Continuous Energy Performance Improvement (CEPI): Industrial Benchmarking Results by Region and Sector

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ABSTRACT

This paper illustrates the state of international industrial energy performance benchmarking using the results obtained from ICF's Continuous Energy Performance Improvement (CEPI) assessments. CEPI assessments have been used in industrial facilities to assess energy performance through benchmarking implementation of technical and management best practice, and to identify the best opportunities for energy efficiency investment.

The assessment of 350 industrial facilities in 15 sectors and 6 countries in the Americas and Asia indicates that there is a significant potential to implement best practices to improve energy efficiency. The largest opportunity applicable to implementation of technical best practices (TBPs) exists in the following energy end-use: motors/fans/pumps and HVAC/air systems; the largest opportunity applicable to energy management best practices (MBPs) exists in the following categories: capacity building, and organization and accountability. The assessment also indicates a close relationship between the extent to which MBPs are implemented and the implementation of TBPs. This correlation tends to be sector-specific and is generally the same in different Canadian provinces. This sector-specific correlation is influenced by the profile of facility sizes (in terms of energy use) of the sector in a province.

Understanding these trends can assist a jurisdiction to prioritize its efforts to increase the competitiveness of its industry.

Overview of Continuous Energy Performance Improvement (CEPI)

Approach

Over the course of a decade of assessing energy management opportunities in industry, ICF has developed a robust, consistent and proven approach which is focused on establishing the conditions in facilities that support investments in energy efficiency. From industry experience, "one-off" energy management performance assessments have a limited degree of success in triggering energy efficiency project implementation and sustained savings. This is because such actions are isolated from the core strategic and operational priorities and functions of the organization.

The approach is referred to as Continuous Energy Performance Improvement (CEPI), as illustrated in

Figure **1**. The approach includes an integrated energy performance benchmarking assessment, which leads to the identification of opportunities and the development of an action plan to implement the opportunities. The energy performance assessment comprises the first of three steps of this four-step continuous improvement cycle and addresses the implementation of both management and technical best practices.

Figure 1. Facility's Continuous Energy Performance Improvement (CEPI)

Integrated Performance Benchmarking and Assessment

The assessment and opportunity identification stages in the continuous improvement cycle are carried out using the ICF integrated performance benchmarking approach. Energy performance benchmarking is defined as a continuous improvement technique that compares and analyzes various energy and resource metrics and practices to determine best practices which are then emulated by an organization. ICF has developed state of the art energy performance benchmarking, which evolved from what was primarily an empirical focus on energy use to a more broad and integrated approach that includes the following three main elements:

- *Energy use performance:* This refers to development of a metric for energy use, and is often expressed per unit of production output, as well as a profile of energy use according to key end-uses.
- *Technical Best Practices (TBPs):* This refers to production systems, efficiency measures, equipment, and/or methods or practices that improve energy performance and which result in an overall improvement/reduction in energy use per unit of production. The objective of the technical best practices analysis is to determine the percent of applicable best practices currently being utilized by the participating industrial facility.
- *Management Best Practices (MBPs):* Management best practice is illustrated by a high level of commitment, awareness, organization and action in support of energy management. The management assessment includes practices that improve energy performance and include approaches from international models, such as ISO 50001[1] energy management practice standard.

[1] Standards Council of Canada (2011). *CAN/CS- ISO 50001:11: Energy Management Systems – Requirements with guidance for use.*

Overview of CEPI Tools and Methodology

The key components of the CEPI approach are the TBP and MBP assessment tools, which are supported by extensive databases of best practices. The assessment tools provide input to the report card and action plan development tools. The action plan is developed in coordination with the facility using the results of the assessment.

The management best practices address the "people" element and the technical best practices address the "technology" element in managing energy. Each of these key components, as well as the methodologies used, is described below.

Technical Best Practice Assessment

The categories of data collection in the TBP assessment include:

- Annual energy use amounts and costs, including for non-purchased fuels, (including self-generation of steam or electricity.)
- Quantity of annual raw fuel or feedstock input, if applicable.
- Capacities, quantities, run time hours, and fuel requirements of plant equipment.

