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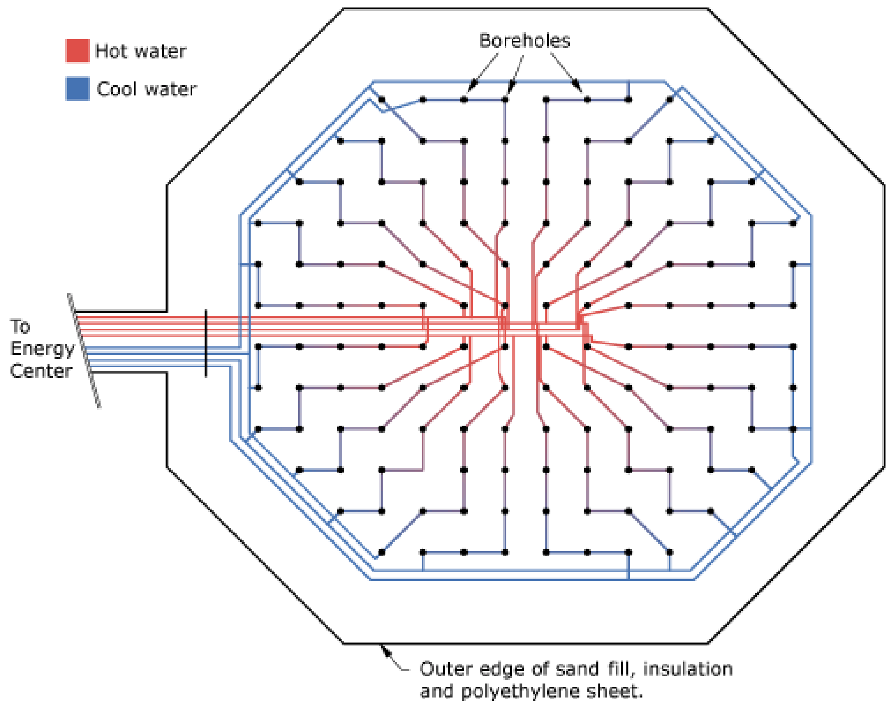
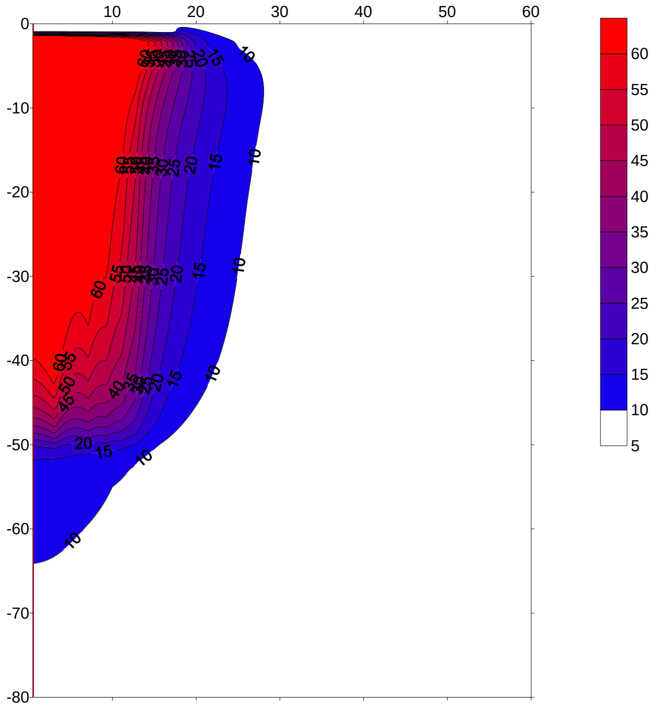
Solar Heating with Seasonal Storage Canadian Activities





Overview

- *Historical Perspective*
  Canadian Activities in Seasonal Storage
- *Why High Solar Fraction?*
- *Ongoing Projects*

  Drake Landing Solar Community
- *New Projects*

  Large Scale Community Study

Historical Perspective - Canada

- 1977-83 University of Toronto, Frank Hooper, Contract with US DOE.
- Simulation tool development and sensitivity study for 10 locations in US.
- 1983-2003 No work on seasonal storage. Solar thermal work focussed on sdhw (low flow systems) and C/I ventilation air heating (transpired solar air collector).
- 2003 Natural Resources Canada initiated work in seasonal storage. Led to construction of 1.5 MWth Drake Landing project, 92% solar fraction, 52 homes.
- 2010 Natural Resources Canada initiated planning for 20 MWth high solar fraction community +1000 homes.

Why High Solar Fraction
Solar Heating Cost vs Solar Fraction

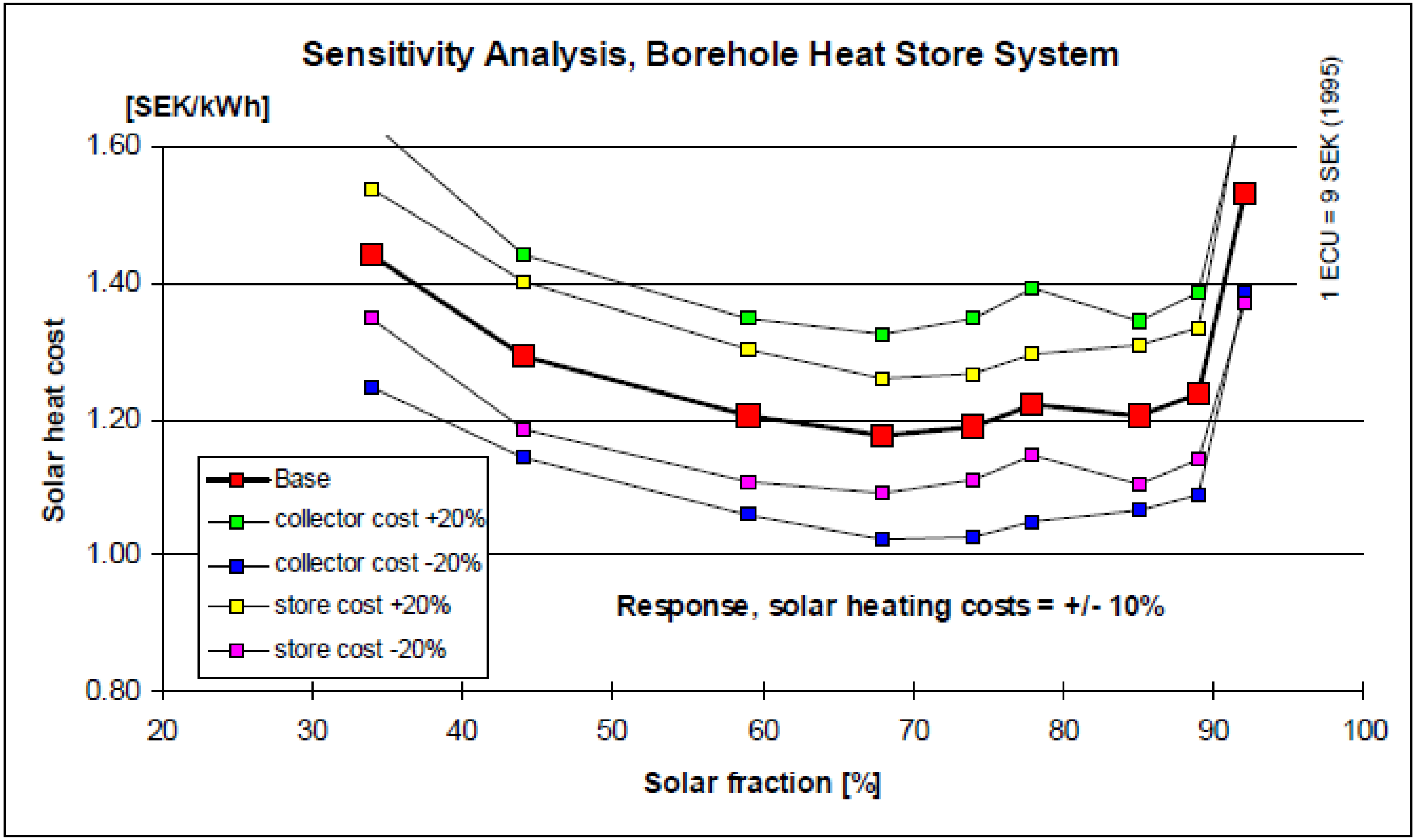


Figure 7.7 Sensitivity analysis of a borehole heat store system. Response of the solar heat cost to a ± 20 % variation in investment costs.

