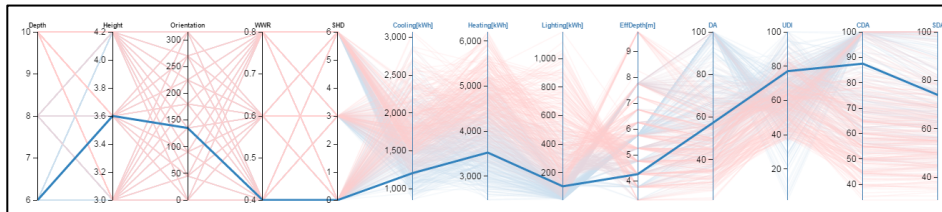




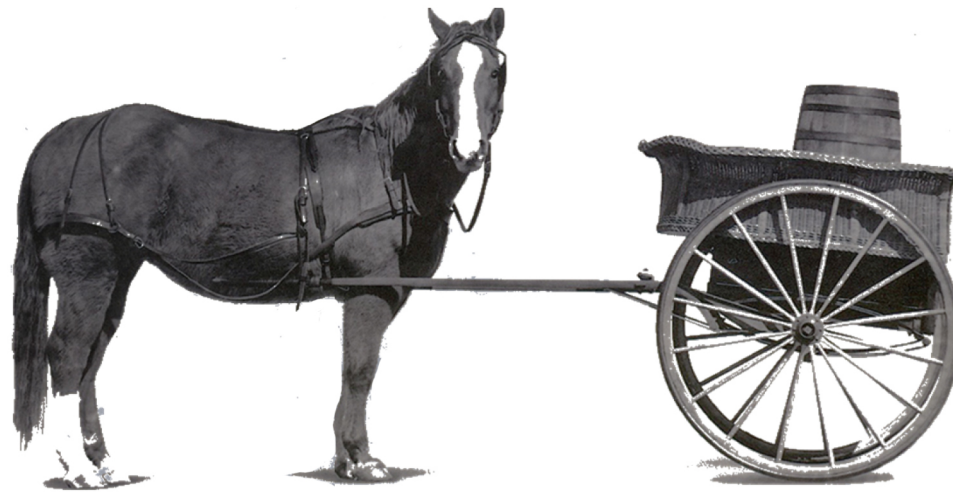
## **Parametrics & Passive House Analytics**

What's next – bringing parametric modeling  
and data visualization to WUFI Passive

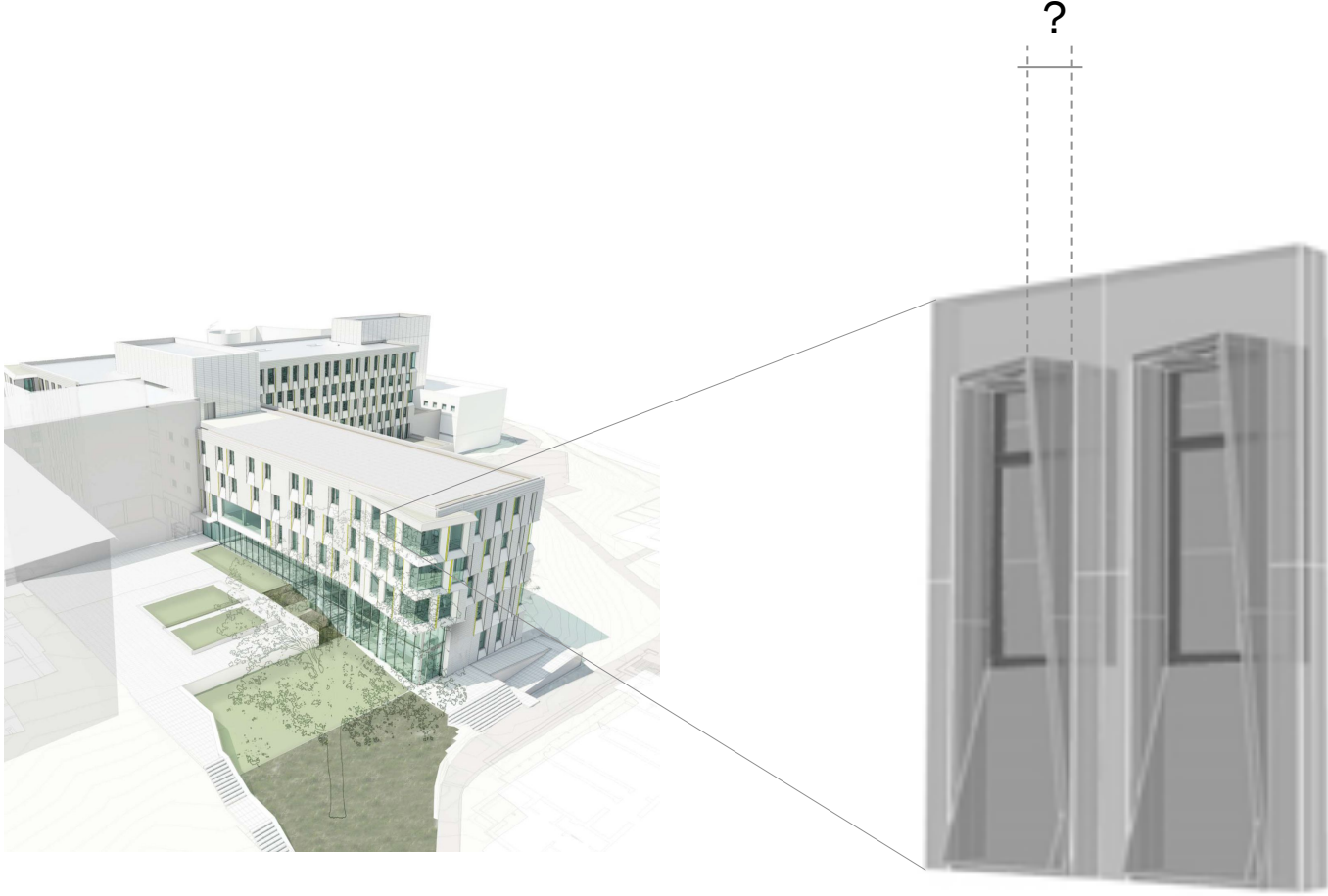
1. Intro
2. Multidimensional Data Visualization
3. How the sausage is made
4. Case Study

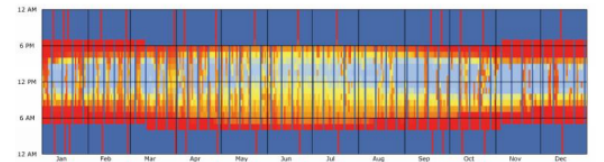
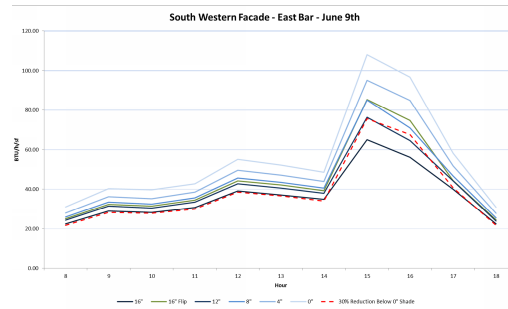
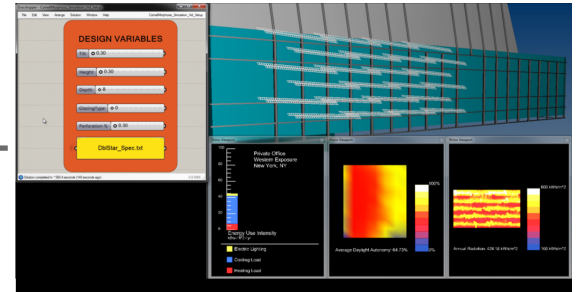
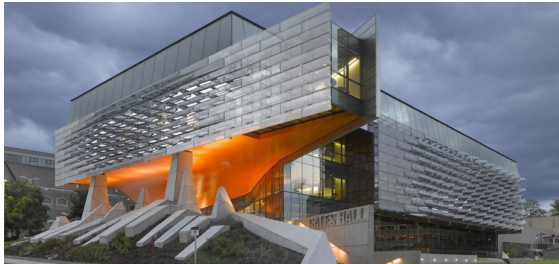
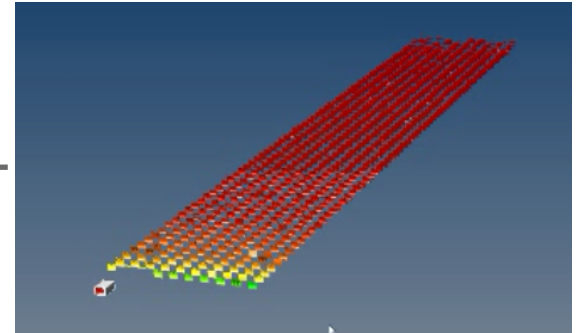
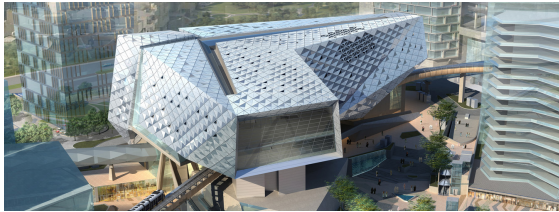
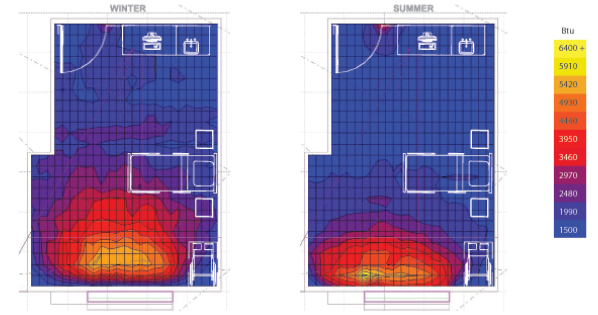
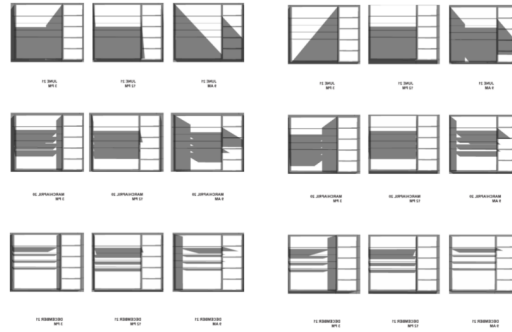