The energy use, raw material use and production data are used to assist with interpretation of the TBP assessment and to derive energy intensity benchmarks for individual plants. Energy intensity benchmarks are very specific to a plant and can only be compared amongst plants with similar processes. In the analysis presented here, energy intensity is not compared amongst different plants or sectors, due to the plant specific nature of energy intensity. The benchmarking comparison in this analysis focuses on the implementation and TBPs and MPBs, as described in section 3.6 below.

The main energy end-uses considered in the TBP assessment include:

- *System*, which refers to the total facility as an end-use and is relevant to opportunities that are applicable to the overall facility and not only specific end-uses. Examples include energy management information systems and sub-metering.
- *Direct-fired heating systems*, which refer to heating systems where the process material is directly heated without use of a heat transfer medium. Examples include ovens, furnaces and kilns.
- *Indirect process heating systems,* which refer to heating systems where a heat transfer medium is used, such as steam and water. Examples include boiler and steam systems.
- *Motive power systems*, which refer to fans, pumps, conveyors, and other motors.
- *Air or gas compressors*, which refer to both utility compressed air systems and process gas compressors
- *Cooling and refrigeration,* which refers to process cooling systems, such as refrigeration loops, cooling towers, etc.
- *Process specific systems*, which refer to energy use systems that are not cross-cutting over different sectors, but are specific to individual sectors, such as distillation columns, electroplating, etc.
- *HVAC and Air system*, which refer to comfort heating, ventilation, air conditioning, and comfort air supply systems.
- *Lighting*, which refers to all lighting systems in the process areas.

- *Other,* which refers to all the energy end-uses not included in the previous end-use. categories, such as on site transportation and forklifts

Management Best Practice Assessment

The management best practices assessment was developed after an assessment of energy management system models from Europe, Australia and New Zealand, USA, Canada and the ISO 50001 standard. This MBP assessment is completed in a workshop setting or interviews with representatives from different levels of the organization that are responsible for energy management systems in the facility. The MBP assessment is organized by the following categories:

- Energy management policy and planning
- Organization and accountability
- Project financing
- Project management
- Monitoring
- Reporting and communication
- Training and capacity building
- Recognition of achievement

Technical and Management Best Practice Databases

The assessment tools are supported by extensive databases of international best practices for energy management. The technical and management best practice databases used in the industrial benchmarking include over 300 best practices. These databases include energy efficiency opportunities applicable to:

- Cross-cutting end-uses
- Sector-specific processes
- Specific countries and industries

The databases were developed with input from experts who work in industrial facilities, universities, national research institutions, industrial associations, consulting companies, and energy utilities.

Data

The energy data collection tools, and management and technical best practice assessment tools used in the CEPI approach were completed through a combination of on-site assessments and remote assessments. Energy use and equipment data, or metered data (where available), were used to develop energy balances and define the energy use by end-use for each facility. The energy use by end-use and saving potential associated with each opportunity were used to determine energy savings estimates for the facility. This paper only focuses on the opportunities and trends to highlight the improvement opportunities to enhance competitiveness, and not the actual potential energy savings quantity.

Scoring of Best Practices Implementation

The extent to which technical and management best practices are currently implemented in a plant is quantified using a scoring system to convert the information collected through the TBP and MBP assessment tools into implementation rates. In the scoring system each response is given a score, according to the following scoring system:

- No implementation or not applicable: score = 0
- Partially adopted: score = 1
- Fully adopted: score = 2
- Fully adopted with measurement control (continuous improvement): score = 3 [only applicable to TBPs and not applicable to MBPs]

The maximum total score is defined as the total number of applicable best practices times the maximum possible score for that measure. Best practices that are not applicable to a particular plant are not included in the calculation of the maximum possible score for a plant. Scores are summarized by energy use area, with each best practice receiving an equal weight in the overall score.

