THE REGULATORY ASSISTANCE PROJECT

Efficiency Power Plant Policies in China

Lessons from International Experience

June 2010

Prepared by the Regulatory Assistance Project
and
The Earnest Orlando Lawrence Berkeley Laboratory, China Energy Group
under
The Partnership for Climate Action

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I. Introduction

The Regulatory Assistance Project's March 2010 report under the Partnership for Climate Action explained the Efficiency Power Plant (EPP) concept and design principles and assessed Guangdong's pioneering efforts. The current report looks at aspects of the international experience that should be useful in improving and expanding EPPs in China and elsewhere. The report focuses on the US in particular, because various states in the US have rich experience with mobilizing grid companies for energy efficiency – a topic that is becoming increasingly relevant in China.

More specifically, this report deals with three topics that will be important for developing a robust EPP policy regime. First, a number of states have had good success with positive incentive mechanisms that have transformed grid companies (or utilities) from aggressive marketers of electricity – and enemies of efficiency – into keen efficiency advocates that canvass customers in search of potential efficiency investments. The details of these mechanisms may be fruitful for Chinese policymakers as they seek to incorporate efficiency into the business model for grid companies in China.

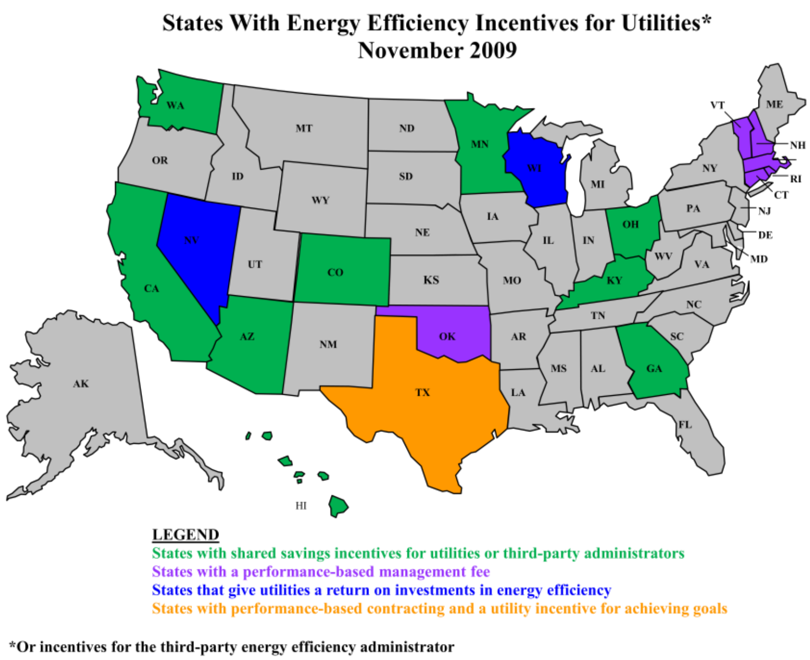
Second, we examine the US experience with on-bill collection. As discussed in the March report, using existing electricity billing procedures to collect financing payments for energy efficiency measures would help facilitate EPPs in China. Many US states have experimented with on-bill collection and their experience shows that the obstacles – particularly grid company resistance and the challenges of bill redesign – can be readily overcome.

Finally, we turn to international audit "best practice". The success of any EPP will be based partly on the quality and efficiency of its audit practices. We look at auditing procedures in the US, Japan and Finland, with an eye to lessons for Chinese EPP developers.

II. U.S. Experience With Energy Efficiency Incentives for Utilities

Beginning in the late 1970s, some state regulators in the U.S. began making regulatory changes to remedy disincentives for grid companies (or "utilities") to provide energy efficiency services. They recognized that, under the *status quo* approach to regulation, energy efficiency reduces utility sales of energy. That means less revenue to cover the utility's fixed costs – and lower profits. (Conversely, increasing sales raises utility profits.) These regulators also understood that utilities have no financial incentive to invest in energy efficiency.[1]

Today, through a regulatory mechanism called "decoupling," electric and natural gas utilities in many U.S. states no longer have their profits linked to energy sales. The periodic review of utility costs (or "rate case") process remains the same as before decoupling, including the determination of the utility's allowed revenue. However, consumer prices are then adjusted up or down between reviews, in order to keep the utility's revenue at just the level allowed to cover its fixed costs – no more, no less.



But decoupling only removes a utility's disincentive toward energy efficiency; it does not motivate it to invest in this least-cost, clean resource. In contrast, utilities in the U.S. that invest in generation facilities have the opportunity to earn a return on their supply-side assets. Similarly, utilities in both traditional and liberalized markets can earn a return on grid investments. To address this discrepancy between incentives to invest in demand- side resources vs. generating and grid assets, many state regulatory commissions have implemented positive financial incentives to encourage utilities to achieve high energy-savings targets. These incentives may be adopted together with decoupling or on a stand-alone basis.[2] The objective is to keep utilities digging deep and comprehensively for both energy and capacity savings.

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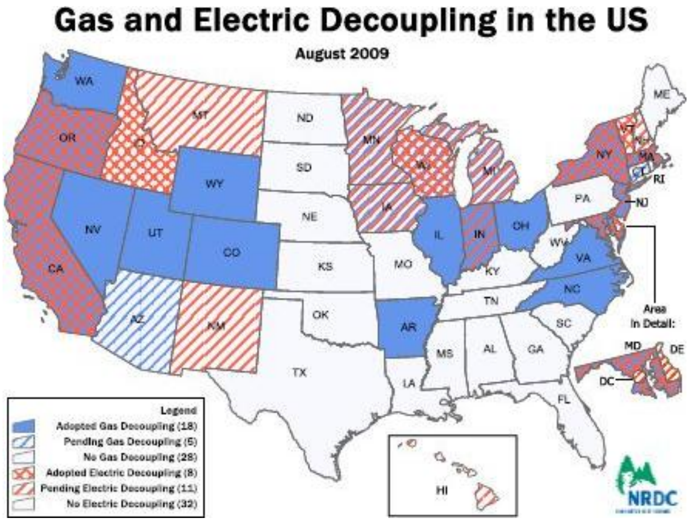
[1] Except during prolonged periods of high market prices where the utility does not have an automatic power cost adjustment.
[2] See incentives map by Lisa Schwartz, RAP, and decoupling map by Natural Resources Defense Council.



Types of Positive Financial Incentives for Utilities

State regulators have adopted two types of incentives:

1. **Performance-based incentives** link the utility's financial reward to the energy (and sometimes capacity) savings achieved. Well-designed, performance-based mechanisms can improve administration of energy efficiency programs by rewarding increased program penetration and reduced program costs. There are several types of performance-based incentives:

   - **Shared Savings**, where earnings are based on a specified percentage of "net" benefits – resource savings minus costs – or the avoided costs of energy efficiency. Typically, the utility must achieve a minimum threshold of energy savings, capacity savings, or both in order to qualify for the incentive. Net benefits increase when the utility achieves cost-effective savings and project costs are reduced. The shared savings approach requires more detailed analysis than other approaches, including determining net benefits and accurately measuring and verifying savings.

   - **Management Fee** - Earnings are calculated as a specified percentage of energy efficiency program costs if the utility achieves or exceeds approved program goals, including energy or capacity savings. The utility also may be required to achieve additional targets such as program participation levels, installation rates for specified measures, and reductions in administrative costs. The management fee approach does not necessarily focus spending on cost-effective programs and net benefits. Regulators can address this issue by tying incentive rates to well-vetted, approved *budgets*, not utility expenditures, by adopting aggressive goals and clear performance metrics, and by exercising careful oversight.

- **Standard Performance Contracting** - Incentive payments are determined by the level of energy (kilowatt-hour, or kWh) and capacity (kilowatt, or kW) savings from installed measures, under pre-established terms.[3]

2. **Cost Capitalization** – Under this approach, energy efficiency program costs are included in the utility's rate base[4] and amortized[5] over time. The utility can earn its authorized rate of return on equity (ROE)[6] on these program costs, as if it were investing in a power plant or distribution substation. This approach helps level the playing field for energy efficiency, compared to utility-owned, supply-side resources. Some jurisdictions apply a bonus to the utility's ROE to make energy efficiency the *most* profitable investment.[7] In addition, amortizing instead of expensing[8] energy efficiency better matches cost recovery to the useful life of efficiency measures – on average seven to 10 years. One downside of this approach is that it does not explicitly tie the utility incentive to program performance.

   The cost capitalization approach has generally fallen out of favor among utilities in the U.S. Utilities must raise more capital, or use retained earnings or internal cash flow, to finance energy efficiency under this approach. Capitalizing energy efficiency also may affect their credit rating. Credit rating agencies may impute more debt on the utility's balance sheet, with no underlying asset like a power plant that the utility's bankers could seize if the debt goes unpaid. Reducing the amortization period to three to five years can help mitigate these problems.

Example Financial Incentives for U.S. Utilities

California Risk-Reward Incentive Mechanism

The California Public Utilities Commission sets energy-savings goals for the utilities it regulates. Beginning with the 2006 to 2008 program period, the Commission established a system of incentives and penalties for achieving, or failing to achieve, these goals. Energy reduction goals were set for electric and natural gas utilities; electric utilities also had demand reduction goals.

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[3] *See*, for example, Lainie Motamedi, Regulatory Assistance Project, "Texas Energy Efficiency Policy and Program Framework and Requirements," October 2009, http://raponline.org/docs/rap_motamedi_researchbrief_2009_10_14.pdf.

[4] The regulatory asset value on which the utility can earn its allowed rate of return.

[5] Recovering capital costs over time through a specified number of recurring payments, generally based on the life of the asset.

[6] ROE is the amount of net income returned as a percentage of shareholders' equity. ROE measures a corporation's profitability by revealing how much profit a company generates with the money shareholders have invested. *See* http://www.investopedia.com/terms/r/returnonequity.asp.

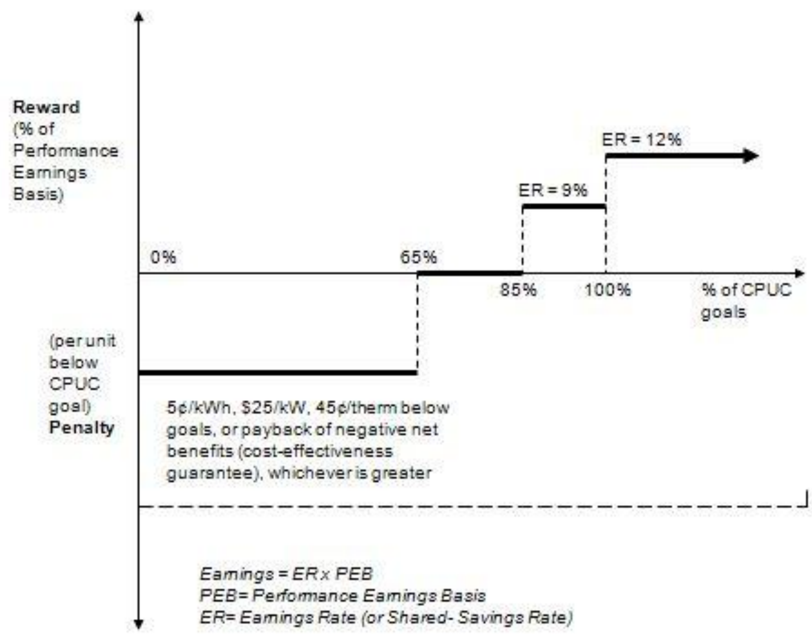
[7] However, a power plant may still be more attractive to the utility because of the relative scale of demand-side vs. supply-side investments.

[8] Program costs can be recovered as expenses or can be treated like capital items by accruing program costs with carrying charges, and then amortizing the balances with recovery over a period of years. Refer to *Utility Incentives With Investment in Energy Efficiency* referenced in "For More Information" at the end of this section.

The utilities had the opportunity to earn incentives if they achieved at least 85 of the goals, based on average performance on all applicable measures. The incentive ranged from 9 percent to 12 percent of net economic benefits. Total incentives and penalties were capped as shown in the figure below. The utility received a portion of the incentive after verification of: 1) actual measures installed and 2) program costs. The final incentive payment was withheld until energy and demand savings were verified.

The utility was not eligible for incentives if it did not achieve at least 80 percent of its goals. The Commission could impose a penalty on the utility if it failed to achieve at least 65 percent of its goals.

The program has been highly controversial as a result of disagreements between the utilities, the Commission, and other stakeholders over actual energy and demand savings achieved and the stair-step approach to incentive levels. The Commission is conducting an extensive review of the program and is making changes to make it more transparent and workable.



See California PUC D.08-09-043 at 8. Earnings and penalties are capped by utility as follows: PG&E - $180 million, SCE - $200 million, SDG&E - $50 million and SoCalGas - $20 million.

Public Service of Colorado Shared-Savings Incentive

A 2007 Colorado law directed the state Public Utilities Commission to offer utilities an opportunity to make demand-side management investments more profitable than other investments. The bill also set a goal that by 2018, energy savings in aggregate must reach at least 5 percent of 2006 energy sales.

Under the Commission-approved approach for Public Service of Colorado, the utility earns an incentive if it achieves at least 80 percent of the adopted energy efficiency goal. The incentive is equal to 0.2 percent of net economic benefits for each 1 percent of savings beyond 80 percent of the goal, with the incentive increasing incrementally to 10 percent of net benefits at 130 percent of goal attainment. (If the utility achieves 100 percent of the goal, it earns an incentive equal to 4 percent of net economic benefits.) The utility earns 0.1 percent of net economic benefits for each 1 percent savings beyond 130 percent, and up to 12 percent of benefits at 150 percent of goal attainment.

