A Strategy for Energy Efficiency Actions in the Mexican Industrial Sector: The Pemex Experience

O. de Buen R., D. Gutiérrez D., G. Ramos N., E. Valdivieso R., and J. González M.
National Commission for Energy Conservation (Conae)
S. Gómez A. and C.E. Hernández, SIASPA (Pemex)

ABSTRACT

Mexico's National Commission for Energy Conservation (Conae) is the national agency in charge of promoting energy efficiency in the country. Conae has supported energy efficiency actions in all economic sectors through a variety of innovative strategies, mainly based on information and training. For PEMEX (Mexico´s national oil company) Conae developed a support strategy that has proven very successful through more than six years of concerted efforts. This strategy was initiated with the integration of a Pemex-Conae working group that identified, based on Pemex´s perspectives, specific needs and opportunities for energy conservation. The strategy evolved from the analysis of individual energy-using systems by actors external to Pemex, to a pilot program that used Internet-based, energy-analysis tools that allowed, with the collaboration of plant operators, for the analysis of a much larger number of systems. This strategy proved its applicability and coincidence with other programs for safety and environmental protection, and the Pemex-Conae effort became a permanent energy efficiency campaign in Pemex with significant reductions in energy consumption and their collateral environmental and economic results. As a result, Pemex achieved savings of 10.6 million barrels of oil equivalent (boe) in 2001, with a value of or nearly 200 million US dollars, and 3.2 million tons of CO2 emissions avoided as a result of these savings.

This paper goes through the most important details of this evolving strategies, annotates its most important results, and highlights its final product, which is a general analysis and evaluation tool that is now being used, together with the main elements of the strategy in Conae´s work with large energy users.

Introduction

Since its inception in 1989 as the national public agency in charge of energy efficiency promotion, Conae has had the specific mandate to provide technical assistance to the all sectors of the economy and to be the authority for national energy-efficiency standards. To follow this mandate, Conae has been developing, with very limited resources, a set of strategies based mainly on information, training and the creation of institutional networks. One key element in this strategy has been the use of Internet as an instrument for information sharing, communication and operation of networks of specialists

Pemex is the national company in charge of the exploration, exploitation and commercialization of oil and associated gas, activities that are reserved to the Mexican state. Pemex is the largest public sector company in Mexico and one of the world's ten biggest. Since it is a large energy consuming entity (in 2001 Pemex used roughly 118 million barrels oil-equivalent for all its different operations), and has installations with many years of

operation, it presents large energy-conservation potentials, scattered in a large number of oil refining, gas processing, and crude oil and gas transportation units.

To pursue these opportunities, Pemex has made several attempts through the last twenty-five years—some integral, some scattered and isolated—to increase its overall energy efficiency. Many times through the years, consultants have been hired for this purpose, but results have been poor or not good enough to make these efforts permanent.

It was in 1995 that an initiative was taken by Conae and Pemex officials to make a concerted effort to renew and strengthen, based on Conae´s technical support, Pemex´s energy efficiency initiatives.

For Pemex, taking advantage of the energy-efficiency opportunities makes the company more efficient, and with greater capacity of supply more energy, save money, and reduce the negative effects of its activities on the environment. For Conae, it has been an opportunity to increase its social benefits, thus strengthening its position as a necessary public agency.

Development of the Program: Steps and Actions

Energy efficiency can be increased through operational or investment measures. For the purpose of this paper we will distinguish the investment measures as "technical". In any case, and in particular for a company as Pemex, to take advantage of energy-efficiency potentials it is necessary to take a very large number of measures, both technical and operational. To do this, Conae´s strategy, in accordance with Pemex´s needs and priorities, evolved through three clear stages.

First Stage: The Pemex-Conae Working Group and the First Energy Audits (1955-1997).

As stated above, the first step in the Pemex-Conae collaboration was the establishment of a working group integrated with personnel from both institutions. It is important to note that those participating for Pemex were mid-level managers, not directly involved with the operational duties of the plants, but with physical presence in the field and capacity to identify needs at plant level.

The Working Group had the objective of identifying and exploiting energy-saving opportunities by applying no- or low-cost investments. During this stage, Pemex officials identified systems that were mostly bottlenecks in production and that they considered could be reduced through energy efficiency (instead of investment in new capacity). Conae, with its own specialists or through consultants under its supervision (mainly from Mexico´s Petroleum Research Institute), did the energy audits for those systems. The Working Group met once a month at Conae´s headquarters to review the analysis process and its results.

