USING OPTIMISATION SOFTWARE IN SUPPORT OF BUILDING CODE DEVELOPMENT

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BC Step Code

ENERGY STEPCODE
BUILDING BEYOND THE STANDARD

Step Level	Energy Modelling	Airtightness	Equipment and Systems	Envelope
Step 1 Enhanced Compliance (BC Building Code Performance)	Required	No target	BCBC is using 9.36.5 OR ERS v15 ref. house (MEUI of 80 kWh/m^2/yr is likely, but not required)	Report on TEDI and PTL (TEDI 50 kWh/ m^2/yr is likely, but not required)
Step 2 10% Beyond Code	Required	3.0 ACH_{50}	10% better than ERS v15 ref. house OR MEUI – 60 kWh/m^2/yr	TEDI – 45 kWhm^2/yr OR PTL – 35 W/m^2
Step 3 20% Beyond Code	Required	2.5 ACH_{50}	20% better than ERS v15 ref. house OR MEUI – 45 kWh/m^2/yr	TEDI – 40 kWh/m^2/yr OR PTL – 30 W/m^2
Step 4 40% Beyond Code	Required	1.5 ACH_{50}	40% better than ERS v15 ref. house OR MEUI – 35 kWh/ m^2/yr	TEDI – 25 kWh/m^2/yr OR PTL – 25 W/m^2
Step 5: 50%+ Beyond Code	Required	1.0 ACH_{50}	MEUI – 25 kWh/m^2/yr (no ERS option)	TEDI – 15 kWh/m^2/yr OR PTL – 10 W/m^2

Purpose:

Use energy and cost optimization to explore three primary questions about high performance housing

Home builders

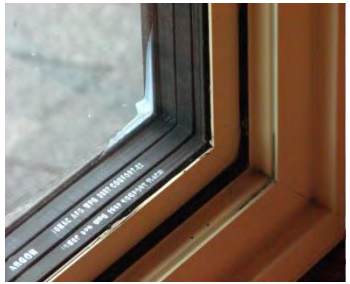
- What will it cost to build?

Home buyers

- What will it cost to own?

Legislators

- What can reasonably be achieved?



There are many ways
to improve energy performance.

Which ones are most cost effective?

.. and consider options together and the number of possible pathways grows exponentially

Component	Options	# of choices
Walls	R16, R18, R22, R24, R30, R40	6
Windows	3 double, 4 triple (U-1.8 to U-0.8)	7
Foundation walls	R11.3, R17, R20, R25	4
Under-slab ins.	R0, R11, R15, R20	4
Exposed floors	R26.5, R29, R35, R40	4
Attic	R40, R50, R60, R70, R80, R100	6
Air sealing target	3.5 ACH, 2.5 ACH, 1.5 ACH, 1.0 ACH, 0.6 ACH	5
DHW heating	Electric & gas tank, 2 x tankless, heat pump	5
Space heating	92% & 95% AFUE, combo, CCASHP	4
Drain water HR	None, 30%, 42%, 55%	4
HRV	None, 60%, 70%, 75% & 84% SRE	5
PV	None, 5 kWp, 8 kWp, 10 kWp	4
	Total number of possibilities	129,024,000

