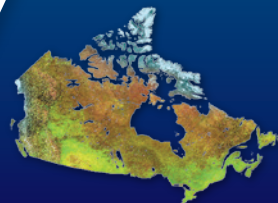




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Process Integration Incentive Program: Results and Impacts 2004-2013



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Background

Process integration — or PI as it is commonly referred to in industry — is a powerful approach to optimizing energy use and power generation in industrial facilities.

A process integration study performs a global analysis of the entire process, looking at all the ways heat is being used, where it can be recovered and what could be the best use for that heat throughout the facility. Since PI examines energy systems as a whole rather than considering equipment items in isolation, it delivers savings larger than those obtained with traditional energy audits. As a result, PI allows achieving premium energy efficiency gains and related greenhouse gas (GHG) emissions, while increasing plant competitiveness and supporting employment in local communities.

In the early 2000s, process integration was identified by Natural Resources Canada (NRCAN) as an innovative energy efficient technology and the approach was successfully piloted in various case studies that were well received by the industry.

Who can benefit from PI?

Industrial facilities suitable for PI have complex energy systems involving several of the following aspects:

- Numerous process streams that require heating or cooling;
- Many heat exchangers;
- Energy intensive equipment (e.g. dryers, evaporators, furnaces, distillation columns);
- Large steam or hot water usage; and
- Large refrigeration load.

Good candidates for PI typically use more than 100,000 gigajoules (GJ) in thermal energy per year, equivalent to a natural gas consumption larger than 2,500,000 m³ annually.

In Canada, over 600 industrial facilities in nearly all industry sectors are suitable for PI, of which 300 are large industries and 300 are medium-sized industries.

NRCAN's PI Incentive Program

Recognizing the significant potential energy saving benefits of PI, NRCAN created the Process Integration Incentive Program to help industrial facilities access PI services. In order to encourage and stimulate the use of PI within a wide range of industrial sectors, the PI Incentive Program was established, in 2004, to offer industries the opportunity to share the cost of undertaking a PI study of their facilities. Managed by the Office of Energy Efficiency's Industry and Transportation Division (OEE), with the technical support of CanmetENERGY PI experts, the Program was launched as a pilot between 2004 and 2006, and was then included in the Federal Government's ecoENERGY Industry program.

Through the PI Incentive Program, a financial incentive of up to 50% of the PI study cost is available to companies participating in the Canadian Industry Program for Energy Conservation (CIPEC¹). The maximum contribution was adjusted over the years from \$75,000 at the program inception down to \$50,000, and then to its current value of \$40,000.

Between 2004 and 2013, NRCAN has supported 62 PI studies for a total funding of \$2.4 million and an average value of PI contributions totalling \$35,000.

Conducted on a countrywide scale, the studies were performed in both large (66% of all PI studies) and medium-sized facilities (34%), all of them operating complex energy systems and processes and using substantial amounts of thermal energy. All provinces were covered except Saskatchewan and Prince Edward Island (Figure 1), with over 60% of all PI studies conducted in Quebec and Ontario (26 and 13 studies, respectively), followed by British-Columbia and Alberta with 7 studies each.

Figure 1. Process Integration Studies Across Canada



¹ CIPEC is a 30+ year voluntary partnership between government and business that champions industrial energy efficiency across Canada (www.nrcan.gc.ca/energy/efficiency/industry/cipec/5153). The CIPEC membership includes 52 associations representing over 5,000 companies and 98% of the Canadian industrial energy demand.

Various industry sectors participated in the program, with pulp and paper and food and beverage being the most represented industries with 47% and 26% of all PI studies performed, respectively. Other participating industries included petrochemicals (including oil refining), mining and metals, and fertilizer and chemicals (Table 1).

Table 1. Process Integration Studies by Industry Sector

| Industry Sector | Number of PI Studies |
|-------------------|----------------------|
| Pulp and paper | 29 |
| Food and beverage | 16 |
| Petrochemicals | 5 |
| Mining and metals | 4 |
| Fertilizer | 3 |
| Chemicals | 3 |
| Other | 2 |
| Total | 62 |

The actual impacts of the PI Incentive Program have been assessed by conducting a number of surveys with participating companies. The information collected confirmed that PI studies not only allowed companies to uncover significant energy saving opportunities that had not been suspected, but also helped them to make better-informed decisions by understanding how energy is actually used throughout their plants.

