Energy Conservation Solutions
in the Upstream Oil and Gas Industry:
an Eco-Efficiency Pilot
2002 - 2005

CETAC-WEST
August, 2005
Cover map courtesy of Oilweek Magazine
August, 2005

Energy Conservation Solutions
in the Upstream Oil and Gas Industry: an Eco-Efficiency Pilot, 2002-2005

This report focuses on economic and conservation opportunities in the upstream oil and gas industry. It is the product of more than three years of dedicated effort by CETAC-WEST with a team of specialists from the service industry, and participation from the oil and gas industry, technology innovators, facilities operators, and government departments and agencies.

The report was motivated by the common desire to continuously improve the industry’s economic performance while conserving resources and the environment for the benefit of present and future generations. Adopting the measures recommended in this report will bring us much closer to meeting those objectives.

I would like to thank those who have brought us this far. We look forward to the continuation of the journey toward greater economic and environmental efficiency in the upstream oil and gas sector.

Sincerely,

Joe Lukacs
President & CEO,
CETAC-WEST
Program Sponsors

This project would not have been possible without its sponsors. In particular, we thank Alberta Energy and Deputy Minister Ken Smith, and the federal government's Technology Early Action Measures (TEAM) Program and Wayne Richardson, Director of the TEAM Operations Office, whose support enabled CETAC-WEST to develop and implement the project.

TEAM
Alberta Energy
Western Economic Diversification
Natural Resources Canada - Office of Energy Efficiency
Alberta Environment
Environment Canada
Program Participants

The success of this project is due to the willing participation of several key players from the upstream oil and gas industry and the service industry. CETAC-WEST thanks them for their participation in the project.

### Industry Participants: Audited and Benchmarked Facilities

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP Canada Energy Company/ATCO Midstream Ltd.</td>
<td>West Pembina Gas Plant</td>
</tr>
<tr>
<td>Husky Energy Inc.</td>
<td>Alliance Oil Battery, Kakwa Gas Plant, Lloyd Terminal,</td>
</tr>
<tr>
<td></td>
<td>Northend Battery, Rainbow Lake Processing Plant,</td>
</tr>
<tr>
<td></td>
<td>Ram River Gas Plant, Pikes Peak EOR Project, Slave</td>
</tr>
<tr>
<td></td>
<td>Oil and Gas Facility, Tangleflags Heavy Oil Battery</td>
</tr>
<tr>
<td>Northrock Resources Ltd.</td>
<td>Bilbo Compressor Plant, Carrot Creek Gas Plant,</td>
</tr>
<tr>
<td></td>
<td>Red Rock Plant, Wolf Creek Plant</td>
</tr>
<tr>
<td>Keyera Facilities Income Fund</td>
<td>Nordegg River Gas Plant, Rimbey Gas Plant</td>
</tr>
<tr>
<td>Nexen Canada Ltd.</td>
<td>Balzac Gas Plant</td>
</tr>
<tr>
<td>PetroCanada</td>
<td>Brazeau River Gas Plant, Ferrier Gas Plant, Hanlan Gas,</td>
</tr>
<tr>
<td></td>
<td>Plant, Wildcat Hills Gas Plant</td>
</tr>
<tr>
<td>Talisman Energy Inc.</td>
<td>Edson Gas Plant</td>
</tr>
<tr>
<td>Shell Canada Limited</td>
<td>Caroline Gas Plant, Waterton Gas Plant</td>
</tr>
</tbody>
</table>

### Service Industry: Audit Team, Technology Demonstration Participants, Alliances

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amine Experts Inc.</td>
<td>New Paradigm Engineering</td>
</tr>
<tr>
<td>Berlie Consulting Services</td>
<td>New Paradigm Gas Processing</td>
</tr>
<tr>
<td>MJ Blair Corporation</td>
<td>Norwest Corporation</td>
</tr>
<tr>
<td>Clearstone Engineering Ltd.</td>
<td>On Site Energy Corp</td>
</tr>
<tr>
<td>DGC Consulting Ltd.</td>
<td>Optimax Energy</td>
</tr>
<tr>
<td>DS Prince Consulting Ltd.</td>
<td>PTAC</td>
</tr>
<tr>
<td>Enefen Ltd.</td>
<td>Power Optimization</td>
</tr>
<tr>
<td>Gartner Lee Limited</td>
<td>Public Safety &amp; Air Quality Management</td>
</tr>
<tr>
<td>N.C. Hircock Process Consulting</td>
<td>RCL Environment Group</td>
</tr>
<tr>
<td>REM Technology</td>
<td></td>
</tr>
<tr>
<td>Saybry Inc.</td>
<td></td>
</tr>
<tr>
<td>Sensor Environmental Services Ltd.</td>
<td></td>
</tr>
<tr>
<td>Sirius Products Ltd.</td>
<td></td>
</tr>
<tr>
<td>Stantec Consulting Ltd.</td>
<td></td>
</tr>
<tr>
<td>Steelhead Reclamation Ltd.</td>
<td></td>
</tr>
<tr>
<td>Sulphur Experts Inc.</td>
<td></td>
</tr>
<tr>
<td>Synchron Automation Inc.</td>
<td></td>
</tr>
<tr>
<td>Trican Well Services Inc.</td>
<td></td>
</tr>
</tbody>
</table>

### Industry Advisory Panel

- Skip Desaulniers/Bryan Forsyth - BP Canada Energy
- Fred Ismailian/Jan Rasmussen/Phil Croteau - PetroCanada
- Bob Morrish - Keyera Facilities
- Roy Kanten - Shell Canada Limited
- Orest Kotelko - Canadian Natural Resources Ltd.
- Barbara Bryden - Husky Energy Inc.
- Peter Dickey - Consultant
- John Squarek - Canadian Association of Petroleum Producers
- Blaine Lee - Leemartin Associates Ltd.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Findings</td>
<td>i</td>
</tr>
<tr>
<td>Program Overview</td>
<td>1</td>
</tr>
<tr>
<td>Integrated Audits - Upstream Oil &amp; Gas Facilities</td>
<td></td>
</tr>
<tr>
<td>1.1 Purpose and Objective</td>
<td>7</td>
</tr>
<tr>
<td>1.2 Identified Energy Savings</td>
<td>7</td>
</tr>
<tr>
<td>1.3 Program Design</td>
<td>8</td>
</tr>
<tr>
<td>1.4 Audit Results</td>
<td>11</td>
</tr>
<tr>
<td>1.5 Confirming Audits</td>
<td>15</td>
</tr>
<tr>
<td>1.6 Potential Future Industry Savings Extrapolated</td>
<td>16</td>
</tr>
<tr>
<td>1.7 Observations and Comments</td>
<td>17</td>
</tr>
<tr>
<td>1.8 Integrated Audits: Going Forward</td>
<td>18</td>
</tr>
<tr>
<td>Benchmarking</td>
<td></td>
</tr>
<tr>
<td>2.1 Purpose and Objective</td>
<td>23</td>
</tr>
<tr>
<td>2.2 Key Performance Indicators</td>
<td>24</td>
</tr>
<tr>
<td>2.3 UOG Benchmarking Clusters</td>
<td>26</td>
</tr>
<tr>
<td>2.4 Process Unit Optimization “Best Practices”</td>
<td>28</td>
</tr>
<tr>
<td>2.5 Benchmarking Program: Going Forward</td>
<td>32</td>
</tr>
<tr>
<td>New Technology Demonstrations</td>
<td></td>
</tr>
<tr>
<td>3.1 Purpose and Objective</td>
<td>37</td>
</tr>
<tr>
<td>3.2 FLEXSEAL Demonstration Project</td>
<td>37</td>
</tr>
<tr>
<td>3.3 Oil and Gas Facility Technologies</td>
<td>38</td>
</tr>
<tr>
<td>3.4 Completed and Validated Technology Demonstrations</td>
<td>40</td>
</tr>
<tr>
<td>3.5 Summary of Confirmed Savings</td>
<td>43</td>
</tr>
<tr>
<td>3.6 New Technology Demonstrations: Going Forward</td>
<td>46</td>
</tr>
<tr>
<td>Industry Rollout and Technology Transfer</td>
<td></td>
</tr>
<tr>
<td>4.1 Purpose and Objective</td>
<td>51</td>
</tr>
<tr>
<td>4.2 Initiatives and Outcomes</td>
<td>51</td>
</tr>
<tr>
<td>4.3 Energy Efficiency Workshops</td>
<td>52</td>
</tr>
<tr>
<td>4.4 Technical Papers and Presentations</td>
<td>55</td>
</tr>
<tr>
<td>4.5 Articles, Publications and Website</td>
<td>56</td>
</tr>
<tr>
<td>4.6 Other Activities</td>
<td>57</td>
</tr>
<tr>
<td>4.7 Rollout: Going Forward</td>
<td>58</td>
</tr>
<tr>
<td>Appendices</td>
<td></td>
</tr>
<tr>
<td>Appendix 1: Audit Results</td>
<td></td>
</tr>
<tr>
<td>Appendix 2: Benchmarking Results</td>
<td></td>
</tr>
<tr>
<td>Appendix 3: Workshop Tabloid</td>
<td></td>
</tr>
</tbody>
</table>
CETAC-WEST, in cooperation with government agencies, the oil and gas industry, the service sector and technical experts, has led an Energy and Environmental Efficiency (Eco-Efficiency) Pilot Program focused on achieving continuous improvement in the upstream oil and gas industry. The Eco-Efficiency Pilot Program confirmed that:

**Energy Conservation is Good Business:**

Even on a pilot basis, the program has been cost effective for both the program funders and participating companies. The program demonstrated that economic efficiency and environmental improvements can go hand-in-hand. The Eco-Efficiency Pilot enabled the industry to identify and realize significant opportunities for energy and fuel gas conservation in the upstream oil and gas sector.

**Large Economic Benefits:**

If the energy savings identified in the 17 audited facilities were extended to all upstream facilities throughout Alberta, the total estimated savings could add up to $500 million annually, or about 15 per cent of energy currently consumed in processing and transporting the oil and gas.

**The Environment Benefits:**

As an added bonus and as a byproduct, the recommended fuel conservation would result in an annual reduction of four to six million tonnes of CO$_2$ that is now released to the atmosphere.

**Environmental Technologies Help Business:**

The Pilot Program demonstrated how existing innovative technologies can provide broad-ranging beneficial and cost-effective improvements for the industry. Strong prices for oil and gas and renewed environmental priorities create a strong economic case for industry to invest in such technology.
Everybody Wins:
When implemented, such fuel-gas savings will benefit:

- The producing companies and their shareholders, who will retain more gas for sale;
- The service sector, which will develop additional expertise and tools to grow such businesses locally and internationally;
- The public and government, who will benefit from royalties on additional volumes available for sale as a result of reduced use of the resource as fuel gas.

