GUIDELINES FOR GREENHOUSE GAS MANAGEMENT FOR INDUSTRIAL EMITTERS IN NEW BRUNSWICK

New Brunswick Department of Environment and Local Government

July 2015

EXECUTIVE SUMMARY

In its 2014-2020 Climate Change Action Plan, the province of New Brunswick has established 2020 and 2050 provincial greenhouse gas (GHG) emissions reduction targets of 10% below 1990 levels by 2020 and 75% to 85% below 2001 levels by 2050. The long-term strategy and actions put forward in the plan will help New Brunswick become a province that is prepared for and resilient to the impacts of climate change and has reduced its GHG emissions while sustaining economic growth.

Industry can take a leading role in helping the province of New Brunswick achieve its targets while sustaining economic growth by implementing actions that save money, improve productivity and lower GHG emissions.

This guide has been developed to assist industrial facilities in developing and adopting a GHG Management Plan, as may be specified in their Approval to Operate, pursuant to the Air Quality Regulation, the *New Brunswick Clean Air Act*.

The document provides a detailed explanation of the considerations which can be included in a typical GHG Management Plan, along with information regarding its submission.

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GLOSSARY OF TERMS

The following words and terms used in this guidance document shall have the indicated meaning:

"Act" means the New Brunswick *Clean Air Act*;

"air" means the atmosphere but does not include the atmosphere within a building or within the underground workings of a mine;

"Approval to Operate *or* **Approval"** means an approval issued under the New Brunswick *Clean Air Act* or the regulations that has not expired or been suspended or cancelled. Every source of emissions in the province must obtain an Air Quality Approval or Approval to Operate from the Department of Environment and Local Government. The Approval specifies the operating conditions and emission limits and can be in effect for up to five years. It's against the law to violate the terms of the Approval.

"carbon dioxide equivalent unit (CO_2e)" is a unit of measure used to allow the addition of or the comparison between gases that have different global warming potentials (GWPs). Since many greenhouse gases (GHGs) exist and their GWPs vary, the emissions are added in a common unit, CO_2e. To express GHG emissions in units of CO_2e, the quantity of a given GHG (expressed in units of mass) is multiplied by its GWP;

"carbon intensity" is the average emission rate of a given pollutant from a given source relative to the intensity of a specific activity; for example grams of carbon dioxide released per megajoule (MJ) of energy produced, or the ratio of GHG emissions produced to gross domestic product (GDP).

"**carbon productivity"** is the amount of GDP produced per unit of carbon equivalent (CO_2e) emitted. It is the inverse of carbon intensity of GDP. Furthermore, when carbon is priced and emissions are restricted, GHG emissions can be viewed as an input into total factor productivity and thus consider its impact on growth along with other input factors such as labour and capital.

"CH_4" means methane;

"CO_2" means carbon dioxide;

"Contaminant" means

a) any solid, liquid, gas, micro-organism, odour, heat, cold, sound, vibration, radiation or combination of any of them, present in the environment,
   i) that is foreign to or in excess of the natural constituents of the environment,
   ii) that affects the natural, physical, chemical or biological quality or constitution of the environment, or
   iii) that endangers the health of human, plant or animal life or the safety or comfort of a human, that causes damage to property or plant or animal life

or renders them unfit for use by persons or that interferes with visibility, the normal conduct of transport or business or the normal enjoyment of life or use or enjoyment of property,

b) any pesticide or waste, or

c) anything that is designated by the Minister as a contaminant under section 7 of the New Brunswick *Clean Air Act*.

“direct emissions” means the release of specified contaminants into the atmosphere from a source;

“GHGs” means greenhouse gases;

“global warming potential (GWP)” is the relative measure of the warming effect that the emission of a specified gas has on the Earth’s atmosphere calculated as the ratio of the 100-year time-integrated radiative forcing that would result from the emission of one kilogram of a given specified gas relative to that from the emission of one kilogram of carbon dioxide;

“HFC” means hydrofluorocarbon;

“indirect emissions” means the release of specified contaminants into the atmosphere from the consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity (i.e. indirect scope 2 emissions from consumption of purchased electricity, heat or steam and/or scope 3 emissions such as those from transport-related activities in vehicles not owned or controlled by the reporting entity).

“industrial facility” means the “source” as defined below.

“Minister” means the Minister of Environment and Local Government and includes any person designated to act on the Minister's behalf;

“N_2O” means nitrous oxide;

“operator” when used with reference to a source, means the person who controls the operation of a source and includes the occupier of the real property upon or in which the source is located;

“PFC” means perfluorocarbon;

“release”, when used with reference to a contaminant or other matter regardless of form, includes the discharging, emitting, leaving, depositing or throwing of the contaminant or other matter and the doing of or the omission to do any other activity in respect of the contaminant or other matter, with the direct or indirect result that the contaminant or other matter enters the air, whether or not the contaminant or other matter previously existed in the air;

“SF_6” means sulphur hexafluoride;

"source" means any stationary property, real or personal, taken as a whole, that releases or may release any air contaminant;

"SWIM" means Environment Canada's Single Window Information Management system, which is a one-window secure online electronic data reporting system accessible at www.ghgreporting.gc.ca;

Where this Guideline uses a term defined in the Act or the Regulation, the term has the meaning set out in the Act or Regulation;

Where this Guideline uses a term defined in the SWIM system that has a meaning that is different, the term is deemed to have the meaning set out in this Guideline.

INTRODUCTION

In its 2014-2020 Climate Change Action Plan, the province of New Brunswick establish 2020 and 2050 provincial greenhouse gas (GHG) emissions reduction targets of 10% below 1990 levels by 2020 and 75% to 85% below 2001 levels by 2050. The long-term strategy and actions put forward in the plan will help New Brunswick become a province that is prepared for and resilient to the impacts of climate change and has reduced its GHG emissions while sustaining economic growth.

Industry can take a leading role in helping the province of New Brunswick achieve its targets while sustaining economic growth by implementing actions that save money, improve productivity and lower GHG emissions.

This guide has been developed to assist industrial facilities in developing and adopting a GHG Management Plan, as may be specified in their Approval to Operate, pursuant to the Air Quality Regulation, the *New Brunswick Clean Air Act*, that lowers their carbon intensity and conversely increases their carbon productivity; thereby improving their trade competitiveness. By integrating and implementing economically achievable GHG emission reduction actions and strategies, such as energy efficiency and continuous improvement, into their operations through their respective GHG Management Plan, industrial emitters in the province of New Brunswick will be able to manage their GHG emissions without reducing their industrial production.