# Our business model

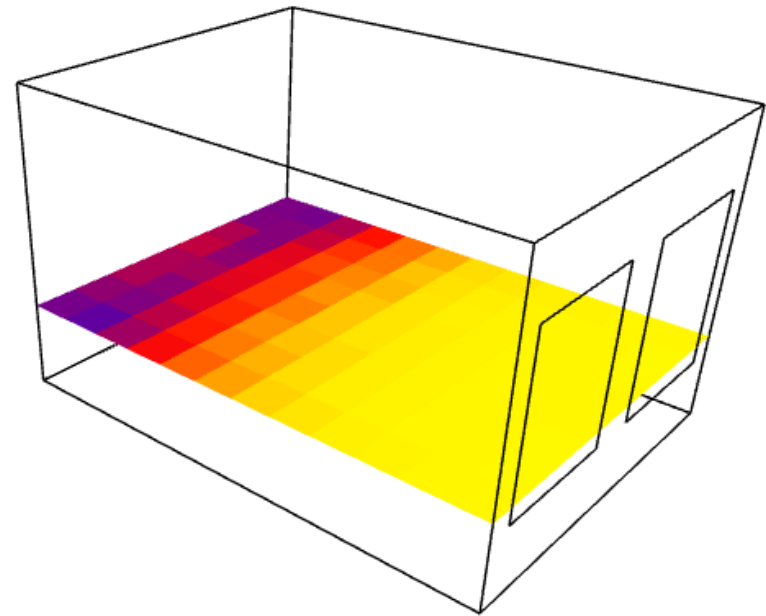


*Prepared by Colin Schless*

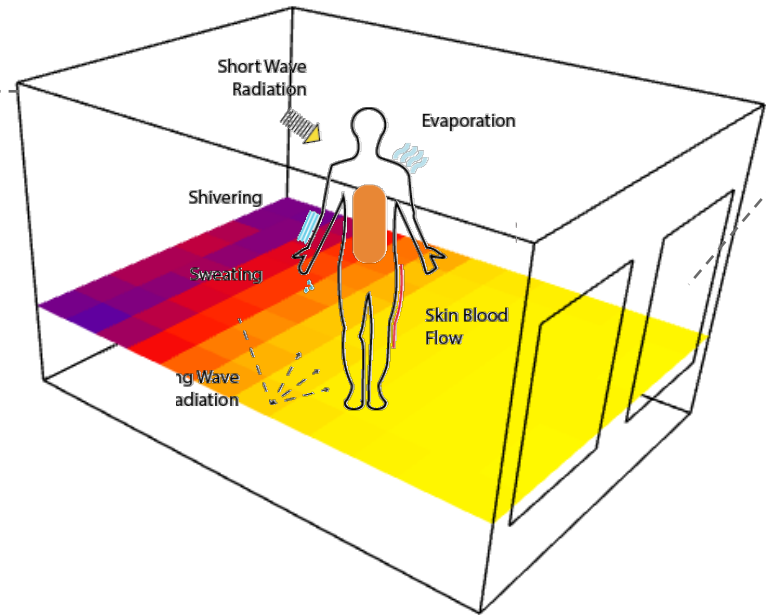




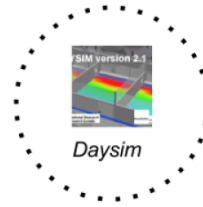
# BOX MODEL



(energy)

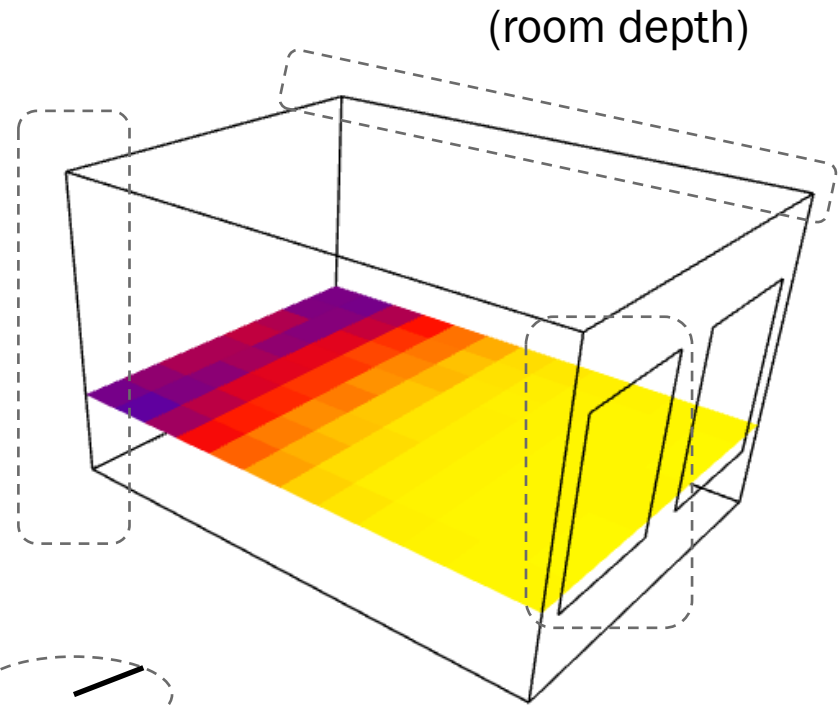


(daylight)





(room height)



(orientation)

(window size )

(shading system)

(glass properties)



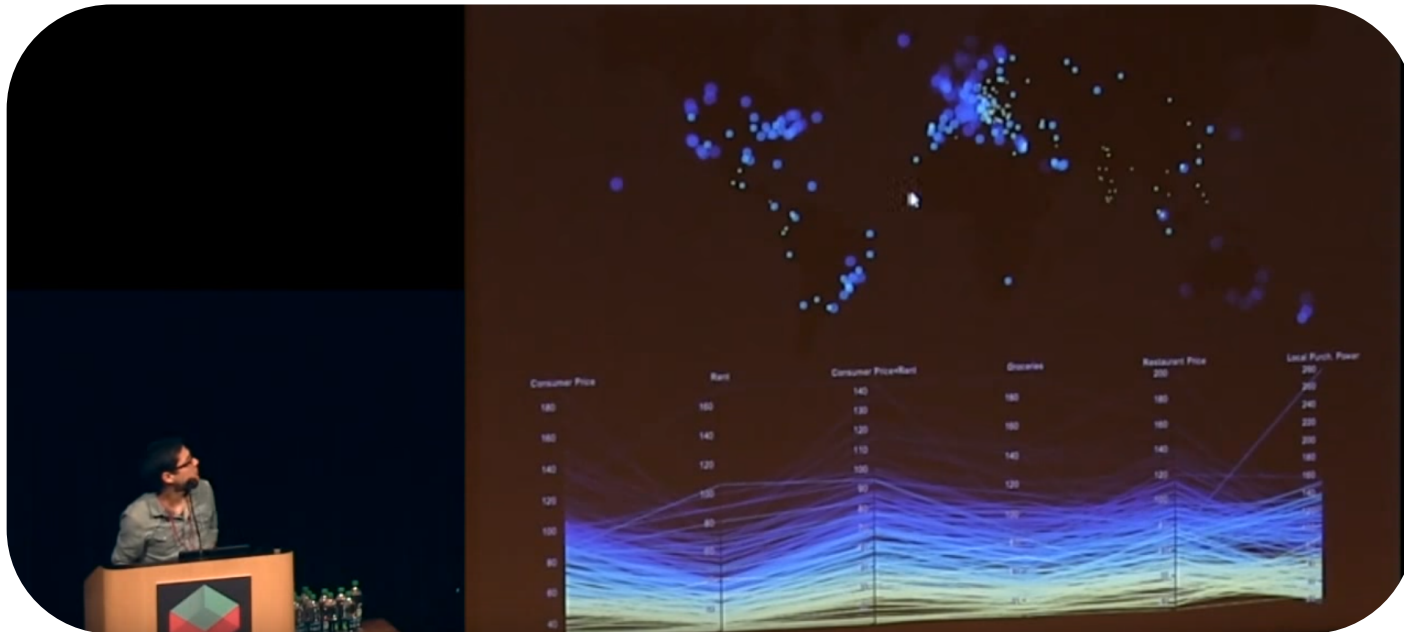
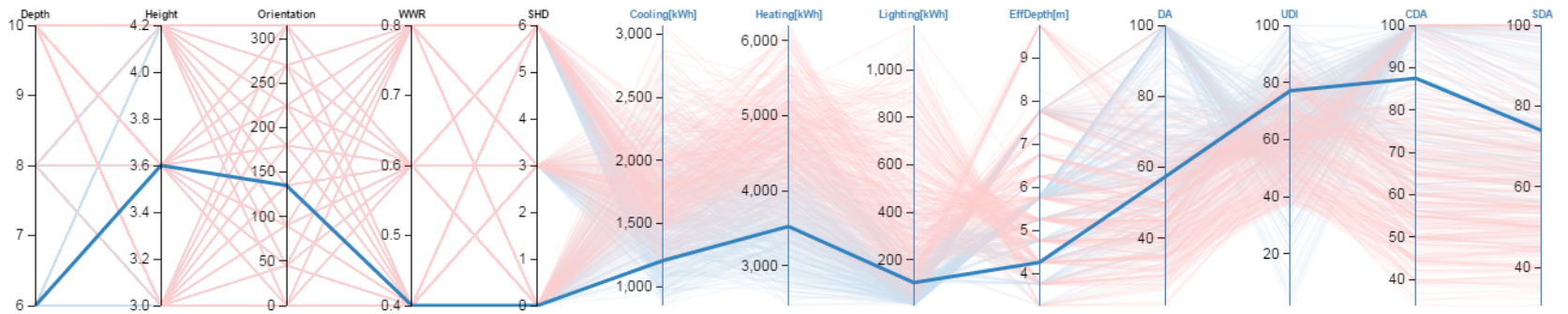
- 3 Room Depths
- 3 Room Heights
- 8 Orientations
- 3 Window to wall ratios
- 3 Shade designs

## 648 Possible Combinations

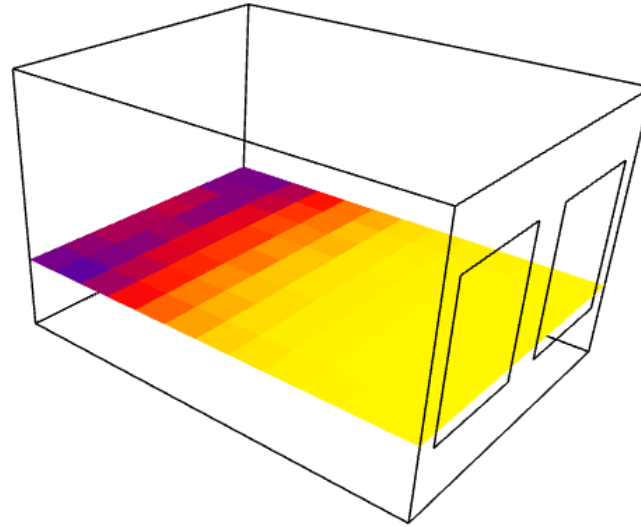
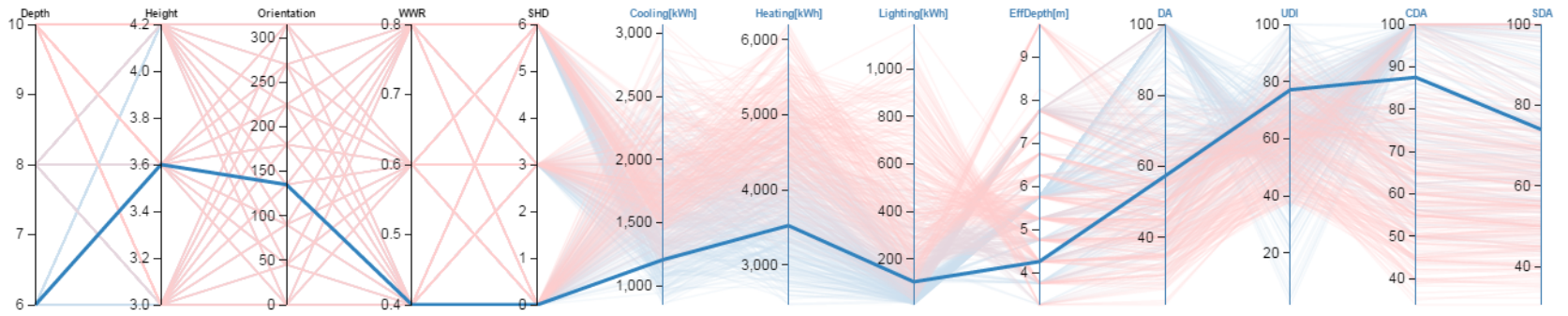
5,832  
Individual  
Results