Going Forward

Although progress on industry adoption has been restrained, after three years, the Pilot Program has delivered documented evidence of significant opportunities to make operational improvements in upstream oil and gas facilities. Such improvements make good economic sense and, as an added bonus, would reduce harmful environmental emissions. However, it has been acknowledged that the Eco-Efficiency Program challenges a number of long-held values and traditional operating practices. Its greater adoption will require fundamental shifts in thinking by much of the industry and by government personnel. Building on the program's success to date, as a minimum, additional effort will be required on the following fronts:

Communication:

An important element of the program has been the communication and promotion to industry and government of the economic and environmental benefits of conservation-minded practices. The keystone of these communications efforts has been the presentation and hosting of four “Energy Efficiency” Workshops. The most recent workshop took place in March 2005 with some 80 participants from the upstream oil and gas industry, industry associations, the service sector and governments. The workshops have proven their value and should be continued in order to further encourage industry to adopt the principles and improvements demonstrated by the Eco-Efficiency Program.
Regulatory Measures:

At the 2005 workshop, a strong message emerged that the introduction of the eco-efficiency practice and innovative technologies would benefit from a regulatory nudge. This regulatory prod could come via a voluntary challenge encouraging industry to implement fuel-gas savings, while backstopping that challenge with regulations that would take effect if those efforts fall short. The Alberta Energy and Utilities Board already successfully employed a similar strategy to dramatically reduce solution gas flaring and venting in Alberta.

Cooperative Action:

CETAC-WEST contends that until the government and industry realize the potentially significant economic and environmental benefits of greater efficiencies in the upstream oil and gas sector, the Eco-Efficiency Program momentum needs to be maintained and field demonstration of improvement opportunities continued. Therefore, CETAC-WEST recommends:

- promotion of additional audits in all sectors of the Upstream Oil & Gas Industry;
- undertaking a more in-depth analysis of field operations and small plants; and
- assessing the nature and extent of regulatory “encouragement” that would be required.

the Eco-Efficiency Program needs to maintain its momentum and continue to demonstrate improvement opportunities. For this to happen, industry and government cooperation and support are essential.
Program Overview

In mid-2000, CETAC-WEST identified conditions in Alberta's oil and gas industry from which it concluded that a unique opportunity existed for the industry, governments and the public to realize significant benefits from the application of principles of eco-efficiency. Based on those conditions, CETAC-WEST postulated that the industry could significantly increase its productivity by becoming more efficient, thereby increasing revenue generation while reducing waste. After delivering its Eco-Efficiency Pilot Program for three years, CETAC-WEST has confirmed that such opportunities exist. However, it will take additional work and leadership by governments and industry to realize the promising potential benefits.

Original Need for the Eco-Efficiency Program

Driven by increasing growth in worldwide energy demand in 2000, Alberta's oil and gas industry faced the following conditions.

- The need for expanded processing or acid gas reinjection capacity.
- Pressure on plant operations to produce more oil and natural gas due to high oil and gas prices.
- The increased activity placing pressure on the environment and raising concern among the public, which was becoming increasingly vocal and demanding of restraints.
- Awareness that voluntary initiatives alone would not be expected to be sufficient to achieve significant action and reinvestment by industry. It was anticipated that leadership from governments would be required through implementation of incentives and regulatory programs.
- Aware of the increased profits realized by industry, the public was questioning how some of this wealth should be invested for the benefit of the environment and society.

In view of these issues, CETAC-WEST suggested action was needed from regulatory bodies to achieve a balancing of interests.

Given the combination of high throughput, high energy prices and high profits, CETAC-WEST proposed that a project to increase efficiencies in the upstream oil and gas (UOG) industry would be timely. Based on eco-efficiency principles developed by the World Business Council for Sustainable Development, CETAC-WEST’s vision was to demonstrate to the UOG industry the benefits of eco-efficiency. CETAC-WEST would accomplish this through a pilot program that identified key areas of process improvement potential and opportunities to demonstrate innovative and more efficient energy and emissions reduction technologies and practices.
Objectives

The spirit of the Eco-Efficiency Program was articulated in the following five major objectives:

• To demonstrate the application of the eco-efficiency concept to the UOG industry, and to government and regulatory agencies, such as Alberta Energy, Alberta Environment, Environment Canada and Natural Resources Canada.

• To identify practical emissions reduction opportunities through increasing process efficiencies as identified in energy and environmental audits at six or more of the large natural gas processing plants.

• To establish a baseline for continuous improvement in the operating plants audited, as well as more broadly in the UOG industry.

• To introduce a practical set of Key Performance Indicators (KPI's) that could be used by plant operating personnel to identify and prioritize areas of operational improvements.

• To identify and demonstrate innovative technologies that would improve plant performance and also reduce harmful GHG environmental emissions.

Pilot Program Plan

The Pilot Program for the upstream oil and gas industry was designed to include four distinct phases:

i. Pilot Integrated Audits
ii. Benchmarking
iii. New Technology Demonstrations
iv. Industry Rollout and Technology Transfer

These four phases were carried out simultaneously. Information and experience gained from each of the phases were utilized in the other areas, enhancing the overall results. Each phase played an important part in the overall design of the program, as described below:

Opportunity Identification – the foundational phase, to identify efficiency improvement opportunities via comprehensive “Integrated Audits” of oil and gas operations.

Performance Benchmarking – the creation of a system of benchmarking for the upstream oil and gas industry to measure improvements and to evaluate energy and emissions performance intra- and inter-industry.
Technology Demonstrations – the matching of feasible solutions to priority needs identified in the audits and the testing and validating, in the field, of the most promising technologies/processes.

Industry Rollout and Uptake – the continuous building of awareness, promotion and education in the oil and gas industry, aimed at fundamental changes in culture and operating practices to facilitate acceptance and adoption of the improved technologies/processes.

Current Situation

Five years after originally identifying the need for its Eco-Efficiency Program in Alberta’s upstream oil and gas industry, CETAC-WEST maintains that need is ongoing, and is in fact event greater now. The conditions articulated in its original proposal in 2000 not only continue to exist, but an unceasing increase in worldwide demand has put even greater pressure on the industry. Consequently the urgency of the conditions that existed in 2000 has increased in magnitude, and the need for the industry to increase operating efficiency has become even more critical.

Timing

The Eco-Efficiency Program was launched officially in October 2001 with funding from Alberta Energy. Full implementation of all four phases commenced on April 1, 2002, when the necessary funding commitments were secured from the provincial and federal governments, and industry. The diagram below depicts the evolution and timing of the ongoing activities, and reflects CETAC-WEST’s commitment to continue the program.
Integrated Audits
Upstream Oil & Gas Facilities

Energy

Product Streams
- Sales Gas
- HC Liquids
- Sulphur
- By-products

Feedstock
HCs, \( \text{H}_2\text{S}, \text{CO}_2 \)

Residual
- Emissions
- Liquids
- Solid Waste
- Heat Losses
- \( \text{CO}_2, \text{H}_2\text{O} \)
1.1 Purpose and Objective

The development of the integrated audit process, carried out by a multi-disciplinary team of leading experts carefully chosen by CETAC-WEST, was the first phase and a very important aspect of the Eco-Efficiency Program. The purpose of this program component was to identify energy and environmental efficiency improvement opportunities in upstream oil and gas (UOG) facilities through the application of a multi-disciplinary and integrated energy and environmental operational assessment.

The objective of the program, at the outset, was to perform audits on six large sour gas plants. Ultimately, through prudent and leveraged use of resources, the program far exceeded this target and conducted 17 audits over the duration of the project.

1.2 Identified Energy Savings

The Integrated Audit project identified potential annual fuel and electrical cost savings for the audited facilities, of more than $14 million. This is approximately 12% of the facilities' current total fuel and electricity expenditures. The current usage and opportunities for improvement are displayed in Table 1.1.

<table>
<thead>
<tr>
<th>Energy (MW)</th>
<th>Value (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Gas Usage</td>
<td>544</td>
</tr>
<tr>
<td>Potential Fuel Gas</td>
<td></td>
</tr>
<tr>
<td>Savings</td>
<td>70</td>
</tr>
<tr>
<td>Electrical Usage</td>
<td>62</td>
</tr>
<tr>
<td>Potential Electrical</td>
<td></td>
</tr>
<tr>
<td>Savings</td>
<td>6</td>
</tr>
<tr>
<td>Total Energy Usage</td>
<td>606</td>
</tr>
<tr>
<td>Total Savings</td>
<td>76</td>
</tr>
<tr>
<td>Savings as % of Total</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.1 Identified Energy Savings for 17 UOG Facilities

Note that energy costs of $5.25/GJ for fuel gas and $60/MWh were used in determining all potential savings presented in this section.
1.3 Program Design

The audit program was designed to be an innovative service for the upstream oil and gas industry to help facilities achieve an overall baseline analysis of the efficiency and environmental performance.

The concept of integration with all experts conducting their diagnostic assessments at the facility concurrently was a key aspect of the audits, and truly defined its innovativeness. This allowed for team interaction and opportunity building in those instances where a potential prospect for energy saving drew on the expertise of two or more of the team members. Furthermore, participating company technical service personnel were always involved in the on-site activities. This allowed them to gain more exposure to the audit process and the potential savings opportunities it provided.

---

**The “Integrated” Audit**

A concurrent examination by a multi-disciplinary team of leading industry experts, to seek out economic and environmental improvements.

Another key concept of the program was the break down of gas processing plants into identifiable process blocks that could be treated separately for optimization and then integrated using the insight of the multi-disciplinary team. Upstream oil and gas production facilities are diverse and comprise several unit operations shown in Figure 1.1.
The audit program was designed to be an innovative service for the upstream oil and gas industry to help facilities achieve an overall baseline analysis of the efficiency and environmental performance. The concept of integration with all experts conducting their diagnostic assessments at the facility concurrently was a key aspect of the audits, and truly defined its innovativeness. This allowed for team interaction and opportunity building in those instances where a potential prospect for energy saving drew on the expertise of two or more of the team members. Furthermore, participating company technical service personnel were always involved in the on-site activities. This allowed them to gain more exposure to the audit process and the potential savings opportunities it provided.

Another key concept of the program was the breakdown of gas processing plants into identifiable process blocks that could be treated separately for optimization and then integrated using the insight of the multi-disciplinary team. Upstream oil and gas production facilities are diverse and comprise several unit operations shown in Figure 1.1.
1.3.1 Audit Team

Expertise required for each audit was based on the type of facility, the level of expertise required and the scope of work. Individual audit teams were drawn from companies that specialize in the provision of services to the oil and gas industry. Table 1.2 lists team members and their role in the audits.

