Real-World Integrated Design Practice and Tools: *Effective Energy Performance Analysis Approaches*

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Introduction

- Cost-effective methods exist for integrating energy efficiency into designs
- Integrated design produces more efficient, marketable buildings
- Many new buildings barely comply with energy codes (e.g., ASHRAE 90.1)
- Lost opportunities from taking “standard approach” to new building design

Why Don’t We Design Energy Efficient/Sustainable Buildings?

- Focus on up-front costs
  - Life-cycle cost-effectiveness ignored
  - Design team squeezed on fees
- Owner does not pay the energy bills
- Scheduling constraints
- Fees tied to quantity instead of quality
- That’s the way it’s always been done
- Marketing – perception vs reality

Approaches to Sustainable Design

- "Integrated Design" or "Environmentally Responsive Building Design"
- Traditional approaches:
  - Design facilitation
  - Iterative building energy modelling
- Energy Performance Workshop concept
  - Originally promoted under BC Hydro's *Design Assistance Program*

Energy Performance Workshop Concept

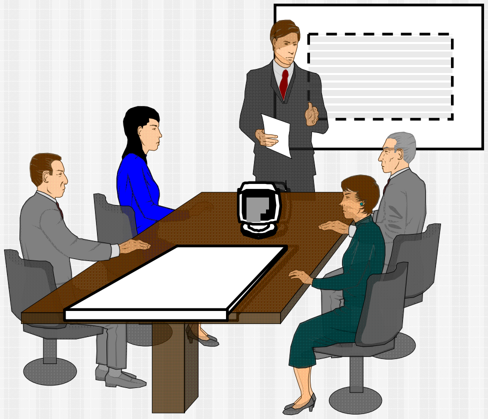
- Exploration of energy-efficiency strategies during any design stage
  - At a key point of the design process
  - Typically, a *single* intensive meeting
- Teams architects, engineers, cost consultant and sponsoring agency with energy analyst
- Allows for quick and educated decision-making

Energy Performance Workshop Process

- Data gathering
  - Questionnaire
  - Building plans
  - Reference data
  - Weather
- Project setup and modelling
- Energy performance workshop (EPW)
- Follow-up and reporting

What Happens During an EPW?

- Interactive working meeting
- Review design and pre-workshop model
- Sensitivity analysis of design options
- Energy efficiency analysis
- Cost-effectiveness screening
- Immediate feedback, including with compliance and program qualification indicators



Developer/Owner Benefits of Integrated Design

- Optimized overall design
- Increased occupant comfort
- Potential to lower capital costs
- Reduced energy and operating costs
- Increased marketability of building
  - 3rd party verification (e.g., LEED)
- Possible incentives

Consultant Benefits of Integrated Design

- Valuable information to assist with early decision-making process
- Forum for verifying savings from creative/atypical design solutions
- Opportunity to optimize systems
- Indicators as to impact on system capacities for possible downsizing
- Immediate feedback on most options (EPW approach)