The utility also receives a $2 million "disincentive offset" on an after-tax basis each year it implements an approved demand-side management plan – a step toward, but short of, decoupling. The performance incentive plus the disincentive offset cannot exceed 20 percent of total demand-side management expenditures. There are no penalties for failure to meet energy efficiency goals.

Performance-Based Management Fee for Connecticut Utilities
Under Connecticut law, prudently incurred costs for approved and successfully implemented energy efficiency programs administered by electric and natural gas utilities are eligible for either: 1) a return in rate base between 1 percent and 5 percent higher than the otherwise applicable rate of return or 2) a "return" within the same range if treated as operating costs.

To implement the law, the Department of Public Utility Control established performance-based incentives for utilities that are tied to approved energy savings goals. Utilities can earn a percentage of approved energy efficiency budgets (not expenditures), ranging from 2 percent for achieving 70 percent of the goals to 8 percent for achieving 130 percent of the goals. (The utility can earn a 5 percent incentive for achieving 100 percent of the goals.[9])

The majority of the incentive is tied to energy (kWh) and demand (kW) savings. Additional performance measures have included goals for programs for low-income households, energy efficiency audits for industrial customers, improving the efficiency of new homes during construction, and targeting regions with electric reliability problems.
The utilities have earned the maximum incentive – 8 percent of energy efficiency budgets – in some years. In 2008, utilities overspent their approved budgets without timely involvement of the Department of Utility Control in that decision. Regulators did not allow an incentive on utility spending beyond approved budget levels, pointing out that: 1) energy efficiency goals are tied directly to the budget and 2) it would be unfair to customers if the utilities earned a higher bonus incentive by simply increasing their budget (without an associated increase in energy savings and other program goals).

Performance-Based Management Fee for the Vermont Energy Efficiency Utility
Under Vermont law, a third-party "Energy Efficiency Utility" provides energy efficiency programs throughout the state under the oversight of the state regulatory commission, the Vermont Public Service Board. The Board contracted with the Vermont Energy Investment Corporation for this service following a competitive bidding process. The performance-based contract for 2009-2011 includes goals in these areas:

- Cumulative electricity savings
- Peak demand savings by season and geographic area
- Total resource benefits
- Goals for specific energy efficiency programs – for example, increased measure penetration in certain business end-uses

Performance incentives are capped at 2.6 percent of the total budget. Minimum performance requirements include the benefit/cost ratio, spending on residential customers and low-income households, program participation by small business customers, and geographic equity to encourage program coverage throughout the state.

[9] Figures are pre-tax.

Nevada Bonus Return on Equity
Under Nevada law, utilities can earn their authorized ROE plus a 5 percent bonus ROE for prudent and reasonable conservation and demand management investments. For example, if the ROE authorized by the Commission is 8 percent, the utility can earn 13 percent on its energy efficiency investments. Such an energy efficiency incentive is in place for Nevada Power Company. The law also allows utilities to request a bonus ROE for "critical facilities" such as reliability investments in the same manner.

Incentive Design

The energy efficiency program manager functions best with clear performance metrics that are aligned with financial risks and rewards. Positive financial incentives make the manager squarely responsible for developing best program designs, partnerships, and marketing strategies.

Among the design considerations for energy efficiency incentives for utilities are the following:

- Performance metrics
  - They should be observable, measurable, verifiable, and clearly aligned with policy objectives, and they should not create perverse incentives.
  - They should focus on strong savings targets – kWh, kW, therms, and carbon – as well as net benefits.
  - Additional metrics should be considered – for example, market transformation indicators, maximizing cost-effectiveness and net benefits, minimizing costs, and equity across customers.

- Earnings structure
  - The incentive should not be higher than required to induce the level of energy efficiency investment regulators desire.
  - Regulators should avoid establishing earnings structures where a small change in energy or demand savings results in a large change in utility earnings. Sliding-scale incentives should be considered instead of steep, stair-step changes in incentive rates.
  - Minimum performance thresholds should be established for the utility to qualify for any earnings.
  - Regulators should consider whether to reward energy efficiency results that fall somewhat below aggressive performance goals.
  - Pre-established penalty provisions should be considered for a utility's failure to reach designated minimum levels of savings, thereby providing a balanced incentive/penalty structure. However, whether and how penalties are established should be carefully considered. They may provide a disincentive for utilities to

  undertake innovative approaches to energy efficiency and to adequately serve certain customer classes.
  - Total dollars for earnings and penalties should be capped.
  - How to link earnings to measurement and verification results for energy and demand savings remains challenging and controversial.

- Evaluation, measurement and verification
  - *Ex ante* vs. *ex post* performance metrics should be carefully investigated when designing incentive structures and should be periodically reviewed.
  - Regulators should address upfront how measurement and verification reports for energy efficiency achievements will be vetted and how stakeholder disputes over savings estimates, and incentive and penalty calculations, will be handled.
  - Regulators should plan for the lag between program results and incentives, as well as their linkage to earnings in the next period.
  - Regulators should consider controllability, measurability, and fairness in determining program metrics as well as evaluation, measurement, and verification.

- Other Considerations
  - Consider whole building approaches when setting energy savings goals and designing energy efficiency programs.
  - Regulators should explicitly address how efficiency programs for low-income households will affect the utility incentive structure, including whether the programs should be included or excluded from savings estimates, program cost calculations, minimum program requirements, and savings thresholds.

Considerations for China

The U.S. experience shows that a number of incentive approaches – with careful design and implementation – can work to promote grid company investment in energy efficiency. The key is to:

1) Identify the cost-effective, achievable potential for energy efficiency over the long term.
2) Establish energy savings goals, with interim targets, that are consistent with this potential.
3) Remove disincentives to grid company involvement in energy efficiency.
4) Tie positive financial incentives to strong grid company performance toward achieving these goals.

Energy efficiency goals can be set in different ways. Some states have adopted energy efficiency resource standards that require achievement of specified energy savings targets over time; others have had success with requiring utilities to compare demand- and supply-side options and acquire all cost-effective energy efficiency.

Besides decoupling and positive financial incentives, U.S. state regulators also have recognized the importance of utilities recovering their costs for energy efficiency in a timely manner. Cost recovery may be addressed through grid company rate cases, a system benefit charge, or a special energy efficiency tariff. A balancing account can track under- and over-collection of utility costs for later prudence review and true-up.

For More Information

National Action Plan for Energy Efficiency, *Aligning Utility Incentives With Investment in Energy Efficiency,* prepared by Val R. Jensen, ICF International, November 2007, http://www.epa.gov/cleanenergy/documents/incentives.pdf.

Peter Cappers, Charles Goldman, Michele Chait, George Edgar, Jeff Schlegel, and Wayne Shirley, *Financial Analysis of Incentive Mechanisms to Promote Energy Efficiency: Case Study of a Prototypical Southwest Utility*, Ernest Orlando Lawrence Berkeley National Laboratory, March 2009, http://eetd.lbl.gov/EA/EMP/reports/lbnl-1598e.pdf and http://eetd.lbl.gov/EA/EMP/reports/lbnl-1598e-app.pdf (appendices).

Peter Cappers and Charles Goldman, *Empirical Assessment of Shareholder Incentive Mechanism Designs Under Aggressive Savings Goals: Case Study of a Kansas "Super-Utility,"* Ernest Orlando Lawrence Berkeley National Laboratory, August 2009, http://eetd.lbl.gov/EA/EMP/reports/lbnl-2492e.pdf.

Michael W. Rufo, Itron Inc., "Evaluation and Performance Incentives: Seeking Paths to (Relatively) Peaceful Coexistence," Proceedings of the 2009 International Energy Program Evaluation Conference, Aug. 12-14, 2009, pp. 1030-1041, http://docs.cpuc.ca.gov/efile/CM/106837.pdf.

Lisa Schwartz and Wayne Shirley, Regulatory Assistance Project, "Energy Efficiency Incentives for Utilities: A Review of Approaches So Far," presented at Idaho Office of Energy Resources Workshop, Oct. 6, 2009, http://raponline.org/docs/RAP_Schwartz_Shirley_UtilityEfficiencyincentives_2009_10_6.pdf.

Tom Roberts, Division of Ratepayer Advocates, California Public Utilities Commission, *California's Shareholder Incentive Mechanism – a Ratepayer Perspective*, presented to the American Council for an Energy-Efficient Economy (ACEEE) Summer Study Conference on Energy Efficiency in Industry, July 2009, http://www.dra.ca.gov/NR/rdonlyres/A69928B3-DEC3-4FC9-BBB7-3E73C9063DCF/0/TomRoberts2009ACEEEpaperFinalMay292009.pdf.

California Public Utilities Commission proceeding to examine the Energy Efficiency Risk/Reward

Incentive Mechanism, Rulemaking 09-01-019, http://docs.cpuc.ca.gov/published/proceedings/R0901019.htm.

Martin Kushler, Dan York, and Patti Witte, ACEEE, *Aligning Utility Interests With Energy Efficiency Objectives: A Review of Recent Efforts at Decoupling and Performance Incentives*, October 2006, http://www.aceee.org/pubs/u061.pdf.

William B. Marcus and Cynthia K. Mitchell, *Critical Thinking on California IOU Energy Efficiency Performance Incentives from a Consumer Advocate's Perspective*, presented to ACEEE Summer Study on Energy Efficiency in Buildings, August 2006, http://www.jbsenergy.com/Energy/Papers/Energy_Efficiency_Performance_Incentives_ACEEE.htm.

Wayne Shirley, Jim Lazar, and Frederick Weston, *Revenue Decoupling Standards and Criteria: A Report to the Minnesota Public Utilities Commission*, June 2008, http://www.raponline.org/Pubs/MN-RAP_Decoupling_Rpt_6-2008.pdf.

Pamela G. Lesh, *Rate Impacts and Key Design Elements of Gas and Electric Utility Decoupling: A Comprehensive Review*, June 30, 2009, http://www.raponline.org/Pubs/Lesh-CompReviewDecouplingInfoElecandGas-30June09.pdf.

III. The US Experience with On-bill Collection of Energy Efficiency Costs

As discussed in the March 2010 report on the Guangdong EPP, the main idea of on-bill collection (OBC) is to take advantage of existing electricity billing systems in order to collect repayments and associated fees – which would then appear as line items on routine electricity bills. This section looks at the US experience with OBC.

In the US, a growing number of states have experimented with OBC programs in which electricity service providers (utilities) pay for energy efficiency measures and then collect the capital costs (along with interest payments) over time from electricity customers.

Although they have been operating in some states for two decades, OBC programs are currently only accessible to a small minority of electricity customers in the US. So far, OBC has almost exclusively focused on residential, local government, and small enterprises. However, regulators in the US have growing interest in OBC.

Two types of OBC

It is useful to classify US OBC programs into two types. The difference between the two lies in whether the responsibilities for payments are assigned to the meter or the original borrower. In the first type, "meter-based" OBC, responsibility for repayment stays with the facility or residence. The current owner or occupier is responsible for maintaining payments, as shown on the electricity bill. Under the second type, borrower-based OBC, responsibility for repayment is attached to the customer who initially accepts the implementation of the efficiency measure (ie, the original borrower). Even if the original customer sells the facility or residence, she is still responsible for repayment. In both of these approaches, the utility pays for the full installed cost of the energy efficiency measures, and the customer pays a monthly on-bill fee to compensate the utility, in addition to the standard delivery charge. The financing term is usually equal to or shorter than the predicted life of the measure. Financing is often shorter in borrower-based systems than meter-based systems.

The experience with meter-based OBC in the US has shown more promise than borrower-based OBC, for several reasons:

- Under US law and financial regulation, meter-based programs are typically not treated as loans. These programs are free from many of the restrictions and oversight mechanisms associated with debt instruments. As a result, they are easier to implement than borrower-based programs (which are considered loans). For example, no credit checks are necessary for individual borrowers.

- Customers appear more willing to adopt efficiency measures under meter-based OBC, because they know they will only have to pay for the measure for as long as they occupy the residence or facility. This mitigates their concerns about their duration of occupancy and obligation to pay for long-life measures.

- Because meter-based OBC allows repayments to be spread out over a number of occupants or owners, financing can be provided on longer terms than would be the case with borrower-based OBC. This opens of the possibility of promoting relatively expensive but long-lived efficiency measures that might otherwise not be adopted due to end-user cash-flow constraints.

Still, borrower-based programs have been successful in a number of states and have the potential to provide large amounts of energy savings. Borrower-based OBC is certainly a legitimate option, if there is some reason that it is more convenient for regulators.

Borrower-based OBC programs

Various borrower-based OBC programs have been implemented across the country with subsidized interest rates and long term repayment options that make them attractive to consumers for investing in energy efficiency measures. Two examples of implementation of borrower-based systems are the programs by the United Illuminating Company in Connecticut and Sempra Energy in California.

United Illuminating Company Program

The United Illuminating Company (UI), a Connecticut-based investor-owned utility, runs an OBC program which focuses on commercial and industrial customers with an average peak demand of 150 kW or less. The financing program consists of a combination of rebates and loans. The program uses state funds to offer rebates to customers of roughly 30-40% of the total project cost, and 0% financing on the remaining portion of the loan. The program has been in operation since 2000, and has loaned approximately $7 million in rebate incentives, as well as $21 million in loans. A select set of contractors are employed for providing the energy efficiency services to customer, who also carry out the marketing activities for the program and are responsible for securing business leads. No credit checks are performed on the customers, and their eligibility is determined by their payment history. Between 2000 and 2007, the program has financed 2,450 projects with 670,000 lifetime MWh saved (York et al, 2008).

Sempra Energy Program

Sempra Energy, a California based utility company, launched an on-bill loan program in 2006, with financing from state funds. It used a structure similar to that of the UI program (a combination of loans and rebates); however, it differed significantly in the type of billing system implemented. In the early stages of the program, it was discovered their existing billing system was not designed to accommodate on-bill collection mechanisms, which proved to be a hurdle in its implementation.

