LEANER AND CLEANER IS GREENER

How to reduce utility costs and track carbon footprints in food and farm-based processing

8-5-3: An operator's primer

Ministry of Agriculture and Food
Ministry of Rural Affairs

Ontario

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Acknowledgements

The ministry wishes to acknowledge the contributions of the following people toward the development of this manual.

Matt Wilson, Don Hilborn P.Eng., Yulong Jiang, Leila Bautista, Tomasz Krzewski, Sheung Hei (Stephen) Chow, Emily Ryder, John Schut, Margaret MacDonald, Shirley Newell, Jennifer Bousfield and Jacquelynn Moody; OMAF/MRA for editorial review and support .

Michael Bettencourt, Sleeman Breweries, Bradley Wiseman, EarthFresh Foods, and Ronald Froese C.A. for technical review.

Tanya Stockman, Natural Resources Canada; Stephen Dixon and Garth White of TdS Dixon Inc.; Alex Keen, CEO Altech Environmental Consulting Ltd.; Kevin Jones, CEO and Michael Fagan, Senior Vice President of The Bloom Centre for Sustainability for their insight and inspiration.

Special thanks to Sandra Bennett, OMAF/MRA for layout and design.

Photography & Images: the Ontario Photo Library.
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FOREWORD

Sub-metering:
A sub-meter is a meter that is placed inside a facility and measures a portion of use.

Sub-metering is an effective way to measure the utility use of discrete equipment systems, motors, rooms (as in lighting or refrigeration) and water lines.

Sub-metering is a building-block of intelligent efficiency.

Energy Management Information System: EMIS can make utility performance visible across an organization, enabling individuals and departments to plan, make decisions and take effective action to manage utility use. This decision-support tool can lead to productivity improvement with the continuous monitoring of utility performance and the identification of savings opportunities that can be sustained beyond an initial two to three year post-implementation awareness period.

KPI : A measure of performance use to ensure corporate goals and values get acted upon at an operations level.

Sometimes the things you do in your business add more cost than you budgeted.

Sometimes cost control goals seem overwhelming.

Sometimes we wish we had tools to fix everything.

The primer builds a case for a disruptive technology. Trained users are able to accurately manage inputs that get lumped into fixed costs, derail operating budgets and cause unnecessary wear, tear and maintenance on equipment. The premise is that intelligent technology tied to the sub-metering of utilities can be applied to product costing models, then used to root out invisible waste embedded in a food or beverage manufacturing facility.

Leaner and Cleaner is Greener is a primer for plant operators who are ready to consider a game-changing way to systematically manage input costs as they grapple with how to meet sustainable mandates. It connects social responsibility, environmental improvement and profit. It's meant to bring the realities of running a plant together with what the market and shareholders want with answers to the following questions:

1. Why do utility use, waste and carbon footprints matter in a food plant?
2. How do you link equipment-based costs to sustainability?
3. What can you do to get started?
4. Where can you go for help?

This primer is based on first-hand plant management experience and the lessons learned from 300 audits done in Ontario's food industry since the mid 1990s. A single **best management practice** is the core, one that is often overlooked or ignored because its benefits are not generally understood. This practice is to **network** utility sub-meters for monitoring and targeting (**M&T**) with a software package known in the industry as an Energy Management Information System (**EMIS**) plus employee **training** to:

- Measure the effectiveness of utility inputs, and
- Create reliable data for utility cost and carbon footprint at the package level.

M&T tied to **EMIS** sets the stage for co-benefits:

- A top down and bottom up **learning strategy** that drives sustainability.
- Data integration into product costing models that can reflect **Key Performance Indicators** (KPI's) to inform and inspire an entire organization, from manufacturing to marketing, purchasing to distribution, and finance to the board of directors.
- **Uncover** invisible costs that affect **Operational Equipment Effectiveness** / Efficiency (OEE) caused by wasted energy, water and solid waste.

M&T is not new. It has been around for decades, but how it's used is different now. With **EMIS** it measures more than time-of-use, volume-of-use and peak demand. Add trained staff and these powerful tools help reveal invisible costs, variable production costs and a carbon footprint. The ability to peel back different layers in your plant and understand how they affect each other will give customers the green proof they want and the factory a sustainability tool that drives variable cost management down to the package level.

Unlocking the utility use, carbon and pollution chains that fetter profit is the focus of many of today's sustainability leaders.

- According to the Aberdeen Group, a business-related research organization, energy and carbon

[1] Shah, Mehul and Littlefield, Matthew. 2010. *Carbon and Energy Management in Manufacturing Operations*, Aberdeen Group.

management are tied to the bottom line.[1] Aberdeen's writers suggest intelligent technology (M&T, analysis, audits, key performance dashboards, simulations, audits and process controls) can link plant energy use and carbon. Combined with training, intelligent technology helps managers reduce utility costs and carbon at the same time.

- Natural Resources Canada uses the term 'environmental efficiency' to explain the energy and environment link. Energy efficiently reduces costs, waste **and** pollution.
- The Ontario Power Authority says energy conservation can increase profitability 10 times faster than new sales. The reverse is also true. Failed measures and/or doing nothing can decrease profitability 10 times faster than lost sales.
- Food retailers like Walmart, Loblaw's and Sobeys see sustainability as pre-competitive.

Food plant design creates invisible costs. Learning how to find these hidden costs is what sustainability is all about. The three-phase approach of this primer suggests a way to reduce processing costs as you learn, enable your plant to join green marketing opportunities and manage your environmental footprint.

Learning how to apply sub-metering in your facility is a sustainable short-cut to higher margins.
It is compatible with the principles of Lean and will provide the information you need to accurately forecast the value of sustainable improvements with data to support a payback-driven process.

And finally, the primer includes a narrative "Sidebar Story" about how a company tackled its utility costs and got greener. We hope it ties the theory of sustainability with a practical learning strategy to get there.

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EXECUTIVE SUMMARY 8-5-3

This primer is one approach to sustainable food processing that sees a food plant as 8 systems in 5 zones with a 3-phase improvement plan.

CARBON NEUTRAL:
Climate change science uses a measurement that is equates all atmospheric pollution to units of carbon dioxide(CO^2) as it is considered the largest contributor to climate change. Most CO^2 comes from the burning of fossil fuels, which releases stored CO^2 back into the atmosphere.

Manufacturers can become carbon neutral when they reduce their fossil fuel use and increase renewable energy use.

To manage this change, people are trained to use a network of utility sub-meters that monitor and track (**M&T**) utility use with a software package known as an Energy Management Information System (**EMIS**). The approach prioritizes low hanging fruit; system optimization and closed loop waste recovery. A processor can halve its use of hydro, water, sewer and natural gas; and almost eliminate waste output (wastewater, solid waste and lost heat) with accurate data to drive sustainable improvements.

How an industry uses utilities creates what environmental regulators call pollution. Consumers understand pollution as carbon footprint. By measuring how 8 systems interact with 5 zones of a food plant it is possible actively manage utility costs and carbon volume at the package level.

This primer does not directly address labour efficiency, procurement, finance or capital cost management. The management of these costs tend to be well understood. Nor is this guide a definitive instruction manual for Lean. Rather, the point of this guide is to help you be consistent and more effectively apply any "efficiency" strategy with a measurable impact on your sustainable goals.

When M&T plus EMIS[2] get tied to product costing models the link between utility costs and carbon are visible at the package level. With this comes the chance to add 10 or even 20 points to your gross margin. Through this process you may be able to achieve a sustainable status of carbon neutral (or even carbon negative).

8 SYSTEMS

The technology used in a food plant falls into eight systems that use energy and/or water, and are often tied to regulations.[3] Over 300 food plant energy and water audits in Ontario shows us that these **8 systems** waste 50 to 95 percent of the utilities they consume. Measure these **8 systems** to effectively drive out the invisible waste that confounds efficiency projects. The **8 systems** include:

LEAN:
The elimination of waste defined by Japanese industry as *muda* (non value-added work), *muri* (overburden/ bottlenecks) and *mura* (uneven work-flow).

1. Heating, ventilation and air conditioning
2. Lighting
3. Compressed air
4. Combustion
5. Refrigeration
6. Motors and Conveyors
7. Sanitation and process water
8. Energy generation

An 8-5-3 approach to utility and waste management **compliments** practices such as Lean and **Six Sigma.**

If you don't have the time to read this or lack the authority to implement, **pass it on** to someone in your organization that does.

In a food plant, technology (equipment) gets bought and installed as discreet systems that stand alone from a utility use perspective. Stand-alone equipment increases utility use. Sustainable manufacturers need to reverse this trend. Energy and water waste from one technology system can be recaptured to replace some or all utility use in another system.

[2] Natural Resources Canada's Office of Energy Efficiency offers introductory training sessions called:
- Monitoring and Targeting, and
- Energy Management Information Systems.

You will find more information on these courses on their website: http://oee.nrcan.gc.ca/industrial/training-awareness/index.cfm?attr=24 .
M&T information sheets are on OMAF/MRA's website: http://www.omafra.gov.on.ca/english/food/business-development/publications/index.html .

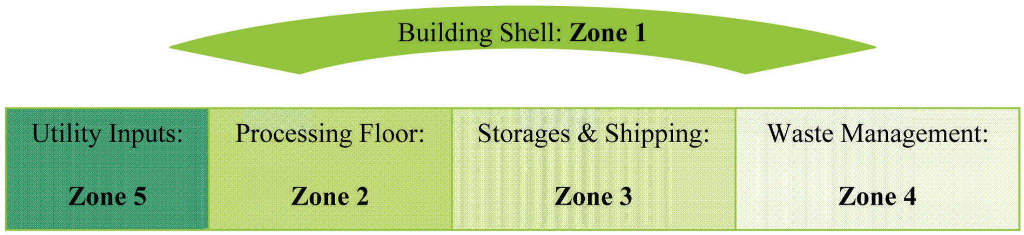
[3] Food and Consumer Products Canada counted the number of regulations and acts that affect the food industry in 2007 and came up with 442 different regulations and acts. Since then the list has grown.

5 ZONES

Systems do the work in a food plant. They also cross zones in a plant. Invisible waste happens as the unintended impact of systems that cross zones in your plant. The isolation of invisible layers of waste system utility use by zone is possible with **M&T** and **EMIS.**

The 5 zones shown in **Figure 1** are numbered in the order of their priority for improvement. The priority sequence for addressing obvious and then the invisible layers of waste is discussed under the **3 Phases** section.

Figure 1: The zones



M&T: Defined as *monitoring* and *targeting* of utility use where meters are placed at the point of use of zones and/or significant equipment processes (for *monitoring*) in a manufacturing plant to measure specific utility consumption. This information is collected as benchmark data which can then be reviewed for cost reduction opportunities and process improvements *targeting*).

3 PHASES

A phased approach avoids costly misadventures. It is a strategic direction where success hinges on a completed "**R**eadying" phase. These phases include:

1. **R**eadying: train staff and management to use and install M&T and **EMIS** (People)
2. **O**ptimization: eliminate leaks then upgrade existing equipment (Process)
3. **I**ntegration: recycle waste heat/water then install greener technology (Technology)

If you only want "**the list**" (what to do) go to pages 87 through 89 in the Appendices.

Be forewarned. Just "the list" can help **drive down** costs, but only for a while.

If what you want is to **drive out** costs and waste, use the primer. The primer can help you understand **how** and **when** to do **what** in a way that a sustainability plan works with Lean and Six Sigma to drive profits forward.

The **R**eadying phase relies upon M&T with EMIS **plus** training to measure data for cost and carbon in product costing models. Leaders in sustainability do this intuitively. This level of detail minimizes mistakes that otherwise get buried in a cost structure because carbon and utility waste is invisible. There are four outcomes that support a sustainability learning culture:

VARIABLE COST: A predicable cost that will increase or decrease with the volume of output, such as labour, materials, energy and water.

- **Continuous improvement** of utility efficiency and control of variable costs,
- **Equipment upgrades linked to leaner and sustainable processing,**
- **Identifiable payback** for environmental improvements, and
- **Verifiable data** for third-party experts who **verify green marketing claims**.

Readying enables operational staff to accurately measure the volume, time and carbon impact of utility use. Behaviour-related waste gets minimized as the first invisible target.

Optimization target leaks and system performance in the zones where systems are intended to operate. As system efficiency improves, utility costs shrink. An effective **O**ptimization process reduces the load on utility input systems (boilers, motors, drivers, compressors, etc.) making replacement and upgrades less costly. Most importantly, this phase trims unavoidable waste.

Integration reuses unavoidable waste before it becomes a burden outside of the zone where it occurs. Sometimes wastes are recaptured as utility inputs. **R**eadying and **O**ptimization can minimize waste below an economic recovery point, that too, is a good thing.

An **8-5-3** approach gives a sustainable manufacturer a way to measure cost and carbon at the package and facility level.

SECTION 1.0: INTRODUCTION

LEANER AND CLEANER IS GREENER: 8-5-3 IS ALL ABOUT:

An approach to managing a manufacturing process that uses intelligent efficiency in order to

- *Cut invisible costs,*
- *Avoid marketing risks linked to poor environmental performance, and*
- *Use real and verifiable data to tap into green market trends.*

Sustainable:
The long term viability with a minimal effect on the environment.

Sustainable manufacturing disrupts the status quo where behaviour has to change. The game-changer is so effective that there will be no desire to go back.

From a corporate point of view, it helps to link energy and water management to carbon management. At the operational level, this can be done in a product costing model if sub-metering systems are installed throughout the plant to measure utility use. This requires a focus on the **8 systems**[4] that are used in food and beverage processing.

When we measure how the **8 systems** perform across a food or beverage processing plant, wastes loads become visible – they can be measured for both cost and carbon. To understand the cost implications of the waste, it is important to see a food or beverage processing facility in terms of the **5 zones** as identified in this primer.

Zone 1: The Building Shell. A building shell does not directly affect processing, yet it has a utility load. The efficiency of a building shell has an impact on overall costs and an indirect (either positive or negative) impact on utility waste in other zones.

Zone 2: The Processing Floor. Most of the direct energy loss in a food or beverage plant is through its processing systems. These losses also add load to other zones like building ventilation or refrigeration.

Zone 3: Storages and Shipping. This zone has very specific efficiency opportunities related to time of use and waste heat or cooling collection for re-use in another area of the plant.

Zone 4: Waste Management. The output zone represents a small portion of a plant where the opportunity lies in waste heat recapture and recycling. This is a potential recovery zone. Water can be recycled or liquid and solid wastes transformed into an energy feedstock for Zone 5.

Zone 5: Utility Inputs. This zone it the gatekeeper of a factory's carbon footprint. Where ever possible, the transformation of processing wastes into utility (energy or potable water) feedstock represents a game-changing reduction in the overall carbon footprint of a facility.

Sustainable Bits: A change in technology disrupts the status quo.

Albert Einstein once said, *'A problem cannot be solved with the same kind of thinking that created it.'* Solutions disrupt problems. Technological solutions are often a trade off between the cost of labour and the cost of energy. On the high seas it was energy density of fuel oil that ended the age of sail, not labour-intensive coal. Personal computers eclipsed the typewriter and the office pool secretary.

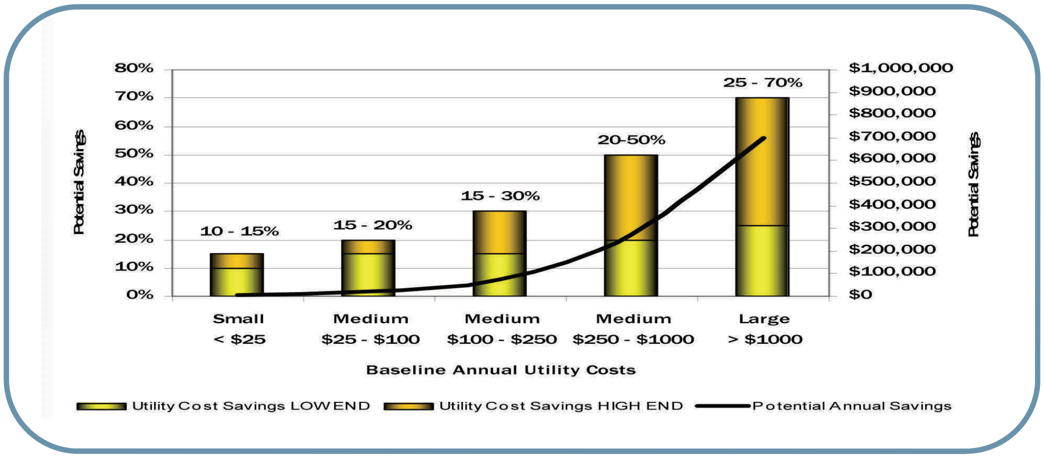
Lesson learned: A disruptive technology changes who plays the game.

[4] This list of 8 systems includes: building shell systems (1); lighting (2); compressed air (3); combustion (4); refrigeration (5); motors and conveyors (6); sanitation and process water (7) and energy generation (8).

Figure 2 illustrates the scale of utility cost reduction that may be possible at various levels of utility use. Note that potential cost savings are relative to the scale of use.

Not all processors can recycle all of their utility and solid wastes on site. The scale of waste matters. Self-identify your scale to establish realistic expectations.

Figure 2: The potential for annual utility cost savings as a percentage of total utility costs



Source: Ranges are based on 300 energy and water efficiency audits in Ontario food plants, 1995 to 2010

1.1 THE 3-PHASE APPROACH

Businesses that are very good at managing their utility costs intuitively follow a three-phase approach described in this primer. The order is important. Each phase builds upon the previous phase in a way to avoid projects that undo each other. The phases are as follows:

Phase 1: Readying **(People)**

- This phase focuses on people and the tools to support intelligent efficiency.
- Build a management team and workforce that uses intelligent tools to see where utility use happens, when it happens, then address wasteful work habits. Behaviour management skills learned in this phase are amplified in later phases.
- Tie utility use and carbon into product costing models at the package level.
- Ensures energy and water waste is measurable.

Phase 2: Optimization **(Process)**

- This phase focuses on the efficiency of systems
- Leak-proof then upgrade process equipment; identify wasted heat and wasted water.
- Ensure energy and water gets used effectively.

Phase 3: Integration **(Technology)**

- This phase focuses on technology that re-integrates waste as an energy source across zones from one system to another.
- Close the loop. Recycle waste heat and wastewater. Pursue green utility sources after internal use is minimized and turn wasted outputs into recovered energy and water inputs.
- Ensures sustainable utility flow between zones.

As your house is brought into order you can integrate your external supply-chain with your sustainability program. The lessons learned in your own plant provide your internal experts with skills to mentor your suppliers in a value-added relationship.

1.2: THE READYING PHASE (PEOPLE)

The **R**eadying phase focuses on toolkit training and management control that sets the stage for continuous improvement. In Canada, this phase starts by using the programs offered by Natural Resources Canada (NRCan). Since 1975 – the launch of the Canadian Industrial Program for Energy Conservation (CIPEC), NRCan has worked with Canada's businesses to improve energy efficiency. Managed by the Office of Energy Efficiency, the program is our national champion of energy awareness training; providing tools and support programs. Learn about CIPEC on NRCan's website www.nrcan.ca.

Over the past 35 years CIPEC found that the hidden cost of waste in energy, water and solid waste is twice the avoidable cost of waste in labour. CIPEC's experience also suggests some labour efficiency is recouped with utility efficiency, when hidden wastes stop adding to labour costs. In other words, **when you measure and control hidden utility costs you also drive out hidden labour costs.**

NRCan has documented businesses in Canada and Ontario that thrive after reducing their net utility use. A lesson learned from NRCan on M&T with EMIS is that companies permanently cut 26 to 40 percent of their utility costs.

There are four reasons to use intelligent metering:

1. To determine **exact utility** use data for energy procurement and carbon tracking.
2. To develop **dual-purpose key performance indicators** for management and shop floor production on input management.
3. To collect **accurate data** for new project development and engineering.
4. To reconcile **accurate data on utility use** and **carbon** into product costing models.

Management and staff can put sustainability into practice by identifying and ending wasteful behaviour; then finding and fixing system leaks (the low hanging fruit) in the zones where they occur.

Sometimes the **R**eadying phase is an uphill battle. Some people take longer to buy in to how sustainability supports their needs. **Appendix 10.2** Getting internal buy-in (pages 55 and 56) provides suggestions on how to approach colleagues and gain their support.

1.3 THE OPTIMIZATION PHASE (PROCESS)

Utility creep: The gradual increase of utility use linked to a lack of monitoring capacity to support efficient management.

8-5-3 will help you identify invisible wastes that **8 systems** have across **5 zones** in a food plant. The **O**ptimization phase focuses on system upgrades using actual baselines developed in the first phase. In this phase production is managed in a continuous improvement feedback loop so that the low-hanging fruit never grows back. **Companies without M&T and EMIS lose their efficiency gains within three to five years.**[5] Energy efficiency experts call this **utility creep**. Utility creep undoes conservation projects when benchmarks and KPI's are lacking.

The **O**ptimization phase focuses on the efficiency of systems in the zones where they operate. Projects include lighting retrofits, variable speed drive installations, compressed air pressure reductions and process controls. Combining M&T with EMIS isolates the operating cost of discrete systems. Accurate data drives the case for mechanical upgrades followed by integration projects where waste loads are pre-measured and costed for re-use in the **I**ntegration phase.

Investment for training and technology is hard to link to baseline efficiency before the fact. Yet we know that measurement can link KPI's to a product costing model; link utility efficiency to process reliability (or OEE), and link Lean to continuous improvement. An 8-5-3 approach employs training, M&T and EMIS to control the variable costs that are not well-measured in a food plant. For retailers like Walmart, Loblaws and Sobeys effective management is pre-competitive. Current variable cost management (i.e.

[5] In 2009 trainers from the Certified Energy Managers course began to describe the issue of utility creep when they presented on behalf of Natural Resources Canada. They studied energy efficiency projects. Facilities that lack meters and targeting systems (M&T) revert to pre-project waste levels. (http://www.cietcanada.com/pdfs/Cem_courseinfo.pdf)

CRADLE-TO-CRADLE (C2C): This is an approach to product design and manufacture developed by William McDonough and Michael Braungart in 2002. C2C minimizes the environmental impact of products by employing sustainable production, operation, and disposal practices and aims to incorporate social responsibility into product development. Products are evaluated for sustainability and efficiency in manufacturing processes, material properties, and toxicity as well as potential to reuse materials through recycling or composting. C2C designs are considered "eco-effective". 2C optimizes human health, recycling and/or composting to ensure product life. The use of renewable energy, water efficiency and quality are important considerations linked to social responsibility. An eco-effective C2C product minimizes or even eliminates negative impacts of a business or industry.

labour and ingredients) must extend to utilities and solid wastes.

1.4 THE INTEGRATION PHASE (TECHNOLOGY)

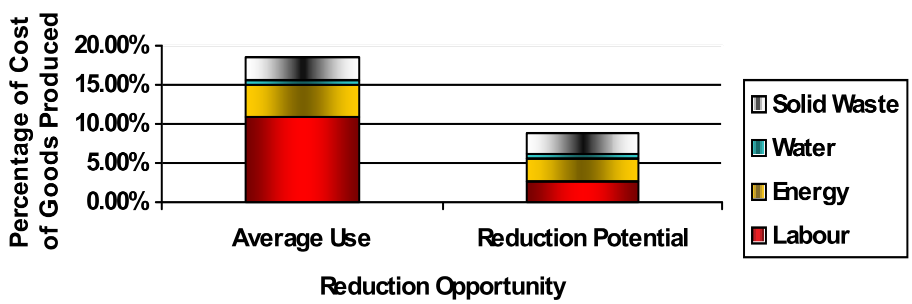
This phase tackles the invisible costs that are the most difficult to manage. At this stage, the focus is how systems interact **between** the zones in your facility. In the first two phases, variable cost control is driven into product costing models. Not only does this position production staff to be responsible for embedded utility waste, but production costs can be accurately modeled down at six decimal points on a million dollar utility bill **at the package level**.

To recapture and recycle unavoidable wastes (heat in cooling and/or drain water, stack heat, air exhaust heat, compressor heat, etc.) a critical mass of cost is needed. **Figure 2** shows how scale affects potential efficiency gains. Businesses at the lower end of utility use may lack the volume of utility "waste" to justify its recovery.

Sometimes the first two phases reduce the utility waste in a plant to where the hurdle rate of process integration is too expensive to justify. An EMIS-linked M&T system provides a reality check that avoids poor investments and right-sizes technology specifications. **Every dollar invested in R**eadying **and O**ptimization **avoids three to five dollars of capital for I**ntegration **in addition to earlier efficiency paybacks**.

Labour is often cited as primary target for efficiency. Interestingly, invisible costs related to utility waste also reduce labour efficiency. More importantly, when utility efficiency is significantly improved, labour efficiency is improved, too. This layer of invisible waste needs to be removed in order to better understand labour efficiency, **Figure 3** demonstrates the relative reduction potential of solid waste, water, energy an labour.

Figure 3: The scale of variable cost reduction potential[6]



Source: NRCan 2011 and Stats Can 2010

The **I**ntegration phase is referred to by some leading practitioners as the "technology phase". European manufacturers fit this phase into cradle-to-cradle obligations that eliminate waste. In North America, Walmart sustainability executives call this keeping "the molecules in play". The point is to return wasted energy and solids back into use by creating internal energy loops.

In the **I**ntegration phase, a facility can reduce their footprint to neutral or negative. Green technology like solar thermal water heating and energy from waste projects that are linked to the utility supply zone are most effective as the last projects.

1.5 CONNECTING EMIS TO PRODUCT COSTING MODELS

The most time-consuming aspect of **8-5-3** is to reconcile EMIS-generated data with product costing models. It takes a team to do this – production, product management and engineering are the likeliest members. Re-build product costing models to reflect utility costs at various metering points. It takes time and attention to detail. There are no shortcuts. Calculate utility costs down to six decimal points ($0.000000) at the package level. This kind of accuracy provides two benefits:

[6] This figure is based on average variable costs as reported by Statistics Canada, 2008 and Natural Resources Canada, 2010.

CARBON CO-EFFICIENT: A number used for the equivalent weight of carbon that is embedded in the volume of use of a utility to make or manufacture a product.

- The carbon co-efficient of any utility (water/electricity/gas) can be converted by volume **and** cost to a CO^2-equivalent which can be aggregated for overall Greenhouse Gas reductions.
- The package-level cost of utilities at six decimal places provides an accurate estimate of package-level Greenhouse Gas impact from processing.

After three months a fairly accurate baseline for product costing models should emerge. Review again after six-months to incorporate further efficiency gains. Thereafter, production and product management need to reconcile baseline data into annual pricing drills.

An extensive appendix on possible sub-meter placements is provided in **Appendix 10.5 Schematic and logic models for patterning an M&T system** (pages 73 to 81).

1.6 SUPPLY CHAIN CONSIDERATIONS

Sustainability flows downstream. Retailers like Loblaw's, Sobeys, Walmart and McDonald's are challenging their upstream supply chain to be greener.

Managing a product's footprint goes beyond the property line. Inputs and outputs have footprints that add to your costs. Once the utility costs are wrestled down in a plant, its time to look upstream. You might find you are a leader, in which case you have a proven model that your suppliers can adopt.

1.7 PLANNING

Consider planning at each stage of the process. The Gantt chart on page 50 is an example of possible timelines for planning, training and project execution. It is critical for sustainability goals to comply with complex environmental and food safety regulations. Senior manager need to look at this, too. A sustainability journey takes time.

The Ontario Food Industry Environmental Coalition (OFIEC) has an environmental self-assessment tool. It is on the Alliance of Ontario Food Processors website: www.aofp.ca .

1.8 SEEING THE ZONES IN A FOOD PLANT AND HOW THEY INTERACT

Figure 4 on page 10 depicts the five zones of a food or beverage plant where inputs are transferred across the **eight technology systems**. Note that the building shell is an arch over the processes.

Sustainable Bits: Did you know?

Water use affects a carbon footprint. Using one cubic meter of municipal water can result in 3.5 kg of carbon emissions from water treatment, food processing and wastewater treatment. This does not include the carbon-equivalent impact of solid wastes in the wastewater stream.

According to the Dow Jones Sustainability Index, sustainable companies are profit leaders.

M&T and EMIS tied to a product costing model can track costs and process-related carbon.

Lesson learned: You can tie efficiency and margin performance to sustainability.

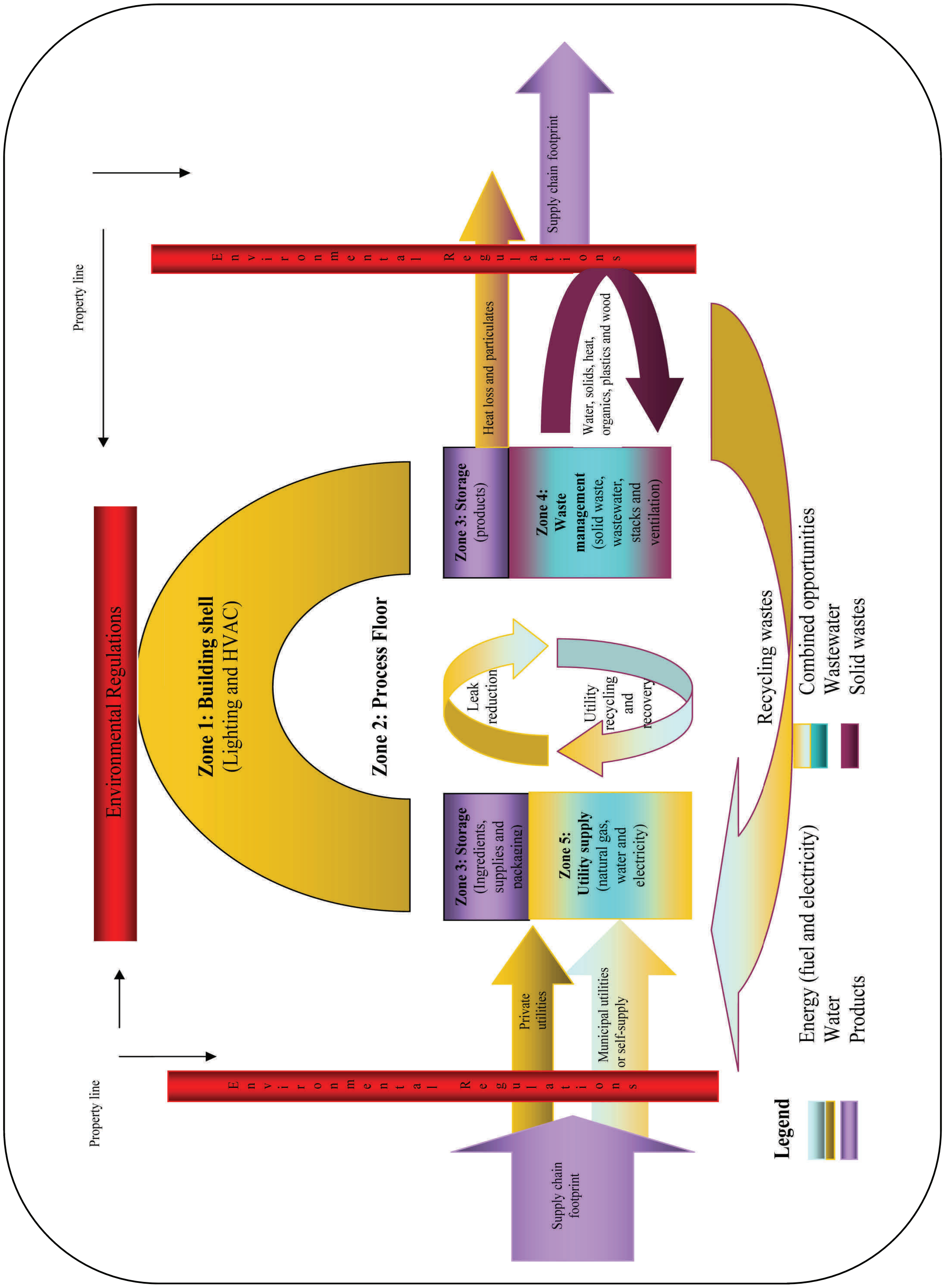


Figure 4: Visualizing the zones and utility reduction opportunities in a food or beverage plant

Explanation of Figure 4 Schematics:

- Inputs to the building shell impact the cost (not the actual processing process).
- Straight arrows represent inputs and outputs that affect the cost of your product.
- The curved arrows represent opportunities for reducing or recycling waste.
- Environmental regulations start at the edge of a property or if natural feature like a river or creek intersects the property.
- The Phase 3 'Internal Integration' arrow represents the recycling potential of production wastes to reduce purchased fuels.