Quantitative Results

Case Studies

Gulf Islands Operations Centre

Gulf Islands Operations Centre

Workshop Highlights

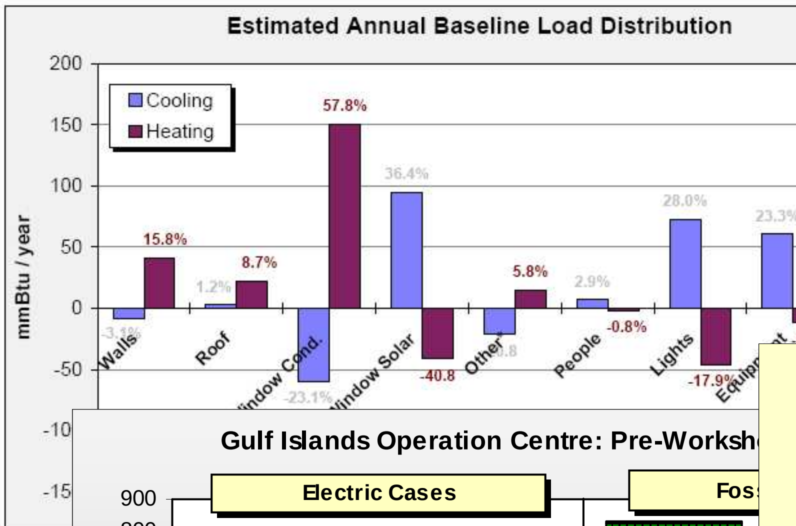
Legend	END-USE	Electricity $	Electricity Savings	Natural Gas $	Natural Gas Savings	Central Steam $	Central Steam Savings	TOTAL COSTS $	TOTAL COSTS Svgs	ANNUAL ENERGY GJ	ANNUAL ENERGY Svgs
	Cooling	20	1.8%					20	1.8%	1	2.8%
	Heating	1,337	-3.1%	0	-1.7%			1,337	-3.1%	64	-3.1%
	Lights	2,825	0.0%					2,825	0.0%	136	0.0%
	Equip.	1,799	0.0%					1,799	0.0%	86	0.0%
	Fans	1,560	-0.1%					1,560	-0.1%	75	-0.1%
	Refrig							0		0	
	Ext. Lts	104	0.0%					104	0.0%	5	0.0%
	Elev.	426	0.0%					426	0.0%	20	0.0%
	DHW	628	-0.1%					628	-0.1%	30	0.0%
	PV							0		0	
	TOTAL	8,699	-0.5%	0	-1.7%			8,699	-0.5%	415	-0.5%
	Total $ Savings	-$44		$0				($44)		(2.0)	
	Fuel Savings:	-0.6 MWh		0 GJ		0 Mlbs					