Drake Landing Solar Community

- First solar seasonal storage community in North America
- First in world >90% solar fraction
- Reduction of 5 tonnes GHG per home per year
- Largest subdivision of R-2000 single family homes in Canada (52 homes)

Major Objectives

- Demonstrate the technical feasibility of achieving substantial fuel energy savings using seasonal storage of solar energy for residential space heating
- Use the measured performance to calibrate computer models for use in a detailed assessment of the potential for solar seasonal storage in Canada.

Weather Data Comparison

	Heating Degree Days					
	Calgary	Amsterdam	Copenhagen	Munich	Stockholm	Vienna
Annual	5199	3010	3611	3733	4291	3167
Rank (1=coldest)	1	6	4	3	2	5

	Incident Solar Radiation (MJ/m^2)*					
	Calgary	Amsterdam	Copenhagen	Munich	Stockholm	Vienna
Latitude (N)	51.12	52.28	55.62	48.12	59.56	48.12
Annual	6426	3937	4289	4750	4280	4731
Rank (1=sunniest)	1	6	4	2	5	3

* *Incident solar irradiation is calculated from horizontal data using the Reindl model. The surface tilt angle is equal to the Latitude.*

Data Source: http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_about.cfm
Calgary weather data: CWEC
European weather data: IWEC

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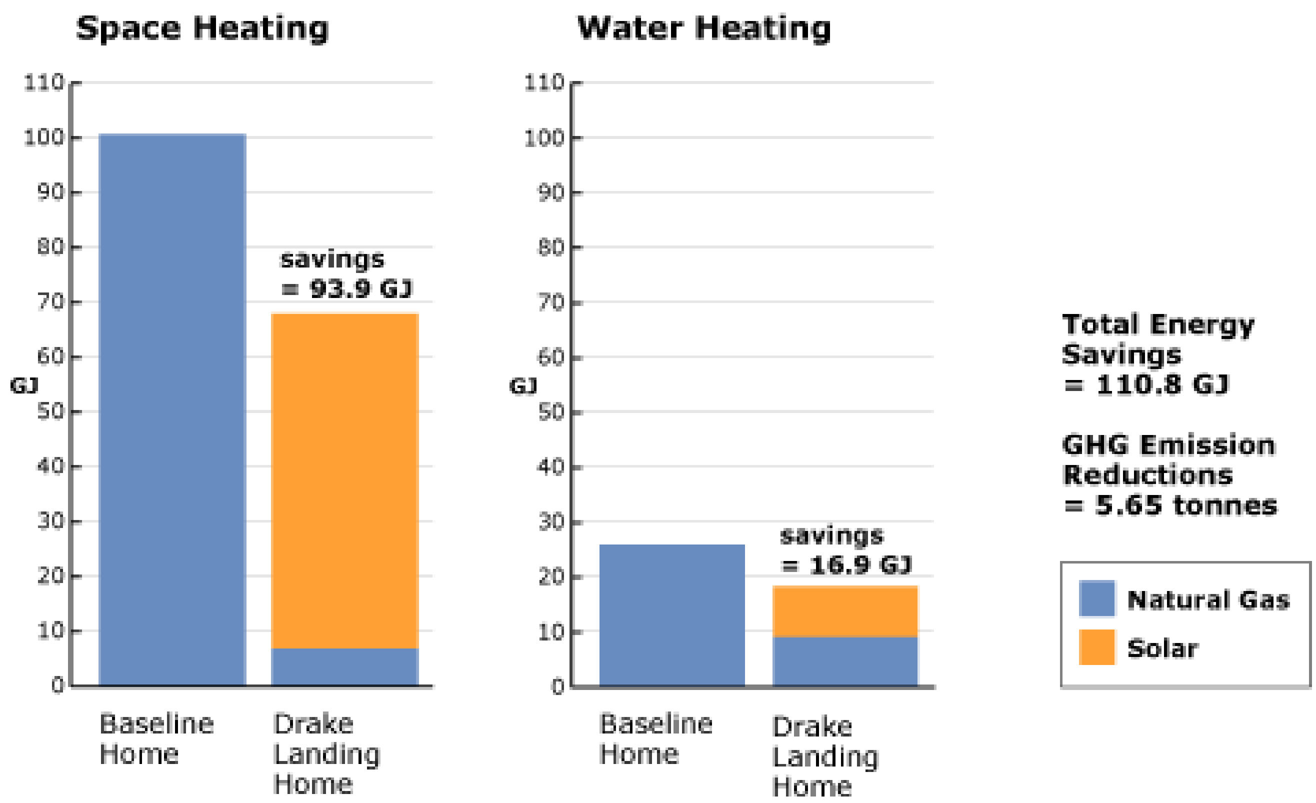
Drake Landing Solar Community