Case study: What some experts in sustainability say about the opportunity

Bob Willard, Canadian author of The New Sustainability Advantage says that there is an opportunity to gain in six areas:

1. Increased revenue	9 percent,
2. Reduced utility use	75 percent,
3. Reduced waste	20 percent,
4. Reduced material inputs	10 percent,
5. Increased productivity	2 percent, and
6. Reduced labour turnover	25 percent.

Willard describes waste in these six areas as a measurable risk with a defined cost equal to 16 to 35 percent of gross earnings where sustainable practices are lacking. He goes on to say that by reducing waste in manufacturing the cost of material inputs goes down. According to Willard, manufacturers that achieve sustainable practices generate "sustainability" capital which can add 51 to 81 percent to overall capital.

The McKinsey Global Institute report *"Manufacturing the future: The next era of global grown and innovation"* (November 2012) *suggests food processors fall into a medium business risk level that indicate sustainable opportunities due to high water and energy use. Combined with the high volume of organic waste and wastewater sustainable food processors can have a unique regional (meaning continental) advantage in North America.*

TOUCHPOINTS: The number of times a package is handled in the processing and logistics cycle until it reaches the customer.

Kievan Zokaei, from S A Partners in the UK has some very direct things to say about where manufacturers can reduce waste. He talks about pre-sustainable manufacturing as a "firefighting mentality". He calls the drivers for firefights touchpoints and invisible waste. Zokaei, a student of Dan Jones, one of the original founders of the "Lean" concept, defines three opportunity areas follows:

Waste inside the plant	10 to 30 percent of production costs
Waste in supply chains	5 to 12 percent of logistics costs
Waste in packaging	2 to 10 percent of packaging

Professor Zokaei suggests that there is at least 20 percent waste in food manufacturers' processing and supply chains. The ability to eliminate wastes is the mark of a sustainable manufacturer. The competitive implication is a gross margin improvement opportunity of up to 25 percent over non-sustainable competitors.

Scott Muldavin, author of Value Beyond Cost Savings says that a building that achieves the gold standard in Leadership in Energy and Environmental Design (LEED) is worth more than an unaccredited building. Willard has agreed with Muldavin and points toward the cost-benefit of LEED's accreditation, where the extra cost of building green is as follows:

LEED Certified:	+2.5 percent more than building code
LEED Silver:	+3.5 percent more than building code
LEED Gold:	+ 3 to 5 percent over building code

At the LEED Gold level, the investment has a 500 percent return on investment (with a $200 per square foot structure and up to a $130 per square foot equity gain); plus utility savings.

Jeff Rubin, the author of The End of Growth was the CIBC World Market's Chief Economist for twenty years. He has linked all four North American recessions since the 1970's to a rise in the price of oil. Rubin suggests that there is a macro-economic link between oil consumption and economic output of 1:2 (it takes one percent more oil use to increase output two percent). Read as an overall indicator of energy efficiency at the individual job level, one should wonder why German manufacturing only lost half of their labour force since 1970 while the U.S.A. lost about two thirds of their manufacturing jobs.

2.0 WHY YOU DO IT

*This section is about **why** Lean, Clean and Green are important. The motivation for and the benefits of a focused approach to sustainability are discussed.*

TRIPLE BOTTOM LINE:

An equal focus on people (social marketing credibility), planet (sustainability) and profit (the bottom line).

Linked together, **Lean, Clean** and **Green can be a competitive edge to** help offset currency fluctuation and low-wage competitors. It is a managed *first aid first*[7] approach to wasting less where it does the most good for sales, the bottom line **and** the environment. In this section you'll find out where to find help and why some projects can undo efficiency. An **8-5-3** approach gets to the triple bottom line, also known as *people, planet, profit.*

The action items are based on **best management practices** and **lessons learned** in Ontario and around the world. Insights provide real steps to reduce related costs in energy, water and waste. These insights can help you find the projects that need to come first in your factory so subsequent projects build upon, rather than undo previous gains.

Case study: How do you market?

Food companies review their prices with customers every year. When the consumer base is larger than the supplier, customers often demand more value for their money. They might want a lower price, or expect something else. Your choices are to:

a) cut the price,
b) lose the customer
c) provide more value

The CEO of a small company recently facing this situation chose to provide more value. How? He launched energy efficiency projects that **shrank and verified** the company's carbon footprint. Key customers valued suppliers who reported their sustainability. The effort improved profit margins enough to offer a token price reduction.

Lesson learned: Sustainability is a product feature that has customer value

2.1 LEAN, CLEAN AND GREEN - THE KEY LINKAGES:

1. ***Lean*** *(and Six Sigma) is about managing costs. You have KPI's to measure how you manage these costs. This primer focuses on utilities (energy and water) and wastes from processing. Other costs, such as labour, finance, capital equipment and procurement are generally well understood. Water and energy are not. They may be "managed" by purchasing or finance.* ***It is unusual for a business to control these inputs to not end up as waste.*** *Factory energy use, water use and processing wastes are often unconnected to where they're first used and this is where measurement tends to be weakest.* ***Lean*** *is used in this primer to draw attention to a way that these wastes can get managed.*

We treat variable costs like electricity, natural gas, water, sewer and solid waste like fixed costs. The bills get paid, without proof of how fully the total volume of raw materials, chemicals, energy, air and water are used. Regulators often describe *waste* as unused raw materials, chemicals, energy, air and water from an industrial process. Waste triggers regulations that add more costs. The actions outlined in this primer reduce those risks.

2. ***Clean*** *is market-driven and protects brand equity. One challenge for production and operations people is to justify why their building should be where a product is made. Brands owe no allegiance to a building. Their*

[7] In Standard First Aid or Emergency Training, trainers point out that in a medical emergency, appropriate first aid increases a victims' chance for survival or rehabilitation. This reference is used to link "8-5-3" to the sustainable "rehabilitation" of a food plant.

equity is consumer demand. Reduce the risks to the place a brand is made and you add to its value. What consumers think about your brand is extremely important and it hinges on your food safety record. A marketable and clean image is paramount to your brand's equity.

Go to any store shelf in Canada. Value products and store brands are often priced 20 percent below leading brands. This is a trigger point for consumers who shop at stores like Walmart or Loblaws. Price draws buyers. Unless things like product integrity, food safety and product origin are known risks, consumers are price-driven.

Products with known risks attract media and regulatory attention making price unimportant to retailers, insurers or consumers. Compromised food safety can cost you customers and higher insurance fees, trigger regulatory penalties, consumer compensation claims, and create product recall and restock costs. These kinds of risks can also get your products de-listed, followed by a bill from retailers for re-configured shelf space. These things can kill a brand and the company that owns it. Only the largest companies have pockets deep enough to protect themselves through these kinds of crises.

One way of minimizing risk is by being clean. Product integrity, food safety and acceptable product origins are consumer demands. Producers, processors and retailers all need to make money to stay in a supply chain. Walmart, Loblaws and Sobeys want problem-free products for their shelves – products with less risk at less cost. Suppliers need to be able to prove their localness, their environmental footprint, a cleaner ingredient list and assure food safety.

3. ***Green** is important to shareholders, retailers and consumers. Shareholders want **sustainability**. Since 1999, the Dow Jones Sustainability Index has proven that companies who sweat the details on sustainability are profit leaders. Retailers want greener products on their shelves because consumers want one less thing to worry about. It starts with knowing how an individual product's footprint is made. The changes you make in your plant are the challenge and the solution. Your lowered-cost, smallest footprint product will definitely help you compete in the market. A credible third-party can validate your sustainability.*

You start by linking utility use to product costing models. Once your internal footprint is managed, it's easier to understand your supply chain footprint and get third-party verification for two things:

GREENWASHING: **To make unsubstantiated and/or misleading claims about the environmental benefits of a product, service or technology.**

- **To measure the green equity in your building:** according to Scott Muldavin of the Green Building Finance Consortium, the Gold standard of Leadership in Energy and Environmental Design (LEED) can add $130 of equity per square foot of a building.
- **To verify green marketing claims**: according to Scott McDougall, President and CEO of TerraChoice, **greenwashing** is a challenge for companies that want to use sustainability as a marketing tool. McDougall suggests that only five percent of products that claim to be green are verifiable; of that only 30 percent avoid greenwashing.[8] For companies that get it right, the market awaits.

In 2010, the U.S. Department of Energy released footprint models of economic activities in American cities. Food ranked the third highest for $C0^2$-equivalent emissions, after buildings and personal vehicle use.[9] The food industry is sensitive to negative attention and this is negative.

Sustainable Bits: A recipe for losing money

A kilogram of waste wipes out the profit from 10 kilograms of finished goods. Every bin of solid waste, every drop of wastewater and every puff of air exhaust contains labour, raw materials, capital, energy, water and heat that failed to get into the product you sell. On top of that loss you'll be paying for waste management and sewer services. And if that's not enough to get your attention, there is a third level of cost called 'regulatory compliance'.

Lesson learned: Sustainability should be lean, clean and green.

2.2 THE BENEFITS OF THIS APPROACH

We all agree with the idea of conservation. Isolating only one utility for reduction can actually create an unsustainable increase in other utilities. Until water, electricity and natural gas use are grouped, trading one utility for another just creates another conservation issue. You need to:

1. **Eliminate** hidden waste from your balance sheet.
2. **Link** specific utility use to the gross margin on every product you make.
3. **Generate** data that a third party can **validate** for an environmental scorecard.

Whatever goes into a processing line comes out at the other end. Leftovers (wastes) increase costs and squeeze margins. Manage previously invisible leftovers by expanding your product costing models to include sub-metered utility use. Drive responsibility to the place where the footprint happens – the plant floor.

Sustainable Bits: "Conservation" is not "sustainability"

Some people think conservation (preserving a resource) is a cure for waste. Others, like Jeff Rubin (former Chief Economist of CIBC World Markets) says industrial growth adds to energy consumption. What Rubin didn't say is that labour efficiency can drive utility use faster than growth. Recessions are energy (and water) "conservation" until market expansion drives new production that uses more energy and water. Industrial use follows economic growth, a paradox that undoes conservation. Is conservation versus industry use is a zero-sum game where conservation's gain is industry's loss?

After forty years of labour efficiency gains in North American manufacturing the solution to this paradox is to break the energy/growth connection (see **Figure 3** on page 8.) A factory can maximize its process efficiency. It is possible to use renewable energy and cradle-to-cradle principles. This is called mass balance efficiency (active management), not conservation (passive non- use.) It starts by managing the invisible waste is in the system.

Lesson learned: Sustainability is active and focuses on mass balance efficiency.

2.3 THE BIG PICTURE

There is always a bottom line in business. The food industry is known as a low-margin manufacturing sector. The cost of compliance for both environmental and food safety regulations add a layer complexity to food businesses.

Figure 5 shows just how much utilities and solid waste cost Ontario's food industry. The link between variable costs like utilities or waste, and profit is linear. A dollar saved on these costs raise the profit column by two dollars.

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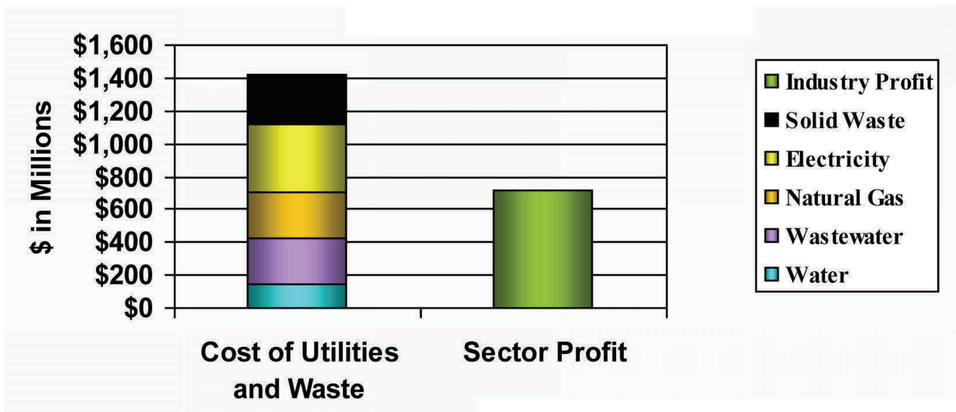
[8] According to McDougall, the "seven sins of greenwashing include labels that have; a hidden trade-off (1), no proof (2), are vague (3), irrelevant (4), suggest lesser of two evils (5), falsely labeled (6) or are a fib (7).

[9] Jones, Christopher and Kammen, Daniel. 2011. *Quantifying Carbon footprint Reduction Opportunities for U.S. Households and Communities*, Energy and Resources Group, University of California, Berkeley, California, U.S.A.

Figure 5: Comparing reducible costs to profit in Ontario's food industry 2008)



Sidebar Story: Nobody markets their pollution

Hellie was an "Old School" marketer with an eye for a trend. Her largest customer had just asked her about the CARBON footprint of her private label product line. Her own business had grown to a $50 million per year enterprise after a name change. The "Locavore" premium brand was gaining market share, but her cash cow was private label (PL). She did well at PL because of her hands-on approach to cost management.

The carbon thing was new. Her lawyer and accountant had both mentioned "the carbon thing." In the same week her engineer, tag-teamed with the Environment and Procurement Managers in the managers meeting on the same thing. New laws were coming, too.

It was Jaz, her newest manager who explained the situation. He saw the opportunity as consumer demand to get off of a treadmill. Jaz explained that the POLLUTION linked to consumer purchases upsets customers no matter how small the amount. If purchases actively contribute to POLLUTION, consumers are as guilty of environmental harm as the polluters whose products they purchase.

"Consumers," Jaz said to Hellie, "Don't want to be part of the problem. You built Locavore Foods by making things people like. Lowering CARBON is something people can like because it's a step in the right direction. Lowering POLLUTION is still POLLUTION." Jaz went on to explain that CARBON is a measurement customers can feel good about when the quantity of carbon gets smaller. It means that their choice is good for them and their world. "The trick," he said, "is to make to cost shrink, too. We could do that, because CARBON can be used to measure and control utility costs.

The next day Hellie asked Jaz if he knew where to start. Jaz asked if he could take a "Spot the Savings" course offered by Natural Resources Canada. Hellie wondered about that. The other engineer, Hec, had helped her run a tight ship, but Hec had died a few months before Jaz came on board. Some of the costs that Hec had helped hold the lid on were starting to spin out of control.

2.4 THE POWER OF KEY PERFORMANCE INDICTORS

Today's manufacturers have Key Performance Indicators (KPIs). Good KPIs help drive cost out of the system by **WHAT** they measure. According to the Aberdeen Group, best-in-class manufacturers measure KPI's to assess these key areas::

- Bottom line impact
- Health and safety related to plant conditions
- Appearance and housekeeping optics for plant guests
- Labour productivity
- Sustainability
- Brand impact

Performance in these very different areas can be tracked and linked together. Again, if we ask **WHY**? The answer is to allow a factory to:

- Reduce operating costs, line downtime and line failures
- Maximize return on assets
- Reduce risks that improve inspection scores
- Delay and/or accurately cost capital projects
- Improve worker productivity
- Meet changes to regulations

An October 2010 study released by Aberdeen Group[10] linked lower maintenance costs to lower energy costs. The key was how energy and other utilities are tracked in a factory.

Figure 6 outlines what best-in-class manufacturers look for. Note that they're less likely to track facility budgets as a KPI, but instead track the amount of money made in the space they use. This KPI is highly sensitive to how you manage invisible waste. **A factory with the lowest use of utilities per package usually has the smallest footprint.** In a world where food companies often own many factories, low environmental impact delivers a powerful benefit to the brand.

The Aberdeen Group study shows that companies who track overall operating costs, energy consumption, space utilization, safety, maintenance response times and on-time work order completion **lowered utility costs by 10 percent and maintenance costs by 14 percent**.

Figure 6: Key performance indicators measured by manufacturers

KPI	Best in Class (percent)	All Others (percent)
Facility operating costs	100	94
Facility budget	86	91
Energy consumption	86	79
Space utilization	55	79
Safety information	71	62
Maintenance response time	71	55
On time completion	64	49

Source: The Aberdeen Group, 2010

[10] Shah, Mehul and Littlefield, Matthew. August 2010. *Carbon and Energy Management in Manufacturing Operations*, The Aberdeen Group, Boston, Massachusetts, U.S.A. Maintenance costs are part of the firefight and an invisible cost for pre-sustainable processors.

Do we know what sustainability, conservation, energy efficiency and environmental stewardship really means? When retailers want it, it's because their customers like it. **Do your KPIs fit this?**

Staff trained to use M&T and EMIS can establish KPI benchmarks to help:

- **Verify** green marketing claims;
  - **Add** a cleaner footprint dimension to support the clean ingredient list,
  - **Generate** data for third-party verifiers and used for green marketing, and
  - **Avoid** the marketing pitfall called greenwashing.

- **Link** the origin of utility and solid waste costs;
  - **Track** exact utility use in product pricing models,
  - **Achieve** key performance indicators for cost savings and compliance,
  - **Drive** cost-linked footprint management to its source, and
  - **Engage** and **track** employee performance.

- **Support** environment department initiatives;
  - **Link** utility input use to emissions impact, and
  - **Corroborate** exact production data with mandatory environmental reports.

- **Support** improvements;
  - **Generate** accurate cost-benefit analysis data for project proposals,
  - **Target** specific utility loads to manage,
  - **Track** the outcome of improvement projects,
  - **Drive** responsibility for utility and waste costs down to the plant floor, **and**
  - **Link** utility efficiency to lower maintenance costs.

- **Provide** verifiable reporting data;
  - **Shows** continuous improvement for corporate reporting requirements, and
  - **Supports** the combination of financial and environmental performance within the same reporting channel.

- **Tackle** invisible costs;
  - **Reveal** the true gross margin performance of highly profitable products, and
  - **Address** under-performing products that steal margin from other products.

An **8-5-3** approach to utilities and waste is based on active management. It is consistent with **Lean** due to the active management of inputs that are otherwise invisible. The approach is **Clean** since carbon and other wastes get easier to find, count and acted upon using the same data. It also looks **Green** to the customer because you have the proof. This is the opposite of *greenwashing* - where a product is marketed as green without providing the proof.

Sustainable Bits: What About Solid Waste?

Solid waste is probably the largest part of a food plant's carbon footprint. Organic waste can emit four tonnes of CO_2 per tonne. Recycle waste to eliminate pollution at the factory level. Some waste is unavoidable. Sustainability leaders regularly achieve 98 percent diversion from landfill. When you engage an energy audit consultant, add a waste audit into the mix.

- You want to find out the value, volume and point source, then find recyclers for metal, cardboard and plastic,
- Separate broken pallets and wood for employees to take home for free as fuel, and
- Find lower-cost solutions for organic wastes. Bio-digesters, composters and feed uses are a lower cost than landfill.

Lesson Learned: Solid wastes may have value and organics can be recycled for less than landfill. In the long run, your organic waste stream might be enough to power your own green energy source.

3.0 HOW YOU DO IT

A list of "things to do" is not the same as how to do them. Sustainability is a journey where the destination depends entirely upon the starting point and the landmarks you pass along the way.

The order in which projects are done (see pages 87 through 89)[11] affects the outcome. The **8-5-3** approach relies upon the **ROI** sequence as follows:

AUDIT:
An assessment of net utility needs and the relative efficiency of both the building and manufacturing processes within that building.

BEHAVIOURAL WASTE:
Lights that are left on, motors and fans left running through the weekend and taps that drip are examples of waste that are related to how people behave. They forget or they ignore things that add 5 to 30 percent to utility bills.

MARGIN CONTROL:
This is generally a management performance KPI with regard to the maximization of revenue and the minimization of costs.

Readying **(People)**

- **Select/appoint** a senior executive as sustainability champion.
- **Choose** a core team of managers/supervisors for a sustainability team.
- **Train** the team through the NRCan "Dollars and $ense" courses (6 modules). It includes M&T, EMIS, Financing, Spot the Savings, and Transportation and Energy Planning.
- **Hire/train** a Certified Energy Manager.
- **Conduct** utility audits and staff training (NRCan has further support for this).
- **Install** an M&T System and EMIS, and then integrate with product costing models.
- **Catch** and **eliminate** behavioural waste.

Optimization **(Process)**

- **Reconcile** updated EMIS data with product costing models.
- **Adjust** budgets to reflect reduced behavioural waste
- **Convert** utility use data into facility and package-level carbon footprints.
- **Fix** the leaks and optimize systems
- **Upgrade** systems based on verified cost input data.

Integration **(Technology)**

- **Recycle** wasted utilities and then pursue renewable energy.
- **Reconcile** updated EMIS data with product costing models.
- **Adjust** budgets to reflect optimized system efficiency.

There are challenges for a manufacturer to consider with sustainability. The balance of this section outlines some challenges with insight into some of the bigger picture.

3.1 THE SCOPE OF ACTION

Margin control makes sense to operations, engineering and maintenance. Hidden costs can be made visible with technology. When hidden costs are identified and fixed, KPI's for efficiency and cost reduction get met. This also creates proof of a reduced carbon footprint that can create brand equity created at the factory. This makes sense to senior management, marketing and sales professionals who need proof of a smaller footprint for the customer and the shareholder.

Many needs get met when M&T with EMIS measures utilities at the point of use and follows best management practices.[12] Corporate sustainability agendas, operational efficiency and marketing can all use the same data set.

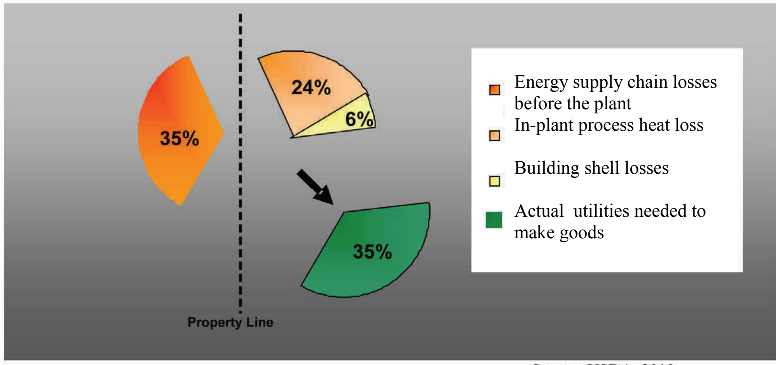
A recent study by the U.S. Department of Energy[13] found an astonishing **65 percent of the energy used by American food plants is wasted.** A third of all waste happens before energy arrives. The remainder is lost in the plant. Two-thirds of every dollar a food processor spends on energy in

[11] Three checklists of best technical and management practices are included in Appendix 10.6, pages 87 through 89.
[12] Described in an Aberdeen Group report *Carbon and Energy Management in Manufacturing Operations* .http://www.aberdeen.com/
[13] http://www1.eere.energy.gov/industry/program_areas/footprints.html

BENCHMARK: To evaluate or check performance by comparing with a standard for expected performance (an internal benchmark). This can also be extended to measure performance against an industry standard (the competition) or a regulatory standard (such as environmental rules).

LIFECYCLE FOOTPRINT: Scientific consensus on how to define, measure and calculate the carbon – equivalent emissions from the full lifecycle of a manufactured product does not yet exist. In theory this includes an impact assessment of water, energy and decomposition for all inputs to post-consumer use. It is often understood that post-consumer and recycled products may count their footprint impact from the point of re-use as an input.

Figure 7: Current lifecycle energy transfer losses in North American food processing



Source: USDA, 2010

the United States fails to 'stick' to the product it was supposed to create. Surprisingly, American food plants are considered to be among the most efficient in the world.

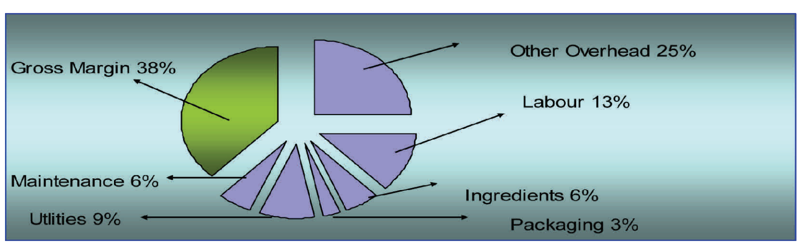
What does **Figure 7** mean to a food processor? Invisible waste in one area creates more invisible waste throughout a production facility. A 50 percent reduction of both building shell and in-plant utility waste reduces supply chain utility waste where 60 percent of energy use would then "stick" to the product.

A benchmark was identified for average effectiveness of food and beverage manufacturers as a consequence of the USDA's work on the lifecycle footprint of energy use attributed to the food processing supply chain versus the actual energy use needed for processing.

Canadian plants aren't much different. Some operators see combined energy costs such as natural gas and electricity to be relatively unimportant. But are they getting the whole picture? A manufacturer whose energy costs less than one percent of the cost of goods sold is not motivated to eliminate 0.5 percent of costs or raise their gross margin by just one percent if energy is viewed as a stand-alone cost. But if you add the cost of waste management and environmental compliance, the impact on gross margin begins to soar.

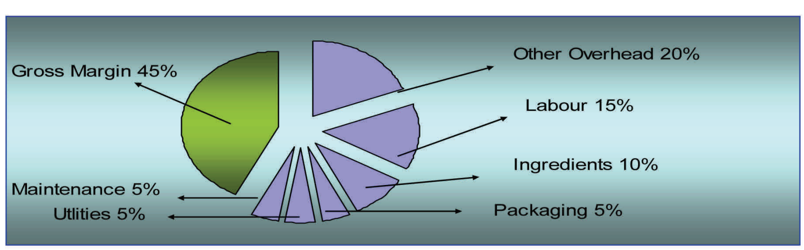
If we assume a package has a 38 percent gross margin and energy waste to be only 10 percent of the cost of production, then factory management is motivated to take energy efficiency seriously. A 50 percent reduction in energy costs would increase their gross margin by 18 percent.

Figure 8: Average food industry cost of production (Canada, 2009)



Source: Stats Can 2011

Figure 9: Same cost of production with 50 percent less utility use



Source: Adapted from Figure 7

These graphs show how gross margin, maintenance and overhead are shrunk. Packaging, ingredients and labour become a larger proportion of the cost of production, but do not increase actual costs. Consequent labour and packaging projects will add more to the margin.[14]

Another challenge is to measure sustainability. A food business must figure out how cost and carbon footprint are linked. Fortunately, a platform exists that provides data for both product costing models and footprint verification. Measuring smokestack emissions, for example, does not help you learn how much actual energy it takes to make a pizza. But footprint modeling isn't just about energy. It's a mass balance equation – the sum of all things going IN to a process reflected in all things coming OUT of the process.

ALL THINGS IN = ALL THINGS OUT[15]

The key to the equation is in the inputs, not the outputs. A mass balance equation must include energy, water, air, raw materials, packaging, chemicals, labour, equipment and overhead. All of these inputs have costs, but not all affect your footprint. The key is to gather enough data to know how and what inputs affect the footprint of your products. Things like fuel and water bring a footprint into your plant and have a secondary impact when they end up as pollution.

To call air an input may seem odd, but in a factory air moves invisibly, collecting heat or cooling and odours. Movement takes energy, which is a cost and a footprint. Air as an output bears environmental compliance cost as exhaust.

A mass balance case study is included in the appendix, **Section 10.3 A simplified mass balance case study** (page 57).

3.2 WHAT IS EFFICIENCY WORTH?

The opportunity grows exponentially with the size of your utility costs. For example, companies with a combined cost of less than $25,000 for water, sewer, energy and waste management should aim for initial savings of about 10 percent. Most of their focus will be in the **R**eadying and **O**ptimization phases – behaviour management and leak reduction. Only after the low-hanging fruit is removed should a company consider a green energy opportunity.

A way to visualize the problem is to look at mass balance yield data of all inputs. **Figure 10** looks at two general kinds of

Sidebar Story: Finding waste, taking action

Jaz, the company's engineer, won a data logger as a door prize at an NRCan's 'Spot the Savings' seminar. When he got back to the plant the next day, he spent a few minutes tracking down the electrical boxes for the air compressor room. Connecting the data logger to the back-up compressor was simple. A week later he retrieved the data, then attached the data logger to the main feed for the air compressor room. After two weeks Jaz read the data. It didn't correlate to production schedules. Frustrated, he packed the data logger back in its box and looked for a place to store it.

The overhead cupboard in the engineering office was overflowing with boxes and studies. Inside, he noticed another data logger and an ultrasonic monitor. It gave him an idea. Over lunch, Jaz went back to the air compressor room and hooked one data logger back up. On the way back, he started sweeping air lines with the ultrasonic monitor, but realized he had nothing to tag the leaks he expected to find. Above him a red tag fluttered on the main air line, indicating a leak. Following the lines, he found 87 more tags fluttering at air leaks and realized why the compressors were running non-stop. He connected the second data logger an aging Hayssen packaging machine.

Back at his desk, Jaz estimated the cost to repair the air lines, including both labour and materials. His data loggers would provide the energy savings information and the proof he needed. Armed with the numbers, he went searching for Sal, the maintenance manager.

[14] This is a good example of a "launching pad" project where input cost management can cascade through a product costing model.
[15] Fuel + water + packaging + ingredients + capital + labour = finished goods + POLLUTION (waste plus emissions)

processors:

- A secondary processor that used manufactured or pre-processed ingredients, and
- A primary processor that takes agricultural products and turns them into ingredients for other manufacturers or a product for foodservice or retail.

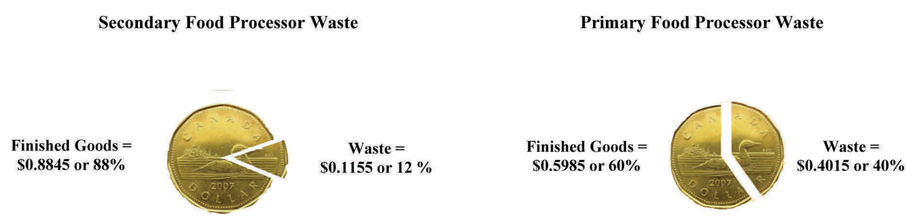
The level of waste for a primary processor can be staggering. Material waste can be more than utility waste.[16] The ability to recover just half this waste improves gross margin returns. A 10 percent improvement in gross margin returns can increase profit as much as 200 percent.

An efficiency target needs to reflect costs. A company with $40,000 in electricity, gas, water, sewer and waste management costs may only be able to achieve a 25 percent reduction; whereas the company that spends $1,000,000 on these costs could target a 70 percent reduction.

HURDLE RATE: The minimum acceptable rate of return, also referred to as MARR.

About 10 percent of your combined utility and waste management costs is a realistic budget for audit assessment, staff training and installing M&T plus EMIS. Companies in the medium-to- high end of the utility and waste management cost curve may need to allocate even more to M&T and EMIS to fully optimize savings. Once your people learn how to measure, manage and plan the reduction of wastes and utility use, project hurdle rates are easier to justify.

Figure 10: Waste in food and beverage processing costs 12 to 40 cents on the dollar



Source: Extrapolation based on recoverability estimates from 300 Ontario-based food industry audits and Statistics Canada, 2008

Sustainable Bits: Budgeting secondary impacts

The 8-5-3 method provides a sequence for how to approach improvements (Readying, Optimization and Integration.) The methodology allows the user to remove layers of invisible waste that create work loads on other systems and in other zones. As leaks are repaired and systems optimized, the amount of work those systems create for themselves and other systems is reduced. As a result, systems have less mechanical wear, maintenance costs go down and OEE (along with labour efficiency) increases.

It is tempting for management to look at a set of expected secondary returns and trim budgets in the year that efficiency projects are planned. Be forewarned. That strategy robs a utility project of its payback capacity as well as obscures the relationship between sustainable practices and impacts.

Secondary impacts on non-utility budget lines should only be reduced after utility projects complete their payback cycle.

Lesson learned: Measure the effect before changing budgets that affect a product costing model.

16 Statistics Canada data was used to generate the potential range of savings. Actual waste factors will vary at the individual plant level.

Sidebar story: The good neighbour

Ron Palfrey missed his neighbour Hec. He missed the conversations they had over the back fence. Ever since Hec passed away, things were going poorly at the plant where Ron worked. The KPI's Ron measured had not improved since the month that Hec died. Hec always had a nugget for him – a project he could do to stay ahead of corporate performance expectations. Costs were rising and the plant manager, Guido was pushy at the bi-weekly maintenance meetings. Ron wondered if head office would fire Guido before Guido had the time to shake up the maintenance and engineering department at Edible Oils Co.

