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Energy Benchmarking:
Canadian Potash Production Facilities
In cooperation with the Canadian Fertilizers Institute

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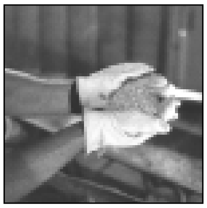
Canadian Potash Production Facilities



The Canadian Fertilizer Institute (CFI)

In cooperation with

The Canadian Industry Program for Energy Conservation (CIPEC)

October 2003

Energy Benchmarking: Canadian Potash Production Facilities

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Introduction

The Potash Industry

There are 11 potash production operations currently active in Canada, all of which are represented through membership in the Canadian Fertilizer Institute. Of these 11 operations, nine are conventional underground shaft mines and two are solution mines. Saskatchewan is home to 10 of the potash mines. The only operating potash mine outside of Saskatchewan is in Sussex, New Brunswick.

The industry production capacity is approximately 19.7 million tonnes of muriate of potash (KCl), or 12.4 million tonnes of potassium oxide (K_2O) per year. In 2000, muriate of potash production totalled 15.0 million tonnes (9.5 million tonnes of K_2O); in 2001, muriate of potash production totalled 13.3 million tonnes (8.4 million tonnes of K_2O). These production totals represent 76 and 68 percent of capacity use for 2000 and 2001, respectively.

Energy Benchmarking Project

The Canadian Fertilizer Institute has been actively engaged with the Canadian Industry Program for Energy Conservation (CIPEC) through its Fertilizer Industry Energy Task Force. On March 14, 2002, the Task Force held an energy benchmarking workshop to discuss opportunities for undertaking an energy benchmarking project. Following the workshop, the three potash-producing companies, which represent all 11 potash operations in Canada, indicated their commitment to participating in an energy benchmarking project. Company representatives from Agrium Inc., IMC Potash and Potash Corp. of Saskatchewan Inc. (PCS) identified appropriate technical personnel to work on the benchmarking project, and the project was carried out over the 2002–2003 fiscal year.

The group agreed to a benchmarking protocol that would allow comparison between operations to the level of detail achievable across all operations without requiring additional capital for installation of metering/monitoring equipment. In addition to collecting energy consumption data, a diagnostic session on energy management practices was conducted at each of the sites.

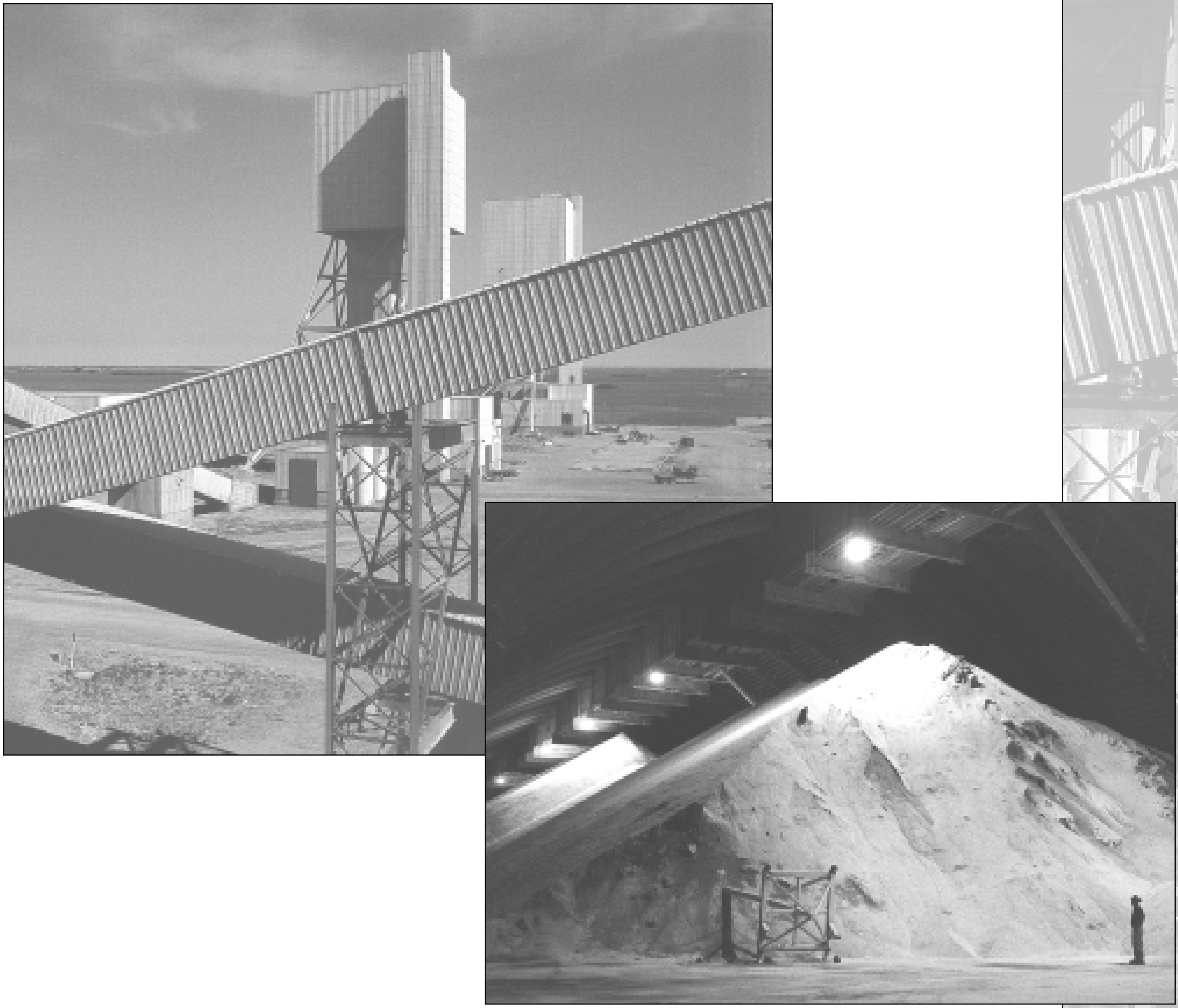
This report presents an overview of the energy consumption, energy use by type, energy-related greenhouse gas emissions and the relationship between energy efficiency and rate of production for the Canadian potash industry. The report also presents inter-mine comparisons of energy consumption for the nine conventional mining/milling operations. In addition to the energy consumption benchmarking data, a summary of energy management practices and areas of opportunity for improvement is presented.