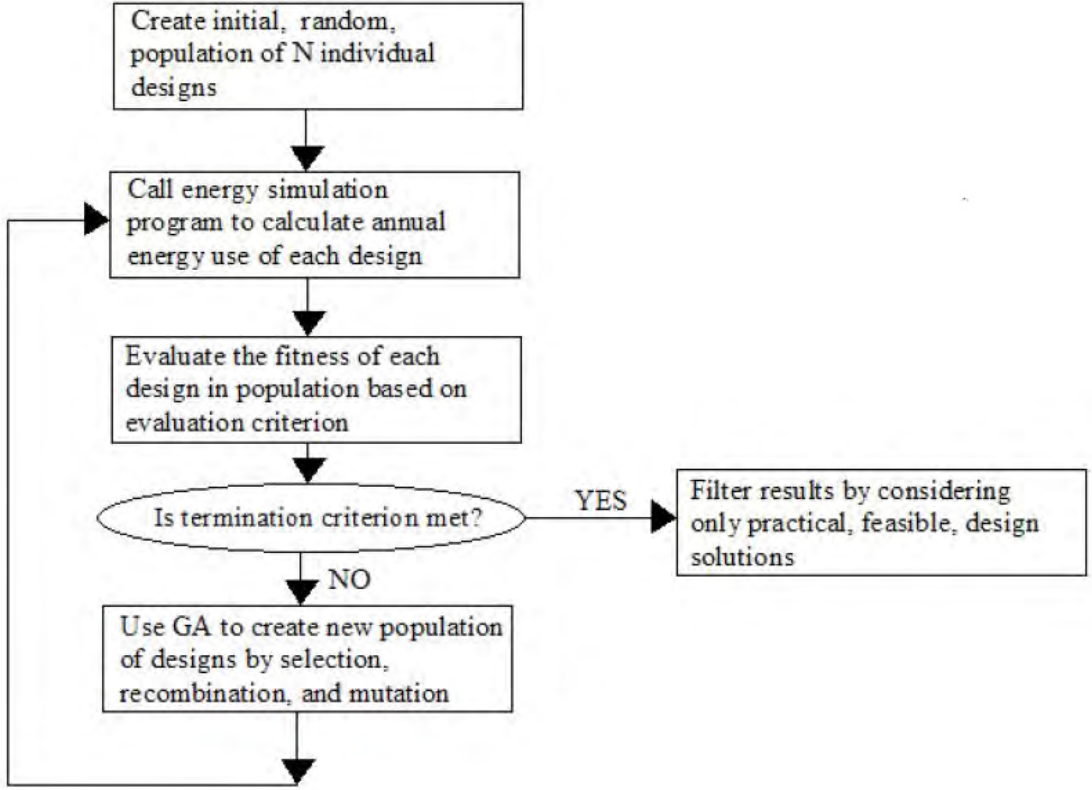
part 9 archetypes considered

- Laneway house (750 ft^2, 2 storeys, on slab on grade)
- Small single family (1,100 ft^2, single storey on heated crawlspace)
- Medium single family (2,550 ft^2, 2 storey with basement)
- Medium single family with complicated shape
- Large single family (5,500 ft^2, 2 storey with basement)
- Quadplex (5,526 ft^2, 1,382 ft^2/unit, 3 storey over underground parkade)
- 6-plex (same building as quadplex with 921 ft^2/unit)