That Saturday when Ron was cleaning his garage he came across Hec's business card. He stuffed it in his wallet, recalling different projects Hec had told him about. One of them was job he had been working on – air leaks, but word was from Locavore that it was that job that did Hec in. Hec was working with his hands above his head tagging air leaks on a Saturday. Somebody found him on the floor early on a Monday morning.

On Monday, Ron was reviewing work orders in the plant cafeteria. It made him think of Hec and he remembered the card he'd placed in his wallet. Ron took out his wallet and found the card, then reached for his cell phone. The number he dialled was Hec's old number, but the voice on the other end was different …

'Jaz here, can I help you?' the voice answered.

'…Uh, Jaz, this is Ron Palfrey. I used to talk to Hec sometimes …' Ron answered slowly. On the other end of the line Jaz waited, too. '…did you know Hec?'

Jaz began the conversation to be polite. He didn't expect to talk about energy efficiency. It made him a little nervous when he found Ron's card in Hec's old rolodex – Ron worked for another food company. But they talked, for at least a quarter hour as Ron told Jaz about all the things Hec had told him to do. In return, Jaz told Ron about the NRCan "Spot the Savings" seminar and the luck he had with using an ultrasonic monitor and two data loggers.

3.3 THE LEARNING CURVE – A WATER EFFICIENCY EXAMPLE

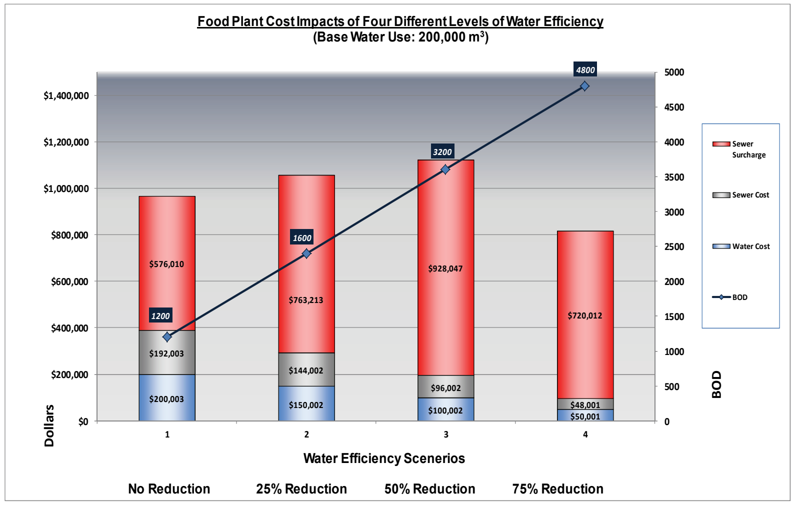
There is a steep learning curve without the M&T and EMIS to connect utility use to point-of-use costs. Too often, efficiency is muddled with an outcome we know as conservation. Conservation is about non-use, whereas sustainability is about the most efficient use. One of the more difficult learning curves is to undo the damage from a too-narrowly focused "conservation" program.

Water conservation can be complex. Food safety requirements are tied to water use. As a company grows its business, it may have a regulated requirement to increase the amount of water used. Food safety and business growth are at the core of the issue, but not the core problem.

The issue for food processors is how to manage water-related costs. This boils down to managing KPI's. Historically, utility costs like water and sewer are treated like "fixed' costs by finance departments. The bill comes in, it may or may not be checked against a gross volume and gets paid – without an accounting for how, why or where water use and sewer charges are generated.

Water conservation projects can reduce stand-alone costs. It looks good, until water is tied to other costs. In a food plant, reducing water use increases sewer surcharges. A food plant can reduce the volume of water per unit of production and increase water-related costs at the same time. **Figure 11** demonstrates how water-related costs can continue to climb as reduced water use increases penalties for wastewater charges when only water use is reduced. Note that both a 25 percent and a 50 percent reduction in water use can result in higher overall water costs as sewer surcharges increase. This figure clearly shows that it takes a 75 percent reduction in water use to offset sewer surcharges and position a water "conservation-only" project as a cost-reduction benefit.

Figure 11: How stand-alone water conservation can impact overall water costs



Water conservation/efficiency projects that lack a wastewater efficiency component can skew KPIs in the wrong direction. A rule of thumb:

- Water is a 0.25 to 0.5 percent stand-alone cost of production in a food plant, and
- Water drives as much as 9 percent of the overall cost of production in a food plant.

This is because of the energy related to water and food safety; wastewater and recoverables lost into the sewer system. The findings from more than 300 food plant utility efficiency audits in Ontario have shown us that these projects return 15 to 400 percent per year on the investment:

- Behavioural change and leak elimination paybacks range from immediate to three months,
- Optimization projects paybacks range from six months to three years,
- Process integration project paybacks are two to five years, and
- Green energy integration project paybacks are two to seven years.

PROCESS INTEGRATION: The collaboration of processes in a facility to reduce costs and wastes, also known as "PI".

PEAK DEMAND: There are two definitions used in this publication and are based upon the context of use. These include:

- The highest volume of electricity use over a 15-minute period that sets a monthly premium on an electricity bill, or
- Electricity use between the hours of 7:00 a.m. and 11:00 p.m., which generally has a premium cost.

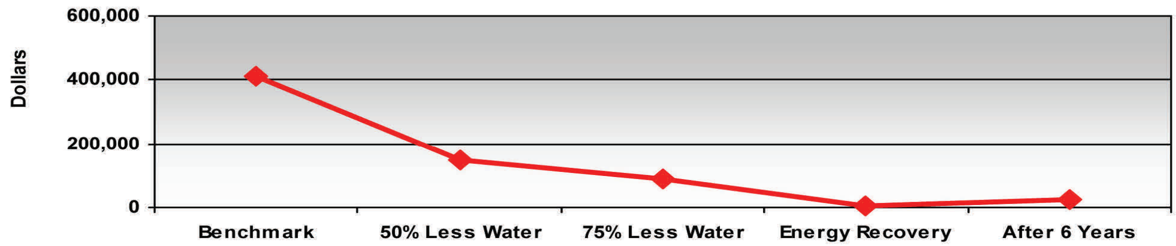
With an integrated approach to sustainability and intelligent efficiency, enabled people can radically reduce invisible and variable costs.

Figure 11 illustrates a 200,000 m³ water user who manages water use, sewer strength **and** recovers energy from water. Overall water-related costs decrease as the volume of water use is decreased. This kind of result is possible when people in an organization are able to use sub- metered information that links water use, energy use and production.

M&T plus EMIS is the toolkit that enables a plant to get and keep variable costs under control. Current trends in Ontario's water rate and sewer surcharge cost increases, suggest a rate of increase at least 10 percent per year for the next decade. Please note that **Figure 11** depicts inconsistent cost savings because of the stand-alone nature of a too-narrow focus of just one of many variables.

Onsite water storage is a carbon-friendly practice. Today, this is a practice too few regions encourage. Leamington and Kingsville in south-western Ontario revived this practice to shift their largest water users from peak demand to 24 hour demand. It reduced municipal peak water demand and the peak **electricity** demand of the water utility by more than 20 percent. The practice has also proved to be a risk reduction strategy for large water users who have sufficient water on site to operate through a 16 hour service interruption.

Figure 12: Reducing annual variable costs from 100,000M³ of water use in a food plant



Source: Adapted from 2010 water rates for Peterborough Ontario, with future cost trends linked to historic data

POWER FACTOR: This occurs in an alternating current (AC) system. The power that is drawn and flows to equipment may distort the wave shape of the current being drawn causing the power draw to be greater than the real power requirement of that equipment.

Case study: Sustainable capital investment; get leaner to be greener

A dollar spent reducing utility use reduces current variable costs and cuts the future cost of closed-loop utility supply by $3 to $5. The following case study is a composite example from brewers around the world, used to demonstrate how zero-carbon and reduced utility use are combined. Capital figures include maintenance.

A brewer with a $3 million annual utility bill considered investing in a co-generation unit to produce electricity and steam for their plant. They learned that a three-megawatt unit would cost between $3.6 and $6 million. The company also decided to establish an annual budget for efficiency projects. They then proceeded to prioritize projects that they had time to complete each year.

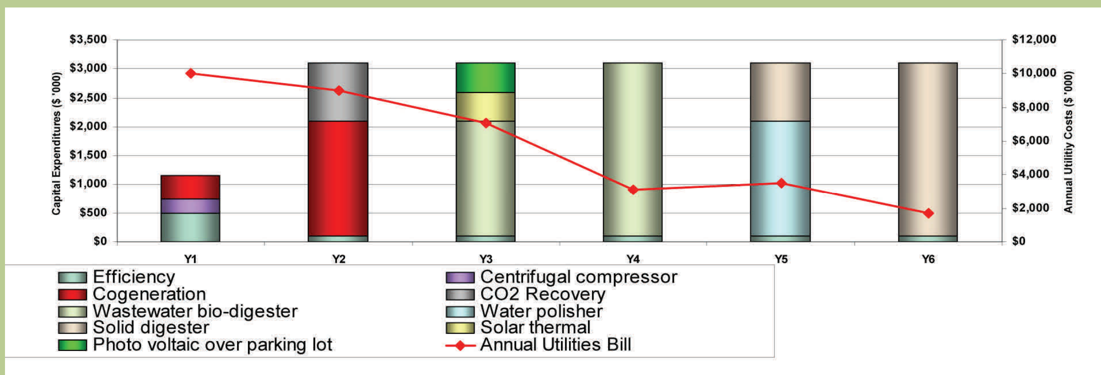
Year one, they started with audits, M&T, EMIS and power factor corrections. Over the next years they tackled process controllers, variable speed drives for large motors, compressed air and refrigeration upgrades. These projects eventually shed almost half of the overall electricity load in the plant.

A 1.65-megawatt turbine then cost them under $2.4 million. For another $1 million investment the company could strip CO^2 from their generation unit to offset $1 million in CO^2 purchases for their beer. Solar thermal and solar photovoltaic projects were added to increase their co-generation capacity for another $1 million.

But the plant also had a wastewater problem. The company was paying a sewer surcharge of $2 million a year. Aware that the organics in their wastewater were easily converted to methane, they concluded that a $5 million wastewater bio-digester could save a further $2 million a year and produce about $1 million in methane that could be co-mingled with natural gas to run their co-generation project.

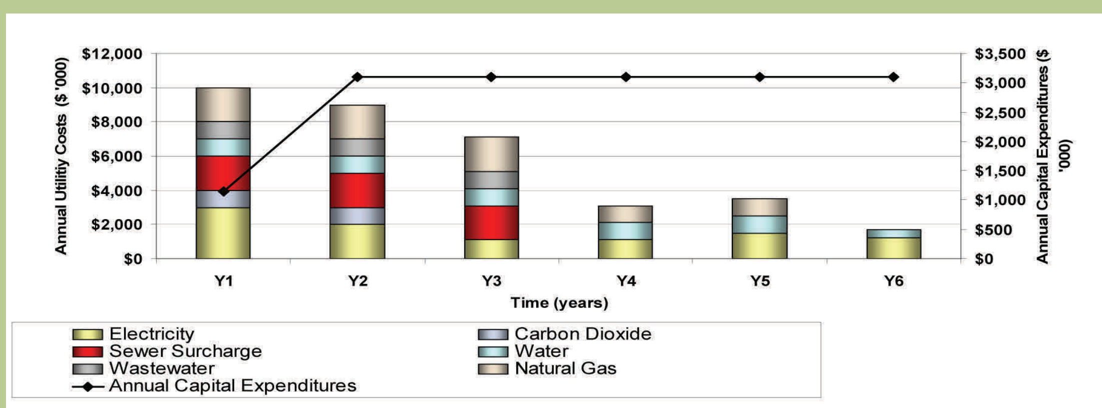
Another $2 million in water polishing equipment and water efficiency cut water use by 50 percent and wastewater by 80 percent, saving another $2 million a year. This was followed by an on-site solid waste bio-digester that converted distillers' grains to energy. The $4 million investment produced $1 million worth of methane for use in a co-generation unit.

Figure 13a: Capital expenditures for efficiency projects and reduced annual utility costs



In the end, $16.5 million in capital projects over six years saves $27 million in utility costs over those same six years *and* creates a negative carbon footprint. Most of these investments qualify for Revenue Canada Section 43 accelerated depreciation for environmental equipment investments.[17]

Figure 13b: Declining annual utility costs (breakout) with efficiency project capital expenditures



Simple paybacks are not the complete picture. A controller will want to understand the time value of these investments. A composite discounted cash flow projection on these projects is included in the appendix. (See **Appendix 10.4**.)

Lesson Learned: If this were a greenfield project, the same investment has a two-year payback.

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17 See http://www.fin.gc.ca/taxexp-depfisc/1999/taxexp99_5-2-eng.asp

A secondary benefit of water storage is to reduce the risk of fire.

In 1905 fire gutted downtown Toronto. The blaze stopped at Jarvis Street – where a factory's rooftop tanks held enough water to stop the fire and spare the residential district. The buildings in the foreground lacked rooftop tanks burned to the ground because the emergency demanded more water than the system could supply.

Figure 14: The aftermath of the 1905 Toronto fire

(Courtesy of the City of Toronto Archives)

3.4 CARBON FOOTPRINT COEFFICIENTS IN ONTARIO (2010)

Water is more costly than it seems. In Ontario, the amount of energy it takes to treat and deliver one cubic meter of drinking water is about **.75kW** (about seven or eight cents with an emission factor of 270g/kWh.)[18] **A food plant can use eight to ten times more energy on its water than a utility uses to purify, pump and treat the same water.**

As an output, wasted water adds another energy cost, plus a much bigger footprint because of the methane gets released from wastewater solids. Companies that supply their own single-use water from wells spend up to 60 percent more money and energy to be self-suppliers than if they had used municipal water.[19] A cubic meter of well water that passes through a plant may have more than $1.75 to $1.90 worth of energy embedded in it – a cost that is equal to or higher than water and sewer service in most municipalities.

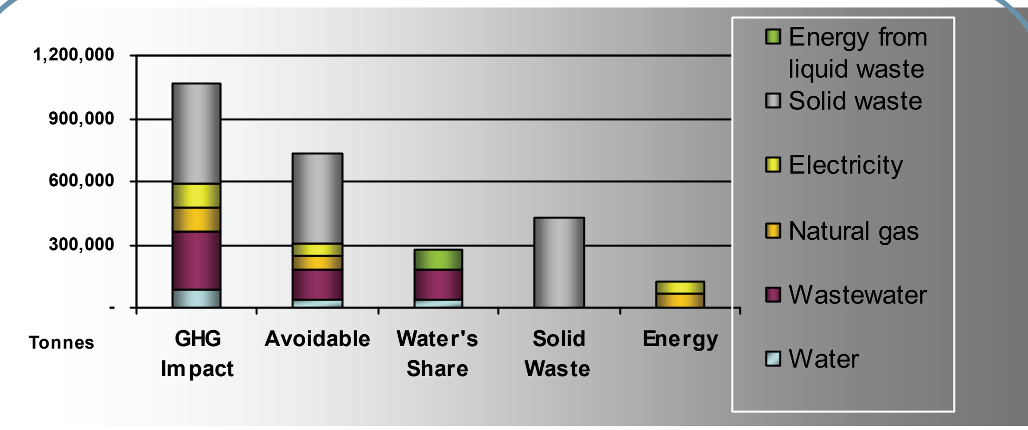
These are invisible costs. Uncovering and reversing those requires measuring.

If the invisible cost of water is not enough to make you think about your water use, statistical data links water use to your carbon footprint. Initial calculations based on 2008 industry data from Statistics Canada suggests as much as 43 percent of your reducible carbon footprint may be linked to water use.

[18] Maas, Carol, 2009. *Greenhouse Gas and Energy Co-Benefits of Water Conservation*.

[19] The cost of efficiency is linked to scale. The present cost of available technology makes conventional self-supply and wastewater treatment a high-cost option for food processors. This may change as newer ultra-filtration technology is developed.

Figure 15: An estimate of the GHG footprint of wastes from Ontario's food industry in 2008 (and the breakdown of what is reducible)



*Based on these coefficients:

Natural Gas	= 0.2kg/m^3
Electricity	= 110g/kW
Water	= 0.75/kW/m^3 [20]
Wastewater	= 1.18kW/m^3
Solid Waste	= 4t CH_4/t

Source: Statistics Canada 2011, Maas 2010, NRCan 1994, USDA 2010, Environment Canada, 2011

CARBON-NEGATIVE PROCESSING: Absorbs or avoids carbon dioxide release.

Bio-methane (derived from solid organic waste or organic waste in a wastewater stream) avoids as much as five times its weight. In CO^2. Green energy sources paired with utility efficiency can shrink the carbon footprint of a facility below zero or into the "carbon-negative" zone.

Electricity in Ontario had a carbon footprint of **110 grams per kilowatt** (2010). This is called the grid footprint. Energy efficiency is the only way to manage this footprint. Once electricity is used in your plant, there is no secondary release – in other words, electricity is clean energy once it's inside your plant.[21]

Natural gas is different. It has a carbon footprint in Ontario of **1,879 grams per cubic meter**, of which 14 percent is created in the supply chain (production, scrubbing and pipeline delivery). The remaining 86 percent is created when it's actually burned (Environment Canada 2011). By reducing the volume of natural gas your factory uses, you'll reduce your footprint in two ways: you avoid the indirect footprint from the gas supply chain *and* you avoid the footprint from combustion.

Fuels derived from wastes like biomass or methane can send a footprint to below zero. Methane produced from processing wastes/wastewater offset combustion and eliminate supply chain fuel footprints. Biomass and methane may have a higher unit cost than natural gas, yet they are the secret to **carbon negative processing**. Using them only makes sense after you've reduced your water, electricity and natural gas consumption as much as possible.

Sustainable Bits: Electricity and water are two-dimensional costs

Peak demand and provincial adjustment costs are based on the highest use of electricity in a month. This measurement is based on time x use. Both electricity and water are affected by this (municipal water and sewer services represent 30 to 60 percent of municipal energy costs where those services are provided. When peak use is reduced, overall costs go down.

The 8-5-3 method prioritizes efficiency from the building shell inward, as things like lighting, compressed air and HVAC efficiency drives down costs and peak, then leaves a "cleaner" picture of the remaining invisible opportunities directly related to process efficiency.

Lesson learned: Invisible waste must be peeled away a layer at a time. The sequence matters.

[20] The carbon-equivalent of water treatment continues to be investigated. Figures in this model are based on data from Maas, Carol. 2010. *The Water Energy Nexus*.

4.0 READYING PHASE (PEOPLE) – GETTING STARTED

A car with a leaky gas tank cannot be driven as far as it's expected to go.

The **R**eadying phase is about finding the hole in the tank. This section covers a first step in a sustainability plan – leadership, management and staff training; the measurement toolkit and existing programs.

4.1 BACKGROUND

Every path to sustainability begins with people. What you do with and for your people makes a difference. Getting started is more than awareness, it is about using the right tools in the hands of the people that do the job. Lasting gains when trained people use an M&T and EMIS toolkit that is tied to product costing models and corporate KPI's that have meaning from the shop floor to the corner office.

The **R**eadying phase gets the most out of what you have in place. The actual benefits **vary.**

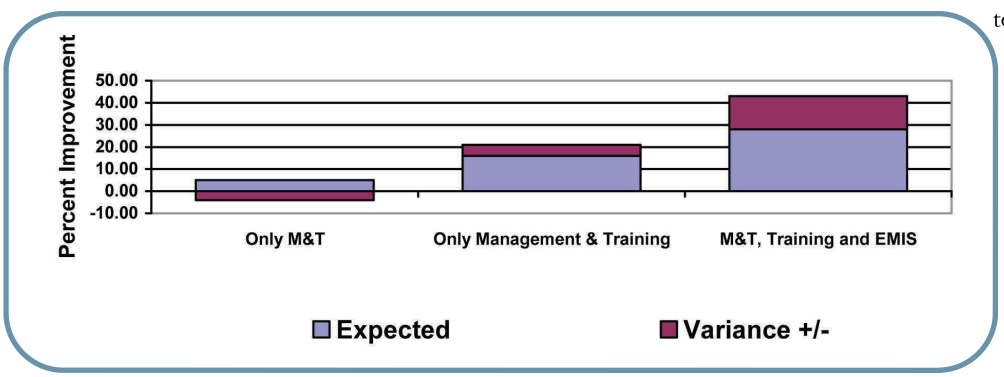
Sidebar Story: Making the Points

Hellie needed 8 points of Gross Margin to keep a private label export deal. Her instinct was to keep the customer, but the rising Canadian dollar and increased trucking costs were making about 20 percent of her business unprofitable. She knew she would break even on depreciation, but that game meant there was nothing left for re-investing in the plant. Hec would have known how to squeeze those points out of the plant and fix her problem ...

- A company can expect to reduce their utility use by 6 to 16 percent when they train their staff but this stand-alone action means efficiencies disappear over three to five years due to utility creep.
- M&T alone is risky and will not assure a positive result (see **Figure 16.**)

The greatest benefit combines training and control technology (M&T with EMIS). It allows the entire organization to get

Figure 16: The impact of utility management actions



Source: Adapted from Natural Resources Canada "Dollars to $ense Workshop ", 2010.

Note: Actual performance depends upon the skill set and motivation of staff.

Sustainable Bits: Why it's so easy for North American manufacturers to make waste

During both World Wars, North America's industries rapidly scaled-up war production. Plentiful electrical power from hydro and coal enabled factories to run 24 hours a day, six days a week. Round-the-clock production meant a higher volume of scrap and waste, which was ignored because of the war. The factories were singularly focused on making war materials. Utilities, supplied by district systems, meant the costs of developing that infrastructure were off the manufacturers' books. Due to the crisis of war, production costing models were skewed to ignore the cost of waste. The wastes were accepted as overhead. The strategy of getting important finished goods out the door helped the Allies win both the First World War and the Second World War. It also entrenched the concept of 'core competency' in business management practices to this day.

Germans call these wars *the Materielschlaght* – the murder of goods. They lost, in part, because their infrastructure ran on a limited supply of coal-based electricity, enough for a single working shift per day. The Germans focused on efficiency and maximised what they had. Even though their industrial manpower was individually more productive than the Allies in North America, they lacked the round-the-clock capacity to make enough war material to offset battle attrition.

It should not come as a surprise that modern sustainable manufacturing principles like lifecycle management have deep European roots.

Lesson learned: Crisis response is behavioural, which gets justified after the fact.

engaged and do their part. It also sets a company up to be able to see the leaks and lapses of awareness that can add between 15 and 40 percent to a company's utility bills. **Figure 16** illustrates this point**.**

A people-based starting point that combines training with M&T plus EMIS is the toolkit that gets sustainable practices understood throughout your company.

The cost of making products involves many inputs like ingredients, packaging and equipment. A warehouse manager cannot hide a lost skid of ingredients on the ledger. But North American procurement practices generally ignore inputs that are available at the flip of a switch. Power and water are easy to use. It's easy to hide utility waste because the way we treat them like a variable cost. We do not track when and how much is used where, so as costs rise, manufacturers see their gross margins erode.

4.2. THE LEAD – WHO IS YOUR SUSTAINABILITY CHAMPION?

Pivotal people in your organization communicate, organise, lead planning and execute. They are your champions. Your sustainability champion will form a results-oriented team and understand that the issue is to manage variable costs without environmental liabilities. The lead needs to be able to link utilities to a carbon footprint; then lead the wider plant transformation.

4.3 TRAINING AND THE TOOLKIT

In Ontario the **R**eadying phase has five components. They are actions that build upon each other. There are no shortcuts.

1. **Train** managers and supervisors.
   - NRCan's Dollars to $ense workshops for managers and supervisors.[22]
   - Certified Energy Management Training for key energy managers.
   - Guelph Food Technology Centre's sustainability workshops.
   - Canadian Manufacturers & Exporters, CIPEC Energy Managers Conference.
   - EMC has workshops and on-line training.

22 NRCan's training modules provide many useful tools. These include a spreadsheet for quantifying variable costs using regression analysis, a self-assessment matrix, and how to model renewable energy projects (RET-screen).

Energy Management Information System (EMIS): EMIS can make utility performance visible across an organization. It enables people and departments to plan, make decisions and take effective action to manage utility use.

This intelligent efficiency decision tool supports production efficiency.

The continuous monitoring of utility performance and the Pinpoint accuracy of savings opportunities sustains efficiency gains beyond one or two year awareness honeymoon linked with new projects

2. **Engage** staff.
   - Use NRCan resources for plant awareness days (posters, videos, printed materials)

3. **Benchmark** utility use and integrate information into product costing models
   - Install monitoring and tracking systems (M&T) for utility use. Ideally sub-meter water, natural gas, electricity and wastewater for discrete functions (i.e. warehouse lighting, building heating/ventilation, air compression, boilers, cookers, pumps, refrigeration, coolers and process line) An embedded M&T system will record real data which can provide you with proof of performance (Key Performance Indicators.)[23]
   - Install EMIS software with your M&T system. EMIS makes it possible to collect data from separate metering points and reconcile to actual production. Your production, product management and engineering staff will need to work out ratios of use on a package basis for every SKU. In the end, a highly accurate cost and processing footprint is possible.

In 2011, the Office of Energy Efficiency (NRCan) published Energy Management Information Systems. This must-read manual outlines how to set up metering systems in a plant. You can find it on their website: http://oee.nrcan.gc.ca/publications/industrial/emis/EMIS_eng.pdf

4. **Verify** your performance with a third party.
   - A Leadership in Energy and Environmental Design (LEED) designation for your existing plant is highly recommended. This is a third-party proof that the market recognizes. Verification of your actual GHG footprint is also a must.
   - Refer to the callout definition on page 33.

5. **Take early action**, fix leaks and manage behaviour by sub-metering utility use.

Canadian Manufacturers & Exporters' 2010 study, 'Advancing Opportunities in Energy Management in Ontario Industrial and Management Sector,' outlines 96 management and technical best practices, including an M&T system. It will help your plant managers and supervisors target and prioritize projects in the leak-fixing stage and catch wasteful behaviour. Leaner and accurate cost information sets the stage for the next phase.

- Review **Figure 46**: The **R**eadying phase management and technical best practice checklist, page 87. Identify what you're going to manage – what comes in and what is lost going out. Once you measure this and meter your plant's systems, you can begin to understand how

Sustainable Bits: Less energy in = Less carbon out

Fuel conversion in a factory has a low efficiency factor (68 percent). That's more than half a plant's carbon footprint. It's so high because of leaks and/or heat loss. To reduce the footprint, start with managing the leaks first, then tackle process efficiency. When that's accomplished the footprint gets smaller and stays smaller when your utilities are also tracked at the point of use.

Non-process energy (lighting, heating, ventilation and air conditioning) have a low efficiency factor. The energy they use is poorly changed into its intended use, again, because of a high level of heat/cooling loss. Start by fixing the leaks before replacing the systems. Change lighting fixtures to higher-efficiency fluorescent systems or LED lighting that improve light levels and worker productivity. Reducing energy to building shell functions like lighting reduces the heat gain that you then vent out of the building.

The fix is like First Aid, you stabilize the major trauma (fix the leaks that cross zones) before you get to surgery (replace technology.)

Lesson learned: Leaks and losses obscure your data (what this author calls "*the Lloyd factor*.")

[23] You can use this same data with NRCan's regression-based spreadsheet to forecast the impact of efficiency projects.

they interact between the zones of your plant.

Target leak and waste reduction to get between 25 percent and 70 percent reductions – if you sub-meter (**M&T** with **EMIS**) and you train staff. Insulation and regular leak detection (for compressed air, steam and water) impact gross margin through discrete processes. With sub-metering in your facility, you'll be able to see changes to the cost of specific products as their production lines begin to work more efficiently.

Added to the loss factors linked to food plant systems on **Figure 17** are behaviour waste and leaks targeted in the **R**eadying phase. Utilities are billed separately, therefore most businesses treat each utility separately. So when it comes time to look at electricity, water or natural gas costs, they are benchmarked separately. But this overlooks the interchangeable nature of utilities and **sometimes a reduction in one utility leads to a change in the use of another**. For example:

- A water efficiency project can increase your sewage strength and trigger sewer surcharges. (See **Figure 11** on page 23.)
- Switching out high density mercury vapour lights for LED or high efficiency fluorescents can reduce your cooling costs in the summer and increase your heating costs in the winter.

The waste factors identified in **Figure 17** are project opportunities for the optimization and/or integration phase(s). These are listed as theoretical (or measurable loss), technical (the highest known efficiency disregarding the cost of attainment) and **proven** (a financially viable best management practice.)

The **8 systems** found in a food plant (see the footnote on page 5) use electricity, natural gas and water. Past the process line, the systems that receive visible waste are the sewer and solid waste management.

Figure 17: Loss factors linked to food plant systems and demonstrated reductions[24]

System	Theoretical waste factor[25]	Potential versus proven targets[26] **Potential**	**Proven**
Building shell systems	70%	60%	**42%**
Lighting	92%	30%	**28.5%**
Compressed air	80%	50%	**40%**
Combustion	70%	55%	**38.5%**
Refrigeration	50%	50%	**25%**
Motors and conveyors	25%	25%	**6.25%**
Sanitation and process water	95%	100%	**47.5%**
Thermal energy generation	65%	80%	**52%[27]**

Source: US Department of Energy, 2010

[24] These targets are based on data collected from more than 300 food plant audits undertaken in Ontario food plants between 1995 and 2010; and over 200 international case studies related to food plant utility efficiency.
[25] This factor refers to a combination of factors that include both the overall conversion efficiency of these systems and/or the rate of efficiency that these systems convert the benefit of utility use into a manufactured product.
[26] The "technical" target is often limited by cost. The "proven target" percentages are a rough estimate of a target that may be achievable utility use reductions for specified systems. For instance, it is possible to reduce electricity costs related to lighting by 28.5 percent (or 30 percent of the 92 percent theoretical waste.)
[27] This factor improvement compares the inefficiency of centralized thermal generation plants to co-generation embedded in a food plant.

Sidebar Story: Two managers on the same road travel in different directions

Ron met Jaz at a Monitoring and Tracking (M&T) seminar that was put on by Natural Resources Canada. They sat next to each other and talked during breaks. One of the things they talked about was how to learn more. The trainers mentioned the Canadian Industrial Program for Energy Conservation or "CIPEC" (pronounced *sigh-peck*) several times. The group met two to four times per year to talk and learn about new technology.

After the seminar, both returned to their plants. Jaz seemed to have an easier time talking the company owner, Hellie, into installing M&T and EMIS. The Ontario Power Authority (OPA) had grant money to help with installation, so Hellie agreed. She wanted to see some progress, knowing that both water and electricity costs were rising.

Ron did not have as easy a time. Nobody at Edible Oil Co. liked his idea about "M&T"– all they saw was a cost with no immediate benefit. Fortunately, Ron had learned about enough one-off fixes to keep busy with other efficiency projects. One project, an air compressor retrofit, cost a quarter-million dollars, but saved $200,000 a year. Ron replaced the plant's air compression lines and fitted balance tanks to the equipment that used the most compressed air. He also switched out 800 horsepower of aging screw compressors for a pair of 250 horsepower centrifugal compressors. The same OPA grant program he had used for the lighting retrofit reduced his payback time on the air compressor project to a year. Ron also found a way to get "controllers" in place where the compressed air use was the highest – an M&T system of sorts. He gained control of how the system worked and could tell when systems were left on and if there were leaks in the system. He kept that to himself – as nobody else seemed to care.

4.4 SUPPORT GROUPS

In Ontario, there are three very useful support/networking organizations that support sustainability in the food industry.

- The first is the federally-run Canadian Industrial Program for Energy Conservation (**CIPEC** pronounced "sigh-peck"), a no-cost program delivered by the Office of Energy Efficiency (**OEE**) at Natural Resources Canada (NRCan). CIPEC is organized by industrial sector into groups they call tables that meet quarterly. They usually meet at a factory to learn about new technology for energy and water management. The group is an entry point for access to federal programs and tools. (http://oee.nrcan.gc.ca/industrial/cipec.cfm)

- Another is the Excellence in Manufacturing Consortium (**EMC**), a not-for-profit membership-based organization focused on Lean. Members from many sectors gather according to local interest for regularly scheduled meetings and training. EMC's motto is "steal with pride" – don't re-invent the wheel, ask somebody who knows. The EMC food sub-group actively pursues hands-on sustainability actions. (http://www.emccanada.org)

- And finally, the newly established Ontario Food Industry Environmental Coalition (**OFIEC**). **The Ontario Food Industry Environmental Coalition** (OFIEC**)** plays an advocacy role for Ontario's food industry for environmental issues as well as develops tools of compliance. (http://www.ofiec.ca).

