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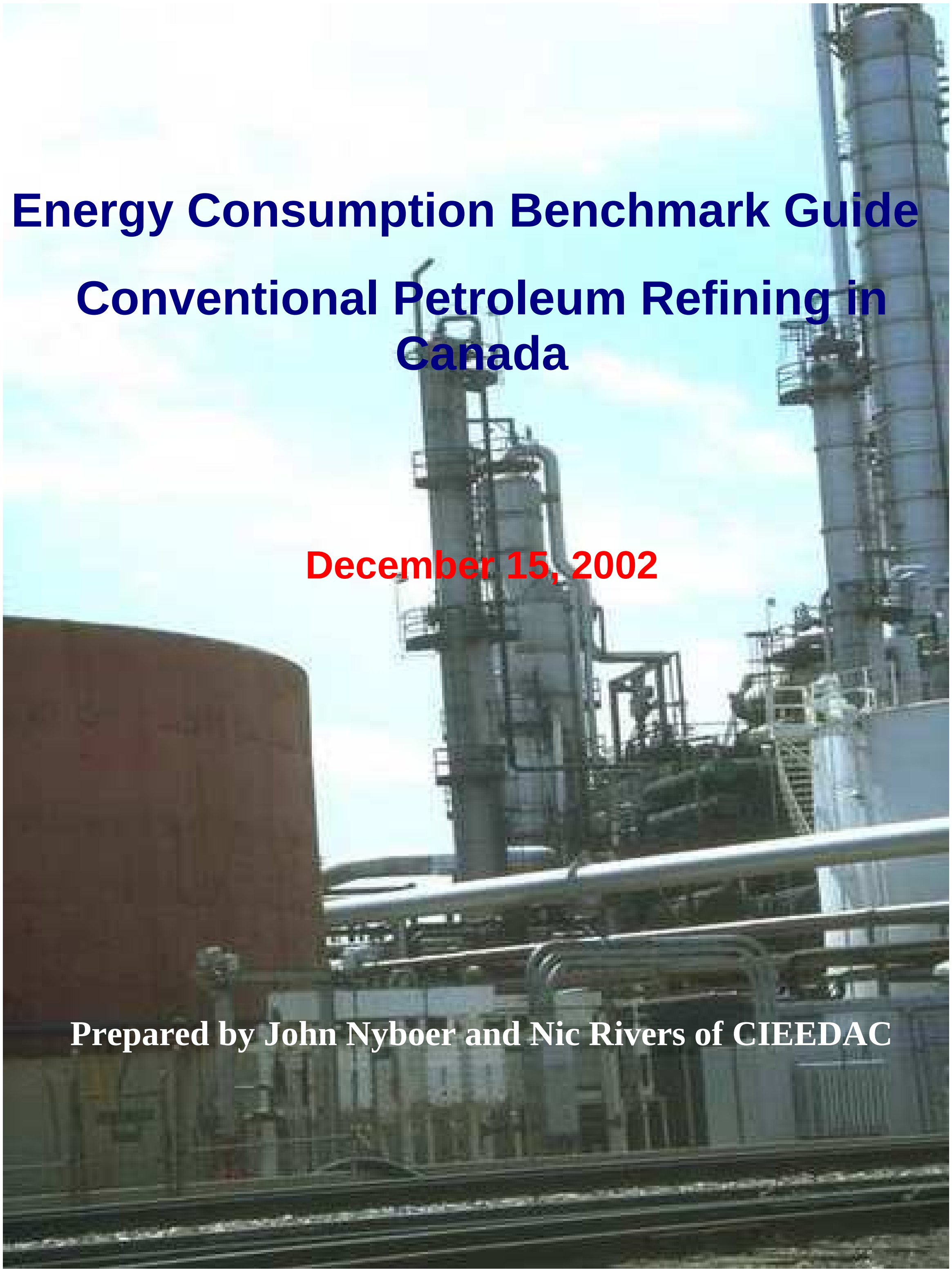