In terms of TBPs, the benchmarking is an assessment of the implementation of technical best practices, which are technically feasible to be implemented at the plant. The TBP implementation score for a plant is an indication of the applicable best practices that are implemented at the plant. This means that scores from different plants and different sectors can be compared with each other, because the scores are not dependent on the specific processes at the plant, unlike energy intensity benchmarking that is dependent on the processes at the plant. The same comparison is applicable to the MBP benchmarking. The MBP scores are an indication of the implementation of applicable best practices at the plant and scores from different plants and sectors can be compared with each other, because it is not process dependent.

Output Tools

Once the data is analyzed, it is typically presented in two ways: each participating facility receives a report card. The report card includes the following elements:

- Overall fuel intensity and breakdown by fuel type, cost, and equipment type.
- Energy and fuel cost intensities, with a comparison to international best practice energy intensity for the facility's location.
- Technical best practice measure implementation scores by energy end-use.
- Estimated potential savings (energy, fuel cost, greenhouse gas savings) for each technical best practice opportunity identified, calculated using facility data, as well as an assessment of relative implementation difficulty and cost.
- Management best practice measure implementation scores by management category
- Useful references for best practice implementation.

The prioritized opportunities are developed into an action plan for implementation. The action plan is a working document and the draft version is developed in consultation with the company. The action plan serves as a project management tool to define the next steps and to track progress of the implementation of the actions for the next steps. This paper does not focus

on the report card and output tools, but focuses on the implementation levels of the TBPs and MPBs, which forms the input of the output tools.

Energy Performance Benchmarking Results

Implementation of Technical and Management Best Practices

The assessment phase of CEPI was applied to 350 facilities for 15 industrial sectors in six countries, located in the Americas: Canada, USA, Trinidad and Tobago; and Asia: China, India, and Bangladesh. The implementation of best practices in these 350 facilities is illustrated in Figure 2 to Figure 4.

Figure 2. Implementation of Technical Best Practices (Sample = 350)

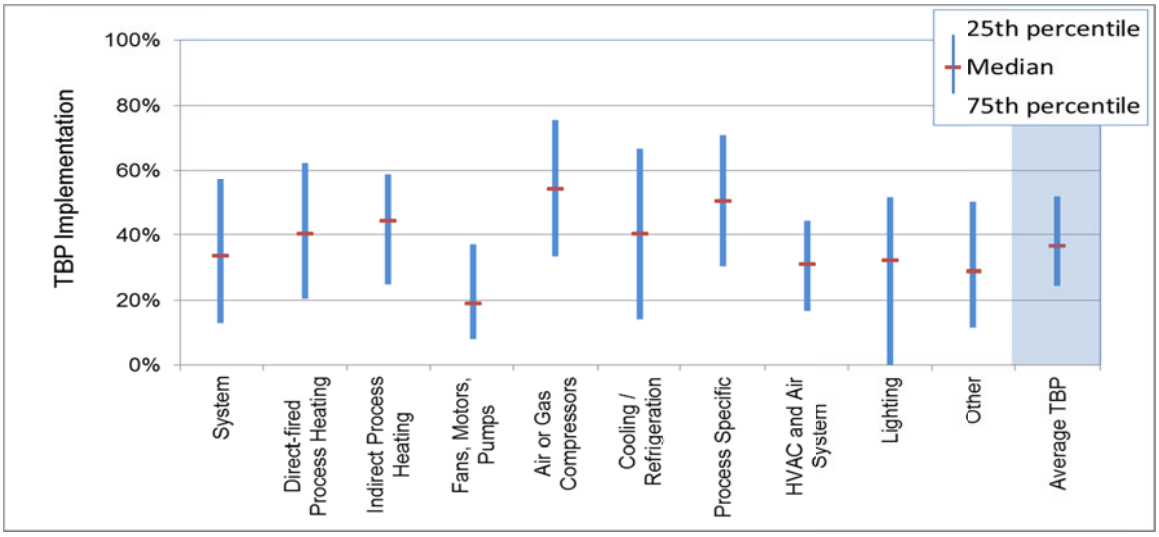


Figure 3. Implementation of Management Best Practices (Sample = 350)