- 6-unit row house (10,300 ft^2, 1,720 ft^2/unit, 3 storey over underground parkade)
- 11-unit row house (same building as 6-unit row with 936 ft^2/unit)
- 10 unit MURB (17,800 ft^2, 1,780 ft^2/unit, 3 storey over underground parkade)
- 20 unit MURB (same as 10 unit MURB with 890 ft^2/unit)

Climate Zones

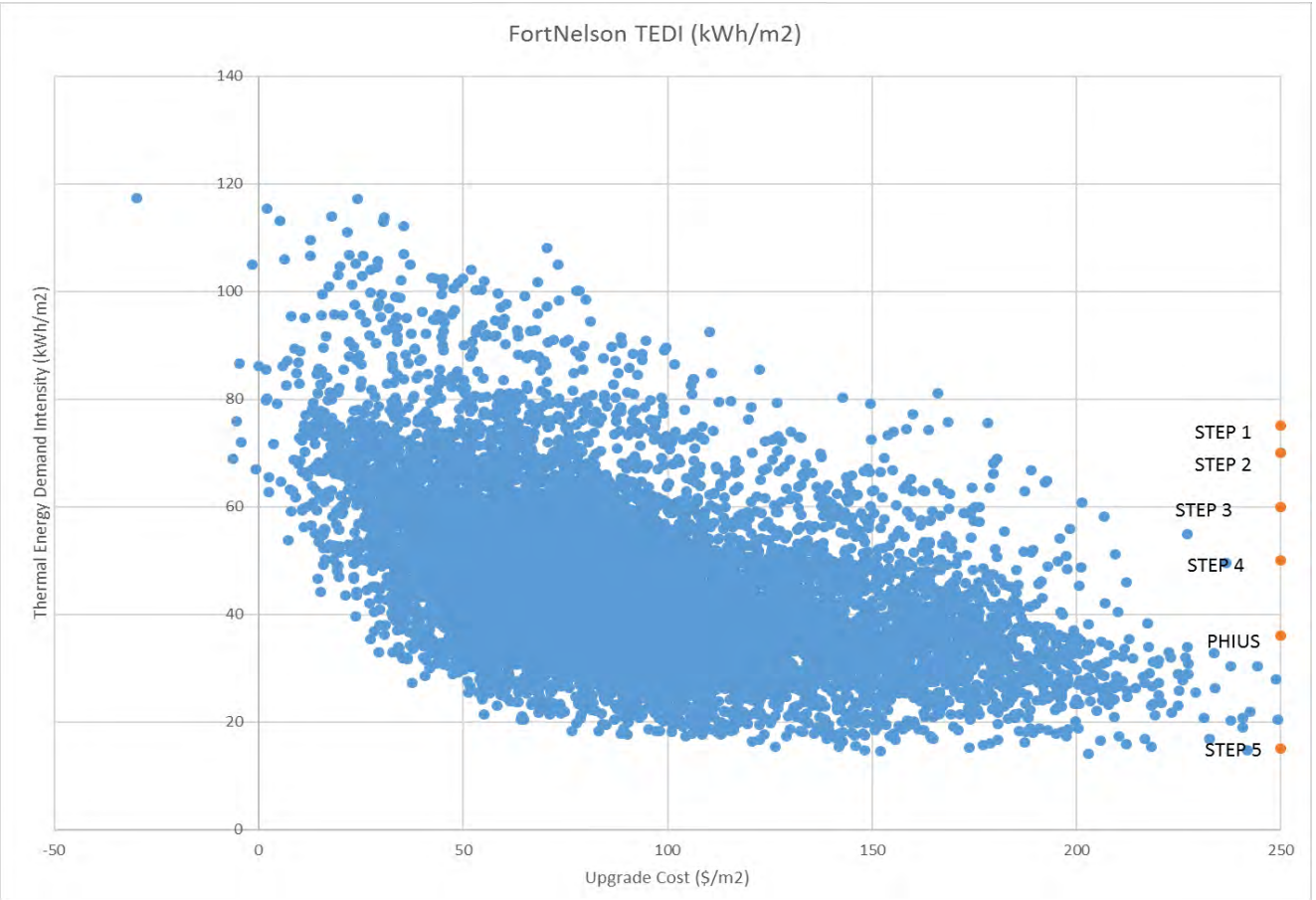
- Vancouver – 2,817 HDD
- Summerland – 3,350 HDD – HOT2000
- Cranbrook – 4,478 HDD
- Fort St John – 5,745 HDD
- Fort Nelson – 6,723 HDD
- Uranium City, SK (Zone 8) – 7,500 HDD – HOT2000