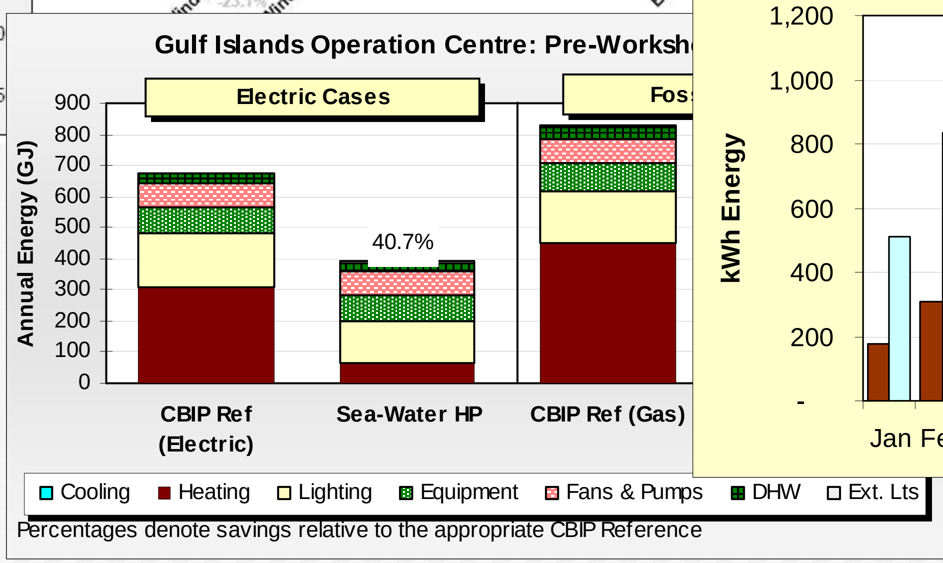
Maximum HVAC Contribution During Peak*

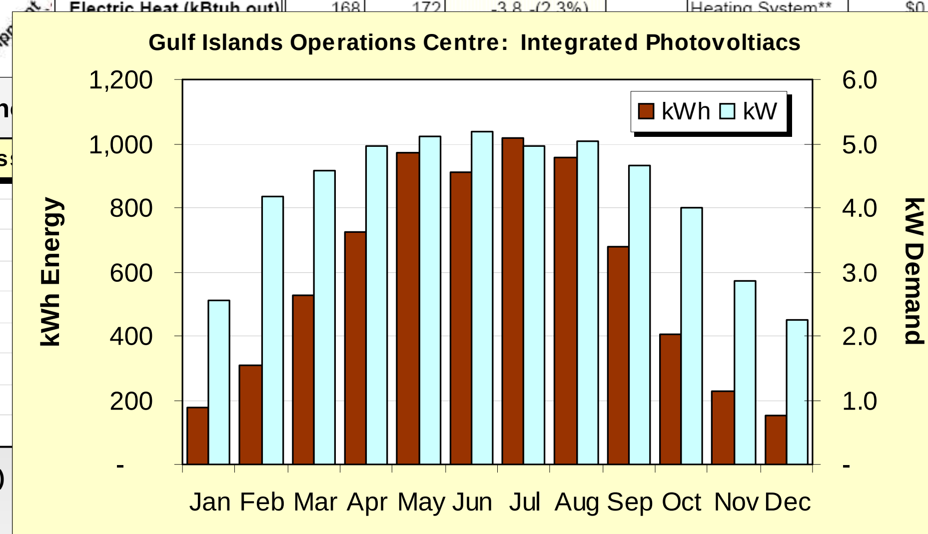
HVAC END-USE	Demand Base	Demand ECM	Peak Load Reduction
Fossil Heat (kBtuh out)	0	0	0.0 -(0.7%)
Steam Heat (kBtuh out)	0	0	0.0 (0.0%)
Electric Heat (kBtuh out)	168	172	-3.8 -(2.3%)

Economic Analysis

Incremental Costs ($)	
Equip. & Labor	$3,000
Annual O&M	$0 /year
Cooling System**	$0 /ton
Heating System**	$0 /kBtuh

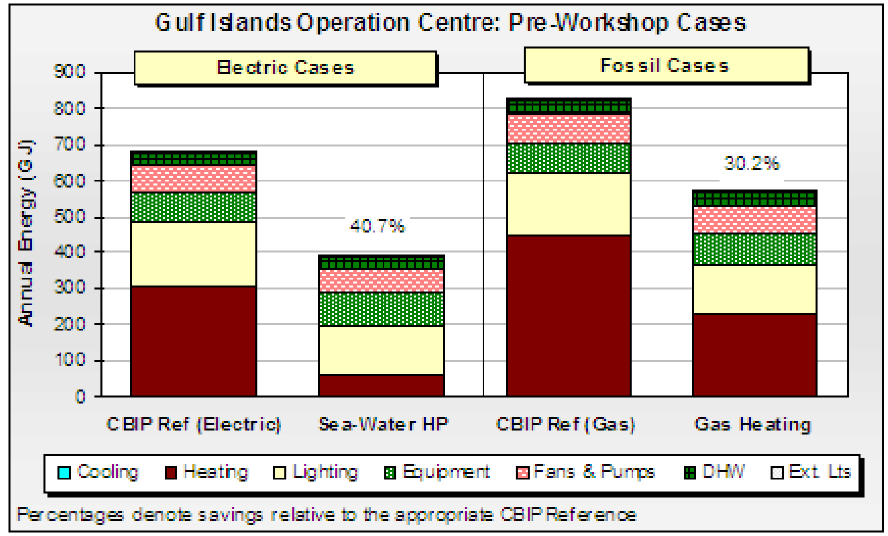






Gulf Islands: Baseline HVAC System Selection

- Building loads typically investigated first
  - Influences on mechanical system configuration and sizing
- Primary heating source influences energy savings
  - Natural gas (typical)
    - Gas line already nearby
  - Sea water source heat pump (100% electric)
    - Ocean nearby