Methodology

The data were collected from each of the operations through a request for information, which was sent to a representative at each site. Following receipt of the data, a follow-up discussion was conducted to ensure comparability. An on-site meeting was held at each potash operation to discuss and verify the energy consumption data.

A diagnostic session on energy management practices was conducted at 10 of the 11 operations using the One-2-Five® Energy methodology.

Greenhouse gas emissions data were also produced based on the energy consumption data and the emissions conversion factors for each type of energy. The conversion factors used are provided in Appendix A.



Benchmarking Results

The results of the benchmarking project are presented in two sections.

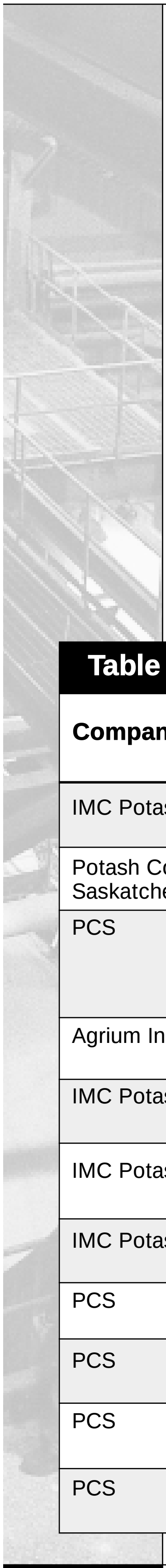
Section 1 – Potash Industry Energy Consumption: This section provides an overview of the data for the entire industry, describes the operations involved in the project and presents data on type of energy consumed and greenhouse gas emissions for the sector.

Section 2 – Inter-Plant Comparisons: This section presents inter-plant comparison data for the nine conventional mining operations and the eight conventional milling operations.The inter-plant comparison data is not presented for the two solution mines and is only partially presented (underground mining portion) for PCS’s Cory Division (thermal leach processing energy data are not presented).The energy data for the higher energy intensity operations include only three data points that represent only two companies and therefore have not been presented individually.

Factors That Influence Energy Intensity

The data presented in the section on inter-plant comparison demonstrate a snapshot of the state of energy intensity for Canadian potash operations for the years 2000 and 2001. There are many factors that influence the energy intensity of each operation, and no attempt has been made to correct for differences related to the following:

- age of plant and equipment
- specific types or design of equipment within each operation
- requirements for dewatering
- underground distance to active mining
- specific operational requirements (i.e., placing mine tailings underground)
- level of production (i.e., no provisions made for shutdowns or production cutbacks)



Section 1: Potash Industry Energy Consumption

Canadian Potash Operations

There are 11 potash production facilities currently operating in Canada. It is recognized that no two of the 11 facilities are exactly the same, but to accurately present the energy benchmarking data for the potash industry, it is necessary to look at two sub-groups. Of the 11 potash mines, nine are conventional underground mining operations, which means that there is underground equipment and personnel. The other two are solution mines, which involve pumping heated water through the ore body to dissolve the potash and pumping the resultant brine solution to a refinery for extraction. Solution mining is a more energy intensive process than conventional mining.

