Drainage Capabilities & Heat Loss of Different Inverted Roof Assemblies

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MORRISON HERSHFIELD

Project Sponsors

Homeowner Protection Office
Branch of BC Housing

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Building Solutions

Introduction

- Why is this project being completed?
  - Different theories regarding drainage
  - Different opinions regarding impact on roof heat loss
  - Previous studies for inverted roofs
- What are we doing?
  - Controlled experiment to simulate and measure impact of different conditions

Objectives

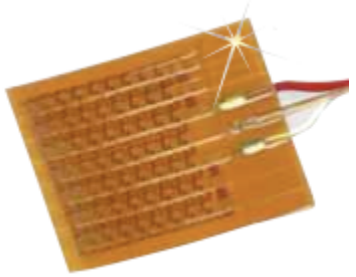
1. Impact of different assemblies on drainage at membrane level or insulation level

2. Impact on the thermal performance during rain periods with different drainage scenarios

3. How significant is it and is it worth changing practice for various climates

Approach

1. Develop calibrated hot box
2. Install sensors to measure heat flow
3. Simulate various rainfall intensities and durations
4. Vary roof assembly drainage configurations



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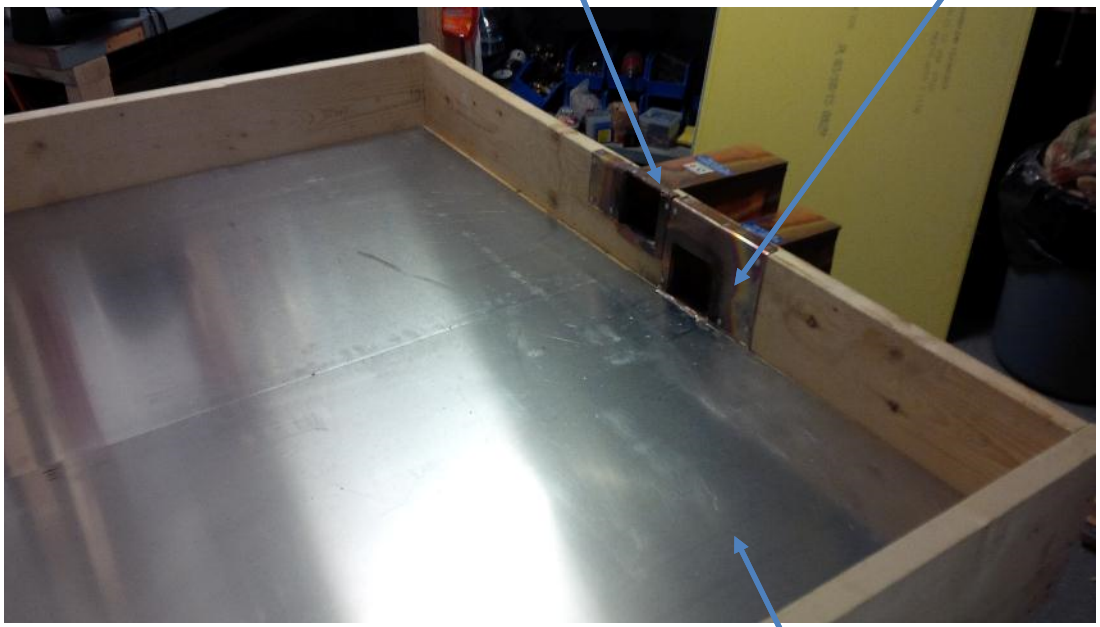
Instrumentation

Sensors

1. Air Temperature (inside and outside box)
2. Heat flux (W/m^2)
3. Surface temperatures
4. Water flow rates (in and out)
5. Water temperature (in and out)
6. Data Acquisition