		Sea-Water HP	Gas Heating
Life-Cycle Economic Cost Comparisons:			
Net Capital Costs:		*$40,000*	*$25,000*
Annual Costs			
Energy Costs:		$8,655	$10,331
Maintenance Costs:	2.0%	$800	$500
Net Annual Costs:		$9,455	$10,831
NPV of Annual Costs:		*$133,260*	*$152,653*
LCC		**$173,260**	**$177,653**
Cost Increase vs. Minimum:		$0	$4,393
		0.0%	*2.5%*
		LOWEST	

Gulf Islands: Evaluation of Individual Measures

Building Loads

- Shell measures: walls, roof, windows
- Lighting: Installed power and controls
- Interior plug/process loads

Heating, Ventilation and Air Conditioning

- Heating and cooling systems and configurations
- Auxiliary components: fans, pumps
- Control strategies

Domestic Hot Water

- Low flow fixtures
- Preheat and water heating approaches

Other (exterior lighting, elevators, etc.)

Renewable Energy

- Photovoltaics

Gulf Islands: Sample Wall Optimization

Design Baseline Construction (R-16.3)

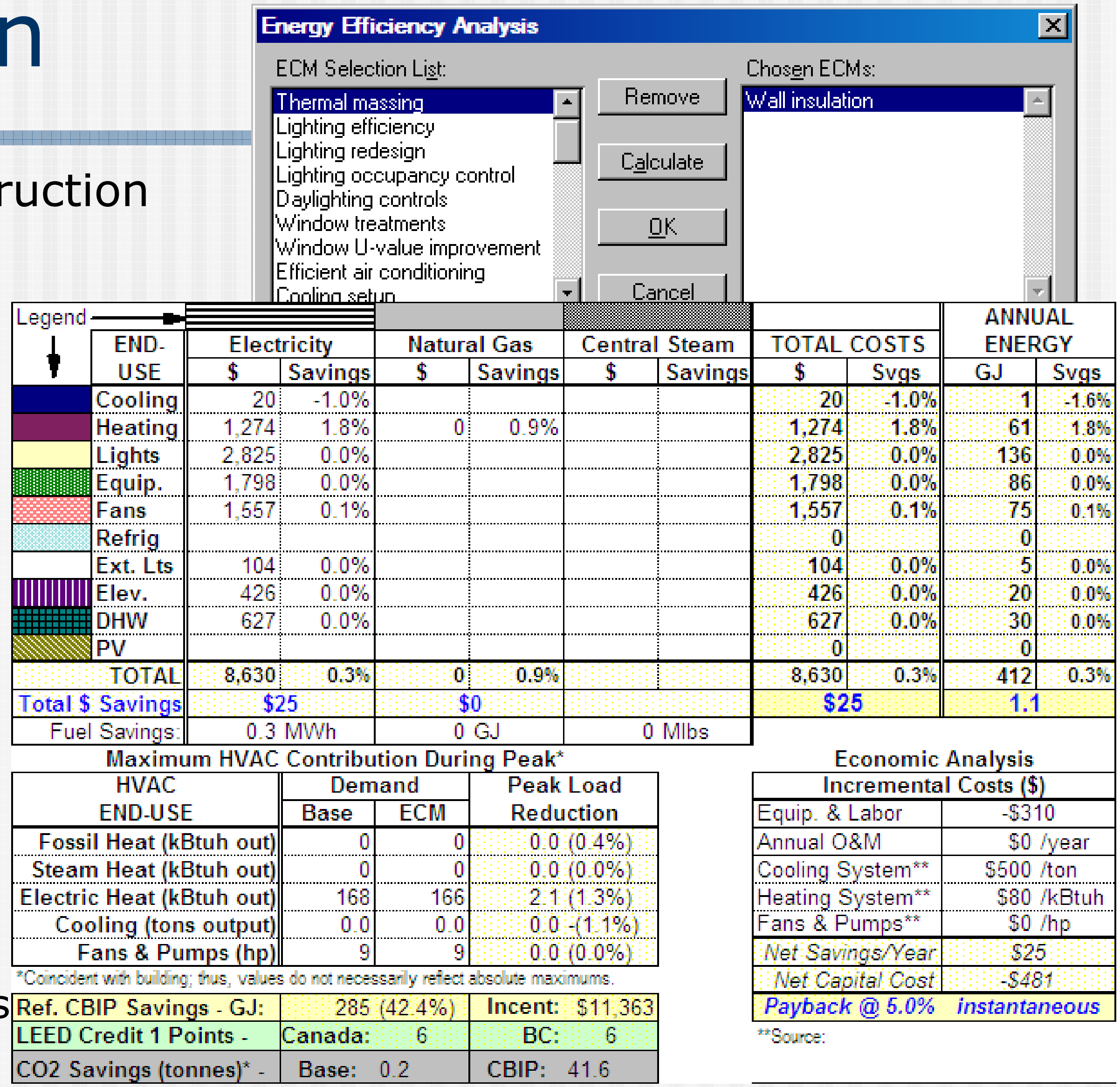
- 4″ rigid polystyrene
- Metal Z-girts

Alternative Con-struction (R-17.8)

- 2″ rigid polystyrene with metal clips
- 2″ batts between steel studs

Final Construction (R-17.6)