4.5 SELF-ASSESSMENT

Self-assessment is a reality check. NRCan has a useful energy management self assessment tool that only takes two minutes. You need to take their training to use it. The tool rates your energy management across six categories:

THIRD PARTY VERIFIER: A credible independent party that can confirm (environmental) claims.

The best way to find the verifier to meet your needs is to ask your retail customers for a referral.

Several verifiers are also listed on page 52.

- Commitment,
- People,
- Planning,
- Financing,
- Communication and
- Tracking.

NRCan's self-assessment tool also rates your level of progress on a scale of zero to four, with four indicating a high level of activity and zero indicating no activity. **Figure 18** is based on the high-level matrix NRCan uses. It suggests six kinds of actions that correspond to your score.

This chart shows that the starting point for sustainability in Ontario is the same for every manufacturer. Energy management contracts and carbon management services are not recommended at the readying or optimization phases.

Until M&T and EMIS are in place for at least 12 months and hidden utility waste is eliminated, energy contracts are risky. To contract energy services while in the midst of getting leaner requires a contract that allows you to sell back unused energy without a big penalty.

Sidebar Story: Managing the big picture is hard work

Jaz wondered why he'd ever let himself take the lead on efficiency at Locavore Foods. The meetings with sales and marketing, human resources and finance felt overly demanding. He barely had time to keep up his regular duties. But after a few months he'd managed to help Trish, the product manager, update the company's product costing models to include actual utility costs by process. That meant Leslie from finance had to re-calculate some of the fixed costs, but it also meant that $70,000 a month was shifted into variable costs. Leslie realized responsibility for the constant variance arising from utilities would now become Lloyd's problem. Lloyd, the plant manager, was not very happy.

Hellie, the company owner, was concerned. The shift in how costs were being accounted for seemed to drop the gross margin by a couple of points.

It took the rest of the quarter for Jaz to prove the impact of the M&T/EMIS system. He'd used the system to track the impact of reducing leaks and stopping wasteful behaviour. He'd focused on how well the plant could sleep and discovered three air exhaust systems that were never turned off. He also found a water valve that poured water into the sewer. With an emphasis on teamwork, he convinced plant staff to turn off equipment at the end of each shift. By the end of the quarter, Locavore was using one-third less water, about 20 percent less electricity and 15 percent less natural gas.

Jaz made sure he thanked the rest of the management team for working with him on the project. Jeff, the human resources director, had taken over energy awareness training for staff. That allowed Jaz to concentrate on the next phase of his project – figuring out the carbon impact of their efficiency gains. He and Trish worked on their calculations for the better part of a week. In the end, their product costing models could identify utility costs by process and the greenhouse gas impact of every product they made.

Hellie was extremely pleased and could now tell her largest customers that Locavore products had a 10 percent smaller footprint than they did a year ago. She wouldn't tell them that her margin was still up 3 points after the price decrease. What her customers wanted wouldn't bite into profits as she According to the product costing models he and Trish had developed, the loss to the gross margin had been recouped and was now showing a positive variance, which meant they were above their target gross margin contribution. initially feared. The last thing she needed Jaz to do was get the third party verifier recommended by their large retail customer to verify their impressive footprint change.

Figure 18: Where are you on sustainability?

Level	NRC Dollars to $ense and CEM	OFIEC member, GFTC Sustainability Services, Utility Audits and LEED Audits	Enbridge, Union Gas and OPA programs	Energy Management Services and Contracting	Carbon Management Services	Support Organizations (Partners in Project Green, AOFP/OFIEC, EMC and CIPEC)
New 0 - 1	♪	♪	♪	—	—	♪
Early 1 - 2	♪	♪	♫	—	—	♫
Skilled 2 -3	♫	♫	♫	♪	♪	♫
Expert 3 -4	♫	♫	♫	♫	♫	♫

Legend:

— Not recommended at this level
♪ Recommended
♫ Should already be engaged

In the **I**ntegration phase, energy use (electricity and gas) should be further reduced. An EMIS-based model of real-time energy demand should be available to support accurate utility contract management. The knowledge of **how much** and **when** a facility needs energy, can help minimize costs. You need to know the two dimensions (time of use and volume) of energy demand in order to proactively manage energy costs.

5.0 OPTIMIZATION PHASE (PROCESS): LINKING SYSTEM IMPROVEMENTS TO ZONES

If only one gear in your car's transmission works, hope that it's not reverse.

Optimization is about improvements that make the technology systems in your plant work more efficiently; it is about how you match what you need with getting it done efficiently. Just like a car can't climb a mountain in high gear or drive fast in a low gear; don't expect the systems in your plant to act the same in every zone of your plant.

This section focuses on the benchmark efficiency of the **8 systems** in your plant and what you might do to optimize those systems. You will find examples of the kinds of projects related to the Optimization phase in **Figure 47** on page 88.

Case Study: How well does your factory rest?

To determine how well your factory runs, you must know how well it rests. One of the first keys to uncovering hidden waste in your plant is find out what isn't getting turned off. This is the first benchmark. A factory that runs one eight-hour shift per day, five days a week should only be 'turned on' about 24 percent of the time. Systems that are left running can cost you four times more in utilities than is necessary. Equipment and taps left running also run up your carbon footprint.

Lesson learned: Invisible behaviour gets caught with M&T and EMIS.

5.1 BACKGROUND

In this manual the processes that convert inputs to outputs are called systems.

Natural **systems** store waste. An oak tree converts air, water and nutrients into acorns. From 1,000 acorns only one or two will sprout while the rest are eaten or become humus. Over millions of years the natural system that stores humus creates fossil carbon (coal, oil or natural gas).

A factory also has systems that change what comes into the building into something else. Most of what comes in goes out unsold. **This is waste**. It includes air and fuel that turns into heat which is then lost. Fuel is turned into ash that combines with air to make dust. Then there's waste that appears as water vapour, scrap packaging, sewer waste, broken pallets, scrap metal, scrap paper, product waste, ingredient waste and so on. We convert inputs into outputs and there are many **leftovers**.
Unlike the oak tree's leftovers, human-made **leftovers** are **pollution**. Consumers hate it and regulators expect manufacturers to pay for it — unless you can leave no trace.

Systems designed to convert a higher proportion of inputs into sellable outputs are environmentally efficient. For the manufacturer, environmental efficiency is measurable:

1. The cash value of converting inputs (the cost of production and logistics).
2. The environmental price tag (the cost of managing the leftovers).
3. The sales related to demand for the product in the supply chain.

Sidebar Story: Take time to network

Jaz had hoped to see Ron at the CIPEC meeting to learn more about his centrifugal air compressor, but Ron didn't show. As a result, he took time to meet a business development consultant from the Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs. The government consultant was chatting with an engineer from Global Cheese that he knew from previous meetings. Jaz introduced himself and asked the engineer if he knew anything about centrifugal compressors. The ministry person interjected, suggesting Jaz speak to Randy from Euro Candies who had also just installed a centrifugal compression system.

Jaz was delighted. He made some more contacts and in the process heard about a couple of other projects he could tackle. He learned about a closed-loop boiler system with stack heat recovery, drain pipe heat recovery and how to reduce air conditioning costs by getting the units off the roof, since summer temperatures reduced their efficiency to almost nothing.

At the end of the meeting Jaz sought out the government consultant again who was talking to a group of people about sustainability audits. When the conversation ended, Jaz asked where he could get more information on the audits and she gave him a list; several engineering consultants, a couple of carbon offset consultants, the Guelph Food Technology Centre and a group that would provide a Leading Energy and Environmental Design audit for an his existing building.

With a little follow up, Jaz would have some answers for Hellie.

5.2 TARGET LOW-EFFICIENCY, HIGH-FOOTPRINT SYSTEMS

The U.S. Department of Energy recently published energy and carbon footprint maps for U.S.- based manufacturing sectors.[28] These models look at energy use (fuel, electricity and steam) by factory system and zone (generation or boilers, co-generation and peak generation). It lists carbon footprints and waste factors for:

- the energy value chain (energy from its source),
- indirect process (the building shell) and
- the direct process (energy related to making product).

Sustainable Bits: The value of high performance

Running motors and drives uses almost two-thirds of the electricity consumed in factories. In Ontario, the cost of running a motor for a year can be five times what it cost to buy it in the first place. A few percentage points of increased efficiency from your motors are critical to lowering your carbon footprint and reducing your energy bills for electricity use, peak demand charges and power factor correction. (Source: Carbon Trust, 2010)

Lesson learned: Screen equipment purchases for both impact on variable costs and carbon

Food manufacturing plants in North America are alike. The only significant difference between American plants and plants in Ontario is the carbon from electricity generation.[29] In this section, **Figures 19 and 20** provide a rule of thumb for targeting efficiency projects.

Read **Figure 19** from left to right. It highlights the **processes** in a factory. **Bolded** numbers are **targets**. Energy is transferred into products three ways:

- The first is burning: with boiler, ovens or driers. They transfer energy directly.
- The second is through motion or transfer: machine drives, motor-driven equipment, fans, pumps, compressed air and process cooling or storage.
- The third way is passive: lighting, space heating and ventilation.

The carbon impact of energy is the footprint associated with how energy is made and moved in addition to how those fuels are used inside a factory. The ratios are adjusted for Ontario. Under the carbon impact columns, the "Heat loss" column is a sub-set of "Onsite carbon" sources.

The U.S. Department of Energy found that inside a food plant 54 percent of the carbon footprint is directly connected to food processing. About 34 percent of the plant's footprint comes from combustion-related energy generation activities (boilers, combined heat and power and peak generators) and about eight percent comes from non-process uses like lighting and HVAC.

[28] These can be found on the NRCan website that hosts the Canadian Industrial Program for Energy Conservation (CIPEC): http://oee.nrcan.gc.ca/industrial/cipec.cfm . On this page scroll to the "CIPEC Information" panel and click on: "Heads Up CIPEC Newsletter." Then click on "Past Editions" and choose **2010 Oct. 1, Vol. XIV No 18.**

[29] According the Ontario Power Authority, Ontario's generation mix in 2010 was 30 percent renewable (hydro, wind, solar and biogas/biomass) with a high level of generation efficiency of 80 percent. About 70 percent of the generation mix was thermal generation (20 percent fossil and 50 percent nuclear) with a generation efficiency close to 38 percent. The American generation mix is almost 90 percent thermal (80 percent fossil and 10 percent nuclear) with a combustion efficiency of about 32 percent, leaving about 10 percent of the generation mix as hydro and renewables. Bottom line: Ontario's electricity greener than electricity in the USA. By comparison, Germany also lags behind Ontario with about 18 percent renewable electricity. Ontario estimates for carbon are based on Ontario's mix of electricity generation, which has 60 percent less carbon than an average kilowatt of electricity than the U.S. (Based on 2010 figures.)

Figure 19: Utility use with corresponding efficiency factor, carbon impact and heat loss[30]

Fuel source	Footprint source	Efficiency factor[31]	Carbon Impact		
			Offsite	Onsite[32]	Heat loss
Fuel (gas)	51%	100%	70%	N/A	N/A
Electricity	48%	53%	27.5%		
Steam	>1%	73%	>2%		
Internal Utility Use					
Onsite generation	>10%	78.5%	67%	33%	21.5%
Steam distribution	>10%	71%	N/A	N/A	9.5%
Process energy	71%	68%	5%	55%	25 ≈ 55%
Non-process energy	10%	59%	1%	12%	41%

Source: Adapted from the U.S. Department of Energy Manufacturing Energy and Carbon Footprint.

Read **Figure 20** from left to right. The chart looks at the carbon impact of various systems in the zones where they are found. It shows energy use by greatest (top of chart) to lowest (bottom of chart) use. The **8-5-3** strategy targets systems from the bottom of this chart and moves up.

There are about 150 things you can do to simultaneously reduce your utility bill and your carbon footprint. Most of them are technical, others involve management and training. They all need M&T with EMIS combined with management and staff training to be effective.

These figures are assumed consistent inside a plant regardless of the offsite generation mix. Figures in the carbon impact column identify the percentage of total onsite carbon for a plant per system.

[30] Bolded numbers in this chart represent low efficiency factors and/or high carbon emissions sources.

[31] This figure is based on estimates as described by the U. S. Department of Energy.

[32] These figures are assumed consistent inside a plant regardless of the generation mix.

Footnotes for page 38:

[33] These figures are based on US Department of Energy coefficients for the U.S.A. and may not align exactly to Ontario's coefficients. To determine exact figures for specific facilities, it is important to use third-party verification. As a rule of thumb, these figures represent the best available industry benchmark data at the time of writing.

[34] These figures are assumed consistent inside a plant regardless of the offsite generation mix. Figures in the carbon impact column identify the percentage of total onsite carbon for a plant per system.

[35] This is a rated efficiency factor. The actual performance of many boilers is significantly different. It's not unusual to see actual performance of conventional boilers closer to 55 percent, which creates a large variance for these figures.

FIGURE 20: System efficiency, carbon impacts and heat loss in a food plant[33]

	Energy Use*	Efficiency	Offsite carbon	Onsite carbon	Heat loss
Energy Conversion (Zone 5 – Energy Generation)					
Boilers	35%	80 to **55%**	**21.5%**	**43%**	14%
CHP**	13%	75%	14.5%	**25%**	
Power Factor Loss	3%	**0%**	**~1 %**	**N/A**	N/A
Process energy (Zones 2, 3 and 4)					
Heating***	48%	82%	**19%**	**22.5%**	**25 to 55%**
Cooling and refrigeration	6%	**65%**	12%	N/A	9.5%
Motors****	15%	**57%**	**22%**	>1%	N/A
------------------------	-----------				
- Pumps	*23%*	*75%*			
- Fans	*11%*	***50%***			
- Compressed air	*11%*	***10%***			
- Materials handling	*9%*	*75%*			
- Materials processing	*37%*	*75%*			
- Other	*9%*	*75%*			
Non-process energy (Zone 1 – Building Shell)					
Lighting	2%	**9%**	3%	3%	**91%**
HVAC	6%	**64%**	6%		**98%**

Source: adapted from U.S. Department of Energy, 2010

Notes: Highlighted numbers indicate priority efficiency targets.
Footnotes 33 through 35 are on page 37.

* This column does not add up to 100%. These figures are averages by system when they occur in a facility.
** Combined heat and power also known as co-generation as a percentage of overall industry use.
*** Includes boilers or CHP.
**** Italicized items represent a break-down of motor-driven energy use.

Sustainable Bits: The best fit saves energy

Electric motors are about 75 percent efficient in the way they convert electricity into motive power. An electric motor is only efficient if its running speed matches the power that's needed. Doubling the speed of an electric motor (a fan, pump or drive) ends up quadrupling the energy it draws. Where possible, use variable speed drive (VSD) controls on motors to help match their speed to the work they do. According to Natural Resources Canada, a VSD can cut at least 20 percent of the electricity a motor uses.

Efficiency measures like VSD controls will reduce a carbon footprint, cut maintenance and motor replacement costs; reduce electricity use, peak demand charges and power factor correction costs.

Lesson learned: When equipment is run harder than it needs to, cost is added on three budget lines;

Sidebar Story: Leaner and cleaner is greener

Jaz and Ron were calling each other regularly. On one call, Jaz was very interested in what the high-ester oil was worth. After that call Jaz crunched some numbers before heading over to Hellie's office.

"I think I know how to get our footprint down to almost zero," Jaz said. "Edible Oil Co. has enough off-spec vegetable oil to fire our new dual-fuel hot water boiler."

"Does it change anything else?" Hellie asked, "such as our Certificate of Approval for air emissions?"

"Nope," Jaz answered. "Vegetable oil is renewable. It drops our footprint and we might even get a carbon credit for getting off of fossil fuels." When Hellie's brow began to furrow, he quickly added, "We have a Site CofA and I included the use of renewable fuels with the changes," Jaz interjected. "I'll call the MOE just to make sure, but I got that when we changed the CofA."

Hellie smiled. To change her environmental approvals had cost her more money than she liked to part with, but Jaz's idea interested her. "Just how much will it cost?" she asked.

"I'll need a tank and some pipes and I think I can contract supply for three years – as much as we need. It'll cost half of what we're paying for natural gas." Jaz was all smiles. With this change the plant would qualify for at least a LEED Silver designation and there were still lots of other changes that could be made.

"Jaz, I like what you're doing," said Hellie. "This will grow the business."

Taking a risk, Jaz asked, "with the money we save, can I look into a wastewater digester? We had a $100,000 sewer surcharge last year and with OPA support I think I can get a one-and-a-half-year return on the investment. Somebody at the Edible Oil Co. will figure out they can burn their off-spec oil soon enough. After that we'll have to pay food-grade prices."

The owner of Locavore Foods didn't laugh with her employees too often, but she did with Jaz that day. She liked how he'd thought beyond the next step. It was the third time he'd mentioned a wastewater digester.

That one, she thought, *makes dollars with sense*.

5.3 LOOK AT YOUR FACILITY AS PROCESSES THAT LOSE ENERGY

> *Perspective is subjective. It depends upon the viewer. Someone that is directly involved in food processing sees a factory as a series of systems that make food. It is harder to see a factory as a series of systems that doesn't lose inputs. This shift in perspective depends on an M&T + EMIS system to turn what is a negative focus into a manageable gain.*

In a simplified way, **Figure 21** on page 42 shows how electricity, natural gas and water flow through a food plant. Wherever energy and water flow, energy losses happen. There are complex systems used on farms and in food plants like boilers that use hydro, water and fuel (natural gas or oil). These systems are depicted differently than systems that use one utility input (but may have multiple "waste" outputs like heat and water.)

Food safety requirements for food production add a zone of complexity to the way we use water, where a dollars' worth of water is linked to $9.00 to $18.00 more in variable costs.

In a food plant it pays to fix the non-contact systems first, as these will be targeted in the **I**ntegration phase and removes peak demand impact on processing systems. Many of these projects are supported by Ontario Power Authority conservation programs. (See http://www.powerauthority.on.ca/opa-conservation)

Air compressors are a excellent example of a system causes multiple energy losses in other systems. First the energy

Sidebar Story: Sometimes the price tag is more than just the equipment

Ron thought his next project proposal was better than the centrifugal air compressor – he wanted to retrofit the boilers. The three 200-horsepower Cleaver Brooks boilers in the plant had been installed in 1962. They were almost antique. New boilers would save the plant almost $50,000 a year in fuel costs – after they fixed the leaks in the steam system. He hadn't anticipated the battle that the environmental compliance department put up. For some reason, their Certificate of Approval from the Ministry of the Environment would have to be changed if they changed their boilers. There was no budget to change the Certificate of Approval.

Ron lost the project and was told to price out a storage expansion for the high-ester oils that the company separated from their healthy-eating oils line. By-product oil accumulated faster than it could be sold. Ron called Jaz to complain.

Sustainable Bits: Process optimization and air compressors

A compressed air system can use 10 to 30 percent of the total electricity in a highly automated food plant; depending upon the kinds of compressors used, the system condition and their work loads. The compression process transfers only eight percent to 10 percent of the electricity it uses into the air it compresses. The rest of the electricity is wasted as heat, noise and vibration. That's a very expensive use of power. Leaks, poor maintenance, misapplication and poor control compound this waste. It's not unusual for companies to find up to a 50 percent reduction in compressed air use with proper management and equipment upgrades.

Energy audits done in food plants in Ontario between 1999 and 2009 have revealed that:

- A 10 horsepower reciprocating compressor will use about $7,000 worth of electricity per year, if running constantly for a single shift, five days a week.
- A reciprocating compressor uses twice the energy of a screw compressor, but has a lower cost of maintenance.
- If compressed air loads are over 200 horsepower a centrifugal compressor reduces the cost of making compressed air by about 30 percent over a screw compressor. Centrifugal compressors require the least maintenance and have a very small physical space requirement.
- Technology, such as air compressors with a very low energy-to-product conversion rate, can have a big impact on reducing the carbon footprint from electricity use.
- These kinds of reductions de-escalate the peak portion of electricity bills for everything else.

Lesson learned: Efficient compressed air systems reduce peak demand and overall electricity use.

conversion of electricity to compressed air is only about 10 percent efficient for screw and reciprocating compressors. The balance of energy is discharged as heat, noise and condensate (water that ends up in your sewer.) This waste is a cost that increases other costs.

Where compressed air demand above 200HP exists, a centrifugal compressor that feeds equipment at 80PSI minimizes the energy load, eliminates a wastewater stream and reduces the radiant heat that needs to be vented and may add to cooling loads. Technologies like centrifugal compressors eliminate the unintended and invisible waste that adds to how hard other systems like air exchange and cooling or refrigeration have to work..

Some of the easiest waste to avoid is linked to how your facility was built. Audits and integrated metering (M&T plus EMIS) on these systems ensures an upgrade keeps performing the way it was budgeted and planned. These are also project areas that can help staff identify invisible waste.

Lighting: T5, T8 or T12 retrofits with controls can save up to 50 percent of annual costs. Low energy lighting also reduces air conditioning and air exchange needs in a hot production area.

HVAC: Upgrade **air conditioning** units by moving them from the rooftop to enclosed buildings[36], install **variable speed drive** on motors that move air. Air movement and wastewater **audits** help drive costs out of your plants.

Electrical Service: **Power factor, peak demand** and **harmonics** affect electricity use.

Power factor is a measurement of the resistance of your building to draw electricity from the grid. The use of electric motors and operating behaviours like open bays will reduce you power factor. A low power factor adds electricity to your overall bill that you cannot use.

Peak demand is a measurement of your highest 15 minutes of electricity demand in a month. This is a separate charge on "demand" meters for most factories and warehouses. Low power factor, inefficient systems (refrigeration, motors and lighting) and poor behaviour management in a business add to peak demand.

Harmonics (the frequency or wave that electricity moves on in your facility) can lead to motor and lighting failures when harmonics are not synchronized.

Water: **Water treatment** (softening or heating) adds to your overall utility costs. You really only need to soften water that will be heated (why add salt to everything?). Every dollar worth of water used in a food plant can drive up to $18.00 in linked costs for energy, sewer, sewer surcharge and environmental compliance.

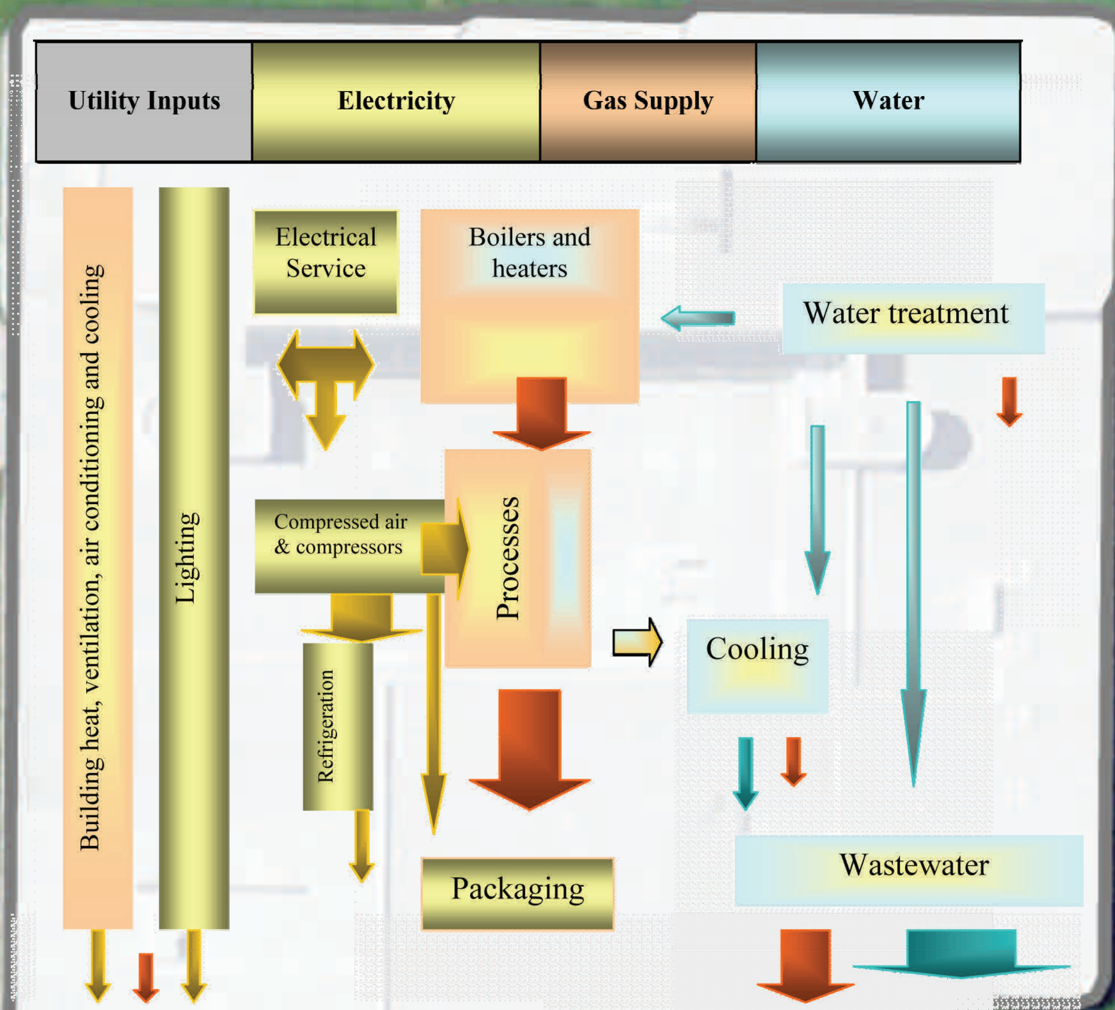
Wastewater: A **water audit** that measures the difference between the water you use and the water you send to the sewer is important. If you have more than 20 percent less sewer flow than water intake look into a sewer use rebate from your municipality. A water audit can help you define **best management practices** for behaviour, opportunities for water re-use and potential sources of free heating or cooling.

LOW POWER FACTOR:
This is generally caused by equipment such as motors and transformers that use a magnetic field. A fraction of the current that is drawn by magnetic equipment is consumed as reactive power and causes resistance to the current that is drawn.

HARMONICS:
Electrical harmonics is non-linear current or voltage in an electrical circuit. The solution is to draw current proportionally to voltage. When harmonics occur, it can cause electricity to be unavailable to electrical equipment like lighting in an intermittent pattern which will damage the equipment over time.

[36] A rooftop air conditioner works at peak efficiency with an air temperature of -10^{C}. The efficiency of that same unit looses two percent of its efficiency for every degree over 30^{C}. The ambient summer time temperature around a rooftop unit on a black roof can climb well above 50^{C}.

Figure 21: Identify waste from utility transfers between systems in a food plant

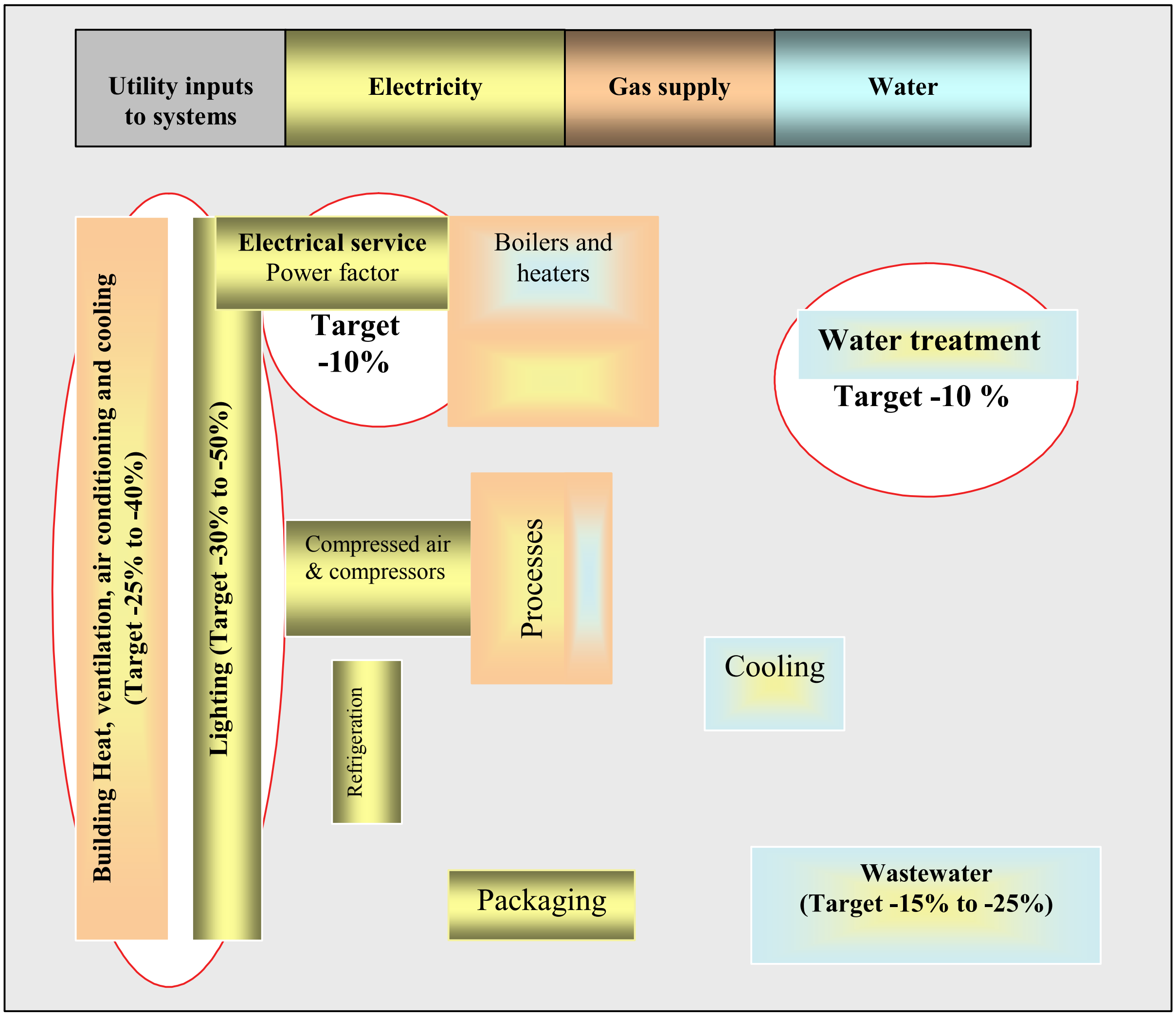


Legend

Utility Waste (by source)	
Gas Supply: Process heat losses to air ~55 %	
Electricity: Heat & resistance losses to air ~ 68%	
Water: Return to sewer ~ 95 to 100%	

Figure 22 identifies starting points that are circled in red. Lighting, HVAC, electrical transformers and wastewater all have hidden costs that hurt productivity.

Figure 22: Optimize utility use that doesn't make a product



Building shell-related utility use is not directly related to making product and should be your first target. It is often the lowest-hanging fruit.

a) Electricity targets

- Target a 25 to 40 percent reduction for HVAC,
- Target a 30 percent reduction of electricity for lighting after a retrofit, and
- Target a 5 to10 percent reduction in electricity costs after a Power Factor Correction.

b) Water/wastewater targets

- Avoid softening treatment of cold water to reduce water soften costs 10 percent.

Some experts suggest that eliminating the leaks also saves on overall maintenance costs – up to 10 percent. Overall Equipment Effectiveness, also known as Overall Equipment Efficiency (OEE) improves as utility use waste is managed. A one percent improvement in OEE can save a company $25,000 to $35,000 per million dollars worth of output. That's added to the gross margin and is over and above cost utility savings.