**Table 1.2 Audit Team**

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Specialty</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCL Environment Group Ltd.</td>
<td>Sour Gas Sweetening and Optimization, Plant Gas Dehydration</td>
</tr>
<tr>
<td>PROCESS CONSULTING LTD.</td>
<td>Refrigeration and Heat Exchange, Rotating Equipment and Compression</td>
</tr>
<tr>
<td>Sulphur eXperts</td>
<td>Sulphur Recovery and Process Optimization, Incineration</td>
</tr>
<tr>
<td>Stantec</td>
<td>Heat Exchangers and Utilities, Electrical Analysis</td>
</tr>
<tr>
<td>CLEARSTONE ENGINEERING LTD.</td>
<td>Fugitive Emissions, Combustion and Utilities</td>
</tr>
<tr>
<td>Power Optimization Ltd.</td>
<td>Field Power Consumption and Optimization, Utilities and Steam Generation</td>
</tr>
<tr>
<td>DGC Consulting</td>
<td>Audit Coordination and Reporting</td>
</tr>
<tr>
<td>NORWEST CORPORATION</td>
<td>Project Administration</td>
</tr>
</tbody>
</table>

All of the team-member companies commenced operations in Alberta in response to the need for specialized engineering and field services in the UOG sector. In this sense, they represent homegrown talent. These companies have developed special expertise and achieved industry-wide recognition and now deliver a range of products and services to clients in the oil and gas industry worldwide.

The service sector historically has been and continues to be an innovative and technological storehouse for the UOG. This is even more important today with the considerable decline in in-house resources and the entry of many small producing and processing companies that simply do not have the expertise to identify and implement energy-saving opportunities. The competence of the service sector is especially apparent in the development of new methods and technologies. The audit program showed the service sector’s willingness to invest considerable effort in demonstrating the positive economic and environmental impacts that can be derived by a fresh look at how operations are conducted.

**Table 1.3 Audit Clusters**

<table>
<thead>
<tr>
<th>Cluster Type</th>
<th>Number of Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sour Gas</td>
<td>6</td>
</tr>
<tr>
<td>Sweet Gas</td>
<td>1</td>
</tr>
<tr>
<td>Conventional O&amp;G</td>
<td>6</td>
</tr>
<tr>
<td>Heavy Oil</td>
<td>4</td>
</tr>
</tbody>
</table>
All of the team-member companies commenced operations in Alberta in response to the need for specialized engineering and field services in the UOG sector. In this sense, they represent homegrown talent. These companies have developed special expertise and achieved industry-wide recognition and now deliver a range of products and services to clients in the oil and gas industry worldwide.

The service sector historically has been and continues to be an innovative and technological storehouse for the UOG. This is even more important today with the considerable decline in in-house resources and the entry of many small producing and processing companies that simply do not have the expertise to identify and implement energy-saving opportunities. The competence of the service sector is especially apparent in the development of new methods and technologies. The audit program showed the service sector's willingness to invest considerable effort in demonstrating the positive economic and environmental impacts that can be derived by a fresh look at how operations are conducted.

1.4 Audit Results

Over the course of the project, a total of 17 audits were completed. The breakdown by production type is shown in Table 1.3.

<table>
<thead>
<tr>
<th>Cluster Type</th>
<th>Sour Gas</th>
<th>Sweet Gas</th>
<th>Conventional O&amp;G</th>
<th>Heavy Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Plants</td>
<td>6</td>
<td>1</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>
A total of 191 opportunities for energy savings were identified. A breakdown of these opportunities by type and occurrence is listed in Table 1.4.

<table>
<thead>
<tr>
<th>Opportunity Area</th>
<th>Opportunity Type</th>
<th>Opportunities Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment &amp; Individual Unit Operations</td>
<td>Heat Exchangers and Coolers</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Compressors</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Pumps</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Field Equipment</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Sub-total</td>
<td>85</td>
</tr>
<tr>
<td>Process Unit Operations</td>
<td>Inlet</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Amine System</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Refrigeration</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Sulphur Recovery</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Dehydration</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Sub-total</td>
<td>42</td>
</tr>
<tr>
<td>Fugitive Emissions</td>
<td>Component Leaks</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Sub-total</td>
<td>31</td>
</tr>
<tr>
<td>Strategic Issues</td>
<td>Control Targets</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Operational Options</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Sub-total</td>
<td>19</td>
</tr>
<tr>
<td>Electrical</td>
<td>Various</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Sub-total</td>
<td>14</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>191</td>
</tr>
</tbody>
</table>
Figure 1.2 is a graphical representation of the number of opportunities identified by type of equipment and process units and other operational functions.

**Figure 1.2  Audit Opportunities by Area**

![Audit Opportunities by Area](image)

**Audited Plant Savings Opportunities** shown in Figure 1.3 demonstrate the opportunities for energy and CO₂E savings for each facility, displayed as a percentage of the overall fuel gas and electric power costs.

The diagram shows that as plants get larger, the percentage of potential energy savings decreases. This is in part due to a greater number of resources allocated to these larger facilities for the day-to-day operations; there tends to be more staff on site. Despite the lower percentage of opportunities, because the magnitude of overall energy costs is greater, there are significant savings opportunities for large plants. Small plants and field operations, by their sheer number also present an opportunity to achieve significant energy savings but these are often neglected due to the relatively small magnitude of individual opportunities.

Opportunities in field activities are being aggressively pursued by a number of niche service sector companies, such as Power Optimization Ltd., which has developed software that quickly identifies abnormal power consumption patterns for motors on pumpjacks, pumps and compressors. Already this examination of electrical consumption has proved to enable electrical savings of more than 20%.
1.4.1 Audit Schedule

Table 1.5 summarizes the typical audit schedule and the activity time requirements. Generally, audits took two to four months to complete.

### Table 1.5 Typical Audit Activities and Time Requirements

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope and Expertise Selection</td>
<td>1-2 weeks</td>
</tr>
<tr>
<td>Budget Development and Approval</td>
<td>4-6 weeks</td>
</tr>
<tr>
<td>Scheduling of Fieldwork</td>
<td>4-8 weeks</td>
</tr>
<tr>
<td>Data Collection and Field Preparation</td>
<td>2-4 weeks</td>
</tr>
<tr>
<td>Fieldwork</td>
<td>1-5 days</td>
</tr>
<tr>
<td>Field Debriefing</td>
<td>1-4 hours</td>
</tr>
<tr>
<td>Report Preparation</td>
<td>4-8 weeks</td>
</tr>
<tr>
<td>Report Presentation and Final Debriefing</td>
<td>1-4 hours</td>
</tr>
<tr>
<td>Follow-up Support</td>
<td>as required</td>
</tr>
</tbody>
</table>

Additional details of the audit design and implementation are provided in Appendix A1.
1.4.2 Greenhouse Gas Emissions Reductions

The potential carbon dioxide equivalent (CO$_2$E) reductions identified in the audits were also evaluated as part of the audit reporting process. Table 1.6 shows the current emissions, including formation CO$_2$, of the first 16 facilities audited. It was estimated that if all the changes recommended were implemented in audited facilities, an overall reduction of approximately 241,000 tonnes CO$_2$E/year could be achieved and would represent a 9% reduction in the overall emissions (including formation CO$_2$) for these facilities, based on current operations of those 16 plants.

<table>
<thead>
<tr>
<th>Current Emissions</th>
<th>Potential Reductions</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tonnes CO$_2$E/y (16 facilities)</td>
<td>Tonnes CO$_2$E/yr</td>
<td></td>
</tr>
<tr>
<td>2,688,268 *</td>
<td>241,606</td>
<td>9.0%</td>
</tr>
</tbody>
</table>

* Includes formation CO$_2$

It should be noted that if formation CO$_2$ is excluded from these numbers, the CO$_2$ reduction, on a percentage basis, would equal or exceed the potential fuel gas savings of 12.5% shown in Table 1.1.

1.5 Confirming Audits

In order to accurately evaluate and quantify the uptake of recommendations and achieved savings from the pilot audit program, a Confirming Audit program was conducted for eight facilities that had participated in the Integrated Audit program. This process allowed for a third-party verification of audit results, rather than relying on “self-reporting” of results from the facility staff, which was originally how the audit confirmations were conducted.

For each confirming audit, a select team of the original process specialists returned to the plant and re-tested some of the original opportunities identified to quantify the actual savings achieved. At these eight plants, 34% of the original opportunities were re-audited. In total, 44% of the dollar value predicted in the audits had been achieved at the time of the re-audit. The results are presented in Table 1.7.
### Table 1.7 Results for the Eight UOG Facility Confirming Audit Program

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Value</th>
<th>CO₂E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Re - Audited Potential (savings originally identified)</td>
<td>3834 m³/h, 995 kW, $8.94 million/y, 154.4 kt/y</td>
<td></td>
</tr>
<tr>
<td>Total Realized (Actual)</td>
<td>1536 m³/h, 806 kW, $3.94 million/y, 69.3 kt/y</td>
<td></td>
</tr>
<tr>
<td>Percentage of Re-Audit Items Realized</td>
<td>40%, 81%, 44%, 45%</td>
<td></td>
</tr>
</tbody>
</table>

*Based on costs of $5.25/GJ and $60/MWh*

On the basis of the actual savings realized at the eight re-audited facilities, it is projected that annual fuel gas savings at the 17 facilities audited are $5.1 million.

### 1.6 Potential Future Industry Savings Extrapolated

The annual fuel gas usage for Alberta's natural gas processing industry has been estimated by the AEUB as $3.4 billion dollars in 2003 with an average fuel price of $5.25/GJ. Based on the results from these audits, a reduction of 15% in consumption is possible through efficiency improvements and if the potential savings are extrapolated to industry as a whole, the fuel gas savings would be over $500 million per year. It should be recognized that projections based upon such a small sample should be viewed with caution. To improve the quality of such estimates, a larger data set covering more facilities and clusters is required.

An added benefit to this reduction would be the related reduction in emissions. The yearly CO₂E savings for Alberta would be in the range of 5.2 mega-tonnes, as shown in Table 1.8.
### Table 1.8  Potential Savings Extrapolated

<table>
<thead>
<tr>
<th></th>
<th>Annual Industry Consumption</th>
<th>Annual Potential Savings – Extrapolated to Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel Gas</strong></td>
<td>$3.4 billion</td>
<td>$500 million</td>
</tr>
<tr>
<td><strong>CO₂E Emissions</strong></td>
<td>35.2 Mt</td>
<td>5.2 Mt</td>
</tr>
</tbody>
</table>

### 1.7 Observations and Comments

Based upon the audit work completed, it is evident that a number of elements recur in each facility and accordingly, the solutions identified are likely to be applicable in a large number of the gas processing plants and UOG facilities in Alberta. Examples of this are tail gas incineration optimization, reconfiguring amine system piping and coolers, and improvements to refrigeration systems used in the separation of natural gas liquids.

Uptake of the recommendations generated by the integrated audits varied by facility and the type of recommendation.

In some instances, the facility being audited took immediate action to initiate improvements occasionally, even while the audit was still in progress. However, the most significant gains identified tend to require longer lead-times to undertake and are not likely to be completed for a year or more after the audit. Some of the recommendations can only be implemented during plant shutdown, which is typically scheduled on a four-year cycle. It should also be noted that some of the recommendations require the participation of regulatory agencies to modify operating approvals or to modify controlled process set points within existing approvals, which means a longer lead time to implement any changes. In most cases, facilities have requested members of the audit team to undertake in-depth investigations and detailed engineering related to certain recommendations contained in the audits.

