Energy Efficiency as Industrial Management Practice: The Ford Production System and Institutionalising Energy Efficiency, presented at the SAE World Congress, Detroit, MI April 3-6,2006. Published by Society of Automotive Engineers (SAE) Technical Series as Paper #2006-1-0829, 2006: Warrendale, PA. industrial-energy.lbl.gov/node/281

International Energy Agency (IEA) 7 July 2006 Industrial motor systems energy efficiency: Toward a plan of action. www.iea.org/Textbase/work/workshopdetail. asp?WS_ID=255

International Organization for Standardization. 2006. The ISO Survey of ISO 9001:2000 and ISO 14001 Certificates—Fifteenth Cycle: Up to and Including December 2005. Geneva, Switzerland. www.iso.org/iso/en/iso9000-14000/certification/isosurvey.html

McKane, Aimee, Wayne Perry, Li Aixian, Li Tienan, and Robert Williams. 2005. Creating a Standards Framework for Sustainable Industrial Energy Efficiency, published September 2005 in Proceedings of EEMODS 05, Heidelberg, Germany September 5-8, 2005 LBNL- 58501 industrial-energy.lbl.gov/node/147

Nakicenovic, N., Alcamo, J., Davis, G., de Vries, B., Fenhann, J., Gaffin, S., Gregory, K., Grubler, A., Jung, T.Y., Kram, T., La Rovere, E.L., Michaelis, L., Mori, S., Morita, T., Pepper, W., Pitcher, H., Price, L., Riahi, K., Roehrl, A., Rogner, H-H., Sankovski, A.Schlesinger, M., Shukla, P., Smith, S., Swart, R., van Rooijen, S., Victor, N., and Zhou, D., 2000. Special Report on Emissions Scenarios: Report of Working Group III of the Intergovernmental Panel on Climate Change. London: Cambridge University Press.

Price, Lynn and Stephane de la Rue du Can, Jonathan Sinton, Ernst Worrell, Zhou Nan, Jayant Sathaye and Mark Levine.2006. Sectoral Trends in Global Energy Use and Greenhouse Gas Emissions. Lawrence Berkeley National Laboratory, July 2006. Berkeley, CA. LBNL-56144 industrial-energy.lbl.gov/node/31

Price, Lynn and Christina Galitsky, Jonathan Sinton, Ernst Worrell, and Wina Graus. 2005. Tax and Fiscal Policies for Promotion of Industrial Energy Efficiency: A Survey of International Experience. Lawrence Berkeley National Laboratory, September 2005, Berkeley, CA. LBNL-58128 industrial-energy.lbl.gov/node/129

Williams, Robert and Aimee McKane, Zou Guijn, Steve Nadel, Jane Peters, and Vestal Tutterow. 2005. The Chinese Motor System Optimization Experience: Developing a Template for a National Program. EEMODS 2005. Proceedings of EEMODS 2005-Energy Efficiency in Motor Driven Systems, Heidelberg, Germany 5-8 September 2005. LBNL-58504 industrial-energy.lbl.gov/node/294

INTERNET RESOURCES

www1.eere.energy.gov/industry/bestpractices/

BestPractices, under the United States Department of Energy (USDOE) Industrial Technologies Program, works with U.S. industry to implement energy management practices in industrial plants. To meet the diverse needs of U.S. industry, BestPractices provides a wide variety of downloadable publications, case studies, technical reports, and software for corporate executives, plant managers, technical staff, and the general public.

industrial-energy.lbl.gov/

Lawrence Berkeley National Laboratory, a multi-disciplinary scientific laboratory managed by the University of California at Berkeley and USDOE, has a website dedicated to industrial energy analysis and programme design, both in the US and internationally. The website includes a range of publications and technical information from LBNL researchers as well as links to other researchers and websites of interest.

www.energystar.gov/index.cfm?c=guidelines.guidelines_index

The US Environmental Protection Agency (USEPA) offers a energy management tools and resources such as guidelines for energy management, sector-based technical guides, and a self-benchmarking index for selected industrial sectors.

www.ase.org/section/topic/industry/clearinghouse/ieeenergymanagement

The Alliance to Save Energy, a not-for-profit organization in the US, has a section of their website dedicated to industrial energy management, including case studies.

energyefficiency.jrc.cec.eu.int/Motorchallenge/

The Motor Challenge Programme is a European Commission voluntary programme through which industrial companies are aided in improving the energy efficiency of their Motor Driven Systems. The website includes useful technical information on motor system efficiency as well as links to other European organizations with programme activities in industrial energy efficiency.