Loans are offered by the program at a 0% interest rate, with loan terms of up to five years for business customers and up to ten years for government customers. Credit checks are carried out on the consumers, for providing the loans. Residential customers are excluded from the program due to consumer protection laws.

Initially, the company allowed for any contractor to participate in the program. However, over time, they moved to a more selective process, in order to ensure the quality of the jobs carried out, and reduce liability as well. Programs focusing on electric and light measures have typically been in the $9,000 range, while those focusing on gas projects have been closer to the proposed cap of $50,000.

Meter-based OBC

There are three essential components of the meter-based approach:

- Repayments are assigned to a meter location, not to an individual customer;
- Billing & payment on the utility bill with disconnection for non-payment; and
- Prescribed measures/products are appropriate & whose savings estimates exceed payments.

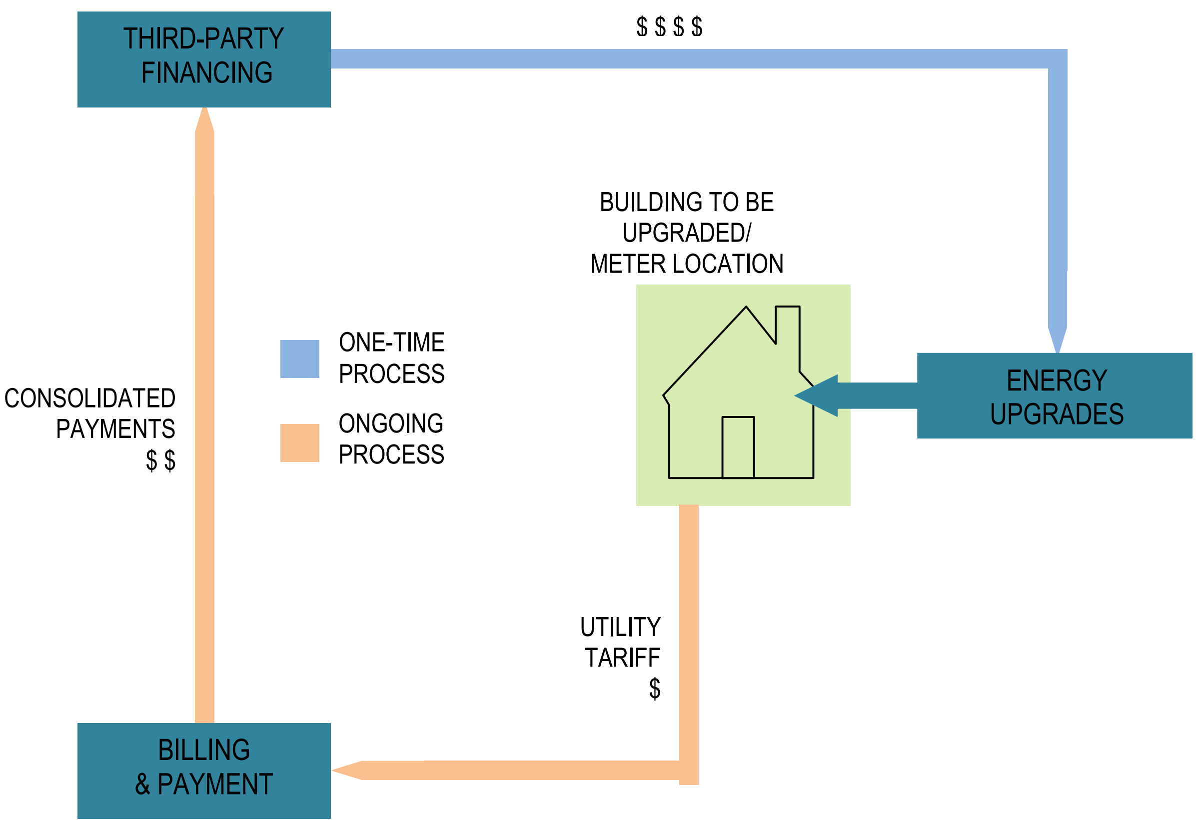


Figure 1: Illustration of the essential components of a typical tariff-based system

The utility tariff is assigned to a meter location, and not to an individual customer. This creates a reliable cash stream over the term of payments regardless who owns or occupies the property. The customers who purchase energy upgrades do not need to pay anything up front, and thus incur no debt. They pay a lower utility bill because the tariff charges are always lower than the estimated savings.

Examples of meter-based OBC

Two examples of successful implementation of meter-based systems are the Pilot Energy Efficiency Program developed by NHEC & PSNH, and the How$mart™ Energy Efficiency Program implemented by Midwest Energy, Inc. These programs are described in detail below.

The NHEC & PSNH Energy Efficiency Pilot Program

In 2001, New Hampshire state regulators launched a pilot program led by two small utilities, the New Hampshire Electric Co-op (NHEC) and Public Service of New Hampshire (PSNH). They adopted a model of a tariff-based system known as Pay-As-You-Save (PAYS®), developed by the Energy Efficiency Institute. PAYS® is designed to be a market-based system with built-in, no-cost incentives for customers, vendors, and capital providers to act in their own interests while producing resource efficiency investment that will benefit society (Zalcman & Cillo, 2006). PSNH began offering this option to customers on a limited basis in January 2002. Full field implementation began in 2002. The NHEC and PSNH pilots ran through the end of 2003 (GDS Associates, 2003). Some of the measures that NHEC installed included CFLs, weatherization of gas heated homes, lighting retrofits, and HVAC retrofit. Those installed by PSNH included lighting, street lighting, exit sign retrofits and window replacement. In summary:

- The pilots were implemented to test key concepts and allow participants to purchase and install energy efficient products and equipment with no up-front cost.
- The utility paid all initial costs associated with the purchase and installation of approved measures. Then, a delivery charge was calculated and added to the customer's monthly electric bill until all costs were repaid.
- The delivery charge amounts that were itemized on the monthly electric bill were based on two thirds of the estimated savings that would come from the measures installed. This way, the monthly charge was designed to be less than the savings realized on each bill once the new measures were installed.
- The payments were linked to the service location and not to the customer. Also, the payments include a small percentage risk mitigation adder (5% for PSNH, 7% for NHEC) to protect the utility from bad debt risks associated with some portion of participants' failure to pay.
- To protect the utilities against other potential risks, three key requirements are included in the for the customers that choose to participate:
    - *Maintenance:* All measures were to be maintained in place and in good working order during the entire repayment period. The utility would help arrange for

repairs, but any associated costs would be added to the delivery charge, or would extend the payment term to ensure recovery of these additional charges.
- *Disconnection:* All payments were to be made on time. The charges were treated like other charges on the electric bill and were subject to service disconnection for non-payment.

- *Disclosure:* If the home or business was to be sold or rented, disclosure of the remaining monthly payment amounts were to be made to the potential purchaser or tenant (since they will be taking over the remaining payment obligation), unless the current owner chose to pay the balance off before the sale or rental.

An independent evaluation of the NHEC & PSNH Pilot was conducted by GDS Associates in December 2003. Their conclusions showed that the responses to the implementation from the participants were very positive and satisfaction with quality of measures and services was high. Some of their specific findings were:

- It was concluded that the program was able to get customers to participate in installing more energy efficiency measures than they otherwise would have done;
- It was found that this approach is a significant contributor in overcoming the barriers of high first cost and difficulty for municipalities to incur long-term debt;
- There were no reported losses associated with the program due to forced disconnections from bad debt, at the time of the survey.

How$mart™ Program by Midwest Energy, Inc.

Another successful on-bill tariff program, designed primarily for the residential sector, is the How$mart™ program by MidWest Energy, Inc. (MidWest), a customer-owned utility based in Kansas. Although this was not an exclusive PAYS® program, it adopts many of its key elements. This program is offered to the residential and small commercial electricity and natural gas customers. 98% of program participants are residential, while 2% are industrial/commercial. After 20 months in operation, the program had approximately 450 projects completed or in the queue. The salient features of this program are (DSIRE, 2010):

- No upfront capital is required by building owner. Efficiency improvements are paid for through a surcharge on the utility bill, which is less than the amount of savings. The surcharge is tied by tariff to the location, and not to the customer. The surcharge was designed to never exceed 90% the projected energy savings associated with the improvements. The 90% is different from the 75% of the typical PAYS® model, and was established to reflect the cheaper energy costs in the Midwest region.
- Some of the energy efficiency measures included insulation, caulking, sealing, high efficiency furnaces, and other measures that would be a ‘permanent’ part of the structure.

- In order to participate in the program, customers need to first have an energy audit performed by a Midwest specialist, which would identify cost-effective improvements that the customer may then have completed by a participating contractor. The audit is free of charge if the customer then participates in the program or if no cost-effective measures are identified.
- The program is available to both renters and building owners, although renters must have permission from their landlord for participating in the programs. In the event that the owner or tenant moves, the surcharge remains attached to the location where the improvements were performed as long as there is proper written disclosure.

As of 2008, Midwest had invested $392,917 in efficiency improvements, with an average investment of $4,678 per customer. The average How$mart™ charge was $39.60 per month, while average estimated savings were $49.00 per month. The customer charge, therefore, was roughly 81% of the estimated gross monthly savings.

<u>Potential problems with OBC</u>

While the on-bill collection mechanisms described above offer many advantages in financing energy efficiency investment, there are some critical issues to be considered in their implementation (Fuller, 2009):

Billing System Limitations: Changing the billing system to allow for adding on-bill repayments can prove to be challenging for some utilities. From the examples, utilities have had difficulties adding the repayment as a line item to the bill. In some cases, the billing mechanisms may be already setup to allow for this addition, in other cases, significant modifications may be required.

Repayment Allocation: When customers partially pay their bills, the repayment allocation (i.e., who gets paid first) is important. If a third-party financer is used for the program, the gas or electric charge will usually be paid first, which increases the risk to the lender.

Utility Commitment: On-bill collection can be difficult to maintain if the utility is not completely committed, because the payments have to run through their systems. This can be an area of concern especially for residential programs. Additionally, the length of the loan repayment terms, especially with tariff-based systems, can sometimes prove to be a hurdle with utilities that typically rely on short repayment periods for customer-based investments (i.e., hard assets held by customers).

<u>Considerations for China</u>

On-bill collection (OBC) of the costs of energy efficiency measures was a key recommendation in the 2007 consultants' report prepared for the Asian Development Bank ahead of the establishment of the Guangdong EPP – although OBC has not yet been adopted in Guangdong or elsewhere. A detailed study on the prospects for OBC implementation in the context of

Chinese EPPs is beyond the scope of this current paper. However, this discussion of the US experience raises several issues.

On-bill collection has a number of advantages for Chinese EPPs:

- It avoids the costly and complex effort of setting up from scratch a billing and collection system dedicated to the sub-project loans. This consideration becomes particularly important if the EPP is intended to expand and cover large numbers of customers, each of whom would be responsible for small periodic repayments. In addition, reducing the cost and complexity of billing operations can support the development of ESCOs.

- As has been the case in the US, the electricity bill can become an effective marketing tool for energy efficiency, most importantly by facilitating easy comparisons by consumers and highlighting the savings associated with energy efficiency.

- On-bill collection is convenient for consumers, who only have to deal with a single bill.

- Implementing on-bill collection can help lay the groundwork for greater grid-company participation in energy efficiency at a later date. In other words, on-bill collection is a way of luring a grid company to "put a toe in the water."

Other considerations for China:

- Establishing OBC programs could be a good first step after the anticipated DSM rule is released.

- The interaction between OBC and financial regulations is important and likely to be very different than in the US. Electricity regulators will have to cooperate closely with their financial counterparts.

References

1. "State Energy Efficiency Policies: Options and Lessons Learned. Brief #3: Paying for Energy Upgrades through Utility Bills", Matthew Brown, Alliance to Save Energy, 2009.
2. "Compendium of Champions: Chronicling Exemplary Energy Efficiency Programs from Across the U.S.", Dan York, Marty Kushler and Patti Witte, American Council for an Energy-Efficient Economy, 2008.
3. Energy Efficiency Institute's March 21, 2006 introduction to PAYS® to the District of Columbia Energy Office; with Fred Zalcman, Director, Energy Project, Pace Law School http://www.paysamerica.org/DCEO-PAYSpres.pdf

4. Process Evaluation of the Pilot “Pay As You Save” (PAYS) Energy Efficiency Program as Delivered by The New Hampshire Electric Cooperative and Public Service Company of New Hampshire
   GDS Associates, December 2003.
5. http:// www.dsireusa.org
6. "Enabling Investments in Energy Efficiency: A study of energy efficiency programs that reduce first-cost barriers in the residential sector", Merrian Fuller, Prepared for CIEE and Efficiency Vermont. September 5. Berkeley: California Institute for Energy and Environment, 2003.

IV. Effective Energy Audit Models in Identification of Cost-Effective EPP Opportunities

Efficiency Power Plants (EPPs) have the overall goal of acquiring demand side resources — that is, energy and peak demand savings – at an aggregated level. There are various design aspects that are employed by EPP administrators to achieve the desired savings. Energy audit program is one of the aspects.[10] Energy auditing is a critical first step for identifying cost-effective EPP opportunities and making sound investment decisions to improve energy efficiency in factories, homes, and buildings. Since the industrial sector is the largest energy user in China, this section focuses particularly on energy auditing activities for industrial facilities as the energy savings opportunities created by industrial EPPs would offer the greatest reduction in energy intensity and load growth. Successful energy audits could help EPP implementers obtain baseline energy use data for a clear understanding of the current power consumption situation, guide further engineering analysis and design, and make informed decisions on pursuing energy efficiency improvement. Successful energy audits could also help EPP program administrators to identify an optimal mix of energy efficiency programs and projects so that a cost-effective EPP portfolio can be developed. From a market perspective, energy audits are the basis for performance contract agreements as well as investment in energy efficiency improvement. A high quality audit can result in identification of cost effective efficiency projects realizing substantial energy/cost savings, while a low quality audit could lead to unrealistic savings analysis, flaws in the engineering design, and potential problems in performance contract agreements. Because energy audits could become a basis for investment decisions relative to energy efficiency projects, energy audit work will more likely have significant economic ramification.