Energy Consumption Benchmark Guide

Conventional Petroleum Refining in Canada

December 15, 2002

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Natural Resources Canada | Ressources naturelles Canada

Energy Consumption Benchmark Guide:

Conventional Petroleum Refining in Canada

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Energy Consumption Benchmark Guide for Conventional Petroleum Refining in Canada

Benchmarking and the Petroleum Refining Sector

Success in the operation of a business or company depends on many factors. Efficiency in the production of one's product is one of these factors. A number of alternatives exist to drive managers and operators towards efficiency targets, one of which is to compare one's operation to others of similar type locally, regionally or internationally. Such comparisons often involve benchmarking, a tool that provides some mean or norm against which comparisons can be made. The purpose of this document is to provide such a tool where one's own refinery can be compared to others to allow the manager to make reasonable, appropriate decisions about energy use and efficiency. Thus, the objectives of this benchmarking guide are to:

- provide a summary picture of the petroleum refining industry in terms of its energy consumption and production,
- give some indication of the variation of efficiencies and intensities that exist within the industry,
- provide a benchmark comparison against which one can compare one's plant to others and
- provide some indication of a relative road to action regarding energy intensity and efficiency.

Industry Background

There are currently 21 operating petroleum refineries in Canada.[1] The industry is concentrated in Ontario and Alberta, which have 7 and 5 refineries respectively.[2] There are 3 refineries in each of British Columbia, Quebec, and the Atlantic Provinces, and a single refinery in Saskatchewan.

The total production of refined petroleum products in 2001 was about 109 million m^3. Fourteen product streams make up the mix of production, with the two dominant products being motor gasoline and diesel fuel oil at 40% and 22% of the total production by volume respectively. Figure 1 portrays production of the major refined petroleum products and the total of all products for 1990 and for 1994 to 2001. In its activity, the petroleum refining industry alone employs almost 4,000 people and generates over $18 billion in annual sales.

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[1] STC records 25 as of 1999; the numbers vary depending on the source and definitions of a refinery. Refineries can produce mostly asphalt, lubricants, or a full slate of products, produced from heavy, light or synthetic crude.

[2] In September 2001, the Parkland Refinery in Bowden, Alberta closed its doors, reducing the number of refineries in Alberta to 4. As the intensity indicators found in this report are based on 2000 data, CIEEDAC lists 22 operational refineries for that year.