When it comes to processing the ore from the nine conventional mines, eight of the operations use a conventional mechanical/ flotation process; one of the operations uses a thermal leaching process, which is more energy intensive. A list of potash operations in Canada and a brief description of each is provided in Table 1.

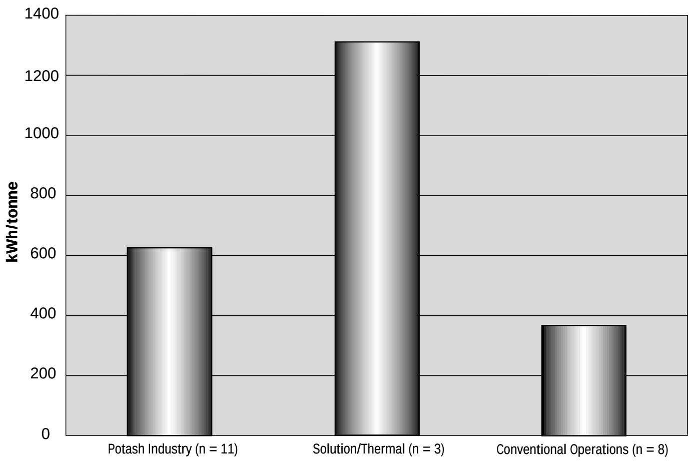
Table 1. Canadian Potash Operations

Company	Location	Type of Operation	Energy Intensity	Production Capacity (tonnes K_2O/year)
IMC Potash	Belle Plaine, Saskatchewan	Solution mine	Greater than 1000 kWh/tonne	1 361 000
Potash Corp. of Saskatchewan Inc. (PCS)	Patience Lake, Saskatchewan	Solution mine	Greater than 1000 kWh/tonne	630 000
PCS	Cory, Saskatchewan	Conventional mine / thermal leach ore processing	Greater than 1000 kWh/tonne	830 000
Agrium Inc.	Vanscoy, Saskatchewan	Conventional mine/mill	Less than 500 kWh/tonne	1 092 000
IMC Potash	Colonsay, Saskatchewan	Conventional mine/mill	Less than 500 kWh/tonne	815 000
IMC Potash – K1	Esterhazy, Saskatchewan	Conventional mine/mill	Less than 500 kWh/tonne	Combined capacity of 2 325 000
IMC Potash – K2	Esterhazy, Saskatchewan	Conventional mine/mill	Less than 500 kWh/tonne	
PCS	Allan, Saskatchewan	Conventional mine/mill	Less than 500 kWh/tonne	1 150 000
PCS	Lanigan, Saskatchewan	Conventional mine/mill	Less than 500 kWh/tonne	2 335 000
PCS	Rocanville, Saskatchewan	Conventional mine/mill	Less than 500 kWh/tonne	1 400 000
PCS	Sussex, New Brunswick	Conventional mine/mill	Less than 500 kWh/tonne	479 000

Average Energy Consumption

Average energy consumption (kWh/tonne), shown in Figure 1, is expressed as an overall total for the potash industry, separately for the solution/thermal leach operations, and for conventional mine/mill operations. For the years 2000 and 2001 (combined average), approximately 20 percent of Canadian potash was produced using the solution mining/thermal leach (higher energy intensity) processes.

Figure 1. Average Energy Consumption (2000/2001 combined average)



n = number of operations

Energy Use By Type

Natural gas represents the largest source of energy type for the Canadian potash industry, representing almost 80 percent of total energy consumed annually. Electricity makes up about 20 percent of the energy consumption on a total MWh basis. The remainder of the energy consumed is in the form of diesel, propane, gasoline or fuel oil. Figure 2 shows the distribution of annual energy consumption by type for 2001. Energy consumption by type for 2000 was the same as for 2001.