The following sections of this document detail the energy, financial and environmental results of the PI Incentive Program. They also describe future activities to address the large potential for PI that remains unexploited.

Program Achievements

In each process integration study funded by the Program, energy specialists with PI expertise gathered extensive data covering the entire plant or unit. These data were then used to build an energy model to reproduce the actual plant operations, and then further analyzed to identify opportunities for energy cost savings. In the analysis, a methodical and structured site-wide approach, supported by specialized tools such as pinch analysis, was used to reduce the process heating and cooling demand through a variety of measures.

Process Integration studies deliver a list of projects to improve the plant energy performance and reduce energy costs. Typical areas of improvement include:

- Best practices and operational changes;
- Utility systems;
- Heat recovery from process streams, effluents and exhaust gases;
- Water savings;
- Cogeneration; and
- Heat pumps.

Energy saving projects are presented in a clear action plan (or roadmap) that maximizes the savings according to the plant's economic constraints related to profitability and capital.

Methodology

The impacts of the PI Incentive Program were evaluated through the survey of companies having completed a PI study with financial support from NRCan. CanmetENERGY, along with three consulting firms specialized in PI services, used a questionnaire and spreadsheets, developed by NRCan, for this purpose.

For each participant contacted, detailed information on the implementation status for each project recommended in the PI study was gathered along with general comments regarding the program. Projects were classified as Implemented, Scheduled, and Not Implemented². Actual impacts were calculated considering projects reported in the first two categories, meaning projects already implemented or confirmed to be implemented shortly.

² Implemented: a project already implemented by the plant.
Scheduled: a project confirmed to be implemented soon.
Not Implemented: a project that is not implemented and unlikely to be implemented in a near future.

As the Canadian Centre of expertise in Process Integration, CanmetENERGY reviewed and analyzed the data collected during the survey so as to evaluate the results for each plant as well as the overall impacts of the Program.

Impacts were evaluated against four performance indicators:

- Annual **fuel savings**;
- Annual **greenhouse gas** (GHG) reductions;
- **Increased power generation**; and
- Annual **economic benefits** generated by the PI projects.

Energy Savings

Energy is a significant expense for industrial facilities that can represent up to 30% of the total production costs in energy-intensive processes. Consequently, reducing energy costs by improved heat recovery and better process operation was the main driver in performing a PI study for all participants.

Fuel Savings

Heat recovery and operational improvement projects improve energy efficiency, leading to reduced fuel consumption used to provide heat to the process. By implementing PI recommendations, participating companies are saving 6,600 terajoules³ (TJ) in fuel energy annually (including fossil fuels⁴ and biomass), enough energy to heat 100,000 homes. Considering the 2013 energy price, these savings are worth approximately \$34 million annually.

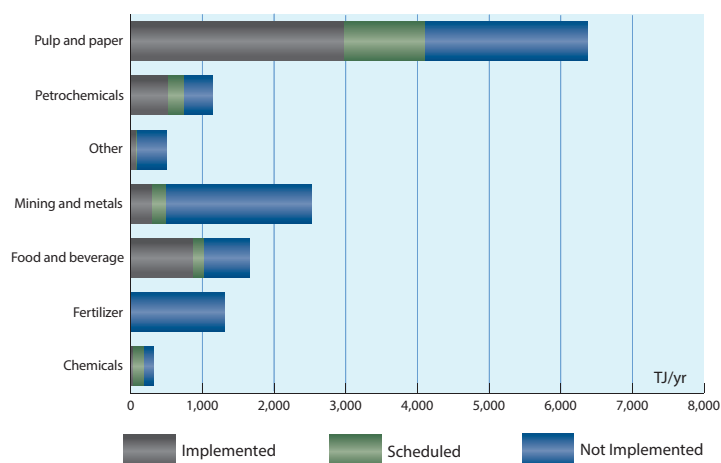
Energy efficiency improvements resulting from the PI study completed at the Viandes duBreton pork processing plant in Rivière-du-Loup (QC) reduced fossil fuel consumption by 57,400 GJ per year (1.15 million L in light fuel oil and 500,000 L in propane)⁵.