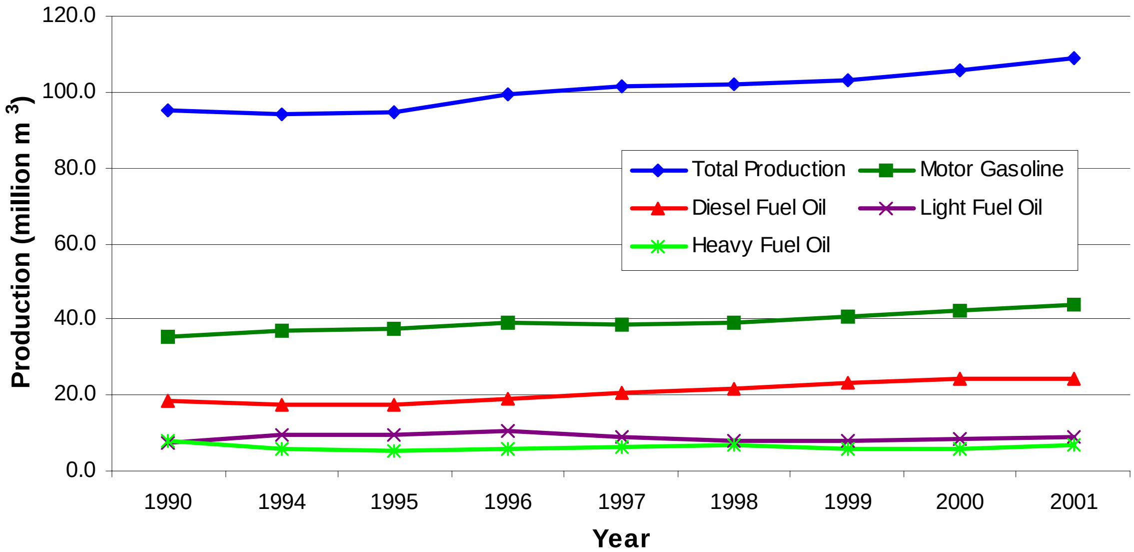

Figure 1. **Refinery Production for Specific Fuels and the Total of all production.** ***Source: STC RPP Cat No. 45-004.***

The information in this report comes from annual surveys conducted by the Canadian Industrial Energy End Use Data Analysis Centre (CIEEDAC) as well as from *Statistics Canada 45-004: Refined Petroleum Products* and *Statistics Canada 31-203: Manufacturing Industries of Canada*. The report uses a combination of publicly available and company confidential data. Canadian refiners have access to much of the presented information through Statistics Canada (STC) and their contracted participation in Solomon surveys. The information provided is useful as an element of benchmarking energy use at petroleum refineries, but inadequate for allocating emissions or energy targets for individual refineries.

Historical Energy Use Profile

Figure 2 shows the total annual energy use by the petroleum refining industry since 1990. Figure 3 shows the energy intensity of production, defined through analyses completed by Solomon Associates on many Canadian plants. Energy data used for both figures are measured in LHV (Lower Heating Value). HHV (Higher Heating Value) energy levels in the sector are about 6 to 10% higher than LHV levels.[3] In comparing 1990 data with 2001 data and observing the figures, some interesting trends appear:

- Energy consumption declined in the late 1990s from its 1990 level, but has increased in the beginning of this decade so that it is now about 3% above its 1990 level.
- Production of refined petroleum products increased throughout the period and is now 14% above the 1990 level. See figure 1 above.

[3] HHV coefficients include all the energy released upon combustion of the fuel. LHV does not include the latent heat of the water vapour (steam) generated as a result of combustion. Generally, the lower the hydrogen content of the fossil fuel, the closer the HHV and LHV coefficients. Statistics Canada and many international organizations use HHV factors to convert from physical units of a fuel to energy units. In certain industries, such as the petroleum refining industry, LHV factors are used.

- One can use these two trends to develop an energy intensity indicator. However, because processes of production are quite specific to the various plants, the type of end products generated, plant operations and the petroleum crude feedstock, we provide here a specific intensity indicator as provided by Solomon Associates as a result of their analyses of plants. This indicator, called the Solomon Energy Intensity Indicator (EII), provides a more realistic reflection of refinery energy intensities.
- CPPI member refiners made a commitment to reduce the energy intensity of production by at least 1% per year from 1995 to 2000. The commitment has been met and surpassed. Commitment to this rate of intensity reduction has now been extended to 2004.