Cooling Peak  
Cooling Energy  
Heating Peak  
Heating Energy  
Lighting Energy  
Daylight Autonomy  
Useful Daylight Index  
Continuous DA  
Spatial DA

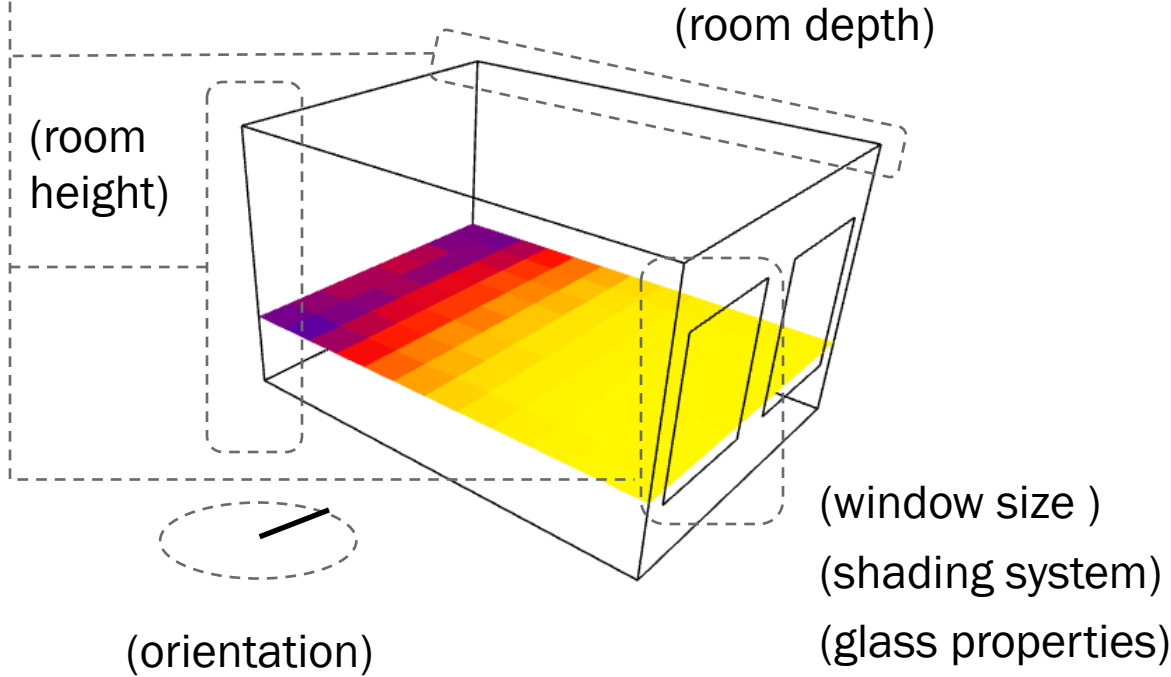
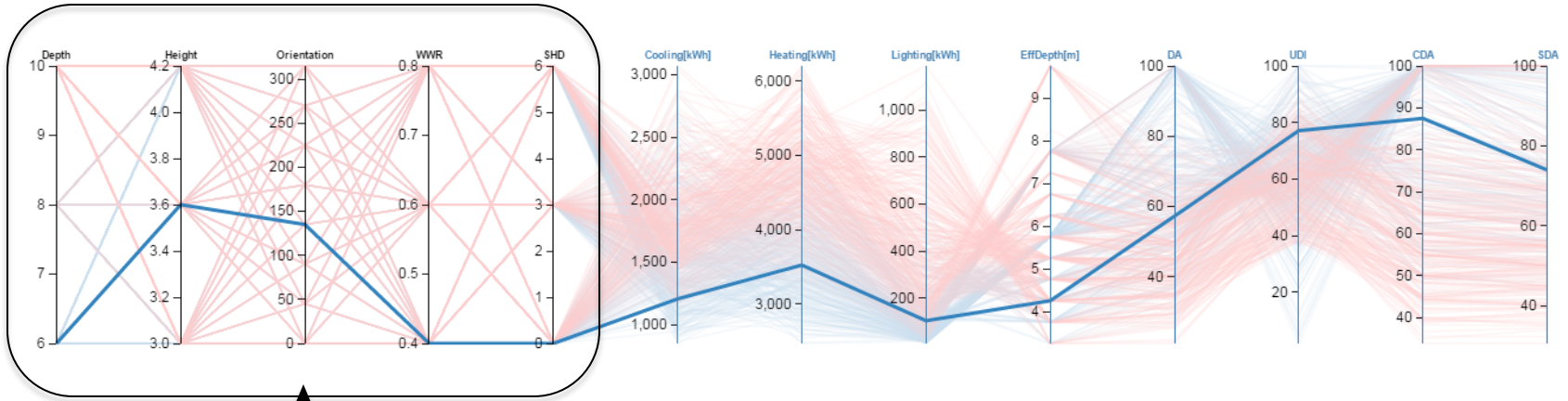
# PARALLEL COORDINATES



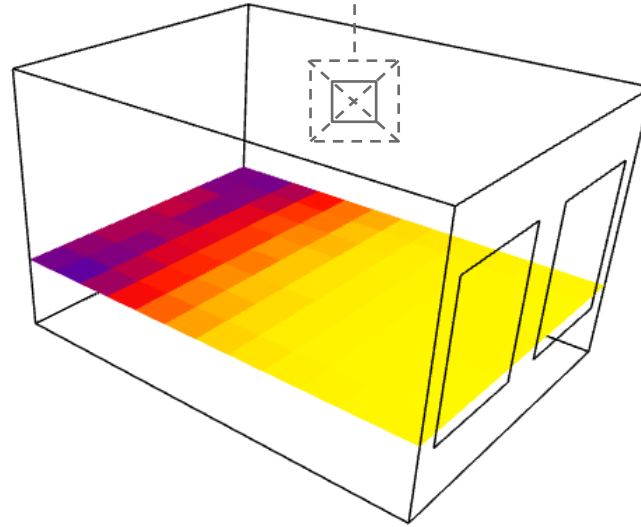
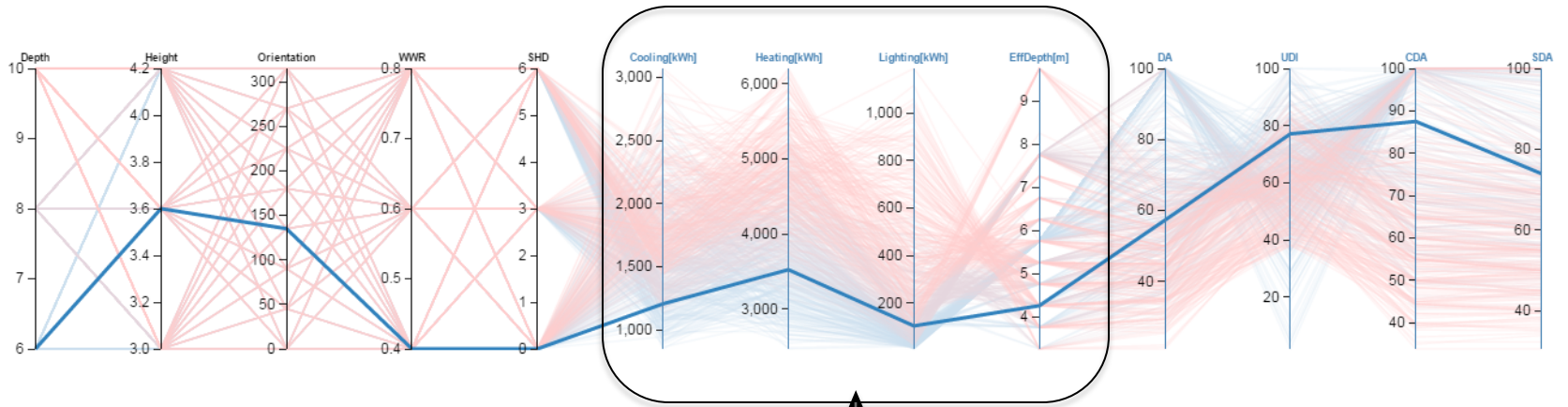
# PARRALEL COORDINATES



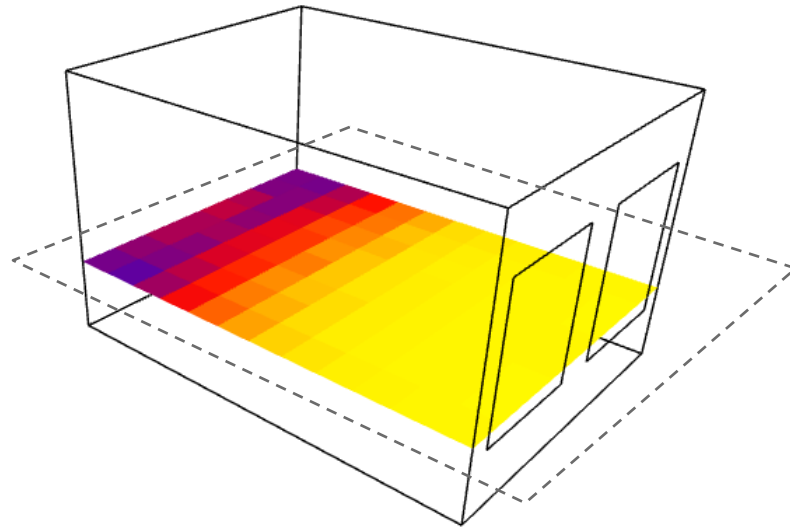
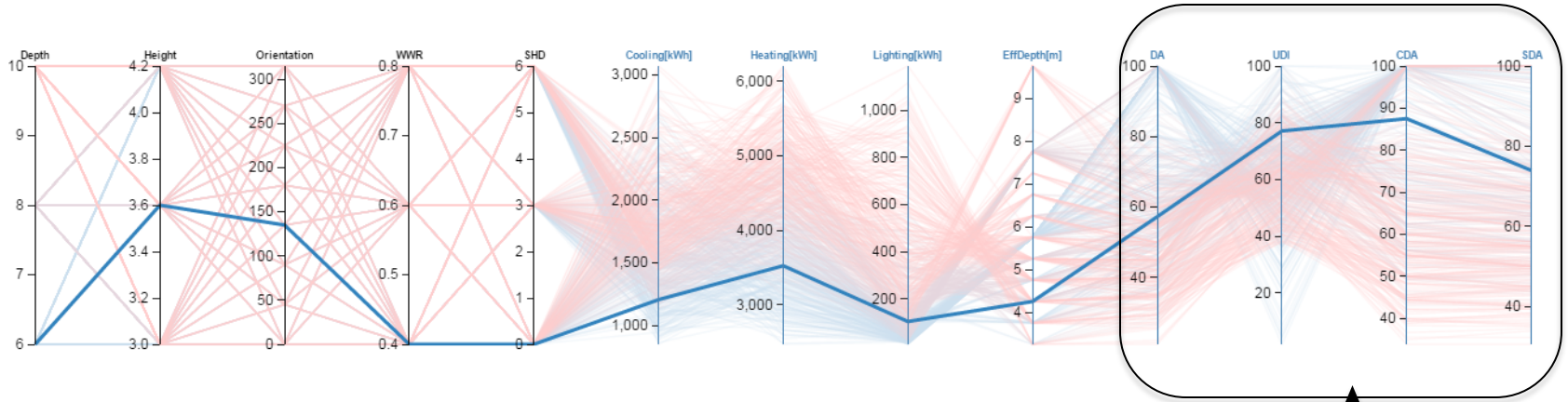
# INPUTS



# ENERGY RESULTS



# DAYLIGHTING RESULTS



Room Depth

Orientation

Shade Qty.