Figure 2. Energy Use by Type, 2001

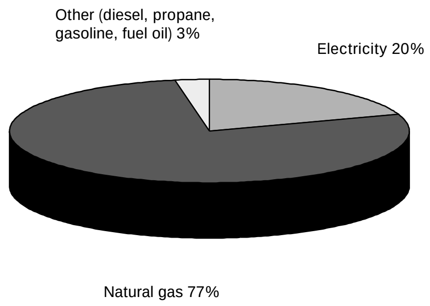
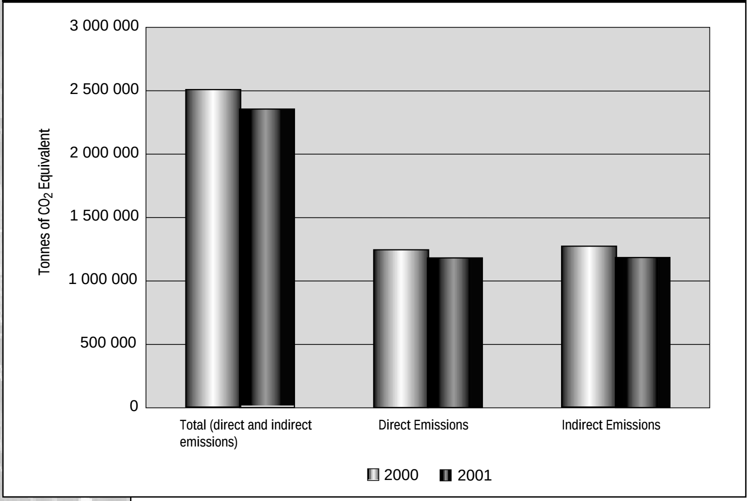


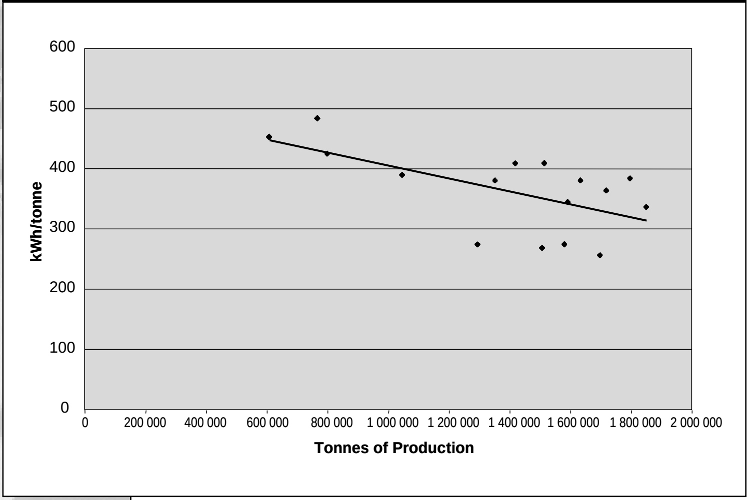
Figure 3. Greenhouse Gas Emissions for Canadian Potash Operations



Greenhouse Gas Emissions

Total greenhouse gas (CO_2 equivalent) emissions from Canadian potash operations are shown in Figure 3. Direct emissions are primarily from the combustion of natural gas fuel. Indirect emissions are calculated based on the use of electricity and Environment Canada's published greenhouse gas emissions intensity of electricity generation by province/territory (provided in Appendix B).

Figure 4. Energy Consumption vs. Production



Energy Consumption vs. Production

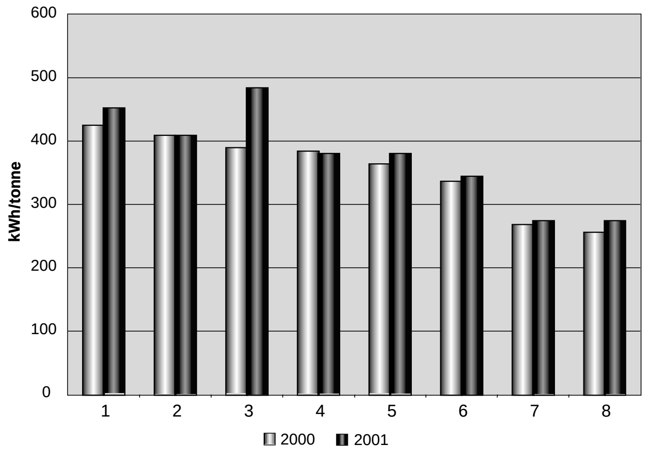
Potash operations generally operate at their greatest efficiency if they are producing at or close to their design capacity. Figure 4 shows the correlation between production (2000 and 2001 data for eight conventional mine/mill operations) and energy consumption per unit of production. The slope of the trend line clearly demonstrates that as production increases, the energy required per tonne of production decreases. This correlation illustrates the point that efficiency gains associated with improvements to the operations cannot be easily separated from efficiency gains or decreases associated with a change to the level of production.

Section 2: Inter-Plant Comparisons

Total Energy Consumption – Conventional Mining/Milling

Total energy consumption is reported in Figure 5 for the eight conventional potash mining/milling operations. The energy consumption numbers include total natural gas, electricity, diesel and gasoline. The data range from a low of 255 kWh/tonne to a high of 483 kWh/tonne, with the highest energy-efficient operation consuming 53 percent of the energy used for the lowest-efficiency operation.