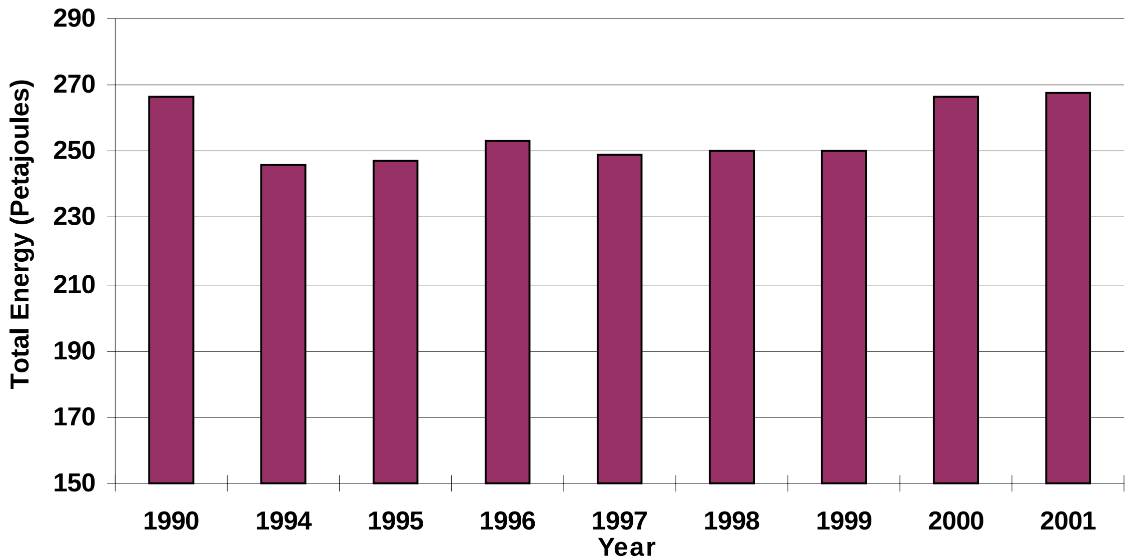

Figure 2. **Total Refinery Energy Consumption.**
Source: CIEEDAC, 2002.

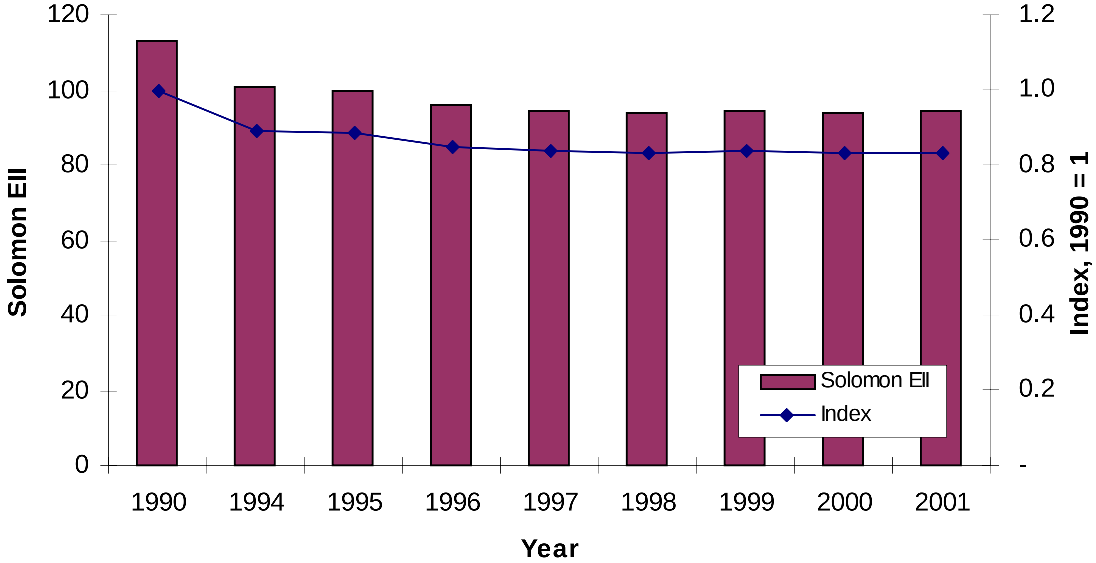

Figure 3. **Average Refinery Energy Intensity based on a composite of Solomon EII for all known refineries.**[4]

Fuel Use Trends

By comparing figure 4 with figure 5, we see that the breakdown of primary fuel use by type has not changed dramatically between 1990 and 2001. Refinery fuel gas continues to make up the largest fraction of consumption, followed by petroleum coke and natural gas. Refinery fuel gas shows the largest relative decline (5%) over the period followed by heavy fuel oil (2%). In part, coke made up for this decline, increasing its share from 18% of consumption to 22%.