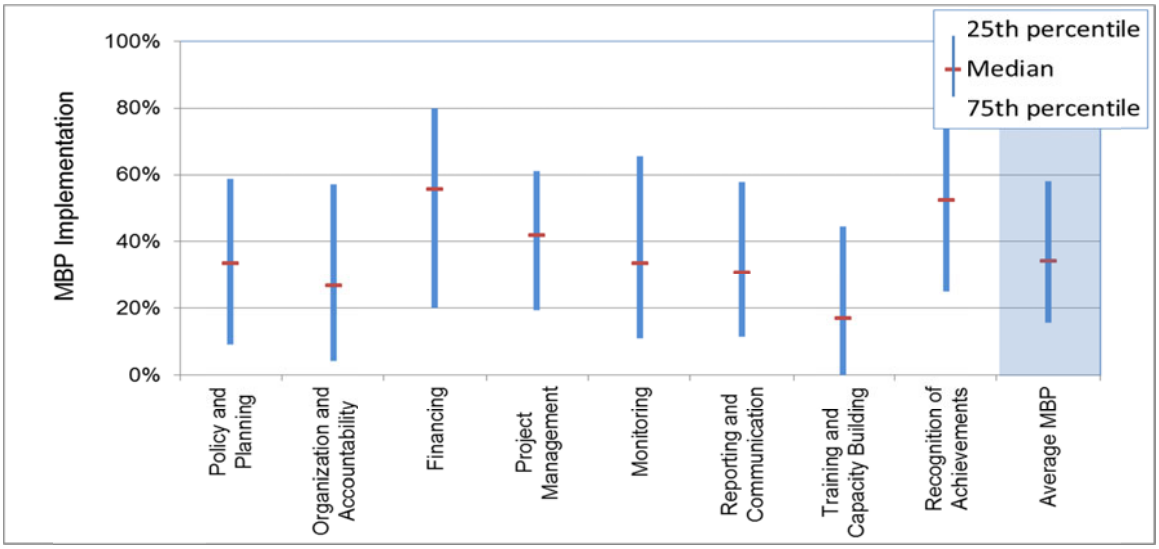
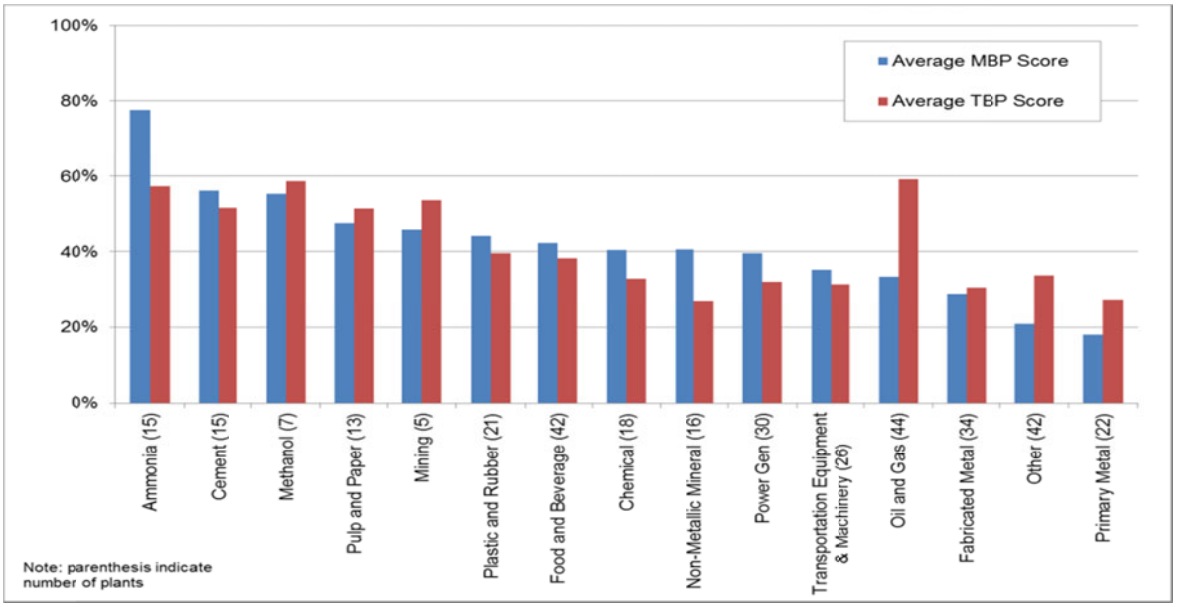