Hot Box and Roof Construction



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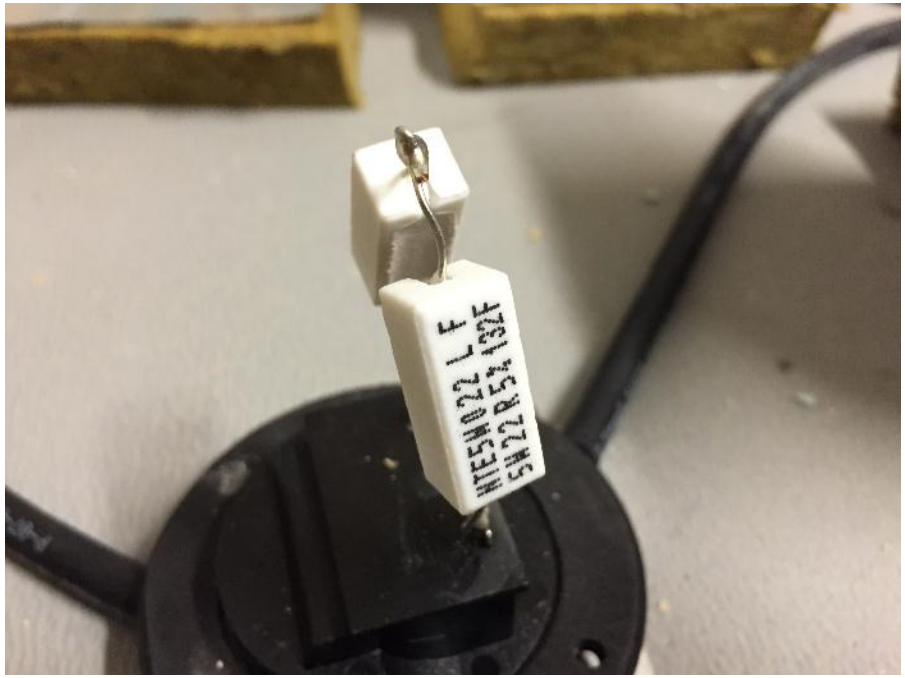
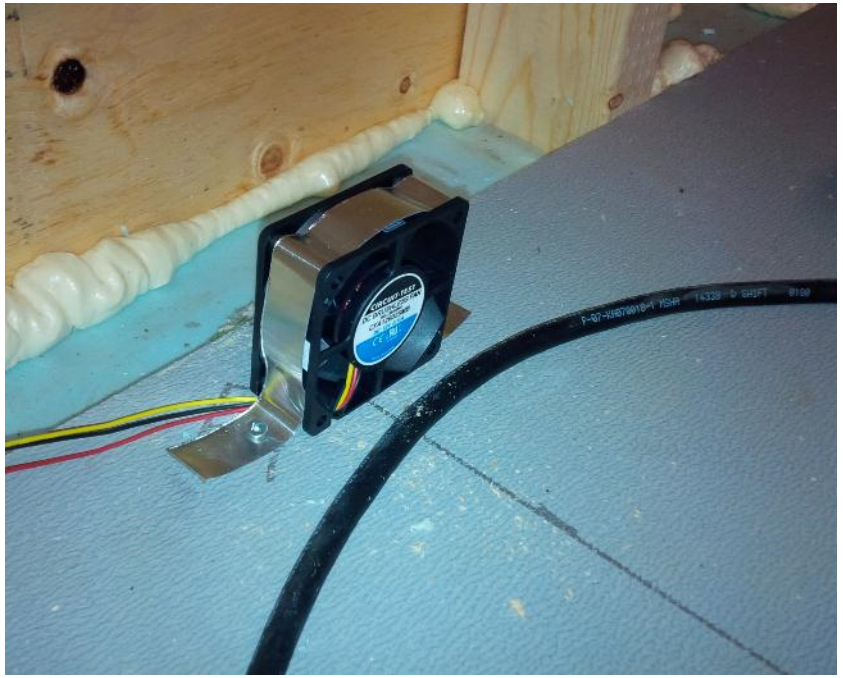
Supplying Heat