GLOSSARY/DEFINITION OF KEY CONCEPTS

Capacity building	Providing the technical and policy training required to prepare individuals and organizations to carry out a new function within a country or region. In the case of industrial energy efficiency, capacity building refers to training designed to develop a cadre of system optimization experts and skilled vendors. The goal is to prepare these individuals to train others and demonstrate system optimization techniques through plant assessments and resulting projects.
Continuous improvement	A term widely used in industry to describe a method of management applied to the manufacturing and supporting processes in a company that requires regular examination of these processes to identify ways to improve efficiency, quality, cost, materials utilization, or other factors. Continuous improvement is not a destination, it is a *process* and is a core concept of the ISO 9000/14000 management series.
Documentation for sustainability	Refers to the process of developing written policies, procedures, and work instructions to document changes in system operations. This documentation is used by a management system such as ISO to ensure that the new, more energy efficient operating practices are sustained over time, despite changes in personnel and production.
Energy management standards	A comprehensive standard, initially voluntary, that establishes the order and consistency necessary for organizations to proactively manage their energy resources. A key feature requires personnel to evaluate the processes and procedures they use to manage energy issues and incorporate strong operational controls and energy roles and responsibilities into existing job descriptions and work instructions.
Industrial standards framework	Industrial standards framework includes energy management standards, policies, training and tools that have the net effect of making system optimization for energy efficiency as much a part of typical industrial operating practices as waste reduction and inventory management. The objective is a permanent change in corporate culture using the structure, language, and accountability of the existing ISO management structure.
Industrial system	Industrial systems include motor-driven (compressed air, fan, pumping, conveyors, other motor/drive configurations) and steam systems. These are supporting systems, rather than industrial processes. They are ubiquitous in the manufacturing environment,

but their applications are highly varied. Facility engineers are typically responsible for their operation. An industrial system encompasses everything from the supply of energy into the system to the production end uses. A pump house, compressor room, or boiler room is *not* an industrial system because it only covers the supply side, not the distribution and end use. The mismatch between supply and end use is the most fertile ground for improving energy efficiency.

ISO — International Organization for Standardization or ISO is the world's largest developer of voluntary international standards for business, government and society. Of these, ISO 9001:2000 and ISO 14001:2004, which give the requirements for, respectively, quality management and environmental management systems, are among ISO's most well-known and widely implemented. They are used worldwide by businesses and organizations large and small, in public and private sectors, by manufacturers and service providers, in all sectors of activity.

Market transformation — Refers to a permanent change or "transformation" in the way that a market functions. In the case of industrial system energy efficiency, we seek to shift buyers and sellers of industrial energy-using equipment from a market based on the sale of equipment components to a market based on the sale of system energy efficiency services, including system assessments, controls, proper piping and storage, and quality maintenance practices in addition to equipment sized for efficient operation. While financial incentives may be required to begin shifting market behaviour, no incentives should be necessary once this transformation has occurred.

System optimization — The process through which an industrial system achieves the most energy efficient operating configuration that is cost-effective for the industrial facility. System optimization requires analysis and measurement to determine the current state of operation and to make recommendations concerning energy efficiency alternatives.

Case study 1.

COMPANIES FORGE INDIVIDUAL PATHS TO ENERGY MANAGEMENT

CONTENTS

1. INTRODUCTION

Scrambling for relief from today's high energy costs, many industrial manufacturers are focusing on their energy consumption and finding ways to manage it. Although there is no "one size fits all" programme, companies are finding positive ways to integrate energy management practices into their daily operations.

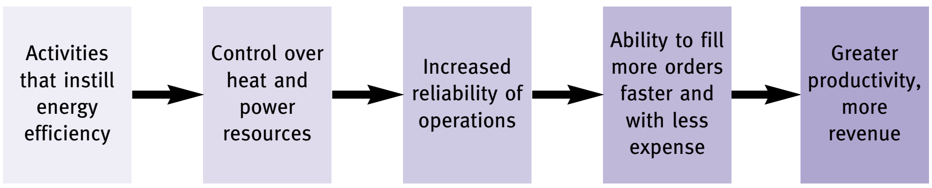
2. BENEFITS AND IMPACTS

As an organizational process, *energy management* improves a company's business performance, while *energy efficiency* describes the practices and standards that are specified by an energy management plan.