The approved document, *Guidelines for GHG Management for Industrial Emitters*, will be updated on a regular basis and will be posted on the Department of Environment and Local Government's website at www.gnb.ca/environment.

Additional information regarding GHG Management Plans can be obtained directly from the Impact Management Branch of the NB Department of Environment and Local Government.

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ENVIRONMENT AND LOCAL GOVERNMENT
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Website: www.gnb.ca/environment

GHG MANAGEMENT PLAN OVERVIEW

A GHG Management Plan is a framework necessary to properly address GHG emissions and reduction potentials. To this end, a GHG Management Plan can help to plan capital stock turnover, manage costs, drive efficiencies, improved stakeholder satisfaction, and create greater competitive advantage for industry.

As an operating condition of their Approval to Operate, pursuant to the Air Quality Regulation, the *New Brunswick Clean Air Act*, specified operators of industrial facilities in the province of New Brunswick are now required to develop and implement a GHG Management Plan as specified in this Guideline document.

The GHG Management Plan should include the following elements:

i) Introduction and past GHG reduction initiatives;

ii) Annual GHG emissions from operations;

iii) Contribution to the total provincial GHG emissions;

iv) Benchmarking;

v) GHG reduction targets;

vi) GHG reduction strategy;

vii) Baseline emissions;

viii) Boundary considerations;

ix) Provincial policy or regulation considerations;

x) Continual improvement; and,

xi) GHG monitoring and reporting.

Further, operators of industrial facilities are encouraged to include the following considerations in their respective GHG Management Plans:

xii) Linkages with parallel pollution reduction opportunities;

xiii) GHG validation and verification; and,

xiv) Research and Innovation.

Additional details on each of these considerations are given in the next sections of this Guideline document.

Industrial emitters are encouraged to meet the *Guidelines for GHG Management for Industrial Emitters in New Brunswick* to the best of their ability recognizing that some industries are better able to incorporate the full scope of the Guidelines while others may not be able to. Further, it is recognized that newer industrial facilities which have incorporated best available technology economically achievable (BATEA) may have fewer emission reduction potentials than existing facilities.

Operators who are responsible for more than one industrial facility requiring a GHG Management Plan as per its Approval to Operate, pursuant to the Air Quality Regulation, the *New Brunswick Clean Air Act*, may choose to tie the individual GHG Management Plans into an over-arching Corporate GHG Management Plan. However, this does not preclude an industrial facility from requiring a GHG Management Plan as per its Approval to Operate, pursuant to the Air Quality Regulation, the *New Brunswick Clean Air Act*.

It is to be noted that the GHG Management Plan along with any Annual Progress Report submitted to the Department of Environment and Local Government will be made available should the public request them, such as per the *Right to Information and Protection of Privacy Act* (RTIPPA).

Once completed, the operator shall submit the GHG Management Plan by mail to:

IMPACT MANAGEMENT BRANCH
ENVIRONMENT AND LOCAL GOVERNMENT
P. O. BOX 6000
3RD FLOOR, MARYSVILLE PLACE
FREDERICTON, NB E3B 5H1

While the submitted GHG Management Plans will last the time period of the industrial emitter's valid Air Quality Approval to Operate, it can be updated at any time if needed by the industrial emitter.

GHG MANAGEMENT PLAN CONSIDERATIONS

In this section, additional details are provided for each of the considerations which typically forms a GHG Management Plan.

Introduction and Past GHG Reduction Initiatives

In the introduction of the GHG Management Plan, the operator should briefly describe the industrial facility and is encouraged to include a brief discussion of past GHG reduction initiatives that the facility has incorporated in the past 5 to 10 years and how these initiatives have reduced the facility's emissions in relation to its 1990 levels, or since its first year of operation if the facility started operating after 1990.

Annual GHG Emissions from Operations

In the GHG Management Plan, the operator shall measure and report the annual direct GHG emissions measured in carbon dioxide equivalent units (CO_2e) for each of the following greenhouse gas and gas species:

i) Carbon dioxide (CO_2);

ii) Methane (CH_4);

iii) Nitrous oxide (N_2O);

iv) Hydrofluorocarbons (HFCs);

v) Perfluorocarbons (PFCs); and,

vi) Sulphur hexafluoride (SF_6).

from the operation of the industrial facility of which the operator controls, including direct emissions from combustion sources, industrial processes, venting, flaring, fugitive, on-site transportation, waste, and wastewater.

In addition, the operator shall report the total annual direct GHG emissions measured in carbon dioxide equivalent units (CO_2e) from the operation of the industrial facility of which the operator controls for the sum of the greenhouse gas and gas species listed above.

The annual direct GHG emissions shall be calculated or determined using one or more of the applicable methodologies, emission factors, equations and calculations that are consistent with Environment Canada's GHG Reporting Program (GHGRP) Guidelines, available at www.ghgreporting.gc.ca.

It is to be noted that, in order to be consistent with the EC GHGRP Guidelines, CO_2 emissions from the combustion of biomass is collected but not included in the industrial facility's total or threshold calculations; however, methane (CH_4) and nitrous oxide (N_2O)

emissions from biomass must be included in the reporting threshold calculation, and reported as part of the industrial facility's GHG emission totals.

In regards to emissions from electricity consumption, the operator shall report the total amount of GHG emissions resulting from the generation of electricity generated at the industrial facility, even if some of the resultant electricity is exported off site. For their parts, the indirect emissions associated with the import of electricity (not generated at the industrial facility) should not be reported as direct emissions as per the EC GHGRP Guidelines.

In regards to scope 2 and/or 3 indirect emissions, these are not required reporting since they are not part of the EC GHGRP Guidelines. However, in consideration of electricity efficiency improvements or other GHG emission reduction based measures, industrial emitters may choose to account and report separately scope 2 and/or 3 indirect emissions reductions as part of their GHG Management Plans in order to provide greater context of their GHG emission reduction activities and targets.

Contribution to the Total Provincial GHG Emissions

In the GHG Management Plan, the operator should consider estimating the industrial facility's contribution to the annual total provincial GHG emissions. This information serves to assess the portion of the provincial GHG emissions that are attributed to the industrial facility of which the operator controls.

For their parts, the annual total provincial GHG emissions can be found on the New Brunswick Climate Change Dashboard website, available at: http://logixml.ghgregistries.ca/New%20Brunswick%20Dashboard%20Solo/

Benchmarking

The operator should consider evaluating the industrial facility's GHG emission intensity and/or the source's energy intensity as per the best practices of the industry to which it belongs (i.e. per unit of output production).

