Pollution Prevention Program for

Commercial Bakeries & Frozen Baked Baked Product Manufacturing and Cookie & Cracker Manufacturing

Prepared for Toronto Public Health
by
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CHEMTRAC

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1.0 BACKGROUND INFORMATION

1.1 ChemTRAC Facilities

In the Metropolitan Toronto area[1], 135 facilities[2] have self-declared with NAICS code 311814 and 311821, which correspond to Commercial Bakeries and Frozen Bakery Product Manufacturing and Cookie and Cracker Manufacturing, respectively. In the 2013 reporting year, 65 unique facilities reported to ChemTRAC as they met or exceeded the reporting thresholds, representing approximately 48% of the facilities implicated in the sector.

1.2 Sector Releases

In the 2013 reporting year, the sector reported releases of four contaminants: acetaldehyde, oxides of nitrogen (NO_x), particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), and volatile organic compounds (VOCs). One (1) facility reported meeting or exceeding the reporting thresholds for acetaldehyde, twenty-one (21) for NO_x, fourteen (14) for $PM_{2.5}$, and twenty-one (21) for VOCs.

1.2.1 Acetaldehyde

Total releases to air of acetaldehyde were reported at 1,936 kg in the 2013 reporting year. Only one facility, Mondelez Canada Lakeshore Bakery, reported releases of acetaldehyde. It is expected that the releases of acetaldehyde result from the fermentation of yeast, in which small amounts of acetaldehyde are produced as a result of incomplete fermentation. See Figure 1 below, describing the formation of acetaldehyde in fermentation. Trace amounts of acetaldehyde would be produced as by-products of incomplete combustion, although it is expected that these emissions would be comparably insignificant.

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[1] Toronto's Metropolitan Area refers to those within a postal code starting with M, to align with the ChemTRAC reporting region

[2] Source: Composite of Scott's Directory (Accessed October 2015), Industry Canada, and the 2013 ChemTRAC reporting year data set.

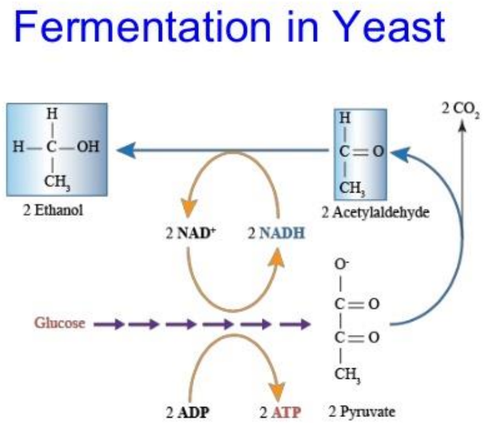

Figure 1: Production of Acetaldehyde from Fermentation [Source: Davidson College]

1.2.2 Nitrogen Oxides (NO_x)

Total releases to air of NO_x were reported at 38,568 kg in the 2013 reporting year. Releases to air of NO_x are expected to be primarily from the combustion of fuel (primarily natural gas) for heating ovens for baking. Releases are fairly evenly dispersed, with the top 4 of 21 reporting facilities accounting for 59% of total emissions. From the ChemTRAC data, the top 10 facilities with the highest air releases for NO_x are provided below in **Error! Reference source not found.**.

1.2.3 Particulate Matter ($PM_{2.5}$)

Total releases to air of $PM_{2.5}$ were reported at 2,011 kg in the 2013 reporting year. Releases of $PM_{2.5}$ are expected to be primarily from the handling and mixing of powdered ingredients such as flour, sugar, and flavours. Secondary sources of $PM_{2.5}$ are expected as by-products of combustion from the ovens, as well as cooling towers. Discharges to air from the facility could be both controlled (via filter or dust collector), and direct (uncontrolled). Other ancillary operations such as handling liquid ingredients handling are expected to emit comparably insignificant emissions. One of the facilities, Mondelez Canada Lakeshore Bakery, released 561 kg of $PM_{2.5}$, which entails about 28% of the total contribution for that particular contaminant. The top 3 reporters from this sector comprise more than half of the releases of $PM_{2.5}$. From the ChemTRAC 2013 data, the top 10 facilities with the highest releases for $PM_{2.5}$ are provided below in **Error! Reference source not found.**.