Optimization Tool Process

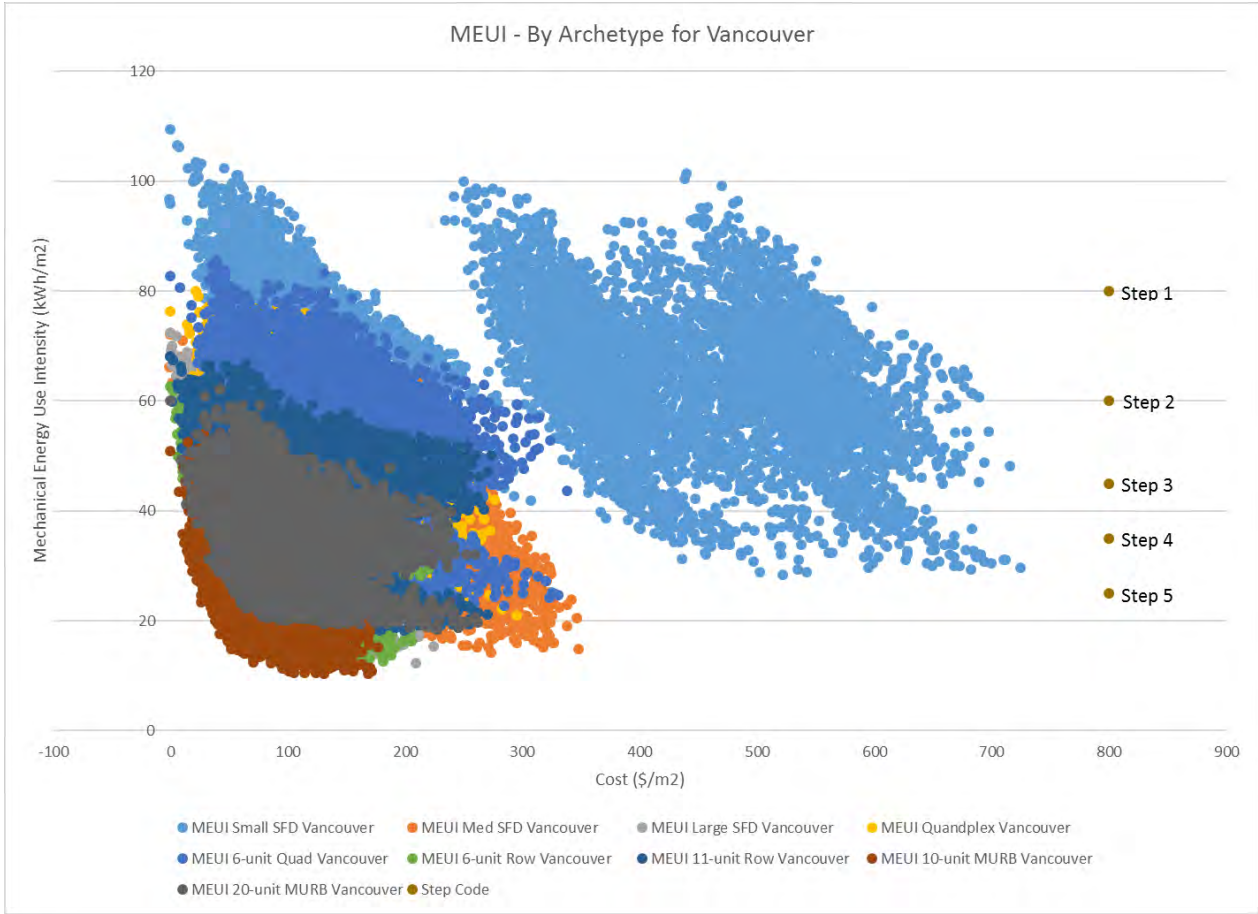


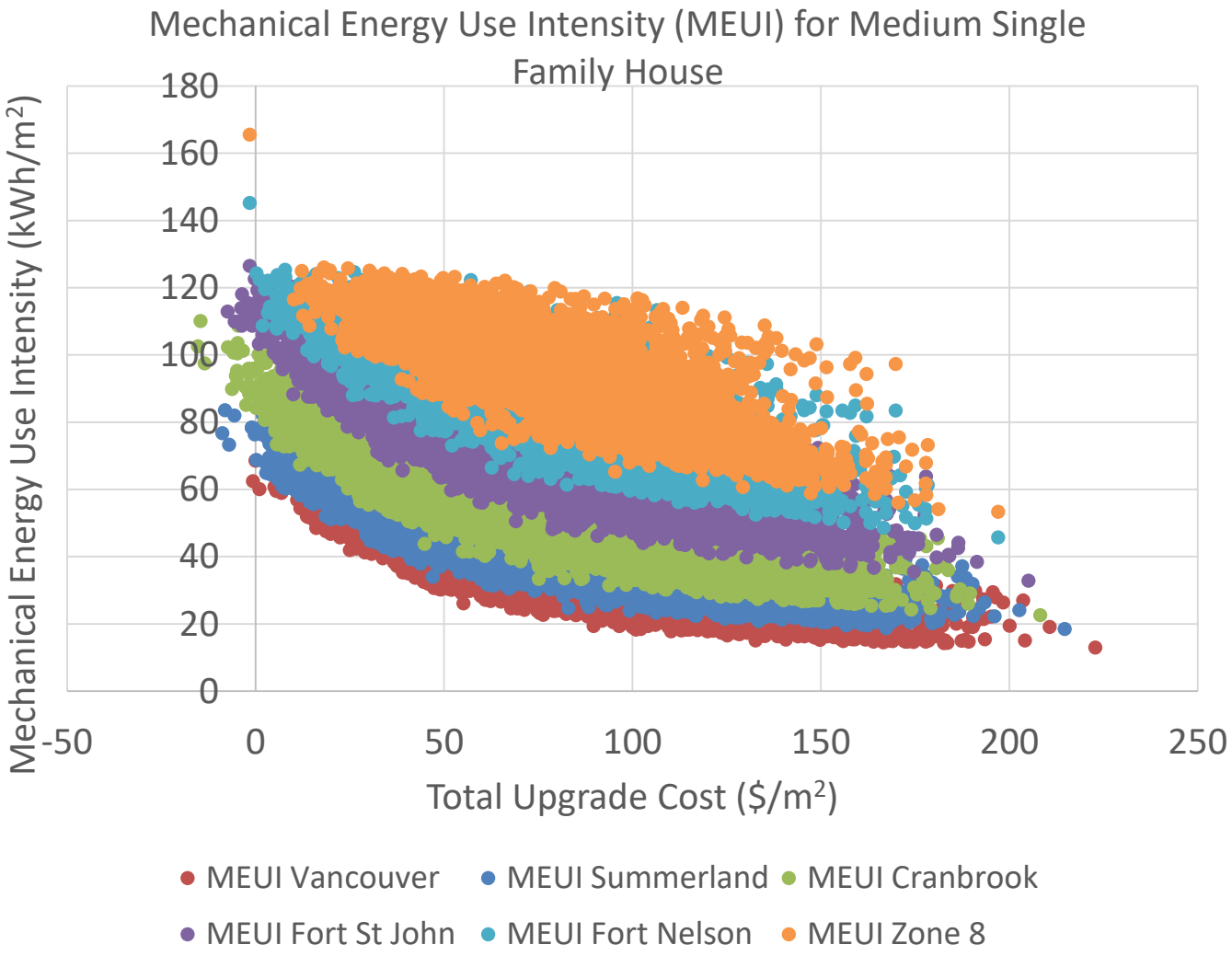
- From my Ph.D. thesis
  - Had used genetic algorithms for optimization
  - Similar for any type of optimization algorithm

