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EFFICIENT RESTAURANT DESIGN: A RESOURCE GUIDE TO ACHIEVING A 35% REDUCTION IN ENERGY CONSUMPTION

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OVERVIEW

The City of Vancouver's new Zero Emissions Building Plan establishes performance targets for new residential and office buildings as conditions for rezoning. All other building types have a target per cent energy improvement over the code minimum. Currently, the design of a new restaurant within the City of Vancouver must meet the *ASHRAE 90.1 – 2010* protocol; this most recent edition of the ASHRAE energy standard now includes specific requirements for the kitchen ventilation system that were not included in the 2007 edition.

The **goal of this guide** is to provide Vancouver restaurant designers and developers with **a reference set of energy efficiency measures (EEMs) and related case-study models** to assist in modelling **designs that achieve a 35 per cent energy improvement** over current code. Where possible, this guide will identify the estimated energy, GHG and cost savings as compared to a 2007 baseline.

Comprehensive energy-efficient design (e.g. exceeding LEED Gold) of a restaurant is a very capital-intense proposition when compared to, for example, the LEED Gold design of an office or residential building. Typically, more than **60 per cent of the energy use/cost is associated with the foodservice process** itself, which involves a wide range of installed equipment for cooking, hot food holding, reach-in refrigeration, walk-in refrigeration, ice making, exhaust ventilation and sanitation (warewashing and cleanup). As well, beyond the premium purchase cost of most ENERGY STAR-rated equipment in these categories, the market does not currently offer any properly documented energy-efficient options for many of the most common equipment types, such as under-counter refrigeration units, under-fired gas broilers, salamanders and range-top burners.

Fig.1 - Energy use, GHG output and energy cost for typical full-service family/casual restaurant built to ASHRAE 90.1 - 2007

energy type	avg. energy use/yr	cost*	GHG**
electric (BCHydro)	425,000 kWh	$38,250	4,675 kgCO2

energy type	avg. energy use/yr	cost*	GHG**
natural gas (FortisBC)	2000 GJ	$14,000	102,860 kgCO2

*CoV baseline rate for hydro: $0.063/kWh (using NRC std. $0.09/kWh)
*CoV baseline rate for gas: $0.031/kWh (using NRC std. $7/GJ)
Conversion rate applied: 1GJ = 278 kWh

**CoV emissions factor - hydro 0.011 kgCO2/kWh
**CoV emissions factor - gas 0.185 kgCO2/kWh

Furthermore, for most operations, the standard foodservice business model provides slender (or razor-thin) profit margins for the first few years of operations. While a conservative design that returns energy savings in the 10 to 15 per cent range can often be economically justified, the budget required for an aggressive energy efficient design (> 25 per cent energy savings) can dramatically increase the equipment budget and term of simple payback (ROI) on this incremental cost.

However, to support the 35 per cent energy saving target required for restaurant rezoning, Fish+ River Consultants (FRC) have drawn upon their extensive first-hand experience with foodservice energy efficiency strategies and have also referenced a well-documented modelling study prepared in 2010 for the U.S. Department of Energy by the Pacific Northwest National Laboratory (PNNL). FRC principal Don Fisher was a participant and co-author of this study, which demonstrated that an integrated design model for mid-sized, (2500 f2 – 232m2) high-volume restaurants can approach whole-building energy savings of 45 per cent beyond the 2007 standard with a simple payback of five years or less. This modelling included one tailored to the Seattle climate zone, which effectively mirrors conditions in the Vancouver area.

Given the high percentage (60 plus) of process energy, technological limitations and the financial challenges of incremental cost and simple payback, clearly any new restaurant project subject to these rezoning requirements will require development of a comprehensive whole-building model to meet these targets. Regardless of the restaurant type or concept under consideration, FRC recommends that most every energy efficiency measure (EEM) listed within this document be considered and applied to the project model.

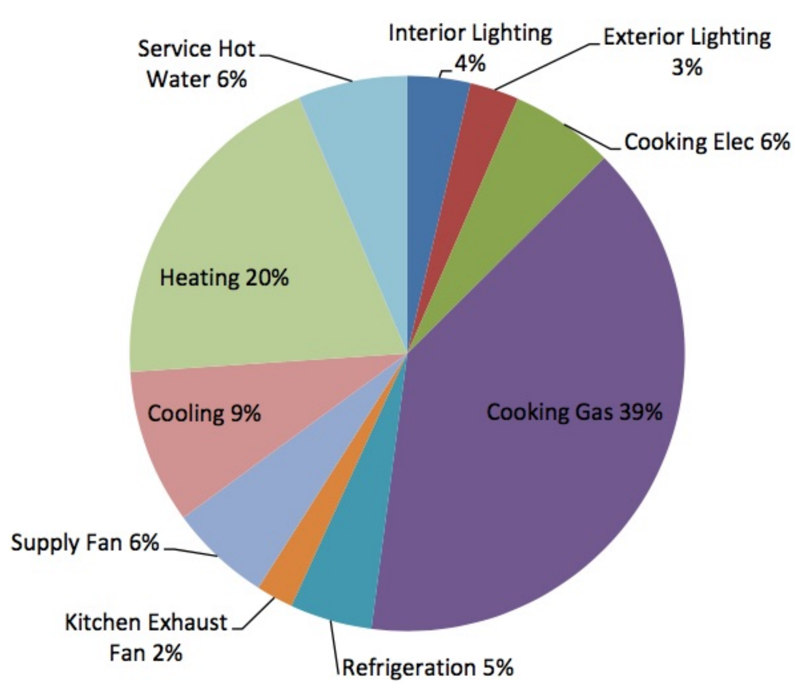
Furthermore, we strongly advise that every restaurant rezoning project make full and comprehensive use of the listed resources to inform their building energy modelling; in our opinion, these reports and resources constitute the most reliable references currently available.