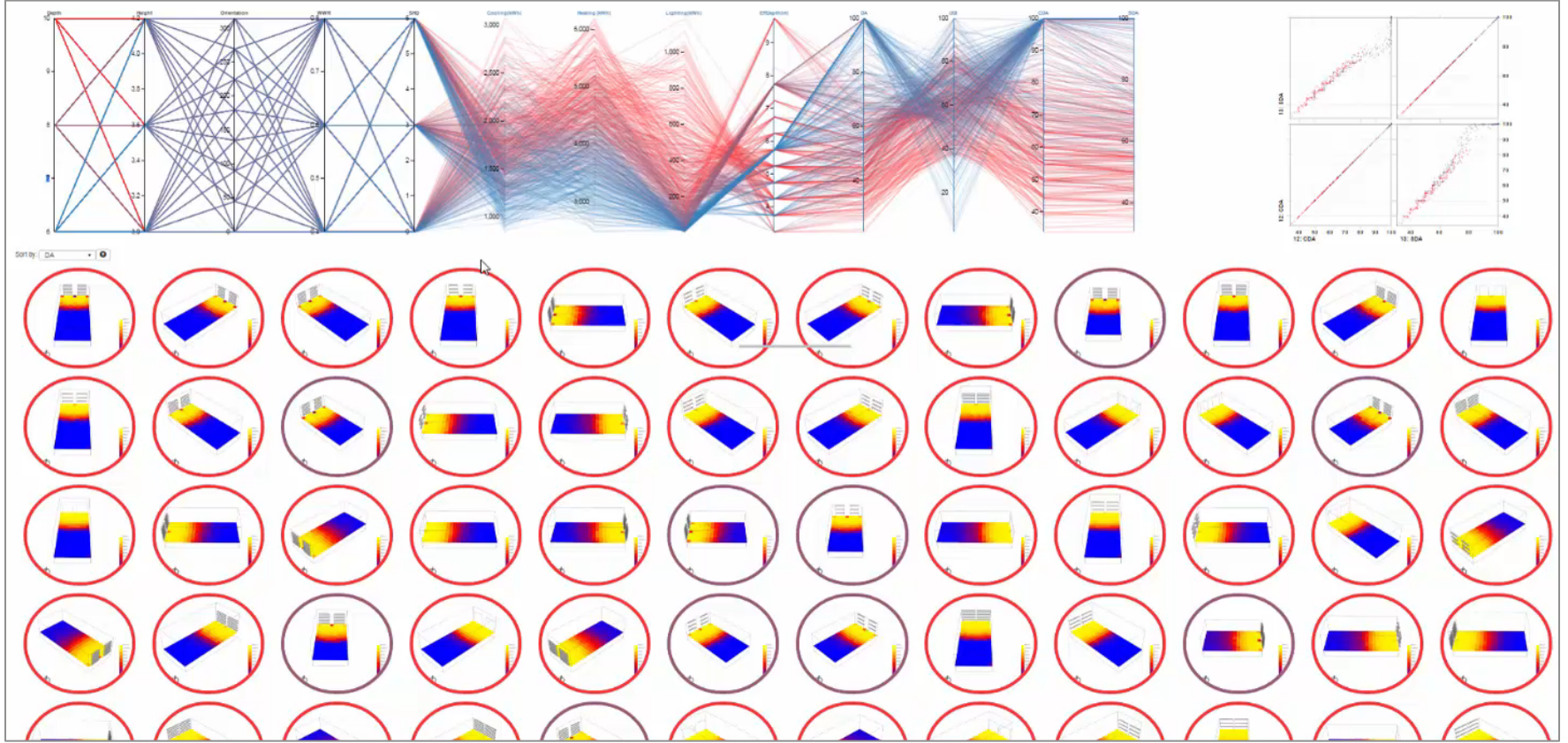
Heating Energy

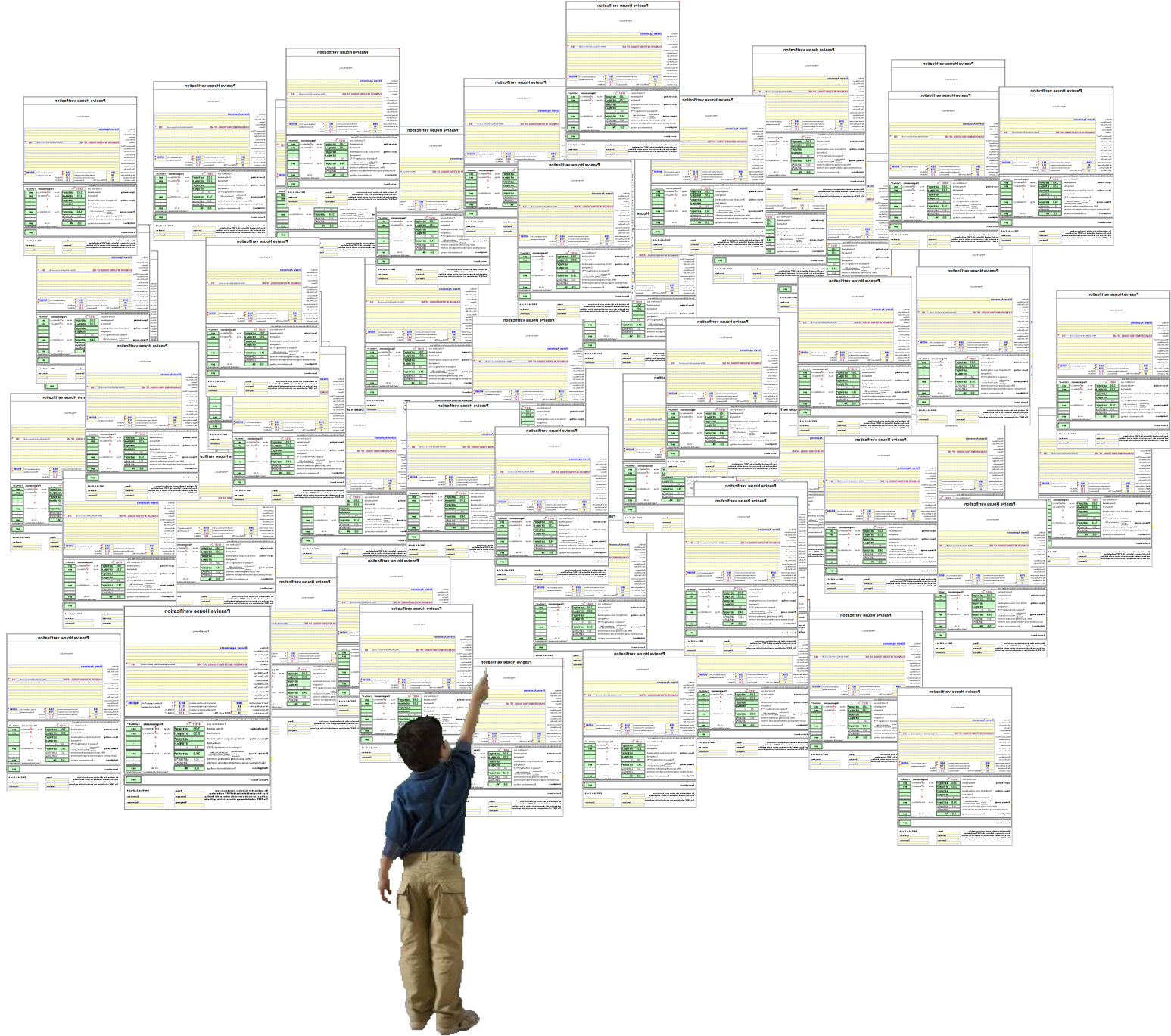
Room Height

WWR %

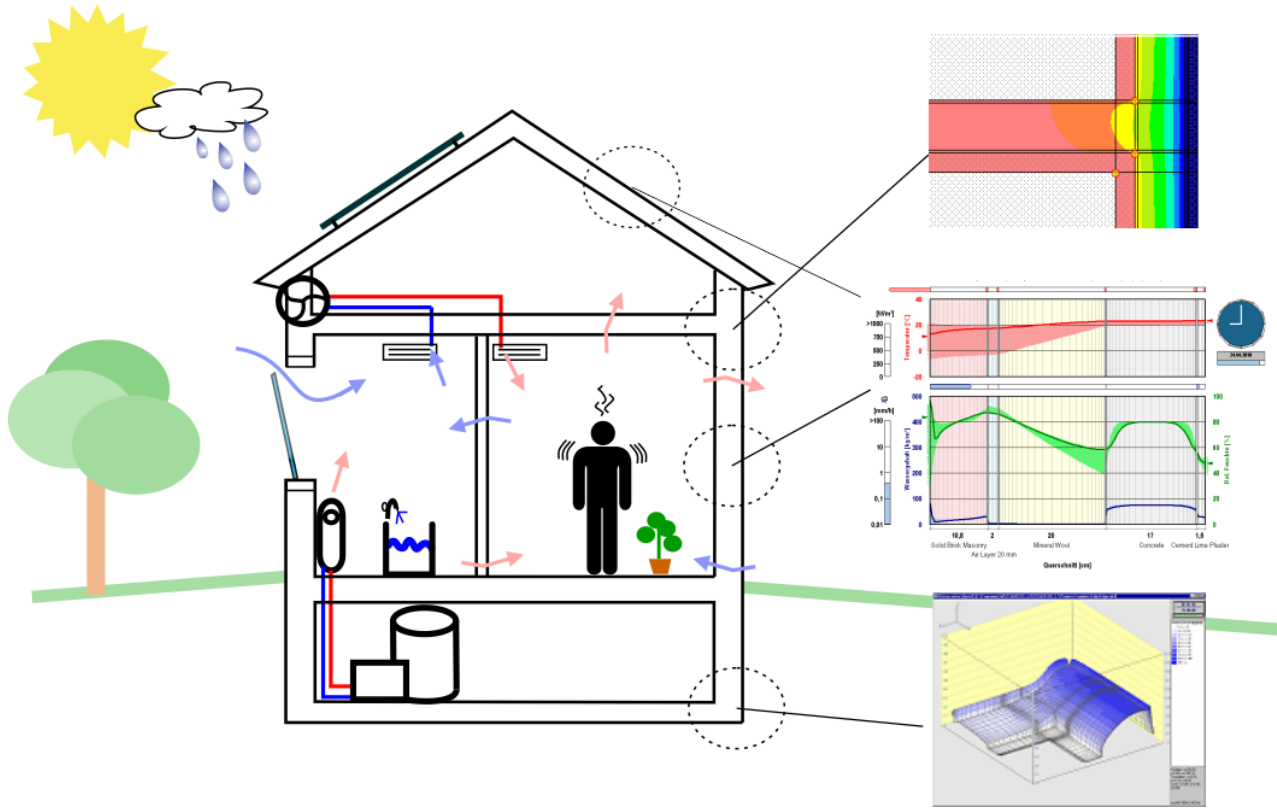
Cooling Energy

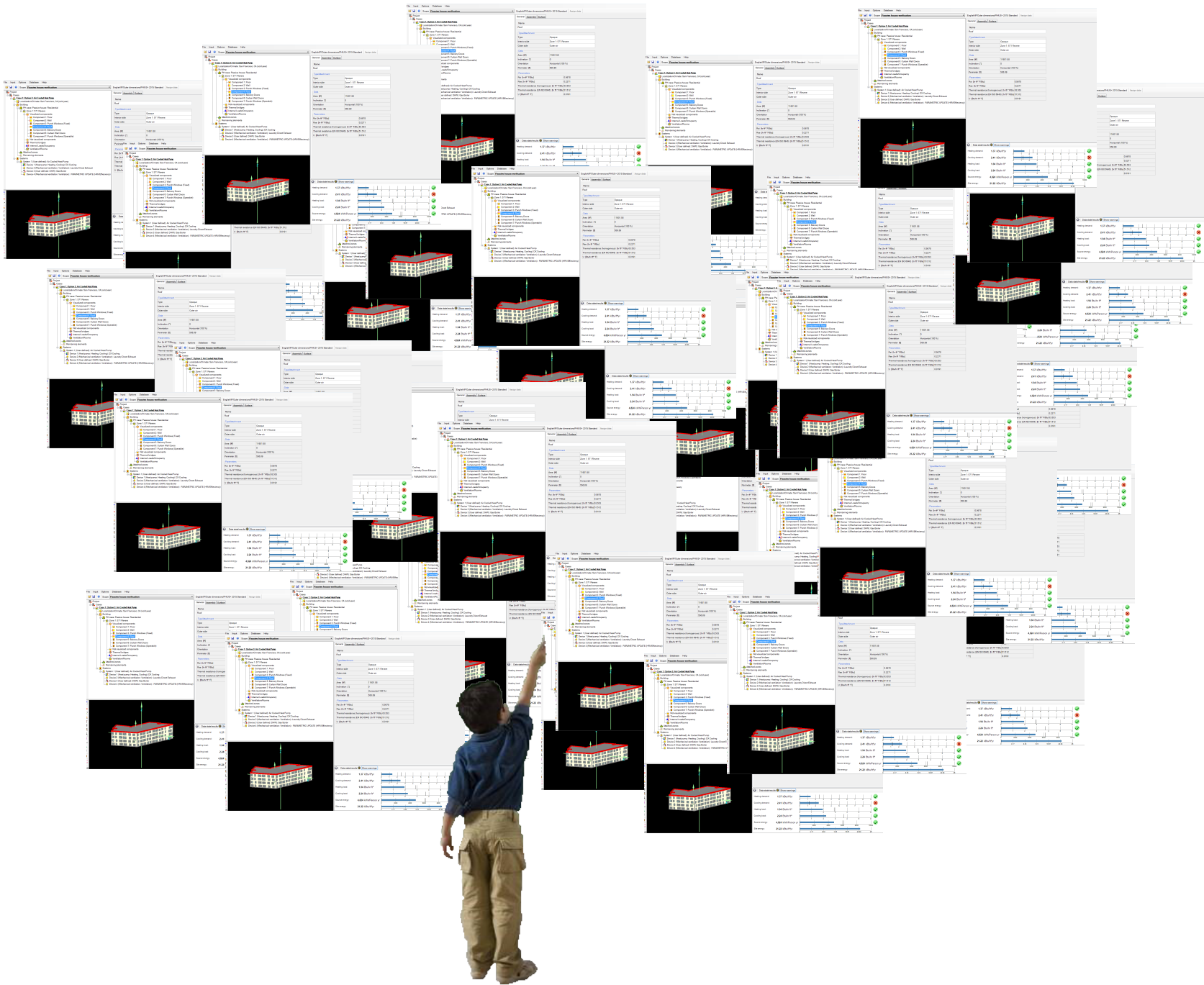
Daylight Autonomy

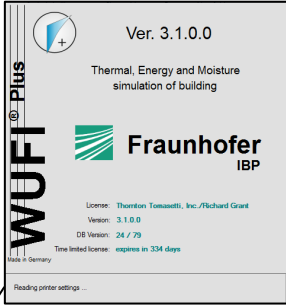




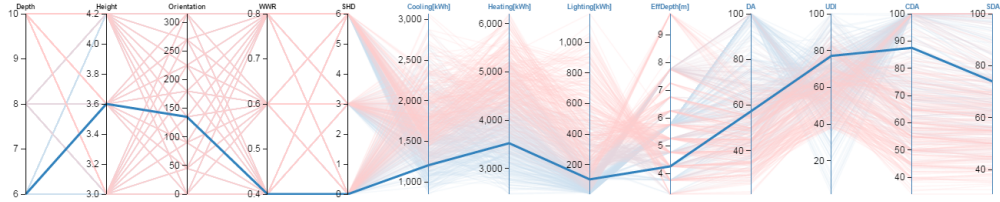




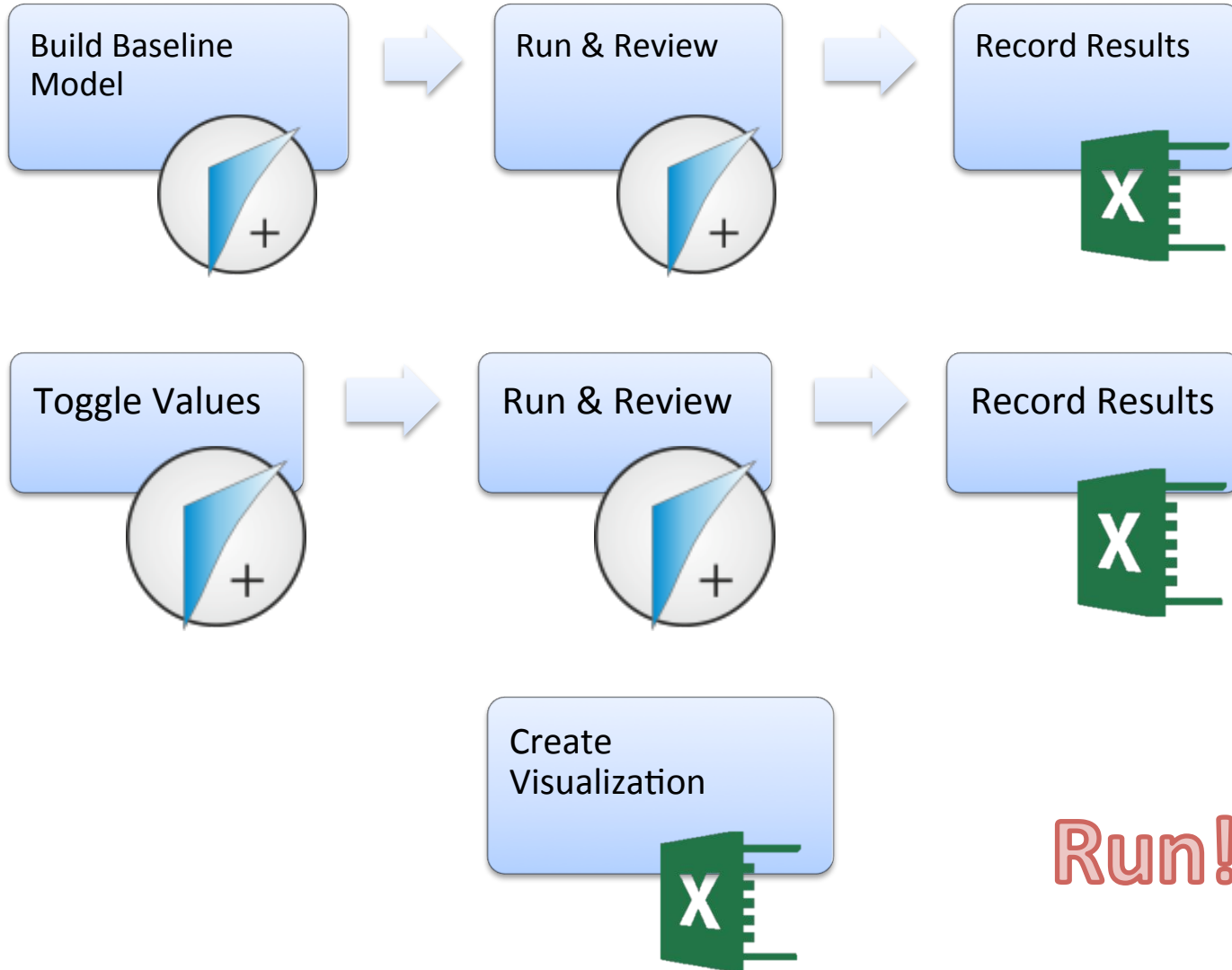