1.2.4 Volatile Organic Compounds (VOCs)

Total releases to air of VOCs were reported at 245,985 kg in the 2013 reporting year. Releases to air from the sector are primarily from yeast leavening of baked goods.[3] Ancillary operations such as the use clean in place (CIP) chemicals, or other detergents are not expected to be significant. From the 2013 reporting year ChemTRAC data, the two facilities releasing the most VOCs, Weston Bakeries Limited Eastern Avenue and Fiera Foods Company, emit 81,000 kg and 73,260 kg respectively, corresponding to a combined 63% of total VOC emissions. The top 10 facilities with the highest air releases are shown in **Error! Reference source not found.**.

1.2.5 Wastewater

The quality and quantity of wastewater is not reported to ChemTRAC. However, most facilities would be subject to the water quality objectives of the municipal by-law. Many of the facilities implicated in this sector would be required to prepare pollution prevention plans for Toronto Water. Given the significance of water use in the sector used in both the process, and cleaning operations, relevant P2 considerations will be mentioned in this report.

Table 1 - Top Releasing Facilities in the Food Sector

Pollutant	**Air Release (kg)**	**Sector Contribution (%)**
Acetaldehyde	**1936**	
Mondelez Canada Lakeshore Bakery	1936	100.00%
Nitrogen Oxides (NOx)	**38568**	
Fiera Foods Company	5286	13.71%
Give And Go Prepared Foods Finch Bakery	5172	13.41%
Mondelez Canada Lakeshore Bakery	4441	11.51%
Mondelez Canada Inc, East York Bakery	4139	10.73%
Give And Go Prepared Foods Humber Bakery	3520	9.13%
Handi Foods Ltd	2270	5.89%
Weston Bakeries Limited Eastern Avenue	2122	5.50%
Dimpflmeier Bakery Ltd	1833	4.75%
Ready Bake Foods Inc North York	1470	3.81%
Commercial Bakeries Corp	1420	3.68%
Particulate Matter 2.5 (PM2.5)	**2011**	
Mondelez Canada Lakeshore Bakery	561	27.90%
Pita Delight Ltd	439	21.83%
Weston Bakeries Limited Eastern Avenue	172	8.55%

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[3] United States Environmental Protection Agency. (1999, June 21). Area Source Category Method Abstract - Bakeries. *Emission Inventory Improvement Program: Volume 3*.

Pollutant	Air Release (kg)	Sector Contribution (%)
Fiera Foods Company	138	6.86%
Ready Bake Foods Inc North York	112	5.57%
Give And Go Prepared Foods Finch Bakery	105	5.22%
Annette's Donuts	102	5.07%
Mondelez Canada Inc, East York Bakery	79	3.93%
Give And Go Prepared Foods Humber Bakery	72	3.58%
Morrison Lamothe Inc	68	3.38%
Volatile Organic Compounds (VOCs) Total	**245985**	
Weston Bakeries Limited Eastern Avenue	81000	32.93%
Fiera Foods Company	73260	29.78%
Dimpflmeier Bakery Ltd	22936	9.32%
Mondelez Canada Lakeshore Bakery	19031	7.74%
The Stonemill Bakehouse Ltd	12036	4.89%
Canada Bread Company Ltd	10152	4.13%
Handi Foods Ltd	6494	2.64%
Weston Bakeries Limited	5804	2.36%
Ready Bake Foods Inc North York	2988	1.21%
Annette's Donuts	2656	1.08%

1.3 Description of Sector Processes and Operations

The Commercial Bakeries and Frozen Bakery Products Manufacturing sector is similar to the Cracker and Cookie Manufacturing sector in that the major process employed at both sectors is baking. As such, they will be described as one while highlighting the fundamental differences in each.

Within the Commercial Bakeries and Frozen Bakeries Product Manufacturing sector the followings are illustrative examples of the baked goods[4]:

- bagels, bread, cakes, croissant, doughnuts, pastries, made in commercial bakeries
- bakery products, fresh or frozen, made in commercial bakeries
- bread, bread-type rolls or buns and biscuits (including frozen), made in commercial bakeries
- buns, bread-type (e.g., hamburger, hot dog), made in commercial bakeries
- communion wafers, manufacturing
- croutons and bread crumbs, made in commercial bakeries
- desserts, frozen bakery, manufacturing
- pastries (e.g., Danish, French), frozen, manufacturing
- pies, dessert type (except ice cream), manufacturing
- pretzels, soft, made in commercial bakeries
- unleavened bread, made in commercial bakeries