Resistor Heaters ~ 50W total



Circulation Fans

Sensor Installation

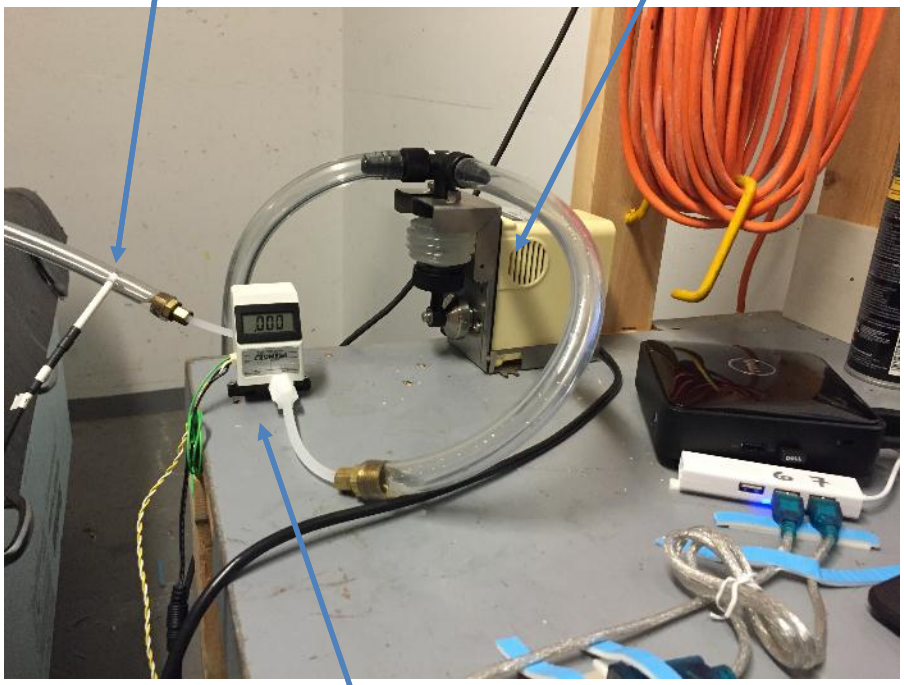
Heat Flux and Temp Sensors

Heat Shield

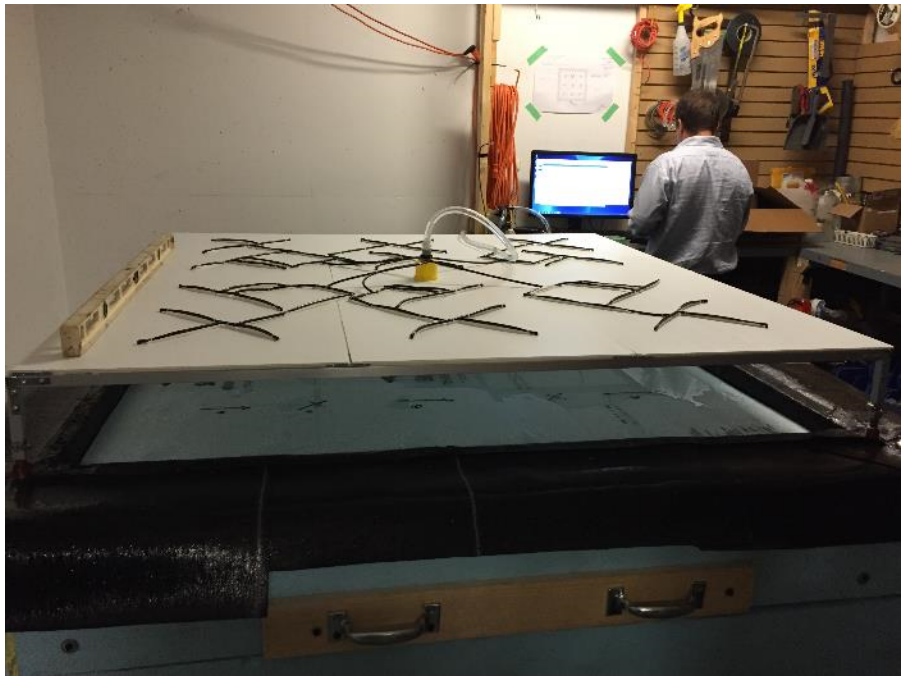
Rain Rack

Temp Sensor

Variable Speed Pump



Flow Meter



Rain Rack Set-up & Distribution

Rain Rack

36 Rain Nozzles

Edge Conditions

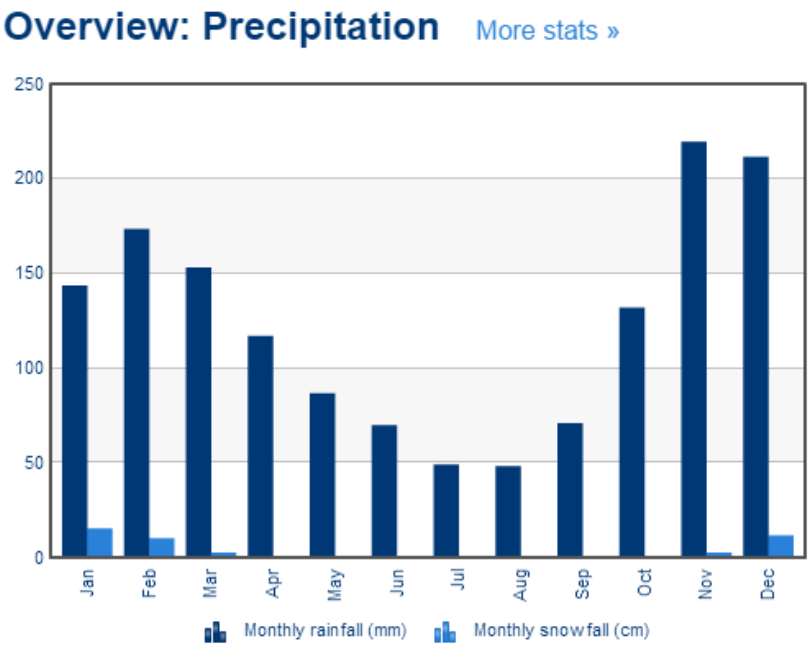
Water Collection

Measuring Volume

Setting Parameters

Rainfall Intensities

- Plan to vary intensity and duration
- Analyze climatic data
- Focus on 2mm/hr – 4mm/hr



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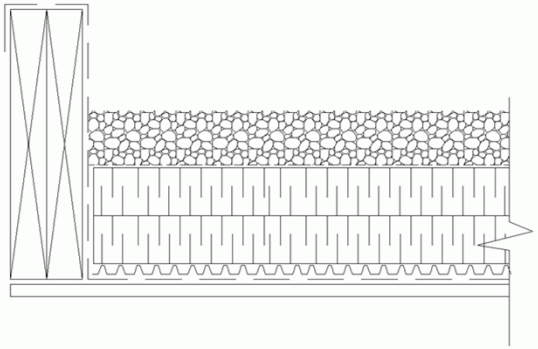
Varying Assemblies

Roof Assembly #1 – Typical Inverted Roof Assembly:
This assembly is commonly used in Vancouver by MH and is recommended by roofing and insulation manufacturers. This assembly will include the following:

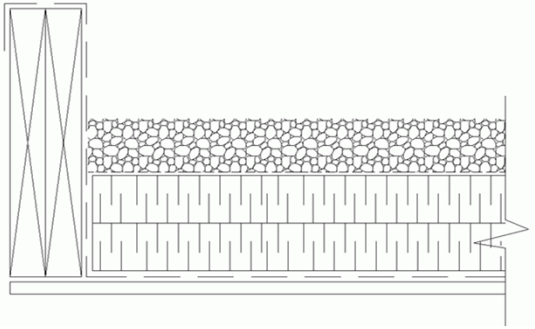
- Gravel ballast
- Filter fabric
- 4" Extruded type 4 Insulation
- Drainage mat
- 2-ply SBS membrane



Roof Assembly #4 – Typical Inverted Assembly with No Drainage Under Insulation:
This assembly will include the following:

- Gravel ballast
- Filter fabric
- 4" Extruded type 4 Insulation
- 2-ply SBS membrane

This assembly will be used as the control for the thermal performance comparison.