+



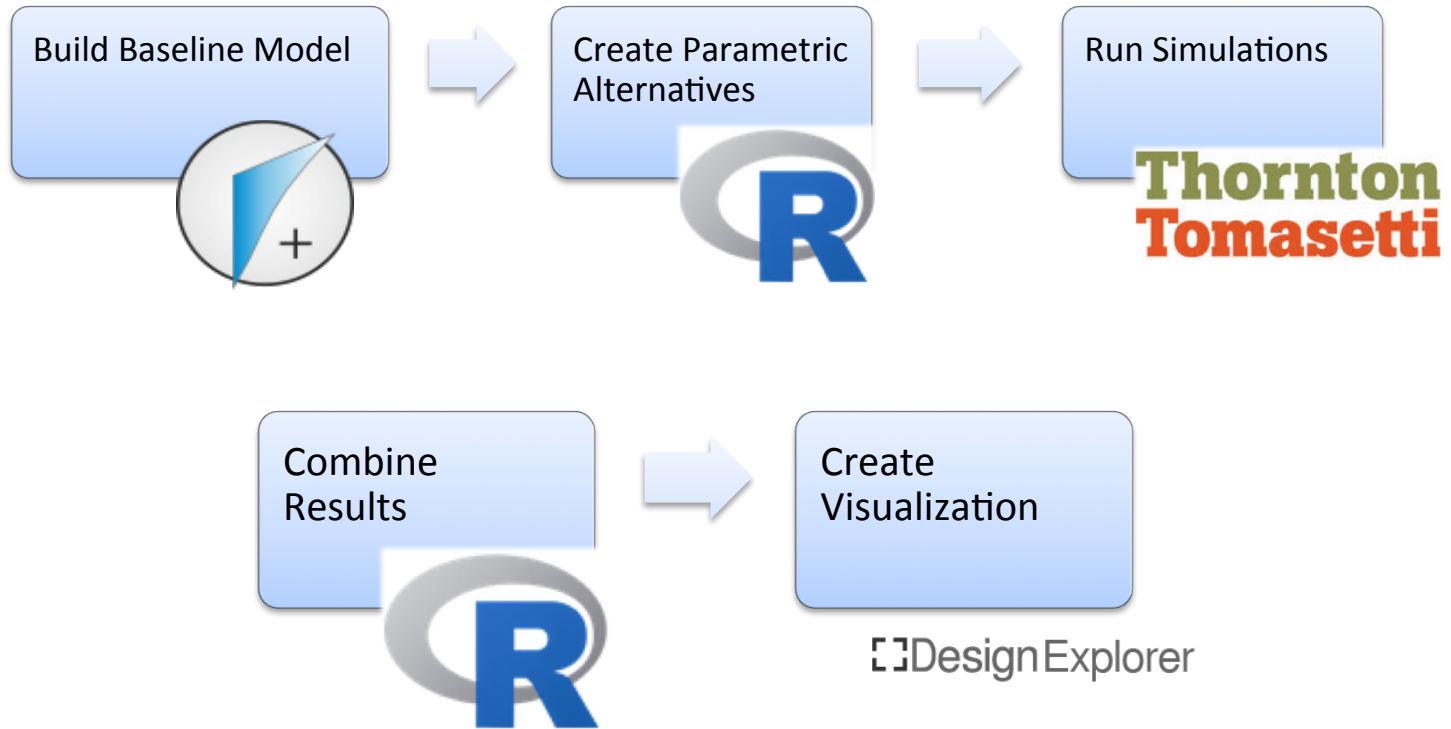
# Current Workflow



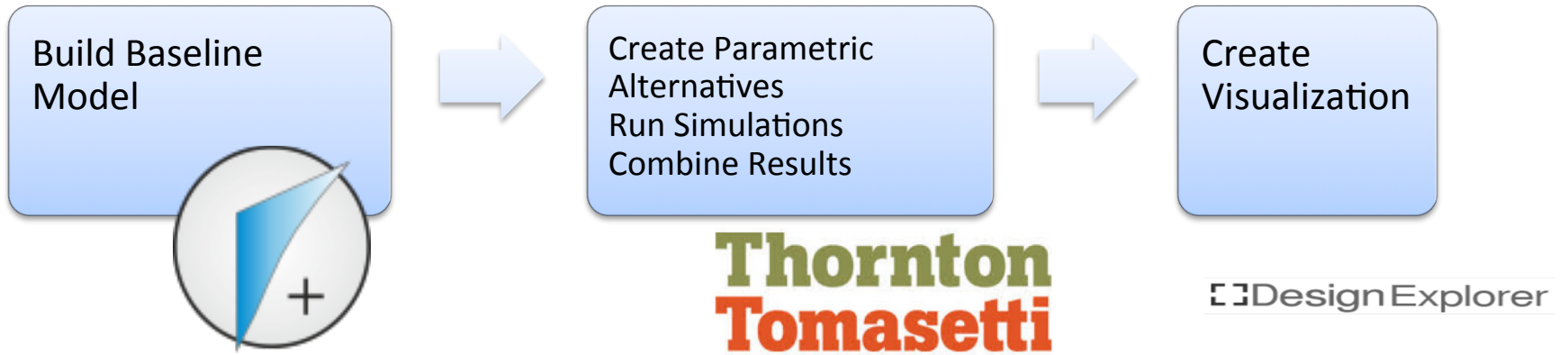
*Repeat*

**Run!**

# Improved Workflow



# Envisioned Workflow

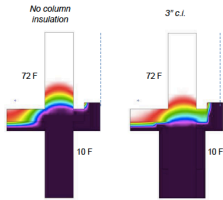
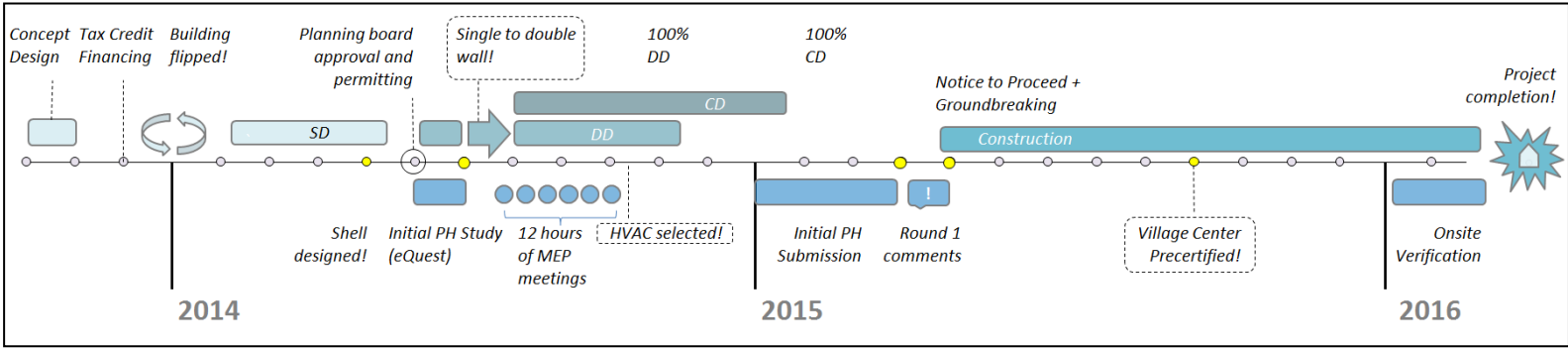
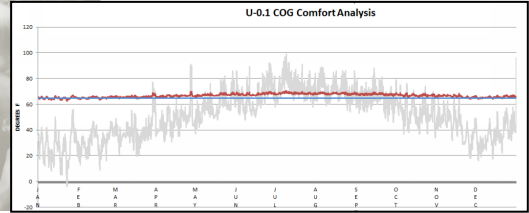
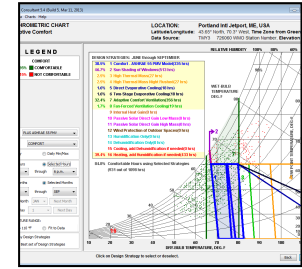