- 3″ rigid polystyrene with metal clips
- Reduction of materials & embodied energy



END-USE	Electricity $	Electricity Savings	Natural Gas $	Natural Gas Savings	Central Steam $	Central Steam Savings	TOTAL COSTS $	TOTAL COSTS Svgs	ANNUAL ENERGY GJ	ANNUAL ENERGY Svgs
Cooling	20	-1.0%					20	-1.0%	1	-1.6%
Heating	1,274	1.8%	0	0.9%			1,274	1.8%	61	1.8%
Lights	2,825	0.0%					2,825	0.0%	136	0.0%
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Elev.	426	0.0%					426	0.0%	20	0.0%
DHW	627	0.0%					627	0.0%	30	0.0%
PV							0		0	
TOTAL	8,630	0.3%	0	0.9%			8,630	0.3%	412	0.3%
Total $ Savings	$25		$0				$25		1.1	
Fuel Savings:	0.3 MWh		0 GJ		0 Mlbs					

Maximum HVAC Contribution During Peak*

HVAC END-USE	Demand Base	Demand ECM	Peak Load Reduction
Fossil Heat (kBtuh out)	0	0	0.0 (0.4%)
Steam Heat (kBtuh out)	0	0	0.0 (0.0%)
Electric Heat (kBtuh out)	168	166	2.1 (1.3%)
Cooling (tons output)	0.0	0.0	0.0 -(1.1%)
Fans & Pumps (hp)	9	9	0.0 (0.0%)

*Coincident with building; thus, values do not necessarily reflect absolute maximums.

Ref. CBIP Savings - GJ:	285 (42.4%)	Incent: $11,363
LEED Credit 1 Points -	Canada: 6	BC: 6
CO2 Savings (tonnes)* -	Base: 0.2	CBIP: 41.6