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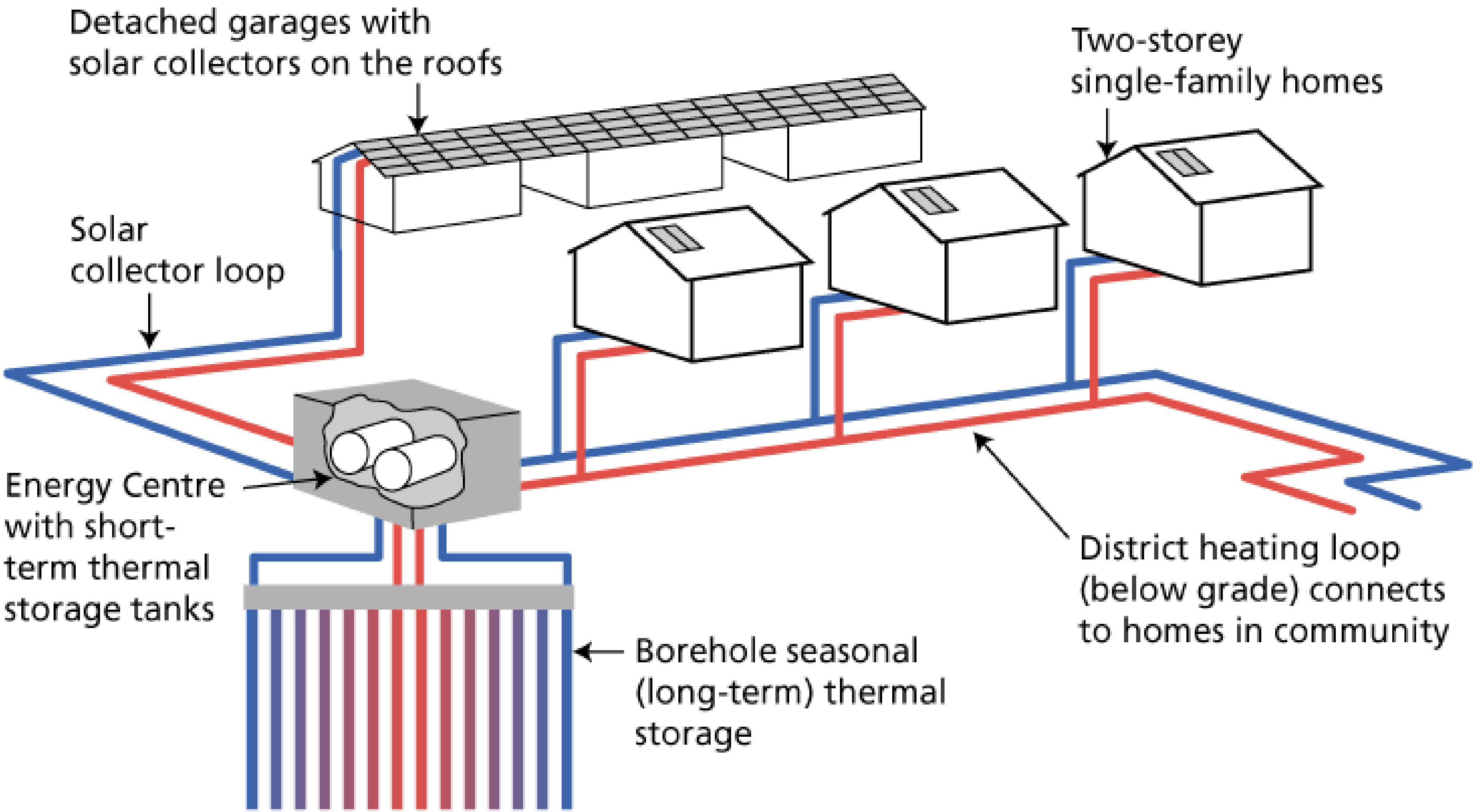
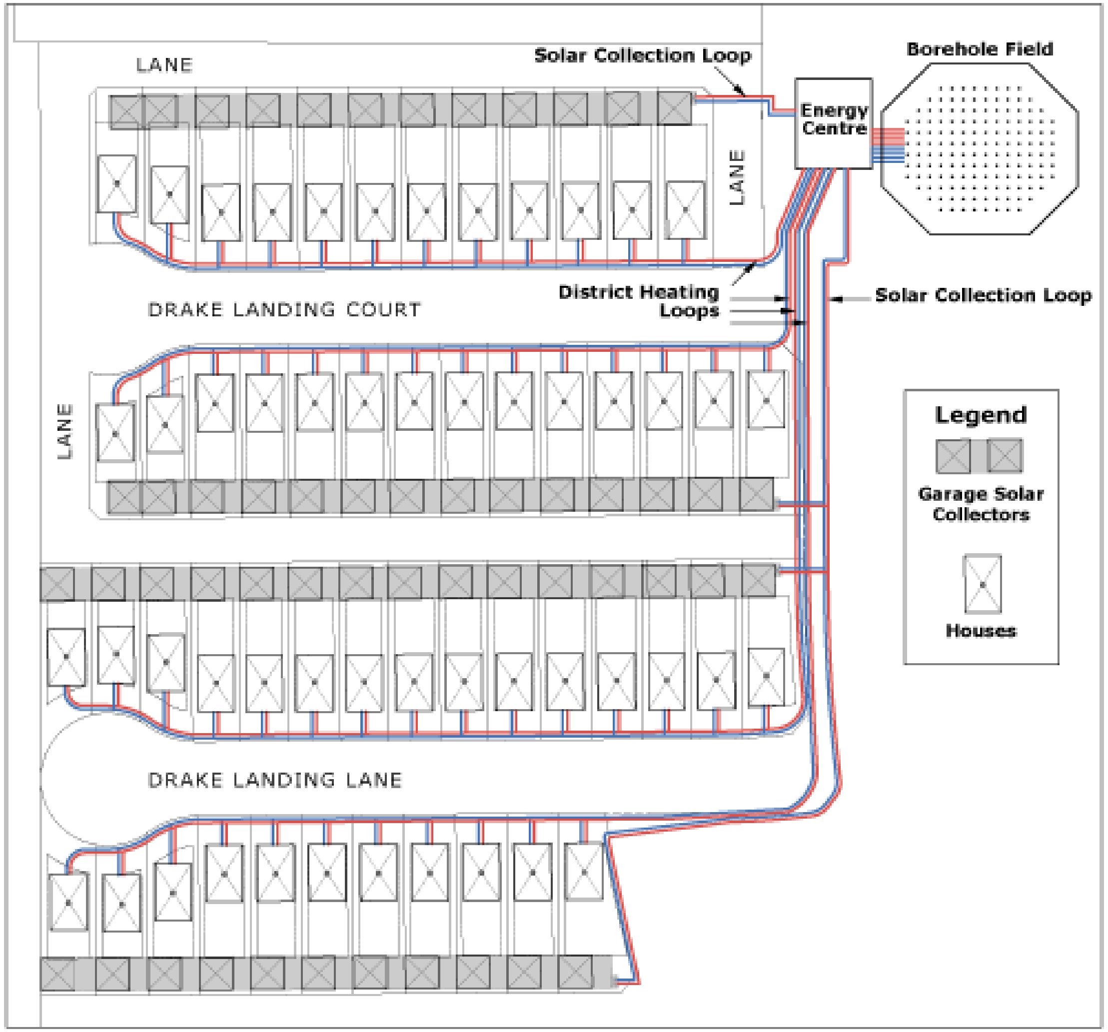
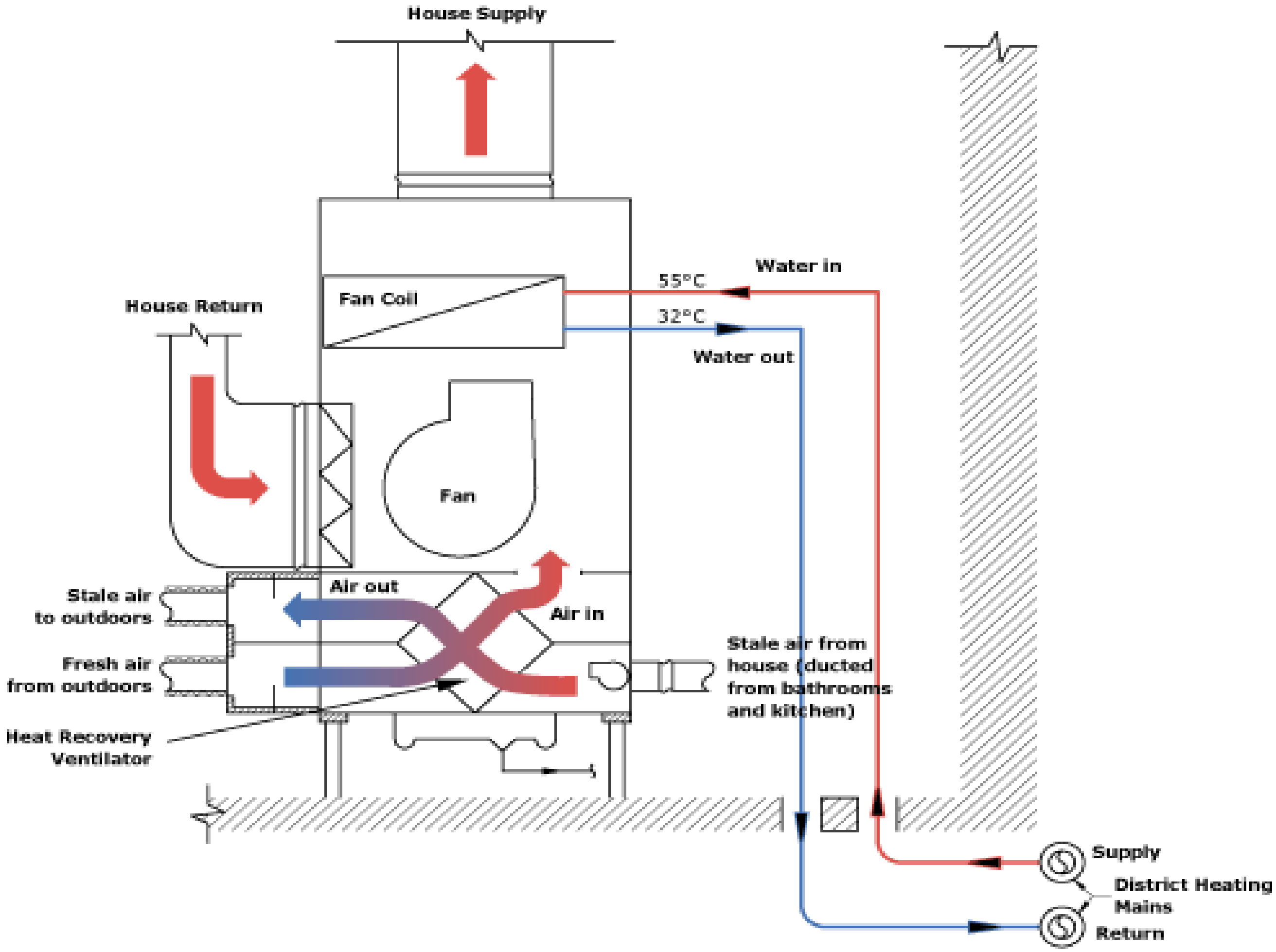
Simplified Schematic