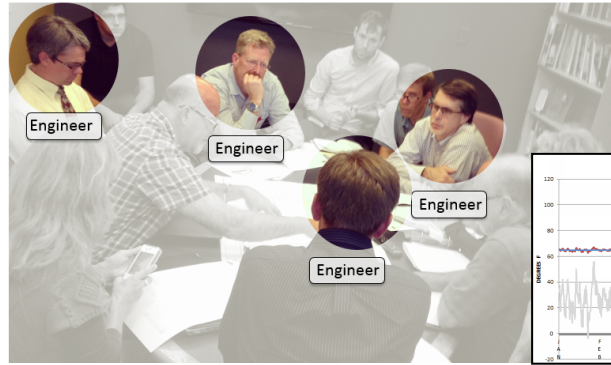


## Case Study- Village Centre Apartments



PHIUS Multifamily of the Year 2016  
PHIUS Affordable Project of the Year 2016  
Largest US Cold Climate Passive House  
3% Increase in first cost

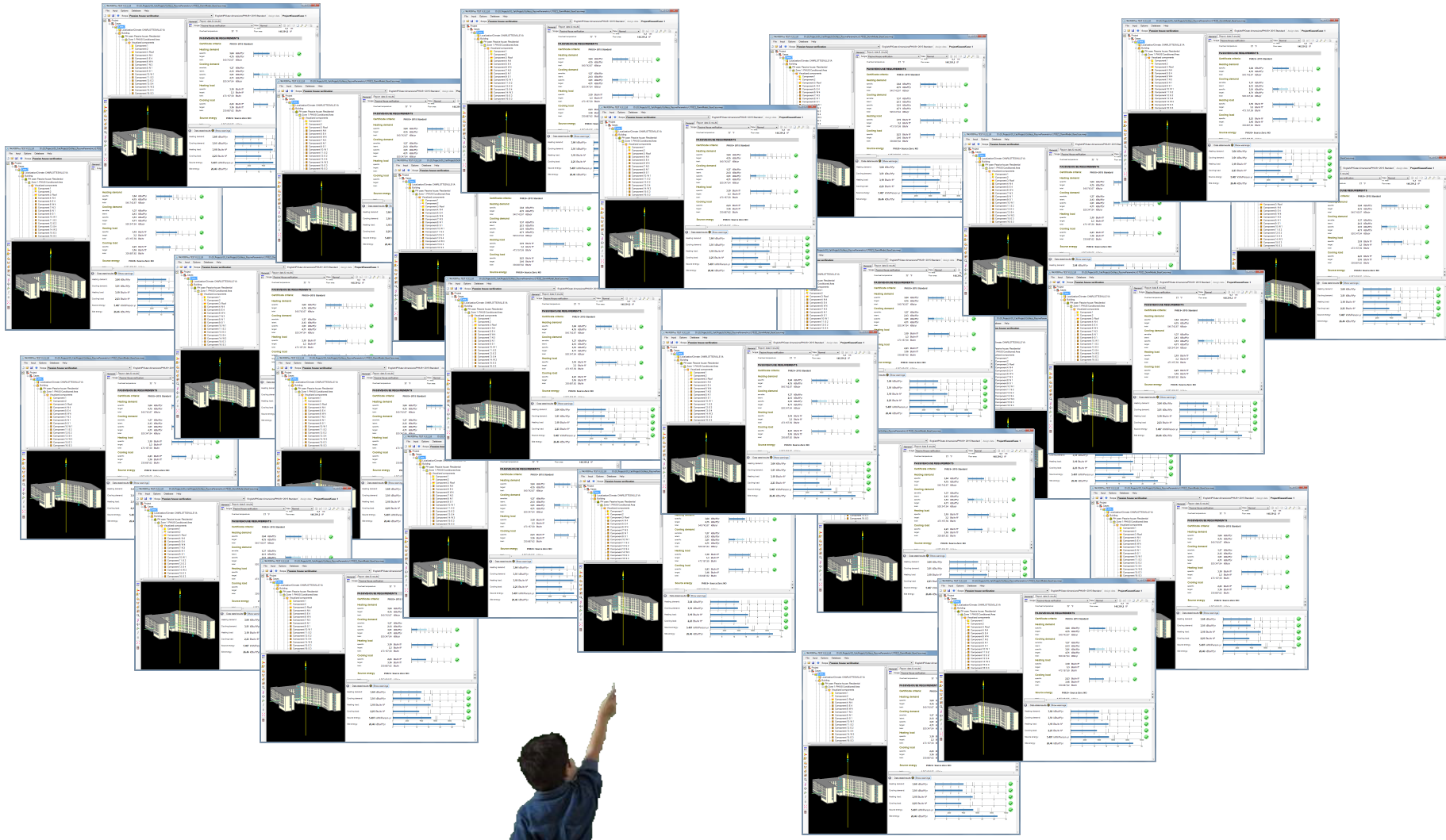
48 units  
54,000 gsf  
3 common areas  
1 dog washing rm