This section discusses various aspects of industrial energy audits by drawing upon international best practices. The discussion covers a variety of topics relative to energy auditing, including the scope of energy audits, type of energy audit, typical auditing procedures, as well as measures and steps needed to assure the success of energy audit activities. At the end, the section provides general observations for China regarding energy audits to underscore the importance of learning from the relevant international best practices.

Scope of energy audit

The scope of energy audits in an EPP program must be in accordance with program goals, and program designers must clearly delineate program boundaries including defining which sectors, facilities, and processes are included in the audit.

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[10] In the U.S., for example, in addition to energy audits, other options that an EPP program designer could adopt include rebate programs, direct-install programs, bid programs, and standard-offer programs. The rebate program offers cash to offset the purchase of a high-efficiency equipment; the direct-install program uses utility or contractors to directly install low-cost, quick pay-back energy efficiency measures in customer facilities at little or no cost to the customer; a bid program sets broad goals such as locations, measures and facility types, and then solicit private contractors to propose specific projects to achieve the goals; and a standard offer program offers energy-saving opportunities to all customer classes under the same terms and conditions and payments are based on "avoided costs" of power plant construction and fuel consumption over a certain period of time.

Different scopes of energy audit programs have different advantages and limitations. A program with a focus on one process or one sector can be targeted to address key issues and can be relatively simple in terms of auditing procedures and processes since the audit only needs to be designed for that specific process or sector. An example of such a program is one that focuses on auditing of the motor systems in the facilities. However, such a narrowly scoped auditing program requires in-depth knowledge and technical know-how for auditors, program designers, and administrators. Energy audits with a broader scope can include multiple sectors and facilities at the same time, and the experiences learned from one sector/facility can be helpful to other sectors/facilities. Nevertheless, due to different processes and data requirements for each sector or facility, a broadened program may naturally evolve into several smaller sub-programs. In some cases, energy audits have initially focused on specific sectors and then are expanded to more sectors as auditing programs became more mature and more sophisticated. For example, Finland's Energy Audit Program (EAP) initially focused on service sector and industrial buildings and processes. As the program evolved and with the introduction of the Voluntary Agreements Scheme, energy audits were extended to cover large energy-consuming process industries, power plants and district heating plants (Hasanbeigi, et al, 2010).

Types of Energy Audits

Depending on the purposes, goals, scopes, and available funding of energy audits, there are two major types of industrial energy audits. The first is a preliminary energy audit, also known as a screening audit or walk-through audit. This is the simplest and quickest version of an energy audit, which can identify simple and standard energy efficiency measures such as lighting replacement, light and occupancy sensors, high efficiency motors, variable speed drives, and so on. This kind of audit is also used by auditors or facility energy mangers to determine whether a more comprehensive audit is warranted. A preliminary energy audit does not require a lot of measurement and data collection, and thus takes a relatively short time and the results are more general, identifying common opportunities for energy efficiency improvement.

The second type of audit is a detailed energy audit (diagnostic audit). This can be a targeted energy audit, which focuses primarily on a particular system, process, or technology, or it can be a more comprehensive audit that covers most processes, equipment or facilities, in order to identify more wide-ranging energy-efficiency measures. For this type of audit, more detailed data and information are required. Hence, the time required for this kind of audit is longer than that of preliminary audits. The results of these audits are more comprehensive and useful since they give a more accurate picture of the energy performance of the facility and more specific recommendation for improvements. One type of detailed energy audit, i.e. the investment grade audit, has increasingly become popular internationally. An investment grade audit is a detailed energy audit carried out at a high level of stringency and with additional emphasis on the financial aspects of energy saving opportunities.

An EPP is a portfolio of various types of demand-side management projects. Energy audits should be designed in a way to identify a mix of energy saving measures – combining low-hanging options and those have longer payback but deeper energy-saving opportunities – so that the total return on investment in the portfolio is attractive to investors and customers. Table 1 is an illustration of a portfolio of energy efficiency measures in an EPP program.

Table 1 Portfolio Composition of Energy Efficiency Measures

Measure	Construction Cost (rmb)	Demand Savings (kW)	Energy Savings (kWh)	Energy Cost Savings (rmb)	Simple Payback (years)
High-E Motors	2,428,292	324.2	2,001,288	1,025,660	2.4
Variable Speed Drives	4,604,000	1,889.6	15,003,004	7,689,040	0.6
Synchronous Belts	1,647,421	168.0	1,302,897	667,735	2.5
Downsize Motors	75,232	11.3	82,117	42,085	1.8
Replace Transformers	3,100,500	123.8	1,084,410	555,760	7.0
Repair Compressed Air Leaks	270,224	337.8	2,670,741	1,368,755	0.2
Total	**12,125,669**	**2,855**	**22,144,457**	**11,349,034**	**1.1**

Source: Steve Booth et al., "Technical, Economic, and Financial Assessment of Energy Efficiency Investment Options," an internal report, October 2008.

Unlike buildings and homes, Industrial facilities are a heterogeneous group and, as such, their energy consumption is very process-dependent and greatly varies from sector to sector and facility to facility. It is necessary to segregate them into sub-populations of similar facilities that share energy use profiles and that can benefit from similar measures. EPP program administrators could utilize the data collected from energy audits to construct an energy use profile for each of the industry classes, which will allow the program administrator to develop strategies and bundles of measures that complement the energy use patterns for each class or sector.

The following example shows how an energy use profile is developed for iron and steel facilities in determining major sources of production-related energy consumption so that they can be the focus for investigating steel plant energy efficiency opportunities. Figure 1 is a breakdown of the final energy end-use in the iron and steel industry in the U.S. Fired systems (excluding boilers), particularly the blast furnace and other furnaces, represent the bulk of energy use in the industry (81%). Boilers use another 7% of total energy use. Motor systems, which include motor driven units such as rolling mills, pumps, conveyors, fans, and materials handling equipment, consume another 7% of steel industry energy use. Heating, cooling, and lighting of facilities accounts for just 3% (U.S. DOE, 2004).

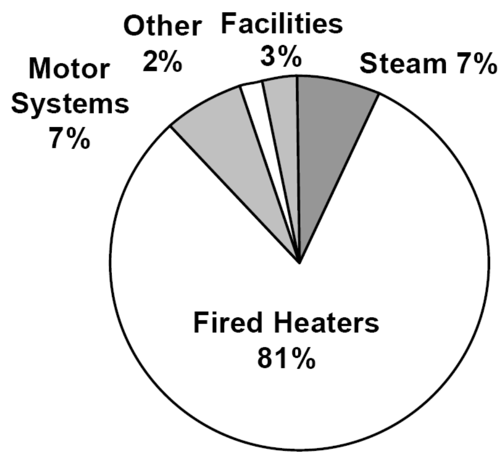

Figure 1. Final energy end-use in the iron and steel industry (Source: U.S. DOE 2004)

Figure 2 illustrates the general flow of energy and losses within the average steel mill in the U.S. As the figure shows, nearly one-quarter of the energy that enters the plant (23%) is lost prior to use in process units. These losses occur in equipment and distribution systems supplying energy to process operations or converting energy to usable work. The majority of onsite losses in the iron and steel industry occur in energy conversion systems. Offsite losses due to the generation of electricity were close to 18% of the industry primary energy use (U.S. DOE, 2004).

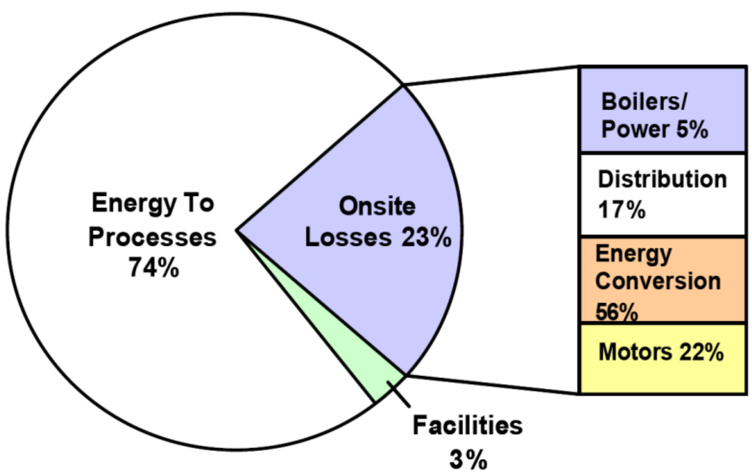

Figure 2. Onsite energy loss profile for the iron & steel industry (U.S. DOE 2004, MECS 1998)

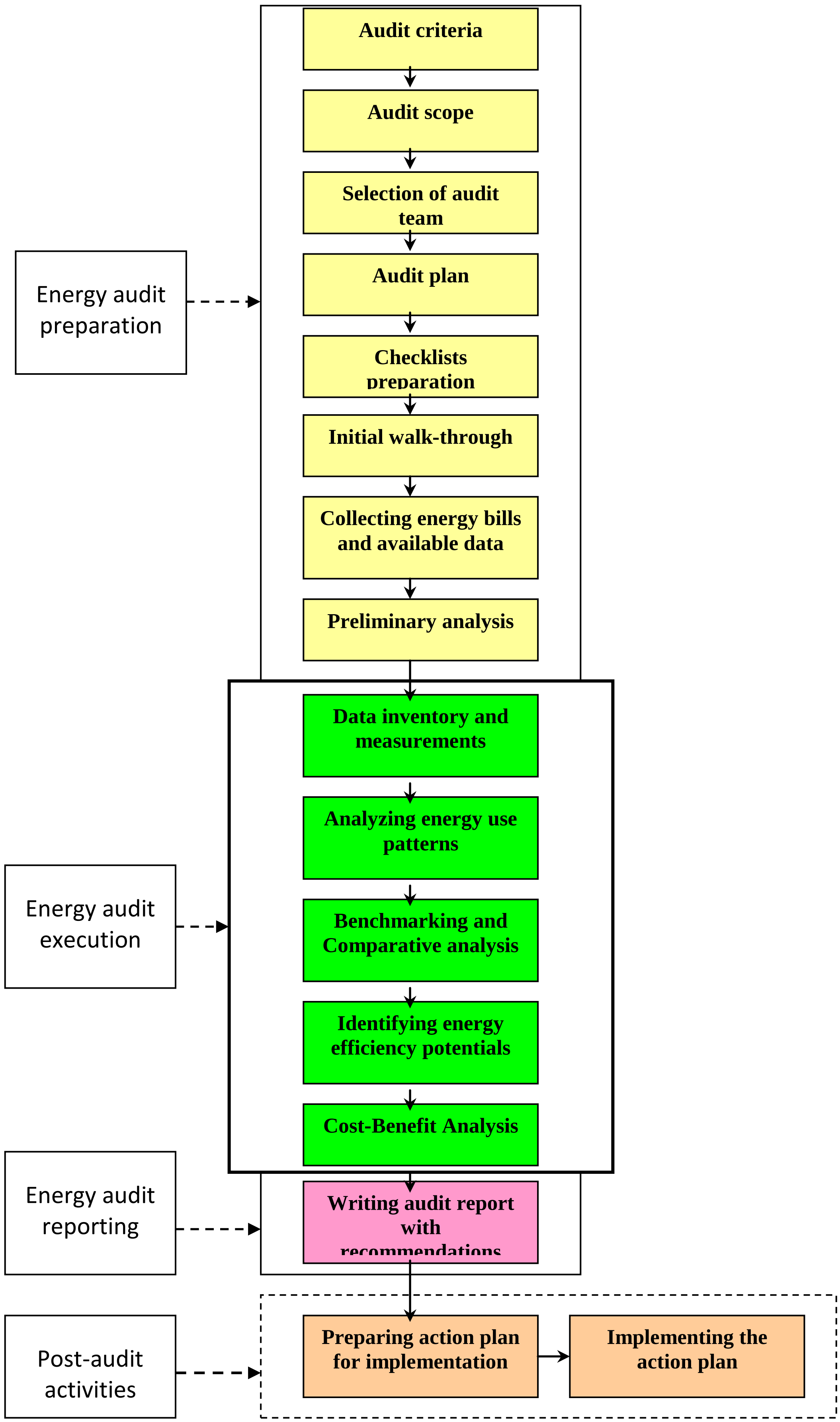

Figure 3. Overview of an industrial energy audit procedure

An energy use profile could be carried out for each energy-intensive industrial sector. The result would be a characterization of potential savings by sector, process, and technology that can enable EPP program administrators to identify readily available opportunities, and to develop measures that achieve the savings needed to meet the goals of the EPP program.

Energy auditing procedures and process

Typical energy auditing procedures include four main steps, each of which has several sub-steps. These four main steps are energy audit preparation, execution, reporting, and post-audit activities. A flow chart describing typical energy-auditing procedures is shown in Figure 3. A preliminary audit (walk-through audit) contains some of the same steps of the procedure shown, but the depth of the data collection and analysis might be different depending on the scope and objectives of the audit. Some the important steps of the energy auditing that are illustrated in Figure 3 are briefly explained below.

Making an Audit Plan

An audit plan outlines the audit strategy and procedure, which will help the auditors to check the consistency and completeness of the audit process and make sure nothing important is neglected or overlooked. The audit plan should provide the following (CIPEC 2009):

- Scope of the audit
- Audit schedule including the timeline for each step of the audit process
- Elements of the audit that have a high priority
- Responsibilities and tasks of each audit team member
- Format of the audit report and its outline

Conducting the Initial Walk-Through Visit

The purpose of the initial walk-through visit is for the energy audit team to become familiar with the facility to be audited. The auditors can go through the processes and systems that they will audit in detail later. The audit team can observe the existing measurement instrumentation on the equipment and the data recorded, so that they can determine what extra measurement and data collection are required during the audit. This phase of the audit is quite useful, especially if the auditors are not made up of plant personnel. The audit team can also meet with the managers of the areas to be audited to provide an introduction and establish a common understanding of the audit process. The auditors can solicit comments from the facility staff and can collect readily available data during the walk-through visit.