Fort Nelson 11 Unit Row House

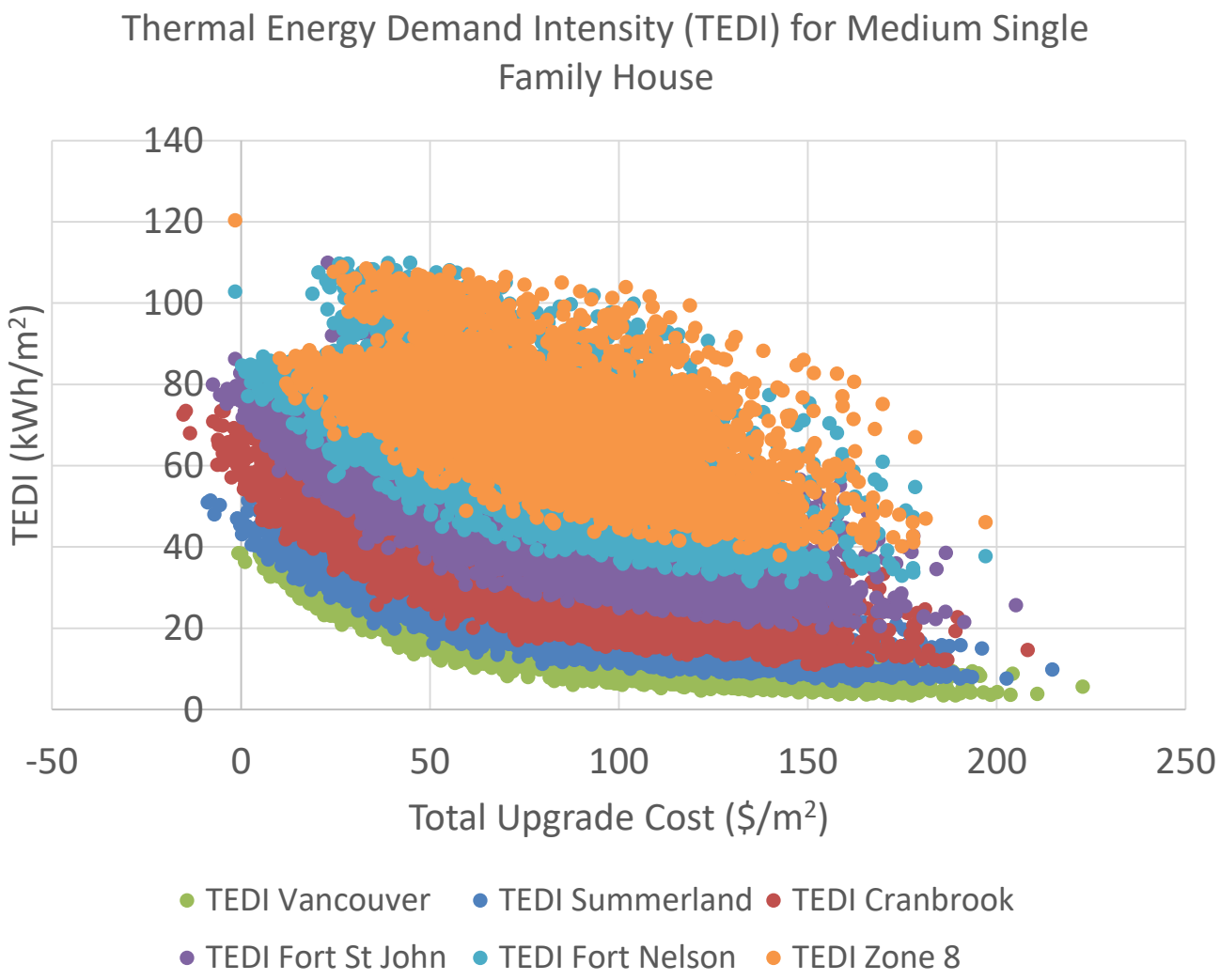


MEUI Impacted by Archetype

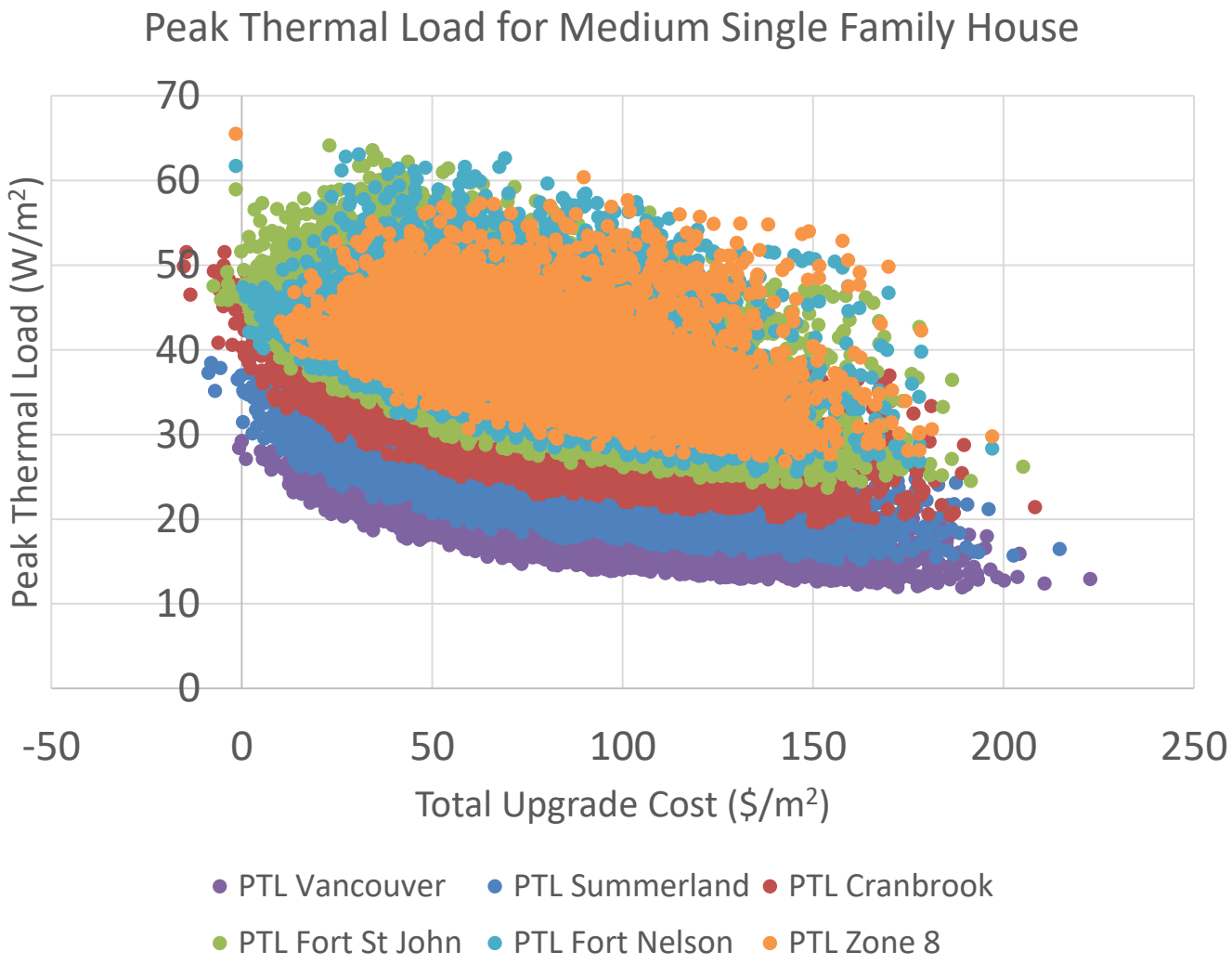




- Step 2 CZ 4: 60
  CZ 5: 90
  CZ 6-8: 100
- Step 3 CZ 4: 45
  CZ 5: 75
  CZ 6-8: 85
- Step 4 CZ 4: 35
  CZ 5: 45
  CZ 6-8: 55
- Step 5: 25 kWh/m²



- Step 2 CZ 4: 45
  CZ 5: 60
  CZ 6-8: 70
- Step 3 CZ 4: 40
  CZ 5: 50
  CZ 6-8: 60
- Step 4 CZ 4: 25
  CZ 5: 40
  CZ 6-8: 50
- Step 5: 15 kWh/m²



- Step 2 CZ 4: 35
  CZ 5: 55
  CZ 6-8: 55
- Step 3 CZ 4: 30
  CZ 5: 45
  CZ 6-8: 50
- Step 4 CZ 4: 25
  CZ 5: 40
  CZ 6-8: 45
- Step 5: 10 W/m²