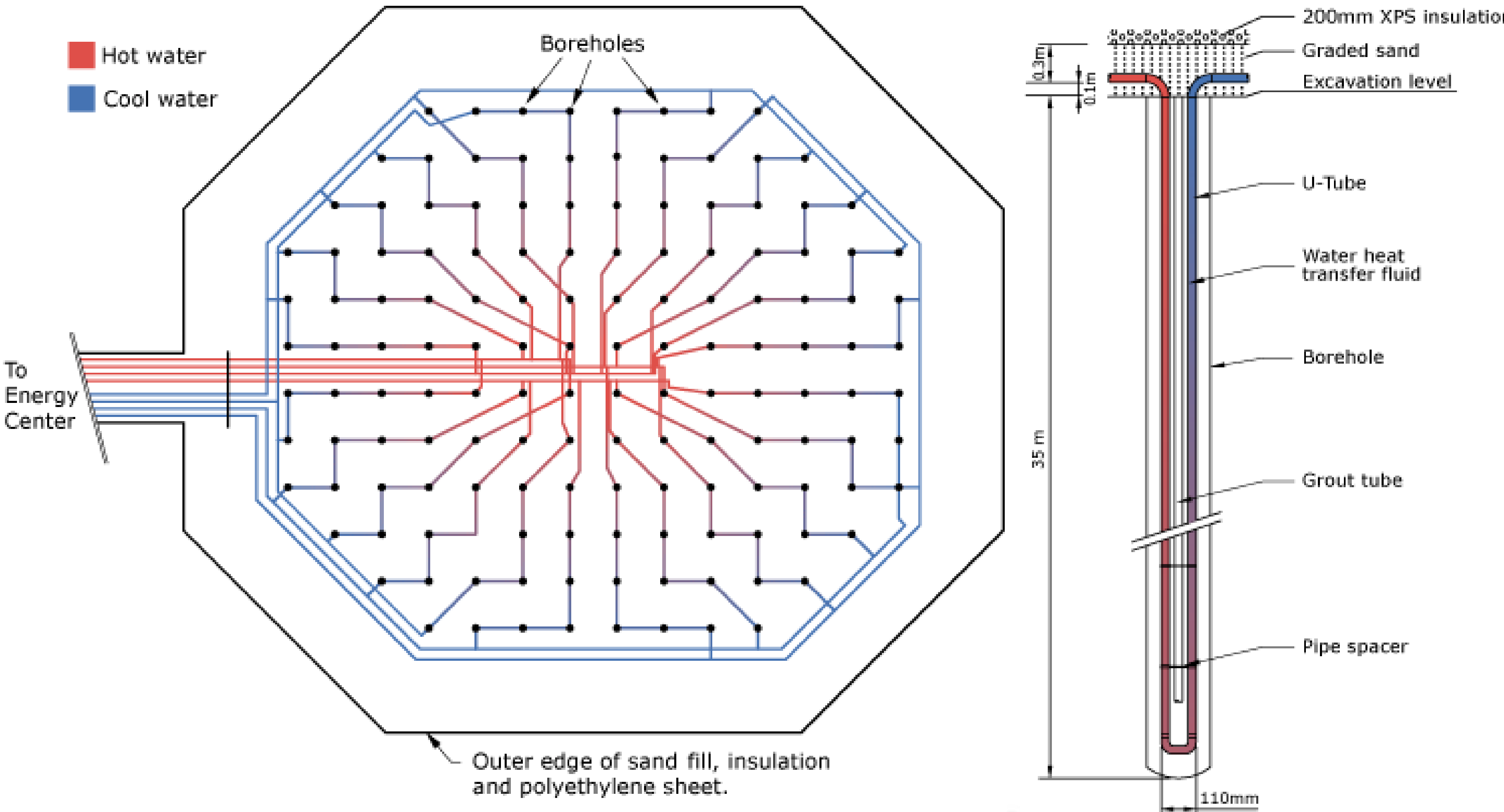
Energy Distribution



Air Handler Unit

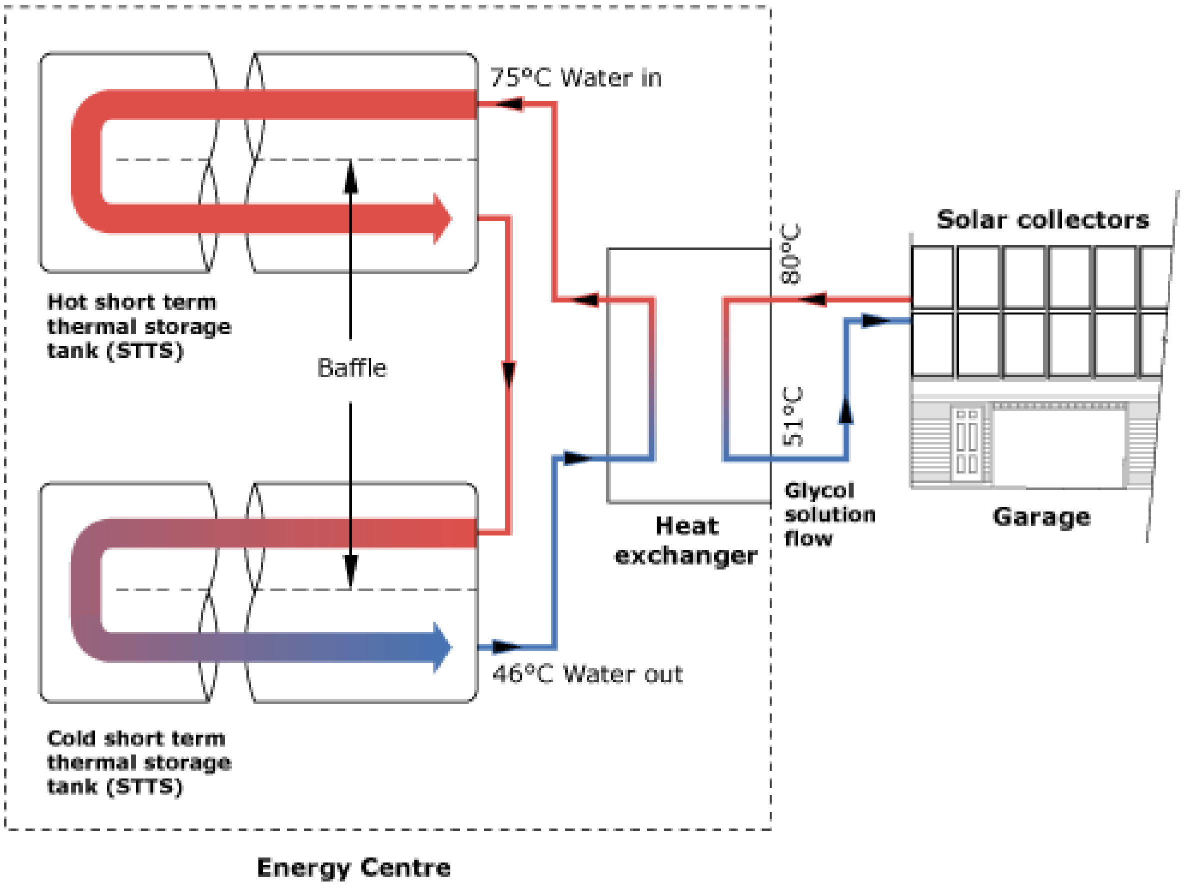


Borehole Thermal Energy Storage




2005/10/18

The Energy Centre



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Thermal Storage

- Short Term Storage: 2 – 120 m^3 (31,700 gal) insulated water tanks
- Seasonal Storage: 144 boreholes, single U-tube 35 m deep X 35 m diameter