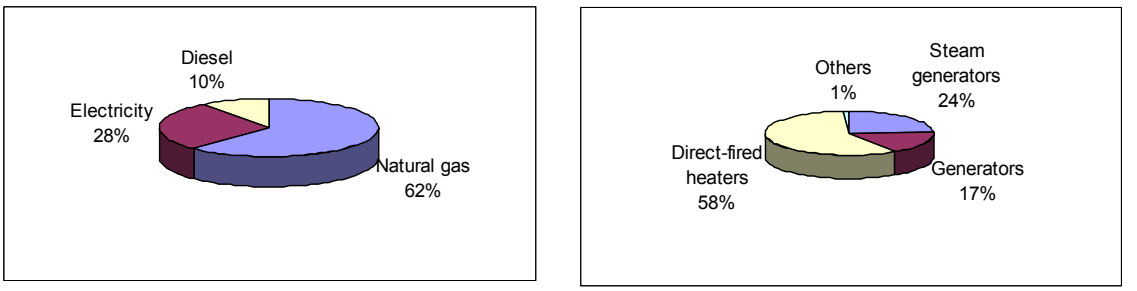
From 1995 to 1997, fifty installations and/or processes were analyzed with methodologies that were specifically designed for a number of them. This work helped identify potential fuel and electricity savings with a value greater than 40 million dollars per year (table 1). Also, significant opportunities to save water and avoid greenhouse gas emissions were identified.

Table 1. Energy Conservation Potentials Identified During the First Phase

Installations/process	Energy conservation potential	Value (Millions US dollars)
Cooling towers	81,000 MWh/per year	$1.6 per year
Direct Fire Heaters	10 MMKcal/h	$140.4 per year
Outdoor lighting	5,100 MWh/year	$2.4 per year
Heat recovery	170 MMKcal/h	$7.2 per year
Steam generation	40 MMm3/year	$2.4 per year

These audits and other more general analyses also helped determine that 60% of the energy consumption in Pemex´s productive goes to direct-fired heaters, steam generators and gas turbines (Figure 1). Based on these studies, Conae's specialists presented to the Working Group different energy-efficiency measures, together with their cost-benefit analysis, to be incorporated into the activities, plans and budgets of the PEMEX subsidiaries. Many of the recommendations of the studies were operational, and their implementation had the expected results, thus bringing the first payback for the efforts.

Figure 1. Typical Distribution of Energy Consumption in Pemex



Second Stage: The "Bottom-Up" Approach and Technical Assistance Through the Internet (1998-2000)

With opportunities for energy efficiency scattered throughout a large number of productive units and a need to increase the scope of the collaboration with the same resources, Conae's second stage focused on ways to multiply the number of installations analyzed with the lower transaction cost and greater technical certainty. Based on the tools and methods developed for the first-stage individual analysis, Conae´s experts designed simplified analytical tools, to be used, with Conae´s help, by plant operators to identify energy-saving opportunities for the most energy-consuming units. The tools were made available, together with other useful information, through the Internet at Conae's web page (Conae page 1998). The types of systems that could be analyzed with these tools were:

- Direct fired heaters
- Cooling towers
- Heat recovery
- Outdoor lighting
- Co-generation

Each tool or methodology included a basic description, formats for data gathering, software with the analysis algorithms, and recommendations for energy efficiency. As Internet is available anywhere at any time with a computer and a phone line, these diagnostic tools became available be applied by Pemex personnel across the country, facilitating in-house energy audits, reducing transaction costs for the identification of the energy-efficiency opportunities (Odón de Buen 2000).

To support this strategy, Conae´s experts, with the help of Pemex´s officials in the Working Group, organized a large number of courses to train operators in the use of Internet and the tools. Through this, Conae established a "bottom-up" approach where energy-efficiency opportunities were identified and implemented directly by the operators of the installations, integrated into their daily operation, thus becoming systemic and permanent. This was not, at this time, a Pemex-wide concerted effort because it was voluntary inside Pemex, but it soon became a fast-growing operation.

In a very positive coincidence and development in 1998, Pemex put into operation the Integral Security and Environmental Management System (SIASPA). SIASPA is a program designed by Pemex to be applied in its installations covering all aspects of industrial safety and environmental protection. Many SIASPA elements, particularly those aimed at reducing environmental impacts, involve energy-efficiency and are also bottom-up, just as the evolving Conae strategy. For that reason, high-level Pemex´s officials, when approached to increase the scope of Conae´s assistance, decided that SIASPA could be complemented with the new Conae diagnostic tools and training.