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[4] http://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getAllExample&TVD=118464&CVD=118471&CPV=311814&CST=01012012&CLV=5&MLV=5&V=77955&VST=01012012

- yeast raised goods, made in commercial bakeries

Within the Cracker and Cookie Manufacturing Sector the following are examples of the products manufactured:

- Biscuits
- Cookies
- Crackers (graham, soda, saltine, etc)
- Graham wafers
- Ice cream cones and wafers
- Zwieback and rusk

A process flow diagram is depicted in Figure 2, which outlines the major operations performed in this sector, as well as the major release points.

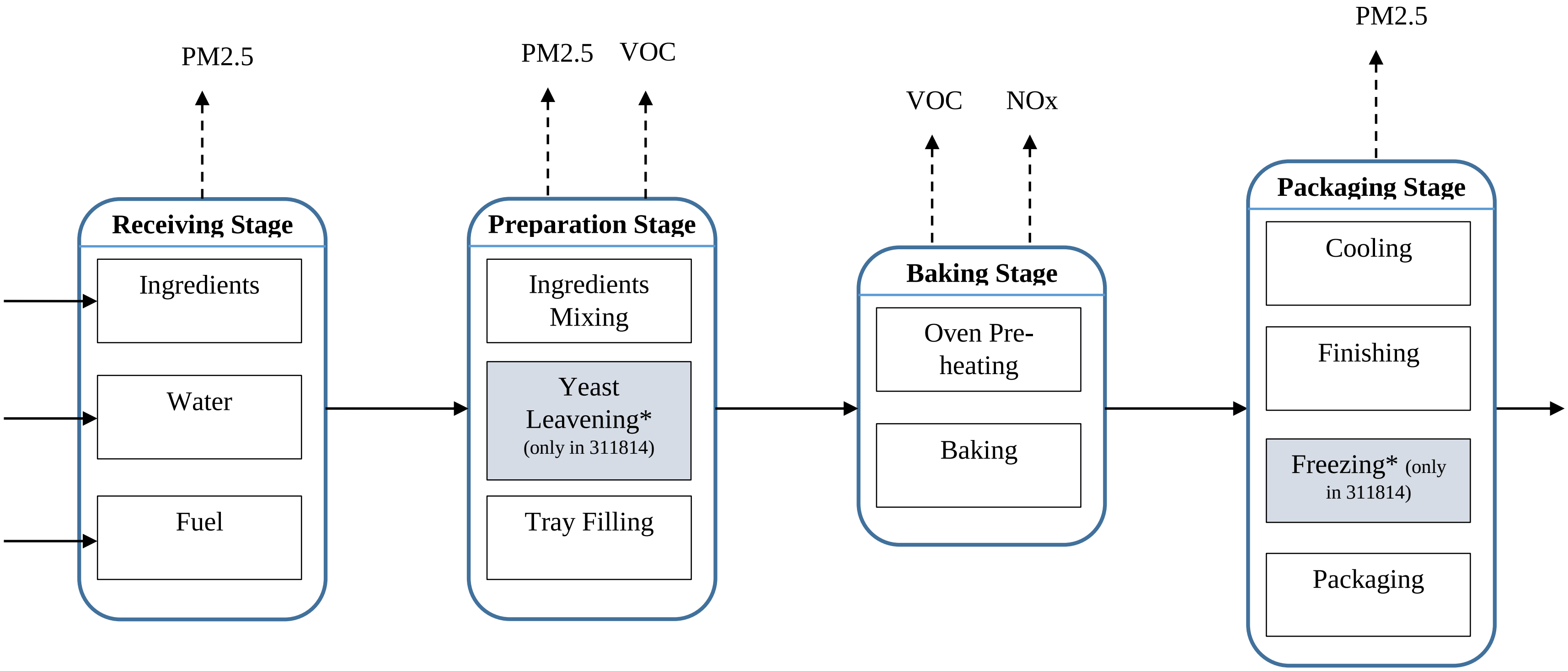

Figure 2 - Process Flow Diagram of Commercial Bakeries and Frozen Food Manufacturing and Cookie and Cracker Manufacturing Industries.[5]

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[5] United States Environmental Protection Agency. (1992, December). Alternative Control Technology Document for Bakery Oven Emissions.