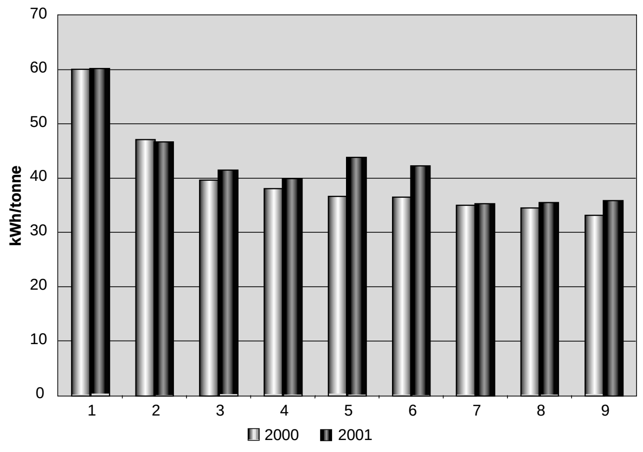
Figure 5. Total Energy Consumption



Average (kWh/tonne)	High (kWh/tonne)	Low (kWh/tonne)	Low:High (percent)
364	483	255	53

Note: In all charts, plants are ordered from highest to lowest; hence, there is not necessarily any continuity in numbering between charts.

Figure 6. Underground Electricity Consumption

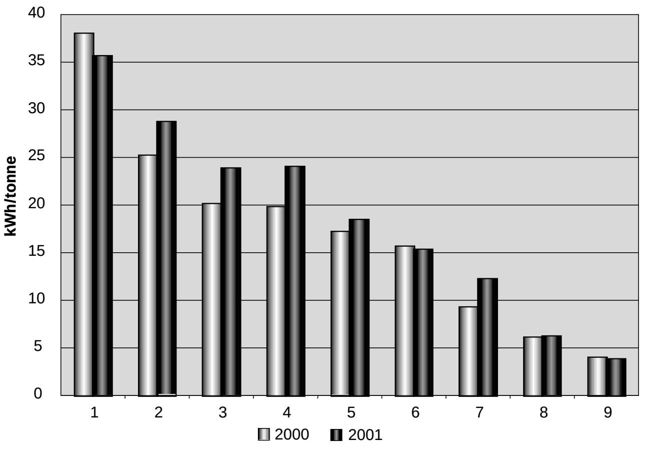


Underground Electricity Consumption – Conventional Mining

Underground electrical energy consumption is shown in Figure 6 for the nine conventional potash mining operations. These companies reported electrical consumption for powering mining machines, hoisting, conveying, ventilation, lighting and dewatering. The range in the data and the difference between the highest and lowest consumption levels are summarized below.

Average (kWh/tonne)	High (kWh/tonne)	Low (kWh/tonne)	Low:High (percent)
41	60	33	55

Figure 7. Underground Natural Gas Consumption



Underground Natural Gas Consumption – Conventional Mining

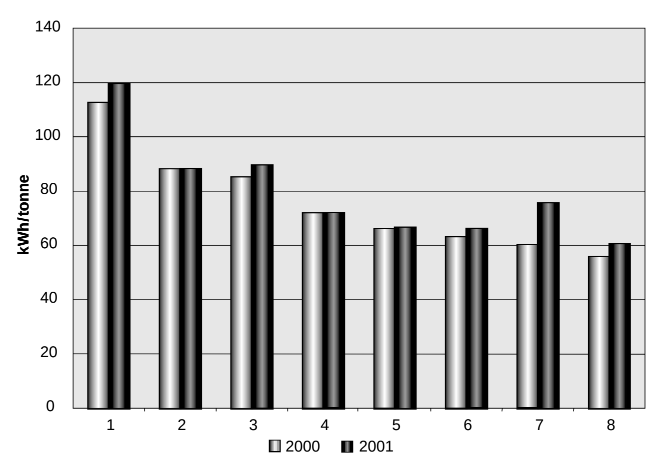
Underground natural gas energy consumption is reported in Figure 7 for the nine conventional potash mining operations. The natural gas consumption reported by potash companies for underground operations was entirely for air heating of mines. For the PCS Sussex mine, propane is used for mine air heating, which is treated in terms of natural gas equivalent. The range in the data and the difference between the highest and lowest consumption levels are summarized below.

Average (kWh/tonne)	High (kWh/tonne)	Low (kWh/tonne)	Low:High (percent)
18	38	4	11

Surface Operations Electricity Consumption – Conventional Milling

The electricity consumption of surface operations is shown in Figure 8 for the eight conventional potash milling operations. These companies reported electrical consumption for mill operations, tailings management and office/administration facilities. The range in the data and the difference between the highest and lowest consumption levels are summarized below.