Analyzing Energy Bills

Energy bills, especially those for electricity and natural gas, are very useful for understanding and analyzing a plant's energy use and associated costs. It is important to understand the different components of these bills, so that an effective analysis can be carried out. Below is the example describing how electricity bills are analyzed.

The electricity bill provides a lot of information about a customer's energy use and associated costs. It also provides important rate information such as consumption rate, demand charge, time-of-use rate, inclining block rates, charge for reactive power, and so on. Understanding rates is also important for planning energy-efficiency retrofits. To predict energy cost savings with the highest accuracy, savings must be calculated based on the time they occur and the rates in effect during each time period (California Energy Commission 2000). Based on the data and information derived from the electricity bills, several calculations can be made. Two possible analyses are given below.

Calculating daily electricity use (kWh/day): Electricity use in the period covered by the electricity bill can be divided by the number of the days given in the bill. Since reading periods in the bills can vary, kWh/day is more useful for identifying consumption trends than the total billed kWh. This can be used later to accurately calculate the monthly electricity use and can also be used for graphical analysis.

Calculating the Load factor (LF): The load factor is the ratio of the actual energy use during a given period (in the electricity bill) to the energy that would have been consumed if maximum demand had been maintained throughout the period.

$$\text{Load factor (\%)} = \frac{\text{Actual energy use during the period (kWh)}}{\text{Maximum demand (kW)} \times \text{Time under consideration (hr)}} \times 100$$

Normally the load factor is less than 100%. That is, the actual energy consumed is normally less than the maximum power demand multiplied by the billing period. In general, if the load factor in a plant is lower, the total cost of electricity will be higher. In other words, the load factor is a useful method of determining if a plant is utilizing its energy-consuming equipment efficiently on a consistent basis (higher LF), or using the equipment just for a short duration (lower LF), thereby being penalized by paying demand charge. Therefore, the plant's load factor should be analyzed to determine the opportunity for improvement and demand control (Morvay and Gvozdenac 2008).

Graphical Analysis for Understanding Energy Use Pattern

Graphical analysis of hourly/daily/monthly/yearly energy consumption for each type of energy used in a plant can help to better understand the energy use pattern in the facility. Sometimes the patterns are unexpected and can lead to opportunities to modify the way energy is used and save energy. For example, one might not normally expect a heavy process industry like the cement industry to exhibit a seasonal variation in energy use because of weather changes. Despite this, if a seasonal pattern shows up in the graphical analysis, this may suggest the need to investigate for the possible sources of energy losses. It is common for a plant's operating conditions or capacities to vary over the year. Therefore, the variation of energy use alone may not truly reflect the condition of energy efficiency in a plant. Thus, it is much better and more accurate to conduct this type of graphical analysis of a plant's energy intensity (EI), which is the energy use per unit of production. EI can be calculated by using monthly energy consumption data obtained from energy bills and the monthly production data.

$$\text{Energy Intensity (kWh or GJ/ tonne)} = \frac{\text{Energy consumption (kWh or GJ)}}{\text{Production (tonne)}}$$

Inventory and Measurement of Energy Use

Gathering data through an inventory and measurement is one of the main activities of energy auditing. Without adequate and accurate data, an energy audit cannot be successfully accomplished. Some data are readily available and can be collected from different divisions of the plant being audited. Some other data can be collected through measurement and recording. The energy audit team should be well equipped with all of the necessary measurement instruments, which can be portable or installed in certain equipment (CRES 2000). The most common data measured during the auditing process includes:

- Liquid and gas fuel flows
- Electrical measurements, such as the voltage, current intensity and power, as well as power factor
- Temperatures of solid and liquid surfaces
- Pressure of fluids in pipes, furnaces or vessels
- Exhaust gases emissions (CO_2, CO, O_2 and smoke)
- Relative humidity
- Luminance levels

Energy Balance Analysis

One of the advantages of conducting an energy balance analysis is that all energy inputs can be quantified and balanced against all energy outputs. A convenient graphical representation of this is the Sankey diagram, in which the energy losses/outflows, the energy gains/inflows, as well as the useful energy in a given energy system are represented quantitatively and in proportion to the total energy inflow, based on existing data from energy bills and invoices, calculations, and in-site measurements in the plant. Presenting the energy flows visually with the aid of the Sankey diagram helps to locate the more critical energy-consuming areas of the energy system and, at the same time, to identify the sources of inefficient energy use.

Scatter Diagram for Presenting the Energy-Production Relationship

Variations in energy use are to some extent due to production variability. However, excessive variation in energy use often occurs that cannot be well explained by the changes of production. A scatter diagram in which production is presented on the x-axis as an independent variable and energy use is presented on the y-axis as a dependent variable can provide useful information on the underlying relationship between energy use and production. Such a scatter diagram does not have any time dimension. If production varies, it is expected that the energy use will vary as well. The position of each point in the scatter diagram is the result of explainable causes and production circumstances that have occurred during the observed period. When the energy-production relationship is visualized in a scatter diagram, variations in performance become visible immediately and the auditor can begin to interpret the variation and take corresponding actions.

Benchmarking and Comparative Energy Performance Analysis

Benchmarking energy performance of a facility enables energy auditors and facility managers to identify best practices that can be replicated. It establishes reference points for managers for measuring and rewarding good performance. It identifies well-performing facilities for recognition and prioritizes poor performing facilities for immediate improvement (Ptm 2009). Benchmarking can be done in variety of ways. Plant performance may be benchmarked to:

- **Past performance**: comparing current versus historical performance.
- **Industry average**: comparing to an established performance metric, such as the recognized average performance of a peer group.
- **Best in class**: benchmarking against the best in the industry and not the average.
- **Best Practices**: qualitatively comparing against certain, established practices or groups of technologies considered to be the best in the industry.

According to the U.S. Environmental Protection Agency's guideline (US EPA 2007), key steps in benchmarking include:

- Determine the level of benchmarking (for example, technology, process, or facility)
- Develop metrics: select units of measurements that effectively and appropriately express energy performance of the plant (e.g. kWh/ton product, GJ/ton product, kgce/ton product, etc.)
- Conduct comparisons to determine the performance of the plant or system being studied compared to the benchmark.
- Track performance over time to determine if energy performance being improved or worsening over time in order to take the appropriate actions.

The US Environmental Protection Agency's ENERGY STAR for Industry program has developed plant energy performance indicators (EPI) to enable energy auditors, facility managers, and corporate executives to evaluate the energy efficiency of industrial plants against similar facilities in the US (US EPA 2008). Another benchmarking tool is the Benchmarking and Energy Savings Tool (BEST-Cement) developed for the cement industry by the U.S. Lawrence Berkeley National Laboratory (LBNL) in collaboration with the Energy Research Institute (ERI) and other partners in China. BEST-Cement is a process-based benchmarking tool based on commercially available energy-efficiency technologies used anywhere in the world applicable to the cement industry (LBNL, 2008).

Identifying Energy Efficiency and Cost Reduction Opportunities

There are various energy systems that can be found in almost all types of industrial facilities, such as motor systems, steam systems, compressed-air systems, pumps, and fan systems. These are so-called “cross-cutting” technologies. In addition, each industrial sub-sector has its own unique production technologies and processes. Energy-efficiency improvement opportunities can be found in both cross-cutting as well as industry-specific areas.

There is a lot of available information to help industrial facilities identify energy efficiency opportunities. For example, US EPA provides ENERGY STAR energy guides for several industries, developed by LBNL (US EPA, 2008b). These guides are a valuable resource on trends in energy use and energy intensity in U.S. industry. They are also a trove of systematic analysis and discussion of energy-efficiency opportunities in manufacturing facilities that are applicable to plants anywhere in the world. Energy auditors and facility managers can use the guide to identify areas for improvement, evaluate potential energy improvement options, develop action plans and checklists for the energy saving programs, and educate company employees. In addition to the guidebooks developed for the ENERGY STAR, LBNL has also developed sector assessments to assess energy-efficient industrial technologies for specific industrial sectors. Energy auditors and managers can download these assessments from LBNL’s web site.[11]

Extensive resources can also be found on the web site of the U.S Department of Energy’s Industrial Technologies Program, including tips, fact sheets, guidebooks and case-studies for different industrial sectors, as well as technical publications and software/tools for different energy systems – such as steam, process heating, motors, pumps, fans, and compressed air.[12]

Cost-Benefit Analysis of Energy-Efficiency Opportunities

Conducting economic and financial analysis to assess the cost-effectiveness of energy-savings measures is an important part of the energy audit process and thus deserves special recognition. A number of financial analysis methods are available for this purpose. The two most common techniques are simple payback analysis and lift cycle cost (i.e. net present value) analysis.

<u>Simple Payback Period (SPP) method</u>

The calculation of the simple payback period (SPP) is often applied to quickly determine whether an efficiency project is economically viable. The payback period is the amount of time (usually measured in years) to recover the initial investment in an efficiency improvement opportunity. The SPP calculation is simple to calculate and easy to understand and is therefore

[11] http://industrial-energy.lbl.gov/node/96
[12] http://www1.eere.energy.gov/industry/

helpful for a "first-cut" analysis of a project and can serve as a quick way to comparing alternatives. SPP, however, ignores all savings that continue after measures pay for themselves. Further, it simplifies the evaluation by not discounting cash flows to reflect the time value of money. In general, payback is best used as a screening method for identifying single project alternatives that are so clearly economical that the full LCC Analysis is not necessary (Fuller and Petersen 1996).

Life Cycle Cost (LCC) evaluation

The LCC is the total cost of acquiring, installing, operating, maintaining, and disposing certain measure or technology over its lifetime. In this method, all future relevant costs are discounted to the present value to reflect the time value of money. The LCC of a technology or measure has little value by itself; it is most useful when it is compared to the LCCs of other alternatives with the same function so that the most cost-effective alternative can be determined.

The general formula for a LCC present-value calculation is provided below:

$$LCC = \sum_{t=0}^{N} \frac{C_t}{(1+d)^t} \qquad \text{(Eq. 1)}$$

Where:

LCC = Total LCC in present-value dollars of a given efficiency project,

C_t = Sum of all relevant costs, including initial and future costs or any cash-flow occurring in year t,

N = Number of years in the evaluation period,

d = Discount rate used to adjust future cash flows to present value.

The general LCC formula shown in Eq. 1 requires that all costs be identified by year and by amount. This general formula, while straightforward from a theoretical point of view, can require extensive calculations, especially when the evaluation period is more than a few years long. A simplified LCC formula for energy efficiency projects is shown in Eq. 2:

$$LCC = I + Repl - Res + E + OM\&R \qquad \text{(Eq. 2)}$$

where:

LCC = Total LCC in present-value dollars of a given project,

I = Present-value of investment costs,

Repl = Present-value of capital replacement costs,

Res = Present-value of residual value (resale value, scrap value, salvage value) and/or disposal costs,

E = Present-value of energy costs,

OM&R = Present-value of non-fuel operation cost and maintenance and repair costs.

The LCC method is complicated and requires more information compared with the SPP method. It, however, offers the advantage of accounting for the time-value of money while provides a consistent way of accounting for all savings benefits and cash flows related to a particular energy-efficiency project during the entire evaluation period. LCC analysis can also help to assess how investment cost for a energy-efficiency project could be offset by its corresponding reduction in operating and maintenance costs (including energy and water costs), relative to the base case.

Preparing an Energy Audit Report

As the last step of an energy audit, the audit team should write a comprehensive energy audit report. In the report, the auditors should discuss their work, explain their findings, and make detailed recommendations for further actions in a well-structured format. The energy audit report should be concise and precise and should be written in a way that is easy for the target audience to comprehend.

Measures for assuring the success of energy audits

Measures such as incentives, monitoring and evaluation, training and quality control, information dissemination, and public recognition of superior performance are all necessary steps to support successful energy audit activities.

Financial and other incentives to support energy audit

Internationally, financial as well as other types of incentives are offered to encourage greater participation of enterprises in energy audit programs. Government subsidies for energy audits come in many formats ranging from providing free audits, to cost sharing, to direct subsidy. Some incentives are only made available to enterprises that have invested in energy efficiency measures as recommended in the audit reports and linked directly to the results of the measures. Other government financial support includes offering special loans with preferential conditions to energy efficiency work that include energy audits. In addition, governments sometimes create special investment funds with the prerequisite that energy audits are performed ahead of time. Besides the financial support, governments in various countries have also provided enterprises with other types of support, including priority access to technical and financial resources, customized assistance, and personalized trainings.