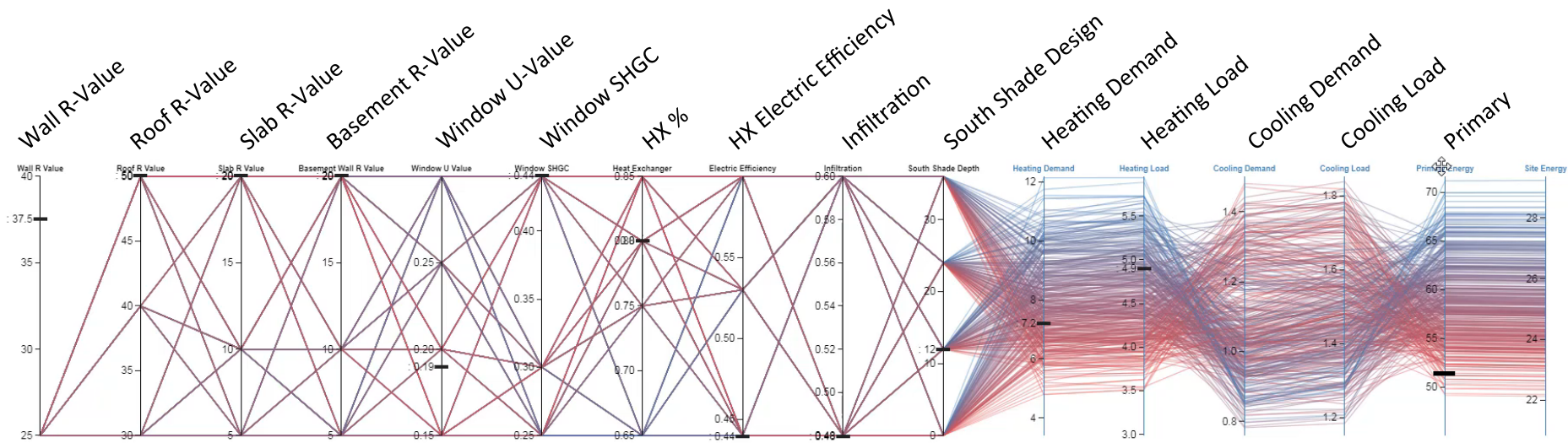
CHOM VILLAGE CENTRE APARTMENTS, Brewer, Maine				
PASSIVE HOUSE - EXTERIOR WALL COST ANALYSIS				
July 26, 2014				
Scope of Work Description	Quantity	Unit Cost	Cost	Cost in
				Baseline Estimate
<b>Exterior Walls</b>				
2x4	25,480 SF	\$2.75 /SF	\$70,070	\$70,070
2x6	25,480 SF	\$4.10 /SF	\$104,468	\$104,468
2x8	25,480 SF	\$5.50 /SF	\$140,160	\$140,160
Baseline Credit: 2x6	(25,480) SF	\$4.10 /SF	(\$104,468)	(\$104,468)
<b>Exterior Sheathing</b>				
1/2" CDX	25,480 SF	\$1.70 /SF	\$43,316	\$43,316
Baseline Credit: 1/2" CDX	(25,480) SF	\$1.70 /SF	(\$43,316)	(\$43,316)
<b>Wallboard Insulation</b>				
2.0" thick	25,480 SF	\$5.60 /SF	\$142,728	\$142,728
4.1" thick (indicated as 3.5")	25,480 SF	\$5.50 /SF	\$140,160	\$140,160
2.0" at windows/door returns	3,300 Lf	\$9.00 /Lf	\$29,700	\$29,700
Baseline Credit: None called	0 SF	\$0.00 /SF	\$0	\$0
<b>Insulated Lath and Gypsum</b>				
18" Floor Rim Joist: Basement	390 SF	\$3.50 /SF	\$1,365	\$1,365
18" Floor Rim Joist: Elevated	2,340 SF	\$9.00 /SF	\$21,060	\$21,060
20" Roof Rim Joist	1,550 SF	\$4.50 /SF	\$6,975	\$6,975
Baseline Credit: None called	0 SF	\$0.00 /SF	\$0	\$0
<b>Cellulose Dry Pack</b>				
1.5" thick	21,590 SF	\$1.80 /SF	\$38,862	\$38,862
7.5" thick	21,590 SF	\$2.30 /SF	\$49,657	\$49,657
1.2" thick	21,590 SF	\$3.80 /SF	\$82,042	\$82,042
Baseline Credit: 1.5" thick	(21,590) SF	\$1.80 /SF	(\$38,862)	(\$38,862)
<b>Foundation Insulation</b>				
2" thick	2,600 SF	\$1.45 /SF	\$3,770	\$3,770
2.5" thick	2,600 SF	\$1.75 /SF	\$4,550	\$4,550
4" thick	2,600 SF	\$2.80 /SF	\$7,280	\$7,280
Baseline Credit: 2" thick	(2,600) SF	\$1.45 /SF	(\$3,770)	(\$3,770)
<b>Subtotal Costs</b>			\$197,418	\$197,418
<b>Add-on at 4%</b>			\$7,897	\$7,897
<b>Total Cost or Cost Increase</b>			\$205,315	\$205,315
<b>Percent Increase over Baseline</b>			4.7%	4.7%





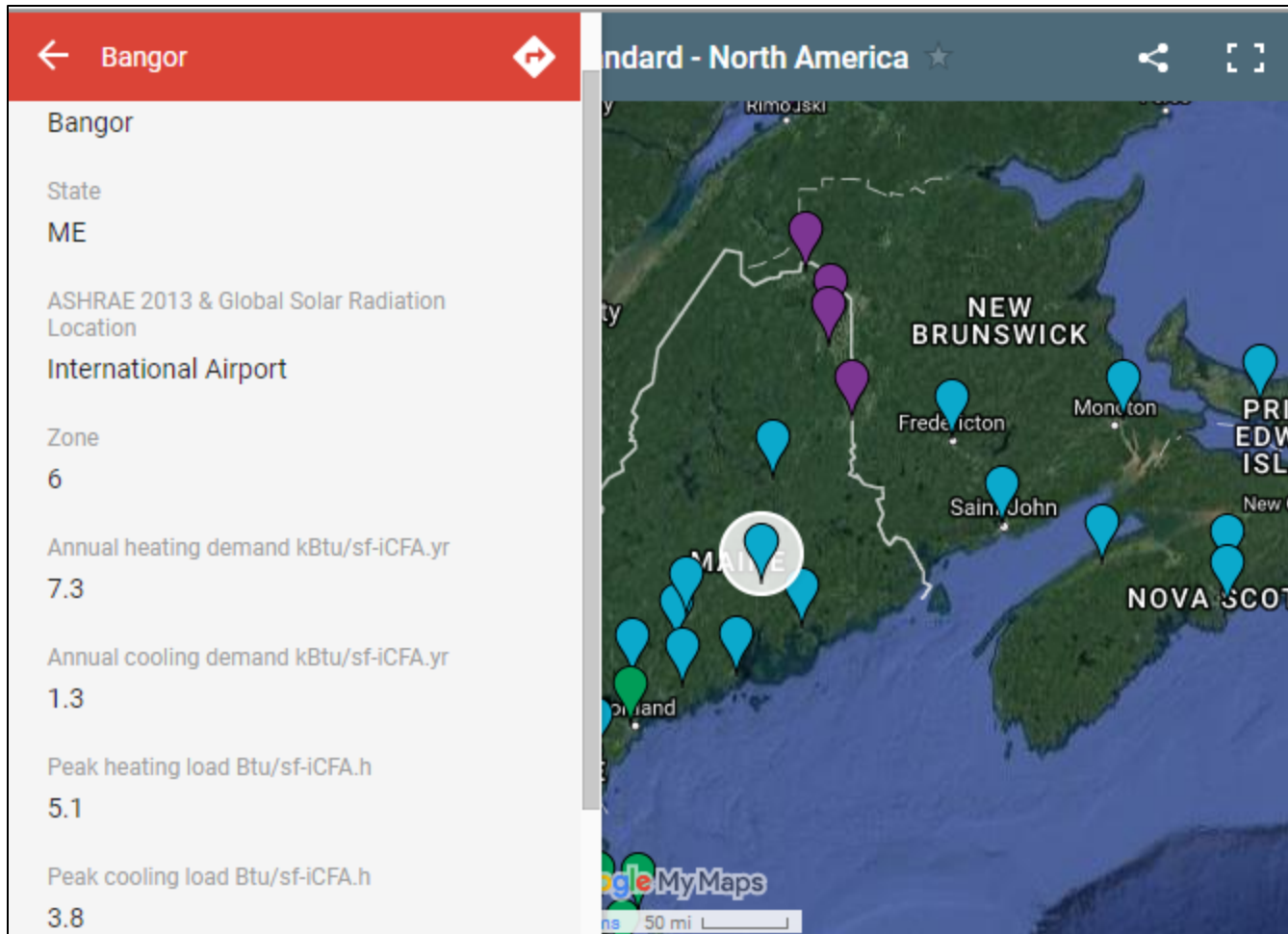


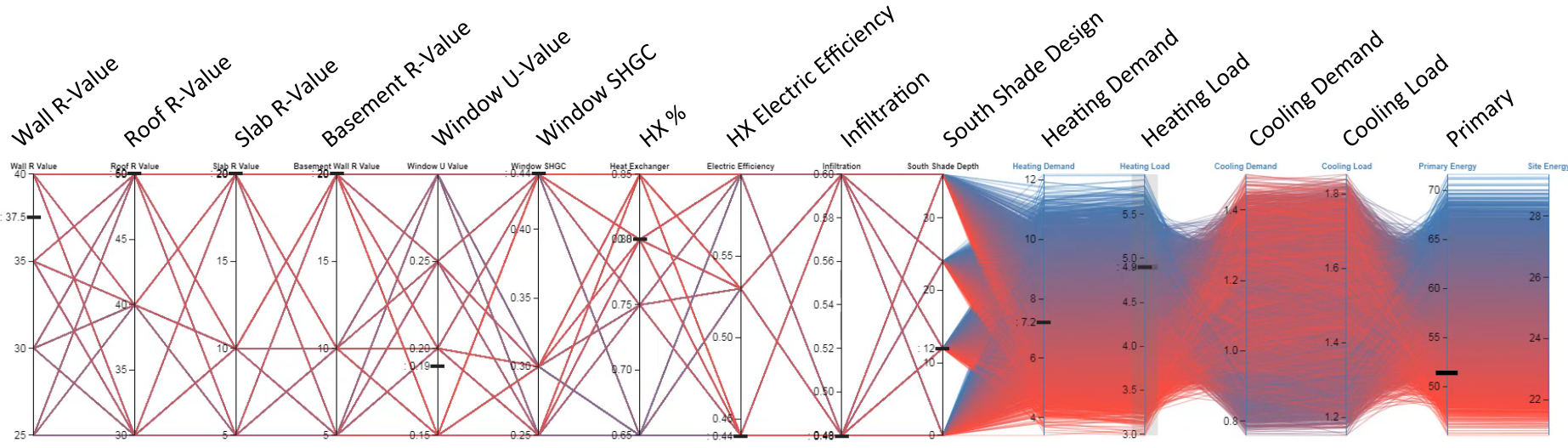
COMPONENT	VALUE
• Wall R-Value	37.5
• Roof R-Value	59
• Slab R-Value	21.4
• Basement Wall R-Value	41
• Window U-Value	U-0.19
• Window SHGC	0.25 – 0.49
• Heat Exchanger	80%
• Electric Efficiency (w/cfm)	0.44
• Infiltration (ACH)	0.48
• South Shade Depth	12"