In order to initiate this new stage, and with energy-efficiency not being at the time an explicit purpose of the SIASPA program, Pemex decided, with Conae´s collaboration and know-how, to launch a campaign for the entire company. In August 1999, SIASPA´s "Campaign for Energy Conservation and Environmental Protection" was started, with the goal of reducing by 5% the energy consumption indexes[1]. To coordinate the SIASPA campaign, the Pemex-Conae Energy-Saving Network was instituted, in place of the Working Group established in 1995.

At the closing of SIASPA´s campaign in July of 2000, approximately 60% of the installations had achieved the 5% reduction goal, obtaining savings estimated at $197 million US dollars (Pemex report 2001). Most—if not all—of this savings were obtained through operational measures performed by plant operators, making Pemex recognize that the campaign reinforced the energy-savings culture among its workers.

From 1997 to 2000, along with hydrocarbon savings, significant reductions of electricity and water consumption were also achieved: more than 27,000 MWh and 12 million m3 per year, respectively. In that same period Pemex reported a reduction of more than 24,000 tons per year of CO2 emissions and 110 tons of NOx. Furthermore, from 1997 to 2000, the utility cut 14 million cubic meters from its natural gas consumption.

Third Stage: The Energy Performance Indexes Approach (2000-)

Beginning in 2001, convinced by the positive earlier results and as a continuation of the SIASPA campaign, Pemex made the energy-conservation effort permanent through the

[1] Total production to total fuel consumption of 244 productive installations comparing the July 1998 values *vis-a-vis* those for August 1999 (Pemex information 1999).

"Institutional Program for Energy Efficient Use". This program had the goal of "reducing the Energy Consumption Index (total production to total fuel consumption ratio) between 1.5% and 5% per business line" (David & Eduardo 2001. But these new goals needed better and more precise evaluation protocols, so Conae´s staff designed and integrated new tools for this purpose, thus allowing for the most accurate picture possible of the energy-efficiency measures impact.[2]

With Conae´s new tools and protocols, the Energy Indicators Control and Follow-up System was established per processing plant, per system and per piece of equipment in all the Pemex petrochemical-centers and gas-processing complexes. To make this system work, the following activities had to be performed:

- Compilation of annual global-energy consumption and production data
- Implementation of energy audits for systems with high energy-consumption
- Integration of energy-efficiency benchmark curves
- Elaboration of an energy-distribution diagram
- Implementation of energy audits at more disaggregated levels
- Definition and establishment of energy indexes in systems and equipment
- Follow-up of energy performance.

The system developed by Conae enabled Pemex, along with training provided by the United States Agency for International Development (USAID) for performing energy and environmental audits—to identify and quantify not only facility energy consumption, but also the raw materials and final products generated by each complex. USAID´s support included training for 320 specialists of the four subsidiaries of Pemex.

Energy consumption and intensity at different levels of the production processes could then be monitored and evaluated. The system was tested in 2001, together with other installations, in the Cangrejera Petrochemical Center to identify savings potentials of nearly 650 million ft3 of natural gas.

A simple graph that was part of this new system and that shows changes in energy intensity as a function of production levels (Figure 2), changed the way Pemex operators evaluated energy intensity changes, and not only helped draw a benchmark reference (as a function of production levels) but also helped locate events in time that decreased energy efficiency, thus helping plant operators to identify the actions to increase energy conservation.

Following Conae´s protocols and using the tools to look at systems at a more disaggregated level, operators were able to "fine-tune" those systems, quantify the impact of these actions, and to identify technical measures for greater energy-efficiency (Table 2).

The impacts of the Pemex-Conae collaboration have been quite significant in the last two years with savings of more than six million BOE.[3]

[2] Pemex and Conae specialists detected that the first evaluations did not permit immediate the correct determination of energy savings because they did not consider production levels but only compared month to month consumption (previous year).

[3] The equivalent of four days oil consumption for Mexico.

Figure 2. Evolution of the Energy-Efficiency Benchmark in Cangrejera Petrochemical Center