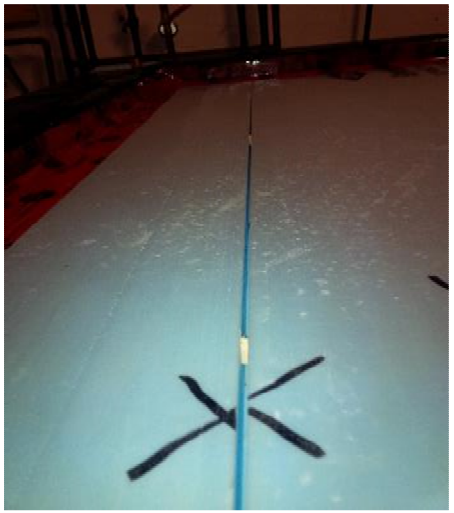


Testing Scenarios

	Drainage Mat		No Drainage Mat	
1/8" Gap	Board Orientation	Flow Rate	Board Orientation	Flow Rate
	Parallel	2, 3, 4 mm/hr	Parallel	2, 3, 4 mm/hr
	Perpendicular	2, 3, 4 mm/hr	Perpendicular	2, 3, 4 mm/hr

No Gaps	Board Orientation	Flow Rate	Board Orientation	Flow Rate
	Parallel	2, 3, 4 mm/hr	Parallel	2, 3, 4 mm/hr
	Perpendicular	2, 3, 4 mm/hr	Perpendicular	2, 3, 4 mm/hr

No Gaps		Flow Rate
	Weathermate	4 mm/hr



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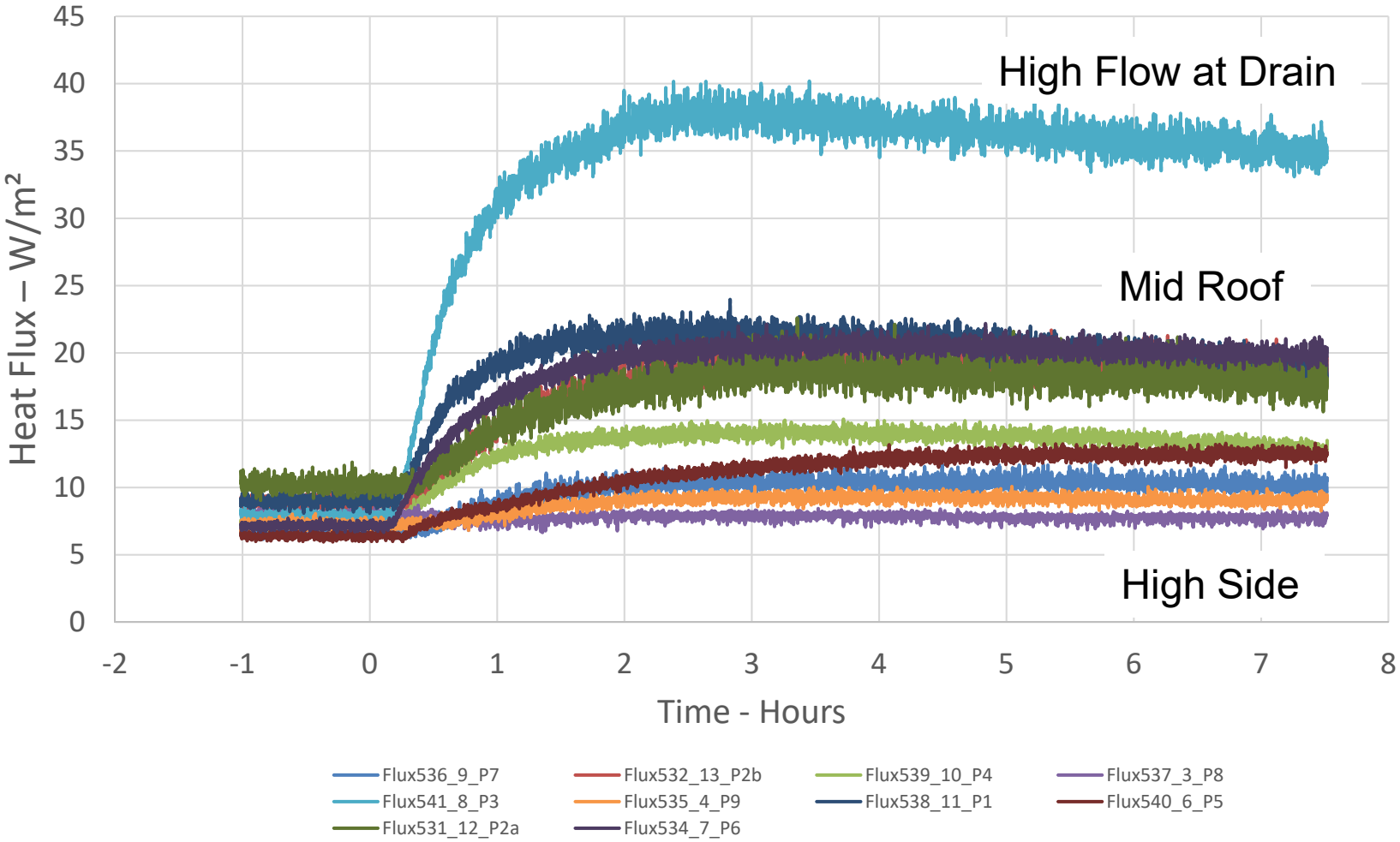
Heat Flux Results