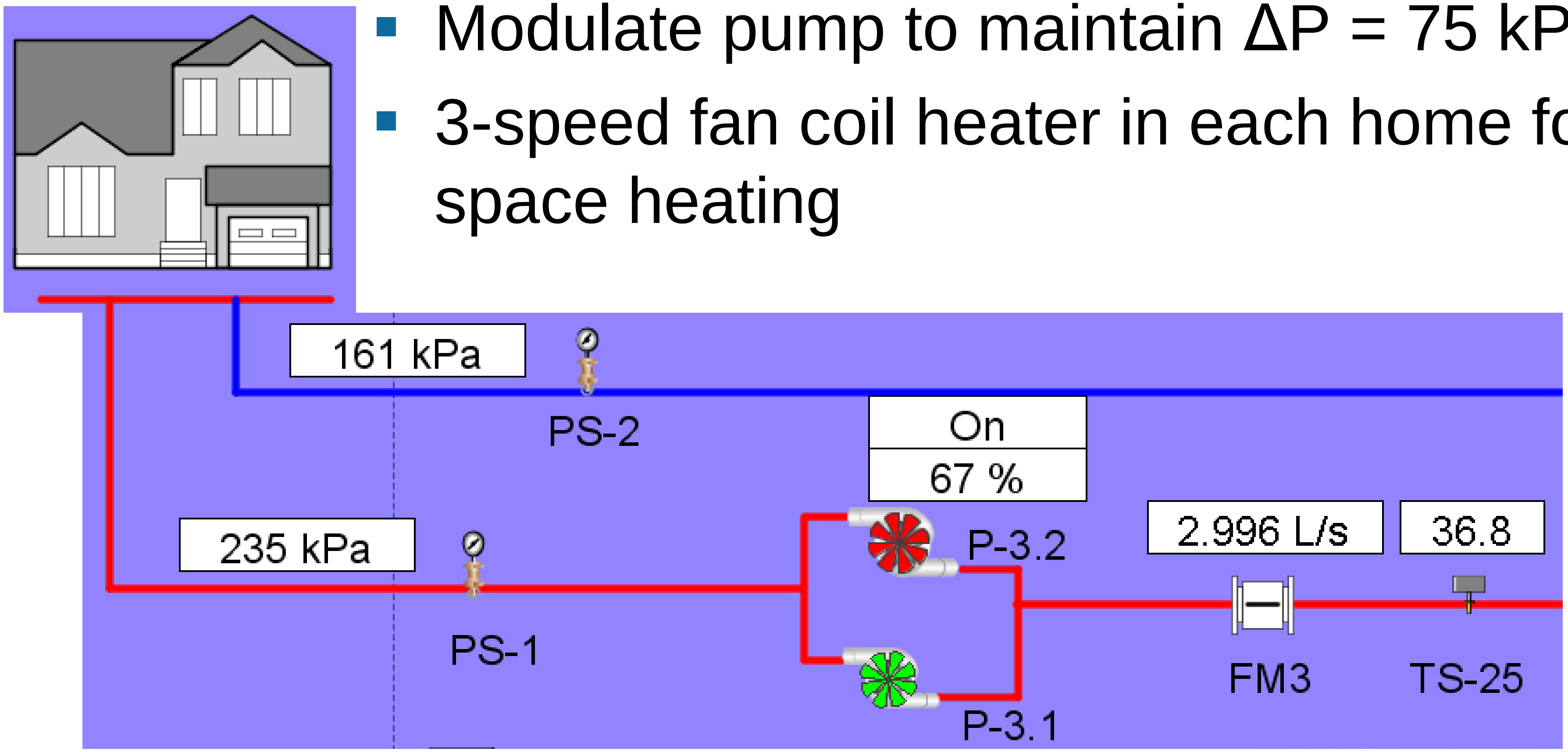
  Soil Volume: 33,700 m^3
  Water Equiv: 15,800 m^3

Solar collector loop controls

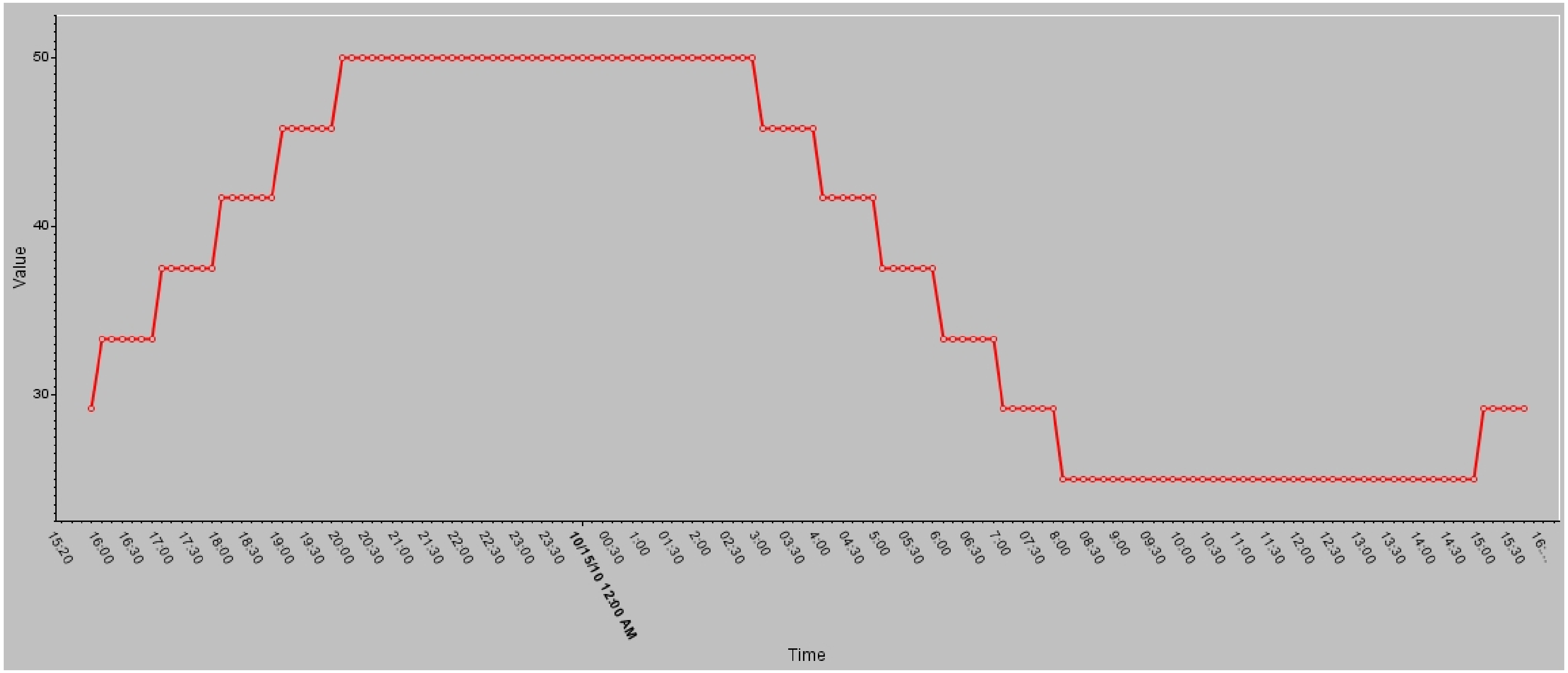
- Flow modulated using VFD drive: T_{HX}(in – out) = 15°C
- Overheat protection provided by dry cooler on Energy Centre rooftop
- Power outage protection provided by PV powered battery backup system

District heating loop controls

- Modulate pump to maintain ΔP = 75 kPa
- 3-speed fan coil heater in each home for space heating