2.0 BARRIERS IDENTIFIED

2.1 Sector Breakdown

Within the sector, 42% of the facilities have less than 10 employees, 25% have 50 or more employees, and 16% have more than 100 employees.[6] Facilities with less than 10 employees are expected to be primarily owner/operator bakeries, whereas facilities with more than 50 employees are a mix of family owned, or partnerships. Small bakeries are likely to support retailer bakery outlets, or the independent grocery stores. Whereas the medium to large size facilities are likely to provide baked goods to restaurants, chain grocery stores, and might be engaged in the export of frozen food products.

2.2 Motivation

As the operations, and processes performed at both small and large facilities are similar, they also share many of the same motivation barriers. Since the food sector as a whole is very taste sensitive, any changes that are perceived to alter taste can be a cause for concern. In our experience, facilities maintain equipment well beyond its serviceable life (or economic viability) because of a belief its performance is linked to the quality of the baked goods they produce. The notable exception for larger facilities is a result of multiple layers of management which requires further corporate approvals.

Motivational barriers identified within this sector include:

- Lack the means to recognize, appreciate and evaluate the environmental consequences of their actions.[7]
- Many small businesses are skeptical about the business benefits of environmental improvements.[8]
- Lack of financial incentives
- Lack of pressure from customers[9] (customers are more likely to be focused on “organic” or “natural” ingredients, than the environmental footprint of the facility)
- Different decision makers may have competing priorities, resulting in frustration with championing P2 initiatives[10]
- Lack of regulatory drivers (low cost of water, ease of air emissions compliance)

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[6] Source: Scott’s Directory and Industry Canada

[7] [7] Subhas K., Diwekar, U. *Tools and Methods for Pollution Prevention*. NATO Science Series. Vol 62. https://books.google.ca/books?isbn=9401144451

[8] Revell et al, 2010. Small businesses and the environment: turning over a new leaf? *Business Strategy and the Environment*, *19*(5), 273–288. doi:10.1002/bse.628

[9] Hassanali, M. Pollution Prevention Practices in SMEs in the GTA. 2005.

[10] Based on our experience working in various industries.

2.3 Knowledge

With a limited number of staff, smaller facilities are not positioned to employ specialists with an enhanced knowledge of P2 measures. Smaller facilities are more likely to learn from business-to-business discussions, suppliers, tradeshows or magazines, and from industry associations. Medium and large facilities are likely to employ technical resources that are sub-specialized in the design and operation of commercial baking equipment, and would be in a position to evaluate process impacts at the facility, but not necessarily the environmental implications.

Within the sector, the following knowledge barriers have been identified:

- Limited or no technical resources in-house (smaller facilities)
- Business may not understand the necessary actions involved in implementation of a P2 technology or practice.[11]
- Unsure how new technologies will impact business
- Desire external expertise to validate potential opportunities[12]
- Risk of failure of new technologies[13]
- Benefits of new P2 technologies not understood[14]

2.4 Financial Resources

Financial investment is one of the major barriers identified that prevent facilities from implementing P2 initiatives. Within the sector, the smaller facilities are typically focused on their day-to-day survival rather than research and investing capital for retrofits or new equipment in order to prevent or reduce pollution. Medium to large facilities engaged in private label manufacturing are often re-equipping their production facilities in order to adapt to their clients changing menu, or new product developments. Private label food manufacturing is the process of manufacturing food products to be marketed under the label of another company, for example President’s Choice®, sold at the Loblaw’s brand of grocery stores is manufactured by independent manufacturers on a contract basis. It is not uncommon for new equipment or lines to be modified every two years in response to customer requirements and menu expansion[15]. Medium to large facilities engaged in “staple foods” production such as breads, crackers, etc., are not likely to make facility upgrades, unless increased capacity is needed to meet customer

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[11] Heath & Heath, 2010. *How to change things when change is hard*. Crown Business.

[12] ChemTRAC Business Panel, 2012.

[13] United States Environmental Protection Agency. (2003, July 15). Dry Electrostatic Precipitator (ESP) - Wire Plate Type. *Air Pollution Control Technology Fact Sheet*.

[14] Ibid.

[15] Discussions with T. Miele. Arytza. 2013.

demand, or as a result of a necessary maintenance activity.[16] Because of the cost competitive nature of the industry, short payback periods of less than two years are often necessary to justify financial investment.