Further, the operator should consider discussing how the industrial facility's GHG emission intensity and/or the industrial facility's energy intensity compares to other similar industrial emitters within the industry sector to which it belongs.

Information on best practices and benchmarking can be found on the Canadian Industry Program for Energy Conservation (CIPEC) website, available at: http://www.nrcan.gc.ca/energy/efficiency/industry/cipec/5153 and on the ENERGY STAR® website, available at: http://www.energystar.gov/buildings/facility-owners-and-managers/industrial-plants.

GHG Reduction Targets

The GHG Management Plan shall clearly state:

i) The industrial facility's GHG reduction targets; and,

ii) The implementation period.

The GHG Management Plan GHG reduction targets should be established as a defined range whereas the low target consists of an economically achievable target while the high target consists of an aspirational target. The target range should be established in keeping with a long-term vision. Typically, industrial GHG reduction targets and supporting strategy are established with a 10-20 year view, while project implementations are typically on a shorter time period (i.e. 1-5 years).

Finally, the operator should consider establishing GHG reduction targets which are consistent with those from the New Brunswick Climate Change Action Plan, or other future specified policy or regulatory instruments.

GHG Reduction Strategy

In order to achieve the reduction targets specified in the GHG Management Plan, a strategy or set of activities needs to be developed and implemented. While there are many options that exist for reducing and mitigating GHG emissions in the industrial sector, they can be divided into the following categories, not limiting to:

i) Management practices;

ii) Energy efficiency;

iii) Fuel switching;

iv) Heat and power recovery;

v) Renewables;

vi) Materials efficiency, recycling and feedstock change;

vii) Capital stock turnover; and,

viii) Research and innovation.

Further insights for each category are given later in this section.

The implementation timelines for these measures vary from short to long-term. Some examples of short-term measures are: implementing energy efficiency measures and establishing, integrating and implementing energy management in the organizational structure. Likewise, fuel switching, implementing heat and power recovery, and integrating renewable energy generation can be categorized as medium-term measures.

Finally, materials efficiency, significant capital stock turnover and incorporating research and innovation are typically long-term action items.

While options to reduce and mitigate GHG emissions are presented in an industry-wide approach in this document, relevant information for the oil and gas, pulp and paper and electricity generation sectors are mentioned, albeit briefly.

In regards to the oil and gas industry, studies have shown that most petroleum refineries can economically improve energy efficiency by 10-20%. Key energy saving options are: the use of cogeneration, improved heat integration, combustion optimization, control of compressed air and steam leaks, reducing fugitive emissions and the use of efficient electrical devices. Other options available include reducing the amount of material flared which increases energy efficiency[1,2].

For its part, mitigation options in regards to the pulp and paper industry include the use of biomass fuels such as spent pulping liquor and manufacturing residuals, combined heat and power to generate electricity, black liquor gasification, heat and steam recovery and recycling of waste paper. Despite the recent energy improvements and use of renewable energy in the pulp and paper industry, research has shown that there is still a technical potential for GHG reduction of 25% and a cost-effective potential of 14% in this sector[3].

In regards to the electricity generation sector, there are a variety of options available in order to increase the overall efficiency in existing electric power plants which in turn, reduces their GHG emissions. To this end, processes can be optimized by using Energy Management Information Systems (EMIS) and other advanced computational tools and software. Other options include: (i) real-time performance monitoring of efficiency, (ii) reducing air, water, steam, and flue gas leakage, (iii) optimizing fuel performance and balancing fuel and air flows to the plant's burners, (iv) steam turbine upgrades, and (v) the use of variable speed motors. Furthermore, existing electric power plants can be retrofitted to operate in a combined cycle mode while improving the efficiency of the power plant's auxiliary systems and the use of novel power factor response mechanisms which can allow the plant to run with a power factor closer to unity than has been traditionally been demanded (improving from 0.86 to 0.95, for example) can all lead to significant increases to the plant's overall efficiency.

Management Practices

Reducing industrial GHG emissions can often be achieved without significant capital investment or increased capital costs by utilising management tools that are readily

[1] Worrell, E. and C. Galitsky, 2005. *Energy Efficiency Improvement Opportunities for Petroleum Refineries - An ENERGY STAR® Guide for Energy and Plant Managers*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL 56183).

[2] Bernstein, L., J. Roy, K. C. Delhotal, J. Harnisch, R. Matsuhashi, L. Price, K. Tanaka, E. Worrell, F. Yamba, Z. Fengqi, 2007. *Industry. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, New York, United States.

[3] Martin, N., E. Worrell, M. Ruth, M., L. Price, R.N. Elliott, A. Shipley and J. Thorne, 2000. *Emerging energy-efficient industrial technologies*. Washington D.C., American Council for an Energy-efficient economy and Berkeley, CA, Lawrence Berkeley National Laboratory (LBNL-46990).

available. One tool that has been proven highly successful in industry for identifying opportunities for reducing energy, which in turn reduces GHG emissions, is an energy audit. Research has shown that energy audits can often provide missing information needed in order to overcome barriers towards implementing energy efficiency measures within an organization[4].

Organisational barriers can provide obstacles for improvement opportunities even when energy is a significant cost for an industry. To this end, energy audits and management systems create a foundation for improvement and provide guidance for managing energy throughout an organisation. The integration of energy management systems into broader industrial management systems has been shown to be beneficial in reducing GHG emissions[5].

In terms of management programs, there are several standards for establishing energy management programs including those from the International Organization for Standardization (ISO) and ENERGY STAR®.

The ISO 50001 Energy Management System Standard provides organizations with a structured framework to manage energy such that it can increase efficiency, reduce costs and improve energy performance. The standard is fully compatible with all of ISO's management systems standards including ISO 9001 (quality management), ISO 14001 (environmental management) and ISO 14064 (GHG reduction and emissions trading). It integrates energy efficiency into management practices by making better use of existing energy-consuming processes. Finally, the ISO 50001 standard has been adopted as a Canadian national standard, and is the recommended standard with respect to this Guideline.

For its part, ENERGY STAR® has developed a series of tools and guidelines related to establishing and conducting an effective energy management program based on the successful practices of their partners. While these tools and guidelines are targeted for companies operating in the United States, they can serve as good references for those operating in New Brunswick.

Appendix A presents further information regarding the ISO 50001 Energy Management System Standard and ENERGY STAR®'s Energy Management Assessment Matrix which is a tool used for evaluating an organization's energy management program.