Given the novelty of the pilot project, and the lack of any regulatory requirement to undertake any action, it is very encouraging to see the level of uptake achieved and the tangible benefits that have been recorded. Moreover, this project has aroused considerable interest at the plant operating level and clearly shows that, given the tools, field staff will embrace the concept of eco-efficiency. Eco-Efficiency audits identify a set of opportunities to make improvements. They stimulate industry to explore and generate new and better operating practices.
1.8 Integrated Audits: Going Forward

Enlarging the Picture

Integrated Audits can and do work. Because of the promising feedback and results from the first phase of the Integrated Audit Program, CETAC-WEST is continuing to encourage industry to take up the cause for the environmental stewardship and the economic gain associated with the program.

By parlaying a program that originally envisioned conducting integrated energy audits on six upstream oil and gas facilities, into one that allowed 17 such audits to be conducted, the Eco-Efficiency Program has already surpassed expectations. However, in the overall context of the upstream oil and gas sector, audits to date represent a relatively small “bite.” It would be advantageous if other individual facilities were able to reap the energy savings by having similar energy audits. Furthermore, a larger sample of audits would provide a better “handle” for extrapolating the audit results to the wider industry.

The pilot program has clearly demonstrated the existence and magnitude of energy savings opportunities in the UOG sector. It is important to seize the initiative and to build on this foundation. In order to encourage industry and government to exploit the opportunities presented, the following actions are recommended:

- promote additional audits to ensure that potential energy savings and projections are statistically relevant;
- undertake a more in-depth analysis of field operations and small plants to examine the opportunities and barriers to implementing improvements, and
- assess the nature and extent of regulatory “encouragement” that would help to overcome some of the ingrained operating practices and industry reluctance to embrace energy savings opportunities.

The audits initially were intended to identify energy efficiency opportunities in individual facilities but they have been called upon to make industry-wide projections. While results of individual audits can be assigned a high level of confidence, the small sample number and the absence of audits in some facility types necessarily reduces the confidence that can be ascribed to industry-wide projections. For this reason alone, there is a compelling need to conduct more audits and to gather more comprehensive data.
CETAC-WEST has examined the energy consumption and energy intensity on a sector or cluster basis throughout the UOG industry and from this has concluded that, an additional 34 audits should be completed in the following sectors:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sour Gas Facilities with ( \text{H}_2\text{S} ) Flaring</td>
<td>6</td>
</tr>
<tr>
<td>Large Compressor Stations</td>
<td>6</td>
</tr>
<tr>
<td>Straddle Plants</td>
<td>2</td>
</tr>
<tr>
<td>Medium and Large Sweet Gas Processing Plants</td>
<td>10</td>
</tr>
<tr>
<td>Various Field Facilities (heaters, separators, dehydrators)</td>
<td>10</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>34</strong></td>
</tr>
</tbody>
</table>

At the conclusion of this program, sufficient information should be available from all sectors of the UOG industry to establish industry benchmarks and to provide a much better basis on which to make industry-wide energy savings projections.

The cost of these audits, including project management, is estimated to be $3.5 million spread over three years. Based upon past experience and potential benefit to operators of audited facilities, it is reasonable to expect industry to contribute $1.5 million towards the program, requiring an investment of about $2 million from various government agencies.

The Bottom Line

The integrated audit tools and the expertise are available; the audit teams are assembled and know their task. Opportunity awaits and we should take advantage of it.
» Levels of Benchmarking

- Industry
- Sector
- Facility
- Unit Operations
2.1 Purpose and Objective

The *purpose* of the Benchmarking Program, a key component of the Eco-Efficiency Program, was to:

- provide the upstream oil and gas (UOG) sector with the means to characterize the performance of its facilities with respect to eco-efficiency measures

- establish a baseline that would lead to the development of continuous improvement programs.

The *objective* was to develop a comprehensive set of energy and environmental indicators for companies to measure and assess their facilities' energy and environmental efficiency performance, both within their company as well as across companies.

The performance indicators are tools for tracking facility, process or equipment performance over time. They allow for a better understanding of operating conditions of facilities, leading to identification and adoption of “Best Practices.” Performance indicators can also help:

- to analyze the improvements to the overall operations of the plant from modifications made to individual unit operations;

- to indicate when operations fall short of ideal conditions.

For this project, indicator selection and development was based on detailed assessments of facilities and the identification of critical activities and process measurement devices. The original strategy for identifying and developing indicators was based on the use of publicly available production data as reported to regulatory agencies. Consequently, all proposed indicators are at the facility level, as that is the level of reporting conducted by the UOG sector. It is also the level of metering and reporting for most, if not all, fuel gas and electrical energy consumption processes.

Feedback from operations personnel obtained at the last three Eco-Efficiency Workshops indicated a greater interest in benchmarking at the unit operation level. In response, the benchmarking project was expanded to include a process unit “Best Practices” component. The aim of this component was to develop useful tools for plant management to optimize process equipment on a unit-by-unit basis.
2.2 Key Performance Indicators

2.2.1 Indicator Development

CETAC-WEST began the benchmarking process with an extensive literature and current practices review, using Key Performance Indicators (KPIs) to track the energy and environmental performance of the upstream oil and gas sector. The indicators are based on World Business Council for Sustainable Development concepts and address issues related to energy and the environment. The process has been applied at a facility level using monthly production data. To the extent possible, the production data has been validated and allocated to provide the appropriate information for each indicator.

Initially, 13 sets of KPIs were compiled from 12 facilities using production data for 2002 and in some cases for all or part of 2003. The original facility level indicators comprised five indicators that directly relate to energy consumption and an additional eight that related to environmental emissions. All of the initial indicators developed in this program dealt with the performance of an integrated facility, and were not equipment or individual process indicators.

As the number and types of UOG facilities in the study increased, so did the number of potential performance indicators.

The program studied 23 facilities. They were classified into four categories, based on processing type:

1. Sour gas processing with sulphur recovery
2. Sweet gas processing
3. Conventional oil with solution gas
4. Heavy oil, including enhanced oil recovery.

The performance indicators developed covered both energy and environmental aspects of facility operations and are listed in the following table. While energy intensity indicators were viewed as primary indicators and environmental indicators secondary indicators, it was clear that without exception, minimizing energy intensity minimizes environmental intensity, specifically for greenhouse gases (CO₂E) and in general for other air contaminants.

<table>
<thead>
<tr>
<th>Production Energy Indicators</th>
<th>Environmental Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Total Energy Intensity</td>
<td>Production Carbon Intensity</td>
</tr>
<tr>
<td>Processing Energy Intensity</td>
<td>Production Sulphur Intensity</td>
</tr>
<tr>
<td>Flaring Energy Intensity</td>
<td>Production Fresh Water Intensity</td>
</tr>
<tr>
<td>Fugitive Emission Energy Intensity</td>
<td>Production Produced Water Intensity</td>
</tr>
<tr>
<td>Field Gathering Energy Intensity</td>
<td>Production Sand Intensity</td>
</tr>
</tbody>
</table>

Feedback and response from the industry to the benchmarking project have identified a number of refinements that would facilitate wider acceptance and use throughout the industry. These include:

• development of fewer, simplified KPIs for specific clusters of plants,
• development and use of site-specific custom-designed KPIs to more closely mirror internal objectives and to complement existing programs,
• process and equipment level indicators that are meaningful to operating personnel for daily efficiency control,
• presenting KPIs so that only similar facilities or clusters are compared within that grouping.

2.2.2 Indicator Decoupling

In response to industry feedback, indicator selection and development reflected operation of facilities and the natural or conventional designation of basic activities. In the case of gas processing facilities, these include inlet compression (in the gathering system or on the plant site), gas processing, flaring and sales compression. Processing can be further subdivided into inlet separation, sweetening, liquids recovery and fractionation and sulphur recovery.
2.2 Key Performance Indicators

CETAC-WEST began the benchmarking process with an extensive literature and current practices review, using Key Performance Indicators (KPIs) to track the energy and environmental performance of the upstream oil and gas sector. The indicators are based on World Business Council for Sustainable Development concepts and address issues related to energy and the environment. The process has been applied at a facility level using monthly production data. To the extent possible, the production data has been validated and allocated to provide the appropriate information for each indicator.

Initially, 13 sets of KPIs were compiled from 12 facilities using production data for 2002 and in some cases for all or part of 2003. The original facility level indicators comprised five indicators that directly relate to energy consumption and an additional eight that related to environmental emissions. All of the initial indicators developed in this program dealt with the performance of an integrated facility, and were not equipment or individual process indicators.

As the number and types of UOG facilities in the study increased, so did the number of potential performance indicators. The program studied 23 facilities. They were classified into four categories, based on processing type:

1. Sour gas processing with sulphur recovery
2. Sweet gas processing
3. Conventional oil with solution gas
4. Heavy oil, including enhanced oil recovery.

The performance indicators developed covered both energy and environmental aspects of facility operations and are listed in the following table. While energy intensity indicators were viewed as primary indicators and environmental indicators secondary indicators, it was clear that without exception, minimizing energy intensity minimizes environmental intensity, specifically for greenhouse gases (CO₂) and in general for other air contaminants.

### Table 2.2 Key Performance Indicators

<table>
<thead>
<tr>
<th>Production Energy</th>
<th>Environmental Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Plant Total Energy Intensity</td>
<td>• Production Carbon Intensity</td>
</tr>
<tr>
<td>• Processing Energy Intensity</td>
<td>• Production Sulphur Intensity</td>
</tr>
<tr>
<td>• Flaring Energy Intensity</td>
<td>• Production Fresh Water Intensity</td>
</tr>
<tr>
<td>• Fugitive Emission Energy Intensity</td>
<td>• Production Produced Water Intensity</td>
</tr>
<tr>
<td>• Field Gathering Energy Intensity</td>
<td>• Production Sand Intensity</td>
</tr>
</tbody>
</table>

Feedback and response from the industry to the benchmarking project have identified a number of refinements that would facilitate wider acceptance and use throughout the industry. These include:

- development of fewer, simplified KPIs for specific clusters of plants,
- development and use of site-specific custom-designed KPIs to more closely mirror internal objectives and to complement existing programs,
- process and equipment level indicators that are meaningful to operating personnel for daily efficiency control,
- presenting KPIs so that only similar facilities or clusters are compared within that grouping.

### 2.2.2 Indicator Decoupling

In response to industry feedback, indicator selection and development reflected operation of facilities and the natural or conventional designation of basic activities. In the case of gas processing facilities, these include inlet compression (in the gathering system or on the plant site), gas processing, flaring and sales compression. Processing can be further subdivided into inlet separation, sweetening, liquids recovery and fractionation and sulphur recovery.