The following financial barriers that have been identified within the sector include:

- Lack of financial capital to invest
- Short return on investment (typically a return on investment must be complete within 1-2 years)[17]
- Capital tied up in other investments (process improvement)

2.5 Time/Human Resources

For small bakeries employing less than 10 people, there is a considerable time demand placed on the owner, and employees resulting in a lack of resources to investigate P2 initiatives. It is not uncommon for the owner/operator to be involved in the managing of operations, customer service, sales, human resources, and accounting functions. As a result of the cost competitiveness of the industry, bakeries with more than 50 employees are generally lean organizations, and the sub-specialized employees are often engaged in performing their day to day duties with little available time.

Time/Human Resource Barriers Include:

- The relatively small number of employees impacts a bakery's ability to release employees for training without impacting operations.
- Lack of available time to explore and research effectiveness of P2 opportunities

2.6 Organizational

In smaller bakeries, it is likely that the owner operator is the decision maker that is weighing the financial risks to implement pollution prevention, whether it be changes to the production line that may alter the quality of the product, or a capital investment for new boilers or ovens. The owner-operator is unlikely to have an environmental compliance/sustainability employee or a team to consult with on the decision, so pollution prevention may often be overlooked.

In larger bakeries, it is likely that a chain of management must agree to implement pollution prevention initiatives. The motivation may come from maintenance workers that identify areas for improvement, or from more senior management indicating that pollution prevention must be implemented as part of

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[16] Discussions with W. Kraus, Weston Bakeries, 2014.
[17] Based on experience working on P2 projects within the sector.

company policy[18]. Internal competing priorities, or the lack of agreement on priority of initiatives can often stagnant P2 initiatives.

The following organizational barriers have been identified:

- Environmental managers may not fully understand production processes and may doubt that P2 opportunities or technologies exist[19].
- Limited worker involvement / no reward for pollution prevention.

2.7 Market

The bakery industry produces goods in response to customer demand, and as customer tastes evolve, the ingredients of the recipe also change. There is a growing market for the use of "organic", "natural", and "sustainable" ingredients[20]. However, none of these certifications is related to the P2 performance of a company. Consumer demand for natural and artificial-free products is pushing manufacturers towards phasing out artificial colourants and flavours[21], such as propylene glycol which is a used as a carrier for flavours not soluble in water. Meeting customer expectations for taste inhibits facilities from switching substantial product modifications, such as replacement of yeast in bread, whose fermentation releases VOCs.[22] A shift in the industry to sustainability is realized by large purchasers such as Walmart, requiring its vendors to complete sustainability report cards. As a result, manufacturing facilities are required to engage in pollution prevention technologies.[23] Although a small portion of distributors require these activities, the trend is growing.

Market Barriers that were identified include:

- Undesirable to make ingredient/process changes that change the flavour, texture, or quality of product
- Distributors do not demand sustainable production throughout their supply chain
- Lack of consumer demand

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[18] http://www.weston.ca/en/Environment.aspx
[19] U.S Congress Office of Technology Assessment. (1994). *Industry, Technology, and the Environment – Competitive Challenges and Business Opportunities.*
[20] (Grunert, Hieke, & Wills, 2014)
[21] http://www.torontosun.com/2015/08/04/kellogg-to-stop-using-artificial-products-in-cereals-snack-bars
[22] (United States Environmental Protection Agency, 1992)
[23] http://www.greenbiz.com/article/inside-walmarts-new-plan-scale-supply-chain-transparency

- Although consumers are full of intent to purchase sustainably produced foods, studies have indicated that these preferences have not translated into a widespread uptake of more sustainable products[24]

2.8 **Technological**

Small bakeries generally do not have the specialized resources in-house to identify technical P2 opportunities. Many of the established medium to large bakeries in Toronto have no, or limited opportunities to expand the bakery because of land use limitations, and parking requirements that create challenges to implementing P2 activities. Even if the technology is available to the sector, proposed pollution prevention may require process shutdown due to modification of the work flow, product, or installing a new equipment, which would lead to loss of production time[25]. In addition to production losses, not only may new technologies require additional training for employees to operate the equipment safely, but may also change product quality or specifications that could lead to customer rejection.