Figure 23:Optimization targets for the processing zone

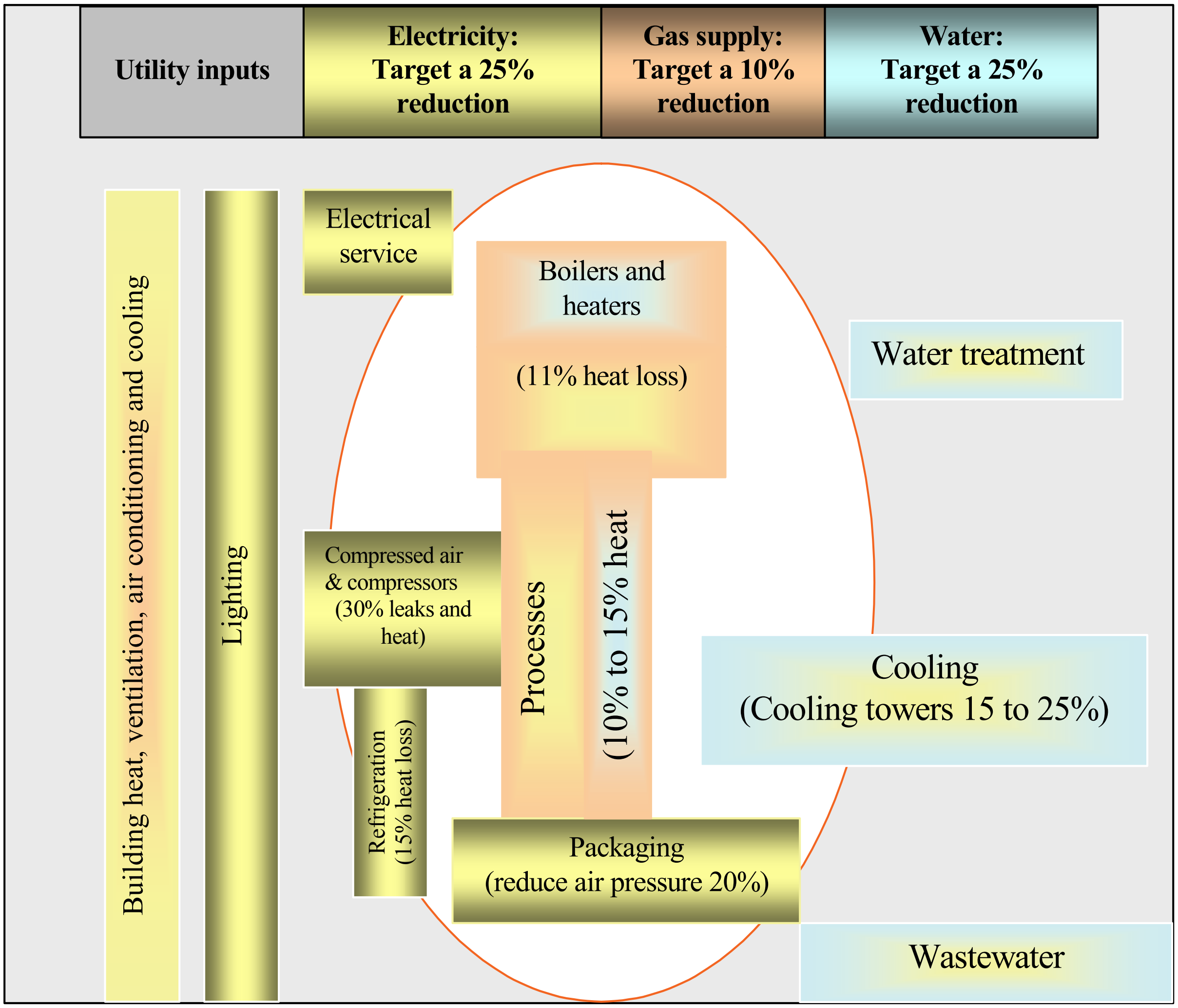


Figure 23 focuses low-efficiency direct contact processes. **Heat loss and compressed air management** are priorities. The complexity of utility use is represented with bi-coloured and tri- coloured systems. These priority targets are a mix of electricity -based and multi-utility systems.

Direct contact systems can be optimized for significant cost reductions. Lessons learned from more than 300 food plant utility studies suggests the following reduction targets for overall utility use:

Electricity

- Leak management and pressure reduction (30 percent of compressed air use) and
- Cooler/freezer efficiency (15 percent of refrigeration load).

Natural Gas

- Closed loop boiler system (11 percent reduction in boiler fuel) and
- Combustion and heat transfer efficiency (10 percent of process heat loss reduction).

Water

- Water cooling towers (15 to 25 percent of water use reduction).

6.0 INTEGRATION PHASE (TECHNOLOGY) – INTERNAL INTEGRATION AND GREEN ENERGY

> *Waste heat or cooling loads, as well as actual performance data is crucial to making a decision on new equipment. Too often, systems are installed for heating or cooling loads that were already being vented in another part of the facility. Not only is the additional utility cost a problem for margin management, but the load delivery system (larger boilers or refrigeration units) can have environmental compliance implications.*

The business case for new equipment in a food or beverage plant depends upon reliable costing data. The most reliable data can come from your own plant, if you have track energy and water use at the system level across the various zones in your facility. **Pinpoint accuracy on variable costs provides a cost-benefit analysis screen for capital equipment investments**.

This section relates to the kinds of projects identified in **Figure 48**on page 89.

6.1 BACKGROUND

When you look for the invisible wastes in your plant, one approach is to link the eight systems with a zone-by-zone analysis. In review, these five zones are:

Complete process integration projects in Phase 3 before greener energy processes are installed, as this is the final "belt tightening" that minimizes your energy or water supply requirements.

6.2 PROCESS INTEGRATION

Compressed air, combustion, refrigeration and water-related systems in a food plant are all potential sources of process integration (PI), where energy lost to the environment in one system has potential to be re-captured and used in another system.

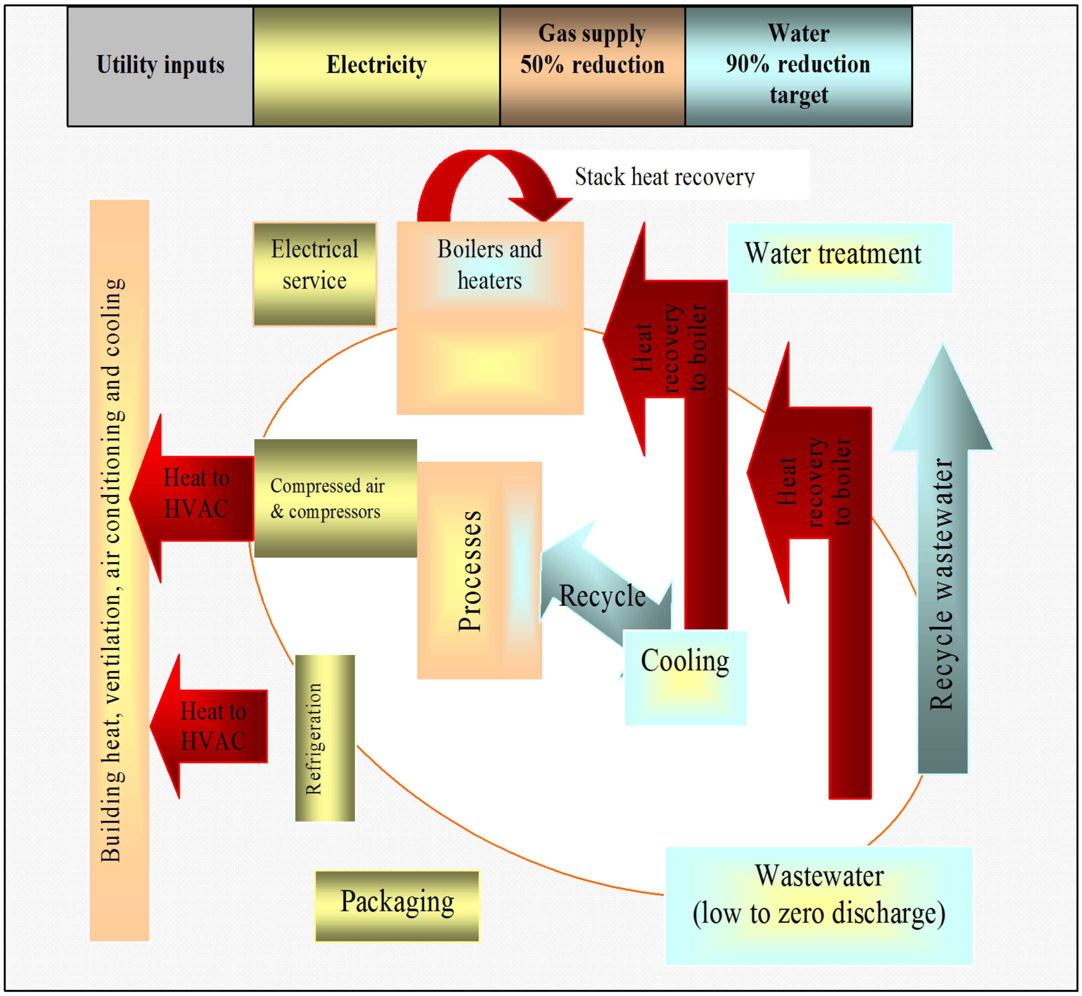
Sidebar Story: Starting over, again

The thought of looking for work unsettled Ron. He had 28 years with EOC. He never expected Jaz to ask him in for an interview on the day the plant closure was announced.

"I need somebody who will keep our efficiency on track," Jaz told Ron, knowing he had his hands full with the new plant Hellie was planning …

Figure 24 shows flows with NRCan's Office of Energy Efficiency, **process integration** in food plants can lead to between 25 and 40 percent overall utility cost savings – but this is only effective after the leak repair and process optimization is completed. Getting the order wrong reduces the effectiveness of the energy re-use. Facilities with sub-metering and process control systems in place can "see" the size of invisible opportunities.

Figure 24: Integration phase targets for waste heat and water recovery



Process Integration Targets

Natural Gas

- The recirculation of waste heat can reduce natural gas use up to 50 percent.

Water/wastewater

- Zero discharge systems can reduce water/sewer costs up to 90 percent.

6.3 TAP INTERNAL "GREEN" ENERGY RESOURCES

In North America and Western Europe, "green" is a market trend. "Greenness" drives sales, share price and profit. To contribute at the factory level, find the upgrades that improve the bottom line **and** reduce carbon footprints. Find your plant's relationship between the cost of utilities and carbon. Every utility has a background footprint[37] from the energy used **and** carbon that's released to make and move electricity, natural gas and water to wherever it is used. First, take a step back from the "green" perspective to look at what it costs to manage your utility use:

- Environmental compliance requirements are tied to water-taking, wastewater discharge, combustion, odour and noise,
- Escaped heat carries odour,
- Wastewater solids cost 10 times more to manage than solid wastes,
- Solid wastes attract rodents and insects, which are a food safety issue, and
- Municipal wastewater charges are tied to municipal water use.

When you extract energy from wastewater or escaped heat, you turn a cost into a benefit. The ability to recycle water reduces incoming water and sewer costs. Less lost heat not only saves on electricity and gas use, but also minimizes the risk of odour complaints.[38] Solid waste, high-strength wastewater, heat and cooling are all potential energy resources.

The utility input supply zone is called Zone 5 because closing the energy and water loop in a factory is a final phase priority. When you extract water and/or energy from waste streams, this re-use reduces costly inputs and costlier outputs. Some things to consider for follow-on green technology include:

- Combustion and energy generation equipment that works for pre-optimized utility use can be two to three times larger than you actually need,
- Combustion and energy generation equipment have minimum performance limits,
- Wastewater treatment and anaerobic digesters have minimum flow requirements, and
- Equipment needs floor space. Add the value of fuel and waste management offsets to waste- related penalties and compliance costs. Compare that to the return on production floor space.

Figure 25 suggests six carbon neutral or carbon negative energy sources. They are as follows:

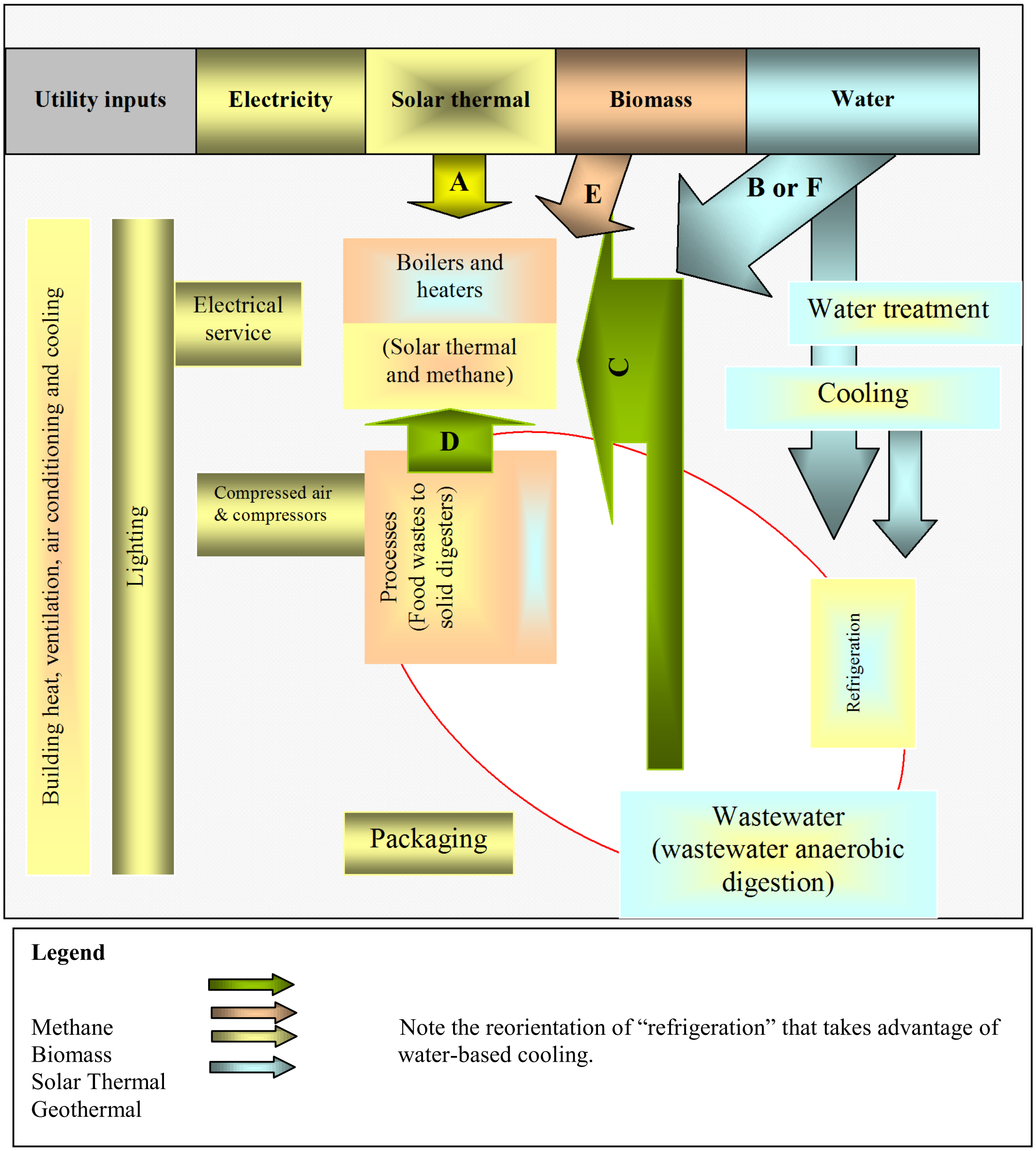
A. Heat from solar thermal panels can produce free heat for hot water,
B. Heat exchangers tied to your in-coming water is another source of heating/cooling,
C. Wastewater with high BOD can be converted into methane to burn in boilers,
D. Solid organic wastes can be converted into methane to burn in boilers.
E. Biomass can be used instead of natural gas, and
F. Geothermal heat from water.

Evidence from the European Union suggests that co-products from raw agricultural materials in food processing can be turned into 25 percent to 120 percent of the processing fuel supply.



[37] See Figure 15: The GHG footprint of wastes from Ontario's food industry in 2008. A summary of co-coefficients is included.
[38] Primary processors (factories that take raw agricultural products and turn them into food products) generally have a very high level of solid waste, high strength wastewater and high energy use that may represent 40percent of their cost of production.

Figure 25: Integration phase targets for waste-to-energy and renewable opportunities



Process Integration Targets in Phase 3

Natural Gas

- Solid waste and high-strength wastewater can be converted into biogas for fuel. While this is not possible in all plants, sometimes 25 percent of overall natural gas consumption can be reduced. The addition of solar thermal energy for hot water heating can further reduce gas or electricity use. These technologies also eliminate a significant portion of your greenhouse gas footprint.

7.0 AN OVERVIEW OF THE FIRST THREE PHASES

This section provides a suggested sequence for projects to minimize the cost of new technology and avoid sequence missteps that can create an unrecoverable capital costs.[39] For example:

- Leak management followed by process optimization can cut an energy load as much as 50 percent (i.e. compressed air systems.)
- New air compression equipment might not make sense after the load is optimized; or smaller and lower cost equipment can be purchased.

7.1 THE SEQUENCE OF PROCESS AND TECHNOLOGY IMPROVEMENTS

You can reduce the cost of utility inputs, your carbon footprint and avoid missteps when you:

- **Install M&T + EMIS + staff training** to link utility use to product costing models and product footprints,
- **Fix low-efficiency systems** related to the shell because they affect everything and add to peak electrical demand,[40]
- **Eliminate leaks** in the processing systems to reduce peak electrical energy,
- **Target losses** from refrigeration and freezers because this is largely peak electrical energy
- **Reuse waste heat** to reduce the volume of natural gas use, and
- **Upgrade combustion systems** and capture free fuel (instead of paying a high sewer surcharge) from a wastewater anaerobic digester to reduce natural gas use.

Every efficiency dollar spent on these projects avoids another $3.00 to $5.00 when you get to the **I**ntegration phase. System upgrades that are benchmarked with M&T and EMIS give a sustainability team the data to justify process integration and green energy investments. In-house experience with the utility-carbon connection does two more things:

1. Helps to get your cost of production completely under control and
2. Provides insight into how to get more from your supplier chain.

Case study: The sequence of efficiency improvements matters

In the1990s the largest source of nitrogen pollution in Europe's Rhine River came from the Ciba pigment plant in Maastricht, (a city in the Netherlands). The plant discharged more than 100 kilos of nitrogen per day in its wastewater. Ciba's neighbour, the SAPPI paper plant needed to add nitrogen to treat their wastewater. It cost them spent thousands of euros a year. The Dutch government paid these companies to look for ways to reduce wastewater impacts through cooperation. SAPPI, a Finnish-owned paper company, and CIBA, a Swiss-owned pigment plant, entered into a third-party joint venture that reduced their combined wastewater costs by more than $3 million a year. The project produces more than $1 million a year in kitty litter by-products from wastewater solids. The combined effluent stream has reduced nitrogen in the wastewater to less than 1 PPM. At the same time, the Dutch government supported co-generation and SAPPI built an 80MW plant.

For 10 years these measures worked. That is, until, EU directed industry to reduce carbon emissions by 25 percent. While both plants aggressively reduced water and energy demands, the directive forces the SAPPI plant to shed so much energy demand that the co-gen plant is no longer viable.

Lesson learned: Optimize processes before you upgrade energy supply systems.

[39] A list of frequently asked questions (FAQ's) can be found in the appendix (Section 10.1, pages 53 and 54.)
[40] Peak electricity is the most expensive electricity and can cost three to five times as much as off-peak power.

7.2 SAMPLE GANTT CHART

Figure 26 provides an aggressive sample timeline on how long it takes to take a factory from an unimproved state to a highly sustainable level.

Figure 26: A sample Gantt chart for implementing sustainable plant management

	Year 1				Year 2				Year 3				Year 4				
Timeline	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Budget
Review certificates of approval																	Simple Payback Or Cost Estimate
Update certificates																	$20,000 to $250,00
Find Champion																	
Select Team																	
Certified Energy Manager training																	$2000
Manager Training																	$500 per
Install M&T and EMIS																	10percent of annual waste and utility costs
Staff Awareness																	Ongoing
Audits																	$5,000+
Fix Leaks																	Ongoing
Benchmark																	Ongoing
Optimize processes																	2 years
Process integration study																	$50,000+
Integrate processes																	3 year s
Develop green energy projects																	3+ year s
Retail sustainability compliance																	
Supplier integration																	

Legend			
	Phase	Action Timeframe	Planning Period
Readying phase			
Optimization phase			
Integration phase			
Supply chain integration			

8.0 UPSTREAM INTEGRATION

Knowing the footprint of your products within the whole supply chain is an important piece of the puzzle. Retailers are demanding their supply chain takes action on sustainability. The message that is being sent by these retailers is that sustainability is **pre-competitive**. This kind of language should sound an alarm for every company that wants to sell its products in retail channels. "Pre-competitive" suggests that it is a looming prerequisite – get sustainable or lose your customer.

Sustainability comes in the form of packaging, lifecycle and third-party verification. Phases 1 through 3 will help you with the processing that happens inside the walls of your plant. Verification is important both from a third party and from the oversight group chosen by your customer that you met their criteria. One of these is the Global Social Compliance program (http://www.gscpnet.com/.)

Be forewarned, these kinds of programs will have a cost associated with them. However, the margin gains you make by improving your sustainability should more than offset the initial cost of compliance.

Every retailer has their own take on the subject. Follow these links to find out what these leading retailers are saying.

Walmart: http://walmartstores.com/sustainability/

Loblaw's: http://www.loblaw.ca/English/responsibility/source-with-integrity/sustainable-sourcing/default.aspx

Sobeys: http://www.sobeyscorporate.com/sustainability/overview/stakeholder_engagement.html

Managing the footprint of the products that pass through your facility can be accomplished within your walls. Inputs and outputs also have process-related footprints that add cost. Once you have wrestled the utility costs down in your plant you will be in a position to integrate with your upstream supply chain on footprint management. You might find yourself the leader, in which case you understand a proven model that you might choose to adapt to your supply chain. Below, is the sustainability agreement developed by Phillips for its upstream suppliers to its electronics and downstream healthcare supply chain.

Phillips: http://www.philips.com/shared/assets/company_profile/downloads/Philips_Supplier_Sustainability_Program_Manual_Final_170209.pdf

Your own company might not have the market power to force suppliers to act. But once your own people understand how to manage your processes in a sustainable way, you will have developed the internal skill sets to navigate supply chain sustainability with discretion.

RESOURCES

9.0 GETTING HELP

What follows is a list of service providers and programs known to the authors at the time of writing. **The lists are not exhaustive.** The intention is to list organizations and government programs to get you started.

Management and staff awareness/training

- Natural Resources Canada: "Dollars to $ense" workshops (www.nrcan.ca) and Certified Energy Manager Training
- The Guelph Food Technology Centre Sustainability Services (www.gftc.ca)

Technical resources, guidebooks and fact sheets

- Canadian Manufacturers & Exporters (www.cme-mec.ca)
- Ontario Agri-Business Association (feed mills, grain elevators and agricultural supply companies), energy and environmental benchmarking tools (www.oaba.on.ca)
- Alliance of Ontario Food Processors/ Ontario Food Industry Environmental Coalition (www.aofp.ca)
- Natural Resources Canada, Office of Energy Efficiency (resource guides and fact sheets.) Energy Management Information Systems http://oee.nrcan.gc.ca/publications/industrial/emis/EMIS_eng.pdf http://oee.nrcan.gc.ca/industrial/equipment/products/index.cfm?attr=24
- Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs (fact sheets and case studies.) www.omafra.gov.on.ca/english/index.html
- B.C. Hydro www.bchydro.com/powersmart/industrial.html
- Manitoba Hydro www.hydro.mb.ca/your_business/index.shtml?WT.mc_id=2024
- Ontario Power Authority http://www.powerauthority.on.ca/industry-stakeholders
- Union Gas http://www.uniongas.com/largebusiness/largebusiness.asp
- Enbridge Gas https://portal- plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=355&PageID=0&cached=true&mode=2&userID=2

Programs and financial support (in Ontario)

- Natural Resources Canada http://oee.nrcan.gc.ca/industrial/financial-assistance.cfm?attr=0
- Ontario Power Authority (Electricity Retrofit Incentive Program) https://saveonenergy.ca/Business.aspx
- Union Gas http://www.uniongas.com/largebusiness/energyconservation/gettinghelp/
- Enbridge Consumers Gas https://portal- plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=355&PageID=0&cached=true&mode=2&userID=2
- Capital Cost allowance http://gazette.gc.ca/archives/p2/2005/2005-12-28/html/sor-dors415-eng.html
- Green Purchasing Alliance http://www.partnersinprojectgreen.com/get-involved/project-green-programs/purchasing-program/green-purchasing-alliance

Third-party verification, LEED accreditation (Leadership in Energy and Environmental Design), and Sustainable Benchmarks and Compliance

- Carbon Counting http://www.carboncounter.info/why.html
- Carbonzero, Carbon accounting: http://www.carbonzero.ca/standards
- Carbon Calculating http://www.partnersinprojectgreen.com/get-involved/project-green-programs/training/carbon-101-reduction-program
- RWDI (accredited carbon verification services) http://www.rwdi.com/
- Treeism (LEED accreditation for existing buildings) john.martin@treeism.ca
- Energy Advantage http://www.energyadvantage.com/
- National Institute of Standards and Technology (NIST), Sustainable Manufacturing Indicators Repository, http://www.mel.nist.gov/msid/SMIR/index.html
- Pace Global http://www.paceglobal.com/
- Global Social Compliance Program http://www.gscpnet.com/.
- British Retail Consortium and Global Food Safety Initiative http://www.cert-id.com/BRC- Certification.aspx?gclid=CK6GlNG_76kCFYio4Aodvx_LWQ

M&T plus EMIS Installation and Consulting

- **AMEC** (Ron MacDonald) Telephone: (519) 650 7100
- **The Altech Group** (Alex Keen) (416) 467-5555 Ext: 223
- **DGE (**Chris Hall) (519)-508-5058
- **Energy@work (**Scott Rouse) (416) 642-0571
- **Third Planet Energy** (Bill Oliphant) (226) 785 0466

10.0 APPENDICES

The appendices contain a variety of tools and information that may be useful. Included are:

- Frequently asked questions (FAQ's),
- Suggestions on how to pose open questions to get your colleagues on board,
- A mass balance case study,
- Schematics and logic models for patterning an M&T system, and
- A list of improvement projects by phase.

10.1 FREQUENTLY ASKED QUESTIONS

Question 1: **How do I know where to start?**

Answer: Install sub-meters in key areas in your plant to learn how much, and of what, you use where. Harvest the information with an Energy Management Information System (EMIS). **Appendix 10.5** identifies potential target locations for installing sub meters for tracking natural gas, electricity and water use. If you can't track the way you use utilities, it's pretty hard to reduce them. **Managers who get the facts make fewer mistakes than managers who guess**.

-

Question 2: **What should be my first project?**

Answer: Train your people so the whole organization understands the change that's needed. Without training and awareness at every level, any fix will be undone within five years. Train staff and managers to use M&T and EMIS to reveal what gets used where. Natural Resources Canada offers excellent training for beginner awareness (http://oee.nrcan.gc.ca/english/). The combination of training and sub-metering systems can help you eliminate the 'oops' factor, or people's mistakes, which can add up to 15 percent to your utility bills.

Question 3: **Do I target waste or footprint?**

Answer: Neither. Grow your margin. Target cost reduction first. Fix leaks and optimize how your plant uses inputs to reduce your costs and your footprint at the same time. A strict focus on just waste reduction or just footprint reduction can actually increase your costs. The aim is to *grow your margin* while you get leaner.

If you add green energy systems to your factory without changing any of your plant processes, it'll cost more than it's worth. Over-building solar electricity and energy-from-waste projects can be expensive. When your goal is to drive alone from point A to point B at the lowest possible cost do you choose a Hummer or a Smart Car?

Question 4: **Which of the 150 projects (Section 10.6 Figures 46 to 48) should I start with?**

Answer: First identify the systems and zones in your plant. Your goal should be to do a project once and not have to do it again. Without training and awareness you look at your plant in the same way you'd look at a 1500-piece puzzle – how do the pieces all fit together?

Start with the non-process energy/water-using systems in the factory: electrical service, lighting and systems related to the zone we called the building shell (heating, ventilation and air conditioning). When they're not efficient, they add waste to everything you do. They're also highly visible to your employees. Projects that spark employee awareness are important and tend to be more effective.

Question 5: **After the starting point, what's next?**

Answer: Every factory has a different path, but the route to the final destination is the same. Let's start back at the beginning:

1. **Build a management team and workforce that use sub-metering in a way that links utility use and waste creation to your footprint**. (**R**eadying phase - **People**)
   - **Empower** a champion,
   - **Train** your managers and staff (NRCan and CEM training is a good place to start),
   - **Invest** in M&T and EMIS to measure and track utility use across your plant,
   - **Reconcile** product costing model M&T and EMIS benchmarks,
   - **Invest** in third-party energy, water and waste efficiency audits,
   - **Get** a LEED audit on your existing building, and
   - **Review** your utility bills for errors and audit your wastewater to see if you qualify for sewer use rebates (when your sewer outflow is 80 percent or less of your water intake, most municipalities will rebate the difference on your sewer bills going back at least 18 months).

3. Eliminate leaks and wasteful work habits (Early Optimization phase **- Process)**
   - **Target** the lowest efficiency non-process systems first, like lighting, HVAC and power factor corrections with your electricity service. This targets 8 to 10 percent of your overall use;
   - **Turn off** the leaks and losses in your process – compressed air leaks, steam leaks and water leaks, and
   - **End** the behaviour that leaves equipment running and adds five to 15 percent of your utility bill.

3. **Optimize existing processes (Late O**ptimization phase - **Process)**

   - **Install** control systems on process equipment. This includes variable speed drives for motors and fans.
   - **Control systems** can save you about 25 percent of utility costs on the processes being controlled,
   - **Install** cooling towers to recycle water and reduce wastewater costs, and
   - **Quantify** up to 55 percent of all invisible process heating losses and 38 percent of all invisible HVAC heating losses the U.S. Department of Energy says you have in your processes NRCan says 25 to 40 percent of your overall energy use can be saved with PI.

4. **Capture 'free' utility sources after your internal use is minimized** (**I**ntegration phase - **Technology**)
   - **Upgrade** your boiler to a closed loop,
   - **Recover** wasted heat and wasted water. NRCan calls this process integration. You capture heat or cooling lost to the atmosphere during one process and uses it in another,
   - **Add** green energy and energy-from-waste technologies after you've squeezed the waste out of the system. Every dollar spent on efficiency saves three to five dollars on the cost of utility-related replacement technology because of lower use, and
   - **Consider** major capital projects such as:
     - Co-generation to minimize the supply chain footprint of the energy you use,
     - Wastewater anaerobic digesters to produce fuel for your boilers, heaters and co-generation,
     - Solar thermal installations for pre-heating process and sanitation water, and
     - Water-recycling.

5. **Manage your supply chain footprint with your production footprint**
   - Once the energy, water and solid waste are trimmed from the plant, you can look beyond your factory to control the same kinds of waste that affect your product.

10.2 GETTING INTERNAL BUY-IN

Changing the way a factory runs requires allies in every department. Help your colleagues understand how sustainability will help them. To do that, you need to think outside your role. It doesn't matter if you work in sales, marketing, finance, engineering, distribution or human resources. Unless you are the CEO or the board of directors, it's unlikely you'll be able to drive this kind of change alone. You need your colleagues and upper management to make it work.

There are ways to get peoples' interest in your organization. At budget review time try asking some leading questions. (You must know the answers before you ask.) Try these ten for starters:

1. What's our electricity use in kilowatt hours and dollars? (per month/year)
2. What's our natural gas use in cubic meters and in dollars? (per month/year)
3. What is our water use in cubic meters and in dollars? (per month/year)
4. What is our sewer use in cubic meters and in dollars? (per month/year)
5. How much is our sewer surcharge? (per year)
6. How much do we spend on water softening? (per year)
7. What is the volume and cost of our solid waste management? (per week/year)
8. What is our rate of waste/scrap rate as a percentage of goods produced?
9. What does our waste/scrap rate cost in cents per unit of goods produced?
10. What is the annual input value of our scrap (including labour and overhead)?

The sum of these questions has an impact on the bottom line. That total is often larger than profit. For many food processors, it's also larger than labour costs. Wrestling down these costs is a sustainability action plan that generates two dollars of gross margin for every dollar saved.

Case study: How Heinz UK discovered invisible waste

Barry Aspey first challenged his colleagues in 2000. The company planned to build a new energy centre. He did a heat balance in the factory and learned that fuel use is deceptive:

- **only 25 percent was fully used in manufacturing processes,**
- 25 percent left the factory through the sewer as heat,
- 25 percent went up the chimney as heat and
- 25 percent couldn't be accounted for.

Barry also learned about:

Boilers and heat distribution
- Boiler maintenance and closed loop configurations save up to 30 percent on fuel.