Storage Charge/Discharge controls depends on % Charge Required



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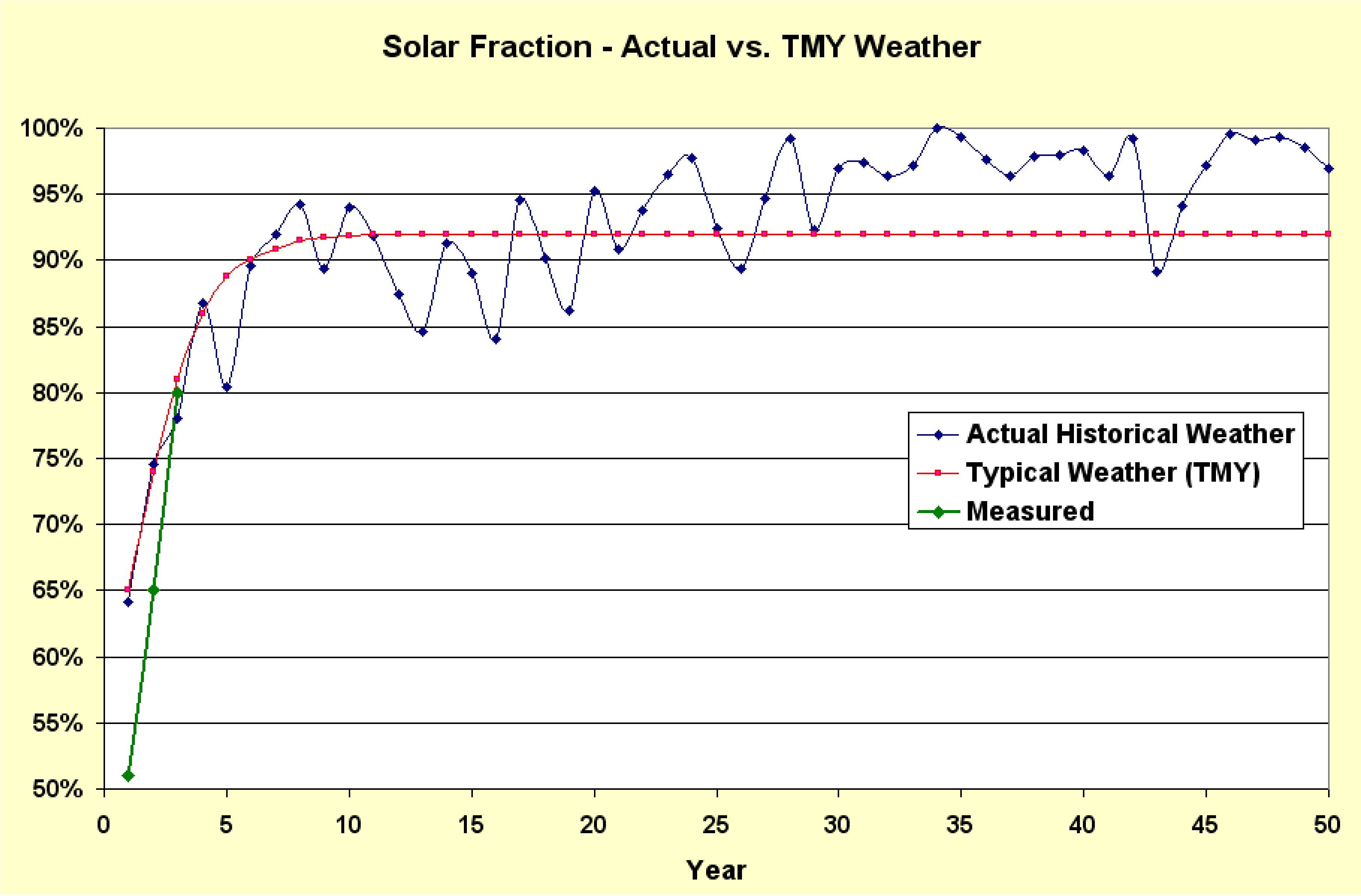
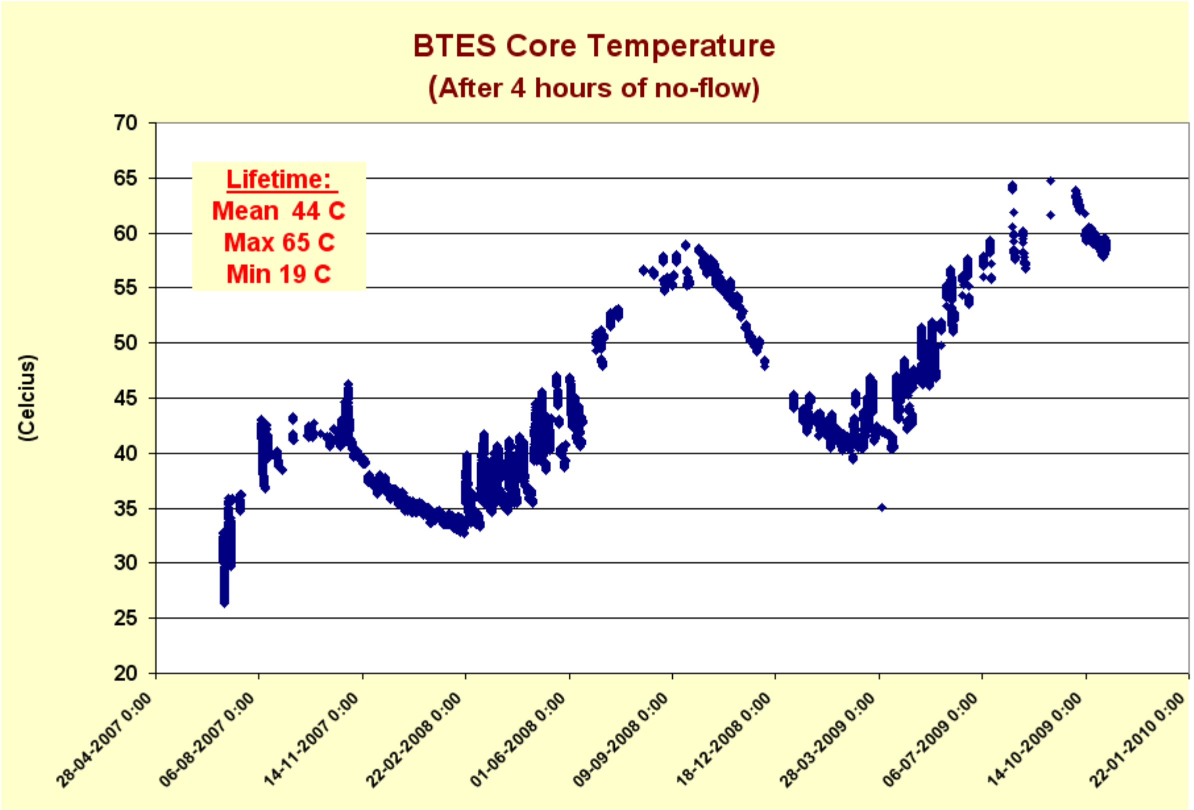
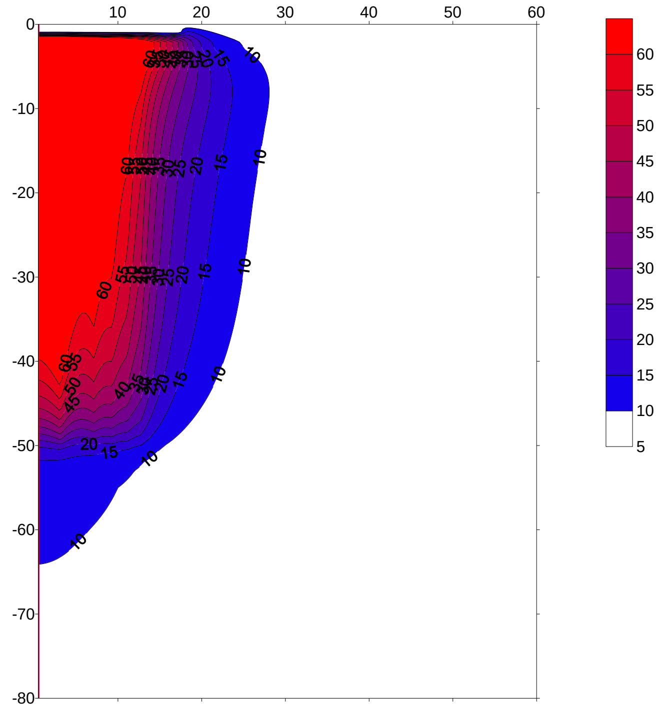
Solar Heating Performance



