# BestPractices

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Assessment Case Study

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OFFICE OF INDUSTRIAL TECHNOLOGIES
ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

### BENEFITS

- Saves more than 6,000,000 MMBtu per year
- Saves an estimated minimum $52 million per year
- Improves process control
- Reduces waste

### APPLICATION

The Equilon oil refinery in Martinez, California, conducted a plant-wide energy assessment focused on three key areas: waste minimization, process debottlenecking, and operations optimization. The resulting recommendations can be implemented in refineries throughout the industry.

# Martinez Refinery Completes Plant-Wide Energy Assessment

## Summary

A plant-wide energy-efficiency assessment was conducted in May 2001 at Equilon Enterprises' Martinez, California, refinery. The assessment identified potential annual savings of $52,485,000 with an estimated capital requirement of $30,993,000. The study identified energy savings of 6,230,600 million British thermal units per year (MMBtu/year). This represents savings of approximately 12 percent of the total energy used at the facility.

## Company Background

The Martinez Refinery, located 30 miles northeast of San Francisco, began operating in 1915. It is now part of Equilon Enterprises LLC, a joint venture between the U.S. refining, marketing, and transportation assets of Shell Oil Co. and Texaco Inc.[1] Equilon refines and markets gasoline and other petroleum products under both the Shell and Texaco brand names in 31 western states. The company has roughly 6,500 employees. Gross revenue in 2000 was $50 billion.

EQUILON ENTERPRISES' MARTINEZ REFINERY

The refinery processes primarily San Joaquin Valley crude oil at the rate of 165,000 barrels of oil per day. It is a high-conversion refinery comprising catalytic cracking, hydrocracking, and coking operations as well as the basic distillation and catalytic reforming processes. The plant includes lubricants and asphalt facilities. Energy costs for the facility were approximately $185 million in 2000. This energy was provided by a combination of purchased natural gas and power from waste streams from the petroleum refining processes.

## Assessment Overview

Encouraged by the U.S. Department of Energy's (DOE) Office of Industrial Technologies (OIT), the Martinez plant initiated the plant-wide energy efficiency assessment in the spring of 2001. OIT co-sponsored the assessment as part of its efforts to improve industrial efficiency, waste reduction, productivity, and global competitiveness for OIT's Industries of the Future.

[1] When the plant-wide assessment was undertaken, the refinery was jointly owned by Shell and Texaco. It is now wholly owned by Shell Oil Products

The study objectives were to identify procedural savings and highly leveraged investment opportunities to reduce energy consumption. Procedural savings include those gained by modifying the operation of existing equipment, generally requiring no initial capital investment. Highly leveraged capital is that invested in a project that returns the initial investment in 2 years or less. Assessment personnel considered process operation requirements as well as the efficiency of energy procurement, distribution, and conversion to useful work.

Assessment staff reviewed the entire energy supply and use chain, including:

- Procurement of supplemental energy (usually natural gas and electrical power)
- Conversion of chemical to thermal energy (combustion efficiency or conversion from electricity to horsepower)
- Distribution efficiency (losses in getting the heat or power to its process use)
- End use of energy in the refining process.

The analysis revealed that optimizing the refining process operations to require less energy, while maintaining throughput and product specifications, would provide much of the available benefit. The assessment team employed a methodology that identified a wide range of conservation opportunities that met a 2-year or less simple payback period. The assessment team was composed of Martinez personnel and Equilon's corporate staff based in Houston, Texas. The total cost of the energy assessment was $275,000; DOE provided $100,000 in cost-share funding.

## Assessment Implementation

The plant assessment began with a benchmarking evaluation of energy use, identifying both the procedural and hardware differences that distinguish the Martinez plant from the industry leaders in energy-efficient refining. As part of the data collection for this evaluation, all of the fired equipment (i.e., any equipment that burns fuel, including all process heaters and boilers) was performance tested using API-532 methodology. This methodology uses the flue gas temperature and stack stoichiometry to calculate the thermal efficiency of fired equipment. This methodology is substantially more accurate than a traditional input/output analysis because it does not rely on flow meters to determine efficiency. (Flow meters are often the least accurate devices in process operations measurements.) The fuel flow meter is used only to quantify the magnitude of the proposed improvement.

Assessment personnel collected process data that included material properties, flows, temperatures, and pressures for most of the major process streams in every unit. Next, they compared actual performance to the petroleum industry's best practices standards[2] to identify opportunities for improvement. The team then estimated the cost of each proposed change and evaluated the return on investment against the criteria for highly leveraged investment.