Refrigeration
- A 1°C difference in temperature can increase costs by up to 4 percent.

Process controls
- Process controls deliver energy efficiency and output increases at no extra cost.

Source: Carbon Trust 2010 http://www.carbontrust.co.uk/cut-carbon-reduce-costs/products-

To get agreement throughout your organization, you will need to think about what other departments want. This might not be the same as what you think is important. Here are a few high level priorities that pique interest from your colleagues' perspectives.

Executive management

- Verify key performance indicators,
- Improve operational equipment efficiency, and
- Cut the carbon footprint and achieve green marketing objectives.

Finance and operations

- Cut waste and the cost of waste handling,
- Reduce maintenance costs, and
- Reduce water and sewer costs.

Plant management and human resources

- Engage workforce in lean and continuous improvement,
- Cut costs at the input and output level without threatening job security, and
- Improve returns with worker buy-in.

Plant management, engineering and environmental compliance

- Avoid environmental regulation trigger points for waste/emissions, and
- Get technical and program support to upgrade facilities.

Everyone has an agenda and it may not be the same as yours. Align your conversation with their agenda. To help decision-makers in other departments buy-in to your agenda, try the following:

With sales and marketing

- This is a way to prove green marketing claims,
- This is a way to cut production costs without losing quality,
- This is a way to protect gross margins when buyers expect lower prices, and
- This is a way to provide customers value without dropping prices.

With operations/production

- This is a way to continuously reduce variable costs like energy, water and solid waste,
- This is a way to prove cost reductions and key performance indicators,
- This is a way to prove process improvements and green status,
- This is a way to improve OEE by $25,000 to $35,000 per million dollars of output, and
- This is a way to engage workers interested in working in a greener workplace.

With finance

- This is a way to drive the responsibility for costs down to the shop floor,
- This is a way to forecast operational equipment efficiency,
- This is a way to reduce operating capital and increase cash-to cash cycles,
- This is a way to increase asset value by up to $130 per square foot[41] and
- This is a way to improve cash-to-cash cycles because input costs for utilities and output costs for waste management can be reduced.

With engineering/maintenance

- This is a mass balance approach to cutting waste,
- This is a way to reduce maintenance and repair costs by 10 to 14 percent,
- This is a way to know what is on where and how much is being used,
- This is a way to help evaluate new equipment purchases, and
- This is a way to justify process controls and other new technology.

[41] Muldavin, Scott, R. 2010. Value Beyond Cost Savings, **Green Building Finance Consortium**.

With procurement

- This is a way to get accurate forecasts for utility contracting,
- This is a way to improve cash-to-cash cycles, and
- This is a template for greener purchasing specifications – to meet or beat the internal footprint profile.

At the head office

- This is a way to integrate production cost management with green marketing objectives and environmental compliance,
- This is a way to drive triple bottom line performance through the organization, from the shop floor to finance, track it and integrate it with performance objectives,
- This is a way to get proven sustainability and a reduced carbon footprint that shareholders, customers and consumers can all appreciate, and
- This is a way to increase the profile of the company to attract new talent.

With human resources

- This is a way to increase the profile of the company,
- This is a way attract new employees that want to work in a greener workspace, and
- This is a training and development project that builds your sustainability expertise.

With the environment department

- This is a way to avoid the end-of-pipe compliance challenges,
- This is a way to change environmental issues from cost centers to profit centers, and
- This is a way to avoid the things that earn environmental fines and tickets

With distribution, logistics and warehousing

- This is a way to get key performance indicators into the buildings, coolers and freezers on par with your logistics and packaging reduction KPI's.
- This is a way to link KPI's to supply chain transparency, and
- This is consistent with a multi-modal strategy for lowering greenhouse gases.

These lists can help. In a meeting or a presentation, how a project is positioned relative to how the big picture is interpreted by everyone around the table depends on two things:

- Your soft skills (how you link your goal to others' needs) **and**
- The numbers.

.Case study: An example from a non-food processor

Company-wide, since 2008 Abitibi Bowater's energy initiatives have achieved out-standing results, including:

- a 71 percent reduction in absolute carbon emissions
- 47 percent self-sufficiency in terms of total energy needs.

To attain this level of self-sufficiency the company used a combination of its own hydro power and cogeneration. (Heads Up CIPEC - October 1 2010 Vol. XIV No. 18)

Lesson learned: Process integration is lean and green

10.3 A SIMPLIFIED MASS BALANCE CASE STUDY.

It takes a major change in the way we all think to drive invisible costs out of production. The end result is not the same for all processors, but generally speaking there can be a gross margin improvement between 12 and 40 percent depending upon the kind of processing you do. It depends on how much energy and water you use and how much solid waste and wastewater you create.

Look at any business from a mass balance perspective and you'll measure more waste than product. Income from a product or service comes from a small slice of the inputs. The ratio of valuable outputs from costly inputs is often defended as "the core competency". But is it?

Primary and secondary food processors, as well as large scale farm operators, should increase their profit when they improve their mass balance conversion. In fact, a highly efficient business will make more goods with less money.

As a rule of thumb, a food plant makes $950,000 (based on cost of production) of goods with $1 million in working capital. Using the same working capital, a sustainable primary food processor could make $1.3 million worth of goods and a secondary food processor could make $1.1 million worth of goods with the same inputs (See pages 60 to 63.). E2 Management reports some industrial sectors have a waste factor as high as 86 percent of the cost of production. The increased productivity comes from the recapture of wasted inputs and the associated improvements to operational equipment efficiency/effectiveness (OEE).

A high level of cost associated with different kinds of waste is measurable. What you can measure you can manage. The trick is to figure out **how** and **what** to measure. In general, most businesses measure and manage about half of their variable costs in the same way.

Figure 27 on the next three pages looks at the business case for a mass balance approach to input management. Mass balance suggests inputs are always equal to outputs. Yet there is a problem for businesses that convert inputs into saleable products. Inputs that get transformed into wastes stay on the cost side of the ledger. To be sustainable, the issue is to mirror mass balance, where inputs are costs and outputs are income.

Case study: Mass balance (a KPI for sustainable processing)

A business case can be illustrated with a simple formula that looks at 6 inputs to manufacture any finished good (FG), be it a product or a service. The "waste" factor for each input can be calculated and measured. For this discussion a hypothetical example is provided in Figure 27. (Actual costs may differ.) The efficiency of a system can be defined as: the yield of an input, the waste of an input and what these represent as a percentage of the cost of production. These inputs are as follows:

Energy (E), Water (W), Labour (L), Materials (M), Equipment (Eq), Capital (C)
(Where Finished Goods (FG) = E + W + L + M + Eq + C)

Lesson Learned: To measure the cost and efficiency of use for all inputs is the starting point for sustainable processing.

Figure 27: A Mass Balance Example of Measuring Sustainable Processing in Ontario's Food Sector

This example is based on Statistics Canada and USDA data sources; and more than 300 Ontario-based food processing facility energy/water audits. ***Figure 27*** *is a snapshot of Ontario's food sector before 2010. It illustrates an opportunity (aka cost of production improvements) where the outcome of improved efficiency is measurable benefit. Improving sustainable performance is an intended outcome of the improvement of processing efficiency.*

Energy (E)

- *The* ***yield*** *of energy is about 5percent for lighting, and is about 50 percent for other equipment—we will use 50 percent for our example,*
- *The* ***waste*** *of energy is therefore on average, 50 percent (since the yield is the other half), and*
- *On average, energy costs represent 10 percent of the cost of production for Primary Processors and 2 percent for Secondary Processors.*

According to the USDA, the food production value chain uses more than 35 percent of all the energy used in the USA (USDA, 2010). According to Statistics Canada, the average cost of energy and water in the food industry was 2.42 percent in 2007.

Water (W)

- *The* ***yield*** *of water into manufactured goods is about 10 percent,*
- *The* ***waste*** *of water is about 90 percent, and*
- *On average, water and waste water costs represent 5 percent of the cost of production for Primary*
- *Processors and 1 percent for Secondary Processors.*

In 2001, food processors in the City of Toronto wastewater discharged 97 percent of the water they used. Food processors that make further value-added products from already –processed goods use considerably less water, according to a 2007 Ontario Ministry of the Environment study, water accounted for an average of 0.05 percent of costs – about one tenth of primary manufacturers' costs.

Labour (L)

- *The* ***yield*** *of labour ranges between 15 and 80 percent — we will use 80 for our example,*
- *The* ***waste*** *of labour is therefore on average, 20 percent, and*
- *On average, labour costs represent 12 percent of the cost of production for both Primary Processors and Secondary Processors.*

In 2007 Statistics Canada reported labour as 11.74 percent of food processing costs.

Materials (M)

- The **yield** of materials is about 50 percent for Primary Processors, and is about 95 percent for Secondary
- *Processors,*
- *The* ***waste*** *of materials is then — on average — 50 percent for Primary Processors and 5 percent for Secondary Processors, and*
- *On average, material costs represent 48 percent of the cost of production for Primary Processors and 60 percent for Secondary Processors.*

Input materials (raw materials and packaging) range from 5 to 70 percent of the cost of production. Half of all raw materials used do not get turned into saleable product.

Equipment (Eq)

- *The yield of equipment is about 80percent (running capacity),*
- *The waste of equipment is therefore on average, 20 percent, and*
- *On average, equipment costs represent 20 percent of the cost of production for both Primary Processors and Secondary Processors.*

The waste is the equipment down-time. Equipment is considered a fixed and depreciable cost.




Capital (C)

- *The yield of capital is about 95 percent,*
- *The waste of capital is 5 percent, and*
- On average, capital costs represent **5 percent of the cost of production for both Primary Processors** ***and Secondary Processors.***

We assume that the cost of money is a loss and is an equivalent of waste. Interest and financial costs of doing business take away from the bottom line and should be considered.

The equation for a **Primary food manufacturer's finished goods (FG),** accounting for standard wastes (yield reductions), becomes:

Primary Food Manufacturer's Finished Goods (FG) =
0.5 E + 0.1 W + 0.8 L + 0.5 M + 0.8 Eq + 0.95 C

The equation for a **Secondary food manufacturer's finished goods (FG)** — with a higher material (M) yield — becomes:

Secondary Food Manufacturer's Finished Goods (FG) =
0.5 E + 0.1 W + 0.8 L + 0.95 M + 0.8 Eq + 0.95 C

If Finished Goods (FG) = $1.00 then:

Primary Food Processor Input Costs	*Secondary Food Processor Input Costs*
E = $0.10	E = $0.02
W = $0.05	W = $0.01
L = $0.12	L = $0.12
M = $0.48	M = $0.60
Eq = $0.20	Eq = $0.20
C = $0.05	C = $0.05
FG = $1.00	FG = $1.00

But add in the "waste" factors (lost heat, unused water, scrap, wasted labour, financial costs and lost process time) and we get a much different metric of how much money all of the "wastes" actually cost a primary manufacturer...

Primary Food Processor Waste (Pre-yield improvements)	*Secondary Food Processor Waste (Pre-yield improvements)*
50% E = $0.05	50% E = $0.01
90% W = $0.045	90% W = $0.009
20% L = $0.024	20% L = $0.024
50% M = $0.24	5% M = $0.03
20% Eq = $0.04	20% Eq = $0.04
5% C = $0.0025	5% C = $0.0025
Waste = $0.4015 per $1.00 of costs	Waste = $0.1155 per $1.00 of costs

In other words, for every $1 of manufactured output, it is conceivable that there may be almost 40 cents of system waste for a primary food processor. In terms of *muda*, every 1 percent of the cost of production that is lost to waste eliminates 2 percent of potential profit.

Some costs that are considered as waste are necessary, like the cost of capital.
Other things considered as waste may yield efficiency opportunities. Examples include:

- **Wasted** equipment is recovered through higher rates of Operational Equipment Efficiency (OEE). Every 1percent increase in OEE yields $25,000 to $35,000 in increased profitability per million dollars of throughput,
- **Wasted** labour is avoided through improved processes and reduced downtime. Simple changes can be as dramatic as increased automation,
- **Wasted** water is eliminated with zero discharge and high efficiency to totally eliminate wastewater treatment costs and reduce incoming water by as much as 80 percent,
- **Wasted** energy is eliminated through heat recovery and improved electrical efficiency; leading energy efficiency practitioners are able to reduce energy waste by 50 to 70 percent,
- **Use** of wastes for energy generation (where applicable) or to extract by-product value may reduce material waste for food processors by as much as 90 percent, and
- **Improved** OEE and waste reductions also impact capital.

Primary Food Processor Waste (Post-yield improvements)	***Secondary Food Processor Waste (Post-yield improvements)***
25% E = $0.025	25% E = $0.005
10% W = $0.005	10% W = $0.001
15% L = $0.018	15% L = $0.018
5% M = $0.024	5% M = $0.03
15% Eq = $0.03	15% Eq = $0.03
4% C = $0.002	4% C = $0.002
Waste = $0.104	Waste = $0.086
Savings = $0.2975 for every $1.00 of Costs	**Savings = $0.0295 for every $1.00 of costs**
***Waste* is reduced by 74. 1 percent**	***Waste* is reduced by 25.5 percent**

Note: These costs are roughly based on actual food industry costs reported by Statistics Canada for 2007 which reported actual costs of production as follows:

- **Energy and water as 2.42 percent,**
- **Raw materials 59.73 percent, and**
- **Labour 11.74 percent.**

What does a Mass Balance perspective say about food processors?

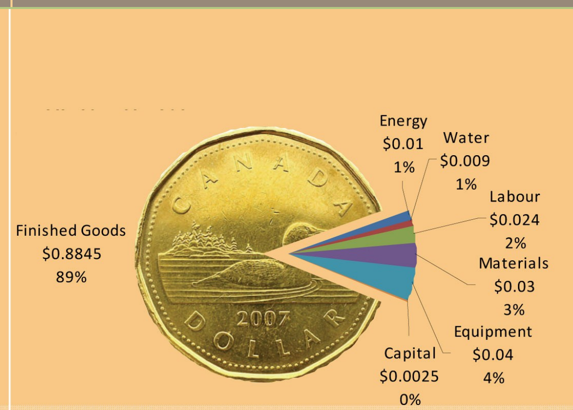
- A Primary Food Processor wastes $0.4015 of every $1.00 of total input costs, and
- a Secondary Food Processor wastes $0.1155 of every $1.00 of total input costs.

BUSINESS CASE SUMMARY:

Some waste is unavoidable — too costly to recovery. The “loonie charts” (below) are extrapolated from a combination of Statistics Canada and USDA data. They offer a business case for a more sustainable way of doing business is based on achievable energy, water and material efficiencies that affect labour efficiency, capital efficiency and equipment efficiency. This kind of efficiency management can be based on the use of an intelligent efficiency technology application that uses M&T and EMIS to measure and disrupt wasteful practices that would otherwise add invisible costs and carbon to a manufacturing process.

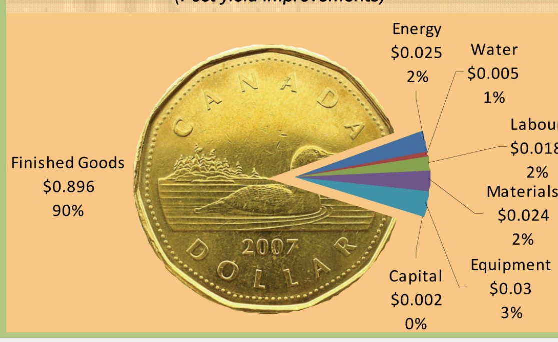
The ability to manage, measure and progressively recover wasted inputs will lead to an improvement in gross margin performance. The ability to find and accurately pinpoint complex cost centers sets the stage for a level of margin control accuracy that can shut the door on low-cost labour and currency competition.

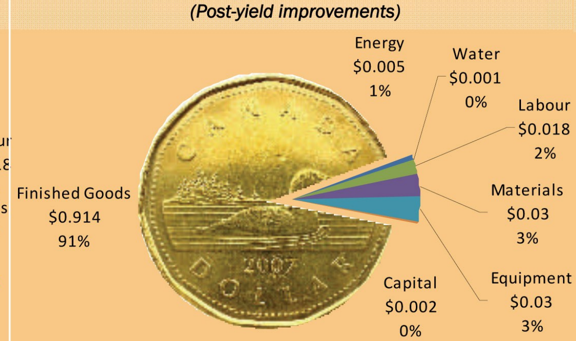
Primary Food Processor wastes	*Secondary Food Processor wastes*



Primary Food Processor Waste (Post-yield improvements)

Secondary Food Processor Waste (Post-yield improvements)





A combination of 6 inputs is required to manufacture any Finished Good (product or service).
Finished Good (FG) = Energy (E) + Water (W) + Labour (L) + Materials (M) + Equipment (Eq) + Capital (C)

Input	Pre-Improvement Waste/$1 Inputs	Post-Improvement Waste/$1 Inputs	Waste Reduction	Input	Pre-Improvement Waste/$1 Inputs	Post-Improvement Waste/$1 Inputs	Waste Reduction
E	$0.05	$0.025	↓ 50.0 %	E	$0.01	$0.005	↓ 50.0 %
W	$0.045	$0.005	↓ 88.9 %	W	$0.009	$0.001	↓ 88.9 %
L	$0.024	$0.018	↓ 25.0 %	L	$0.024	$0.018	↓ 25.0 %
M	$0.24	$0.024	↓ 90.0 %	M	$0.03	$0.03	↓ 0.0 %
Eq	$0.04	$0.03	↓ 25.0 %	Eq	$0.04	$0.03	↓ 25.0 %
C	$0.0025	$0.002	↓ 20.0 %	C	$0.0025	$0.002	↓ 20.0 %
Total	**$0.4015**	**$0.104**	**↓ 74.1%**	**Total**	**$0.1155**	**$0.086**	**↓ 25.5%**

The bottom line:

A Primary Food Processor can get a 74.1 percent waste reduction ($0.104 waste per $1.00 if inputs).

The bottom line:

A Secondary Food Processor can get a 25.5 percent waste reduction ($0.086 per $1.00 of inputs.)

10.40 BUDGETING CAPITAL EXPENDITURES AND CASH FLOW ANALYSIS

In an annual capital planning cycle operations is seldom without its shopping list of projects presented for scrutiny of the company controller. From an operational point of view based on simple payback, too often good projects are cut from the list. This appendix is intended to provide operational staff an insight into what a controller looks for in a proposed project that affects risk, the time-value of money, the cost of financing, depreciation and cash flow.

A **simple payback period** (simple payback) measures how long a project takes to "pay itself off". Short payback periods (less than one year) are better than long payback periods (more than one year). Simple payback is used at the operational level because it is easy to understand. A $100,000 project with a $50,000 per year return has a simple payback of two years ($50,000 per year for two years equals $100,000.) 'Nevertheless, simple payback lacks the depth that financial evaluation demands.

Businesses plan annual budgets. Projected expenses are categorized as **capital expenditures** or as part of an **operating budget**. The **operating budget** factors in expected costs for a 12 month (annual) cycle. **Capital expenditures** last longer than a year to "pay off", and use "long term money" to pay for the expense (this includes long-term debt or retained equity.)

From a controller's point of view, simple payback does not recognize the time value of money or cash inflows after the payback period. It also does not assess risk, the cost of financing, depreciation or any opportunity costs associated with a project. Life cycle costing analysis provides a realistic financial picture of an energy retrofit project.

A controller uses a different set of screening tools to forecasts whether or not the expected rate of return on any project can cover the cost of money. This involves the evaluation of a capital project based on its impact on internal cash flow projections and reflects how efficiently financial resources are used.

It helps operational project champions to understand this:

- Financial tools used to measure money use are to Finance what M&T with EMIS tied to product costing models is to the operational measurement of sustainable input use.

This section presents a controller's perspective on the two projects delves into the weeds of the case study on page 24. When an operational champion understands how financial screens are used to measure a project, better project proposals emerge. Figures 28 to 30 illustrate the financial tools that controllers use. Then projects are analysed against simple payback.. The financial decision on which project is considered "the best" or the most financially sound is based on how money gets used.

10.41 WEIGHTED AVERAGE COST OF CAPITAL (WACC)

A controller uses a **weighted average cost of capital (WACC)** calculation to measure the cost of capital. This example combines money from two sources, each with their own (hypothetical) borrowing rate (long-term debt and shareholder's equity.)

Assumptions:

- Interest on long-term debt is the cost of borrowing; we will use a rate of 6 percent, and
- Shareholder's Target Return on Equity is subjective and is determined by the owner or shareholders as an earning benchmark; for this example we will use a rate of 20 percent.

Figure 28: Assessing WACC on a $150,000 Lighting Project

Capital Source	Amount	Rate	Annual Cost
Long-term Debt	$37,500	6% (bank rate)	$2,250
Shareholder Equity	$112,500	20% (management)	$22,500
Therefore Debt = 25%	$150,000		$24,750

WACC = $24,750 / $150,000 = **16.5 percent**

A "hurdle rate" of 16.5percent is needed for a controller to consider a project to be viable.

10.42 THE TIME VALUE OF MONEY

Controllers look at the value of money over time, both as an investment and as a cost. In both cases they will use the corporate hurdle rate to measure both the benefit (future value) and the risk (present value) of a project.

Future value: A dollar invested today is worth more than a dollar in the future. The concept is based on compounded interest that is paid on an investment. **Figure 29** uses a 16.5 percent hurdle rate to determine a "future value" of borrowing $100.00 over several years.

Figure 29: The future value of investing $100.00 at a 16.5 percent hurdle rate

Year	Investment	Hurdle Rate	Interest Payment	Future Value (compounded)
1	$100.00	16.5%	$16.50	$116.50
2	$116.50		$19.22	$135.72
3	$135.72		$23.39	$158.11
4	$158.11		$26.09	$184.20
5	$184.20		$30.39	$214.60

Present value: This table takes an investment at present (at a given hurdle rate) and calculates its declining value into the future. An investment in the present that uses money at any given rate of return or interest is worth less in the future. Since future money is worth less, it is discounted. **Figure 30** illustrates this concept. This is the opposite of future value.

Figure 30: The present value of borrowing $100.00 with a 16.5percent hurdle rate

Year	Present Value of $100.00 at 16.5percent (compounded)
1	$85.84
2	$73.68
3	$63.32
4	$54.29
5	$46.60

By discounting future cash flow a controller compares **present value** with the cost of the project. This will determine if the project earns a desired rate of return.

10.43 NET PRESENT VALUE (NPV)

Net present value (NPV) measures the difference between the outflow of money and the inflow of money (future money is discounted as in **Figure 30**. This compares the value of a dollar today to the value of that same dollar in the future. When NPV is positive (>0) a project should be acceptable. If NPV is negative (<0) a project is likely to be rejected because the associated cash flow will drain financial resources.

There are circumstances where support programs such as grants or accelerated depreciation rates will distort an NPV calculation. It is important to be aware of how support programs may distort a project and be able to address these issues to defend a project.

Figures 31 through 38 (pages 66 to 71) compare simple payback to NPV on two projects

10.44 INTERNAL RATE OF RETURN (IRR)

The internal rate of return (IRR) method finds the discount rate, which matches the cash inflows, and the cash outflows leaving a Net Present Value of zero. A company can then make capital investment decisions based on the projects that have the highest IRR; if the interest rate (not the hurdle rate) is below 6 percent[42], a project with IRR above 6 percent creates a positive cash flow.

10.45 ACCELERATED DEPRECIATION AND GRANTS

The Canadian government currently has a long list of grants and tax incentives for wind, solar, biomass, biofuel and host of other clean sources of energy. Ontario also has green energy support programs.

Tax rules allow a company to accelerate depreciation for some capital projects. Accelerated depreciation (or bonus depreciation) means most of the depreciation is taken in the first few years of the ownership a capitalized asset. This reduces income tax payments in the first few years of the asset's life. Highly profitable companies with a large proportion of their capital invested in equipment, like accelerated depreciation. Such programs are intended to increase capital equipment spending by businesses.

Most companies use a government's depreciation rate schedule, unlike very large and trans- national companies that will reconcile an internal depreciation rate every year against the capital cost allowance (CCA) that is listed by the government's depreciation schedule. This allows these larger companies to adjust their CCA against taxable income.

10.46 BUSINESS CASE: MEASURING FINANCIAL RISK ON PROJECTS IN A BREWERY

Background

- 200,000 square foot manufacturing facility with 100 employees,
- Labour rate at $25 per hour, plus $1.80 per $100 of insurable earnings in workers' compensation costs, and
- Current annual electrical bill totals $1.4M.

Project 1: Lighting Efficiency Upgrade Assumptions

Existing lighting system

- Metal halide 400 W enclosed fixtures used in a grid pattern throughout the plant. They offer marginal illumination and lighting quality that deteriorates over the bulb lifespan (high lamp lumen depreciation factor),
- The share of the current $1.4M annual electrical bill that is linked to lighting is $100,000, or about 7 percent of total electrical costs (at $0.50/sq. ft.),

[42] A 6 percent interest rate is used for illustration purposes only. A controller would use a fixed rate based on an actual borrowing rate.

- Current HVAC costs are $70,000 (5percent of the electrical bill), and
- Current workers' compensation costs are $72,000 ($720 per employee at average salary of $40,000).

The project involves replacing the system with:

- Two-lamp 34 W, T12 open fixture fluorescent fixtures at a capital cost of $150,000.

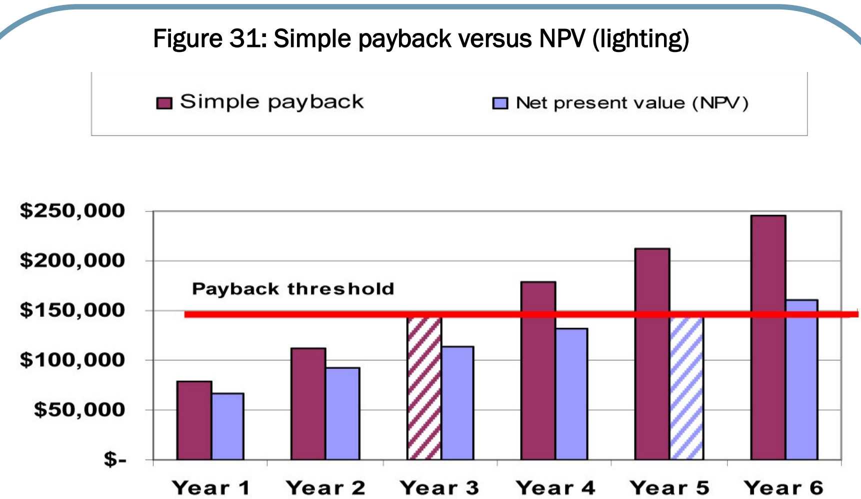
Implications and assumptions

- Reduces the annual lighting bill to $70,000 (30 percent reduction of $30,000),
- HVAC costs will be reduced to $67,900 (3 percent reduction of $2,100).
- Less injuries due to better lighting, workers' compensation costs reduced to $70,560 (2 percent reduction of $1,440),
- Book depreciation duration for the lighting system is 25 years with no scrap value. Tax depreciation is over 3 years,
- The upgrades halve the number of fixtures and ballasts, and reduce the number of lamps by 75 percent, lowering annual maintenance costs to $3,600 (40 percent reduction of $2,400), and
- These fixtures can be specified with 'high–low' ballasts combined with occupancy sensors for additional savings.

Further reading: see NRCan's NPV and IRR examples for lighting:
http://oee.nrcan.gc.ca/publications/equipment/lighting/14056

Figure 31: Simple payback versus NPV (lighting)

This figure shows how simple payback (~3 years) is less reliable than NPV (~5 years) for assessing the actual amount of time a projects needs to meet a payback threshold.



Lighting Upgrade:

Simple payback (~3 years) versus NPV payback at 16.5% (5 years)

Figure 32: Depreciation schedules (lighting)

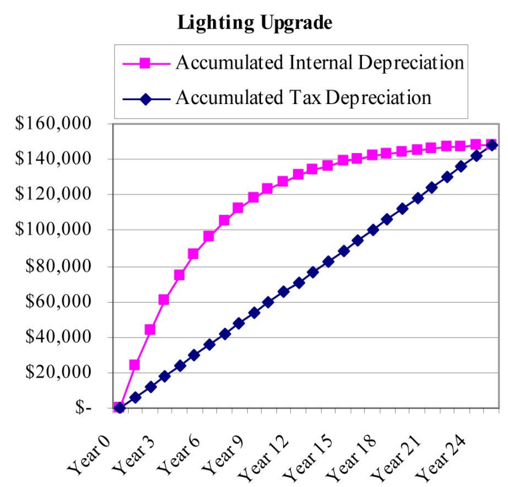


Figure 32: Depreciation schedules (lighting) on the next page compares the 25-year Canada Revenue depreciation schedule (in black) to a hypothetical internal depreciation rate. Companies often use a faster internal depreciation rate on equipment to factor in equipment replacement.

This is often the case for highly profitable companies to strategically update equipment.

Figure 33: Cash flow implications (lighting)

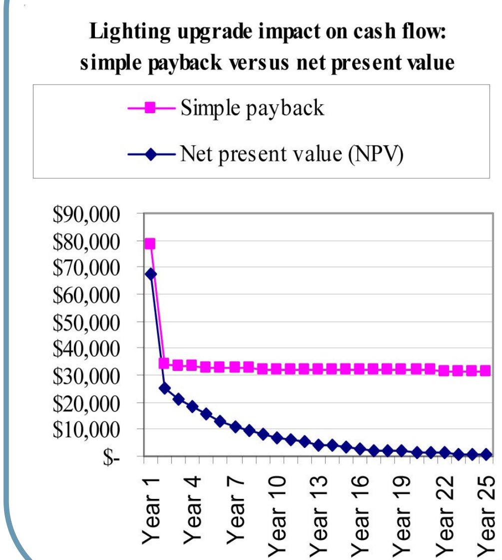


Figure 33: Cash flow implications (lighting) demonstrates the difference between simple payback and NPV. From a cash flow perspective, NPV suggests that the lighting project is negligible after 10 years whereas simple payback suggests the project has a 25-year payback The difference is the risk in a simple payback model. Note that there is a steep decline after year one, which is the impact of a grant.

IRR on this project is 10.9 percent.

Project 2: Compressor optimization and upgrade

A: Replacement of screw compressors without optimization

Existing compression equipment:

- 6 25-year old screw compressors totalling 800HP,
- Air compression costs $700,000 (50 percent of total electrical costs),
- Maintenance costs are $70,000, or 10 percent of compressed air costs, and
- Three full time employees operate and maintain the system.

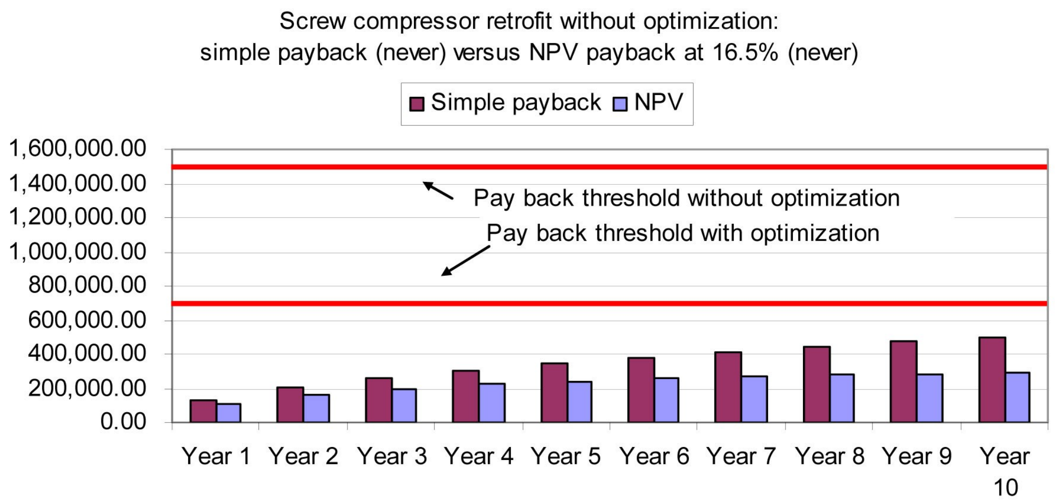
The project involves compressor replacement:

- Modern, high-efficiency screw compressor technology reduce requirement by 50HP and
- Capital replacement cost of 750HP is $1.5M.