Figure 8. Surface Operations – Electricity Consumption

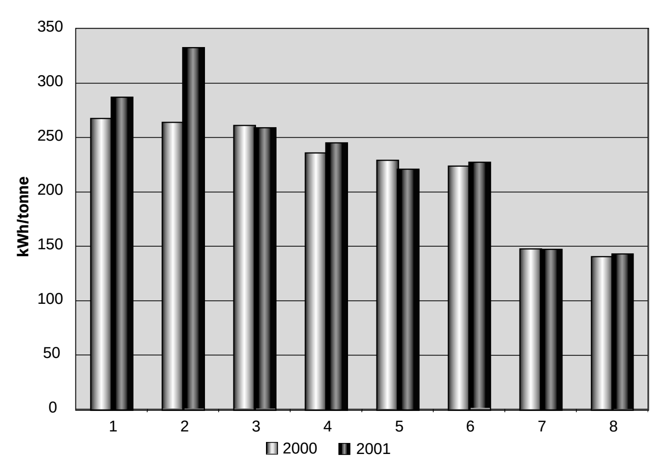


Average (kWh/tonne)	High (kWh/tonne)	Low (kWh/tonne)	Low:High (percent)
80	120	55	46

Surface Operations Natural Gas Consumption – Conventional Milling

Surface operations natural gas energy consumption is shown in Figure 9 for the eight conventional potash milling operations. These companies reported natural gas consumption for building heating, steam generation and product drying. The range in the data and the difference between the highest and lowest consumption levels are summarized below.

Figure 9. Surface Operations – Natural Gas Consumption

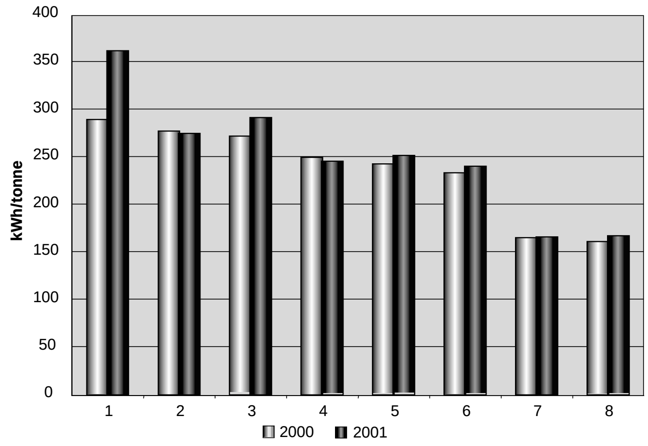


Average (kWh/tonne)	High (kWh/tonne)	Low (kWh/tonne)	Low:High (percent)
227	323	142	43

Total Natural Gas Consumption – Conventional Mining/Milling

Total natural gas energy consumption is shown in Figure 10 for the eight conventional mining/milling operations. These companies reported total natural gas consumption for mine air heating, building heating, steam generation and product drying. The range in the data and the difference between the highest and lowest consumption levels are summarized below.

Figure 10. Total Natural Gas Consumption

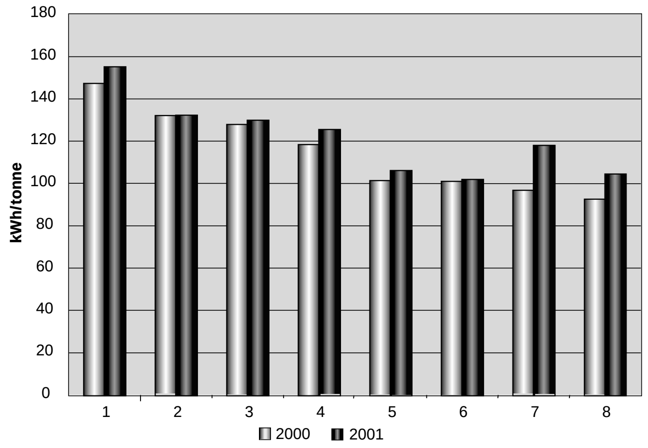


Average (kWh/tonne)	High (kWh/tonne)	Low (kWh/tonne)	Low:High (percent)
242	360	160	44

Total Electricity Consumption – Conventional Mining/Milling

Total electricity consumption is shown in Figure 11 for the eight conventional mining/milling operations. These companies reported electrical consumption for powering mining machines, hoisting, conveying, ventilation, lighting, dewatering, mill operations, tailings management and office/administration facilities. The range in the data and the difference between the highest and lowest consumption levels are summarized below.