Additional details on the ISO 50001 Energy Management System Standard can be found on CIPEC's website at: http://www.nrcan.gc.ca/energy/efficiency/industry/cipec/5379 or on the ISO 50001 website at: http://www.iso.org/iso/home/standards/management-standards/iso50001.htm.

For its part, additional information on ENERGY STAR®'s Energy Management tools and guidelines can be found on the ENERGY STAR® website at:
http://www.energystar.gov/buildings/facility-owners-and-managers/industrial-plants.

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4 Schleich, J., 2004. *Do Energy Audits Help Reduce Barriers to Energy Efficiency? An Empirical Analysis for Germany*. International Journal of Energy Technology and Policy, 2, pp. 226-239.

5 McKane, A., W. Perry, A. Li, T. Li, and R. Williams, 2005. *Creating A Standard Framework For Sustainable Industrial Energy Efficiency*. Presented at Energy Efficiency in Motor Driven Systems (EEMODS 2005) Conference, Heidelberg, Germany, 5-8 September 2005.

While energy management programs can be implemented following one of several standards, typically, a successful program in energy management begins with a strong commitment to continuous improvement of energy efficiency. Generally, this involves assigning oversight and management duties to an Energy Director, establishing an Energy Policy with GHG emission reduction targets, and creating a cross-functional Energy Team. Steps and procedures are then put into place to assess performance, through regular reviews of energy and GHG emissions data, technical assessments, and benchmarking. From this assessment, a baseline of performance is developed and goals for improvement are set[1].

In addition, organizations should strive to make personnel at all levels aware of energy use and efficiency goals. Research has shown that employee training and engagement and an organization's adoption of energy efficiency in their day-to-day practices are beneficial[6]. In general, good results have been obtained from programmes that provide regular feedback on the organization's energy performance.

Other management tools used in industry include GHG inventory and reporting systems. These tools allow industry to develop strategies to adapt to changing government and consumer requirements by understanding the sources and magnitudes of its GHG emissions. To this end, protocols for inventory development and reporting have been developed which define an accounting and reporting standard that companies can use to ensure that their measurements are accurate and standard. Since protocols are generally industry specific, operators need to verify which protocols are applicable to their needs, such as the Greenhouse Gas Protocol (GHGP), ISO 14064 and IPCC. A list of protocols by industry can be found on the Canadian Standard Association (CSA) Carbon Dashboard's website: http://www.carbondashboards.ca/protocols.cfm.

Finally, organizations can use benchmarking to compare their operations with those from of others, to industry averages, or to best practices. This allows them to determine their opportunities to improve energy efficiency or to reduce GHG emissions.

Energy Efficiency

Improving energy efficiency in industry can provide significant opportunity for reducing energy use and its associated GHG emissions[7]. Many industrial processes have very low energy efficiency and average energy use is much higher than the best available technology economically achievable (BATEA) would permit.

There are several factors that affect the energy efficiency of industrial facilities, these include choice and optimization of technology, operating procedures and maintenance, and capacity utilization. Research has shown that large amounts of energy can be saved by strict adherence to designed operating and maintenance procedures[8].

In regards to excess energy use, there are many problems that can cause this effect, such as steam and compressed air leaks, poorly maintained insulation, and air leaks in

[6] Caffal, C., 1995. *Energy management in industry*. Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET). Analysis Series 17. Sittard, Netherlands.
[7] International Energy Agency (IEA), 2006. *Energy Technology Perspectives 2006: Scenarios and Strategies to 2050*. International Energy Agency, Paris, France.
[8] US DOE, 2004. *20 Ways to Save Energy Now*. US Department of Energy, Washington, D.C., United States.

boilers and furnaces. Finally, frequent shutdowns and poor thermal integration are notable causes of low capacity utilization.

Further, there is a large potential for energy efficiency improvements in relation to the use of electric motors systems in industry. It has been shown that electric motor-driven systems account for over 60% of industrial electricity use[9]. In order to achieve maximum efficiency in these systems, it is important to properly size all components, to improve the efficiency of end-use devices (pumps, fans, etc.), to reduce electrical and mechanical transmission losses, and to use proper operation and maintenance procedures.

Another potential for energy efficiency savings relies in identifying and eliminating compressed air leakages, whereas typical estimates indicate that approximately 20% of compressed air is lost due to these leaks.

For their parts, there are still energy efficiency measures that may be applicable for steam boilers, distribution systems, furnaces, and process heaters. These include general maintenance programs, improved insulation, combustion controls and leak repairs in the boilers, improved steam traps, condensate recovery, preheating combustion air, optimizing combustion controls, and using oxygen enrichment or oxy-fuel burners. Finally, it is to be noted that boiler systems can also be upgraded to cogeneration systems which are more energy efficient[10,11].

A summary list of energy efficiency opportunities in industry, which is not meant to be complete, is given in Appendix B.

Fuel Switching

Generally, industries use fuel for steam generation and/or process heat, with the choice of fuel being determined by cost, availability and environmental considerations. It is estimated that industrial fuel switching within fossil fuels (replacing coal or oil with natural gas or biomass) can reduce GHG emissions by 10-20%[12].

Waste materials can also be used as input fuel for steam generation. Used oil and solvents, and sewerage sludge are currently being used by a number of industries. Waste materials can reduce GHG emissions compared to an alternative where they are disposed of without energy recovery[13]. However, the use of waste materials is limited not only by their availability but also by environmental regulations, e.g. airborne toxic materials[14].

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9 Xenergy, Inc., 1998. *Evaluation of the US Department of Energy Motor Challenge Program*. Burlington, Massachusetts, United States.

10 Einstein, D., E. Worrell, and M. Khrushch, 2001. *Steam systems in industry: Energy use and energy efficiency improvement potentials*. Proceedings of the 2001 ACEEE Summer Study on Energy Efficiency in Industry - Volume 1, Tarrytown, NY, July 24-27th, 2001, pp. 535-548.

11 US DOE, 2002. *Steam system opportunity assessment for the pulp and paper, chemical manufacturing, and petroleum refining industries - Main Report*. US Department of Energy, Washington, D.C., United States.

12 Intergovernmental Panel on Climate Change (IPCC), 2001. *Climate Change 2001: Mitigation. Intergovernmental Panel on Climate Change (IPCC)* [B. Metz, et al. (eds)]. Cambridge University Press, Cambridge, United Kingdom.