Table 2 Incentives for Energy Audits in Selected Countries

Type of Subsidies	Country Example	Program	Subsidies
Offered through free services	Germany	Regional energy audit program	Free energy audits to qualified small and medium enterprises
	United Kingdom	Carbon Survey Scheme (as part of the Carbon Trust)	Provide general carbon surveys through free detailed audits to eligible companies
Offered through cost-sharing plans	Belgium	Energy Audits for Industry	Provide up to 75% of the audits costs, only to companies that have implemented recommended energy-savings measures
	United States	Save Energy Now	Offer free 3-day energy audits to qualified companies while companies contribute their share to pay for their own employees and staff for energy audits
Indirect subsidies	Portugal	Regulation for Energy Management Program	Provide participating companies access to more financial opportunities
Tax incentives	Belgium, Denmark, Netherlands and United Kingdom	Various programs	Tax exempted if energy-efficiency investments are made. The UK's Enhanced Capital Allowance Scheme allows a business to claim 100% first-year tax relief on their spending on qualifying energy-saving technologies. Businesses can write off the entire capital cost of their investments in energy-saving technologies against their taxable profits for the year during which the investment made
Special Loans and Funds	Germany, France	Various programs	Special Energy Efficiency Fund for Small and Medium Enterprises in Germany offered loans with preferential conditions for investments in energy efficiency including energy audits. Through the Energy Conservation Guarantee Fund, investment funds were created in France with the condition that energy audits were undertaken beforehand
Other incentives	U.S.	Save Energy Now	Qualified companies receive access to resources (case studies, publications, guidebooks, etc.) and software tools. Companies who voluntarily pledge to cut energy intensity by 25% in ten years are given higher priority in getting customized assistance, personalized resources and financing opportunities The *Save Energy Now* recognizes outstanding companies through public award of Energy Champion Companies and Energy Saver Companies.

Source: Hasanbeigi, et al, 2010

Monitoring and evaluation of energy audit

The monitoring and evaluation of energy audit activities includes the reviews of a collection of information such as the number of audits, the costs of audits, as well as how the recommended measures are implemented. The information is normally collected from the energy audit reports submitted by facilities. In the Save Energy Now Program, an initiative launched by the U.S. Department of Energy (DOE), manufacturing companies who want to participate in DOE-funded energy audit are required to file applications that provide energy consumption data. This provides a foundation to monitor and evaluate the progress of the measures taken by the participating companies. In this program, a DOE account representative and a technical account manager are assigned to each participating company. Through these contacts, the program can have frequent updates, reports on progress, and more detailed examinations of companies' performance.

Training, certification, and quality control of energy audits

Internationally, systematic training programs have been developed to ensure the success of energy audit programs. In the U.S., DOE has a training program throughout the year and around the country that provides system-wide and component-specific trainings to enterprises and qualifies energy professionals for energy audits. To become a qualified energy specialist for conducting energy audits, individuals need to attend one of the qualification trainings (each lasting two to three-and-half days), pass practical and/or written tests, and become proficient in using the relevant DOE tools. DOE has published, with a searchable database, a full list of qualified energy specialists on its website.[13]

[13] http://www1.eere.energy.gov/industry/bestpractices/qualified_specialists/

To foster professional development of energy auditors, many countries have gone one step further to not just train but also certify auditors. The U.S. based Association of Energy Engineers (AEE) developed the Certified Energy Auditor (CEA) and Certified Energy Auditor in Training (CEAIT) programs which are both recognized by the U.S. federal government, Fortune 1000 corporations, utilities, and energy service companies. All applicants are required to meet specific educational and/or experience criteria, complete extensive energy auditing training program, and pass a four-hour written examination with questions covering a great diversity of areas of knowledge such as energy auditing methodology, auditing instrumentation, auditing tools, economic analysis, building systems technology, lighting, HVAC, building envelope, controls, boilers and steam systems, water auditing, and reviewing auditing reports. To remain certified, energy professionals need to accumulate eight professional credits every three years, earned by carrying out energy auditing activities, participating in energy auditing-related seminars and college courses, obtaining professional awards, or having papers presented and published.[14] Besides the US DOE program, Table 3 provides some other international examples of training and certifying energy auditors.

Table 3 International Examples of certifying Energy Auditors

Country	Program	Certification through
French	French Energy Auditing Program	Trainings followed by the published energy audits' "specifications"; authorize and publish the list of qualified energy auditors
Finland	Finnish Energy Auditing Program	Training courses, seminars and tools for energy auditors; three levels of energy auditors based on their qualifications
Australia	Required in 2009 National Greenhouse and Energy Reporting Amendment Bill of Australia	Auditors are required to have tested technical knowledge and proven auditing experiences
Japan	Energy Conservation Center of Japan (organizer)	Energy auditors and mangers need to pass the national examinations of qualified energy managers and complete the energy management training for certification.

Source: Hasanbeigi, et al, 2010

Quality control is important for preventing repeated mistakes in subsequent audits or reports. When conducting quality control, there is a range of stringency, from only looking through the defined procedures and required format of auditing reports, to deeper analyses on audit findings and provided suggestions. Quality controllers can utilize many tools to check energy audit reports. Computer-based software and checklists are easy to implement and can ensure the reports are compared based on the same criteria. Self-evaluation forms for auditors and feedback from clients are valuable for improving the auditing process as well. Conducting an independent re-audit or verification audit is also an effective means to control the quality of an energy audit.

[14] Please visit AEE's official website for detailed information on its various certification program: http://www.aeecenter.org/i4a/pages/index.cfm?pageid=3330

Other supporting measures

To effectively support energy audits, additional measures such as information dissemination and public recognition are needed. These measures can be utilized to increase public awareness or positive recognition of energy audits. They can also be used to convince targeted groups (e.g. industrial plants) to participate, identify problems, and make improvements. Dissemination of information can be done in many ways: through educational seminars, case studies, guidebooks, technical publications, brochures, newsletters, magazines and newspapers. Publicly recognizing superior performance in energy auditing with awards can be an effective mean to publicize best practices and stimulate greater participation in energy audits. Table 4 provides a list of international examples of supporting measures.

Table 4 International Examples on Supporting Measures

Supporting Measures	Countries of Examples
Brochures, newsletters, and case studies	US, Japan, UK, Canada
TV advertisements	France
Public recognition through awards	U.S., India
Installation of energy conservation navigation systems to visualize energy consumption	Japan
Publicize best practices through seminars, publications and handbooks	US, Japan, and European Union
Technical assistance (tools, guidebooks, software)	U.S., Canada

Source: Hasanbeigi, et al, 2010

General observations for China

During last two decades, but especially in the 11th five-year plan period, large-scale energy audits have been performed in industrial facilities throughout China. Pursuing energy audits has contributed significantly to the overall improvement of energy efficiency in China while at the same time helped Chinese enterprises build a basic structure of enterprise energy management system. In spite of the progress, however, many issues remain in China preventing energy audits from achieving their full potential. A recent survey in six Chinese provinces and cities has identified the following areas in which further improvements are needed:

- The value of energy audits in promoting energy efficiency opportunities and the necessity to create a long-term mechanism and supporting measures to spur more energy audits have not been truly reflected in China's legislative and regulatory efforts.
- Most energy audits in China are mandatory for meeting the government target. While mandated energy audits can help mobilize enormous resources and substantial number of enterprises to meet the energy target rather quickly, it is hard to go beyond the target to achieve deeper energy-saving opportunities. Due to the obligation of meeting specific targets, energy audits in China tend to have limited scopes. There is also a weak link between the technical assessment and economic and financial feasibility of energy efficiency measures in China's energy audit practice.

- In spite of some local efforts in providing financial incentives to support energy audits, the majority of energy audits in China are self-funded by enterprises. There is a lack of proper incentives for supporting energy audits.
- For a relatively long period, China's focus has been on developing its economy. Enterprises whose goal is to pursue greater economic output have not placed their focus on efficient use of resources. As a consequence, in many enterprises, knowledge about industrial energy efficiency is relatively limited, staff knowledge of energy efficiency technologies is weak, and experience with identifying energy-saving opportunities is underdeveloped. The lack of systematic training and certification programs for energy professionals has further hindered development of a strong capacity for energy audits in China.

In the wake of China's recent policy push for energy service contracting, energy audits will become even more important; they will be the basis for the development of a robust energy service market. International best practices discussed in this section would certainly help China find ways to address these issues and improve the design and development of effective energy audit programs.

References

Booth, Steve et al., *Technical, Economic, and Financial Assessment of Energy Efficiency Investment Options*, an internal report, October 2008.

California Energy Commission, 2000. "Energy Accounting: A Key Tool in Managing Energy Costs." Available at: http://www.energy.ca.gov/reports/efficiency_handbooks/index.html

Canadian Industry Program for Energy Conservation (CIPEC), 2009. Energy Savings Toolbox – an Energy Audit Manual and Tool. Available at: http://www.oee.nrcan.gc.ca/publications/infosource/pub/cipec/energy-audit-manual-and-tool.pdf

Canadian Industry Program for Energy Conservation (CIPEC), 2009b. Energy benchmarking and best practices guidebooks. Available at: http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/benchmarking_guides.cfm?attr=24

Center for Renewable Energy Sources (CRES), 2000. Energy Audit Guide – Part A: Methodologies and Techniques. Available at: http://www.cres.gr/kape/pdf/download/guide_a_uk.pdf

Fry, Terry et al., DSM Program Procedures Manual – Industrial Energy Efficiency Program, August 2008

Fuller, S.K. and Petersen, S.R., 1996. Life-cycle cost manual for the federal energy management program. U.S. National Institute of Standards and Technology. Available at: www.bfrl.nist.gov/oae/publications/handbooks/135.pdf

Hasanbeigi, Ali et al., Industrial Energy Audit Guidebook: Guidelines for Program Developers and Energy Auditors. LBNL Report, June 2010

Lawrence Berkeley National Laboratory and Energy Research Institute (LBNL & ERI), 2008. BEST-Cement for China. Benchmarking tool for cement industry: the tool and handbook. Available at: http://china.lbl.gov/research/industry/benchmarking/best-cement/best-cement-china

Lawrence Berkeley National Laboratory (LBNL), 2009. Sector Assessments reports. Industrial Energy Analysis. Available at: http://industrial-energy.lbl.gov/node/96

Morvay, Z.K. and Gvozdenac, D.D., 2008. Applied Industrial Energy and Environmental management. John Wiley & Sons Ltd. UK.

Phylipsen, D., Blok, K., Worrell, E., de Beer, J., 2002. "Benchmarking the energy efficiency of Dutch industry: an assessment of the expected effect on energy consumption and CO2 emissions." Energy Policy 30 (2002) 663–679.

Pusat Tenaga Malaysia (Ptm), 2009. Introduction to Benchmarking and its Tools. Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP). Available at: http://www.ptm.org.my/mieeip/pdf/ebenchmarking.pdf

U.S. DOE (2004) Energy Use, Loss and Opportunities Analysis: U.S. Manufacturing & Mining. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Industrial Technologies Program. December 2004. Available at: http://www1.eere.energy.gov/industry/energy_systems/pdfs/energy_use_loss_opportunities_analysis.pdf

U.S. Department of Energy's Industrial Technologies Program (US DOE ITP), 2008, Technical publication. Available at: http://www1.eere.energy.gov/industry/bestpractices/technical.html

U.S. Environmental Protection Agency (US EPA), 2007, Guidelines for Energy Management. EnergyStar Program. Available at: http://www.energystar.gov/index.cfm?c=guidelines.guidelines_index

U.S. Environmental Protection Agency (US EPA), 2008, "Plant Energy Performance Indicator." Energy Star Program. Available at: http://www.energystar.gov/index.cfm?c=in_focus.bus_industries_focus#plant

U.S. Environmental Protection Agency (US EPA), 2008b, "Energy Guide- Opportunities for Improving Energy Efficiency in a Focus Industry." Energy Star Program. Available at: http://www.energystar.gov/index.cfm?c=in_focus.bus_industries_focus#plant

Appendix

Energy Auditing Programs in Selected Countries

Energy Auditing Program in the U.S.

In the United States, through its Industrial Technology Program (ITP), the Department of Energy (DOE) operates two types of energy auditing, or energy assessments, to both large and medium-sized eligible manufacturing facilities. Table 1 shows the details of the two programs.

Table 1: Assessment Options under the Save Energy Now Program and Industrial Assessment Centers in the US

Targeted Companies	Implementing Agencies	Duration	Services	Subsidies/ Financing
Large plants (≥500 Billion Btu/year in primary energy consumption)	Energy Experts (who are Best Practice Qualified Specialists)	3-day system assessment	Apply DOE's software tools and technical assistance to a specific area Provide hands-on learning to plant personnel	Free and cost-shared
Medium plants (annual primary energy consumption > 26 Billion Btu/year, but < 500 billion Btu/year)	University-based Industrial Assessment Centers (IACs)	1-day assessment	Highly trained IAC faculty and students apply DOE software and technical assistance Identify energy saving opportunities	Free of charge to SMEs
All plants	Information Center of Energy Efficiency & Renewable Energy at DOE	N/A	Technical assistance and guidance to all sizes of plants Customized energy efficiency consultation to SMEs Providing information on energy management and financial support	Free of charge

Source: U.S. Department of Energy, *Save Energy Now* Program, Industrial Assessment Centers, and EERE Information Center

Subsidies and Other Incentives

Free energy audits (called "energy assessments" in the U.S.) are provided under the Save Energy Now and Save Energy Now LEADER Programs. To be eligible for a three-day large plant audit, the participating facility must have an annual combined energy consumption of at least 500 billion Btu (~528 TJ) (exceptions are allowed only if companies have special circumstances). Companies that do not join the LEADER program, i.e., do not sign a voluntary pledge to reduce their facilities' energy intensity by 25% over ten years, need to pass the cost-benefit reviews conducted by ITP to determine whether they are eligible for an assessment (US DOE ITP, 2009a). The three-day assessments, which mainly focus on process heating, steam systems, pumps, fans, and compressed air systems, consist of: DOE auditing tool training by Energy Experts and identification of potential energy-savings opportunities (in day one); data collection and applying the software tools to quantify savings potentials in day two; and supplemental software tool analysis and discussion of implementing identified measures in day three. For companies participating in the Save Energy Now LEADER program, the assessments conducted by the Energy Experts are provided free-of-charge, and the participating companies only pay for their staff members to work with the assessment teams (US DOE ITP, 2009a).