Unchecked energy expenditures are like cumulative tax burdens on each stage of production. Thus, effective energy use can directly improve productivity. Aside from lower energy bills, other benefits include greater capacity utilization, reduced scrap rates, compliance with emissions and safety regulations, and enhanced risk management.

The best industrial energy management programmes engage human, technical, and financial resources. Energy performance criteria usually reflect input from engineering, maintenance, finance, and utility staff, and all staff are accountable for outcomes. Coordinated energy decision-making improves a company's competitiveness and ultimately contributes to its wealth, as illustrated in the diagram.

Figure I. Cumulative benefits of energy management in industry



3. TEN PATHFINDERS

To better understand effective energy management programmes, the U.S. Department of Energy's (DOE) Industrial Technologies Programme (ITP) supported a sample study conducted by the Alliance to Save Energy. Ten companies were studied: 3M, C&A Floorcoverings, Continental Tire North America, DuPont, Frito-Lay, Kimberly-Clark Corporation, Merck & Co., Mercury Marine, Shaw Industries, and Unilever HPC. Many of them used ITP information resources and software tools in creating their energy management programmes.

They cited these reasons for establishing their programmes:

- Energy expense control and management of energy price volatility;
- Control of other expenses, such as capital expenditures;
- Increased revenue potential through identification and replication of capacity improvements;
- Improved product marketing through visible resource stewardship;
- Risk mitigation related to environmental liabilities and operational reliability.

Though some common threads run through the programmes, they are all different. Each has noteworthy features and results. Here are some examples:

- Both ***3M*** and the manufacturers that purchase its many products know that their markets require goods and materials with low environmental impacts; 3M has reduced its own energy consumption per pound of product at least 20 per cent since 2000. Managers believe that resource stewardship simply makes good business sense.
- ***Georgia-based C&A Floorcoverings*** matches its energy-efficiency initiatives with its business goals. In two years, C&A reduced its annual costs for natural gas, which topped $US 800,000 annually, by 10 per cent by adopting an ANSI-certified standard, "Management System for Energy 2005," as a template for its programme.
- Energy consultants and in-house management worked together to help a ***Continental Tire North America*** plant in Illinois reduce its energy consumption per tire produced by 31 per cent. Continental also partnered with an energy services company (ESCO) to incorporate self-sustaining energy management procedures into its operations.
- With more than 100 plants in 70 countries, ***DuPont*** has made energy efficiency a high priority, applying a "Six Sigma" methodology to energy management. Through 2002, more than 75 energy improvement projects had been implemented, with average annual savings of more than $US 250,000 per project.
- ***Frito-Lay's*** energy management focuses on results and requires extensive monitoring, measurement, and communications. The company's efficiency initiatives have yielded a return of more than 30 per cent on efficiency investments.

- ***Kimberly-Clark Corporation*** employs best practices to reduce air emissions, upgrade waste water treatment, minimize process water use and packaging, and eliminate landfills and toxic chemicals at more than 165 plants worldwide. The company has reduced energy use per ton of product by about 12 per cent.
- The corporate energy programme at ***Merck & Co.*** holds site managers accountable for reaching performance targets. The company's goal is to cut site energy costs by 22 per cent in four years and avoid 250,000 tons of carbon emissions. Energy efficiency was used as a strategy to increase production from existing assets, offsetting the need to make capital investments in new capacity.
- ***Mercury Marine,*** a marine propulsion systems manufacturer, gives a single manager the authority to make energy improvements, assigns cost control responsibility to production units, and uses information technologies to monitor energy flows and to bill production units for their energy use. A centralized compressed air system has reduced the company's $US 7 million annual electricity bill by nearly $US 500,000.
- Using DOE plant assessment methods and ITP BestPractices materials, a demand-side engineer at ***Shaw Industries*** documented potential energy savings of $US 1 million per month in the first six months of his tenure. In-house staff use DOE resources in energy assessment and remediation activities.
- ***Unilever's Health and Personal Care Division's*** energy management programme features a simple budget-to-actual spreadsheet comparing the energy performance of 14 facilities. The spreadsheet information has inspired facility managers to save $US 4 million in energy costs and another $US 4 million in avoided costs. This activity has caught the attention of Unilever's Board of Directors.