Implications

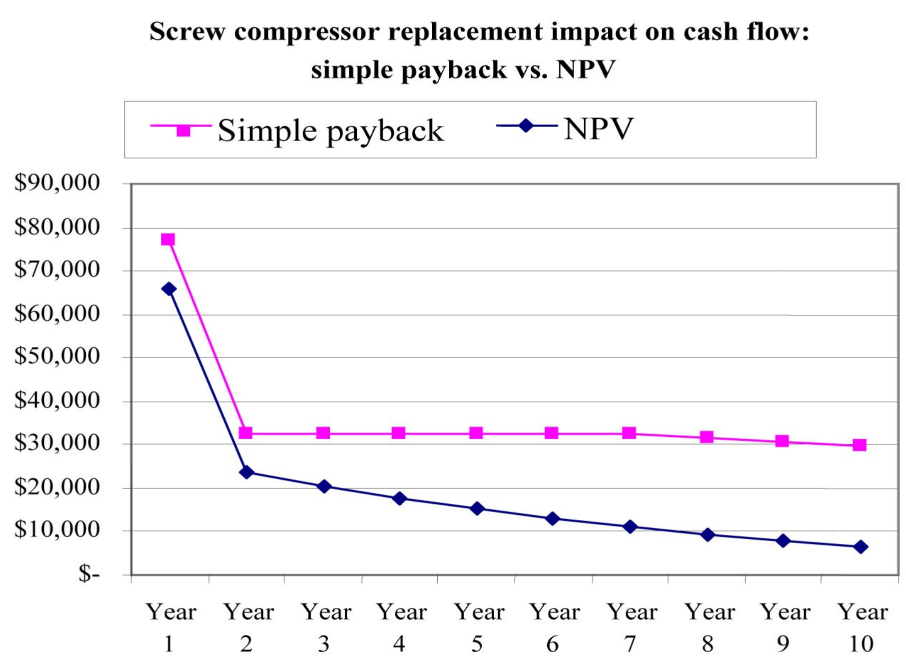
- Reduces the compressed air bill to $630,000 (10 percent reduction of $70,000),
- Maintenance costs will be reduced to $63,000 (10 percent reduction of $7,000),
- There is no impact on jobs, and
- Depreciated over 10 years with a scrap value of $20,000.

Figure 34: Screw compressor simple payback versus NPV



It should be very clear in **Figure 34** to both the controller and operations that this project cannot generate a desired payback; as it fails the simple payback method and NPV. With a10-year depreciation, the project failed. Had the optimization been applied to this project, the reduced horsepower requirement might have reduced the overall project cost by 50 percent. System optimization was still considered a failure. The project is too risky, hence few manufacturers replace compressors. **Without optimization, this project has a -30.6 IRR and with optimization the IRR is still negative. It suggests a more sustainable technology is needed**.

Figure 35: Screw compressor cash flow comparison for simple payback versus NPV



In **Figure 35** the steep decline in payback between Year 1 and Year 2 is, once again, the impact of an energy efficiency grant. The simple payback analysis demonstrates a more or less straight line and positive impact on cash flow. The NPV differs from the outset and the decline in the rate of return on the project represents a financial risk.

B. System optimization followed by combined cycle compressor installation

Existing compression equipment:

- 6 25-year old screw compressors totalling 800HP,
- Air compression costs $700,000 (50 percent of total electrical costs),
- Maintenance costs are $70,000, or 10 percent of compressed air costs, and
- Three full time employees operate and maintain the system.

The project involves:

- An **energy efficiency audit** ($25,000 cost),
- Subsequent **leak reduction, repairs and upgrades** ($50,000 cost),
- Reducing overall over all compressed air demand by 50 percent (down to 400HP), and
- Replacement system is a **combined cycle air compressor** with a capital cost of $250,000. The technology efficiency enables the plant's new 400HP demand to be met with a more efficient 200HP – a further 200HP reduction.

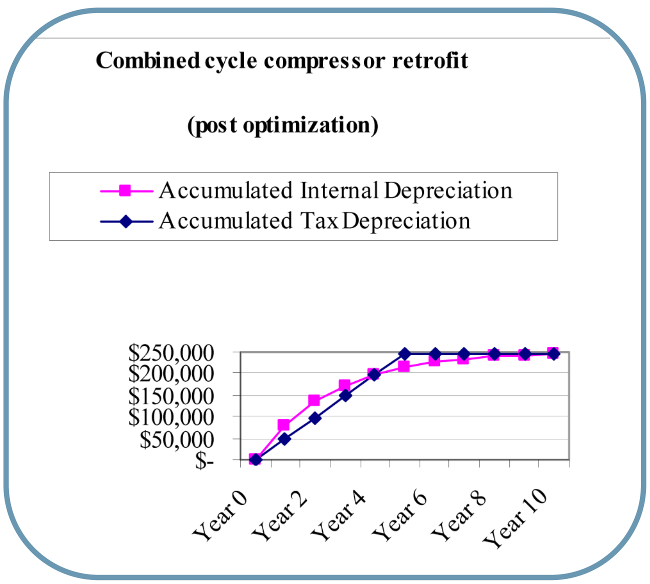
Implications

- Reduce compressed air bill is $175,000 (75 percent reduction of $525,000),
- Maintenance costs will be reduced to $63,000 (10 percent reduction of $7,000),
- Labour requirement is reduced by 2/3 to $100,000 (66 percent reduction of $200,000), and
- The replaced screw compressors have a scrap value of $50,000.

One of the most complex sets of calculations a controller will look at is the impact of depreciation on cash flow. This is often measured in two ways:

- As an "internal" depreciation rate based on a corporate replacement schedule, and
- As a tax-based depreciation rate where Revenue Canada identifies the expected functional life of the equipment.

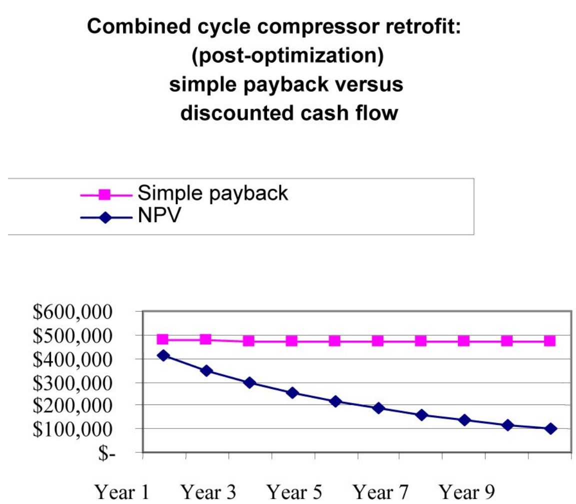
Figure 36: Comparing internal versus tax-based depreciation



It should be very clear that the two rates differ, but the replacement of this equipment might be considered after 5 years. This rate suggests that a 16.5 percent hurdle rate for air compressors is too low. Therefore, the hurdle rate for this air compressor project may need to be above 33 percent (double the corporate target) in order to pass the controller's tests. (In this case, the project well exceeds the hurdle rate.

Compare **Figure 36** (compressors) to **Figure 32** (lighting) where the internal depreciation rate on lighting suggests a functional equipment life of between 10 and 12 years. Again, this is the life-expectancy of the equipment.

Figure 37: Cash flow implications of a combined cycle compressor project



In **Figure 37** it is easy to see the impact of discounted cash flow on the NPV line. At first glance, what the simple payback straight line improvement of $500,000 per year for 10 years looks like it is eroded by NPV. A controller sees this as an excellent project as the NPV break even point is Year 2.

The last example in this appendix, **Figure 38** (page 71) is an excellent example of how NPV analysis can identify a project that is better than expected. When project payback is less than one year cash flow implications are immediate.

Look closely at how the rate of return climbs faster for the simple payback after Year 1. **Figure 38** is a textbook example of why simple payback can be so deceiving for operations. Over 10 years this NPV model suggests that the rate of return is half of what the simple payback model suggested.

The lesson in this comparison is that any project proposal that looks reasonable based on simple payback, has to be viable in three years or less in order to meet a corporate 15 to 20 percent hurdle rate. Anything less will fail a controller's risk assessment.

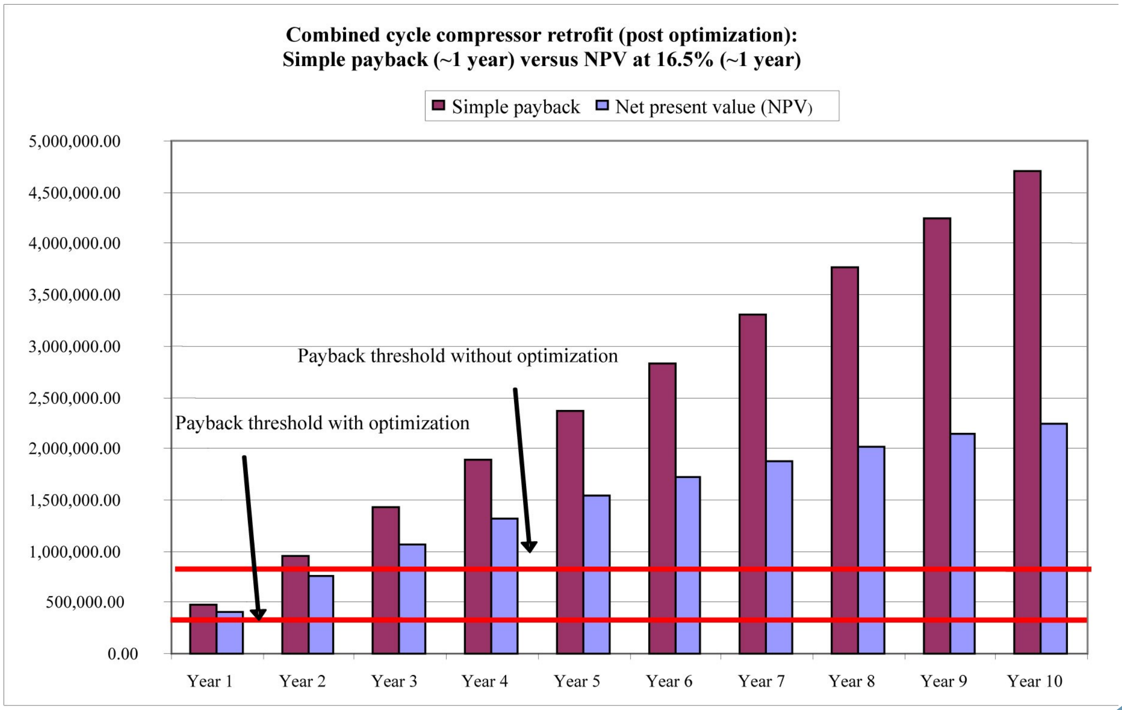
What has become evident in the food industry is that the simple payback model has been ratcheted back every decade. As controllership has been refined at the manufacturing level, it seems more and more difficult to find "the" project. As a rule of thumb[43]:

- Prior to the 1990's, three-to-five-year simple paybacks were generally acceptable,
- By the mid 1990's a three-year payback was expected,
- By 2000 food processors reported a need for a 2-year simple payback, and
- Today plant managers suggest that they need a 1-year payback to clear corporate hurdles.

The continual narrowing of payback expectations based on controller screening validates the need for accurate cost management at the operations level. **Figure 38** (below) not only demonstrates how important it is to know what to expect from a controller's scrutiny, but that this project is twice as effective after the compressed air system is optimized.

[43] Based on the author's one-on-one interviews with food processing plant and operations managers since 1987.

Figure 38: The impact of optimization on simple payback versus NPV for a compressor project



There are other factors to consider when it comes to capital investment. A project such as the combined cycle compressor example is limited in its ability to generate a pay back value for its contribution to a green marketing plan or a corporate mandate for LEEDs accreditation.

The IRR on this project is 111.6 percent.

10.47 BUSINESS CASE SUMMARY

An awkward lesson for project champions invested in a simple payback model is that a controller's analysis is financially conservative to weigh the impact of interest, depreciation, cash flow, future earnings and future value against a project cost and its variables. This analysis can seriously derail a project's likelihood of approval whenever variable costs are omitted or incorrect.

If there is any insight to gain is that the controller's calculations are based on the data that is provided by a project champion. For sustainability projects, this means data with regard to the 50 percent of variable costs that are poorly understood in manufacturing (utilities and waste) must be understood and managed before a capital investment exercise happens in order to improve the likelihood of a sustainability project's success. In other words, **R**eadying is a risk reduction action (training, **M&T** and **EMIS**).

As a rule of thumb, the relationship between simple payback and NPV is as follows:

- When simple payback is under 1 year, NPV analysis the same payback;
- When simple payback is 2 years, NPV analysis has a 3-year payback;
- When simple payback is 3 years, NPV analysis has a 5-year payback;
- When simple payback is 5 years, NPV analysis has an 8-year payback, and so on.

This relationship seems to follow the Fibonacci sequence (0, 1, 1, 2, 3, 5, 8, 13, 21 …) What ever a simple payback is, add the following number for an estimate of the NPV. While this is not exact, it will help identify a winning project.

Whenever NPV rejects a "good" project proposal based on payback, rest assured that the likeliest weakness is a lack pinpoint measurement (**R**eadying) or missed the leaks and losses (**O**ptimization) that hide in the data needed to prove the project..

Sustainable Bits: The take-away on understanding financial risk

In this case study, a Readying phase identified the opportunity and an effective Optimization phase reduced the compressor load by half. In this case, awareness of a highly efficient technology (combined cycle) made the project financially viable.

The remarkable efficiency gain would be lost in three to five years (see page 28) without staff training, M&T and EMIS. From a financial perspective, an incomplete Readying phase is the same as if finance fixed a five-year interest rate on a mortgage at 5 percent and allowed the lender to double the interest rate despite the agreement. The Readying phase is a cost/risk reduction screen at the plant level.

Lesson learned: An effective Readying phase is to operations what NPV is to finance.

Sustainability projects can go beyond a simple payback model, IRR or NPV. When a company's owners recognize the asset enhancement value of a LEED-accredited building, another set of decisions needs to be made. A high performance sustainable property can increase its asset assessment value by as much as $130/ square foot. This is an additional $26 million asset value for the brewery case study (pages 24 and 25) that could be used as collateral for expansion or to increase the book value of a corporate asset.

10.48 CAPITAL COST ALLOWANCE (CCA) A TAX INCENTIVE FOR ENERGY EFFICIENCY PROJECTS

Canadian tax law makes alternative energy sources, such as solar, wind and biofuels attractive to manufacturers.

Capital-cost allowance (CCA) is a tax deduction through depreciation for business-related capital assets. Businesses deduct a fixed percentage of depreciation each year. There are 40 CCA classes described in the regulations of Canada's Income Tax Act. The CCA rate for to each asset class is reflects the economic life of that asset class.

In some cases a CCA rate of depreciation is less than the economic useful life of an asset. In such cases it is considered to be an accelerated capital-cost allowance.

For more information, see the web pages listed below.

http://oee.nrcan.gc.ca/industrial/financial-assistance/1965
http://www.cra-arc.gc.ca/tx/bsnss/tpcs/fts-paa/nrgy-eng.html

Accelerated CCA for manufacturing and processing sectors [44]

Eligible machinery and equipment acquired by the taxpayer in 2012 or 2013 will continue to be included in Class 29 and eligible for a 50percent straight line CCA rate.

Accelerated CCA for clean energy generation

For eligible assets acquired after March 21, 2011, that have not been used or acquired for use before March 22, 2011, Class 43.2 is amended to include equipment that is used by the taxpayer, or by a lessee of the taxpayer, to generate electrical energy in a process in which all or substantially all of the energy input is from waste heat.

Income Tax Regulations – under Classes 43.1 and 43.2 – certain capital expenditures on systems that produce heat and/or electric power efficiently from fossil fuels or from alternative renewable energy sources are eligible for accelerated capital cost write-offs, at 30 and 50 percent, respectively, on a declining balance basis. Without these accelerated write-offs, many of these assets would be depreciated at annual rates of 4 percent to 20 percent.

In addition to the Class 43.1 or Class 43.2 capital cost allowance, the Income Tax Regulations allow expenses incurred during the development and start-up of renewable energy and energy conservation projects (i.e. Canadian Renewable and Conservation Expenses [CRCE]) to be fully deducted or financed through flow-through shares.

To qualify as CRCE, expenses must be incurred for a project for which it is reasonable to expect at least 50 percent of the capital costs incurred would be the capital costs of equipment described in Class 43.1 or 43.2.

CRCE includes certain intangible costs such as feasibility studies and pre-construction development expenses associated with renewable energy and energy efficiency projects for which at least 50 percent of the cost of depreciable assets relates to equipment eligible for Class 43.1 or Class 43.2 capital cost allowance (CCA) treatment.

A variety of renewable energy production assets are included in Class 43.1 and 43.2, including:

- *Co-generation and specified waste-fuelled electrical and heat generation systems;*
- *Wind turbines;*
- *Electrical generating equipment that uses only geothermal energy;*
- *Small hydroelectric facilities;*
- *Stationary fuel cells;*
- *Photovoltaic and "active" solar equipment used to heat a liquid or gas;*
- *Equipment powered by certain waste fuels (e.g. wood waste, municipal waste, biogas from a sewage treatment facility);*
- *Equipment that recovers biogas from a landfill; and*
- *Equipment used to convert biomass into bio-oil.*

10.5 SCHEMATIC AND LOGIC MODELS FOR PATTERNING M&T

Product costing models can reflect track utility use to the penny. The ability to track energy and water use through a plant drives how managers and staff use these inputs.

The next few pages shows how Jaz, from the Sidebar Stories set up Locavore Foods, our hypothetical factory with four production lines to make the case. There are six schematics of the same plant that identify possible sub-metering locations. This is not intended to be exhaustive or definitive. It's an example of how to sort through the information that needs to be gathered and verified to be able to manage utilities and waste.

Jaz's example focuses on just one product line and sets up an inventory of the data sets for each zone of the plant linked to that line. For this example, **all the numbers given for the data sets in these examples are hypothetical.** There are no standard equations to follow; you will have to use your own data. In your own plant, it takes time and effort to figure out how the flow of energy and water use affects different production lines. And this is impossible to do without trained people using M&T and EMIS.

In the end, your challenge is to build a system that tracks utility use throughout your plant that:

[44] Taken from Canada Revenue Agency Capital Cost Allowance Guide.

- Lets the zones of your plant ‘talk’ to each other about what utility they’re using and when,
- Drives active responsibility for variable cost control down to where they happen, and
- Provides data that can be converted into footprint information at the package level.

Sidebar story: How Jaz benchmarked his plant and developed costing models

One of the first things Jaz had done after participating in a Dollars and $ense workshop was to hire an environmental efficiency engineer to do a utility audit. He followed up on list of engineering companies that his OMAF/MRA contact had provided and chose Eco-Optima.

The engineer from Eco-Optima had sold him on a methodical approach to mapping and benchmarking utility use through his plant . The way he explained how to combine and optimize the Ontario Power Authority, gas utility and municipal water efficiency programs, as well as act as project manager for the M&T and EMIS installation was a winner. Not only would Eco-Optima help him write the program applications, but their offer of project management included overseeing the installation of a remote system as well as help him create KPI dashboards. The dashboard idea had sealed the deal for Jaz, as he needed a way to make utility use real to people on the plant floor.

As the project progressed, Jaz liked the way Eco-Optima focused on a methodical approach to figuring out how and where utility use happened in the plant. The plan was to measure **8 systems** in **5 zones** with wireless sub-meters. That framework began a **3-phase** action plan that the Eco-Optima engineer explained would help focus Jaz on a project sequence that could minimize the cost of the big energy integration projects wanted to do right away.

“Jaz” Chris looked at him straight in the eye, “ do you really want me to cost out the refrigeration upgrade before you cut the load?”

Jaz responded with a quizzed look.

“You have heat loads from lighting, your black roof, humidity and your compressor room all driving the refrigeration load up. We won’t know how to right-size the compressors, or if we only need to install variable speed drives until you get all those extra loads peeled away.” Chris added, minimize the waste first and you might save $20 to $30 thousand a year on energy. Then you can figure out if you need to buy two or three new compressors with variable speed drives instead of the five you have now.”

Jaz did the mental calculation. The ability to reduce the refrigeration compressor capacity could drop his electricity cost at least $30 thousand more. “Okay, but what about a wastewater digester?”

“Same thing again, Jaz.” Chris pointed to a clean-up crew., two men were hosing down the floor, pushing scraps into the drain. “Until they start to scoop and shovel the big stuff, you won’t know what you really have.” Just then another one of the sanitation crew tipped a mixing kettle over for rinsing. “You know, sewer surcharges cost ten times more than solid waste disposal. And I don’t really know what the right energy demand is for your combustion systems. Every dollar you spend on readying and optimization will save you $3 to $5 on the green energy systems you’d like to have right now.”

“And if I don’t wait?” Jaz wondered aloud.

“Then when you get around to optimizing, you’ll find your pet projects are oversized and don’t work below their minimum threshold. You’ll lose your job and Hellie will decide to sell the company.” Chris added, “I know that because I was in your shoes once, too …”

Jaz sat straighter in his chair. “So how long will it take to get to that point?”

Chris thought a moment. “First you apply to the OPA **save On Energy** program and your gas utility, for their audit and metering programs. The **R**eadying will take about four months and it takes us to the end of the year. In the new year, you start with some benchmarks to cost out **O**ptimization projects. We go back to the OPA, the gas utility and the city to get as much done as possible next year. Within 18 to 24 months you could be starting your **I**ntegration phase. By then, it’s the third calendar year and you can make another round of program applications to help pay for what you want to do.”

“And all I have to figure out then, is how to tie all of this into my product costing models? Jaz asked.

“Yup. I don’t think Hellie would want me to know that kind of thing….”

Continued …

Sidebar story: How Jaz benchmarked his plant and developed costing models (continued)

Eco-Optima proposed a system of metering that was two layers deep. The first layer was to look at various technology systems in the facility. There were **8 systems** that Chris described as follows:

1. Heating, ventilation and air conditioning were lumped together because of they were building shell functions.

2. Lighting was metered separately.

3. Compressed air had its own metering system.

4. Combustion equipment (the boilers , oven and fryers were each metered.

5. The refrigeration and freezer compressors were separately metered.

6. Motors and conveyers were metered as plug loads for production lines and significant rooms.

7. Sanitation and process water was metered by boiler feed, process use and plant sanitation. Washroom and staff water use was not metered, but could be calculated as the difference between metered and unmetered water use.

8. Energy generation functions, (electrical use in the boiler room , electrical and compressor room were also metered.

Then Chris showed Jaz how to separate different **zones** in his plant. This was to help him track energy use by production line and product. The **5 zones** he described as follows:

Zone 1: The building shell. This was the skin of the plant and a few of the areas where processing was not done. This included the offices, washrooms, the employee lunch and change rooms, and the mechanical room. Things like lighting, ventilation, heaters and air conditioning and plug loads for could all be measured, and allocated to specific product lines. Chris suggested that Jaz could develop a benchmark based on the number of hours each production line ran in a year or by the floor space each production line used. Then he could get a value to include in his product costing models.

Zone 2: The processing floor was divided into four areas. These zones aggregated motor loads, compressed air, natural gas and direct lighting.

Zone 3: Storage and shipping areas were included in this zone. Jaz would have to figure out a proportional use of the various rooms in Zone 3, which included refrigerant use, lighting and plug loads use in those areas.

Zone 4: The waste management area was something that Jaz had not considered as important until Chris showed him how much the garbage compacters, exhaust fans and dedicated tow motors cost to operate. It also gave Jaz an insight into how to manage solid wastes. Hec had started to separate metal, plastics and cardboard for recycling. The next step was t o separate out the organic wastes that could go to a composter or even a bio-digester. The tipping fees for landfill had gone up again and this would save a few hundred dollars a week. They had never audited which line was making waste, either.

Zone 5: The utility inputs areas (boiler room, electrical room, compressor room and water room were identified as a group, which Jaz eventually came to understand as costly input sources. Costs from these areas would be allocated to various production lines based on the intensity of use and volume of production. When pressed as to why these areas were considered a separate Zone, Chris explained that these were the areas that were most affected by process integration and green energy. By starting with them as a separate zone it made it easier to track optimization opportunities in Phase 2 before launching integration opportunities in Phase 3.

Throughout the readying phase, Chris helped Jaz manage what he kept referring to as the “People” part of the process. Staff were trained how to use the sub-metering system and interpret the reports that Hellie called her Key Performance Indicators for the plant floor. Within the first month Lloyd, the plant manager was catching the systems that were left running. Utility costs were coming down.

A couple of optimization projects had been included in the OPA and gas utility project proposals. A lighting retrofit with motion sensors in low traffic areas, a new capacitor installation to improve the power factor in the plant; new insulation on hot water lines, steam trap audits, a new boiler maintenance schedule and an air line retrofit all happened in very short order.

By Christmas, Lloyd was thoroughly won over. Electricity use was down 20 percent, natural gas consumption was down 15 percent and water use was down 33 percent. Staff were engaged and the $70,000 a month variable cost that he had had to accept was now in his control. Lloyd really liked that he could pinpoint who was doing the right thing.

Sidebar story: How Jaz sub-metered and benchmarked his plant (continued)

What tickled Lloyd most was that is maintenance costs were beginning to track down by about 10 percent and his OEE had gone up 2 percent. With all the projects going on, Lloyd realized that this holiday season was a lot less hectic. For once, rush orders were not followed by equipment breakdowns and the gross margin was going up.

Sustainability was falling into place, but not without intentional control. As the plant champion, Jaz developed an 8-step action plan.

Step1: Identify utility use by system and zone (see Figures 39 to 45, pages 75 through 81.)

Step 2: Benchmark actual utility use.
Jaz and Lloyd developed a master table of utility use for the plant, by volume and cost. Jaz added carbon coefficients to get a sense of what they were looking at. The result was a simple table. They then projected the next year that included efficiency gains already made.

Locavore Foods Utility Use (Actual 2010)[45]

Utility	Cost ($)	Unit Price	Volume	Coefficient	Carbon (tonnes)
Electricity	$200,000	10.4¢/kW	1,923,076 kW	110g/kW	211..5
Natural gas	$150,000	12¢/m^3	1,250,000 m^3	200g/m^3	250
Water	$150,000	$1.00/$m^3$	150,000 m^3	.75kw/m^3	12.375
Sewer	$180,000	$1.20/$m^3$	150,000 m^3	1.18kW/m^3	19.47
Sewer surcharge	$85,000	57¢/kg	149,122 kg	4kg $CO^{2}e$/kg	596.491
Total	**$765,000**				**1090 tonnes $CO^{2}e$**

Variance ($75,000) - based on efficiencies

In the new year the municipal sewer sampling results began to have an impact. Lloyd's strictly-enforced clean-up practices had eliminated one third of the surcharge. Lower charges would take effect, but solids were being re-directed to solid waste. It would save money, but not carbon.

Over coffee, Jaz and Lloyd wondered about their solid waste costs. Their diversion from the sewer meant a couple more truck-loads of waste to landfill. Was there a better solution? An anaerobic bio-digester was operating on the outskirts of the city. A representative that plant to was due in to talk to them soon.

"Twenty tonnes a week?" Lloyd poured over the summary table Jaz had before him? "At $90 a tonne? What's the good news?"

Jaz winked, the bio-digester rep had entered the cafeteria. "I hear they charge $30 a tonne for tipping and 80 percent of our solid waste is organic. We just have to figure out how to separate it."

Lloyd did the mental math. For $60,000 he 'd separate it himself. "We'd get over the 95 percent diversion rate..." Lloyd trailed .

"And loose about 4000 tonnes of carbon off of our footprint and Hellie can land the Green Star account ..." Jaz added under his breath, rising to welcome the bio-digester operator.

[45]Authors note: All of these figures are hypothetical. Locavore Foods does not exist. Unit prices are also hypothetical, for demonstration purposes only. Coefficients are recent and published estimates. They can be found on page 27, in the body of Figure 15. Sewer surcharges are based on solids and converted to solid wastes.

Sidebar story: How Jaz benchmarked his plant and developed costing models (continued)

It took some time to puzzle out the expected budget, but they got there. A lot of optimization projects were planned for the new year. Jaz was unsure of when the program approvals would come through.. The two of them agreed to use their benchmark data, which was corrected to reflect the efficiency gains in 2010.

Step 3: Project new year utility use

Locavore Foods Utility Use (Projected 2011 before efficiency projects)

Utility	Cost ($)	Unit Price	Volume	Coefficient	Carbon (tonnes)
Electricity	$168,000	10.4¢/kW	1,615,385 kW	110g/kW	178
Natural gas	$130,700	12¢/m³	1,089,063 m³	200g/m³	218
Water	$106,030	$1.00/m³	106,030 m³	.75kw/m³	8.75
Sewer	$127,200	$1.20/m³	106,030 m³	1.18kW/m³	13.75
Sewer surcharge	$60,000	57¢/kg	105,300 kg	4kg C02e/kg	421
Total	$765,000				839.5 tonnes CO²e

Step 4: Projected known efficiency gains for the new year

Electricity	$33,600	10.4¢/kW	(323,077 kW)	110g/kW	(35.54)
Natural gas	$32,675	12¢/m3	(272,292 m³)	200gm/m³	(27.23)

Step 5: Estimate Locavore Foods Solid Waste Costs (Projected 2011)

Type	Tipping Fee	Revenue	Volume	Coefficient	Carbon (tonnes)
Organic*	($30)/tonne	(24,960)	832 tonnes	4kg C02e/kg	3,328 tonnes
Metals	$42/tonne	$875	20.8 tonnes	N/A	N/A
Cardboard	$12./tonne	$624	52 tonnes	N/A	N/A
Plastic	$0	$0	52 tonnes	N/A	N/A
Scrap wood*	$0	$0	20.8 tonnes	4kg C02e/kg	83 tonnes
Landfill	($90)/tonne	($5,600)	62.4 tonnes	N/A	N/A
					3,411 tonnes CO²e

Step 6: Calculate total CO² emissions from current year, identify new projects and measure case output

Projected CO²e reduction from 2010 all sources:	**3,661 tonnes C02e (81 percent) of known coefficients.**
Tipping Fees in 2010:	$85,000
Projected Tipping Fees for 2011:	$30,560

The new year promised a number of projects:

- variable speed drives on large motors ,
- compressed air balance tanks,
- a centrifugal air compressor,
- a roof repair that would lighten the roof colour,
- a freezer de-humidification system,
- air curtains ,
- new high efficiency replacement motors and
- a new dual fuel boiler to burn off spec vegetable oil from the Edible Oil Company.

By mid-year these projects were expected to reduce monthly electricity bills by a further 40 percent before year end and cut the cost of combustion fuel in half.

*Locavore separated these in 2011, organics to bio-digester and wood (scrap pallets) offered to staff for free.

Sidebar story: How Jaz benchmarked his plant and developed costing models (continued)

With benchmarks identified and a projected budget, Jaz could work with Trish, the Product Manager to integrate data into product costing models.. They started with Line 1, a frozen line that was dedicated to Locavore's signature brand *Hellie's Homefries*.

To begin the process, they needed:

- The annual cases count for *Hellie's Homefries* (400,000),
- The number of packages per case (24), and
- The benchmark utility cost of each metering point.

They totalled costs for each metering point by utility (which they could also translate into an estimate of carbon.) Utility costs were summarized (as cost and carbon) to identify values at the case and/or package level. (See author's notes on page 82).