Pulp and paper is the sector where the largest impacts are obtained with 62% of the total fuel energy savings achieved (4,100 TJ per year), followed by food and beverage (15% of total fuel savings) and petrochemicals (11%).

Results obtained in the pulp and paper industry can be explained by the number of PI studies done in the sector and the large thermal energy consumption as well as potential savings in paper mills. Moreover, several mills used funding from the Federal Government's Pulp and Paper Green Transformation Program (PPGTP) to implement PI recommendations. In contrast, a small implementation rate was observed in processes already well integrated or difficult to retrofit economically such as in fertilizer and mining and metal industries (see Figure 2 for detailed data by sector).

At Maple Leaf's Rothsay plant in Dundas (ON), a PI study identified 11 energy efficiency measures. One of these projects, a very attractive heat recovery measure, generated natural gas savings of 30,000 GJ per year representing 6% of the plant's natural gas usage. Following the study, the same project was also implemented in two other Rothsay facilities located in Moorefield (ON) and Brandon (MB)⁶.

Figure 2. Impacts of PI Projects — Fuel Reductions by Sector



"We used a PI study to save close to \$1.8 million a year in natural gas and electricity at our Toronto brewery. It's one of Molson's biggest and most complex facilities".

Jim Pomeroy, acting Brewery Manager, Molson Coors, Toronto, ON, 2011

³ Terajoule = 1 thousand gigajoules (1 TJ = 1,000 GJ)

⁴ Fossil fuel: natural gas, heavy oil, light oil, refinery gas and propane

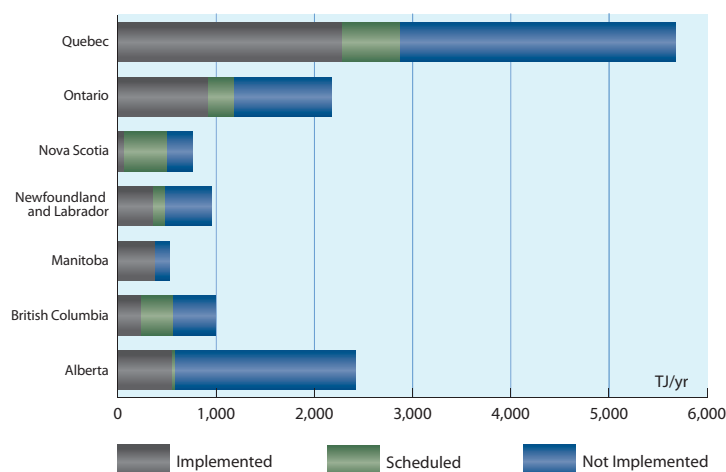
⁵ Ref: Quebec's Ministère des ressources naturelles, 2012

⁶ Ref: Union Gas Maple Leaf Foods/Rothsay Enercase, 2009

⁷ Ref: CIPEC Annual Report 2011

With a larger number of PI studies conducted in Quebec and Ontario, more savings are obtained in these provinces with 44% and 18% of the total fuel savings, respectively (Figure 3). Interestingly, with only 7 studies performed in Alberta (11% of total studies), potential savings identified in this province represent 21% of the total. Most of these studies were conducted in very large petrochemical and fertilizer sites where large potential savings were identified. However, the inherent nature of these processes makes them difficult to retrofit, leaving a large portion of this potential unexploited.

Figure 3. Impacts of PI Projects — Fuel Reductions by Province



The total fuel energy savings identified by the PI studies represented 13,900 TJ, giving an average implementation rate of 47% (Table 2). The major limiting factors for not implementing more saving measures was the availability of capital for energy projects, most of the resources being directed towards production projects. Several companies reported that some other measures identified would be implemented as the cost of natural gas, currently low in 2013, will increase and the projects will become more profitable.