Technological barriers identified include:

- Lack of specialized staff training to implement new technology
- Reliant on suppliers to develop recommendations (smaller facilities)
- Lack of floor space for process modification or installation of new technology
- Fear of results / misinformation within the industry

2.9 **Regulatory**

The commercial bakeries industry is heavily regulated in general, as are most food manufacturing facilities. However, bakeries in general are not subjected to additional specific regulations from Environment Canada, or the Ontario Ministry of the Environment and Climate Change. As such, no regulatory barriers could be identified for this sector.

3.0 REVIEWED POLLUTION PREVENTION TECHNOLOGIES

3.1 **Nitrogen Oxides (NOx)**

NOx emission are expected to be primarily from the combustion of natural gas for heating ovens or tunnel dryers. Opportunities for pollution prevention are using electric ovens, increasing energy efficiency of the process, and using low NOx combustion technologies.

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[24] Horne, R.E., 2009. Limits to labels: the role of eco-labels in the assessment of product sustainability and routes to sustainable consumption. *International Journal of Consumer Studies.* 33,175-182.

[25] Hassanali, et al. *The Toronto Region Sustainability Program: insights on the adoption of pollution prevention practices by small to medium-sized manufacturers in the Greater Toronto Region*. 2005.

The conversion of natural gas to electric ovens is not endorsed by any of the jurisdictions reviewed in this report. While a 100% reduction in NOx emissions can be achieved, the lower operating costs associated with natural gas provides no financial incentive to change. Infrared ovens, however, can be powered by electricity or fuel, but use 50-80% less energy, and consequently, a proportional reduction in emissions because they do not require a large volume of air to be heated.[26] Infrared heating is generally considered more intense, and may not be compatible with all baked goods.

Integration of internal heat recovery, also known as flue gas recirculation, will allow facilities to operate their ovens in the same manner, but use less fuel and produce less NOx emissions as a result. The industry requires 895 BTU/lb of product on average[27]. Strategies to reduce natural gas consumption include strategic oven selection, oven placement, minimizing heat up time, optimizing product movement and efficient oven burners. The opportunity to recapture waste heat represents potential to significantly reduce natural gas consumption and heating cost. Typically, 1% of fuel use is saved for every 25ºC reduction of exhaust gas temperature.[28] This can be achieved using various forms of heat exchangers to heat process water.

- Weston Bakeries installed a heat recovery system that saves the facility 86,000 to 95,000 m^3 of natural gas per year, corresponding to savings of $27,000 and reduction of 137 to 152 kg of NOx emissions.[29]
- A heat exchanger can be installed to capture heat energy from the exhaust gases from the oven. This captured heat will pre-heat the required air for combustion, reducing the fuel required to heat this air, recovering costs of about $8000 and resulting in a typical payback period of 2 to 4 years.[30]
- Maintaining burners, including replacing damaged or obsolete burners, increases the energy efficiency of the oven, reducing NO_x emissions. These actions typically have a payback period of 1.5 years.
- Burner optimization during commissioning, typically having a payback period of 5 to 10 months
- Repairing air leaks ensures that only the contents of the oven are heated and not the surrounding environment, ensuring efficient fuel usage and reductions of NOx, and having a payback period of less than 1 year.

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[26] Masanet, E., Therkelsen, P., & Worrell, E. (2012). *Energy Efficiency Improvements and Cost Savings Opportunities for the Baking Industry.* Ernest Orlando Lawrence Berkeley National Laboratory.

[27] Ibid.

[28] Ibid.

[29] Ibid.

[30] Ibid.

Common technologies in the industry for further NOx reductions can be achieved using end-of-pipe technologies such as low NOx burners, ultra-low NOx burners, and flue gas recirculation. Ultra-low NOx burners can reduce NOx emissions by 80%, and are one of the least expensive technologies that can reach high reductions.[31] Flue gas recirculation involves recirculation of cooled flue gas to reduce temperature and lowering the NOx concentration that is generated. The performance and cost of low NOx burners and flue gas recirculation are comparable, around $300/ton of NO_x emissions removed.[32]

3.2 Particulate Matter ($PM_{2.5}$)

$PM_{2.5}$ emissions are expected to be generated from:

- Delivery and transfer of powdered ingredients
- Mixture of powdered ingredients
- Finishing of product using powdered ingredients

Powdered ingredients are a necessity of the product recipe, and so ingredient substitution is not an option because the market demands for a specific taste. As a result, the remaining pollution prevention options involve control of the fugitive emissions and treating these using an end-of-pipe technology.