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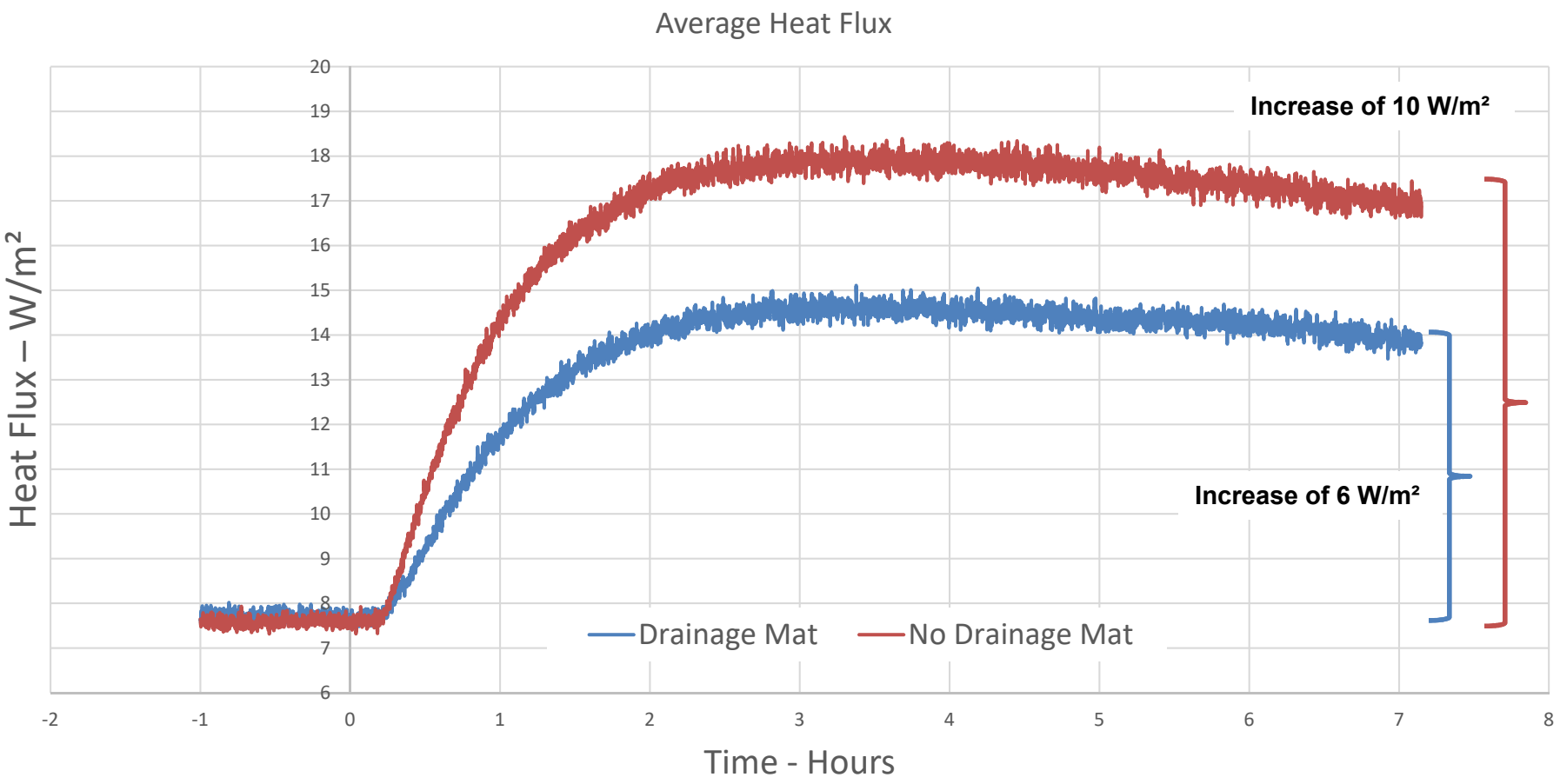
Drainage Mat vs. No Drainage Mat



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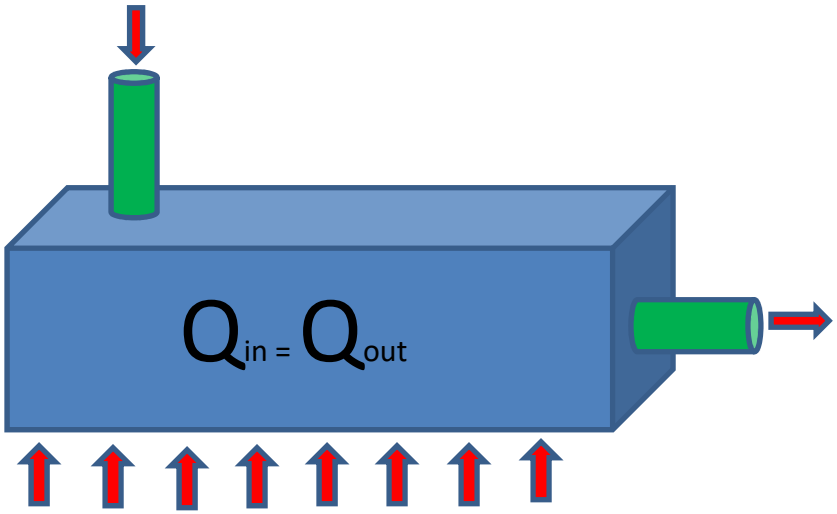
Testing Accuracy