Project implementation rate of 47%:

A clear indication that the measures identified were practical, technically feasible and cost effective.

Table 2. Impacts of PI Projects — Implementation Rate

| Implementation Status of PI Projects | Fuel Savings |
|---|--------------------|
| Implemented | 34% |
| Scheduled | 13% |
| Not implemented | 53% |
| Implementation rate | 47% |
| Identified fuel savings | 13,900 TJ/yr |
| Implemented fuel savings (implemented + scheduled) | 6,600 TJ/yr |

Increased Electricity Generation

In recent years, provincial governments and electric utilities have developed incentive programs for the production of electricity from renewables and industrial waste heat (e.g., Ontario, British-Columbia, etc.). In increasingly global and competitive markets, this represents an opportunity to diversify revenues and increase plant profitability. Where biomass, a carbon neutral energy source, is used to produce steam, process steam savings obtained through PI measures can be turned into renewable power — or "green power" — in turbines. This is the case in the pulp and paper industry where several mills used PI to maximize revenues from electricity sales, taking the most from their existing turbines or providing a strategic approach to install new ones. In another sector, a large amount of waste heat is used to produce electricity using the organic Rankine cycle, a new technology to produce power from relatively low temperature heat sources.

"The new turbine has enabled the mill to sell surplus power to the provincial grid and convert all steam savings initiatives to increased renewable electricity generation. With the revisited pinch study, the new condensing turbine and the strategic vision for energy management, we can consider a whole new configuration for the mill that will reposition us in a new quartile in energy management and competitiveness⁸."

Bill Adams, Manager of Engineering Services, Domtar, Kamloops, BC, 2010

The implementation of PI recommendations allowed participating companies to increase their renewable power generation capacity by 55 megawatts (MW) representing 460,000 megawatt hours (MWh) of electricity produced from renewable sources or the annual electricity consumption of 100,000 Canadians. Selling this electricity to local utility generates approximately \$35 million annually in additional revenues.

⁸ Ref: Heads-Up CIPEC, September 1, 2010, Vol. XIV, No. 16

It is worth noting that several pulp and paper mills used PPGTP funding to implement larger power production projects than those recommended in their PI studies, such as the upgrade of their biomass boiler or the installation of a larger capacity turbine. To maintain a conservative approach to estimating the impact of the PI Program, only the portion attributed to PI was considered, and not the overall impacts of these larger projects.

PI energy impacts



Fuel savings: 6,600 terajoules per year, enough to heat 100,000 homes



Renewable electricity: 460 gigawatts hours per year, equivalent to the electricity consumption of 100,000 Canadians

Greenhouse Gas Emission Reductions

Impacts on greenhouse gas (GHG) emissions were calculated for both direct and indirect emissions. Direct GHG reductions are the emissions associated with a lower fossil fuel usage at industrial sites while indirect GHG reductions are mostly related to the renewable electricity generated on-site and electricity savings⁹.

Overall, implemented PI projects are reducing direct GHG emissions by 306,000 tonnes per year (t/yr). Of this total, 57% is obtained in the pulp and paper sector with an average GHG reduction of about 9,000 t/yr in each participating mill. Indirect GHG reductions represent an additional 85,000 tonnes annually, mostly from plants located in Alberta, Ontario, and, to a lesser extent, British-Columbia.

Total GHG reductions, including direct and indirect emissions, amount to 390,000 t/yr. This represents the equivalent of the annual emissions of more than 100,000 cars.

PI environmental impacts



Total GHG reductions: 390,000 tonnes per year, equivalent to the emissions of 100,000 cars

Other Benefits

By improving the design and the operations of participating facilities, process integration also allowed significant reductions in water usage and effluent production (notably in pulp and paper), a reduced electricity consumption (notably in food and beverage and petrochemicals) and the debottlenecking of critical processes at certain facilities which translates into increased production. Together, these additional benefits are worth \$5 million annually.