4. CONCLUSION

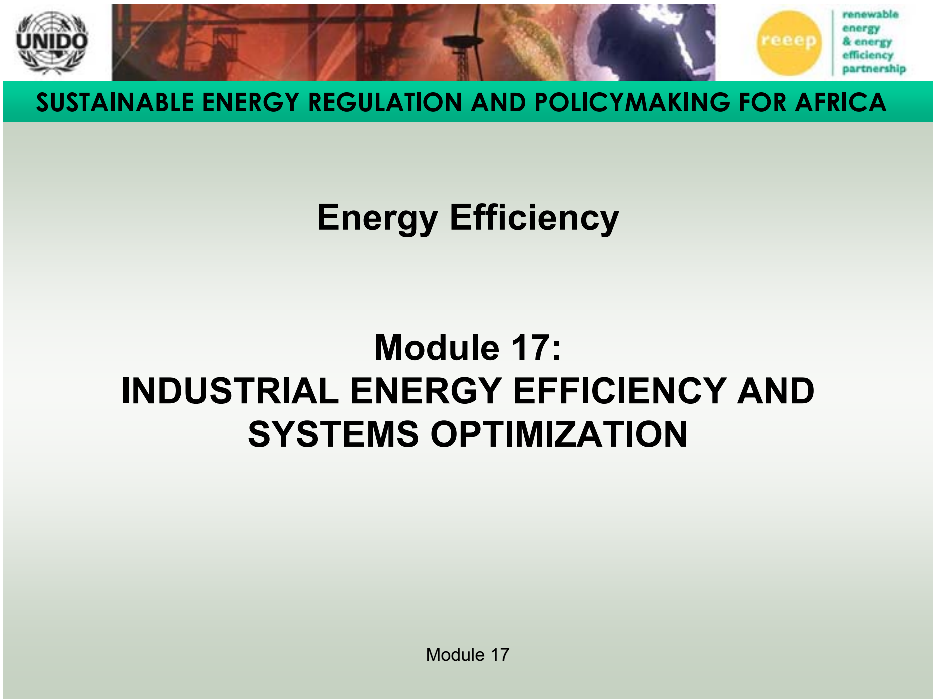
Market conditions, asset management strategies, corporate involvement, a structure of authorities, and linking energy performance to business goals all seem to be major factors in effective corporate energy management programmes.

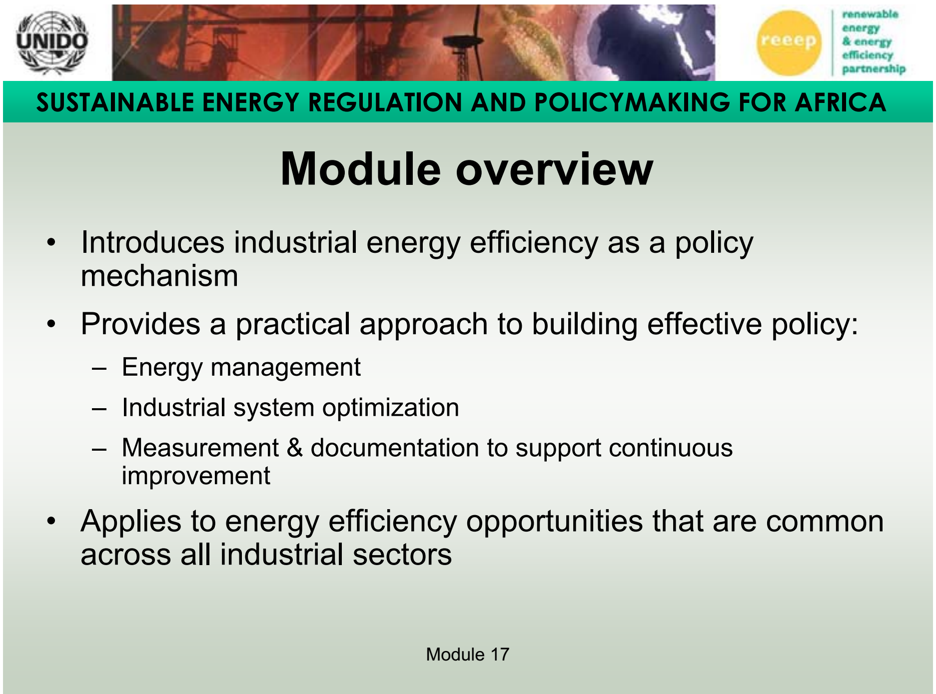
More and more companies are tailoring programmes to their own particular characteristics and needs. Their approach to energy management reflects their organizational profiles and abilities, and their commitment to improving productivity and profits through more efficient energy use.