A joint team of refinery and corporate personnel then met with the operating and technical support personnel for each of the refinery processing units. This team conducted a data-based review of current operations, looking for opportunities to apply industry-leading operational practices and hardware design. Because many process-related ideas involve some tradeoff between process yields and energy use, the team supported whichever outcome resulted in the greatest economic benefit.

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[2] Industry best practice is defined as the technologies and practices employed to achieve industry leading energy efficiency. Industry leadership is defined as achieving the best usage index in the Solomon benchmarking study. The actual standards are proprietary.

Opportunities were considered in three primary areas:

**1. Waste minimization**

- Flaring
- Steam vents and leaks
- Fouling in condensing turbines and eductors (i.e., steam-powered venturis used to draw a vacuum on a steam turbine surface condenser)
- Boiler blowdown control
- Surface condenser vacuum
- Heat exchanger bypassing
- Fired equipment excess air and excess draft
- Unit recycle and minimum flow
- Energy conservation equipment. (This equipment includes waste heat boilers, air preheat, hydraulic turbines, steam turbines to minimize letdown, feed/effluent exchangers.)

**2. Process debottlenecking**

- Furnace limits (tube metal temperature limits that constrain the maximum firing rate on furnaces in coking service)
- Condenser limits (heat transport limitations in distillation column overhead condensers that limit column capacity at a given operating pressure).

**3. Operations optimization**

- Management systems and targets (optimization instructions given to operating personnel to control unit operation)
- Distillation
  - Minimize pressure
  - Reflux/reboil ratio to feed
  - Composition specification economics (This refers to the comparative economics between the value of a product with a given concentration of impurities vs. the cost of eliminating those impurities. If a product doesn't meet specifications, it is considered worthless; one that exceeds specifications has no additional value over one that meets them.)
- Use of minimum steam pressure
- Furnace and Heat Exchange
  - Network cleaning and antifoulants
- Cost of power
- Hydrogen system optimization
  - Minimum inert gases, purity cascade (Hydrogen requirements for hydrotreating are driven by the purity of the hydrogen; control of that is achieved by venting part of the system out of the unit, usually to fuel, and replacing it with a purer makeup. Cascading hydrogen refers to preferentially routing the purest hydrogen to the higher-pressure units and using their vent streams to supply units where the purity requirement is not as high.)

– Hydrogen-to-oil ratios (Units that consume hydrogen maintain an excess supply of free hydrogen to avoid being stoichiometrically limited. The hydrogen-to-oil ratio defines how much excess is maintained.)

- Condensate return
- Heat integration.

## Results and Recommendations

Once the energy-saving opportunities were reviewed, the assessment team estimated the energy savings that would be gained by implementing the most promising ideas. This was accomplished by using historical operational data and by developing a scope estimate of the necessary changes. The team also identified process risks associated with these changes. Recommendations were limited to process technology already successfully implemented in other facilities.

The assessment produced recommendations with an estimated annual benefit of more than $52 million. The scope of these changes ranges from procedural modifications to significant hardware redesign.

## Overview of Specific Actions Identified in the Assessment

The assessment identified opportunities in the following primary areas.

- ***Improve the efficiency of fired equipment***. Fired equipment accounts for most of the heat release within a refinery. Some efficiency improvement can be achieved by lowering furnace draft and excess oxygen. The majority of the savings will result from additional stack heat recovery. Estimated savings: $11,796,000.

- ***Utility system optimization.*** Utility system savings can be obtained from minimizing condensation on turbine drives and by biasing steam production to the most efficient boilers. Estimated savings: $5,368,000.

- ***Maintenance.*** Refinery energy systems often require periodic renewal. The opportunities at Martinez will involve heat exchanger cleaning and insulation repair. To achieve significant energy and cost savings, Equilon would need to invest in maintenance measures, primarily for insulation repairs and heat exchanger cleaning. Total expenditure is estimated at $9,850,000. Estimated savings: $14,288,000.

- ***Quench elimination.*** Quenching a process (reducing a process temperature by mixing with a colder fluid) often occurs in refinery operations. The recommendations focus on optimizing stripping steam and water injections needed for process control. Estimated savings: $13,106,000.

- ***Hot rundown between units.*** Retaining the heat in the intermediate processing stream going from one unit to another is much more efficient than cooling the streams for storage and then reheating them when needed. Implementing the process control necessary to do this has the additional benefit of reducing working inventory. Estimated savings: $4,270,000.

- ***Eliminate waste.*** These recommendations identify processing that can be eliminated without affecting output. Estimated savings: $2,667,000.

- ***Other process changes.*** Most of these recommendations involve adding hardware or controls to improve process results while reducing energy consumption. Estimated savings: $1,000,000.

BestPractices is part of the Office of Industrial Technologies Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

### Project Partners

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