Economic Analysis

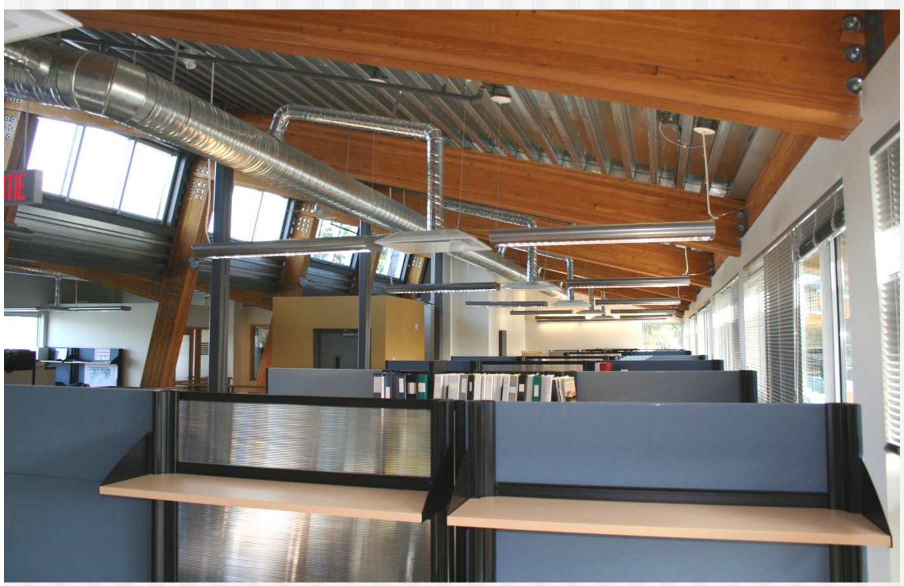
Incremental Costs ($)	
Equip. & Labor	-$310
Annual O&M	$0 /year
Cooling System**	$500 /ton
Heating System**	$80 /kBtuh
Fans & Pumps**	$0 /hp
Net Savings/Year	$25
Net Capital Cost	-$481
Payback @ 5.0%	instantaneous

**Source:

Gulf Islands: Efficiency Measures

Building Shell

- Minimize thermal bridging
- Insulation materials and R-value optimization
  - Roof insulation *reduced* from 4” to 3”



- Glazing amounts and characteristics
  - Only 22% window area but plenty of daylight

Gulf Islands: Final Proposed Design

- Annual Savings vs. Baseline Heat Pump Design
  - 112 MJ/m² (9850 Btu/ft²) → 25.3%
  - $2.33/m² (22¢ per ft²) → 25.1%
  - 15.8 year LCC payback (4.9 years without photovoltaics)

- Annual Savings vs. Baseline Natural Gas Heated Design
  - 304 MJ/m² (26800 Btu/ft²) → 47.9%
  - $3.85/m² (36¢ per ft²) → 37.3%

- Annual Savings vs. LEED Reference
  - 415 MJ/m² (36500 Btu/ft²) → 57.7%*
  - $8.72/m² (81¢ per ft²) → 67% in regulated end-use savings (75% for final application)
  - 10 LEED Canada EAc1 points (+1 ID point for final application)

Whitehorse Office & Firehall

- Potential Heating: Electric, Oil and GSHP
  - Proceeded with GSHP for evaluation
  - Reran all measures with HPs fed by Oil boiler
- Envelop Measures (22 options)
  - R-60 roof insulation: poor payback
  - R-100 roof insulation: 10 – 16 year payback with sprinkler elimination
  - R-20 bay roof batts – 18-yr payback with GSHP, 7.3-yr with distributed HP case
  - Triple pane windows – 2.6 yr payback (GSHP)

Whitehorse Office & Firehall

- Heating Systems
  - Optimized GSHP and distributed HP cases
  - GSHP: -3% – -6% IRR
- Final Workshop Results
  - 14 measures identified for adoption, including changing GSHP system to distributed HP
  - Over $920,000 in capital cost *reductions*
  - Over $40,000/year in annual utility bill savings
  - LEED EAp2 qualification & improvement from zero to 5 EAc1 points