5. REFERENCES

From the Summer 2006 issue of US Department of Energy's Energy Matters http://www.eere.energy.gov/industry/bestpractices/energymatters/

By Christopher Russell, Principal, Energy Pathfinder Management Consulting, LLC


UNIDO
reeep
renewable energy & energy efficiency partnership
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA
Energy Efficiency
Module 17:
INDUSTRIAL ENERGY EFFICIENCY AND SYSTEMS OPTIMIZATION
Module 17


UNIDO
reeep
renewable energy & energy efficiency partnership
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA
Module overview
• Introduces industrial energy efficiency as a policy mechanism
• Provides a practical approach to building effective policy:
– Energy management
– Industrial system optimization
– Measurement & documentation to support continuous improvement
• Applies to energy efficiency opportunities that are common across all industrial sectors
Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview (2)

Other issues to be addressed include:

- Programme design
- Developing enabling partnerships
- Building a national and regional market for energy efficiency services
- Financing mechanisms
- Industrial standards framework as an integrating mechanism

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Introduce the concept and benefits of industrial energy efficiency to government officials, policy-makers, and regulators
- Provide an overview of policy measures that promote industrial energy efficiency
- Describe how to develop a programme based on these policy measures that is sustainable and has market support, and
- Introduce a broader international framework for industrial energy efficiency

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- Describe the benefits and barriers of industrial energy efficiency
- Describe the policy mechanisms that can contribute to greater industrial energy efficiency
- Understand the fundamental goals of energy management and industrial system optimization
- Become aware of the international context for undertaking an industrial energy efficiency programme

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial Energy Use

- On a global basis, industry represents:
  - 40% of electricity use
  - 77% of coal and coal products use
  - Major contributor to CO_2 emissions[1]
- In developing countries:
  - Industry frequently requires 50% of the energy supply (excluding transport)
  - Economic development can exceed energy supply, creating barriers to growth

[1] International Energy Agency (IEA) Statistics Division and IEA 7 July 2006 Industrial motor system energy efficiency: Toward a plan of action.

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial Energy Use in Africa

- Is growing rapidly
  - Intergovernmental Panel on Climate Change (IPCC) projects average annual growth rates for sub-Saharan Africa of 5.1% to 7.3% through 2030[2]
- Offers an opportunity “to do it right”, to moderate use, increase industrial sustainability, and improve competitiveness
  - Integrate energy efficient practices as industrial facilities are built or expanded
  - If fully integrated into management practices, energy efficiencies will persist over the life of the facilities

[2] Special Report on Emissions Scenarios: Report of Working Group III of the IPCC, 2000, Nakicenovic, N., Alcamo, J., et.al.

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Introduction

- In industry, energy efficiency is more related to operational practices than in commercial or residential sectors
  - In commercial and residential buildings, energy efficient lighting and appliances provide the same level of service without regard to the user
  - In industry, system energy efficiency is greatly affected by changes in production volumes, products, and practices

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Barriers to EE in Industry

- Principal business of industry is production, not energy efficiency
- Traditional approaches to industrial system design and operation emphasize reliability, not energy efficiency
- Energy efficiency components do not, in themselves, result in energy efficient systems
- Lack of connection between operational budgets (energy costs) and capital budgets (equipment purchases) creates barriers to correcting inefficiencies

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Creating Effective Policy

- Establish broad policy goals, such as energy management standards
- Build awareness of benefits of energy efficiency
- Address perceived risk from operational changes
- Work with users and suppliers of industrial systems to develop necessary technical skills and tools
- Transform the industrial market to greater energy efficiency
  - Immediate benefits in two years
  - Permanent change that contributes to economic growth & sustainability

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial Energy Efficiency in the USA

- From 1993-2004, the US Department of Energy's Best Practices program identified 255 trillion Btu per year, or $US 1.4 billion in annual energy cost savings, from the application of industrial energy management best practices
- Equivalent to the energy used in 1.55 million homes[3]

[3] United States Department of Energy presentation to the International Energy Agency, May 2006

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why Industrial Energy Efficiency?