13 Humphreys, K. and M. Mahasenan, 2002. *Towards a sustainable cement industry - Substudy 8: Climate Change*. World Business Council for Sustainable Development (WBCSD), Geneva, Switzerland.

14 International Energy Agency (IEA), 2006. *Energy Technology Perspectives 2006: Scenarios and Strategies to 2050*. International Energy Agency, Paris, France.

Heat and Power Recovery

In virtually all industries, energy recovery can provide major energy efficiency and mitigation opportunities. This can be in the form of heat, power or fuel recovery.

Opportunities for heat recovery at lower temperatures are possible with the use of chemical heat sinks in heat pumps, organic Rankine cycles and chemical recuperative gas turbines. Other opportunities are related to the use of new, more efficient heat exchangers, more robust (e.g. low-corrosion) heat exchangers, and the use of heat pumps to recover low-temperature heat.

Heat recovery systems need to be energy-efficient and cost-effective (i.e. process integration). Generally, it is estimated that cost-effective energy savings of 5-40% are generally found in process integration analyses[3].

For its part, power can be recovered from processes operated at high pressures using pressure recovery turbines. Opportunities for the use of pressure recovery turbines exist in blast furnaces, fluid catalytic crackers and natural gas grids. In addition, pressure recovery turbines can be used instead of pressure relief valves in steam networks and organic Rankine cycles from low-temperature waste streams.

Finally, in regards to cogeneration or combined heat and power (CHP), which involves using energy losses in power production to generate heat for industrial processes and/or district heating, it is estimated that large mitigation potentials still exist in industry[15,16]. It is to be noted that generally, the main challenges of integrating CHP technologies to existing industrial processes are related to the economics of the residual heat usage.

Renewable Energy

Energy generated from renewable sources can be used in industrial processes to lower GHG emissions, while demonstrating corporate social responsibility. In some industries, the use of renewable energy is well established. Biomass is widely used in the pulp in paper industry for the generation of heat. Some industries use wind or solar energy to generate electricity, which is typically used internally for industrial processes while any surplus is sold to the local electricity distributer or system operator.

In New Brunswick, the Large Industrial Renewable Energy Purchase Program (LIREPP), allows qualifying large industrial customers to sell electricity generated from renewable electricity generating facilities located in New Brunswick, such as biomass and river hydro to NB Power. The revenue from renewable energy sales will assist these qualifying customers to reduce their net electricity costs and thereby increase their competitiveness in the global market. Interested proponents should contact NB Power or the New Brunswick Department of Energy and Mines for more details on this program.

[15] Laurin, A., J. Nyboer, C. Strickland, N. Rivers. M. Bennett, M. Jaccard, R. Murphy, and B. Sandownik, 2004. *Strategic options for combined heat and power in Canada*. Office of Energy Efficiency, Natural Resources Canada, Ottawa, ON, Canada.

[16] Lemar, P.L., 2001. *The potential impact of policies to promote combined heat and power in US industry*. Energy Policy, 29, pp. 1243-1254.

Materials Efficiency, Recycling and Feedstock Change

Materials efficiency is defined as the reduction of energy use by the appropriate choice of materials and recycling. In the industrial sector, recycling is the more common option and can occur both internally within facilities and externally, as in the waste management sector.

Feedstock change or materials substitution is also applicable in the industrial sector. Some examples of materials substitution is the addition of wastes (blast furnace slag and fly ash) and geo-polymers to clinker to reduce GHG emissions from cement manufacturing. In some material substitution options, there can be an increase of emissions from the industrial sector that will be more than offset by the reduction of emissions in other sectors, such as the production and use of lightweight materials for vehicle manufacturing. Additionally, the use of bio-materials is another case of material substitution that has been used in certain applications.

Finally, industries can look at minimizing raw material inputs and product redesigns to reduce their GHG emissions.

Capital Stock Turnover

In general, capital stock turnover tends to slow the introduction of new clean and efficient technologies in the market place. Industries can look at accelerating capital stock turnover as a method of reducing their GHG emissions while using tools, such as life-cycle cost analysis, to evaluate available options.

Research and Innovation

While innovation needs to be at the core of any progressive organization in order to remain competitive and propel revenue growth, it can also play a significant part in reducing industrial GHG emissions. To this end, industries are encouraged to invest in and include innovation measures in their GHG reduction strategies.

Since many businesses in New Brunswick do not have the resources to perform research to develop and commercialize new process improvements and innovation, the New Brunswick Innovation Foundation (NBIF) has developed an Innovation Voucher Fund. The Fund seeks to provide existing businesses operating in the province the opportunity to access researchers and research facilities needed to develop and commercialize new innovations. The Innovation Voucher Fund can be used for concept validation, development, and/or the testing and evaluation of existing innovations. Additional information on the NBIF Innovation Voucher Fund and other funding available to businesses can be found at the NBIF website: www.nbif.ca.

Finally, it is to be noted that innovation measures for reducing GHG emissions may involve more than one industry. For example, by integrating energy and material flows and by using heat-cascading systems, co-sitting of industries, often named eco-industrial parks, has shown to reduce GHG emissions[17].

GHG Management Plan Requirements

In the GHG Management Plan, the operator shall clearly identify and summarize the strategy or set of activities that will be taken in order to achieve the established GHG reduction targets specified in the GHG Management Plan.

The operator should consider subdividing the strategy and action items into short, medium and long-term categories based on their implementation timelines and should provide a rationale for each of them.

Finally, the operator shall state how often the GHG Management Plan be updated and revised. While the submitted GHG Management Plans will last the time period of the industrial emitter's valid Air Quality Approval to Operate, it can be updated at any time if needed by the industrial emitter, i.e. if major facility refurbishments are undertaken. The GHG Management Plan will need to be renewed with the renewal of the industrial emitter's valid Air Quality Approval to Operate.

Baseline Emissions

In the GHG Management Plan, the industrial facility's GHG reduction targets shall be quantified relative to a reference level of GHG emissions, which will be referred to as the baseline emissions.

The baseline emissions must be both verifiable and subject to validation if required, in order to comply with potential future federal and/or provincial emissions policy requirements.

In the case of an industrial facility that had direct GHG emissions totalling 50,000 tonnes or more of CO_2e in a year of commercial operations in any of the years 2010, 2011 or 2012, the baseline emissions shall be determined by calculating the average of the total annual emissions for the years 2010, 2011 and 2012, as expressed in the following formula:

$$BE = \frac{TAE_{2010} + TAE_{2011} + TAE_{2012}}{3}$$

where

BE is the baseline emissions in CO_2e; and

TAE is the total annual emissions in CO_2e for the year indicated.