### 2.2.3 Monitoring and Tracking Tools

Typical results for facility monitoring and tracking with performance decoupling are presented in Figure 2.1. In this example, the facility was a large sour gas plant. Decoupled activities include:

- Plant Total Energy Intensity (PTEI)
- Processing Energy Intensity (PEI)
- Plant Flare Intensity (PFI)
Performance was tracked for a year. The decoupling of the activities is demonstrated in Figure 2.1 where, in February, a spike in the Plant Total Energy Intensity (PTEI) was due in large part to an increase in the Flaring Intensity. Whereas in October, an increase in the PTEI is due more to increases in the Plant Energy Index.

Figure 2.1 Decoupled Activities of a Large Sour Gas Plant

2.3 UOG Benchmarking Clusters

Like facilities, such as sour gas processing plants, were examined as part of the program to evaluate performance variations and performance averages and, where possible, to identify best performance potential. As an example, Figures 2.2 through 2.5 show the Plant Total Energy Intensity (PTEI) results that were calculated for the 23 plants benchmarked. The PTEI is the sum of all the fuel gas and electrical power consumed divided by energy equivalent of all the product streams from the facilities (the Energy Equivalent Potential or EEP). The different clusters shown here include the sour gas, sweet gas, oil and gas facility, and heavy oil.

Figure 2.2 Sour Gas Cluster - Energy Intensity
Of interest in the cluster comparisons is the wide range in energy intensity performance for each cluster. However, it is important to note that these results are just for the production processing facility itself and do not include field production and gathering activities. Although the primary focus was on facility operations, some field data was obtained through the benchmarking process. These results, and additional benchmarking data, are available in Appendix A2, which is available on CETAC-WEST’s website: www.cetacwest.com.
2.4 Process Unit Optimization “Best Practices”

Feedback from industry participants at the Eco-Efficiency Workshops prompted the development of specific best practice tools related to the individual process units. These tools focused on evaluating unit operation performance and optimizing their functioning in a manner more closely aligned to the needs of the operators, and that provides easy-to-understand help with analyzing the performance of specific units.

Experts specializing in targeted operation areas were called on to develop “Best Practice” or “Optimization” models. These models were then validated in the field at five or six test sites. Validation not only served to establish the robustness of the model, but also demonstrated that it could be a practical and useful tool for operating personnel.

Once completed, these models were then presented to industry in various rollout activities, including the annual Eco-Efficiency Workshop, held in Kananaskis. The first completed model, diethanolamine (DEA) for gas sweetening, was introduced at the 2004 Workshop. The subsequent three models were presented at the 2005 Workshop.

2.4.1 Completed Models

Table 2.2 outlines the potential savings that could be achieved if the models are widely implemented in the industry.

<table>
<thead>
<tr>
<th>Model</th>
<th>Potential Savings ($ millions/year)</th>
<th>Potential Natural Gas Savings (E$ M^3$/year)</th>
<th>Potential CO$_2$E Reductions (t CO$_2$E/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycol Dehydration</td>
<td>53.0</td>
<td>180,000</td>
<td>372,000</td>
</tr>
<tr>
<td>Amine (DEA and MDEA)</td>
<td>66.4</td>
<td>315,000</td>
<td>690,000</td>
</tr>
<tr>
<td>Compression</td>
<td>20.0</td>
<td>40,700</td>
<td>200,000</td>
</tr>
<tr>
<td><strong>TOTAL SAVINGS</strong></td>
<td><strong>139.4</strong></td>
<td><strong>535,700</strong></td>
<td><strong>1,262,000</strong></td>
</tr>
</tbody>
</table>
2.4.2 Model Descriptions

Glycol Dehydration Optimization

Glycol dehydrators are used in gas processing to remove water from natural gas. Dehydration helps to prevent hydrate formation as well as to reduce pipeline corrosion. Glycol is hygroscopic, which means it is capable of absorbing water vapour from a gas stream. Since glycol dehydration is a cyclic process (glycol is used in a non-batch mode), after absorbing the water vapour, the glycol needs to be “regenerated”, a process involving the boiling off of this absorbed water in a distillation column and subsequent venting of the steam and associated hydrocarbons into the atmosphere. Boiling is achieved by burning of fuel gas in a heater (reboiler) so the energy consumer is the reboiler. As part of the process unit optimization component of the benchmarking program, a model was developed to assist in optimizing glycol dehydrators. The goal of this optimization model was to assist operators to produce adequately dry sales gas, and in the process to do the following:

- Optimize dehydrator energy usage (minimize fuel gas firing in the reboiler)
- Reduce benzene emissions (go overhead with the vapourized steam)
- Reduce operating costs (glycol consumption, maintenance, filters, fuel gas)

It is estimated that there are approximately 2,400 glycol dehydrators in Canada that are suitable for optimization. If just half of these dehydrators are optimized using the model, there is the potential for the following annual savings:

- $53.0 million.
- 370,000 tonnes CO\textsubscript{2}E.
- 180,000 E\textsuperscript{3}M\textsuperscript{3} natural gas.
Amine Gas Sweetening Unit  DEA and MDEA
The amine sweetening unit is used to remove H₂S and CO₂ from raw gas in another cyclic process. H₂S must be removed to ppm levels prior to sales because of its toxicity and CO₂ is removed to less than 2 volume percent because of its corrosiveness to pipelines in the presence of water and its inability to provide energy when burned. Once absorbed by the amine, the H₂S and CO₂ is flashed out of the solution via steam regeneration, meaning it is a significant energy consumer in sour gas processing operations.

The amine circulation rate is critical in terms of acid gas removal and energy consumption because a reduction in energy consumption is directly related to a reduction in amine circulation rate. CETAC-WEST contracted the development of two models for optimizing amine plant efficiency and energy consumption. Both DEA and methyldiethanolamine (MDEA) plants were modeled. The model output is in the form of a nomograph, which allows the amine circulation rate to be optimized for acid gas removal and simultaneously establishes the minimum energy required to regenerate the amine solution.

The models are now being used on a daily basis and have resulted in an immediate and measurable decrease in energy consumption in the plants demonstrated. It is estimated that there are approximately 200 amine units that could be optimized in Canada. This optimization would result in the following yearly savings:

- $65.0 million
- 700 kilo-tonnes CO₂E
- 315,000 E³M³ natural gas
Compression Optimization

Compression of natural gas (raising the pressure of a gas stream from a lower to a higher value) is a large, and growing, component in energy consumption in natural gas plants. As natural gas is produced from a formation, reservoir pressures decline, resulting in an increased need for compression of natural gas (to meet sales gas pipeline pressures). During the pilot audits, it was found that inlet valve leakage was a widespread phenomenon and that a reduction of 10% of compression energy usage can be achieved with good monitoring and maintenance of the compressor valves.

The compressor model was developed to help operators identify valve leaks on their compressors. It is estimated that on an average compressor, the reduction of a 5% valve leak will help to achieve a reduction in operating costs of up to $10,000 per year. This translates into the following yearly savings, if the model is rolled out industry-wide:

- $20 million
- 200 kilo-tonnes CO₂E
- 40,000 E'M³ natural gas

2.4.3 “Best Practices” Rollout

Rollout of the completed “Best Practice” models to industry is ongoing.

- The amine optimization models are now included in the Amine Experts Seminars, which are delivered at six locations worldwide annually have been presented to operating staff at five plants in Alberta.
- The glycol dehydration model has been made available to individual users and industry associations.
- The compressor optimization program is explained and made available to users free of charge in conjunction with audits and routine trouble-shooting of plant equipment.
2.5 Benchmarking Program: Going Forward

Ensuring the Message Hits the Mark With Facilities Operators

Benchmarking opens the way for additional energy savings in the upstream oil and gas sector. It therefore is important that funding has been secured through Natural Resources Canada to continue the Benchmarking Program into 2006. Work in both the indicator and the “best practices” areas are scheduled to be completed. Such continued funding recognizes the value of the Benchmarking Program.

Specifically, a more thorough examination of the various sectors within the upstream oil and gas industry, including sectors not yet examined, is planned for work in the facility level process indicator area. Using the original KPI formulations, the program will expand to cover sour gas plants with flaring, sour gas plants with H2S reinjection, straddle plants, field facilities and compressor stations, and to help derive sector and industry benchmarks. Natural Resources Canada has made an initial commitment of $250,000 to March 31, 2006 to begin this work. Additional funding will be sought for the continuation.

Plans call for the performance of some 48 facilities (five to ten from each industry cluster) to be calculated for three years. Using these data, sector level process indicators will be developed to help establish the acceptable range for operations in each sector. Ultimately, industry level indicators will be developed to help evaluate the upstream oil and gas industry’s energy performance relative to other industries.

2.5.1 Education

Despite the progress achieved so far through the Eco-Efficiency Program, facility benchmarking protocols are still not well understood at the facility level throughout much of the UOG industry. This means that the insight about benchmarking gained so far has had limited impact in providing guidance for energy efficiency improvement programs and for tracking performance. Additional educational efforts are needed. That means that besides continued funding for benchmarking, the educational component of the rollout program must also be refined and an effective delivery mechanism developed and tested.
Benchmarking

2.5 Benchmarking Program: Going Forward

Ensuring the Message Hits the Mark With Facilities Operators

Benchmarking opens the way for additional energy savings in the upstream oil and gas sector. It therefore is important that funding has been secured through Natural Resources Canada to continue the Benchmarking Program into 2006. Work in both the indicator and the “best practices” areas are scheduled to be completed. Such continued funding recognizes the value of the Benchmarking Program.

Specifically, a more thorough examination of the various sectors within the upstream oil and gas industry, including sectors not yet examined, is planned for work in the facility level process indicator area. Using the original KPI formulations, the program will expand to cover sour gas plants with flaring, sour gas plants with HS reinjection, straddle plants, field facilities and compressor stations, and to help derive sector and industry benchmarks. Natural Resources Canada has made an initial commitment of $250,000 to March 31, 2006 to begin this work. Additional funding will be sought for the continuation.

Plans call for the performance of some 48 facilities (five to ten from each industry cluster) to be calculated for three years. Using these data, sector level process indicators will be developed to help establish the acceptable range for operations in each sector. Ultimately, industry level indicators will be developed to help evaluate the upstream oil and gas industry’s energy performance relative to other industries.

2.5.1 Education

Despite the progress achieved so far through the Eco-Efficiency Program, facility benchmarking protocols are still not well understood at the facility level throughout much of the UOG industry. This means that the insight about benchmarking gained so far has had limited impact in providing guidance for energy efficiency improvement programs and for tracking performance. Additional educational efforts are needed. That means that besides continued funding for benchmarking, the educational component of the rollout program must also be refined and an effective delivery mechanism developed and tested.

Educational guides and programs are necessary and will be delivered to assist corporate energy and environmental practitioners to integrate these tools into their operations.

More importantly, they are necessary to assist plant operators in developing and applying appropriate facility and operational level performance indicators. These indicators:

- will effectively monitor and track performance;
- indicate problems and reinforce the positive results of energy optimization actions.

Monthly or, in some cases, annual performance assessments would provide an acceptable sample frequency and assist facilities in monitoring their continuous improvement programs. To continue with this KPI work and develop sufficient industry analysis, $250K is needed per year over the following three years.