- Managers of industrial facilities always seek ways to reduce costs & improve reliability of production
  - Materials utilization, labour costs, production quality, energy costs, and waste reduction are all subject to regular scrutiny
  - *Energy efficiency* is typically not considered

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial Systems & Energy Efficiency

- Offer one of the largest opportunities for energy savings, largely unrealized
- Both markets and policy makers focus on individual components
- Components offer a 2-5% improvement potential, whilst *systems* offer a 20-50% improvement potential
- Energy efficient systems also contribute to improved reliability & control and lower maintenance costs
- Higher production volume may be possible through better utilization of equipment assets
- Payback periods are short- a few months to 3 years

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What motivates Industry to become more Energy Efficiency?

- Cost reduction
- Improved operational reliability and control
- Ability to increase production without requiring additional, and possibly constrained, energy supply
- Avoidance of capital expenditures through greater utilization of existing equipment
- Recognition as a “green company”
- Access to investor capital through demonstration of effective management practices

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Lack of Awareness Leads to Inefficiency

15 kW Motor
Efficiency is ~ 91%

Pump head: 36 m
Flow rate: 97.6 m^3/h
=> hydraulic power: 9.6 kW

Combined pump and motor efficiency = 59%

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Optimizing a Motor System: Pump + Motor + Discharge Valve

There is > 28 m pressure drop across the throttled valve

Useful hydraulic power = 2.1 kW

Actual *System* Efficiency is only 13%

Courtesy of Don Casada, Diagnostic Solutions

Replacing the existing motor in this system with a more energy efficient one would accomplish little

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Issue #1: Optimizing Systems for EE

- Energy efficient system design techniques are not taught at university—they are learned through experience
  - Systems are often designed to be reliable at the lowest first cost investment, rather than to operate efficiently
  - Unless the process load is truly constant, effective system design must support efficient operation at a variety of loads

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Issue #2: Optimizing Systems for EE

- Plant and operations staff frequently experience difficulty in achieving management support
  - Management is focused on production, not energy efficiency
  - Management doesn’t understand the relationship between operational cost and equipment life cycle cost (operational cost is often 80% or more of the life cycle cost)

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Issue #3: Optimizing Systems for EE

- Most optimized systems lose their initial efficiency gains over time due to personnel and production changes
- Not integrated with quality control and production management systems

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial EE Programme Elements

Essential elements:

- Energy management standards
- System optimization training
- Tools to assist companies in documenting and sustaining their energy efficiency improvements

Other enabling policies:

- Recognition programmes
- Favourable tax policies
- Sectoral targets

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Tips for Success

- Involve industry early—both suppliers and users
- Be consistent and transparent in both planning and implementation
- Plan meetings well—avoid wasting the participants' time
- Be balanced—avoid any appearance of product bias

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Learning from Process Management

- Like industrial systems, successful industrial processes are complex and changing, but they are:
  - Consistent
  - Adaptable
  - Resource efficient
  - Continually improving
- These goals are often achieved through widespread adoption of a management system to maintain and improve quality, such as:
  - International Organization for Standardization (ISO)
  - 6 Sigma
  - Total Quality Management

What if system energy efficiency were fully integrated into these management systems?

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What are ISO 9000 and ISO 14000?

- ISO 9000 provides a framework for organizations to continuously improve the quality of their operations and production
- ISO 14001 provides a framework for organizations to achieve and demonstrate their commitment to responsible environmental management
- Companies may participate in one or both ISO certification programmes
- ISO 9000/2000 allows the combination of both programmes

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Management

- ISO currently has no explicit programme for energy efficiency
- Use an ISO-compatible energy management standard to link ISO 9000/14000 quality and environmental management system and industrial system optimization for energy efficiency
- Combine use of the standard with ISO-friendly documentation

Result: build energy efficiency into an existing ISO continuous improvement programme

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Management Standards

- Objective: achieve permanent change in the corporate culture of an industrial facility using the structure, language, and accountability of the ISO management system
- Existing examples of energy management standards in the US, Denmark, Sweden, and Ireland; reference ISO principles
- UNIDO is facilitating international cooperation on energy management standards

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy MS: Typical Features

- Strategic plan requiring measurement, management, and documentation for continuous improvement for energy efficiency
- Cross-divisional management team:
  - Led by an energy coordinator
  - Reporting directly to management
  - Responsible for implementation of the strategic plan
- Policies and procedures to address all aspects of energy purchase, use, and disposal