Limitations of the Study

Limited to the archetypes studied

- Differences between 2-storey + basement to single storey

Limited to the upgrades considered

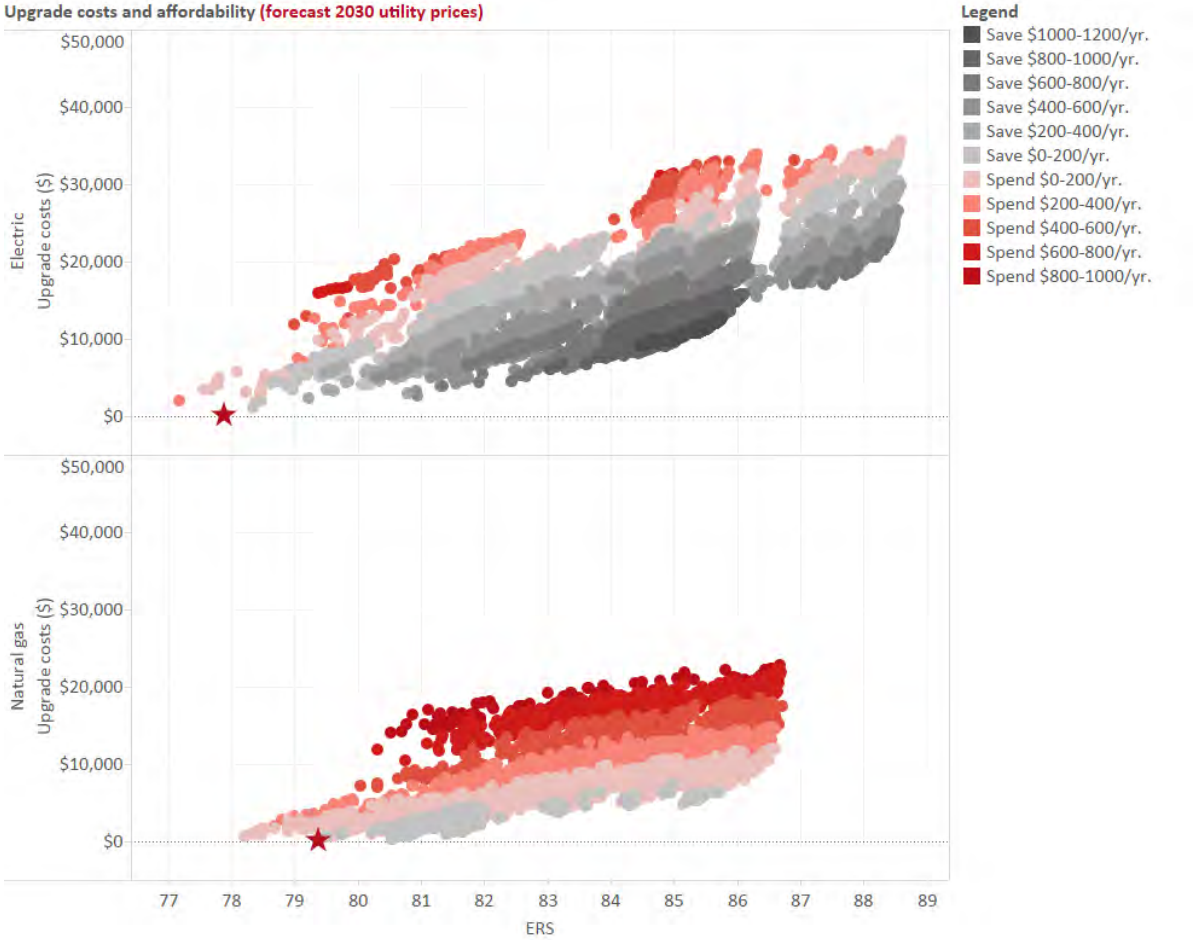
Only ~0.008% of combinations evaluated

Limited to orientation considered (East & North)