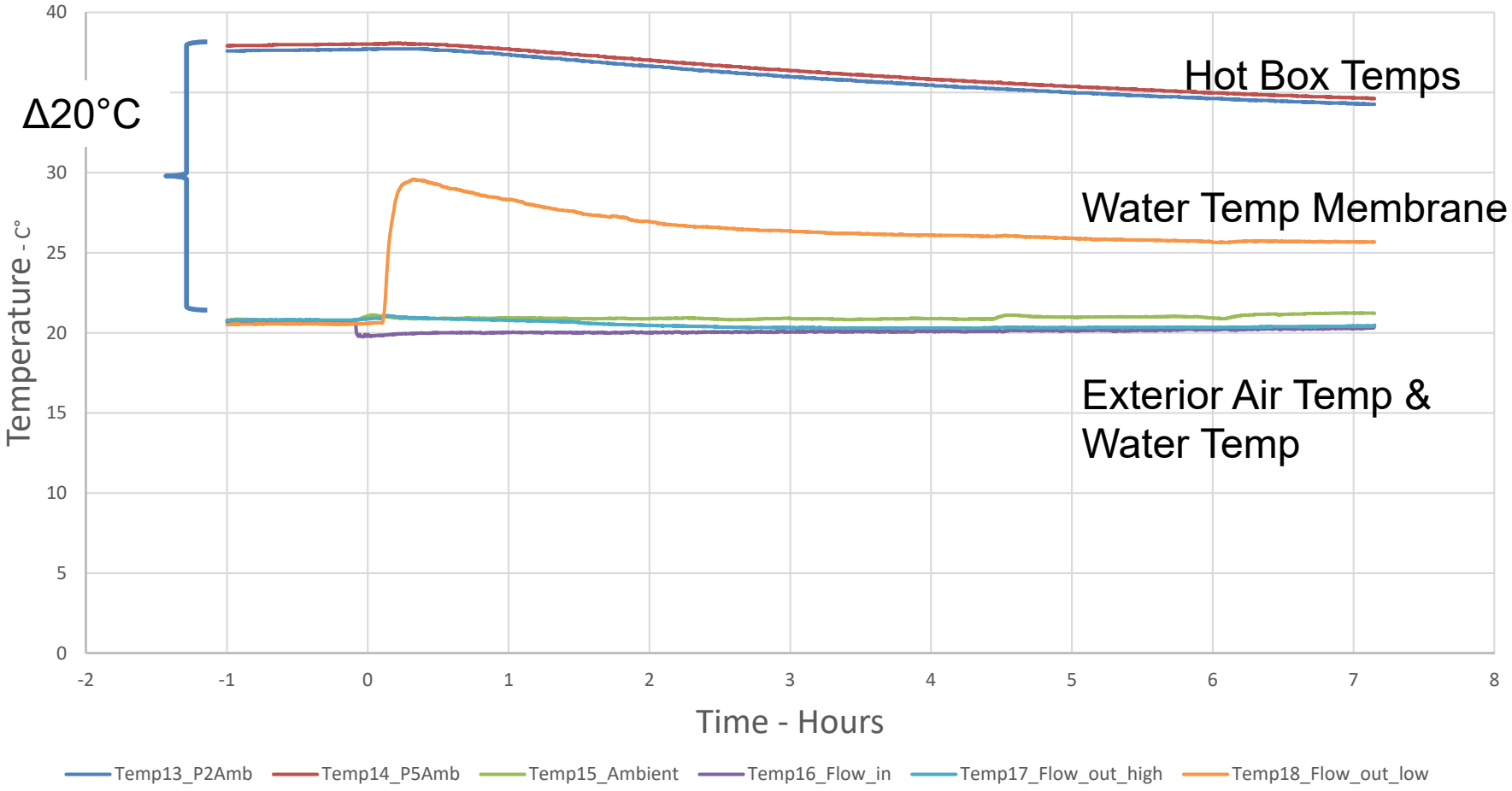
- Multiple re-tests to check repeatability
- Compared heat loss through roof assembly with water temperature increase
- Installed redundant sensors to confirm data



Findings – Vapour Permeable Sheet Membrane

- Vapour permeable membrane over insulation
- Leakage rate is negligible
- Change in Heat Flow is >10%