BTES Core Temperature





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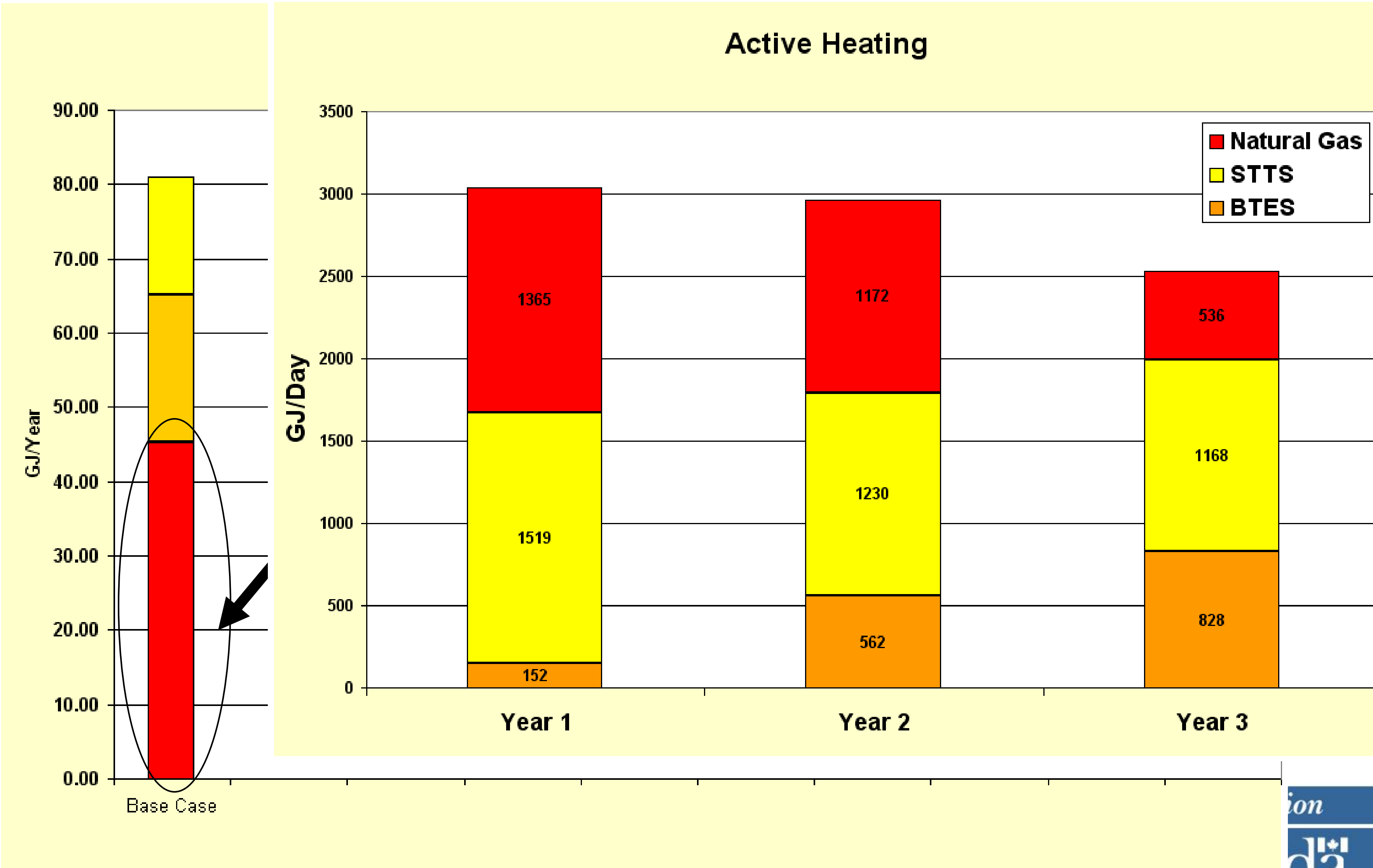
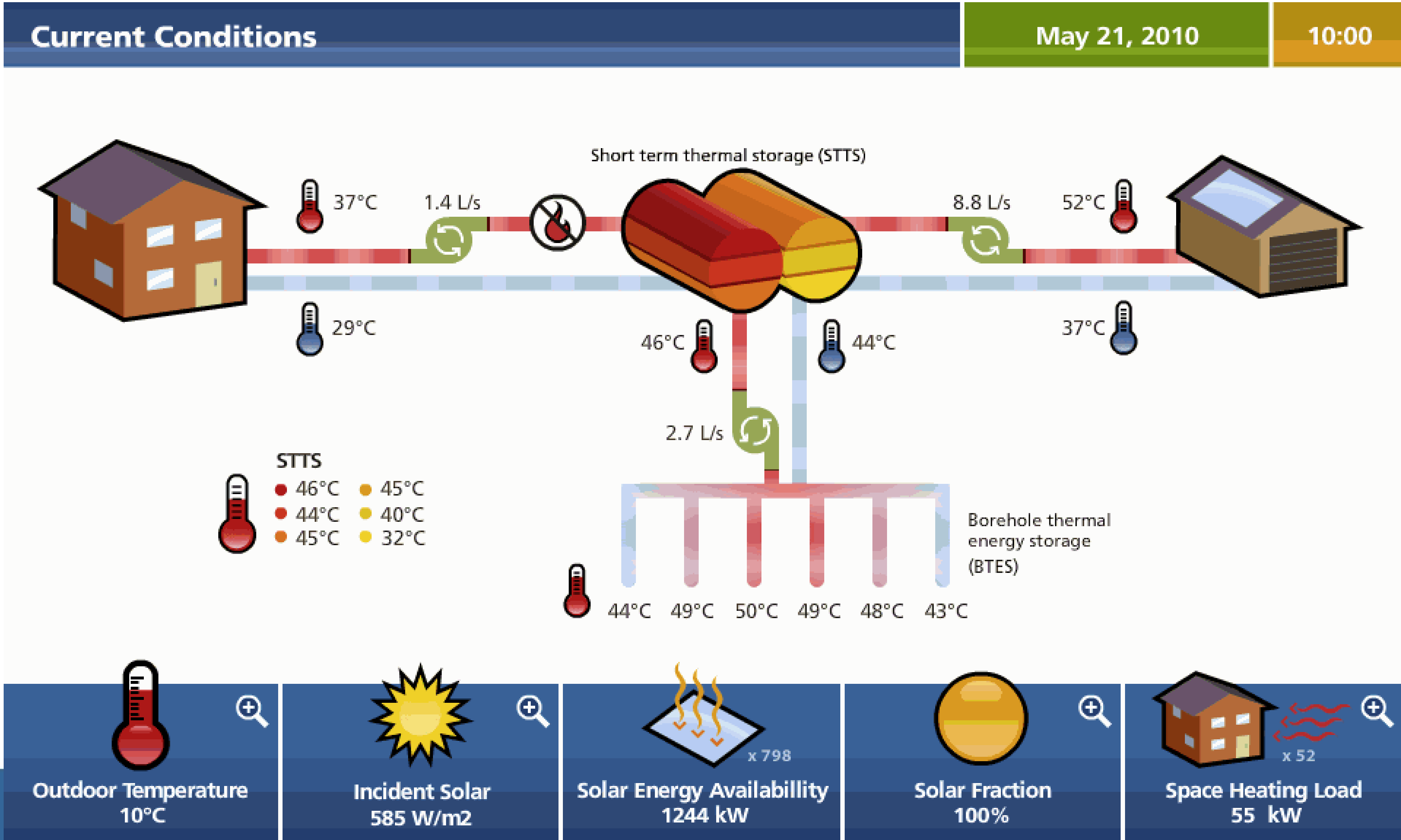
Space Heating Load – Active Portion



Recent Improvements

- Reduction in collector flow rate (20 C temp rise vs 15 C). Enhanced thermal storage stratification.
- Lower flow rates reduce electricity consumption (1/2 the flow, 1/8th the electricity).