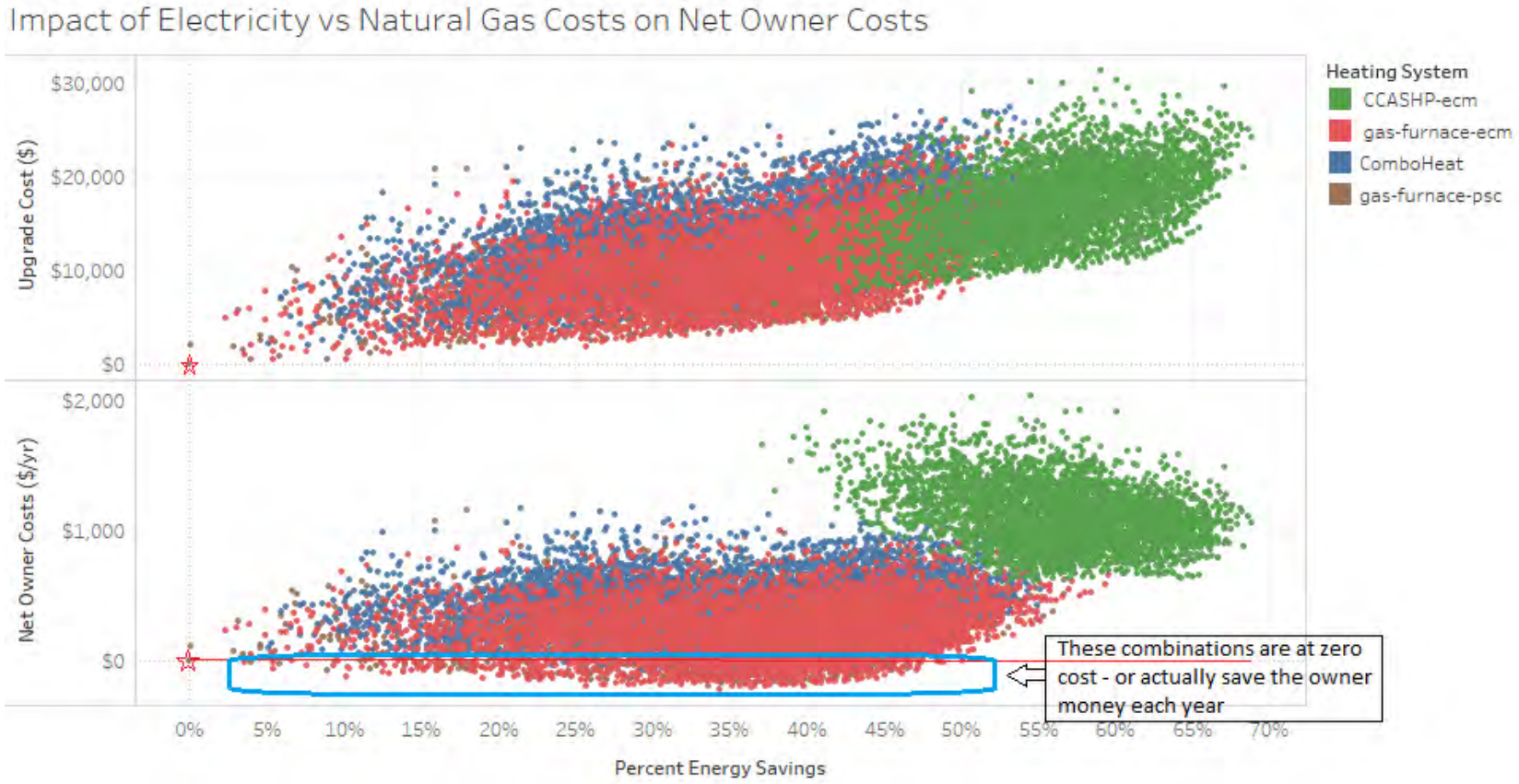
Visualization of Large Data Set

- Optimization creates a large data set
- A lot of analysis can be derived from the data
- Different visualization techniques can be implemented to better draw out trends
- Machine learning could be applied to dataset to create other predictive tools

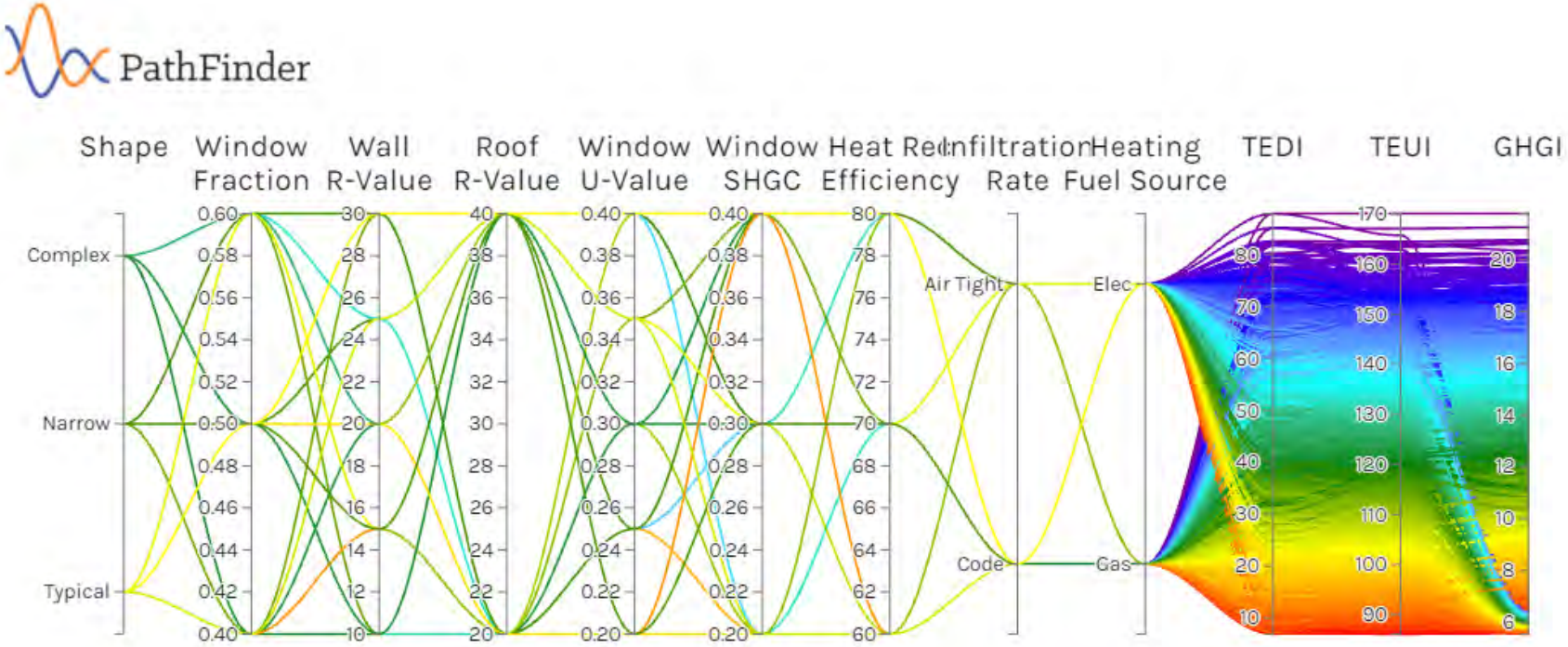
Visualization used in LEEP Using Tableau



Colouring Different ECMs



Building Pathfinder



www.buildingpathfinder.com/launch/

More Information

- Results of the overall Metrics Research study are posted at: www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/energy-efficiency/energy-step-code/resources

Thank You

- Questions: rcharron@nyit.edu