Delivery of powdered ingredients to the facility, as well as to the mixing container, can occur in a closed loop pneumatic system outfitted with integral dust collectors. Collection efficiency for dust collectors can reach 99.9%.[33] An added benefit of increased collection efficiency is minimization of ingredient loss.

Another common end-of-pipe technology to control $PM_{2.5}$ is an electrostatic precipitator (ESP). ESPs operate by creating a corona between two oppositely charged plates to charge particles in the exhaust stream, and move them to walls of the ESP to drop out of air. They reach collection efficiencies greater than 95%, and can be relatively inexpensive, costing $38 to $260 per metric ton of product.[34]

3.3 Volatile Organic Compounds (VOCs)

VOCs are expected to be emitted mainly from the leavening of yeast, and secondary releases would include emissions from flavours, equipment cleaning chemicals, and trace amounts from the combustion of natural gas. Yeast is a fundamental ingredient in the baking industry because of its ability to produces

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[31] American Bakers Association. (2015). *Air Emissions Guide for Bakery Sources.*

[32] Bell, R. D., & Buckingham, F. P. (2003). *An Overview of Technologies for Reduction of Oxides of Nitrogen from Combustion Furnaces.* MPR Associates, Inc.

[33] American Bakers Association. (2015). *Air Emissions Guide for Bakery Sources.*

[34] United States Environmental Protection Agency. (2003, July 15). Dry Electrostatic Precipitator (ESP) - Wire Plate Type. *Air Pollution Control Technology Fact Sheet*.

gases that bubble through the mixture and create the light, bubbly texture typical of many cakes and breads while also adding flavour profiles.

Opportunities for reduction of VOCs can be grouped into three categories:

- Process changes and recipe reformulation
- Thermal destruction end-of-pipe technology
- Non-thermal end-of-pipe technology

The main opportunities to reduce emissions of VOCs via process changes and recipe reformulation are by reducing the amount of time that yeast has to produce VOCs, and by substituting yeast with other functional ingredients. Substitutes such as baking soda can be used and have been explored in Irish Soda bread and cornbread. Both opportunities have proven a change in taste, texture, and quality of the product, and so the market barriers demanding a specific product prevent these opportunities from being technically feasible.

End-of-pipe control technologies include combustion control devices: thermal oxidation, catalytic oxidation, and non-combustion control devices carbon adsorption, scrubbing, condensation and bio-filtration. For most, the cost of the control device decreases as the size of the oven increases. A summary of end-of-pipe VOC controls reviewed can be found in Table 2. It should be noted that no technologies were identified that would yield payback periods less than 4 years. Based on our experience, end-of-pipe VOC controls in this sector are generally driven by compliance with O. Reg 419/05 – Air Pollution Control. If a facility is unable to demonstrate compliance with the point of impingement air quality limits, than it will be required to implement pollution control equipment in order to achieve to receive an environmental compliance approval from the Ministry of Environment and Climate Change (MOECC). Medium to large size facilities are expected to be implicated by this requirement, which becomes more challenging for the sector as a whole in 2020, when the MOECC requires the atmospheric chemistry dispersion modelling to be do with a more advanced model (US EPA AERMOD).

Table 2 - End-of-pipe VOC Control Technologies

Technology	Type	Description	Removal Efficiency	Cost	Feasible?
Thermal Oxidation	Combustion Technology	The exhaust stream is exposed to a flame and combusted, oxidizing VOCs.	>98%	High[35] – supplemental fuel	Low – high costs and emissions, and NOx associated with supplemental fuel combustion

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[35] Ralcorp's Cottage Bakery installed a $750,000 thermal oxidizer to a frozen bread and cake manufacturer employing 625 people.