PI other impacts

- Reduced water consumption and electricity consumption;
- Increased production;
- Raised heat recovery potential awareness; and
- Developed energy reduction roadmap.

In addition to cost benefits, the exposure to PI also contributed to changing the perception and approach to energy efficiency in some plants by providing the tools they needed to demonstrate the savings potential, therefore creating a new momentum to save energy.

"Seeing all these tangible economic benefits has generated a lot of employee and management enthusiasm¹⁰."

Scott Spencer, Manager of the Green Energy Project, Zellstoff Celgar, BC, 2011

In many cases, companies indicated that process integration provided them with a valuable action plan for improving their plant energy performance. With this information, they are better able to take well-informed investment decisions and to build their energy strategy for the years to come.

"PI is the best way for us to get the most accurate picture of energy consumption. We are using the results to build our five-year energy reduction plan¹¹."

Marc Désaulniers, Manager of Energy Conservation, Kruger Products, QC, 2011

At the Kruger pulp and paper company, process integration was adopted corporately and PI studies were conducted in all their large energy-consuming mills, allowing the company to save millions of dollars in production costs.

⁹ Indirect GHG reductions were calculated considering the plant location, since GHG emissions related to electricity generation differ considerably across Canada.

¹⁰ Ref: Heads-Up CIPEC, March 15, 2011, Vol. XV, No.6

¹¹ Ref: CIPEC Annual Report 2011

"We are now convinced that process integration constitutes a systematic and powerful approach when analyzing the potential energy savings of all plant processes. It goes well beyond conventional energy audits that are often limited to the analysis of utility systems. Moreover, this approach provides a short, medium and long-term vision to improve the energy efficiency of a facility¹²."

Craig Richardson, Director of Engineering, Consumer Products, Maple Leaf Foods, Toronto, ON, 2005

Finally, by improving the profitability of participating companies the Program contributed to maintaining jobs in facilities facing hard times, notably in the changing pulp and paper industry. It also allowed the creation of new jobs in engineering firms that performed detailed engineering studies and implemented the PI projects.

A Cost-Effective Approach

These positive impacts were achieved with a total incentive of \$2.4 million allocated between 2004 and 2013. In turn, this financial assistance generated an estimated \$110 million in direct capital industry investments for the implementation of PI recommendations¹³. Taking a conservative approach due to some uncertainties on capital investments, the average payback period for all implemented measures is estimated at about 1.5 years. This is a clear indication that process integration is a cost-effective approach for both industry and Government that provides practical and technically feasible measures. However, it is worth saying that these results were achieved with a 47% implementation rate; therefore, impacts could have been even greater if companies had implemented all of the PI recommendations with a longer payback period.

Cost effectiveness



| | |
|---|------------------|
| Government investment | \$2.4 million |
| Industry investment | \$110 million |
| Average payback | 1.5 year |
| Cost per tonne of GHG avoided¹⁴ | \$1.60 per tonne |

¹² Ref: Letter to CETC-Varenes, November 18, 2005

¹³ About \$75 million in energy efficiency projects and \$35 million in renewable electricity generation. When larger-than-recommended cogeneration projects were implemented by the sites, only the portions attributable to PI have been considered in the PI impact analysis.

¹⁴ Assuming a 5-year project life span and direct GHG reductions only.

"I would recommend a pinch analysis to any industry. The savings are remarkable; the study has already paid for itself ten times over¹⁵."

Don Breen, Vice-President Strategic Planning & Government Affairs, Northern Pulp Nova Scotia Corporation, NS, 2012

Overall Satisfaction

Interviewed company representatives were thoroughly satisfied with their PI studies, conveying that their businesses benefited tremendously from process integration and that they would definitely recommend others to undertake a PI study.

Even in situations where it identified opportunities already known on some level to plant personnel, PI nevertheless provided valuable information to better understand this potential, to rank the various opportunities in a clean action plan and to demonstrate the profitability of energy efficiency to the plant's management.

In spite of PI's proven results, companies stated that NRCan's funding was a crucial factor in making a convincing case for a PI study and that most studies would not have been possible without this Government assistance.