Figure 11. Total Electricity Consumption



Average (kWh/tonne)	High (kWh/tonne)	Low (kWh/tonne)	Low:High (percent)
120	155	92	59

Energy Management Practices

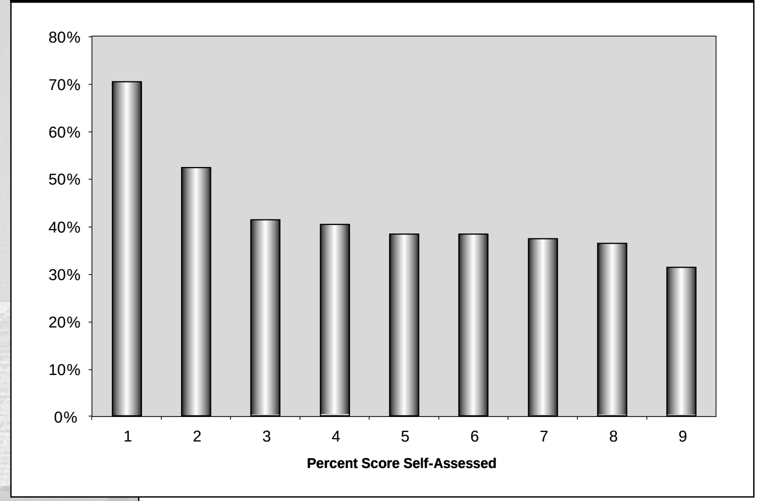
A unique aspect of the potash industry benchmarking project was the analysis of energy management practices that was completed using the One-2-Five® Energy diagnostic program at 10 of the 11 sites.

In the facilitated sessions, each operation assessed its level of development and implementation in the 10 key areas of importance for driving sustainable improvement in energy efficiency and energy cost reduction. The key areas assessed were as follows:

- Leadership – demonstrated commitment from the senior management team
- Understanding – understanding the opportunities that exist within the operation for energy savings
- Planning – developing plans for improvement that are backed up by key performance indicators to track progress
- People – making the people that utilize energy accountable for their usage as well as investing in people (training) and resource availability
- Financial management – reviewing capital and operating budgets in relation to energy management
- Supply management – assessing how energy is purchased in a competitive market as well as reviewing mechanisms employed to ensure a high level of quality and reliability
- Operations and maintenance – ensuring that energy management issues are incorporated into operating and maintenance procedures
- Plant and equipment – establishing guidelines and evaluations of new designs and innovations to enable energy efficiency to be optimized
- Monitoring and reporting – ensuring that the right energy flows are metered and that usable reports are developed in order to track and proactively manage energy
- Achievement – assessing how the operations are performing against established targets and reviewing projects to ensure that the right outcomes are achieved

The diagnostic sessions were conducted by an accredited facilitator and involved three to eight site personnel. Participants varied from site to site but were drawn from the following areas of responsibility: site or general manager, mine manager or superintendent, mill manager or superintendent, energy manager, maintenance manager, environmental manager and financial manager/accountant.

Figure 12. One-2-Five® Energy Diagnostic Session Results

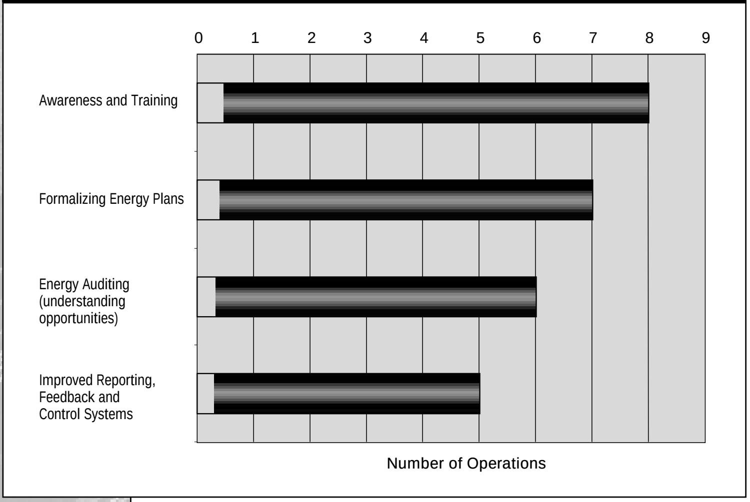


Results of One-2-Five® Energy Sessions

The results shown in Figure 12 represent the current state of development of energy management systems and processes at Canadian potash operations using the One-2-Five® Energy methodology. The average self-assessment score for Canadian potash operations was 43 percent; the international average for mining operations (36 sites) is 27 percent. This gives an indication that the sector overall is outperforming the international mining community in this regard.