[17] Heeres, R.R., et al., 2004. *Eco-industrial Park Initiatives in the USA and the Netherlands: First Lessons*. Journal of Cleaner Production, 12(8-10), pp. 985-995.

In the case of an industrial facility that was not in commercial operations prior to the year 2013 and that had direct emissions totalling 50,000 tonnes or more of CO_2e in 2013, the baseline emissions shall be the total annual emissions for the year 2013, as expressed in the following formula:

$$BE = TAE_{2013}$$

where

BE is the baseline emissions in CO_2e; and

TAE is the total annual emissions in CO_2e for the year indicated.

Boundary Considerations

The industrial facility's boundary considerations for the GHG Management Plan shall be consistent with the definition of the source used in the operator's Approval to Operate and Environment Canada's definition of a facility. It is important to note that the boundary considerations are applicable only to the industrial emitter's direct emissions; to this end, the industrial emitter may specify greater boundary considerations if scope 2 and/or 3 indirect emissions are included in the GHG Management Plan.

Provincial Policy or Regulation Considerations

The operator should indicate to which manner the GHG Management Plan is consistent with the New Brunswick Climate Change Action Plan and other applicable federal and provincial policies and regulations.

The New Brunswick Climate Change Action Plan is available at:
http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/ClimateChangeActionPlan2014-2020.pdf

Link with Parallel Pollution Reduction Opportunities

The operator is encouraged to link the GHG Management Plan to other air and/or water pollution reduction opportunities and capital investment strategies, as these may reinforce each other, and should happen concurrently.

If the GHG Management Plan is linked to other air and/or water pollution reduction opportunities, the operator should provide information on this consideration.

GHG Validation and Verification

The operator does not need to seek third party validation and verification of GHG emission reductions in order to fulfill the industrial facility's GHG Management Plan commitments. The information reported by the operator should nevertheless be verifiable, which means in a manner that would allow an industrial facility's emissions to be verified by the government or a certified third party.

However, the operator can choose to seek validation and verification of the industrial facility's significant GHG emission reductions, in accordance with established offset or other verification protocols (such as GHGP, ISO 14064 and IPCC), if the industry wishes to obtain their respective present or future economic value.

Continual Improvement

The GHG Management Plan, typically should be part of a broader Environmental Management System (EMS) containing an Energy Management sub-system; a structured framework for managing an operation's significant environmental impacts. This provides a process through which organizations can engage with employees, customers, clients and other stakeholders. Whatever scheme is adopted, the elements will largely be the same, following the PDCA method (Deming cycle) of:

i) Plan what you're going to do;

ii) Do what you planned to do;

iii) Check (study) to ensure that you did what you planned; and

iv) Act to make improvements.

Through this cycle, all GHG Management Plans set a framework through which the operation can build on-going 'continuous improvement' to improve carbon productivity.

This system allows operations to adjust and learn from a multi-faceted network of influences not just environmental but also, economic and social.

To this end, the operator shall implement a Continual Improvement Strategy or a GHG Management Plan Follow-up Program, in which:

i) The operator shall verify and evaluate the effectiveness of GHG reduction measures specified in the GHG Management Plan;

ii) The operator shall identify and implement remedial actions items as needed in order to meet the GHG reduction targets and strategy specified in the GHG Management Plan.

iii) The operator shall identify and incorporate "lessons learned" into normal procedures; and,

iv) The operator shall address evolving climate change knowledge, technology, policy and legislation.

The Continual Improvement Strategy or GHG Management Plan Follow-up Program should be incorporated into the industrial emitter's normal operations.

GHG Monitoring and Reporting

For all industrial facilities emitting 50,000 tonnes of CO_2e or more per year, as a requirement of Environment Canada's GHG Reporting Program (GHGRP), the operator will continue to monitor and report the industrial facility's annual GHG emissions, for the previous calendar year, through Environment Canada's Single Window Information Manager (SWIM) by the annual June 1st reporting deadline.

During the reporting process, the operator shall at the same time report to the province of New Brunswick by selecting the EC and & NB reporting options (available for the 2016 reporting cycle) which creates a combined report that is submitted once and goes both to the New Brunswick Department of Environment and Local Government and to Environment Canada.

It is to be noted that SWIM is normally ready to collect data submissions by the spring of each year; therefore operators are able to submit their information well in advance of the June 1st reporting deadline.

In addition, **by July 1st of each year**, the operator shall submit, for the previous calendar year, an Annual Progress Report that shall include as a minimum, the following summary information:

i) Calculations and estimates of the annual direct GHG emissions in carbon dioxide equivalent units (CO_2e) for each of the greenhouse gas and gas species specified in this document (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) from the industrial facility's operations. In addition, the operator shall calculate and estimate the total annual direct GHG emissions measured in carbon dioxide equivalent units (CO_2e) from the industrial facility's operations for the sum of the greenhouse gas and gas species listed.

ii) Progress made on GHG reduction targets and strategy as specified in the GHG Management Plan;

iii) Effectiveness of GHG reduction measures or action items that have been implemented; and,

iv) Lessons learned which may lead to further improvements that can be shared with government and other operators.

The operator shall mail the completed Annual Progress Report to:

IMPACT MANAGEMENT BRANCH
ENVIRONMENT AND LOCAL GOVERNMENT
P. O. BOX 6000
3RD FLOOR, MARYSVILLE PLACE
FREDERICTON, NB E3B 5H1

SELECTED RESOURCES

The following is a guide only and is not intended to be an exhaustive or a prescriptive list. The operator is responsible for identifying and utilizing the most relevant resources. Where necessary, information from secondary sources such as those listed below must be supplemented by detailed studies prepared by qualified professionals.