"The PI incentive is critical to support industry in completing studies to evaluate energy improvements. NRCan's contribution had a significant impact on approving the expenditure for the PI study¹⁶."

Wayne Steinke, Process Engineer, Canadian Fertilizer, Medicine Hat, AB, 2011

¹⁵ Ref: Heads-Up CIPEC, August 1, 2012, Vol. XVI, No.13

¹⁶ Ref: Process Integration Survey, February 25, 2011

For a Wider PI Adoption

Market analyses estimate that over 600 Canadian industrial facilities are suitable candidates for a PI study, a number ten times greater than what has been covered thus far. The convincing results achieved to date therefore represent only 10% of the possible reduction in energy consumption and associated air emissions within Canadian industry, meaning that a vast potential for process integration exists and is still unexploited in Canada (Table 3).

In order to accelerate the wider adoption of process integration across Canada, NRCan and its provincial partners have developed a professional development course to build a PI capacity within the Canadian engineering firms and consultants community. The course was very successful in Quebec, with 150 engineers trained, and is progressively being deployed across Canada in collaboration with provincial partners. The course allows participants to gain a deeper understanding of the underlying concept of PI and how to sell and conduct a PI study in practice.

Table 3. Total Market PI Potential Impact

| Impacts | 600 Plants |
|---------------------|------------------|
| Fuel savings | \$350 million/yr |
| GHG reductions | 3.4 million t/yr |
| Electricity sales | \$100 million/yr |
| Industry investment | \$1 billion |

Participants are also taught in the proper use of CanmetENERGY's PI software INTEGRATION to quickly evaluate heat recovery opportunities in industrial facilities, making PI studies easier, faster and more affordable. INTEGRATION capabilities are currently being expanded to quickly analyze and optimize industrial cogeneration plants in order to increase the efficiency of existing systems, to maximize the sales of renewable electricity or to evaluate the potential for new cogeneration opportunities.

Conclusions

Process integration is a powerful approach to achieving superior energy efficiency gains and related GHG emission reductions, all while increasing competitiveness and supporting employment in Canadian industries.

As numbers and statistics demonstrate, the PI studies conducted so far under the NRCan PI Incentive Program have yielded impressive results (Figure 4). Overall, the Program generated enough energy savings to heat 100,000 homes, GHG reductions equivalent to the emissions of 100,000 cars, and increased renewable power generation equivalent to the electricity consumption of 100,000 Canadians. It also provided companies with substantial cost benefits by reducing their operating costs and generating new revenues, therefore strengthening their competitive position.

Participating companies were satisfied with their PI studies and unanimously acknowledge the importance of the funding to support the study which otherwise would not have been possible. By recommending others to undertake a PI study, industries agree this is the right thing to do in order to have a strategic approach to energy efficiency.

Yet, despite its very positive results, NRCan's PI Incentive Program covered just about 10% of suitable Canadian facilities, meaning that impacts could potentially be ten times greater.