Technology	Type	Description	Removal Efficiency	Cost	Feasible?
Regenerative Oxidation	Combustion Technology	The exhaust stream passes through a ceramic bed to heat the stream to its ignition temperature, oxidizing VOCs	>98%	High – high heat recovery available	Low– high capital costs, NOx associated with supplemental fuel combustion
Catalytic Oxidation	Combustion Technology	The exhaust stream is combusted in the presence of a catalyst, allowing for altered conditions of lower organic concentrations and temperature	>98%	High – low energy, high capital costs required	Low – high capital costs
Carbon Adsorption	Non-combustion Technology	Activated carbon beds adsorb organic compounds from the exhaust stream, such as VOCs	>95%	Moderate	No – properties of exhaust stream degrade performance of carbon beds
Scrubbing	Non-combustion Technology	Organic compounds are adsorbed by a liquid in a packed tower	>95%	Moderate – wastewater treatment required	Low – performance limited by dilute VOC concentration
Condensation	Non-combustion Technology	VOCs are removed from the exhaust stream by cooling the gas below the dew point, condensing VOCs	>95%	Moderate – wastewater treatment required, refrigeration costs high	Low– not economically feasible
Bio-filtration	Non-combustion technology	The exhaust stream is passed through a bed of soil, in which microorganisms break down VOCs	Variable	High	No – high temperatures of exhaust gas can kill microorganisms

3.4 Biochemical Oxygen Demand (BOD)

BOD is the amount of dissolved oxygen required by biological organisms to break down organic matter in the water leaving the facility. It is a surrogate parameter that is proportional to the amount of organic matter in the effluent. From baking facilities, it is expected that high BOD is a result of food waste and cleaning operations that involve washing organic matter such as flour or sugar down the drain. These ingredients are fundamental to the baking process, as is the cleaning of tools used to handle, mix and bake them.

The organic compounds that increase BOD such as flour and sugar cannot be substituted because they are fundamental to the baking process. Minimizing waste products and disposing of wasted food products by means of solid waste instead of the wastewater stream are viable options to reduce the BOD of a facility’s effluent water stream. Disposal of food products by means of solid waste can be achieved by physical dry collection of food wastes or scraps baked onto cook ware and directing this waste into compostable waste treatment. Alternatively, food product waste can be cleaned via water streams and then removed from this water by various wastewater treatments. Wastewater treatment is an alternative that reduces changes to a facilities processes, but is much more costly to install and maintain.

Manufacturers in Toronto must comply with the City's Sewer Use By-law, which limits the effluent BOD to 300 mg/L. As a result, it is expected that most food manufacturing facilities should already implemented pollution prevention strategies and wastewater treatment technologies to comply.

3.4.1 Cleaner Production Case Study

Cleaner production (CP) is an emerging consideration in the bakery industry, and is becoming increasingly popular in numerous countries. The uptake of CP in Canada is still considered low as a result of comparable low water usage and wastewater discharge rates.

A baker in Australia that produced bread, bread rolls, as well as pastry products and cakes used CP to improve its environmental and economic position[36]. Specific information about the bakery's water use, and characteristics are provided below:

- Bakery is highly automated
- Facility used 719,000 L/week of water, 59% was used in production. 41% for cleaning activities
- Production of pastry and bread rolls contributed to 35%, and 36% of the wastewater volume, respectively.
- Chemical Oxygen Demand (COD) loads from the pastry, bread rolls, and night cleaning were 29%, 25%, and 38% respectively
- Approximately 1.7 tons of dough per week was lost in the waste stream (0.5% of total mass of ingredients ~$4000/month)
- Pancoat oil and white oil were used in production, main contributors to fats/oils/grease in wastewater.

P2 Activities implemented

- Relocation of drains for easier collection of dough, and installation of screens at drain points to capture fallen dough.
- Modification of cleaning strategies, reuse of water discharges for cleaning operations
- Equipment modification to reduce oil loss.
- Total cost savings of $27,700/month were achieved.

4.0 POLLUTION PREVENTION OPPORTUNITIES

The following have been identified as potential P2 options for facilities and have been described in Section 4

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[36] Gainer, D. *The Country Bake Story – How a modern bakery is achieving productivity and efficiency gains through cleaner production.* Sustainable Energy and Environmental Technology. 2008. P. 573-578

- Low NOx burners
- Flue gas recirculation
- Closed-loop ingredient receiving & mixing
- Regenerative oxidation
- Catalytic oxidation
- Minimizing wasted products
- BOD/water usage
- Energy efficiency
- Heat recapturing

The bakery industry is one of the largest water users in North America[37]. Stringent wastewater discharge regulations, and cost of pre-treatment are the most common reasons for facilities to invest in pollution prevention activities. The most commonly implemented P2 initiatives in the sector include water conservation and clean production.

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[37] Wang, L. *Waste Treatment in the Food Processing Industry*. CRC Press. 2013. P273-290