Canadian Industry Program for Energy Conservation (CIPEC)
Available at: http://www.nrcan.gc.ca/energy/efficiency/industry/cipec/5153

Canadian Standard Association (CSA) Carbon Dashboard
Website: http://www.carbondashboards.ca/protocols.cfm

Energy Savings Toolbox - An Energy Audit Manual and Tool, Canadian Industry Program for Energy Conservation (CIPEC)
Available at: http://www.nrcan.gc.ca/sites/oee.nrcan.gc.ca/files/files/pdf/energy-audit-manual-and-tool.pdf

ENERGY STAR® - Industrial Energy Management, Benchmarking and Best Practices
Website: http://www.energystar.gov/buildings/facility-owners-and-managers/industrial-plants

Environment Canada's GHG Reporting Program (GHGRP)
Website: www.ghgreporting.gc.ca

ISO 50001 - Energy Management
Website: http://www.iso.org/iso/home/standards/management-standards/iso50001.htm

New Brunswick Clean Air Act
Available at: http://www.gnb.ca/0062/pdf-acts/c-05-2.pdf

New Brunswick Climate Change Action Plan
Available at: http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/ClimateChangeActionPlan2014-2020.pdf

New Brunswick Climate Change Dashboard
Website: http://logixml.ghgregistries.ca/New%20Brunswick%20Dashboard%20Solo/

New Brunswick Innovation Foundation
Website: www.nbif.ca

Other Resources Related to Energy Efficiency in Industry

International Energy Agency (IEA), 2014. *Energy Technology Perspectives 2014: Harnessing Electricity's Potential*. International Energy Agency, Paris, France.

International Petroleum Industry Environmental Conservation Association (IPIECA), 2007. *Oil and Natural Gas Industry Guidelines for Greenhouse Gas Reduction Projects*. London, United Kingdom.

Laurin, A., J. Nyboer, C. Strickland, N. Rivers. M. Bennett, M. Jaccard, R. Murphy, and B. Sandownik, 2004. *Strategic options for combined heat and power in Canada*. Office of Energy Efficiency, Natural Resources Canada, Ottawa, ON, Canada.

Worrell, E. and C. Galitsky, 2005. *Energy Efficiency Improvement Opportunities for Petroleum Refineries - An ENERGY STAR® Guide for Energy and Plant Managers*.

APPENDIX A

ADDITIONAL INFORMATION ON ISO 50001 AND ENERGY STAR®

ADDITIONAL INFORMATION ON ISO 50001 AND ENERGY STAR®

In this section additional information on energy management is presented, albeit briefly, notably, information on the ISO 50001 Energy Management System Standard and information on the ENERGY STAR® Energy Management Assessment Matrix. Further information on these tools are available on their respective websites as identified in the Selected Resources section.

ISO 50001

The ISO 50001 standard is intended to provide organizations with a framework for integrating energy performance into their management practices in order to increase energy efficiency, reduce costs, improve energy performance and reduce GHG emissions.

ISO 50001 is intended to accomplish the following:

i) Assist organizations in making better use of their existing energy-consuming assets;

ii) Create transparency and facilitate communication on the management of energy resources;

iii) Promote energy management best practices and reinforce good energy management behaviors;

iv) Assist facilities in evaluating and prioritizing the implementation of new energy efficient technologies;

v) Provide a framework for promoting energy efficiency throughout the supply chain;

vi) Facilitate energy management improvements for GHG emission reduction projects; and,

vii) Allow integration with other organizational management systems such as environmental, and health and safety.

In terms of methodology, the ISO 50001 standard follows the PDCA method for continual improvement which can be briefly describe as:

i) Plan: conduct the energy review and establish the baseline, energy performance indicators, objectives, targets and action plan necessary to deliver results in accordance with opportunities to improve energy performance and the organization's energy policy;

ii) Do: implement the energy management action plans;

iii) Check: monitor and measure processes and the key characteristics of its operations that determine energy performance against the energy policy and objectives and report the results; and,

iv) Act: take actions to continually improve energy performance and the energy management system.

Figure A1 shows the basis of the approach used in ISO 50001.

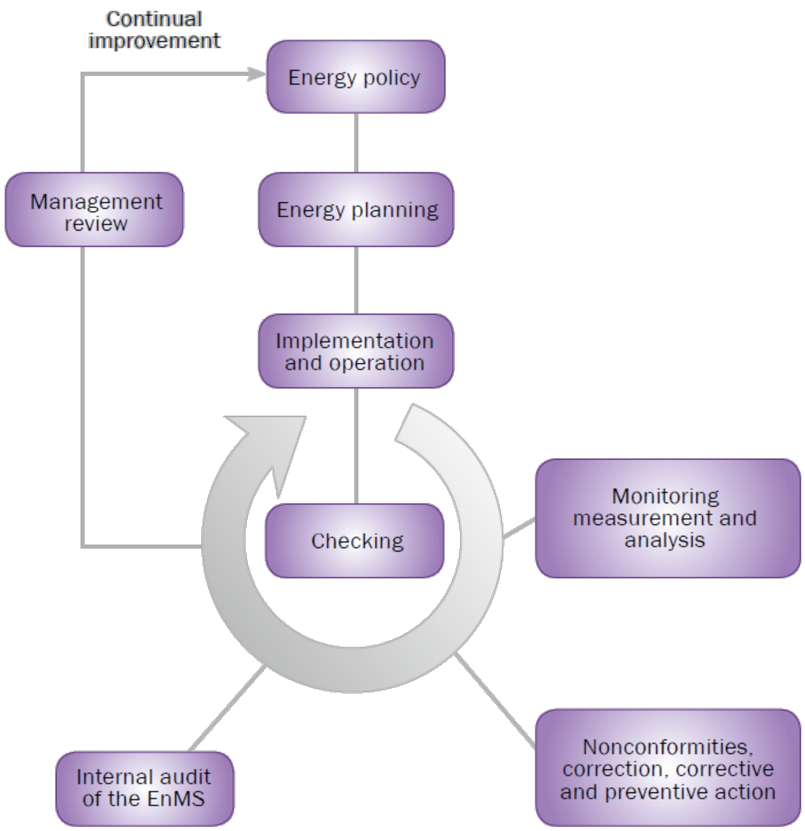

Figure A1: ISO 50001 Energy Management System Model[18].

ENERGY STAR® Energy Management Assessment Matrix

Based on the successful practices of ENERGY STAR® partners, the U.S. EPA has developed tools and guidelines for establishing and conducting an effective energy management program[19].

In order to help organizations and businesses compared their energy management practices to those outlined in the guidelines, an assessment matrix has been developed

18 International Organization for Standardization (ISO), 2011. *Win the energy challenge with ISO 50001 – ISO 50001 Energy Management*, Genève, Switzerland.

19 Available at: http://www.energystar.gov/buildings/about-us/how-can-we-help-you/build-energy-program/guidelines.

as shown in Figure A2. To this end, the assessment matrix outlines the key activities from the guidelines along with three levels of implementation: (i) little or no evidence, (ii) some elements, and (iii) fully implemented.

By identifying the degree of implementation for each of the key activities, organizations and businesses can easily compared their respective energy management program to the elements of the ENERGY STAR® Guidelines for Energy Management. Finally, the assessment matrix will help to identify an energy program's strengths and weaknesses and provide ideas for improvements.