The results of the diagnostic sessions are helpful in assessing the overall status of energy management practices in the sector but are more useful as a tool to assess the areas of greatest opportunity for improving energy management programs and driving sustained performance improvement.

Figure 13. Key Areas Identified with the Greatest Potential for Improvement



Areas of Potential Opportunity

Each One-2-Five® Energy session identifies four specific aspects of an energy management program that, if further developed, would bring the greatest value to the companies' overall energy performance. Figure 13 highlights the areas identified most consistently in the sessions as being in the top four (out of 22) elements, representing the greatest potential for improvement.

A brief description of each of the areas identified in Figure 13 is provided in the following.

Awareness and Training

An area that may produce immediate results is raising the general awareness of energy conservation across the organization. Raising awareness of energy across the site can be an effective tool to help identify and drive many of the lower-cost savings opportunities associated with behavioural issues. It essentially develops a much broader network of personnel able to at least be aware of energy as an issue, and many unexpected but useful suggestions can result as everyone begins to understand what they can do to control energy waste. Effective programs typically use multiple communications methods – a few suggestions are newsletters, screen savers, intranets and posters. Best results are often achieved by educating personnel on how they can save energy at home, where it affects their own pocket. Awareness of energy and good energy practices are then translated to the workplace.

Formalizing Energy Plans

Establishing an energy plan is an exercise that can effectively drive both a strategic and action-oriented program. Typically, a three-year strategic plan supported by a one-year budgeted action plan is an excellent start. The energy planning can develop action items that arise from recent energy reviews or audits and the One-2-Five® Energy diagnostic. Inclusion of shorter-term actions (e.g., 90-day plans) that have defined outcomes will help maintain focus and realize early (and visible) benefits from energy management.

Energy Auditing (Understanding Opportunities)

All sites have undertaken energy management projects in the past, but in many cases there has not been a formal approach to quantifying the main areas of energy use and identifying and prioritizing the opportunities for savings. Conducting an energy baseline study of operations from a comprehensive perspective may give the organization insight into opportunities for cost control beyond the already-captured "low-hanging fruit."

Improved Reporting, Feedback and Control Systems

Most sites indicated that they had adequate systems in place to meter and monitor energy consumption (seven sites regularly monitor the energy use of major facilities, cost centres and energy intensive end-users using metered data). The area identified for potential improvement is in the management of the information for effective reporting and feedback systems, ensuring that variances in energy performance are identified and acted on. One practical way to progress in this area is to ensure that accountabilities for energy performance are correctly established and that operations personnel use the information to design their own reports.

Appendix A: Conversion Factors

Conversion Table

To Convert	To	Multiply By
kWh	Megajoules	3.6
kWh	Gigajoules	0.0036
kWh	m^3 (natural gas)	0.0966
kWh	Litres (diesel)	0.0931
kWh	Litres (gasoline)	0.0994

Conversion Factors for Greenhouse Gas Emissions From Fuels

To Convert	To	Multiply By
Natural gas (GJ)	Tonnes of CO_2 equivalent	0.0513
Diesel (litres)	Tonnes of CO_2 equivalent	0.00276
Gasoline (litres)	Tonnes of CO_2 equivalent	0.00249
No. 2 fuel oil (litres)	Tonnes of CO_2 equivalent	0.00284

Source: Canada’s Greenhouse Gas Inventory 1990–2000. Greenhouse Gas Division, Environment Canada (June 2002).

Appendix B: Greenhouse Gas Emissions From Electricity Generation By Province/Territory

Electricity Generation and Greenhouse Gas Emissions Details for Canada[1]

Sources	**Average Intensity[2]** *g CO_2e/kWh*				
	1995	**1996**	**1997**	**1998**	**1999**
Newfoundland and Labrador	33	32	29	23	22
Prince Edward Island	1660	2320	1460	4070	1890
Nova Scotia	715	693	715	724	727
New Brunswick	21	17	18	74	52
Quebec	1.6	1.6	1.8	9.0	5.8
Ontario	121	137	173	233	237
Manitoba	6.8	10.5	6.9	30.3	19.0
Alberta	939	930	957	944	902
Saskatchewan	857	860	888	891	876
British Columbia	45.7	10.6	17.2	27.2	18.6
Yukon, Northwest Territories and Nunavut	357	341	371	359	341
Canada	**184**	**177**	**198**	**225**	**214**

Sources:
Greenhouse Gas Division, Environment Canada
Electricity generation data from Statistics Canada's *Quarterly Report on Energy Supply–Demand in Canada*, Cat. No. 57-003

Notes:
[1] Data presented include both utility- and industry-generated electricity intensities.
[2] Accuracy of greenhouse gas intensity is diminished in cases where industrial cogeneration is significant.

Notes