Victoria Extended Care

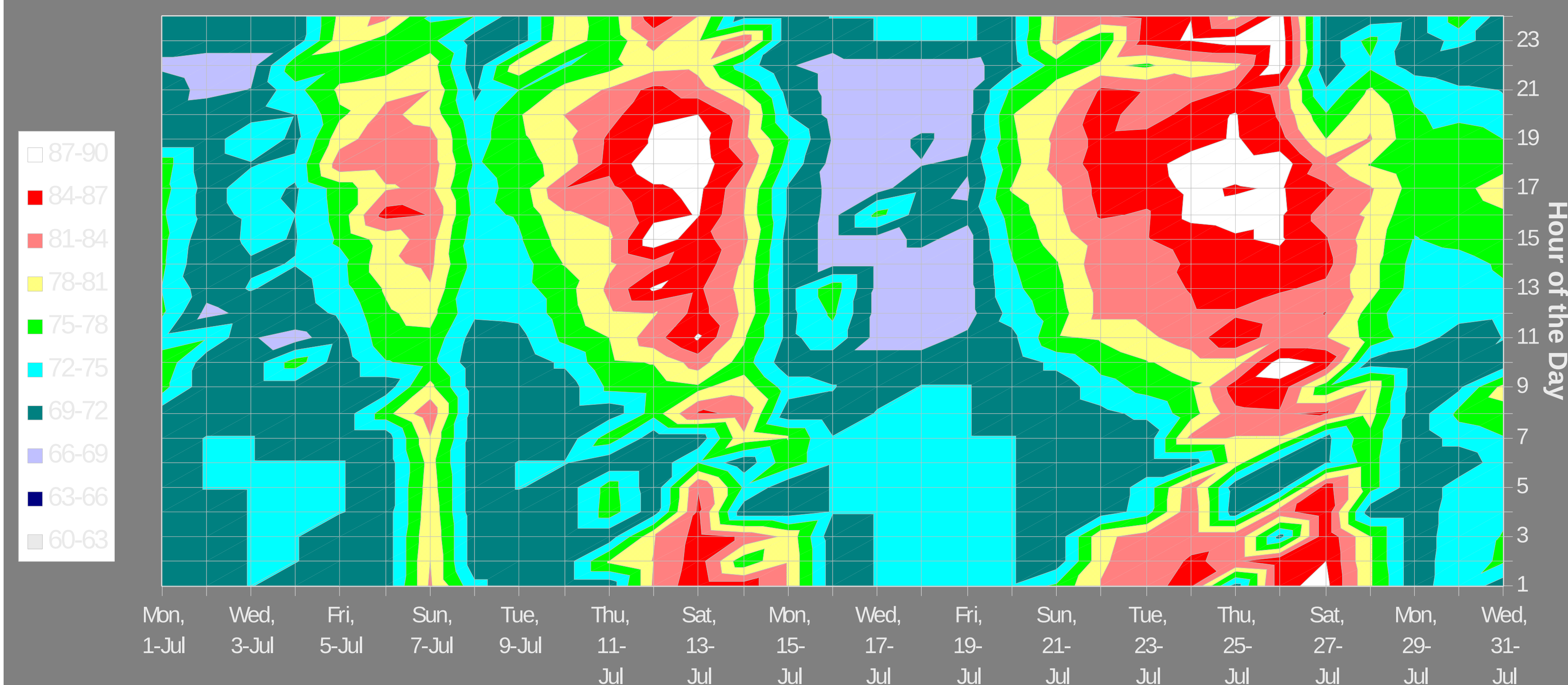
- Flushing over-ride controls to reduce outside air level
  - Still meets provincial standards
  - Reduces heating annual costs by $26,000
- Savings:
  - Worst case: $4,300/year with capital cost increase of $23,000 (4.8 yr payback)
  - Best case: $3,100/year with capital cost *reduction* of $22,000
  - 27-28% CBIP savings with $80,000 incentive

Victoria Apartment Complex

- Residential and commercial building
- Energy savings originally projected at roughly 40-50% over code-compliant case
  - Ground-source heat pump system
  - Heat pump DHW
  - Low-e windows
- Over 18% savings in energy costs from single metering