CORE ENERGY EFFICIENCY MEASURES

The energy efficiency measures (EEMs) necessary to achieve a 35 per cent energy reduction apply to the following design categories: food prep, cooking and holding equipment; HVAC systems; commercial kitchen ventilation; water heating and sanitation, refrigeration, lighting and building envelope.

Per the PNNL study (*see Fig.2 below*) each end-use category can contribute by varying degrees to the total energy savings.

Fig.2 - Proportion of Energy Savings from Different End-Use Categories[I]



I PNNL-19809- Technical Support Document: *50% Energy Savings for Quick-Service Restaurants* (US DOE -2010)

As well, a number of the listed EEMs have been annotated (in italics) with respect to their ability to be readily modeled.

1 - FOOD PREP, COOKING AND HOLDING EQUIPMENT

The fundamental energy efficiency measure (EEM) within the kitchen is the specification of ENERGY STAR appliances (where applicable). [*Modeling appliance energy reduction is a complex task, requiring knowledge of each appliance and its energy efficiency specification. However, specification of ENERGY STAR equipment is generally standard practice in LEED design. It is often modeled as a single load*].

Within the scope of optimizing cooking equipment, an energy efficient design can consolidate equipment and reduce the number of appliances. For example, a combination oven/steamer could replace a convection oven and compartment steamer. A high-performance griddle could effectively reduce the size of this appliance (e.g., 4 ft. down to 3 ft.). The application of high-efficiency (electric) induction cooktops can dramatically reduce energy use and footprint, however at a significantly greater incremental cost. [*This design strategy is not typically incorporated within standard LEED design*].

Another effective EEM in both energy savings and GHG reduction is to maximize opportunities to ' fuel switch' from natural gas to electric equipment. Decades of testing have proven that high-efficiency ENERGY STAR electric appliances rarely if ever compromise performance and reliability versus equivalent gas equipment. However, as previously mentioned, with certain equipment categories where ENERGY STAR options are unavailable (gas range tops, charbroilers, etc.) there are very few electric equivalents available.

2 - HVAC SYSTEMS

Restaurants are unique spaces regarding their HVAC system design in that they generally have two distinct thermal zones — the dining and the kitchen zones that typically are conditioned by constant air volume systems. The dining zone typically is driven by occupancy in the space, which dictates how much outdoor air is required. However, in the kitchen zone the dominant use of outdoor air is to replace the air exhausted by the hood vents, thus maintaining a positive pressure in the kitchen.

Candidate EEMs for these systems include:

- High-efficiency rooftop units [*generally standard practice in LEED design*]
- CO2-based demand control of outdoor air to dining room [*However, this measure competes with DCKV, the recommended EEM- see below*]
- Dedicated Outdoor Air Supply for Makeup Air (DOAS)
- Direct-fired makeup air units [*Subject to local code. Also competes with specification of a DOAS*]
- Programmable thermostats [*not easy to model, but being incorporated in all new design*].

3 - COMMERCIAL KITCHEN VENTILATION (CKV)

An effective design of the exhaust ventilation system (as a subset of the HVAC system) must include optimization of the layout of cooking equipment and proper hood style/specification to minimize total airflow. The prescriptive EEMs in ASHRAE 90.1 include the following measures.

If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5,000 cfm then it shall have one of the following:

A. At least 50 per cent of all replacement air is transfer air that would otherwise be exhausted;
B. Demand ventilation system(s) covering at least 75 per cent of the exhaust air. Such systems shall be capable of at least 50 per cent reduction in exhaust and replacement air system airflow rates, including controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle. *Note that variable speed exhaust controls are now referred to as demand-controlled kitchen ventilation (DCKV) systems.*
C. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 per cent on at least 50 per cent of the total exhaust airflow.

A supporting measure is to specify low-velocity diffusers, such as perforated grilles or fabric filters, instead of 4-way and other high-velocity diffusers. This measure augments the fundamental measure of reducing exhaust airflow by improving hood capture efficiency. It will also support improvements in thermal comfort (as does the DOAS application). [*However, it is difficult to model the incremental energy savings*].

An aggressive LEED design may consider solar panels or solar wall for preheating makeup air. [*Which though novel, is not generally cost-effective*].