Temperatures



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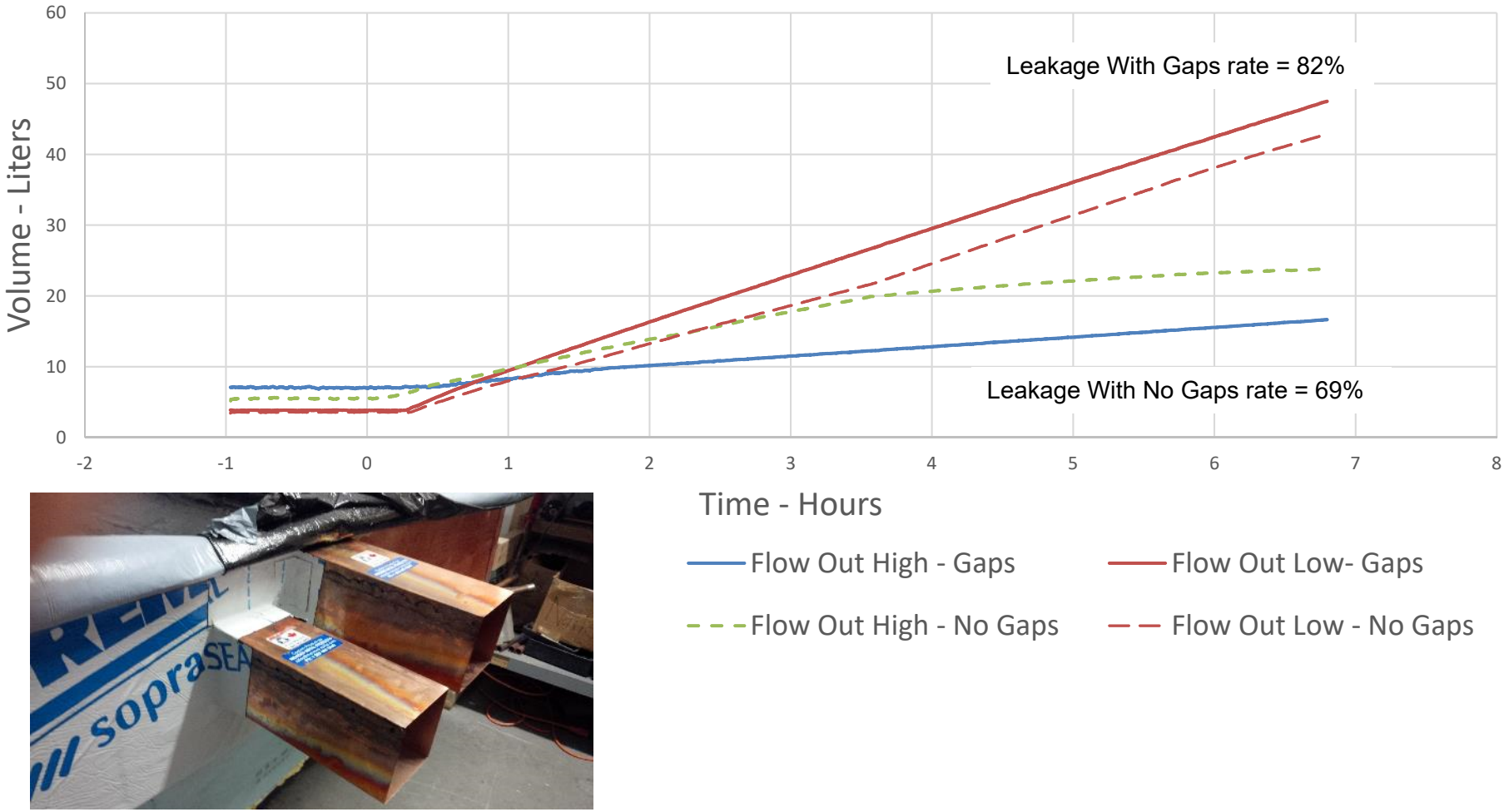
Leakage Rates



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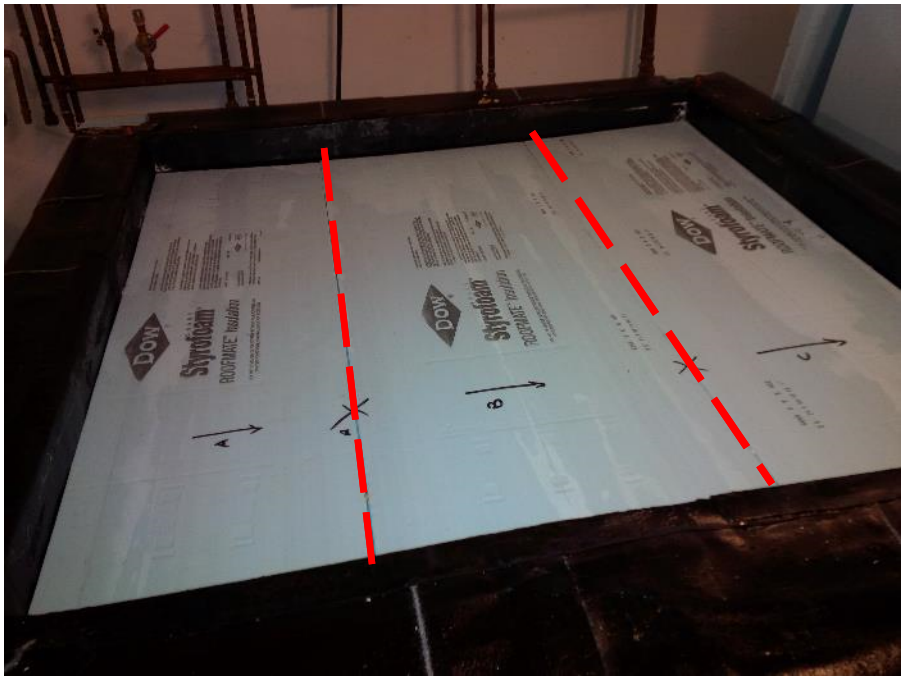
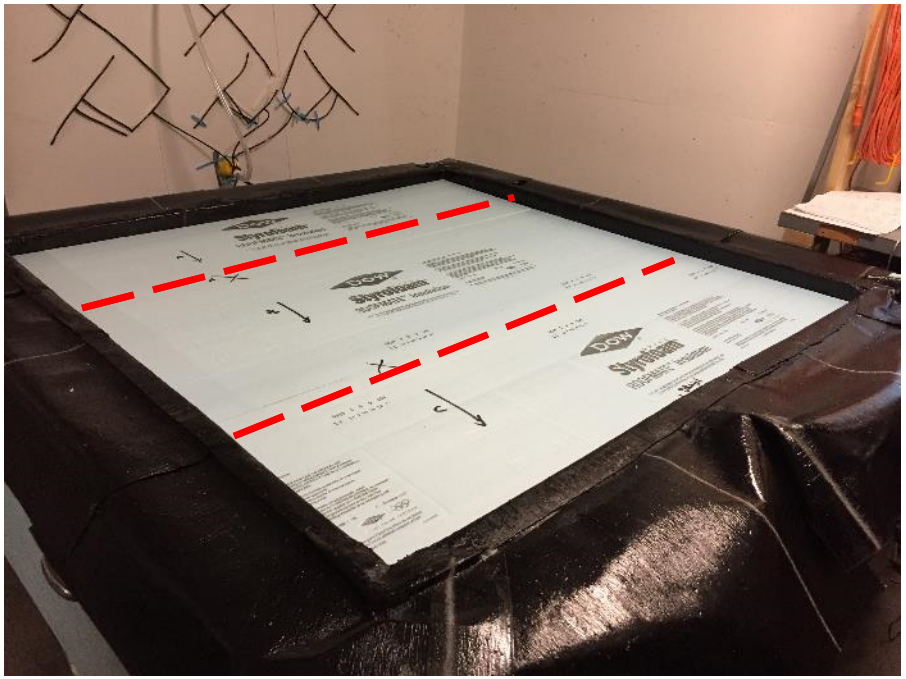
Insulation Orientation