Smaller enterprises that are not eligible for the three-day assessments can apply for a one-day free energy audit offered by one of the university-based Industrial Assessment Centers (IACs). The one-day energy assessments are offered at no cost to small-and-medium manufacturers, and provide a brief but thorough evaluation of a manufacturing plant. Through the one-day on-site visit, auditors and experts (usually made up of university faculty and students) perform data collection, interviews with plant managers and complete a plant tour as well as a brainstorming session on identification of energy-savings opportunities. After the visit, a post-assessment report will be submitted to the client company with recommendations and explanations of anticipated savings, implementation costs and simple payback periods (Anderson, 2004). A follow-up call is made about one year after the plant visit in order to review the assessment impact. An evaluation of the IAC program has shown that more than half of the recommended measures are adopted and that high costs or lack of financing is one of the main barriers to adopting energy-efficient measures (Harris, 2000; Thollander, 2007).

Participating companies receive access to resources (case studies, publications, guidebooks, etc.) and software tools (US DOE ITP, 2009a). The *Save Energy Now LEADER Program* engages companies who voluntarily pledge to cut energy intensity by 25% in ten years. In return, these companies are given higher priority in getting customized assistance, personalized resources and financing opportunities (US DOE ITP, 2009b).

The *Save Energy Now Program* recognizes outstanding companies in their efforts on energy efficiency and emission reduction through public award of Energy Champion Companies and Energy Saver Companies (US DOE IPT, 2009c). The Information Center of Energy Efficiency & Renewable Energy at DOE offers industrial facilities a wide variety of information and resources on financial opportunities, such as grants, cooperative agreements, continuation awards, and renewal awards, or through other organizations in EERE's funding stream (US DOE EERE Information Center, 2009).

Training, Certification and Quality Control

In the U.S. DOE Industrial Technologies Program, a qualification training program has been established to provide qualified energy experts for industrial facilities. The program covers the main cross-cutting systems, including compressed air, pumping, process heating, steam, and fan systems. To be recognized as an energy specialist for each system, participants need to attend a qualification workshop varying from 2 to 3.5 days. Depending on the different requirements of each workshop, participants complete the training course, pass practical and/or written tests, and become proficient in using the relevant DOE tools (US DOE ITP, 2009d). Qualified energy experts help industrial plants to identify energy-saving opportunities and improve their energy efficiency. The full list of DOE energy experts can be found on DOE's website, with a searchable database (US DOE ITP, 2009d).

In order to qualify for energy assessments offered by the US DOE Save Energy Now Program, companies are required to file applications that provide average annual fuel use and energy consumption data. This provides a foundation to monitor and evaluate the progress of the companies. After the energy assessments, DOE will contact the companies to follow up for feedback and implementation progress (US DOE ITP, 2009e). Under the Save Energy Now LEADER Program, a DOE Account Representative and a Technical Account Manager are assigned to each LEADER company. Through the appointment of contacts, the program can have frequent updates, reports on progress, and more detailed examinations of companies' performance (US DOE ITP, 2009a and 2009b)

Energy assessments offered through the U.S. DOE's Industrial Assessment Centers and Save Energy Now Program are conducted by Energy Experts, or BestPractices Qualified Specialists. DOE publicizes a list of qualified specialists on their website for cross-cutting energy consuming systems: compressed air, fans, process heating, pumping and steam. In order to become a qualified specialist, engineers who meet prerequisites are required to take a qualification workshop and training program, which includes mastering assessment tools and passing practical and written exams.

Finnish Energy Auditing Program

Finland has an active energy audit program (EAP) since 1992. The EAP program is a standalone program that focuses on energy audit in several sectors, including buildings and processes in service (both private and public[15]) and industrial sectors, as well as energy-intensive process industry.

When the Finish Energy Audit Program was created, the initial emphasis was on "service and industrial sector buildings and processes". However, as the program evolved and by the introduction of the Voluntary Agreement (VA) Scheme, the energy-intensive process industries entered the EAP in 1998.[16] The first explicit goal for the EAP was set in 1993 with ambitious targets. Based on experience, the goals changes overtime, as displayed in Figure 1.

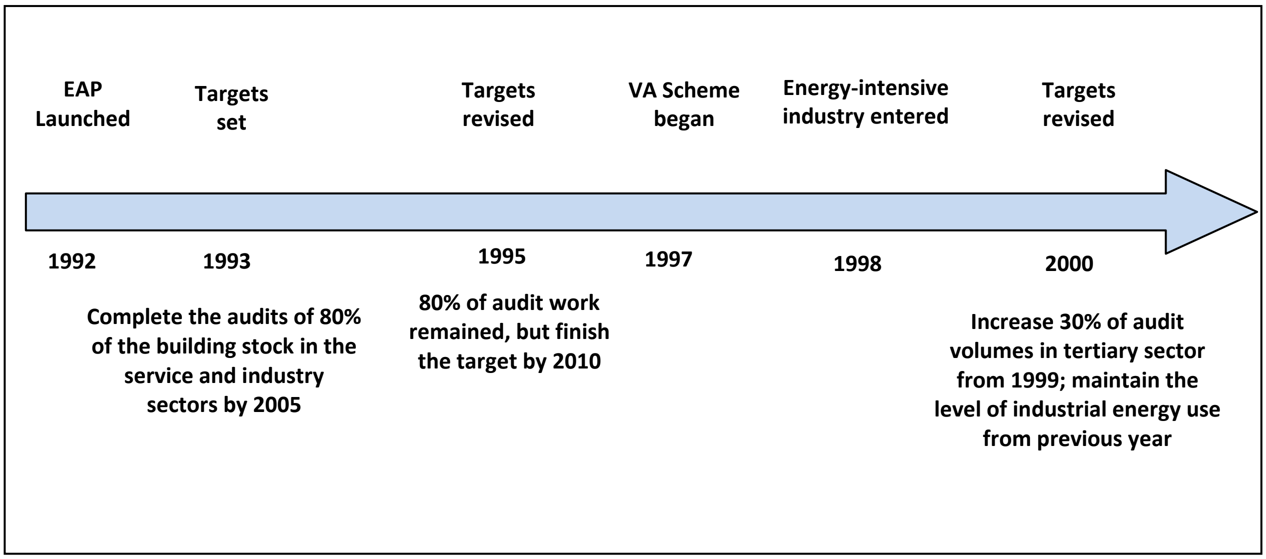

Figure 1: Development of Goals of the Energy Audit Program, 1992-2000
Source: Vaisanen& Reinikainen, 2002.

Finland's VA Scheme, which covers around 85% of total industrial energy use and more than 50% of the building stock in the service sector, was launched in 1997. Because the VA Scheme requires all participating enterprises and organizations to conduct energy audits, it is a key instrument for promoting the implementation of energy audits. After voluntarily signing agreements with the government, the enterprises agreed to reduce energy consumption and commit to conduct energy audits and implement suggested cost-effective energy-saving measures found in the audits.

Subsidies and Other Incentives

Subsidies have been used as a main instrument to promote energy audits since 1992. Around

[15] Public service sector refers to municipalities and non-governmental organizations.
[16] Residential sector and government-owned buildings were excluded from the EAP, but covered in the Condition Assessment Scheme and the Agreement on the Promotion of Energy Conservation, respectively.

40% to 50% of energy audit costs are covered by subsidies. Once the VA Scheme was established, subsidies for power plants and district heating plants and networks have also been available since 1998. The Ministry of Trade and Industry (MTI) in Finland provides 50% subsidies to industrial enterprises and municipalities that signed agreements with the MTI (Vaisanen & Reinikainen, 2002). Interestingly, the Finnish government also grants a 10% subsidy for investments in energy-saving measures that are recommended in the energy audit reports.

The applications and payments of subsidies were managed by the Energy Department of MTI from 1992-1993. After Motiva was established, most of the administration of the energy audits was transferred from MTI to Motiva, except for the subsidies-related work. Instead, management of subsidies was moved to local offices, i.e., 15 regional Employment and Economic Development Centers (EEDC). Figure 2 shows the structure of the EAP program in Finland.

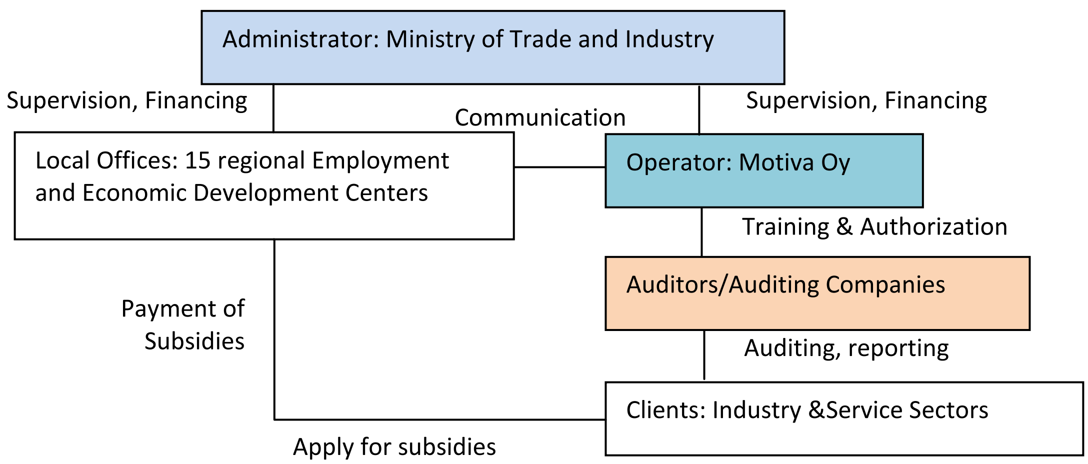

Figure 2: Structure of the Energy Audit Program in Finland
Source: Vaisanen & Reinikainen, 2002.

Training, Certification and Quality Control

Motiva offers four types of training to auditors, as shown in Table 2. In order to be authorized, auditors are required to take the Motiva Energy Auditor Basic Course and to pass the exam by the end of the training. A second chance is allowed to those who failed the test, but an extra fee of €83 Euros will be charged. There are three certificates for auditors: LVI-auditor for a qualified mechanical auditor; S-auditor for an electrical auditor and P-auditor for the personnel of clients from the process industry.

The Finish EAP develops a software tool called MOTIWATTI 2.0 for auditors to simulate individual energy-saving measures based on entered data. This software is given to auditors who participated in the training courses offered by Motiva (Vaisanen & Reinikainen, 2002). The *Energy Auditor's Handbook* was developed in 2001, with three main components: 1) an overview of Finland's EAP and energy audit programs in other countries, principles on writing energy auditing reports, and how to calculate the savings and investment; 2) how to conduct auditing in mechanical and electrical systems in practice; 3) guidelines for special systems and special areas, e.g., swimming pool equipment. Beside the Best Practice Reports mentioned above, two excel-based data sheets were provided to auditors as well, with the purpose of data collection. These data sheets were also used in the Energy Inspection Audit.

Table 2: Types of Energy Auditing Training In Finland's EAP

Training Type	Content	Duration	Mandatory/ Voluntary
Motiva Energy Auditor Basic Course	Energy audit procedures for mechanical and electrical auditors; software training	2-day training, started in 1993	Mandatory
Energy Auditor Extension Course	Current affairs, news, updates on EAP	Annually since 1998	Voluntary
Process Industry Auditor Seminar	Administrative procedures (for process industry only) to energy managers of the clients; present case studies	Seminars, started in 2000	Voluntary
MOTIWATTI 2.0 Software Course	Training of using the auditors' tool	Regional training tour	Voluntary

Source: Vaisanen & Reinikainen, 2002.

Quality control, managed by Motiva, is standardized through a standard checklist grading system in 2002. Developed by the Energy Audit Team of Motiva, the system counts the number of faults of audit reports, i.e., fatal (-60 points), major (-5 points) and minor (-2 points), and then graded them as "Excellent" (91-100), "Good" (76-90), "Satisfactory" (61-75), "Poor"(51-60) and "Failed"(<50). Motiva provides both the written evaluations and the quality control checklist with comments to all auditors. Auditors with "excellent" and "good" grades are recommended to clients, if needed.

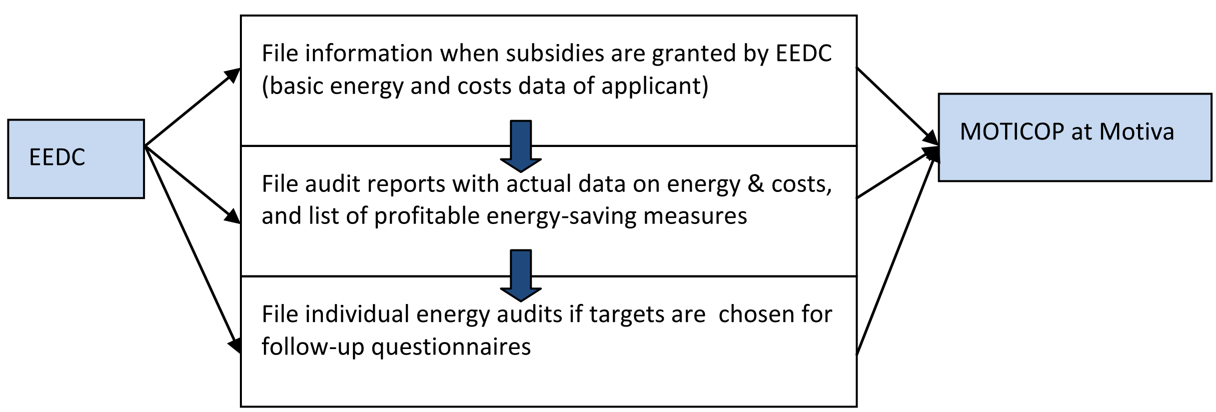

Figure 3: Three-stages of data filing to the monitoring system

Monitoring and Evaluation

An online monitoring system – MOTICOP - is established to monitor the progress of the EAP. The system is Microsoft ACCESS-based and designed to document all audit-related data. Figure 3 shows the stages of data filling into the monitoring system. It is reported that by the end of 2000, MOTICOP "contained information on 4,466 individual audited buildings/sites and over 19,500 energy saving measures" (Motiva, 2009).