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

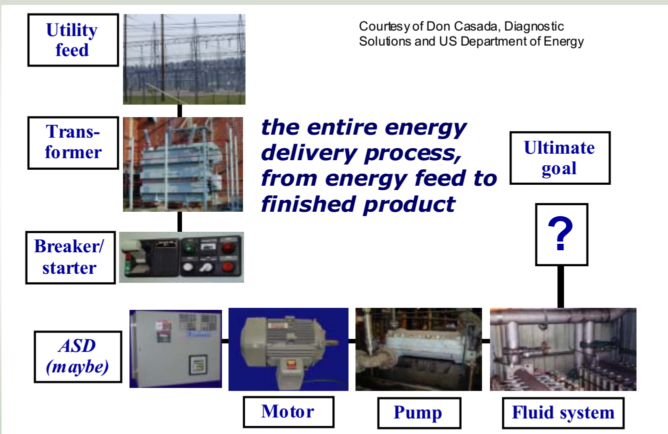
Energy MS: Typical Features (2)

- Projects to demonstrate continuous improvement in energy efficiency
- Creation of an energy manual—a living document that evolves over time as additional energy saving projects and policies are undertaken and documented
- Identification of key performance indicators, unique to the company, that are tracked to measure progress
- Periodic reporting of progress to management based on these measurements

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What is a System?



Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What is System Optimization?

- System optimization seeks to design and operate industrial systems (i.e. motor/drive, pumping, compressed air, fan, and steam systems) to provide excellent support to production processes using the ***least amount of energy that can be cost-effectively achieved***

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

How are Systems optimized?

This process includes:

- Evaluating work requirements
- Matching system supply to these requirements
- Eliminating or reconfiguring inefficient uses and practices (throttling, open blowing, etc)
- Changing out or supplementing existing equipment to better match work requirements and increase operating efficiency
- Applying sophisticated control strategies and variable speed drives that allow greater flexibility to match supply with demand
- Identifying and correcting maintenance problems
- Upgrading ongoing maintenance practices

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Building Technical Capacity

- UNIDO has worked with a team of international experts:
  - Developed and a training curriculum specifically designed to build the necessary technical capacity
  - Piloted successfully in China 2001-2005

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy savings from system improvements (China pilot programme)

System/facility	Total cost (US$)	Energy savings (kWh/year)	Payback period
Compressed air /forge plant	18,600	150,000	1.5 years
Compressed air /machinery plant	32,400	310,800	1.3 years
Compressed air /tobacco industry	23,900	150,000	2 years
Pump system /hospital	18,600	77,000	2 years
Pump system /pharmaceuticals	150,000	1.05 million	1.8 years
Motor systems /petrochemicals (an extremely large facility)	393,000	14.1 million	0.5 years

Courtesy of Robert Williams, UNIDO 2005

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Building Technical Capacity: System Optimization Training

- Goal: create a cadre of highly skilled system optimization experts
- Target groups: individuals with prior background in mechanical or electrical engineering from:
  - Government-sponsored or NGO energy centres,
  - Industrial facilities,
  - Equipment manufacturers and distributors,
  - Consulting firms and engineering services companies.
- Selection of trainees is *critically* important to overall success of programme

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

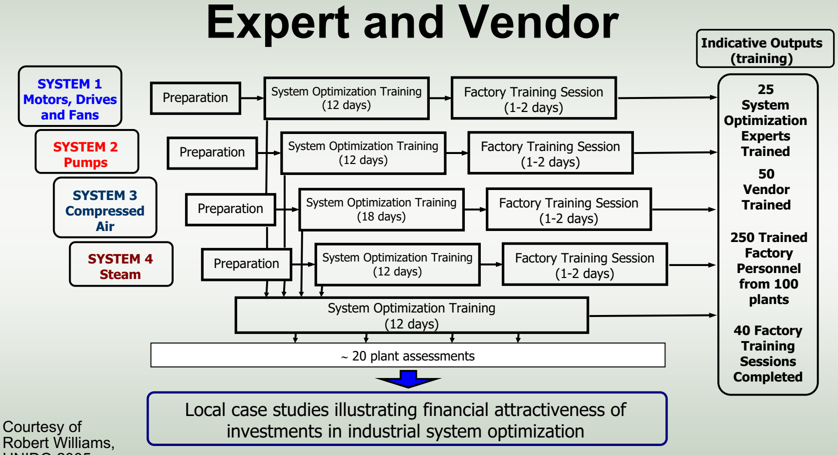
System Optimization Training

- Conducted by a team of international experts
- Training is intensive and system specific
- Both classroom & hands-on measurement training in industrial facilities
- Prepares trainees to:
  - Conduct system assessments
  - Develop energy efficiency improvement projects
  - Offer awareness training to industrial facilities on system optimization techniques