Figure 4. MBP versus TPB by Sector (Sample = 350)



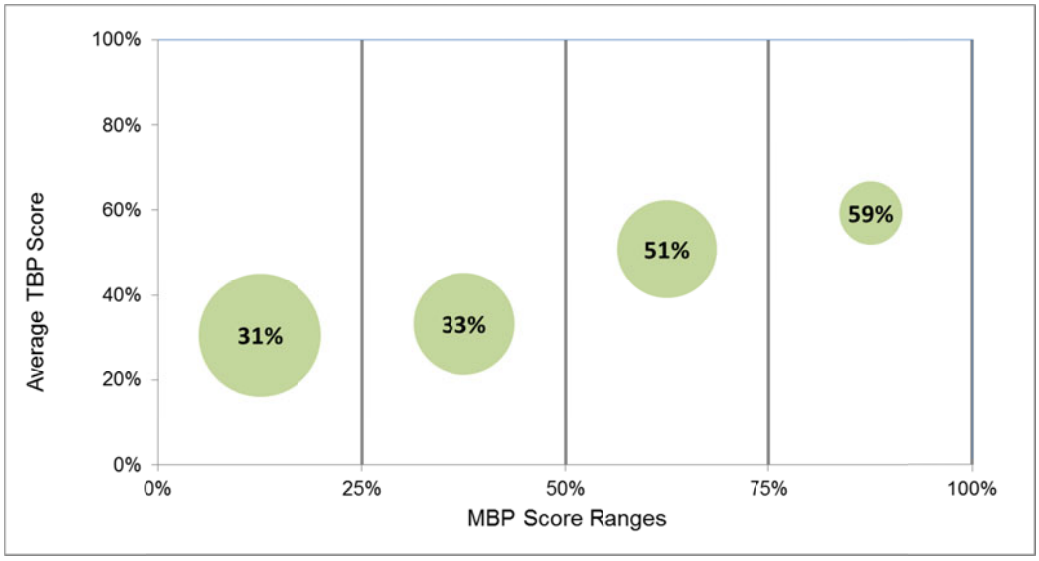
The sample of 350 industrial facilities indicates that 50% of the facilities have implemented less than 36% of the applicable technical best practices, and 75% of the facilities have implemented less that 52% of the applicable TBPs. A significant opportunity exists to improve energy efficiency by implementing the applicable TBPs not yet installed. The most significant opportunities exist with the end-uses: motors/fans/pumps and HVAC/air systems. In reference to these end-uses, 75% of the facilities have implemented less than 37% and 44% of the applicable TBPs, respectively.

In terms of management best practices, half of the facilities have implemented less than 35% of the best practices and 75% of the facilities have implemented less than 58%. Facilities seem to focus on project financing and recognition of achievement, while training and capacity building, and organization and accountability received the least amount of attention.

Comparing the average scores of TBP and MBP implementation by sector in Figure 4, a relatively close correlation is observed. A sector's average TBP and MBP are within 10% of each other, except for four sectors where the difference is larger: Other Manufacturing (13% difference), Non-Metallic Mineral (14%), Ammonia Manufacturing (20%) and Upstream Oil and Gas (26%). The top five sectors, which have implemented the most TBP and MBP practices are: Ammonia, Cement, Methanol, Pulp and Paper, and Mining.

Figure 5 presents a correlation of the average TBP and average MBP scores for all the facilities. The assessment indicates facilities that have implemented an average of between 75% and 100% of the MBPs (10% of all the facilities), has on average implemented 59% of the TBPs, while facilities that have implemented on average between 0% and 25% of the MBPs (39% of all facilities), have implemented on average 31% of the TBPs. The benchmarking of 350 plants indicates a higher implementation of MBPs correlates with a higher implementation of TBPs.