Parallel Insulation
Change is Heat Flux ~ 69%



Perpendicular Insulation
Change is Heat Flux ~ 93%

Inverted Roof Heat Loss Testing

Heat Loss Factors in an Inverted Roof:

1. Water drainage (top of insulation and membrane)
2. Gaps in insulation (thermal or installation)
3. Insulation panel direction (perpendicular or parallel)
4. Drainage mat or No Drainage mat

Inverted Roof Heat Loss Testing

Why is Heat Loss Increased when insulation is installed directly to the roofing membrane?

Heat Loss Theories:

1. With no drainage mat the water is flowing directly on the roofing membrane

2. Raised edges at lap joints provides drainage paths under the insulation

3. With a solid core drainage mat the water is flowing over the surface of the drainage mat

SBS lap joint

Inverted Roof Heat Loss Testing

Summary of Findings:

1. Installing a vapour permeable secondary membrane over the insulation
2. Installing a **solid core** drainage mat under the insulation
3. Install insulation panels with tight joints and staggered layers of insulation

Inverted Roof Heat Loss Testing

Outcomes and Future Work

- Using a filament drainage mat under the insulation
- Use a monolithic membrane
- Compare to other climates
- Grooved insulation
- Test different roof slopes
- Relate to capital costs, operating costs and energy consumption

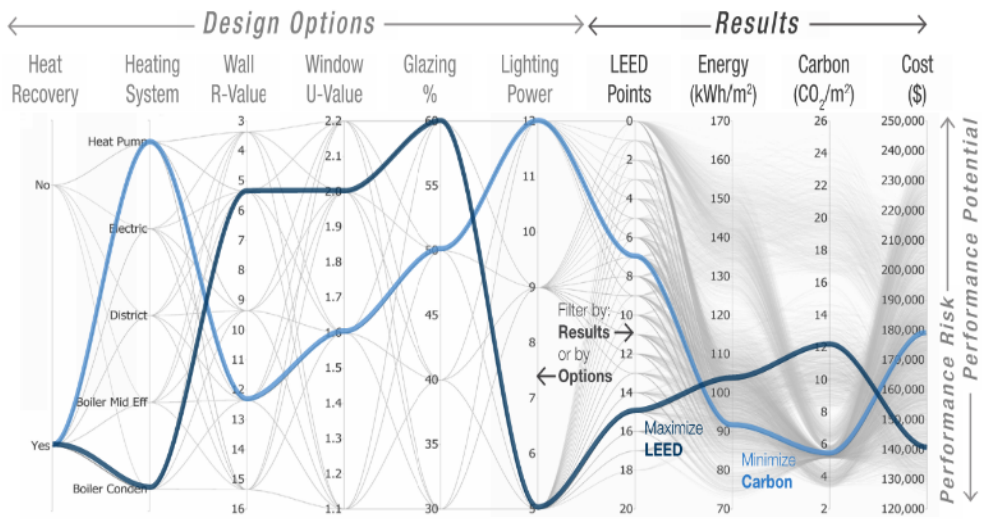


Figure 2 Building Performance Map effectively communicates design criteria alongside simulation results to architects, engineers, owners, and policy makers. Two discrete simulations (design option scenarios) have been highlighted in blue showing relative performance in the context of thousands of other possibilities.

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Thank You