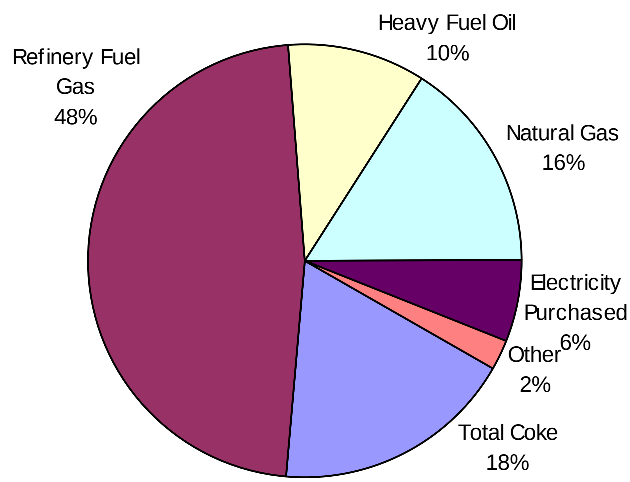

Figure 4. **Petroleum Refinery Fuel Use in 1990.**
Source: CIEEDAC, 2002.

[4] Solomon Associates also develops a confidential Canada wide indicator not available to CIEEDAC. The factors presented here are simply the weighted average of all plants that submitted data to CIEEDAC.

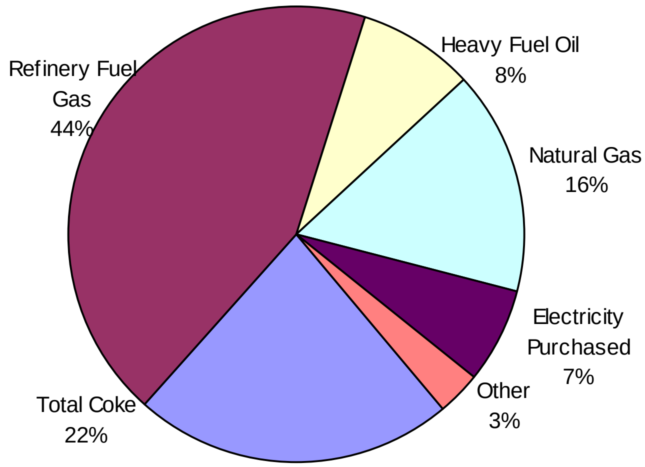

Figure 5. **Petroleum Refinery Fuel Use in 2001.**
Source: CIEEDAC, 2002.

In absolute terms, the quantity of coke consumed increased by almost 25% between 1990 and 2001 while refinery fuel gas dropped by about 8%. Purchased electricity also increased significantly over the period, by about 14%. The largest decline in fuel use was the near 19% decline in heavy fuel oil use. These trends can be observed in figure 6.