Figure 5. TBP versus MBPs (Sample = 350)



Note: The bubble size reflects the number of facilities.

Implementation of Technical and Management Best Practices

The data indicates differences in implementation of best practices by region. As an example four provinces in Canada are compared with each other and results are illustrated Figure 6. The provinces are: Alberta (AB), Ontario (ON), New Brunswick (NB) and Nova Scotia (NS). Sectors with sufficient sample sizes were compared and results are presented in Figure 7.

Figure 6. Implementation of Best Practices in Canadian Provinces

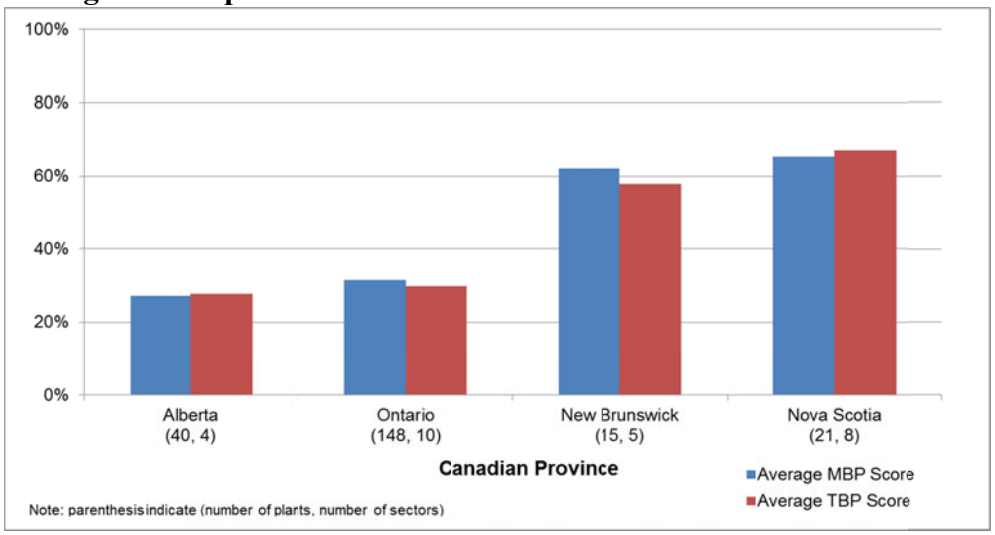
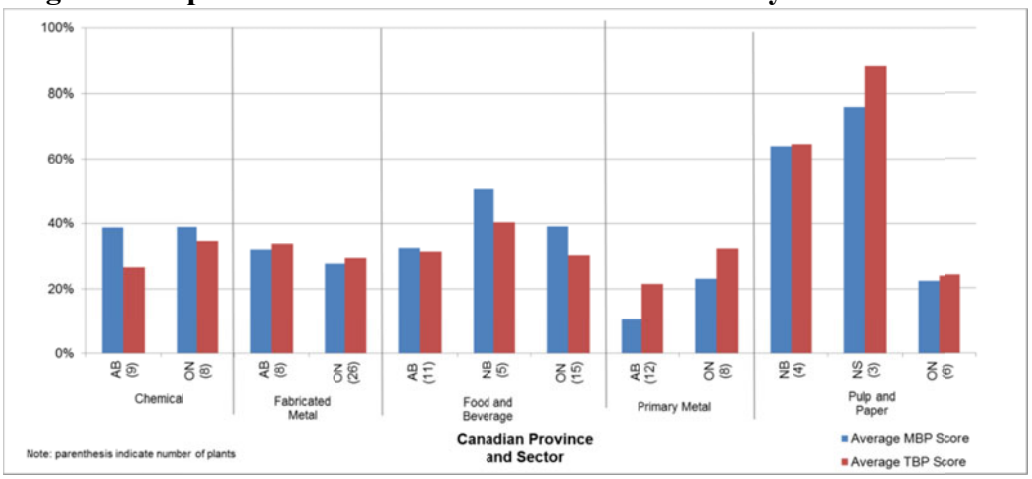