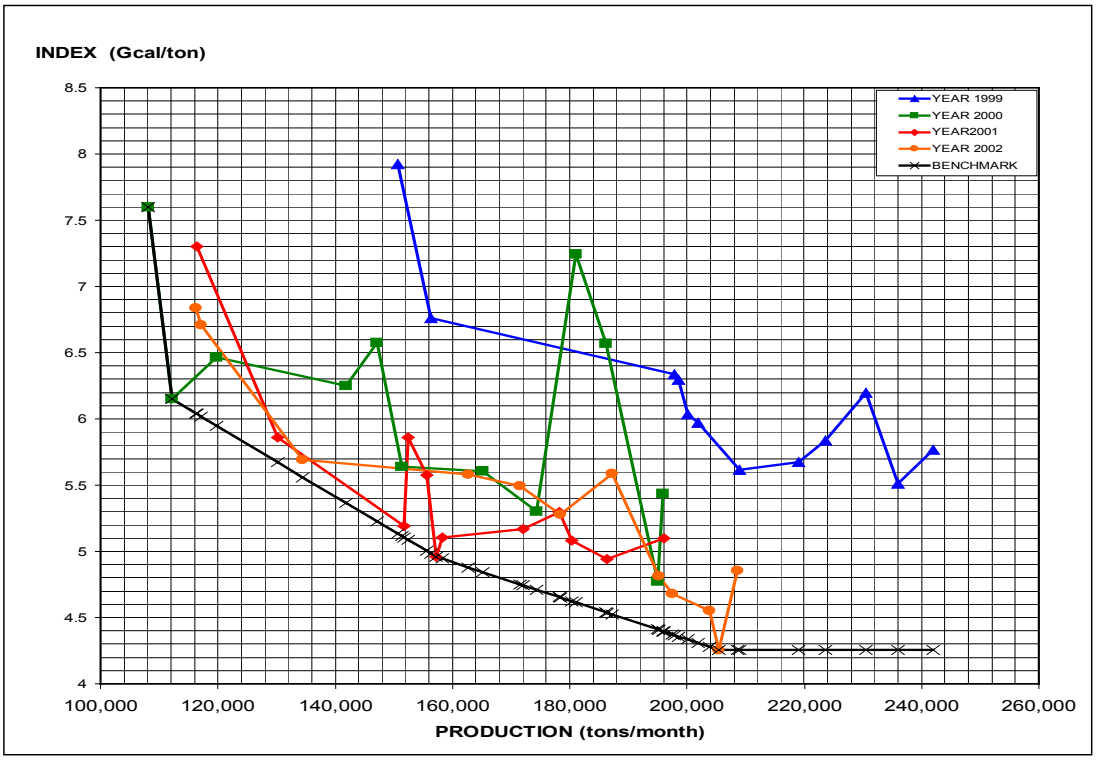


Table 2. Energy Savings and Potentials at Cangrejera Petrochemical Center

Petrochemical center	Production	Index (Gcal/ton)		Variación	Saving		Potential	
		2001	2002					
	(ton/moth)	(Gcal/ton)	(Gcal/ton)	(%)	(Gcal)	(BCE)	(Gcal)	(BCE)
Cangrejera	195183	5.0872	4.8130	-5.70	-440590	-312609	1062883	754140
Tula	2649	9.0362	8.5572	-5.60	-79048	-56087	26794	19011
Independencia	18679	2.7736	3.1004	10.54	-67351	-47787	238762	169407
Pajaritos	17415	-	5.8889	-	320795	227611	206600	146588
Morelos	45694	19.3151	22.6598	14.76	727709	516327	1322087	938052
Cosoleacaque	54473	4.3097	3.3931	-27.02	634760	450377	416925	295818
Escolín	3923	27.3301	11.4025	-139.69	497351	352882	782011	554855
Total:					1,593,625	1,130,715	4,056,062	2,877,872

With this monitoring and evaluation system, Conae has been able to complete a program-design and development cycle that started with individual systems and closed with tools and protocols that allowed for an integral analysis of energy-conservation opportunities.

Conclusions

Through a process that was both technical and institutional, Conae was able to become Pemex main external and institutional support for a company-wide program that has proven very successful. This program was based on several principles:

1. Team work. From the start, Conae and Pemex personnel made it clear that they were to work as a unit for the benefit of both institutions.
2. Focus on Pemex´s priorities, by identifying bottlenecks that could be eliminated with energy-efficiency measures. As good results became obvious, trust in energy efficiency became widespread as well as Conae´s credibility.
3. Involvement of plant operators in the identification of the opportunities and their implementation. Ownership is always a basic element in energy efficiency efforts.
4. Use of state-of-the-art information-dissemination technology to increase replicability, reduce transaction costs and facilitate operator involvement. This included easily available technical support that could respond in a short time.
5. An intensive training program in the use of the tools and its media (Internet). This helped reduce the resistance that comes from ignorance and allowed for personal contact among those who would later communicate through the Web.
6. Permanent program evolution to greater scope. Conae never stopped adjusting its tools and protocols to increase its impact on Pemex´s energy consumption.
7. Permanent impact evaluation, to justify the effort and give feedback to the program-design process.

It is important to note that the tools and protocols designed by Conae, along with other practices, are part of Conae's strategy for its Energy Efficiency Program for Industry and has been successfully applied at the Federal Electricity Commission (CFE) and in industrial and mining companies. Additionally, the approach is being adapted for Conae's Program for small and medium-sized enterprises.

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