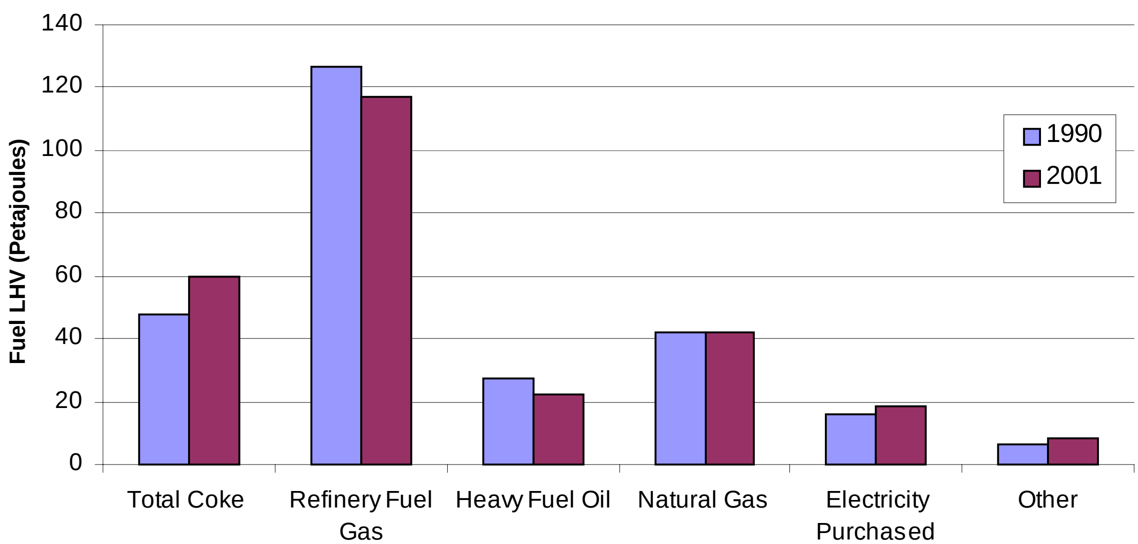

Figure 6. **Petroleum Refinery Fuel Use in 1990 and 2001.**
Source: CIEEDAC, 2002.

Benchmarking

Figure 7 shows the Solomon Energy Intensity Index (EII) for participating refineries (16 refineries participated in 2001). The Solomon EII value indexes the energy efficiency of a plant using a technology explicit computer model that determines the "standard" energy efficiency of a plant by computing standard energy consumption for each technology present in the plant and the type of crude charged to these technologies. A Solomon EII value of 100 is standard. A Solomon EII plant-specific value below 100 indicates a more efficient plant, while a value above 100 indicates a less efficient plant. In this representation, we see that 6 of Canada's plants are better by up to 22% than the Canadian average while the remainder are worse.

Note that, while the graph displays a Canadian average, this average is an estimate from the weighted averages of all operations undergoing a Solomon analysis. The actual Canadian average as determined by Solomon Associates is considered confidential; the estimate here is to be taken as indicatory rather than actual.

Many different factors can affect energy use in a plant. For example, differences in crude characterization, petroleum products generated, technology and general practices can all be significant in determining a plant's energy use. Solomon Associates' analyses of these plants take these differences into account and provide the most reliable view of the efficiencies of the various plants. Comparing the differences between the most energy efficient plants and the least efficient plants show that there probably is potential for energy efficiency improvements in many plants. Because of the importance of reduced energy consumption to both society and industry competitively and environmentally, these potential improvements deserve attention. By generating benchmarks such as these, we hope to stimulate such a review and encourage economic actions that improve energy efficiency.