Figure 7. Implementation of Best Practices in Sectors by Canadian Provinces



The industrial sectors in the provinces of Alberta and Ontario are relatively large and consist of facilities that have a wide range of energy use, from small/medium size facilities to very large energy intensive facilities. These provinces are compared with the provinces of New Brunswick and Nova Scotia, where the industrial sectors are relatively small and are dominated by larger energy intensive industrial facilities. These differences in sizes may explain why the provinces of New Brunswick and Nova Scotia have on average significantly higher implementation of best practices compared to Alberta and Ontario. This observation is supported by an analysis of the Ontario facilities, where 75% of the facilities that have implemented more than 50% of MBPs are large plants[2] and 65% of the facilities that has implemented more than 40% of TBPs are large plants.

[2] Large facilities were defined as facilities where annual energy use is: > 20,000 MWh electricity or > 500,000 m^3 natural gas.

Figure 7 indicates the implementation of best practices in a sector is relatively similar in different provinces. For example, the difference of the average TBP score of a sector in different provinces is less than 11%, except for the Pulp and Paper sector where the largest difference is 64%. The significant difference in the Pulp and Paper sector can be explained by the size of facilities in the provinces. In the Nova Scotia and New Brunswick sample the facilities are almost all larger energy using facilities, while the Ontario sample contains a number of smaller energy use facilities.

Conclusion

The energy performance benchmarking data, based on the assessment of implementation of technical best practices and management best practices at 350 industrial facilities located in the Americas and Asia, indicates:

- A *significant opportunity to implement technical best practices*, because 75% of the facilities have implemented less that 52% of the applicable TBPs.

- The *end-uses with the most significant opportunities* are: motors/fans/pumps and HVAC/air systems. In reference to these end-uses, 75% of the facilities have implemented less than 37% and 44% of the applicable TBPs.

- A *significant opportunity to implement management best practices*, because half of the facilities have implemented less than 35% of the best practices.

- The *most significant management best practices opportunities* are in the areas of: capacity building, and organization and accountability.

- A close *correlation* exists between implementation of *MBPs and TBPs*:

    - The higher MBP score a plant has, the more likely it is that the plant has a high TBP score. Facilities that have implemented an average of between 75% and 100% of the MBPs (10% of all the facilities), has on average implemented 59% of the TBPs, while facilities that have implemented on average between 0% and 25% of the MBPs (39% of all facilities), have implemented on average 31% of the TBPs.
    - The average TBP and MBP scores of a sector are in most cases within 10% of each other.

- The five sectors which have implemented the most TBPs and MBPs are: Ammonia, Cement, Methanol, Pulp and Paper, and Mining.

- Industrial sectors tend to have *similar market penetration rates in different Canadian provinces*, except when the size of facilities affects the sector's provincial profile.

- *Larger facilities tend to have higher scores* in both the implementation of TBPs and MPBs, when compared to small and medium enterprises (SME), for example:

  - Canadian provinces that have industrial sectors where the population has a larger portion of large facilities (such as New Brunswick and Nova Scotia) have higher TBP and MBP scores compared with provinces where the population contains a smaller portion of large facilities (such as Alberta and Ontario.)

  - In Ontario 75% of the facilities that have implemented more than 50% of MBPs are large plants, and 65% of the facilities that has implemented more than 40% of TBPs are large plants.

Understanding these trends can assist a jurisdiction to focus its efforts to effectively increase its industry's competitiveness. For example:

- Assisting companies to increase the implementation of MBPs is a relatively low cost effort that will lead to the increased implementation of TBPs.

- Identifying the end-uses with the lowest implementation of TBPs and a relatively high energy use, such as motors/pumps/fans, provides a clear opportunity for targeted demand side management programs.
- Defining industry sectors with low implementation of TBPs and MBPs provides a good opportunity for targeted programs to assist these sectors to improve energy use performance and competitiveness.

  Larger facilities (in terms of energy use) are progressing well to improve performance through implementation of best practices, while the small-medium size enterprises (SMEs) are lagging and needs assistance to improve.