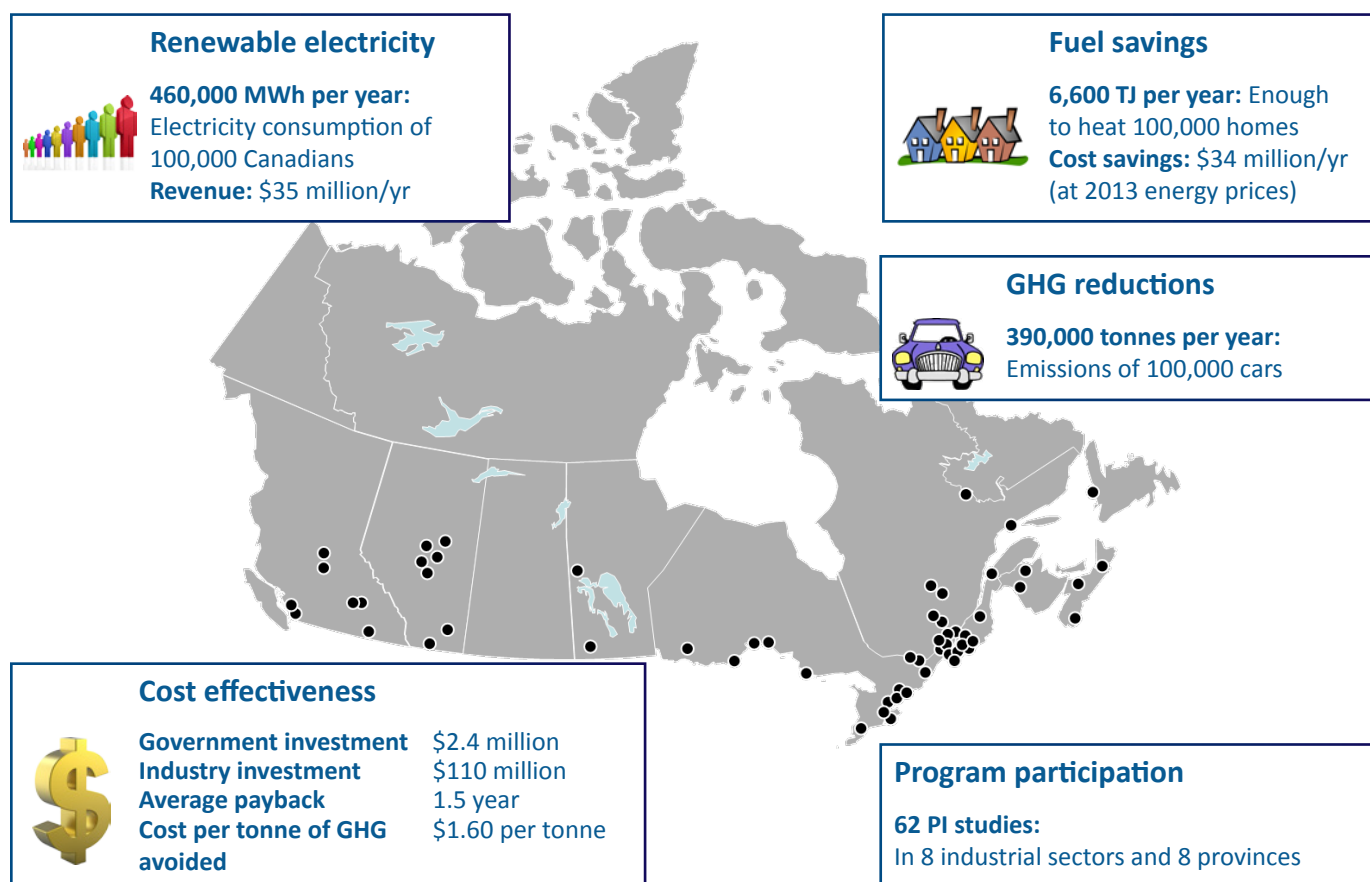
In an accelerated scenario for a wider adoption of process integration across Canada, a broader PI Program can have a substantial influence to increase the competitiveness and viability of Canadian industry and to achieve substantial impacts countrywide. Such a program would target key elements needed to increase both the supply and demand for PI services, including awareness of the PI benefits, capacity building, technical support and incentives.

"A PI study puts a lens on exactly what's happening throughout the entire plant. With data that are specific, we're able to make well-informed investment decisions to achieve the best possible savings with attractive paybacks. It's important to note that after all of the significant energy efficiency improvements we've already made, this PI study identified even more opportunities for strengthening our bottom line and steering our viability. Think your plant is running efficiently? Think again. Unless you've undergone a study like this, assume absolutely nothing¹⁷."

**Doug Dittburner, Energy Conservation Specialist,
Unilever, Toronto, ON, 2007**

¹⁷ Enbridge Gas Distribution Unilever Process Integration Case Study, 2007

Figure 4. Process Integration Incentive Program Achievements



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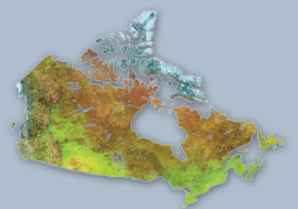


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