ENERGY STAR® Energy Management Assessment Matrix

	Little or no evidence	Some elements	Fully implemented	Next Steps
Make Commitment to Continuous Improvement				
Energy Director	No central or organizational resource Decentralized management	Central or organizational resource not empowered	Empowered central or organizational leader with senior management support	
Energy Team	No company energy network	Informal organization	Active cross-functional team guiding energy program	
Energy Policy	No formal policy	Referenced in environmental or other policies	Formal stand-alone EE policy endorsed by senior mgmt.	
Assess Performance and Opportunities				
Gather and Track Data	Little metering/no tracking	Local or partial metering/tracking/reporting	All facilities report for central consolidation/analysis	
Normalize	Not addressed	Some unit measures or weather adjustments	All meaningful adjustments for organizational analysis	
Establish baselines	No baselines	Various facility-established	Standardized organizational base year and metric established	
Benchmark	Not addressed or only same site historical comparisons	Some internal comparisons among company sites	Regular internal & external comparisons & analyses	
Analyze	Not addressed	Some attempt to identify and correct spikes	Profiles identifying trends, peaks, valleys & causes	
Technical assessments and audits	Not conducted	Internal facility reviews	Reviews by multi-functional team of professionals	
Set Performance Goals				
Determine scope	No quantifiable goals	Short term facility goals or nominal corporate goals	Short & long term facility and corporate goals	
Estimate potential for improvement	No process in place	Specific projects based on limited vendor projections	Facility & organization defined based on experience	
Establish goals	Not addressed	Loosely defined or sporadically applied	Specific & quantifiable at various organizational levels	

Figure A2: ENERGY STAR® Energy Management Assessment Matrix (1 of 2)[19].

Create Action Plan				
Define technical steps and targets	Not addressed	Facility-level consideration as opportunities occur	Detailed multi-level targets with timelines to close gaps	
Determine roles and resources	Not addressed or done on ad hoc basis	Informal interested person competes for funding	Internal/external roles defined & funding identified	
Implement Action Plan				
Create a communication plan	Not addressed	Tools targeted for some groups used occasionally	All stakeholders are addressed on regular basis	
Raise awareness	No promotion of energy efficiency	Periodic references to energy initiatives	All levels of organization support energy goals	
Build capacity	Indirect training only	Some training for key individuals	Broad training/certification in technology & best practices	
Motivate	No or occasional contact with energy users and staff	Threats for non-performance or periodic reminders	Recognition, financial & performance incentives	
Track and monitor	No system for monitoring progress	Annual reviews by facilities	Regular reviews & updates of centralized system	
Evaluate Progress				
Measure results	No reviews	Historical comparisons	Compare usage & costs vs. goals, plans, competitors	
Review action plan	No reviews	Informal check on progress	Revise plan based on results, feedback & business factors	
Recognize Achievements				
Provide internal recognition	Not addressed	Identify successful projects	Acknowledge contributions of individuals, teams, facilities	
Get external recognition	Not sought	Incidental or vendor acknowledgement	Government/third party highlighting achievements	

Figure A2: ENERGY STAR® Energy Management Assessment Matrix (2 of 2)[19].

APPENDIX B

SUMMARY LIST OF ENERGY EFFICIENCY OPPORTUNITIES IN INDUSTRY

SUMMARY LIST OF ENERGY EFFICIENCY OPPORTUNITIES IN INDUSTRY

Table B1: Summary List of Energy Efficiency Opportunities in Industry (1 of 2)[20].

Management & Control Energy monitoring Site energy control systems	**Process Integration** Total site pinch analysis Water pinch analysis
Power Generation CHP (cogeneration) Gas expansion turbines High-temperature CHP Gasification (Combined Cycle)	**Energy Recovery** Flare gas recovery Power recovery Hydrogen recovery Hydrogen pinch analysis
Boilers Boiler feedwater preparation Improved boiler controls Reduced flue gas volume Reduced excess air Improve insulation Maintenance Flue gas heat recovery Blowdown heat recovery Reduced standby losses	**Steam Distribution** Improved insulation Maintain insulation Improved steam traps Maintain steam traps Automatic monitoring steam traps Leak repair Recover flash steam Return condensate
Heaters and Furnaces Maintenance Draft control Air preheating Fouling control New burner designs	**Distillation** Optimized operation procedures Optimized product purity Seasonal pressure adjustments Reduced reboiler duty Upgraded column internals
Compressed Air Maintenance Monitoring Reduce leaks Reduce inlet air temperature Maximize allowable pressure dew point Controls Properly sized regulators Size pipes correctly Adjustable speed drives Heat recovery for water preheating	**Pumps** Operations & maintenance Monitoring More efficient pump designs Correct sizing of pumps Multiple pump use Trimming impeller Controls Adjustable speed drives Avoid throttling valves Correct sizing of pipes Reduce leaks Sealings Dry vacuum pumps
Motors Proper sizing of motors High efficiency motors Power factor control Voltage unbalance Adjustable speed drives Variable voltage controls Replace belt drives	**Fans** Properly sizing Adjustable speed drives High-efficiency belts

[20] Worrell and Galitsky, 2005.

Table B1: Summary List of Energy Efficiency Opportunities in Industry (2 of 2)[20].

Lighting Lighting controls T8 Tubes Metal halides/High-pressure sodium	**High-intensity fluorescent (T5)** Electronic ballasts Reflectors LED exit signs
Desalter Multi-stage desalters Combined AC/DC fields	**Hydrocracker** Power recovery Process integration (pinch) Furnace controls Air preheating Optimization distillation
CDU Process controls High-temperature CHP Process integration (pinch) Furnace controls Air preheating Progressive crude distillation Optimization distillation	**Coking** Process integration (pinch) Furnace controls Air preheating
VDU Process controls Process integration (pinch) Furnace controls Air preheating Optimization distillation	**Visbreaker** Process integration (pinch) Optimization distillation
Hydrotreater Process controls Process integration (pinch) Optimization distillation New hydrotreater designs	**Alkylation** Process controls Process integration (pinch) Optimization distillation
Catalytic Reformer Process integration (pinch) Furnace controls Air preheating Optimization distillation	**Hydrogen Production** Process integration (pinch) Furnace controls Air preheating Adiabatic pre-reformer
FCC Process controls Power recovery Process integration (pinch) Furnace controls Air preheating Optimization distillation Process flow changes	**Other** Optimize heating storage tanks Optimize flares