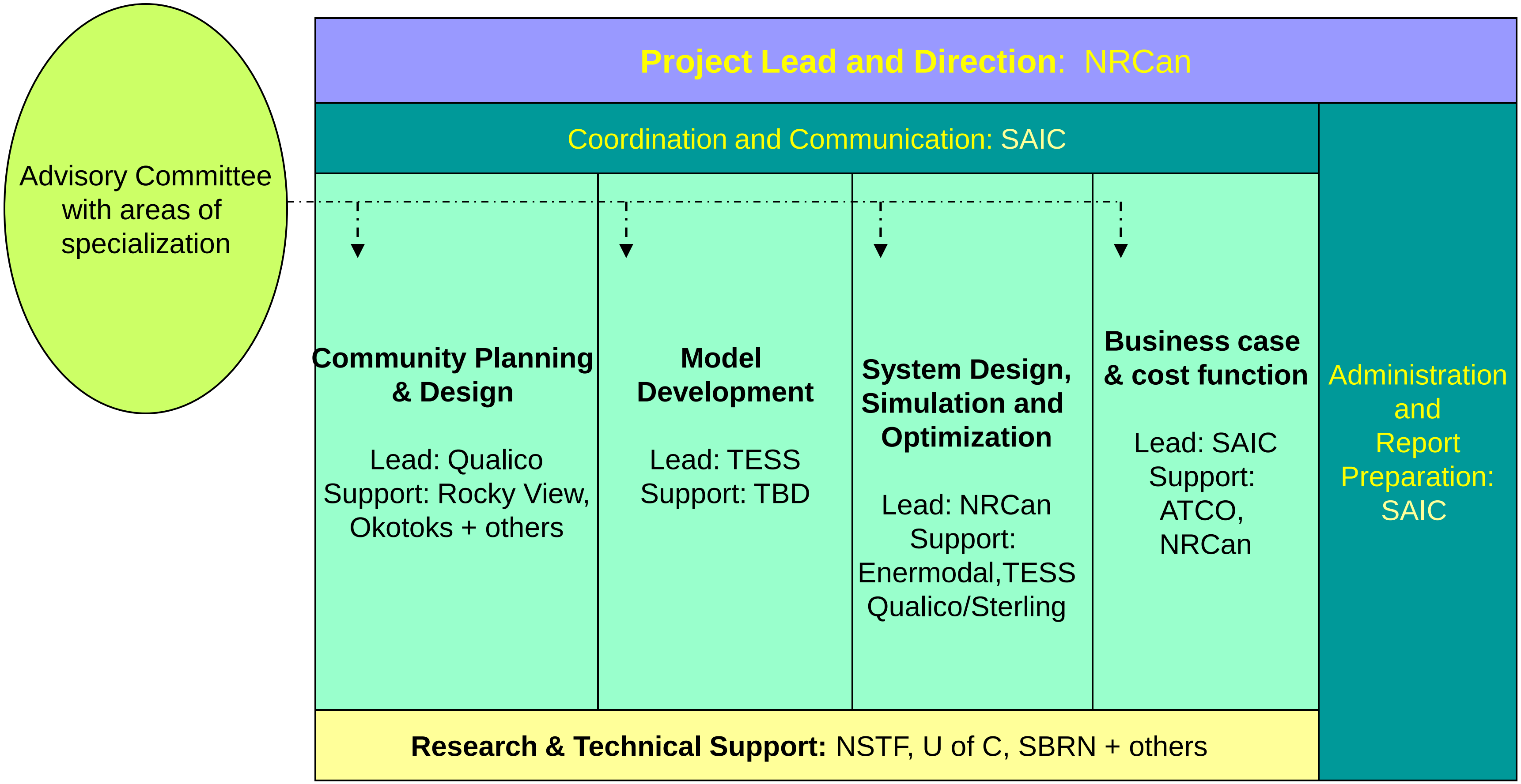
Visit dlsc.ca for live performance updated every 10 minutes



NRCan Activities for 2010/11

- Complete the year 4 DLSC monitoring & verification of system performance upgrades
- Evaluate and further optimize the DLSC system controls
- Begin research and design of a much larger scale DLSC community (up to 20 times larger)
- Goal is 40% solar cost reduction

Large Scale Study Team Structure



Feasibility Study Schedule

		2011												2012		
Task	Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Concept development															
2	System design & boundaries															
3	Model development															
4	Simulation and parametrics															
5	Cost determination & function															
6	Business case model & analysis															
7	Feasibility report and publications															

Preparation for Alberta CCEMC EOI

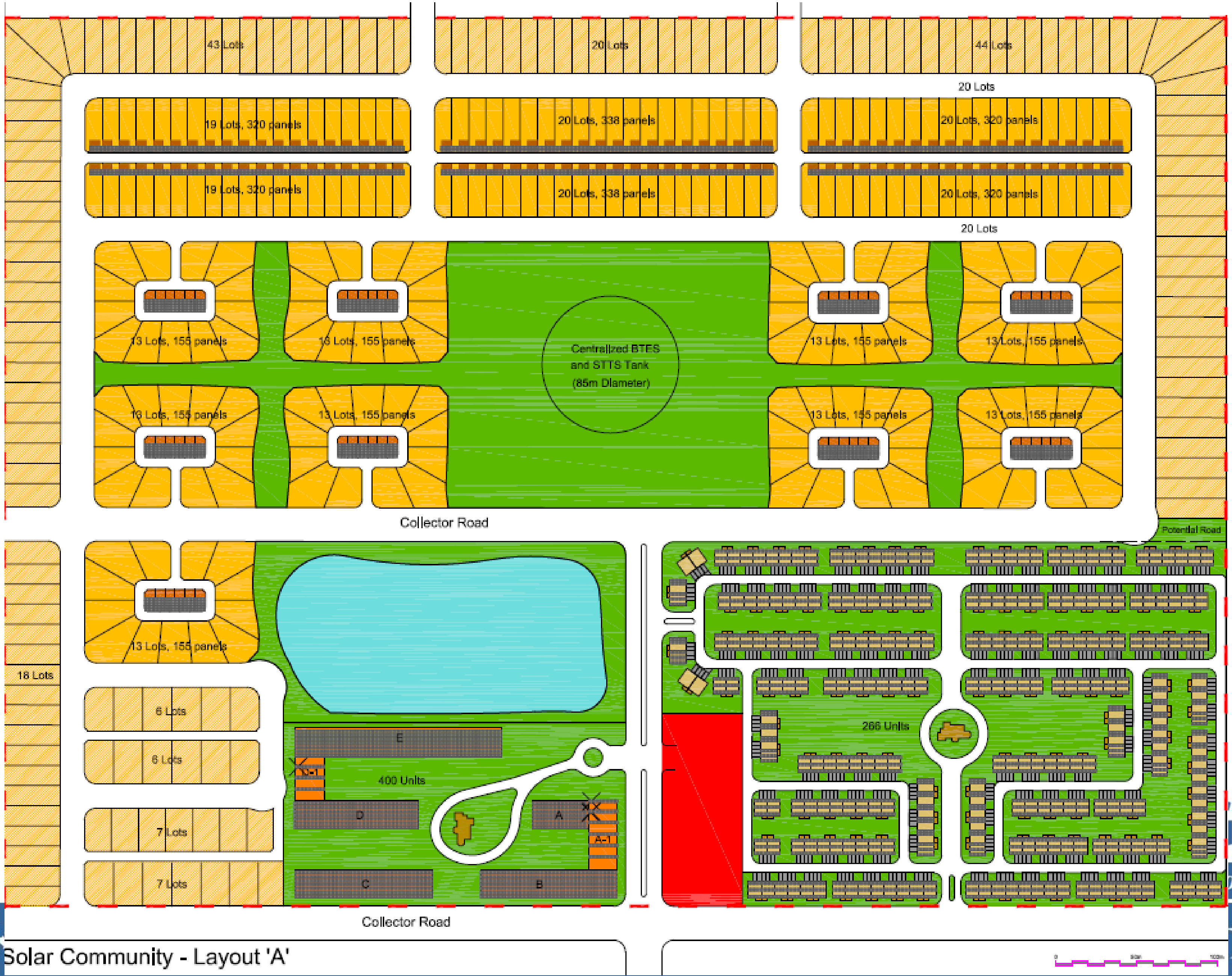
Alberta CCEMC EOI Application submission

Preliminary Implementation Schedule

	Year 1				Year 2				Year 3				Year 4				Year 5			
Description	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Detailed design																				
Engineering																				
Procurement																				
Phase 1 construction																				
Phase 1 commissioning																				
Phase 2 construction																				
Phase 2 commissioning																				
Phase 3 construction																				
Phase 3 commissioning																				

Earliest Year 1 of implementation could be 2013.
Site construction could start in late 2014 or early 2015.

+1000 Home Community Plan



TRNSYS Simulations

- 200 living unit pod
- Heating loads same as Drake Landing
- Solar fraction 92% - 93%
- Expand district loop and vary number of collectors, number of boreholes and volume of STTS

Achieving 92% - 93% Solar Fraction

Comparison with 4 times Drake Landing :

- 2800 vs. 3192 collectors (12.3% reduction)
- 432 vs. 576 boreholes (25% reduction)
- 600 vs. 960 m3 STTS (37.5% reduction)

Options

Collectors	Boreholes	STTS Volume (m3)
2800	432	600
2800	504	480
2800	576	240

Reduced Heat Load

- Heating loads 35% less than Drake Landing
- Solar fraction 91%

Comparison with 4 times Drake Landing :

- 2000 vs. 3192 collectors (37.3% reduction)
- 288 vs. 576 boreholes (50% reduction)
- 360 vs. 960 m3 STTS (62.5% reduction)

Initial System Sizing Estimates

- 30,000 m2 solar thermal collectors
- 85 m diameter centralized BTES field
- 20 MWth peak output

Thank you !

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