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

System Optimization Training - Expert and Vendor



Courtesy of Robert Williams, UNIDO 2005

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Documenting for Sustainability

ISO 14001:

Purpose is to provide a framework for organizations to achieve and demonstrate their commitment to an environmental management system that minimizes the impact of their activities on the environment[4]

[4] Note: a similar framework for ISO 9001:2000 pertains to quality

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

ISO Certification Process

- Each participating company establishes a management system that supports continuous improvement
- To maintain certification, companies must maintain a Quality Environmental Management (QEM) Manual
- ISO-certified independent auditors regularly check for company compliance
- If non-compliant, a company must file and implement a plan of correction

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Management and ISO

- To integrate energy management standards, a company must develop procedures for energy systems
- **Procedure**
  - General description of a process:
    - purpose and scope,
    - how activity is performed
    - responsible person,
    - why activity is important to efficient operation,
    - what equipment is required,
    - timetable for activity,
    - documentation and reporting required.

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Management and ISO (2)

- Incorporated into company's QEM manual
- Supports company's policy of efficient operation of energy systems

- **Project**
  - Companies need projects to demonstrate continuous improvement (example—initiating leak management programme or replace throttle valve with speed control)
- **Work instructions**
  - Step-by-step information to assist operations staff in maintaining improvements realized through project implementation;
  - Staff trained to follow work instructions;
  - Instructions are posted in an area accessible to staff.

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Other Enabling Policies – Energy Efficiency Agreements

- Signed, negotiated agreement with specific targets tied to units of production
- Long-term outlook (typically 5-10 years)
- Includes an implementation plan for reaching the targets
- Includes annual monitoring of progress toward the targets
- Require supporting programmes—technical assistance, recognition to succeed

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Other Enabling Policies – Energy Efficiency Agreements (2)

- Most effective programmes
  - Are legally binding
  - Set realistic targets
  - Include sufficient government support
  - Include real threat of increased government regulation or energy/GHG taxes if targets are not achieved

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Building a Market for Industrial Energy Efficiency Services

- Role of government
  - Develop and issue energy efficiency standards
  - Support the provision of training and tools to industry, consultants, and suppliers to aid in compliance
  - Recognize industrial facilities that comply with standards
- Role of industry
  - Responsible for compliance with national standards for corporate energy management
  - Implement system optimization projects

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Building a Market for Industrial Energy Efficiency Services (2)

- Role of suppliers
  - Participate in vendor training
  - Introduce industrial customers to system optimization concepts
- Role of consultants and energy service companies
  - Participate in experts training
  - Conduct system assessments and develop projects

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Developing Enabling Partnerships

Partnerships are needed to:

- Build ownership to change existing practices and behaviours for greater energy efficiency
- Reach industrial firms with the system optimization message through existing business relationships
- Develop credibility within specialized industrial sectors
- Ensure that proposed policies are practical
- Engage the financial community and help them understand the financial benefits of energy efficiency
- Recruit the best talent to become trained in system optimization techniques
- Successfully launch an industrial energy efficiency programme

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing Considerations

- Most system optimization projects are relatively small ($US 10,000-$US 250,000)
- Typically do not require off-balance sheet financing
- This may vary depending on the availability of local capital
- Financing options can include:
  - Loans, either guaranteed or at a subsidized interest loan rate

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing Considerations (2)

- Financial incentives such as rebates, dealer incentives, or utility incentives
- Leasing arrangements that allow monthly payment from plant operating budget rather than capital expense;
- Vendor provision of the service rather than equipment;
- Third party financing via an energy service performance contract, such as shared savings arrangement.

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial Standards Framework

- Framework includes:
  - Energy management standards
  - Policies, such as recognition and agreements
  - Training, for energy management and system optimization
  - Tools, such as the System Optimization Library
- Purpose:
  - Standardize, measure, and recognize industrial system optimization efforts
  - Provide flexibility so that factories can approach system optimization incrementally
  - Produce *permanent change in corporate culture* -integrate energy efficiency into management practices

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Industrial energy efficiency is an often overlooked element of national energy policy
- Developing countries have a particular opportunity to increase their competitiveness by applying energy efficient best practices as industrial facilities are built or expanded
- If system energy efficiency is not addressed during facility development, the resulting wasteful energy practices can persist for 10-20 years or more[5]

[5] Depending on the useful life of the major equipment

Module 17