4 - WATER HEATING AND SANITATION

The principal EEMs for consideration within the design include:

- Condensing (high-efficiency) water heaters and boilers [*standard in LEED design*].
- Ultra low-flow pre-rinse spray valve (PRSV) of less than 1 gpm [*may or not be applicable*].
- ENERGY STAR dishwasher with integrated exhaust air heat recovery [a *promising new technology*].
- Drain water heat recovery [*expensive and technically challenged*].
- Point use water heating for lavatories.
- Re-circulation pump time clock and pipe insulation. Demand-pumping could be considered within this measure.
- Solar thermal for preheating distributed hot water (DHW)
- Refrigerant heat recovery (desuperheater) from walk-in refrigeration for preheating DHW
- Heat pump water heater (where applicable).

5 – REFRIGERATION

The principal EEMs for consideration within the design include:

- High-efficiency compressor package for walk-ins [*difficult to establish specifications for restaurant designers*]

- On-demand defrost controls for walk-in freezers [*this is a relatively new control strategy, completing with ineffective control measures*].
- Retrofit remote condensing for reach-ins and ice machines [*standard in LEED design*]. Ice machine measure includes upsizing and off-peak controls. [*not standard practice*].
- Strip curtains or swing doors for walk-in refrigeration [*standard in LEED design*].

6 – LIGHTING

The principal EEMs for consideration within the design include:

- Low-watt density design.
- Daylight harvesting.
- Occupancy sensors.

  Occupancy sensors are ideal for: storage rooms, break rooms, restrooms and offices. However, modeling the impact is difficult, if not impossible.

7 - BUILDING ENVELOPE AND MISCELLANEOUS

- Envelope and glazing per ASHRAE 90.1
- Cool roof
- Energy management systems

  [EMS systems cannot be modeled effectively, as they are only as good as the best manager. However, field monitoring projects have shown energy savings in the range of five to 15 per cent when EMS is applied. EMS cannot be effectively modeled. Costs range from $5K to $25K installed, challenging the ROI.]

KEY RESOURCES

The primary resources for this guide are available for complimentary download via these links.

As previously indicated, in our opinion, the most comprehensive resource for any restaurant in the Vancouver area aiming to maximize energy efficiency via a whole-building design remains the PNNL study referenced in this document (as applied to the Seattle climate zone). It effectively outlines the modelling strategies and best options for foodservice energy efficiency.

- **Technical Support Document: 50% Energy Savings for Quick-Service Restaurants** (*Zhang, Schrock, Fisher, Livchak, Zabrowski, Lane, Athalye, Liu*) - Prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory (Richland, Washington) September 2010

And with decades of lab testing of commercial foodservice equipment under their belt, the Food Service and Technology Center (FSTC) is the go-to resource for detailed information on most every category of restaurant equipment and system.

Their website is loaded with complimentary resources, including: equipment test reports, life-cycle analysis (LCA) calculators, case studies, design guides (including DCKV) and relevant industry publications.

- **Food Service and Technology Center (San Ramon, Calif.)**

And attached as Appendix I is a chart detailing the average energy-efficiency ratings, both conventional and ENERGY STAR, for the electric and gas-powered equipment typically used by a full-service family/casual restaurant. This equipment list would mirror the energy consumption described in Fig. 1.

Appendix I - Full-service restaurant - energy use for typical equipment list

Applance Type	std gas (% EE)	std gas (GJ/yr)	ES gas (%EE)	ES gas (GJ/yr)	std elec (%EE)	std elec (eGJ/yr)	ES elec (%EE)	ES elec (eGJ/yr)	HE induc.(%EE)	HE induc (eGJ/yr)
Main Kitchen/Cookline										
Convection Oven	35%	60	48%	45	60%	50	76%	35		
Charbroiler 24"	30%	200			55%	125				
Primary Grill 48"	39%	130			75%	50			95%	35
Egg Grill 24"	40%	85	54%	75			75%	25	95%	17
Two Burner Cooktop	30%	65							95%	20
Four Burner Cooktop	30%	110							95%	35
Deep Fryers (x 4)	35%	450	55%	350			86%	200		
Prep Kitchen										
Four Burner Range w/std.oven	40%	125							95%	60
Hot Holding Cabinet						7.2		4.4		
Combi-Oven			60	60			60	50		
Reach-in Cooler - dbl >40 cu.ft						4		3		
Reach-in Freezer - sgl <30 cu.ft						8		6.5		
Undercounter Coolers (x 4)						17		14		
Service/Beverage Area										
Refrigerated Work Table -sm						3		1.6		
Refrigerated Work Table- lg.						4.5		2.5		
Ice Cream Chest						3.2		1.8		
Ice Machine -cube >1000 lbs.						31		27		
Dishwasher						28		21	heat exch.	16.2
Total usage		1165		530		330.9		391.8		183.2

Assuming 5,000 hrs/yr operations

kWh to GJ = x 0.0036 per NRCan