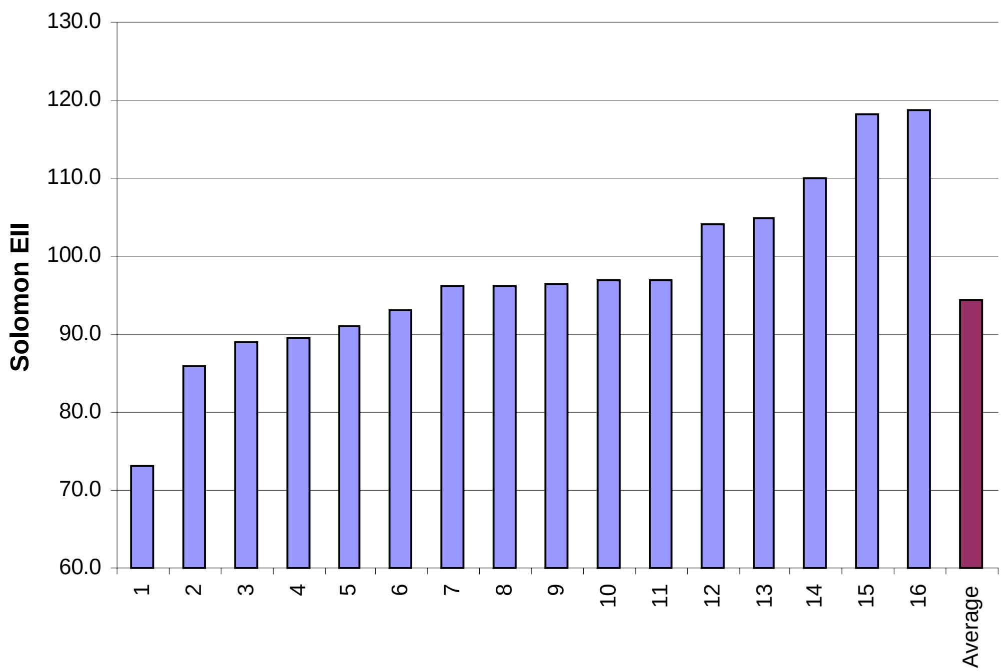

Figure 7. **Solomon Energy Intensity Index of Participating Individual Refineries.** ***Source: CIEEDAC, 2002.***

How to Benchmark Your Plant

1. Participate in a Solomon Analysis for your plant(s).
2. If your plant's EII is lower than 100, your plant's performance is better than standard. If your plant's EII is higher than 100, your plant's performance is worse than the standard.
3. Compare your plant's EII value with that of other petroleum refineries (see figure 7).
4. If the energy intensity in your plant is **equal to or better than those in the top 4** (upper quartile), your plant could be considered to be an energy use innovator. Keep it up by maintaining your energy monitoring program and excellent operating practices and continue looking for opportunities to improve your efficiency.

   If your plant energy use ranks **between 5 and 11** on the graph, your plant may need to invest more effort in determining how to improve energy use.

   If your plant energy use ranks **between 12 and 16** on the graph, your plant is not as energy efficient as your competitors' plants, for many possible reasons. An energy audit may identify areas in which plant performance could be improved.

Energy efficiency in petroleum refineries is not simply a matter of best technologies and best maintenance practices; each refinery is, in some sense, unique because both the input crudes and the mix of outputs from a plant are likely to be unique. Activities such as reviewing the processes, installing new heat recovery systems, improving upgrade and maintenance practices, and running on-site assessments or audits of energy performance can all contribute to enhance energy efficiency and potentially reduce GHG emissions. Efficiency levels may currently be structurally based, or merely be an artefact of initial installation and construction specifications. If this is the case, it is likely that such structural "inefficiencies" can be addressed only as your plant modernizes its facilities and processes.

Achievements

Petroleum refineries have recognized the value of improved energy efficiency for some time and have steadily improved their aggregate energy efficiency since 1990. This, in itself, is an indication of the degree to which the modern plant operator / manager finds improved efficiency important (see figure 2). Member refineries of the CPPI have committed to continual improvement in energy intensity by 1 percent per year through 2005. Refineries have accomplished these gains through innovative capital investments and improvements to operations.

- Petro-Canada installed a heat recovery system on a crude unit at one of its refineries to recover waste energy and reuse fuel in feed furnaces. The $750,000 project will save substantial amounts of fuel and emissions each year, in addition to saving about $250,000 per year in reduced fuel costs.

- Shell Canada Limited initiated a number of process upgrades at its facilities that improved efficiency of steam and hot water systems, vacuum pumps, furnaces, and compressors. The net effect of the upgrades was a 70,000 tonne downstream reduction in carbon dioxide emissions and a 1.7 percent improvement in energy efficiency.
- Imperial Oil Limited launched its Global Energy Management System (G-EMS) by putting its Strathcona refinery through an intensive assessment of energy usage. Twenty experts spent two months assessing on-site energy efficiency performance and preparing recommendations for improvements based on global best practices. Imperial Oil Limited plans to undergo a similar process for other refineries. This work is part of an ongoing effort by Imperial Oil Limited to seek and capture energy efficiency opportunities.