2.5.2 Bettering Best Practices

In addition to the process indicator work, more “Best Practices” models will need to be completed in 2006. Candidates currently being considered for this project include:

- Tail Gas Incineration
- Utilities Utilization Model
- Economic Model for Energy Efficiency

As with previous models, work will include both a modeling phase and field validation at a minimum of three sites. Costs for a completed study is about $100,000 per model, which covers both the model development and field validation. The resultant models will then be rolled out into the industry through CETAC-WEST and the service industry participants.

The Bottom Line

Thanks to the Eco-Efficiency Program, significant progress has been made on benchmarking. Critical groundwork has been completed, but further funding is required to extend the scope of benchmarking and to educate the industry and those working in it about its value.
New Technology Demonstrations
3.1 Purpose and Objective

The purpose of the Technology Demonstration component of the Eco-Efficiency Program is to assist in overcoming the significant challenges to bridge the gap between potential and the status quo in the UOG industry. With its commitment to traditional operating practices, the UOG industry has been slow to adopt more energy-efficient and emissions-reducing practices and technologies.

The objective of the Technology Demonstration component is to prove to production plant personnel the significant economic and environmental benefits of adopting innovative technologies, thereby encouraging their wide-scale use.

The project aims to demonstrate innovative technologies that have the potential to optimize operations in gas production facilities or the field and which address existing deficiencies and needs.

Demonstration activities had two main thrusts, namely:

1. The FLEXSEAL project: a demonstration of a process for plugging abandoned wells using a patented asphalt emulsion.
2. Oil and Gas Field Technologies to optimize energy use within production operations.

3.2 FLEXSEAL Demonstration Project

Steelhead Reclamation Ltd. has developed a proprietary process (FLEXSEAL System) to address surface casing vent gas flow issues associated with the abandonment of problem wells, where conventional techniques have proven unsuccessful.

The national estimate for emissions associated with surface casing vent flow in 1996 was approximately 10 megatonnes of CO$_2$E. Wells in Alberta and Saskatchewan were the source for over 95% of these emissions. Current data suggest that emissions from this source are increasing. This is likely due to the increasing number of wells and limited effort made to effectively seal problem sources. Since these emissions are generally associated with suspended and / or non-producing wells they will increase in number.

1. Clearstone Engineering Ltd., 1999 estimate of greenhouse gas emissions in the Upstream Oil & Gas industry conducted for the Canadian Association of Petroleum Producers.
Furthermore, they will continue to emit in the long term unless an aggressive program is implemented to address the source.

As part of the FLEXSEAL technology demonstration, one well was completed with FLEXSEAL in Alberta in October 2004. This well originally had issues with surface casing vent flow along the annulus of the second casing string. At the time of the testing, the surface casing vent flow was measured at 0.29 m³ per hour. After the technology was applied to the well, the test was successful with elimination of gas flow from the surface casing vent. This translates into a yearly GHG saving of 26 tonnes for this well.

The ten wells that were originally part of the project plan could not be completed due to delays in regulatory approval for testing the technology. However, given the interest in the technology of two UOG companies, there is the potential to remediate up to 12 more wells in 2005/2006 using this technology.

3.3 Oil and Gas Facility Technologies

The objectives of the oil and gas technology demonstration component of the Eco-Efficiency Program are twofold, namely:

- To seek out areas in which current equipment, processes and practices are not providing optimal performance.
- To demonstrate the value and practicality of adopting better equipment and methods.

The Integrated Audits and industry-sponsored initiatives have identified significant opportunities to reduce energy consumption and reduce GHG emissions in almost every aspect of gas production as shown by the chart below.

Within the areas, significant opportunities for improvement were found related to:

- Fugitive emissions
- Compressors
- Fired equipment such as process heaters, dehydrators and utility boilers
- Burners and incinerators
- Natural gas engines and drivers
- Sour gas sweetening processes
- Pneumatic driven devices
- Refrigeration
- Fractionation
- Electrical power management
Activities during the project sought out innovative technologies and proponents that could support efforts to optimize energy consumption and/or reduce GHG emissions in each of the above areas. More than 20 technologies were assessed. Of these, ten have been undertaken and their performance measured under field conditions, three are still in progress, two were withdrawn at the request of the proponent and five have not commenced but are still considered to be good candidates for future demonstrations.

**Summary of Technology Demonstrations to Date:**

<table>
<thead>
<tr>
<th>Technologies Assessed</th>
<th>Technologies measured under field conditions</th>
<th>Under on-going testing</th>
<th>Withdrawn from testing at request of proponent</th>
<th>Good candidates not yet tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

A brief description of the Technology Demonstration process and the technologies assessed is presented as follows.

**The Technology Demonstration Process**

The Technology Demonstration process follows these general steps:

**Opportunity Identification:** Activities over the course of the Eco-Efficiency Program identified innovative technologies that could support efforts to optimize energy consumption and/or reduce GHG emissions in the upstream oil and gas sector.

**Proof of Concept Testing:** Once identified, technologies must be evaluated to ensure they provide an energy efficiency or emissions advantage. Generally this is accomplished by examination of technology prototypes or results from existing field installations.

**Field Validation:** The field validation is the most challenging and time-consuming component of the process. Partner UOG companies, who provide access to sites and field support must be identified. Because the application of any new technology has a certain amount of risk associated with it, it is often difficult to secure project partners. Additionally, resource constraints of both the host and the demonstrating companies often make it difficult for the technology to be sufficiently monitored and results tracked.
3.4 Completed and Validated Technology Demonstrations

1. Stack Top Temperature Reduction

*Savings based on optimized operations having regard to plant throughput, sulphur recovery efficiency, terrain and atmospheric conditions.*

The first phase of this project involved a computer simulation built upon the thermodynamics and kinetics describing incineration of sulphur compounds found in tail gas from sulphur recovery units. This model showed that operation of the incinerator at a lower temperature was theoretically possible, which led to the second step, undertaking plume dispersion modeling based upon the incinerator model output. When the plume dispersion model output showed that the predicted ground level concentrations of SO₂ was within regulatory limits, application was made to the regulatory authorities to allow field testing under the proposed operating parameters. The field test confirmed the model outputs and the facility has been able to reduce fuel consumption by 15% and reduce GHG emissions by as much as 10 kilotonnes of CO₂E per year. CETAC-WEST was successful in recruiting PTAC and industry as partners and contributors to this project. This technology has application at many of the 48 large sour gas production plants in Alberta and British Columbia and, if implemented, would result in yearly savings of approximately $10 million and 100 kilotonnes CO₂E for the industry.

2. Pneumatic Controller Emissions Reduction

*Savings based upon reduced fuel gas emissions.*

A large percentage of pneumatic devices are powered by fuel gas due to the absence of power and instrument air in remote field areas. *Pneumatic controllers have been estimated to account for approximately 18% of all methane emissions in the upstream oil and gas industry,* consuming $100 million per year worth of fuel gas, resulting in 10 megatonnes of CO₂E emissions, per year. In Western Canada, there are more than 100,000 sites where this technology can be applied.
This inline device reduces the volume of fuel gas vented from the pneumatic controller flapper nozzles by reducing the gas pressure and amplifying the signal to the controller. The control device (flow control valve, pressure control valve, temperature control valve) operates normally with the addition of the device. Field testing was conducted at six sites where a measured decrease in natural gas consumption of an average of 70% was recorded. Assuming a market penetration of 25% for the technology, savings of $25 million per year worth of fuel gas could be saved, or 2.50 megatonnes of CO₂E.

3. Gas Powered Air Pump

*Uses fuel gas as an indirect motive force thereby eliminating fuel gas venting for the operation of control devices and injection pumps.*

This technology has the potential for application at many of the more than 100,000 gas wells in Alberta and British Columbia but more particularly at the 30,000 sour gas wells where propane is often trucked in and used as the motive force for the valves as the sour process gas cannot be vented to the atmosphere. If the technology were to achieve a total market penetration of 10% in the sour gas well market, approximate yearly propane savings of $75 million could be achieved. Because propane gas has no greenhouse gas equivalency, there are no associated GHG reductions for this project.

4. Natural Gas Engine Controller

*Fuel savings through the optimization of engine performance.*

These controllers allow natural gas engines to operate in a lean-burn mode thereby reducing fuel consumption as well as reducing the emission of unburned hydrocarbons from the engine exhaust. The device also allows the engine fuel demand to more closely follow engine load than is the case with existing engines. PTAC, industry and government also participated in this project, in which, an average decrease in fuel consumption of 23% and a 33% reduction in GHG emissions was recorded. This technology could be applied to the more than 8,000 natural gas engines employed in the upstream oil and gas sector. If a market penetration of 25% is achieved, it could result in fuel savings in excess of $30 million per year and 250 kilotonnes CO₂E emissions.
5. Firetube Immersion Heater

*Savings through design, operation and maintenance improvements.*

Heaters are widely employed in the UOG industry to heat treaters, glycol dehydrators and for line heating. PTAC facilitated a study, sponsored by industry and CETAC, in which heaters installed at existing installations were found to operate at very low thermal efficiencies, resulting in excessive fuel consumption. Work completed to date has shown that deficiencies exist in the design, application, operation and maintenance of these units and that a 20% to 30% improvement in thermal efficiency is achievable. It has been estimated that there are 40,000 firetube heaters in service in Western Canada. If 30% of these heaters were fully optimized, it would generate fuel savings of about $45 million per year and GHG reductions of over 450 kilotonnes CO\(_2\)E per year for the industry.

6. Catalytic Incineration of Vented Solution Gas

*GHG savings through combustion of vented methane.*

Because methane has a global warming potential that is 21 times greater than that of carbon dioxide, it is preferable to combust methane emissions, thereby reducing the gas to carbon dioxide and water prior to releasing it into the atmosphere. PTAC and industry also supported this technology, which focuses on this concept and reduces GHG emissions by the conversion of vented methane gas to carbon dioxide. Field measurements showed a conversion efficiency of 70% on tested systems. This technology targets heavy oil well sites where beneficial capture of associated gas is not economic. It is estimated that the technology could reduce CO\(_2\)E emissions by up to 100 kilotonnes per year. However, until an emission trading market and CO\(_2\)E reduction targets become well defined, there will be little market pull for this technology.
3.5 Summary of Confirmed Savings

Table 3.1 outlines the confirmed CO₂E savings that were achieved as a result of the field testing conducted for each of the completed demonstration projects.