Victoria Apt. Project: Sample Integrated Design Feedback

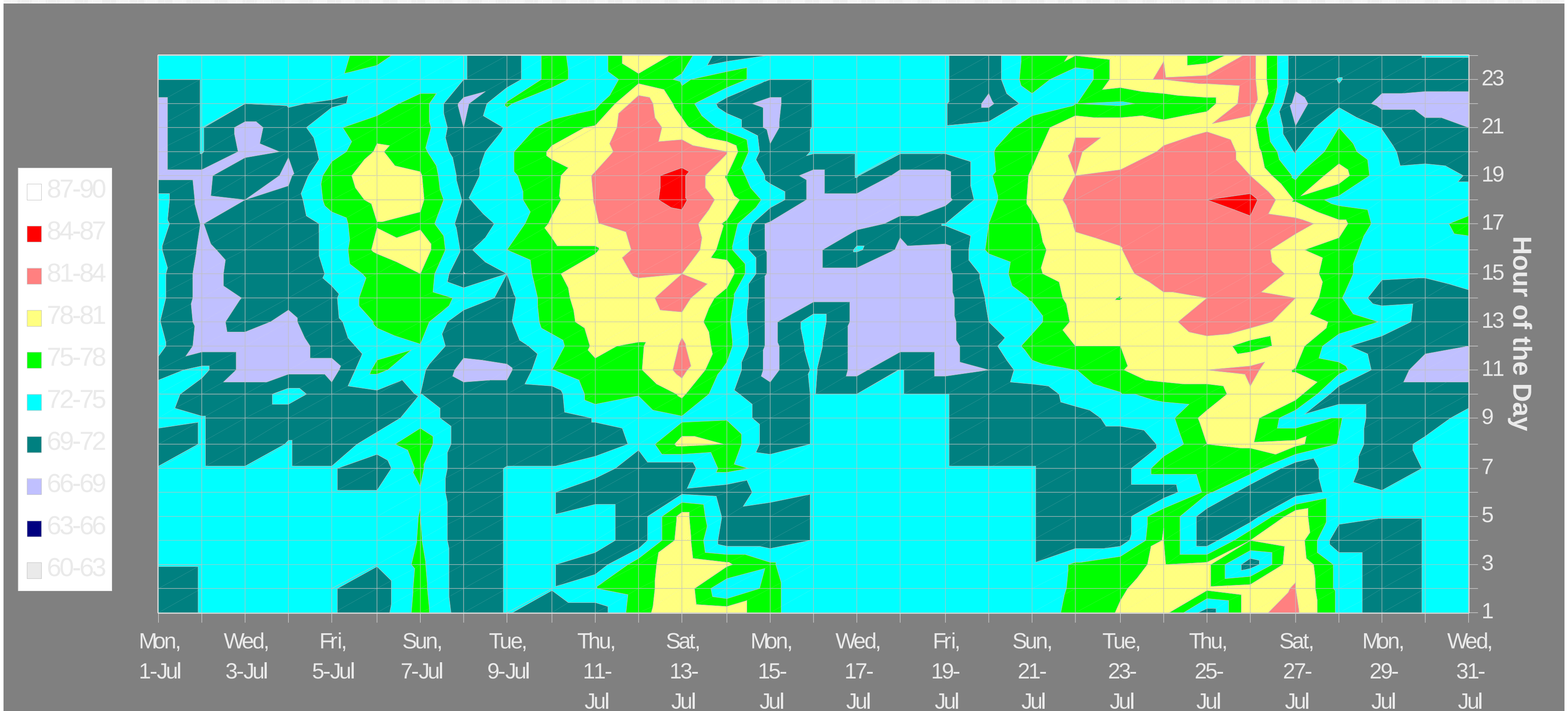
Temperature Profile with Standard Windows



Max. Temp = 89.3° F

Victoria Apt. Project: Sample Integrated Design Feedback

Temperature Profile with High Perf. Windows



Max. Temp = 85.2° F

Keys to Success

- Receptive and flexible design team, including owner
- Communication!
- Quick and timely feedback
- Appropriate level of detail
- Recognizing value of process
  - Possible marketing edge
  - Design incentive/penalty structure

Conclusion

- Energy performance workshop as a key component of integrated design
- Enhanced speculation on energy issues
- Provides valuable and timely feedback during *entire* design process
- Substantiation of efficiency strategies
- Secondary benefits (marketability, code compliance, emissions reduction, etc.)

Thank you!