Step 7: Integrate Locavore's sub-metering data by line by system and zone into product costing models (annual cost in dollars)[46]

Metering Points	Lighting	Process Electricity	Compressors	Fuel	Water	Sewer	Waste	Total
Zone 1								
Building shell/HVAC	$3,360	$3,360	$0	$13,070	$2120.60	$2,544	$611.20	**$25,065.80**
(Includes: Cafeteria, Mechanics Room and Offices)								
Zone 2								
Process Line 1	$6384	$37,027.20	$37,000	$6,535	$27,398.15	$33,853.20	$42,463.36	**$190,762.91**
(Includes: Mixing and packaging areas)								
Zone 3								
Frozen (ingredients)	$786.60	N/A	(Included in Zone 2 calculations ———)					**$786.60**
Refrigerated Storage	$165.60	N/A	(Included in Zone 2 calculations ———)					**$165.60**
Dry storage	$27.60	N/A	(Included in Zone 2 calculations ———)					**$27.60**
Packaging storage	$154.56	N/A	(Included in Zone 2 calculations ———)					**$154.56**
Receiving	$296.70	N/A	(Included in Zone 2 calculations ———)					**$296.70**
Frozen (finished)	$662.40	N/A	(Included in Zone 2 calculations ———)					**$662.40**
Shipping	$296.70	N/A	(Included in Zone 2 calculations ———)					**$296.70**
Zone 4								
Waste Management	$41.40	$62.10	N/A	N/A	(Included in Zone 2 calculations ———)			**$103.50**
(Solid organics, wood waste. Plastics and sewer surcharge are included in Zone 2, based on audits where waste was created.)								
Zone 5								
Water	$1.38	$1,600,80	N/A	N/A	N/A	N/A	N/A	**$1602.18**
Boiler room	$2.76	$1,600.80	N/A	$27,316.30	$10,603	$12,732.60	N/A	**$52,246.46**
Electrical service	$1.38	$1,600.80	N/A	N/A	N/A	N/A	N/A	**$1,602.18**
Compressor room	$1.38	$1.600.80	N/A	N/A	N/A	N/A	N/A	**$1,602.18**

Locavore's Utilities and Waste related to Process Line 1

	Lighting	Process Electricity	Compression	Fuel	Water	Sewer	Waste	Total
Cost:	$12,157.46	$45,252	$37,000	$46,921.30	$40,178.75	$49,129.8	$43,074.56	$246,713.87
Carbon[e]:	12,859 kg	47,863 kg	39,135 kg	195,505 kg	3320 kg	5314 kg	835600 kg	1,169,596

Step 8: Calculate cost and carbon by case and package

Line 1:	**Utility and waste cost per case** (based on 400,000 cases)	$0.6167847	**Carbon per case**	2.92399 kg
	Utility and waste cost per package (based on 24 per case)	$0.025700	**Carbon per package**	122 grams

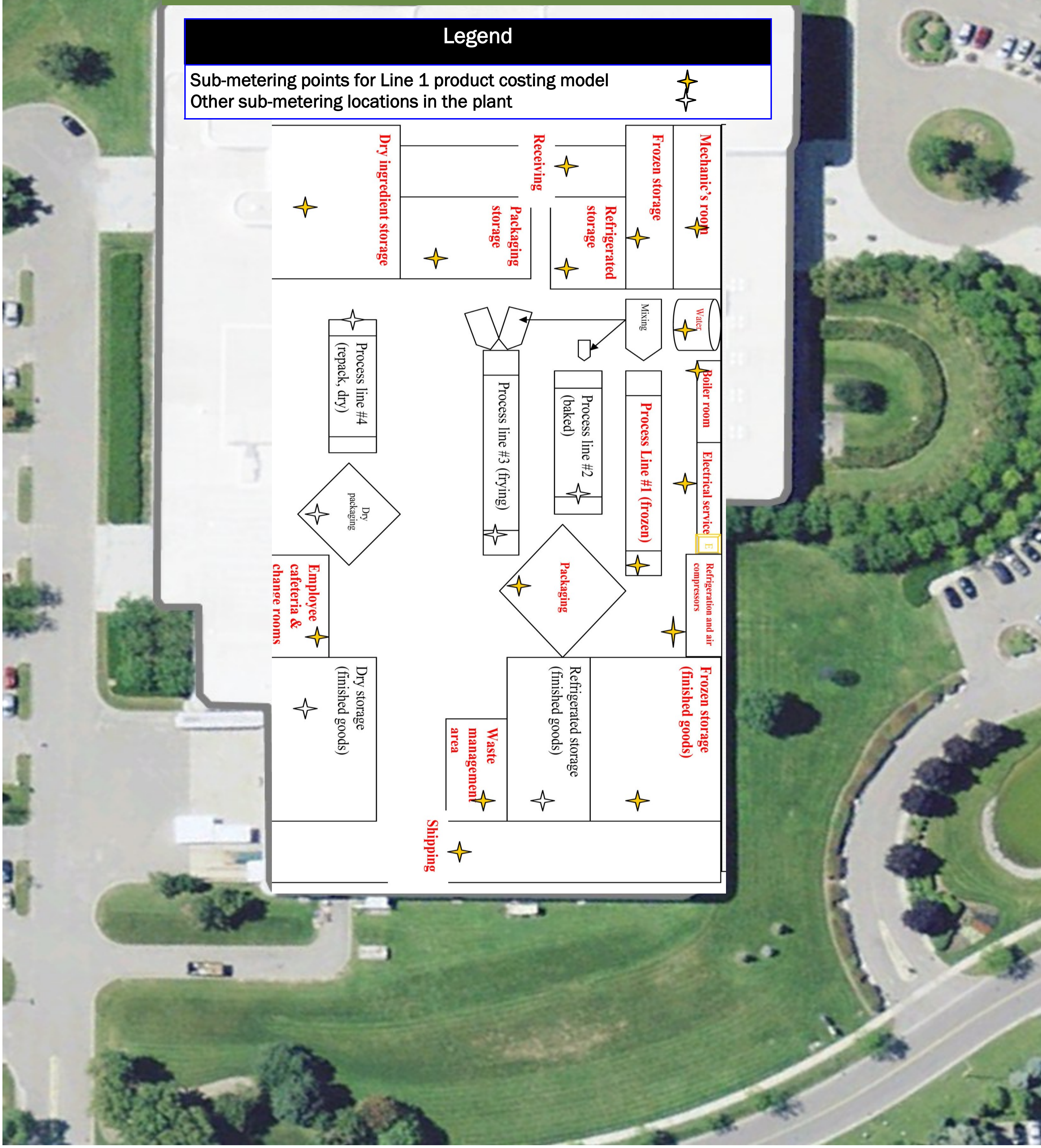
The benchmark data that flowed through the costing models was an eye-opener for Jaz. He had told Hellie that the initial footprint was down 30 percent. He was wrong. The unverified calculations suggested they had reduced carbon by over 75 percent in the very early stages of their sustainability drive. While the change in solid waste management had the largest impact on carbon, they had only begun to reduce costs. It made him think about how to design the rumoured new plant as a carbon-negative facility.

[46] These figures do not address ingredient, packaging or logistics lifecycle costs and/or carbon. Nor do they include water softening, sanitation chemical or boiler chemical conditioning costs.

These figures are entirely hypothetical actual facility waste and utility benchmarks do vary widely and are based on a combination of equipment configurations, frequency or duration of use, time of use and scale. Utility costs and carbon coefficients are not actual and not intended for use, as utility costs vary by location and carbon coefficients vary by year. Actual carbon validation requires an accredited third party.

These figures and calculations are intended for illustrative purposes only and not for use as a template. The challenge in every plant is to develop a sub-metering system that works for that location that is integrated with an intelligent information system that can be designed to automatically fill costing model data information once benchmarks have been established. **Benchmarks will require constant review as efficiencies are gained.**

Figure 39: Locavore's sub-metering locations



Locavore's calculations for Line 1 lighting electricity.

Zone #1 Shell-related lighting formula: (.43R + .26S)

- 43 percent of all products that pass through receiving (R) go to Line 1.
- 26 percent of all finished goods from Line 1 pass through shipping (S).
- 18 percent of labour is related to Line 1, so 18 percent of employee cafeteria and change rooms (ECCR) will go to Line 1 costs.

Zone #2 Process and packaging lighting formula: (FL + .38PR1 +.42ECCR + .12MR)

- 100 percent of frozen line (FL)
- 38 percent of packaging room #1 capacity (PR1)
- 42 percent of plant labour is lined to the frozen line, so 42 percent of the employee cafeteria and change rooms (ECCR) is assigned to process and packaging
- 12 percent of the mechanic's time is used on the frozen line, so 12 percent of the mechanic's room (MR) is assigned to the process and packaging

Zone # 3 Refrigeration and storage formula: (.95FS + .30RS + .28PS + .05DS + .80FGST)

- 95 percent of all inputs from frozen storage (FS) go to Line 1.
- 30 percent of all inputs from refrigerated storage (RS) go to Line 1.
- 28 percent of all packaging from packaging storage (PS) go to Line 1.
- Five percent of all inputs from dry storage (DS) go to Line 1.
- 80 percent of all frozen goods finished storage (FGST) is used by Line 1.

Zone #4 Wastewater and solid waste formula: (.15WMA)

- 15 percent of waste management area (WMA)

Zone #5 Energy and water supply formula: (.05WR + .08ER + .72CR)

- Five percent of water is used for sanitation on the frozen line, so five percent of the water room (WR) lighting is assigned to the frozen line.
- Eight percent of electricity use happens on the frozen line, so eight percent of the electrical room (ER)
- 85 percent of refrigeration. This is 72 percent of the capacity that comes from the compressor room (CR).

Figure 40: Locavore's lighting electricity allocation chart for Line 1[47]

Area in the Plant	Symbol	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Receiving	(R)	43%				
Shipping	(S)	26%				
Frozen line	(FL)		100%			
Packaging room #1	(PC1)		38%			
Employee cafeteria and change rooms	(ECCR)	18%	42%			
Mechanic's room	(MC)		12%			
Frozen storage	(FS)			95%		
Refrigerated storage	(RS)			30%		
Packaging Storage	(PS)			28%		
Dry storage	(DS)			5%		
Finished goods storage	(FGST)			80%		
Waste management area	(WMA)				15%	
Water room	(WR)					5%
Electrical room	(ER)					8%
Compressor room	(CR)					72%

[47] These calculations are all hypothetical and for demonstration purposes only. Your own calculations will have to be determined based on actual data.

Locavore's calculations for Line 1 process electricity.

Zone #1 Building shell-related process electricity formula: (.18AC +.28AE + .18ECCR)
- 18 percent of air conditioning (AC) is used in the processing line 1 zone
- 28 percent of all make up air comes from air exchange (AE)
- 18 percent of labour is related to line 1, so 18 percent of employee cafeteria and change rooms (ECCR) will go to line 1 cost

Zone #2 Process and packaging electricity formula: (.60M + .20FL + .38PR1 +.42ECCR + .12MR)
- 60 percent of mixing (M) for frozen line is assigned for non-lighting electricity
- 20 percent of frozen line (FL) non-lighting electricity is assigned
- 38 percent of packaging room #1 capacity (PR1) is for non-lighting electricity
- 42 percent of plant labour is lined to the frozen line, so 42 percent of the non-lighting electricity employee cafeteria and change rooms (ECCR) is assigned to process and packaging
- 12 percent of electrical use from mechanic's room (MR) non-lighting electricity is assigned to the process and packaging

Zone # 3 Refrigeration and storage (no formula in this example)
- There were no non-lighting electrical uses in storage areas.

Zone #4 Wastewater and solid waste formula: (.15WMA)
- 15 percent of waste management area (WMA) capacity is used by line 1

Zone #5 Energy and water supply formula: (.05WR +.08(ER + .72CR)
- Five percent of the water room (WR) non-lighting electricity is assigned to the frozen line.
- eight percent of the electrical room (ER) non-lighting electricity is used by line 1
- 85 percent of refrigeration supports the frozen line. This is 72 percent of the capacity that comes from the compressor room (CR).

Figure 41: Locavore's process electricity allocation chart for Line 1

Area in the Plant	Symbol	Zone 1	Zone 2	Zone 4	Zone 5
Frozen line	(FL)		60%		
Mixing Area	(MA)		20%		
Packaging room #1	(PC1)		38%		
Employee cafeteria and change rooms	(ECCR)	18%	42%		
Mechanic's room	(MC)		12%		
Waste management area	(WMA)			15%	
Water room	(WR)				5%
Electrical room	(ER)				8%
Air exchange	(AE)	28%			
Air conditioning	(AC)	18%			
Compressor room	(CR)				72%

Locavore's calculations for Line 1 Natural Gas use

Zone #1 Building shell-related process electricity formula: *(.18HRC)*

- 18 percent gas consumption of the heating and compressor room (HCR) is allocated to heating the frozen line work area.

Zone #2 Process and packaging electricity (N/A)

- There is no gas directly used on the frozen line

Zone # 3 Refrigeration and storage (N/A)

- There is no gas directly used in storage areas.

Zone #4 Wastewater and solid waste (N/A)

- There is no gas directly used in the wastewater and solid waste areas.

Zone #5 Energy and water supply formula: *(0.5BR)*

- Five percent of the boiler room (BR) hot water is budgeted for sanitation on line 1.

Figure 42: Locavore's natural gas allocation chart for Line 1

Area in the Plant	Symbol	Zone 1	Zone 5
Boiler Room	(BR)		5%
Heating and compressor room	(CR)	18%	

Locavore's calculations for Line 1 compressor use of utilities

Assumptions for line 1:
1. Electricity use for compressed air and refrigeration is calculated separately. These are high-use systems that require separate sub-metering.
2. A master flow meter is used to measure the volume of compressed air servicing the entire plant.
3. Frozen line 1 has an embedded spiral freezer.
4. The packaging area is refrigerated to accommodate line 1 product and line 3 products. Line 1 product uses 41 percent of the capacity of the packaging area.
5. For this example it was determined that 82 percent of all refrigeration compressor capacity was related to storages.

Refrigeration Capacity (RA)
Zone #2 Process and packaging share of refrigeration formula*: (.08RC + (RC x .03 x. 41)*)
- Line 1 uses eight percent of the refrigeration capacity (RC)
- Line 1 packaging accounts for 31 percent of the refrigeration capacity used in the packaging area (PA)

which is three percent of total refrigeration capacity (RC)

Zone # 3 Refrigeration and storage formula: (.95FS x .12RC x .12) + (.3RS x .08RC) + (.8FSFG x .42RC)
- Line 1 uses 95 percent of the frozen storage (FS) throughput which uses 12 percent of refrigeration capacity (RC)
- Line 1 uses 30 percent of the refrigerated storage (RS) throughput which uses eight percent of refrigeration capacity (RC)
- Line 1 uses 80 percent of the frozen storage finished goods (FSFG) throughput which uses 32 percent of refrigeration capacity (RC).

Air Compressor Capacity (CA)
Zone #2 Process and packaging share of refrigeration formula: *(.04CA + .04CA + .26CA)*
- Line 1 mixing uses four percent of the compressed air (CA)
- Line 1 processing uses four percent of compressed air (CA)
- Line 1 packaging accounts for 24 percent of the compressed air capacity

Zone #4 Waste management area formula: *(.18WMA x .013CA)*
Line 1 generates 18 percent of the waste management area (WMA) volume and WMA uses 1.3 percent of the total compressed air.

Figure 43: Locavore's refrigeration and compressed air allocation chart for Line 1

Area in the Plant	Symbol	Zone 2		Zone 3	Zone 4
Frozen line	(FL)	8% (RC)	4% (CA)		
Mixing Area	(MA)		4%(CA)		
Packaging room #1	(PC1)	31% (RC)	24% (CA)		
Frozen storage	(FS)			12% (RC)	
Refrigerated storage	(RS)			8% (RC)	
Finished goods storage	(FGST)			32% (RC)	
Waste management area	(WMA)				1.3% (CA)

Locavore's calculations for Line 1 sewer use

Assumptions for this example:

1. All sanitary waste (human) is linked to a separate metered system for incoming water.
2. Sewer use related to line 1 is tied to estimates of water use for sanitation of the mixing area, processing line and waste management area based on water meters. Actual sewer flow from the boiler room and compressor room is metered.

Zone #1 Shell-related sewer use N/A

Zone #2 Process and packaging electricity formula: MA = (.005SF + .005Water) + PA (.0085SF)

- The mixing area (MA) uses 0.5 percent of water for sanitation and is assessed at 0.5 percent of sewer flow (SF)
- The processing area (PA) line 1 uses 0.85 percent of water for sanitation and is assessed 0.85 percent of sewer flow.

Zone #3 Refrigeration and storage

Zone #4 Wastewater and solid waste formula: WMA = (.0013SF)

- The waste management area (WMA) uses 0.13 percent of water for sanitation and is assessed as 0.13 percent of sewer flow.

Zone #5 Energy and water supply formula: (.13BR x .02) + (.001BR x .001x .57)

- The boiler room (BR) sewer meter is responsible for 13 percent of sewer flow and line 1 was found to use two percent of boiler room output
- The compressor room sewer meter is responsible for 0.01 percent of sewer flow and 57 percent of the compressor room capacity is linked to line 1 production.

Figure 44: Locavore's sewer use allocation chart for Line 1

Area in the Plant	Symbol	Zone 2	Zone 4	Zone 5
Frozen line	(FL)	0..85%		
Mixing area	(MA)	0.5%		
Waste management area	(WMA)		0.13%	
Boiler room	(BR)			.0026%
Compressor room	(CR)			0.0075%

Locavore's calculations for Line 1 water use

Water use assumptions:

1. Water is metered coming into the processing plant.
2. Sub-meters are used in identified production (mixing, processing lines, etc.)
3. Energy and water supply area water use is accounted for in downstream meters.

Zone #1 Shell-related line 1 water N/A

Zone #2 Process and packaging electricity formula: (.005Water) + (.0085Water) + (.00003Water)

- Line 1 mixing area (MA) only uses water for sanitation (0.5 percent of total)
- Line 1 processing line only uses water for sanitation (0.85 percent of total)
- Employee cafeteria and change rooms use 0.003 percent of the total water use.

Zone # 3 Refrigeration and storage N/A

Zone #4 Wastewater and solid waste formula: (.0013Total Water Use)

- Waste management area (WMA is metered at .13 percent of water use.)

Zone #5 Energy and water supply (NA)

Figure 45: Locavore's water allocation chart for Line 1

Area in the Plant	Symbol	Zone 2	Zone 4
Mixing Area	(MA)	0.5%	
Frozen line	(FL)	0.85%	
Employee cafeteria and change rooms	(ECCR)	0.003%	
Waste management area	(WMA)		0.13%

Author's Notes:

Figures 39 through 45 illustrate the sub-metering points and the way costs and carbon were calculated. To calculate the utility costs on the Frozen Line (Line 1), the product costing model calculations for this hypothetical example is based upon hypothetical totals from the percentage of use for each area. The examples use these assumptions:

- Case volumes are hypothetical and used for illustrative purposes only.
- Real time energy use and cost capacity would exist in the intelligent metering system.,
- Calculations are based on six decimal points (0.000000) which equal one dollar per million dollars,
- Electricity costs are allocated for the time each zone creates cost, divided by the volume of the line as a proportion of the total plant production,
- Water (including hot water) is used for sanitation only,
- There is no compressed air use on the line, and
- Office, mechanics room and cafeteria utility costs are included in building shell (Zone 1) costs as a single line item to determine gross margin.

The formulas that correspond to Figures 39 through 45 are meant to provide insight into things like the cost of utilities down to a single package. This is true overhead cost management. Marketers see products differently. Cost only matters if cost is a negative attribute. The positive attribute marketing people understand is the carbon footprint information which is why this product attribute is calculated.

It is important to note what is excluded in this calculation such as lighting from areas in the plant (other production lines and warehousing) not related to the specified line.

The ability to separate invisible non-manufacturing costs from the cost of production is a critical step in getting the responsibility for using utilities driven down to where they are used. The point of these figures is to help you sort out the kinds of information is that you will have to calculate in order to get reliable data. Experience has shown that rigorous standards for cost data at six decimal points (0.000000)[48] ensures that behavioural wastes and system failures get caught and are kept out.

[48] Financial accounting systems generally operate at no more than 4 decimal points (0.0000). This level of scrutiny is equal to $100 per $1 million. Utilities, like water can drive nine times their cost in invisible related costs, so a $100 discrepancy in water costs may hide another $900 of invisible costs. A pricing drill related to a product costing model that is set at six decimals (0.000000) sets the bar to ensure the transparency of utility use.

10.6 SUGGESTED MANAGEMENT AND TECHNICAL BEST PRACTICES BY PHASE

The Technical Best Practices lists below are ***the*** *"to do" lists. These lists contain more than 150 projects; each of them are payback-driven cost control projects. Completed in sequence with intelligent technology, sustainability becomes a measurable with cost control action plan that can deliver a positive gross margin and customer response.*

Figures 50 through **52** were adapted from a Canadian Manufacturers & Exporters report produced in 2010, plus a compilation of projects linked to work done with the City of Toronto Wastewater Services, The City of Hamilton, the City of London, the City of Guelph and the Town of Leamington.

These examples are organized by phase so that you can avoid costly mistakes.

Readying phase **(People)**

This primer suggests that you start with training people, M&T and EMIS. This first step puts trained people in place with a toolkit that finds invisible costs, production line by production line and across every system in your plant.

To build competence with managing utility costs, start with leaks and building shell system improvements. These costs eat **Gross Margin** and obscure actual use.

Optimization phase **(Process)**

Next, processing system upgrades and process energy optimization will minimize the load on the systems like boilers, compressors (air and refrigeration) and electrical service.

Integration phase **(Technology)**

Finally, use reduced and quantified waste streams to create energy to significantly reduce your footprint. This is the process integration phase, where waste streams are captured for re-use. Each dollar you spend in the first two phases saves three to five dollars in this phase.

This roadmap is a simplified set of directions. Your own path may be different, but the landmarks are the same. It is possible to reduce energy and water use by 50 to 70 percent over three to five years with efficiency measures.

Some food processors in Ontario have no sewer bill. Others have tapped into their waste streams to eliminate the carbon footprint related to processing. An over-dependence on water and sewer services; unmanaged electricity and natural gas use; and an ingrained habit of creating solid waste is learned behaviour. The "leftovers" from industrial systems are pollutants that consumers detest and regulators use to rightfully justify punishing costs for compliance.

It takes a major change in the way we think to drive out of the invisible cost of production. There are habits that North Americans manufacturers learn because public utility and waste management infrastructure exists. In order to change this paradigm we need to think through the problem.

To paraphrase Albert Einstein,

"Nobody ever solved a problem the same way they created it."

Figure 46: **R**eadying phase management and technical best practice list checklist

Management Best Practices
- ⌂ Sub-metering (**M&T with EMIS**)
- ⌂ Internal and sector benchmarking
- ⌂ Product costing models linked to sub-metering data
- ⌂ Energy management training (NRCan)
- ⌂ Certified Energy Manager training (NRCan)
- ⌂ Energy, water and solid waste audit
- ⌂ GFTC sustainability assessment (process, packaging, supply chain, solid waste and environmental compliance)
- ⌂ Leading Environment Efficiency Design assessment / LEED (for existing buildings)
- ⌂ Learning cell participation (NRCan/CIPEC, EMC, Partners in Project Green)
- ⌂ Sewer Use Rebate

Behaviour Best Practices
- ⌂ Staff awareness program (NRCan)
- ⌂ Monthly sweeps for air, steam and water leaks
- ⌂ Pre-wash/rinse equipment scrape-down

Technical Best Practices – Energy Systems

HVAC
- ⌂ Ventilation Optimization
- ⌂ Air Compressor Heat Recovery
- ⌂ Automated Temperature Control
- ⌂ Reduced Temperature Settings
- ⌂ Destratification Fans
- ⌂ Warehouse Loading Dock Seals
- ⌂ Air Curtains
- ⌂ Ceramic-painted Walls and Roofs

Lighting
- ⌂ High Efficiency Lights and Ballasts
- ⌂ High Efficiency Lighting Design
- ⌂ Automated Lighting Controls
- ⌂ Lighting Harmonization

Compressed Air Systems
- ⌂ Air leak survey and repair
- ⌂ Sequencing compressors

Combustion Systems
- ⌂ Economizer
- ⌂ Boiler Right Sizing and Load Management
- ⌂ Blowdown Heat Recovery
- ⌂ Condensate Return
- ⌂ Advanced Boiler Controls
- ⌂ Blowdown Control
- ⌂ Insulation
- ⌂ Boiler Maintenance
- ⌂ Boiler Water Treatment
- ⌂ Minimize De-aerator Vent Losses

Steam systems (imported steam)
- ⌂ Steam Trap Survey and Repair

Steam boilers
- ⌂ Steam Trap Survey and Repair
- ⌂ Blowdown Heat Recovery
- ⌂ Process Heat Recovery to Preheat Makeup Water
- ⌂ Blowdown Control
- ⌂ Insulation
- ⌂ Boiler Water Treatment

Hot water heaters and boilers
- ⌂ Water heater Maintenance
- ⌂ Insulation

Furnaces/ kilns/ovens/ dryers
- ⌂ Insulation
- ⌂ Air Curtains
- ⌂ Free cooling
- ⌂ Doors, Covers and Curtains

Cooling & Refrigeration
- ⌂ Improve insulation of refrigeration system
- ⌂ Impeller Trimming

Pumps
- ⌂ Impeller Trimming

Fans/Blowers
- ⌂ Minimize damper losses on fans

Other Motors
- ⌂ Premium Efficiency ASD Compressor
- ⌂ Use cooler air from outside for make up air

Technical Best Practices - Wastewater
- ⌂ pH management
- ⌂ Regular Grease Interceptor maintenance
- ⌂ Phosphorus and Nitrogen correction
- ⌂ Screened grates

Technical Best Practices – Process Water
- ⌂ Steam/condensate recovery
- ⌂ Nozzle maintenance
- ⌂ On-site water storage with 24-hour draw
- ⌂ Air compressor water recovery
- ⌂ Refrigeration compressor room water recovery

Technical Best Practices - Sanitation
- ⌂ High pressure nozzles
- ⌂ Leak management
- ⌂ Low Phosphorus and Nitrogen chemical cleaners
- ⌂ Pre-wash/rinse physical scrape-down

Technical Best Practices – Solid Waste
- ⌂ Waste audits
- ⌂ Waste recycling
- ⌂ Waste diversion
- ⌂ Scrape and squeegee before wash down

Sources: CME, 2010 and various Ontario municipalities

Figure 47: Optimization phase technical best practice energy and water checklist

Technical Best Practices – Energy

HVAC
- ☐ High efficiency packaged HVAC
- ☐ Ventilation Optimization
- ☐ Automated Temperature Control
- ☐ Reduced Temperature Settings
- ☐ Destratification Fans
- ☐ Warehouse Loading Dock Seals
- ☐ Air Curtains
- ☐ Ceramic-painted Walls and Roofs

Lighting
- ☐ Automated Lighting Controls

Compressed Air Systems
- ☐ Improved energy efficient design
- ☐ Improved energy efficient electrode material
- ☐ Upgrade from reciprocating to screw compression
- ☐ Upgrade to centrifugal compressors

Combustion Systems
- ☐ Integrated Control System
- ☐ High Efficiency Burner
- ☐ Economizer
- ☐ Boiler Right Sizing and Load Management
- ☐ Boiler combustion air preheat
- ☐ Advanced Boiler Controls
- ☐ Boiler Maintenance
- ☐ Boiler Water Treatment

Steam boilers and steam systems
- ☐ Direct Contact Hot Water Heaters
- ☐ High Efficiency Burner
- ☐ Water heater Right Sizing and Load Management
- ☐ Blowdown Heat Recovery
- ☐ Boiler combustion air preheat
- ☐ Process Heat Recovery to Preheat Makeup Water
- ☐ Advanced water heater controls
- ☐ Blowdown Control
- ☐ Boiler Water Treatment

Furnaces/ kilns/ovens/ dryers
- ☐ High efficiency burner controls
- ☐ Advanced heating and Process Control

Cooling & Refrigeration
- ☐ Premium efficiency pump
- ☐ Optimization of pumping system
- ☐ High efficiency multiplex compressors
- ☐ High Efficiency Chiller
- ☐ Optimized Distribution System
- ☐ Floating head pressure controls
- ☐ Premium efficiency refrigeration control system
- ☐ Smart Defrost Controls

Pumps
- ☐ Premium Efficiency Control with ASDs
- ☐ Premium efficiency fans and blowers
- ☐ Optimized duct design to improve efficiency
- ☐ Premium efficiency control, with ASD
- ☐ Synchronous Belts

Fans/Blowers
- ☐ Premium Efficiency Motors
- ☐ Correctly sized motors
- ☐ Optimized motor control

Other Motors
- ☐ Synchronous Belts
- ☐ Premium Efficiency ASD Compressor
- ☐ Replace pneumatic motors with mechanical
- ☐ Low pressure blower to replace compressed air
- ☐ Optimized sizing and pressure of compressor system
- ☐ Optimized distribution system (incl. pressure)
- ☐ Optimized sizes of air receiver tanks
- ☐ Adjustable Speed/Variable frequency drive
- ☐ Sequencing Control

Process Specific
- ☐ Optimized process controls

Technical Best Practices - Wastewater
- ☐ Caustic soda recovery
- ☐ pH management

Technical Best Practices – Water Supply
- ☐ 24-hour water ingress to on-site storage
- ☐ Engineered storage for 60percent of daily process needs

Technical Best Practices – Process Water
- ☐ Water Cooling Towers
- ☐ Final Rinse Water Re-use
- ☐ High-efficiency water softening
- ☐ Nozzle maintenance
- ☐ On-site water storage with 24-hour draw

Technical Best Practices - Sanitation
- ☐ Ozone sanitation systems for tanks, trucks and drums

Technical Best Practices – Solid Waste
- ☐ Compaction equipment

Sources: CME, 2010 and various Ontario municipalities

Figure 48: Integration phase technical best practice energy, water and solid waste checklist

Technical Best Practices – Energy

HVAC
- ⌂ High efficiency packaged HVAC
- ⌂ Solar Walls
- ⌂ Radiant Heaters
- ⌂ Ground Source Heat Pump
- ⌂ Ventilation Heat Recovery
- ⌂ Air Compressor Heat Recovery

Combustion Systems
- ⌂ Instantaneous Steam Generation
- ⌂ Boiler combustion air preheat
- ⌂ Process Heat Recovery to Preheat Makeup Water
- ⌂ Co-generation
- ⌂ Bio-digestion or biomass energy generation

Steam boilers and steam systems
- ⌂ Direct Contact Hot Water Heaters
- ⌂ Boiler combustion air preheat
- ⌂ Process Heat Recovery to Preheat Makeup Water

Hot water heaters and boilers
- ⌂ Solar Thermal Heating

Steam systems (imported steam)
- ⌂ High Efficiency Oven
- ⌂ High Efficiency Dryer
- ⌂ High efficiency Kilns
- ⌂ High efficiency Furnaces
- ⌂ Induction Heating

Furnaces/ kilns/ovens/ dryers
- ⌂ Exhaust Gas Heat Recovery
- ⌂ Process heat recovery to preheat product
- ⌂ High efficiency multiplex compressors
- ⌂ High Efficiency Chiller

Technical Best Practices - Wastewater
- ⌂ Anaerobic Wastewater Digestion
- ⌂ Ultra-filtration for re-use
- ⌂ Non-contact water re-use
- ⌂ Product water recovery
- ⌂ Sewer heat recovery
- ⌂ Net Zero discharge

Technical Best Practices – Water Supply
- ⌂ Water vapour recovery
- ⌂ Closed-loop water re-use
- ⌂ 24-hour water ingress to on-site storage
- ⌂ Engineered storage for 60percent of daily process needs

Technical Best Practices – Process Water
- ⌂ Solar hot water pre-heat
- ⌂ Steam/condensate recovery
- ⌂ On-site water storage with 24-hour draw
- ⌂ Ultra filtration technologies
- ⌂ Air chilling
- ⌂ Air compressor water recovery
- ⌂ Refrigeration compressor room water recovery
- ⌂ Non-contact process water heat exchangers

Technical Best Practices - Sanitation
- ⌂ Ozone sanitation systems for tanks, trucks and drums

Technical Best Practices – Solid Waste
- ⌂ On-site waste-to-energy conversion

Sources: CME, 2010 and various Ontario municipalities

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Perspective is subjective. It depends upon the viewer. Someone that is directly involved in food processing sees a factory as a series of systems that make food. It is harder to see a factory as a series of systems that doesn't lose inputs. This shift in perspective depends on an M&T + EMIS system to turn what is a negative focus into a manageable gain.

The sequence process and technology improvements

You can reduce the cost of utility inputs, your carbon footprint and avoid missteps when you:

☐ **Install M&T + EMIS + staff training** linking utility use to product costing models and product footprints.

☐ **Fix low-efficiency systems** related to the shell because they affect everything and add to peak electrical demand.

☐ **Eliminate leaks** in the processing systems to reduce peak electrical energy.

☐ **Target losses** from refrigeration and freezers because this is largely peak electrical energy.

☐ **Reuse waste heat** to reduce natural gas use which has large carbon footprint.

☐ **Upgrade combustion systems** and capture free fuel (instead of paying a high sewer surcharge) from a wastewater anaerobic digester to reduce natural gas use.

The U.S. Department of Commerce definition of Sustainable Manufacturing:

"For the purposes of Commerce's Sustainable Manufacturing Initiative, sustainable manufacturing is defined as the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound." Source: http://www.trade.gov/competitiveness/sustainablemanufacturing/how_doc_defines_SM.asp

For more information:
www.ontario.ca/omafra

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