### Table 3.1 Technology Demonstration Confirmed Savings

<table>
<thead>
<tr>
<th>Demonstration Project</th>
<th>Confirmed Savings ($/year)</th>
<th>Confirmed Savings (e³m³ fuel/yr)</th>
<th>Confirmed Savings (tonnes CO₂E/yr)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLEXSEAL Project</td>
<td></td>
<td>1.84</td>
<td>26</td>
<td>Methane leak elimination at one test well with low vent rate.</td>
</tr>
<tr>
<td>Stack Top Temperature Reduction</td>
<td>$650,000*</td>
<td>3.90*</td>
<td>9,900*</td>
<td>Awaiting regulatory approvals to make changes in field.</td>
</tr>
<tr>
<td>Pneumatic Controller Emissions Reduction</td>
<td>$2,000</td>
<td>9.72</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>Gas Powered Air Pump</td>
<td>$55,000</td>
<td>59,881 litres liquid propane</td>
<td>Not applicable</td>
<td>No GHG emissions associated with propane emissions.</td>
</tr>
<tr>
<td>Natural Gas Engine Controller</td>
<td>$93,000</td>
<td>474.45</td>
<td>957</td>
<td>Side by side comparison on identical 800 HP engines.</td>
</tr>
<tr>
<td>Firetube Immersion Heater Optimization</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Fieldwork complete, results not yet available.</td>
</tr>
<tr>
<td>Catalytic Incineration of Vented Solution Gas</td>
<td>-</td>
<td>NA</td>
<td>42.50</td>
<td>Incineration of normally vented methane from one heavy oil well.</td>
</tr>
<tr>
<td>Confirmed Annual Total Savings</td>
<td>$800,000</td>
<td>60,000 litres propane/year</td>
<td>4,386 e³m³ fuel gas/year</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11,000 tonnes CO₂E/year</td>
<td>11,000 tonnes CO₂E/year</td>
<td></td>
</tr>
</tbody>
</table>

* confirmed under test conditions
Potential Industry-wide Savings

Table 3.2 shows the potential economic and fuel gas savings for the completed and validated technology demonstrations that were undertaken during the course of this project. For each technology a maximum market penetration was assumed, typically in the range of 10% to 20% of the market.

<table>
<thead>
<tr>
<th>Demonstration Project</th>
<th>Potential Savings $Millions / year</th>
<th>Potential Savings kilotonnes CO₂E / year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stack Top Temperature Reduction</td>
<td>$65</td>
<td>575</td>
</tr>
<tr>
<td>Pneumatic Controller Emissions Reduction</td>
<td>$25</td>
<td>250</td>
</tr>
<tr>
<td>Gas Powered Air Pump</td>
<td>$75</td>
<td>-</td>
</tr>
<tr>
<td>Natural Gas Engine Controller</td>
<td>$125</td>
<td>1,000</td>
</tr>
<tr>
<td>Firetube Immersion Heater Optimization</td>
<td>$45</td>
<td>450</td>
</tr>
<tr>
<td>Catalytic Incineration of Vented Solution Gas</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td><strong>TOTAL POTENTIAL SAVINGS</strong></td>
<td>$240</td>
<td>1,625</td>
</tr>
</tbody>
</table>

* This device displaces propane emissions; hence there are no associated CO₂E reductions.

** This device incinerates gas emissions; hence there are no fuel savings associated with the technology, but significant CO₂E reductions can be achieved.
Validation of Process Unit Optimization Models

As part of the benchmarking program, four process unit optimization models were developed and bench tested. In order to confirm the performance of these models, field testing was conducted to both validate the models and to ensure that the optimization steps were operator friendly. The salient points arising out of the field demonstrations are listed below:

**DEA and MDEA Process Unit Optimization**

Amine sweetening systems are almost universally employed to remove \( \text{H}_2\text{S} \) from sour gas. These processes are energy intensive and historically, operators have been reluctant to optimize energy consumption due to the threat of falling below the sales gas specification for residual \( \text{H}_2\text{S} \). The field demonstrations to validate the model allowed operators to firstly determine the minimum flow rates and energy input requirement but more importantly allowed operators to approach these conditions with confidence.

**Glycol Dehydrator Process Optimization**

Glycol dehydrators are employed to remove moisture from raw gas in order to prevent freezing and the formation of hydrates in pipelines. Many of the more than 2,000 field dehydrators in use are oversized for current gas flows and are generally over circulated. A significant concern is that dehydrators are usually unmanned and are inspected regularly, but infrequently. Operators are therefore reluctant to deviate from a “proved save” operating point. The field validation provided operators with a better insight to dehydration principles and resulted in meaningful reductions in energy input.

**Compression Process Optimization**

It was shown during the audits that internal valve leakage on compressors was a significant source of energy losses. The exact determination of valve losses is normally conducted by engineers and is often overlooked by field operators provided the compressor is meeting the required throughput. This project developed a simple means of identifying the approximate magnitude of valve leakage using data available at each compressor. The purpose of this tool is to identify when maintenance is required to reduce energy consumption. The field validation of the models has given operators the understanding and confidence to more closely monitor compressors performance and initiate needed maintenance.
3.6 New Technology Demonstrations: Going Forward

Extending the Search for Solutions

The New Technology Demonstration program has been a great success but the full potential is far from being realized.

The Technology Demonstration component has focused on helping the UOG sector by:

- optimizing existing equipment and systems; and
- finding and demonstrating new and better equipment and operating procedures.

While six technologies and four process unit optimization examples were demonstrated and validated during the pilot program, the UOG industry can employ and will require an extensive suite of technologies to economically achieve the full potential of fuel savings and CO₂ reductions identified through the Eco-Efficiency Program. Based upon feedback from the Eco-Efficiency Workshops, there is strong industry interest in continuing to identify and demonstrate innovative technologies. Eight additional demonstration projects have already received strong endorsement and most of these could be tested and validated over the next 12 months if this program is continued.

The process of properly cataloguing potential technologies and conducting a thorough technical evaluation of their merits and applications is difficult, requires detailed knowledge of and intimacy with the industry, and demands a good understanding of regulatory requirements and drivers. Facilitating the advancement and commercialization of technologies is a central role and purpose of CETAC-WEST. This means that CETAC-WEST is ideally positioned – technically and geographically – to use its industry networks and draw on its experience to help entrepreneurs commercialize innovative technologies that can enhance UOG sector performance.

Due to the long incubation time for many of the technologies and the time required to...
obtain industry and regulatory acceptance, it is essential that a long-term program be established and maintained. **It is therefore proposed that funding in the amount of $1.8 million be provided to sustain a three-year program of gap identification, technology matching and preliminary approvals including host site agreements.**

CETAC-WEST anticipates that over the next several years *industry, the service sector and entrepreneurs, will present as many as 100 potential technologies in response to gaps highlighted by audits and benchmarking.* Additional needs and opportunities will be identified by industry organizations such as PTAC and CAPP. A rigorous screening of potential technologies is likely to reduce the initial set to some 20 technologies that are of genuine interest to industry and are worthy of support to proceed to the field-demonstration stage.

Following the initial screening, and at the discretion of funding agencies, such as TEAM, SDTC and Alberta Innovation & Science, additional funding may be advanced to support specific technology demonstrations under field settings. CETAC-WEST would continue to be involved with these projects and would provide a coordinating role to ensure that the demonstration projects are properly monitored, results are independently validated and that final project reports are prepared. In addition, CETAC-WEST would promote the uptake of successfully demonstrated projects through a variety of venues such as annual workshops and publications.

**The financial requirements for New Technology Demonstrations are presented below:**

<table>
<thead>
<tr>
<th>Program Component</th>
<th>CETAC-WEST Eco-Efficiency Program Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 Field Demonstrations (6 projects)</td>
<td>$0.6 million</td>
</tr>
<tr>
<td>Identification, Evaluation and Submission of Additional Technologies during Years 2 and 3</td>
<td>$1.2 million</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1.8 million</strong></td>
</tr>
</tbody>
</table>

**The Bottom Line**

The experience gained through the Eco-Efficiency Pilot Program and the ongoing involvement in auditing and benchmarking throughout the UOG industry provide CETAC-WEST with tools necessary to effectively and efficiently evaluate technologies and to bring innovators, industry and funders together at the final evaluation and selection stage.
Industry Rollout & Technology Transfer
What is Being Done to Share the Eco-Efficiency Results

4.1 Purpose and Objective
The goal of the Industry Rollout and Technology Transfer activity was to generate industry-wide commitment to energy and environmental efficiency action plans. This was done by continuous building of awareness among industry and stakeholders of the means and benefits of carrying out integrated audits, introducing new technologies and benchmarking UOG operations. This component is focused on:

- building awareness of the opportunities for both increased profitability from energy savings and reduced GHG emissions in the industry;
- promoting the tangible results of the integrated audits and technology demonstrations; and,
- educating the industry with facts and data on how to practically capture the improvement opportunities that are identified.

4.2 Initiatives and Outcomes
CETAC-WEST undertook a number of activities aimed at initiating the rollout of the practices and findings from the Eco-Efficiency Project. The main activity areas of this component of the program consisted of:

1. Energy Efficiency Workshops
2. Technical Papers and Presentations
3. Articles, Publications and Website

In carrying out these activities, CETAC-WEST obtained insights from industry. This proved valuable as CETAC-WEST continued to re-evaluate and redesign the project in order to maximize the value delivered to industry and stakeholders. The interactive Energy Efficiency Workshops proved to be the most effective means of sharing program results with industry and for providing CETAC-WEST with feedback and input during this initial phase of the program.

Over the life of the project, there was an evolution in industry's acceptance of applying eco-efficient concepts and interest in taking action. However, there is still much hesitation on the part of industry to take action, as evidenced by the recurring themes voiced by workshop participants especially related to the challenges of changing long-established practices and making the economic case for reducing waste and becoming more energy efficient.
Rollout activities, particularly the Energy Efficiency Workshops, positively impacted the overall program by increasing industry's acceptance and, therefore, participation.

Indicators of that positive industry response included:

- An increase in the number of audits delivered to 17, versus the initial target of 6.
- Demonstration of six innovative technologies, results of which were presented to workshop participants. Workshop participants expressed a strong interest in seeing more technology presentations.
- Completion of several “confirming audits,” which reviewed 41 out of 191 recommendations from the integrated audits, and which show responses to the audits led to:
  - fuel gas savings of 67%
  - savings of 29% in electrical consumption
  - savings of $3.94 million/year realized (approximately 44% of the total possible value of $8.99 Million for the 41 recommendations)
  - reduction of GHG emissions of 69 kt/year of CO₂E.

---

4.3 Energy Efficiency Workshops

The central rollout vehicle was the annual two-day Energy Efficiency Workshops. Targeted mainly at industry operational personnel, the workshops were designed to achieve:

- knowledge transfer and feedback;
- dissemination of useful findings and practices to stakeholders;
- encouragement of adoption of technology and process improvements, and
- invitation of industry feedback on all elements of the Eco-Efficiency Program.

Between March 2002 and March 2005 CETAC-WEST delivered four workshops. The workshops hosted a total of 270 participants, including plant engineers and managers from the UOG sector, service industry personnel and government representatives. The first was held at the Banff Centre for Management, and the latter three at Kananaskis Village. Key objectives of the workshops were to examine and debate:

- the merits of developing and adopting energy efficiency measures, and
- barriers faced by industry to adopting energy efficiency measures.
Results and findings to date were presented at each of the workshops, which also featured industry panels along with representatives of plants that participated in integrated audits.