Motiva conducts a program-level evaluation each year since 1995. Annual evaluations include information on annual savings in heat, electricity, water usage and cost of energy and water savings. Information is collected from follow-up questionnaires, submitted reports with compressive analysis, and all audits that were subsidized in the program. In the evaluation, realization rates of recommended energy-efficient measures are analyzed. The main implementation barriers, including profitability issues, financing difficulties, and non-valid proposals, are identified.

Results and Lessons Learned

The key results for the industrial and energy sectors are provided in Table 3, and detailed results for more sectors can be found in the Country Report of Finland (2002) under the Audit II project.

Table 3: Results for energy audits in industrial and energy sectors in Finland, 1992-2000

Sector	Total # of Audits	Total # of sites/plants audited *	Heat and fuels savings (TWh/yr)	Electricity savings (TWh/yr)	MTI's subsidies (million Euros)
Industry	448	747	40.7	22.7	6.14
Energy sector	14	22	N/A	N/A	0.30

* In some cases, there were more than one site/plant in one audit package.
Source: Vaisanen & Reinikainen, 2002 and Motiva, 2009.

For industrial sites that used less than 10 GW per year, 175 sites were audited during the period of 1995-2000. Annually, total costs of consumed energy and water in the audited industrial plants were around 16.7 million Euros, and the estimated savings were 2.7 million Euros, which was about 15.7% of the total costs of energy and water. For industrial sites with energy consumption between 10 and 70 GWh per year, 46 sites were audited. The total costs of consumed energy and water in the audited plants were around 36.9 million Euros/year, and the estimated savings were 4.9 million Euros/year, which was about 13.6% of the total costs (Vaisanen and Reinikainen, 2002).

Energy Auditing Program in France

In 1999, an Energy Audit Program "*Aide à la décision*" (Decision Making Support Scheme) was launched in France. This program covered both industry and building sectors, except for individual single houses.[17] The voluntary-based energy auditing program was administrated by the French Environment and Energy Management Agency (Agence de l'Environnement et de la Maîtrise de l'Energie, or ADEME). The program is operated at the local level by the regional delegation network of ADEME, which has three central departments around France, 26 regional branch offices, three national territory offices, and one representative office in Brussels, Belgium (ADEME, 2008). These regional delegations are in close contact with potential clients. Technical central departments of each sector manage the technical matters with EAP.

Through the project of "Regional Funds for Energy Efficiency" during 1984-1992, ADEME signed partnership contracts with regional authorities (e.g., Regional Chamber of Commerce) on equal financial participation on rational use of energy (Despretz, 2002). ADEME was also in partnership with sectoral players (e.g., trade federations and technical centers). Thus, ADEME tightened its connections with both the regional authorities and the government ministry, and this relationship allowed better communication, promoting and conducting of energy audits, easier access to key findings and dissemination of the results. Figure 4 shows the connections and structure of the energy auditing program in France.

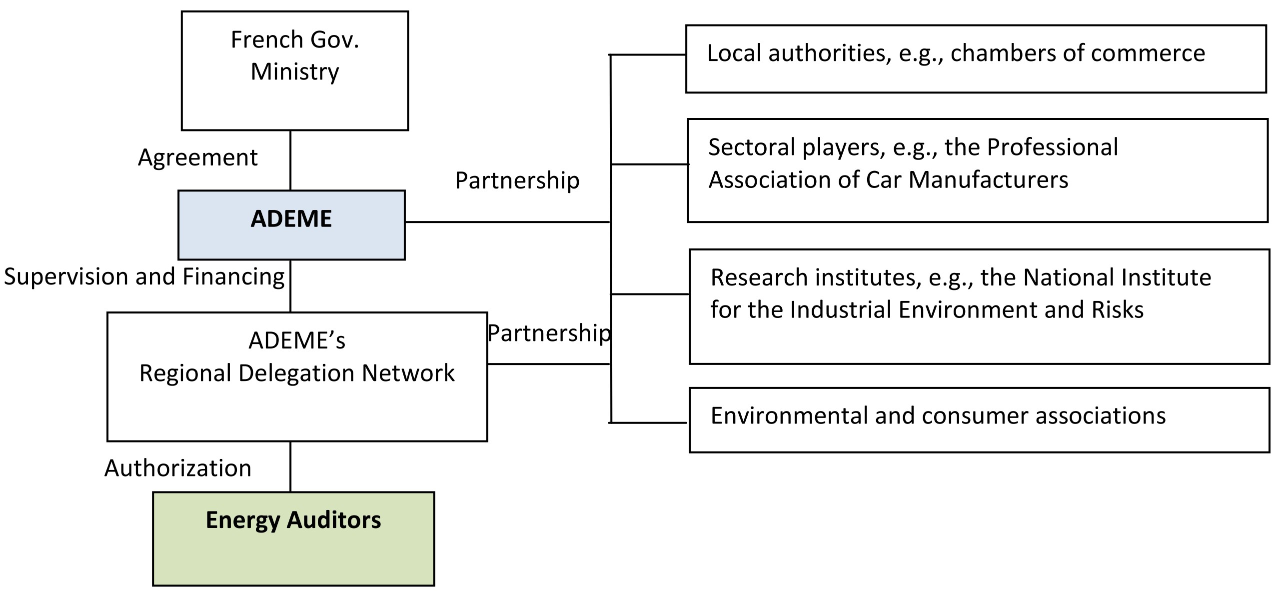

Figure 4: Structure of the Energy Auditing Program in France
Source: ADEME, 2008 and Despretz, 2002.

[17] A self auditing tool is available on French Environment and Energy Management Agency (Agence de l'Environnement et de la Maîtrise de l'Energie, or ADEME)'s website for individual single houses.

Subsidies and other incentives

Subsidies are given to industrial sectors in the program in the form of co-payments for energy auditing costs. These subsidies vary from 50% - 70% of the audit cost depending on the different types of energy audits (see Table 4). Subsidies or incentives are paid to the clients only after the energy auditors fulfilled the requirements of the audit specifications and the auditing reports are evaluated by the regional delegations (Despretz, 2002).

Table 4: Subsidies for Energy Audits in Industrial Sector, the EAP Program

Energy audit types	**% of costs as subsidies**	**Maximum subsidy per audit**	**Auditing Content**
Pre-audit	70%	2,300 Euros	Rapid assessments, raise interests and awareness and identify easy & quick measures for improvement
COE (Energy Advising)	70%	75,000 Euros	Audit a branch or stock of plants collectively
Audit	50%	30,000 Euros	Detailed assessments
Feasibility study	50%	75,000 Euros	Detailed study and analysis on specific energy or technology

Source: Despretz, 2002.

Because of the FOGIME Scheme (Fonds de Garantie des Investissements de Maîtrise de l'Energie) in France, conducting energy audits is also beneficial to industrial plants in terms of getting bank guarantees. The FOGIME program was funded by ADEME and a branch bank of the development bank for small and medium enterprises (SMEs), “Banque du Développement des PME (BDPME)”. The program guarantees loans to the private sectors with a goal of attracting SMEs to invest in energy efficiency and renewable energy. Usually, a guarantee covers medium to long term risks of 2-15 years and “insures the risk taken by the financial institution providing the loan”. Compared to a common coverage rate offered by BDPME to other SME projects, the FOGIME scheme covers 70% of the loan (FOGIME, 2000). However, in order to be eligible for a bank guarantee, the plant is required to conduct an energy audit and have the audit approved by ADEME. Thus, this mechanism encourages the participation of industrial companies in energy auditing.

Training, Certification and Quality Control

Under the EAP program, the detailed content of the auditing work of each type of energy audit models is defined by “specifications”. These specifications are provided to energy auditors as well as clients by the regional delegations. To build up the capacity of energy auditors and increase the quality of energy auditing, “training tour” sessions are organized around France. The content varies depending on which sector, i.e., building or industry, the auditors came from. The basic structure of a 2.5 - 3 day training includes (Despretz, 2002):

- Presentation of ADEME scheme and the EAP program
- Introductions to energy auditing model specifications
- Description of the most encountered errors and omissions

- Presentation and training of auditing software and tools
- Demonstration of two real case studies by trainees

ADEME authorizes qualified independent energy professionals to be energy auditors, and ADEME also publishes lists of certified consultants through an agreement for technical and non-technical requirements with energy consultants. Although a certified energy auditor is mandatory for the audit, charted energy auditors have a greater market advantage with official and public authorities. On the other hand, it is reported that the number of charted consultants is relatively small, about 60 for the building sector and 50 for the industry sector.
In addition to random checking of the auditing reports, ADEME can also conduct an independent re-audit. If the audit is not satisfactory, the auditors who are responsible could be expelled from the charter list. Clients' complaints can also be a key reason to repeat the audits.

Other Supporting Measures

Since the French Energy Auditing Program covers the industrial sector, the commercial sector, the public service sector, and apartment buildings, the promotion is conducted for the whole program. However, sector-oriented brochures and pamphlets are distributed to specific sectors and local authorities. Financing schemes are explained and frequently asked questions were answered in the documents.

ADEME publishes newsletters regarding major activities and issues and posts them on its website.[18] ADEME also held two campaigns aimed at raising public awareness of energy efficiency and conservation, rather than directly promoting energy audits, through magazines and newspaper in September 1999 and through a series of TV commercials in 2001.
It is also reported that inquires regarding the costs of different energy audits for the building sector are conducted before or at the initial stage of the program. A few surveys are also launched in order to understand auditors and clients' responses to the program on various matters, such as costs, energy auditing models, and auditing guidelines (Despretz, 2002). It is not clear though whether this was conducted in one specific sector or in multiple sectors.

Monitoring and Evaluation

Under the French Energy Auditing Program, "technical information" (the type of the audit, number of buildings or plants, name of auditors) regarding the energy audits is required for each application for subsidies. The applicants who received the subsidies are further required to provide ADEME with "a synthesis paper sheet *proforma* of the auditing results" (Despretz, 2002). Regional delegations around France collect the sheets periodically. However, in order to evaluate the program or auditing results by using this approach, submitted technical information and performance sheets are required to be of high quality and contain enough information for evaluation and validation.

[18] The latest one can be found at http://www.ademe.fr/htdocs/publications/international/10/index.htm

Results of the EAP program were better documented for the building sector than for the industry sector, as shown in Table 5. Potential energy savings from energy-efficiency measures were also provided for building sector (Despretz, 2002).

Table 5: Results of auditing activities under the French EAP Program, 1999-2001

Sector	**1999**		**2000**		**2001**	
Building sector	Subsidies (Euros)	# of Bldg.	Subsidies (Euros)	# of Bldg.	Subsidies (Euros)	# of Bldg.
COE (Energy Advising)	203,000	364	505,000	2,387	151,000	600
Pre-audit	196,000	223	654,000	337	676,000	643
Audit	568,000	116	580,000	587	659,000	971
Feasibility Studies	569,000	57	422,000	1,641	714,000	875
Industry & Agriculture	Subsidies (Euros)	# of operations	Subsidies (Euros)	# of operations	Subsidies (Euros)	# of operations
Total	N/A	N/A	1,653,000	367	2,694,000	343

Source: Despretz, 2002.

References

Anderson, S. N., 2004. "Information programs for technology adoption: the case of energy efficiency audits." *Resource and Energy Economics , 26* (1), 27-50.

Despretz, H., 2002. *Audit II: Country Report France.* Available at: http://www.motiva.fi/files/1921/CR_FR.pdf

Energy Conservation Guarantee Fund (FOGIME), 2000. "Aides financières." Available at.: http://www.ademe.fr/entreprises/Aides/

French Environment and Energy Management Agency (ADEME), 2008a. "Energy Efficiency in the European Union: overview of policies and good practices." Available at: http://plan-deplacements.fr/servlet/getBin?name=7F7F38D623795D65F276532157107B851228989839298.pdf

French Environment and Energy Management Agency (ADEME), 2008b. "ADEME in facts and figures." Available at: http://www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=17614

Harris, J. A., 2000. "Investment in energy efficiency: a survey of Australian firms." *Energy Policy, 28* (12), 867-876.

Motiva, 2009. *Areas of Operation*. Available at: http://www.motiva.fi/en/areas_of_operation/

Thollander, P. D., 2007. "Energy policies for increased industrial energy efficiency: evaluation of a local energy programme for manufacturing SMEs." *Energy Policy , 35*, 5774-5783.

U.S. Department of Energy's Industrial Technologies Program (US DOE ITP), 2009a. *Save Energy Now FY 2010 Program Developments*. Available at: http://www1.eere.energy.gov/industry/saveenergynow/pdfs/sen_fy2010_program_developments.pdf

U.S. Department of Energy's Industrial Technologies Program (US DOE ITP), 2009b. *Save Energy Now LEADER Companies.* Available at: http://www1.eere.energy.gov/industry/saveenergynow/leader.html

U.S. Department of Energy's Industrial Technologies Program (US DOE ITP), 2009c. "Industrial Energy Savings Recognition." Available at: http://www1.eere.energy.gov/industry/saveenergynow/recognition.html

U.S. Department of Energy's Industrial Technologies Program (US DOE ITP), 2009d. "Qualified Specialists." Available at: http://www1.eere.energy.gov/industry/bestpractices/qualified_specialists/

U.S. Department of Energy's Industrial Technologies Program (US DOE ITP), 2009e. "Energy Assessments." Available at: http://www1.eere.energy.gov/industry/saveenergynow/assessments.html

U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy's Information Center (US DOE EERE Information Center), 2009. Available at: https://www1.eere.energy.gov/informationcenter/

Vaisanen, H., & Reinikainen, E., 2002. *Audit II Country Report Finland.* Available at: http://www.motiva.fi/files/1945/CR-FIN.pdf