The workshops were extremely valuable for CETAC-WEST in helping to shape the project's future direction. Industry input was actively sought at each of the sessions and the feedback was incorporated into the program design and planning going forward. Program organizers were constantly encouraged by industry feedback, which was characterized by openness among the attendees toward adopting more efficient practices. Accompanying that receptive attitude was a recognition that much more work needs to be done. Everyone providing feedback stated that the workshop was useful, with over 90% stating that they would attend future sessions or recommend that someone from their organization attend.

Highlights of each of the Energy Efficiency Workshops follow:

**4.3.1 March 13 to 15, 2005 “Energy Management”**

The general theme of the March 2005 Workshop was introduced with the questions, “Whose gas is it?” and “Who will benefit from fuel-gas conservation?” CETAC-WEST presented findings from all 17 integrated audits, results of testing process unit optimization tools, analysis of Key Performance Indicator data, and results of several exciting and innovative technology demonstrations carried out under the program.

Michael Bruni, head of the Alberta Energy and Utilities Board's Energy Team, gave the keynote address on the future of energy conservation in Alberta. On fuel gas, he said, “As a regulator we have an expectation that industry will seriously look at the issue of fuel consumption and that they will begin seeing fuel gas as a valuable marketable product.”

---

**Who will benefit from fuel-gas conservation?**

**we have an expectation that industry will seriously look at the issue of fuel consumption and that they will begin seeing fuel gas as a valuable marketable product**
4.3.2 April 4 to 5, 2004 “Improving Gas Plant Efficiency”

Seventy-nine people attended the Workshop in 2004, at which the question posed was, “Is the Gas Ours to Waste?” Results of eight integrated audits that had been completed were presented, as well as progress to date on the benchmarking and technology demonstrations. Using audit findings, case studies were developed for the first time around the individual processing units, rather than the audited facilities. This enabled an enhanced appreciation of the merits of the integrated audit process.

4.3.3 April 13 to 15, 2003 “Improving Gas Plant Efficiency”

“What You Measure, You Can Manage” was the key message of the second workshop. It attracted 83 participants, and featured the first CETAC-WEST Environmental Efficiency Awards acknowledging the leadership of industry representatives who agreed to be the first candidates for integrated audits. Workshop participants received the results from the first three audits, along with commentary from an industry panel composed of representatives from the audited facilities. A preliminary set of KPIs proposed under the benchmarking component was also presented for UOG industry reaction and feedback.
4.3.4 March 3 to 5, 2002 “Improving Operational Efficiency”

The first Energy Efficiency Workshop, held prior to full implementation of the Eco-Efficiency Program, aimed at assessing industry acceptance of the concept and confirmed the vision for the program. Thirty attendees took part, consisting of plant managers and operators and potentially key audit team members. The workshop was pivotal in confirming both the scope and viability of an Eco-Efficiency Project aimed at fostering new practices and attitudes within a mature industry sometimes set in its ways.

4.4 Technical Papers and Presentations

CETAC-WEST also developed and delivered several technical papers on the Eco-Efficiency Program design, achievements, benefits and practices, and made presentations at key conferences aimed at promoting the program findings to wider audiences, such as:

- *Sulphur Seminars and Amine Seminars, Sulphur Experts and Amine Experts*, International Workshops held several times each year. Sulphur Experts and Amine Experts, members of the audit teams, have incorporated results of the process unit optimization into their seminar programs.


- *Air Issues Steering Committee, PTAC*, January 2004. An update on the Project was provided to Steering Committee Members.


Air Issues and Technical Review Forum, PTAC, November 2002. The Energy and Environmental Efficiency program was introduced and results of the first pilot audit were presented by a CETAC-WEST team with BP Energy.

Industrial Energy Audit Incentive Program, Canadian Industry Program for Energy Conservation (CIPEC), October 2002. A presentation on the integrated audits was made to Small Explorers & Producers Association of Canada (SEPAC) members.

### 4.5 Articles, Publications and Website

Since its inception, the Eco-Efficiency Program has generated a significant amount of publicity as a result of a number of articles written about it and as a result of CETAC-WEST's own publications. The articles, in publications targeted at key stakeholders, summarize highlights of the program results and benefits.

#### 4.5.1 Articles

4 Industry Rollout and Technology Transfer

- Advisory Board Briefings  Development of special briefings for the Program's Industry Advisory Board, that consists of senior industry and government stakeholder representatives.

4.5.2 Publications

CETAC-WEST publications are another tool available for promoting the benefits of the program. Following the last workshop in March 2005, CETAC developed and published a tabloid-style informational paper with details on the workshop presentations and message. Information on the audit results, guest speakers and technologies presented are included in the publication. It is being distributed widely throughout the oil and gas industry, as well as to government and infrastructure stakeholders. The tabloid is in this report in Appendix 3.

4.5.3 Website

CETAC-WEST also has information about the program on its website: www.cetacwest.com. The website will continue to be enhanced, with particular emphasis on making information available that would be of greatest value to industry.

4.6 Other Activities

Dissemination of program results and benefits will also be achieved through partnerships and collaborations with other organizations. During the 2002/2003 fiscal year, CETAC-WEST and PTAC developed and executed a Memorandum of Understanding (MOU) that outlines synergies of a collaboration between the two organizations in promoting energy and environmental efficiency, and the potential roles of each organization.

Consultations with a number of industry-driven organizations (such as the Canadian Association of Petroleum Producers, the Alberta Energy Research Institute, the Industrial Research Assistance Program and Climate Change Central) and individuals have also taken place throughout the life of the project. The consultations occurred one-on-one and through industry advisory panels.

CETAC-WEST has also produced numerous reports to stakeholders, which has included information that has been more broadly publicized through federal and provincial government channels.
4.7 Rollout: Going Forward

Continuing to Deliver the Message

Industry Rollout and Technology Transfer activities delivered up to March 31, 2005 have been effective in developing awareness within the UOG sector of:

- practices and tools for achieving better performance
- the benefits of applying those practices and tools.

However, the UOG industry is large and varied. Much more work is needed to make an energy-efficiency culture take hold.

CETAC-WEST has estimated that the total investment made in the Eco-Efficiency Program to March 31, 2005, by industry and the federal and provincial governments, is over $3 Million. Important seeds have been planted, some have taken hold but more cultivation is needed.

In order to reap the full benefits of investments to date, it will be necessary to continue reaching out to industry to promote the results and benefits of the adoption of more energy-efficient practices by the UOG industry for at least another three years. It is also important that the activities be continued uninterrupted, in order to maintain the momentum that has been building over the last three years.

Activities planned for the 2005/2006 fiscal year include:

- In May 2005, CETAC-WEST and Natural Resources Canada's Office of Energy Efficiency made a presentation at the Industrial Energy Technology Conference in New Orleans on the results of the Eco-Efficiency Program in the Canadian UOG industry.
• CETAC-WEST will work with audit team members and technology demonstration clients, to produce several papers on the Eco-Efficiency Program results for presentation at selected technical and environmental conferences in the coming year.

• Over the summer of 2005, representatives from CETAC-WEST and the audit team will visit UOG facilities in Alberta and present the findings from the program and encourage participation in similar energy conservation activities and the uptake of more efficient technologies and processes.

• One-day workshops, focusing more on new technologies, are being examined as a potential means for going forward with the program.

A more comprehensive and intensive program that would most effectively achieve the roll out of the Energy Efficiency results and benefits would cost $250,000 per year. In particular, a successful program for achieving rollout objectives would be focused on creating means and opportunities to establish an industry network allowing the findings of this project and other initiatives to be disseminated and shared among key industry players.

• Alberta Energy has committed $125,000 per year to the year ending March 31, 2007. Therefore CETAC-WEST is seeking to match Alberta Energy's commitment and an additional $250,000 for the following year. Those funds would enable augmentation of its Rollout activities through a number of other initiatives. Initiatives proposed by CETAC-WEST include the following:

  • Eco-Efficiency Workshops – The four workshops delivered over the last four years have proven to be the most effective tool for creating awareness and for network-building. Therefore, continuation of the Energy Efficiency Workshops will continue to be a centrepiece of the of the ongoing Industry Rollout program. In response to a strong interest expressed by industry participants, a session focused on promoting innovative new technologies would be targeted as the next session.

  • Enhanced Web Presence – CETAC-WEST would augment the information available on its website. It would also investigate the possibility of using the Internet to facilitate communication with and among industry representatives.

  • Newsletters and Publications – The Energy Efficiency Workshop tabloid was effective in publicizing the highlights of the program. Similar publications will be targeted for publication on a regular basis.
Summary of Funding Needs

It is apparent that important strides have been made through the Eco-Efficiency Pilot Program. However, more remains to be done to build on the achievements to date and to further disseminate to industry and other interested parties the findings and practical recommendations arising from the program. Additional investments by the federal and provincial governments and industry will be required to achieve these objectives. The portions required from federal and provincial government programs for the different phases of the Eco-Efficiency Program are estimated at:

- Integrated Audits: $2,000,000
- Benchmarking: $1,050,000
- New Technology Demonstrations: $1,800,000
- Industry Rollout: $750,000
- Proposed Project Funds: $5,600,000

As a minimum, industry participation is expected to match the government investment in both the Integrated Audits and the New Technology Demonstrations. Therefore, CETAC-WEST estimates the total value of the proposed program extension would be approximately $10 million.

Additional knowledge and information developed over the three year stage of the program would enhance savings opportunities identified for the industry. In addition to the acquisition and promotion of additional information based on facility-type, a more in-depth understanding of data will better equip industry to take action. The addition of new and improved technologies encouraged by more technology demonstrations is expected to double the potential for savings to $1 billion from the currently estimated $500 million per year.

The Bottom Line

The Eco-Efficiency Program will not have achieved its full potential by only sharing the findings and benefits of the integrated audits and benchmarking with those directly involved in those initiatives. Keeping the information close to the vest, amounts to preaching to the converted. The Eco-Efficiency Program still has an important message to deliver. Delivery can only be accomplished if the resources are available to continue to rollout the message.
ALBERTA ENERGY ACKNOWLEDGEMENT AND DISCLAIMER

The project for which this report was submitted was funded (in part) by:

- Her Majesty the Queen in right of Alberta, as represented by the Ministers of Energy and Environment
- Her Majesty the Queen in right of Canada as represented by the Ministers of Environment, Natural Resources Canada, and Western Economic Diversification Canada

This report and its contents, the project in respect of which it is submitted and the conclusion and recommendations arising from it do not necessarily reflect the view of the sponsors, their officers, employees or agents.

The sponsors, their officers, employees or agent, and consultants make no warranty, express or implied, representation or otherwise, in respect of this report or its contents.

The sponsors, their officers, employees and agents and consultants are exempted, excluded and absolved from all liability for damage for injury, howsoever caused, to any person in connection with or arising out of the use by that person for any purpose of this report or its contents.
Appendices

Appendices are available at:
www.cetakwest.com