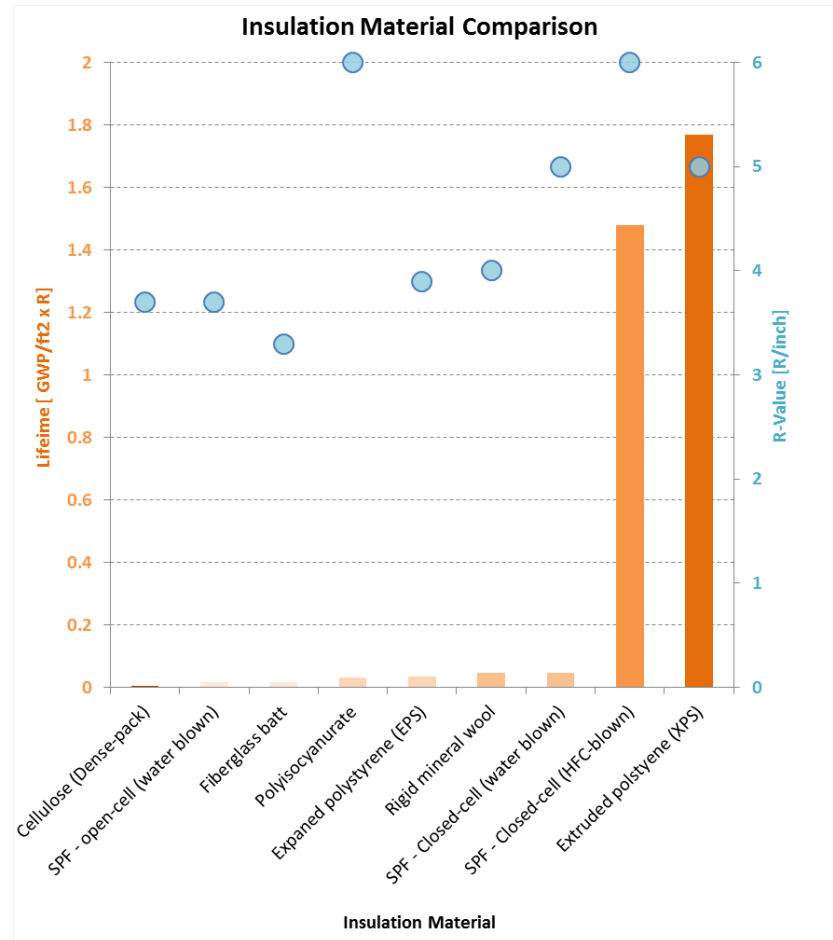
x 100,000

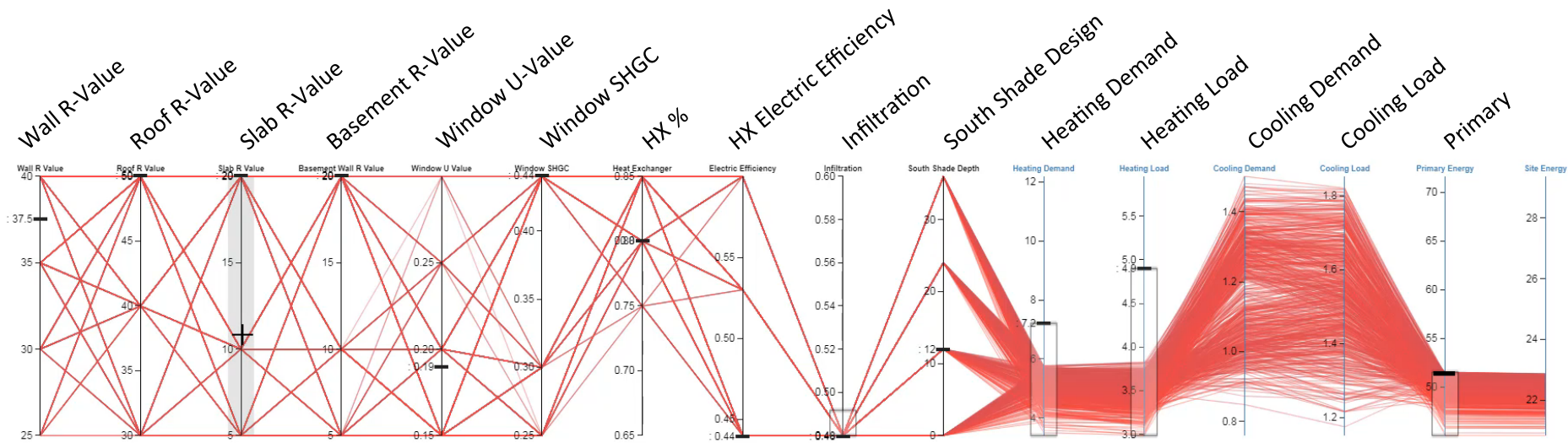
Randomly selected to 10,000





# Where do we start?

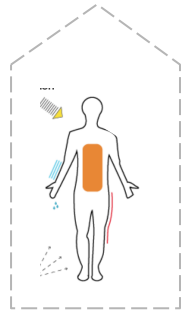
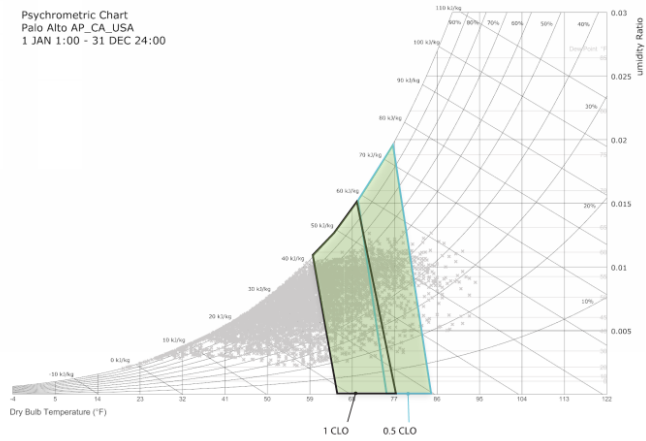




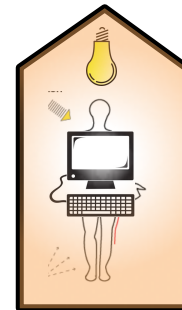
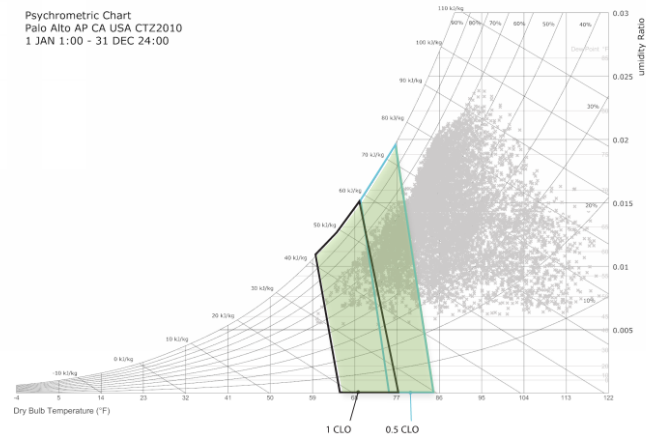
*Slab: 17,379 sf (2" less XPS insulation)*  
*Walls: 1,870 sf (4" less Spray Foam insulation)*

# What next?

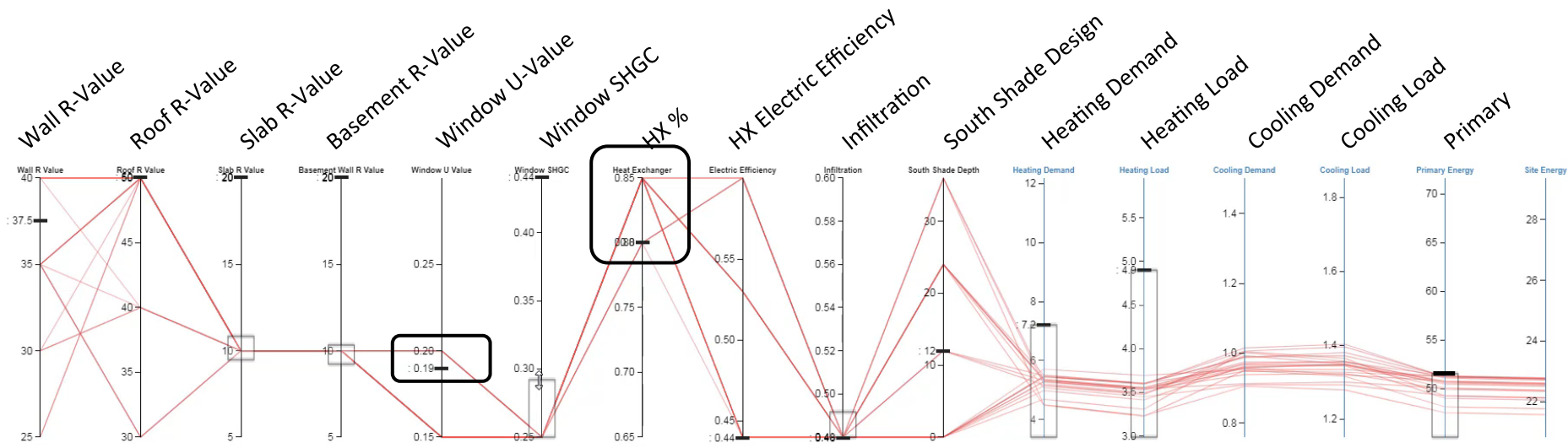
Psychrometric Chart  
Palo Alto AP\_CA\_USA  
1 JAN 1:00 - 31 DEC 24:00




Psychrometric Chart  
Palo Alto AP CA USA CTZ2010  
1 JAN 1:00 - 31 DEC 24:00







# What's left?



**Scope of Work Description**

**Framed Walls**  
 2x4  
 2x6  
 2x8  
 Baseline Credit - 2x6

**Exterior Sheathing**  
 1/2" CDX  
 Baseline Credit - 1/2" CDX

**Nailboard Insulation**  
 2.6" thick  
 4.1" thick (indicated as 3.5")  
 2.6" T at window/door returns  
 Baseline Credit - None carried

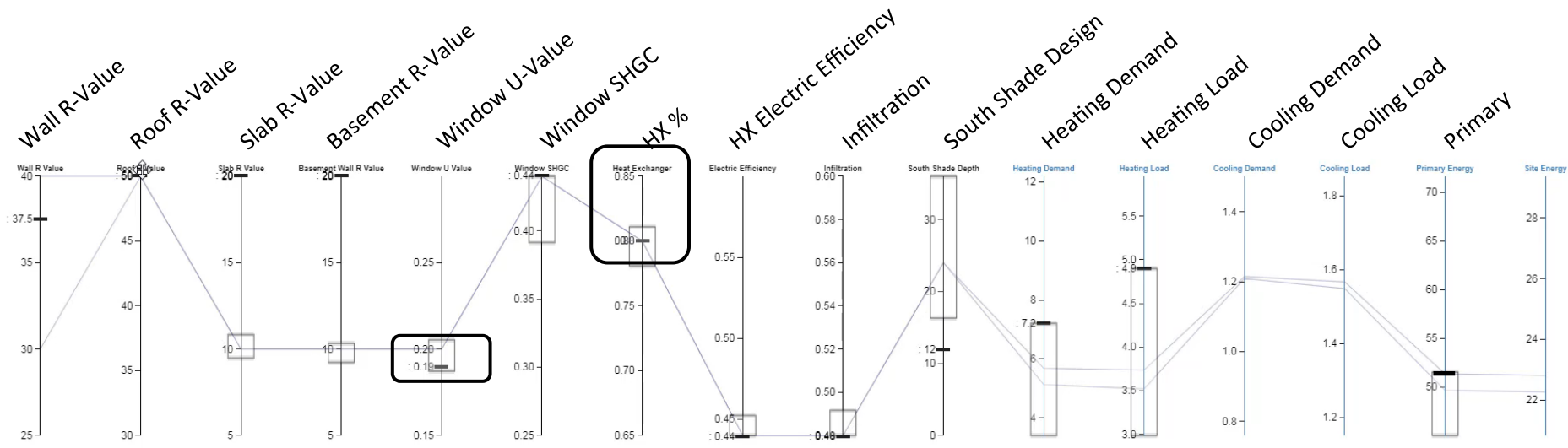
**Sprayed Urethane Foam**  
 18" Floor Rim Joists - Basement  
 18" Floor Rim Joists - Elevated  
 20" Roof Rim Joists  
 Baseline Credit - 5.5" Cellulose

**Cellulose Dry Pack**  
 5.5" thick  
 7.25" thick  
 12" thick  
 Baseline Credit - 5.5" thick

**Foundation Insulation**  
 2" thick  
 2.5" thick  
 4" thick  
 Baseline Credit - 2" thick

Subtotal Costs  
 Add-ons at 10%  
 Total Cost or Cost Increase  
 Percent Increase over Baseline

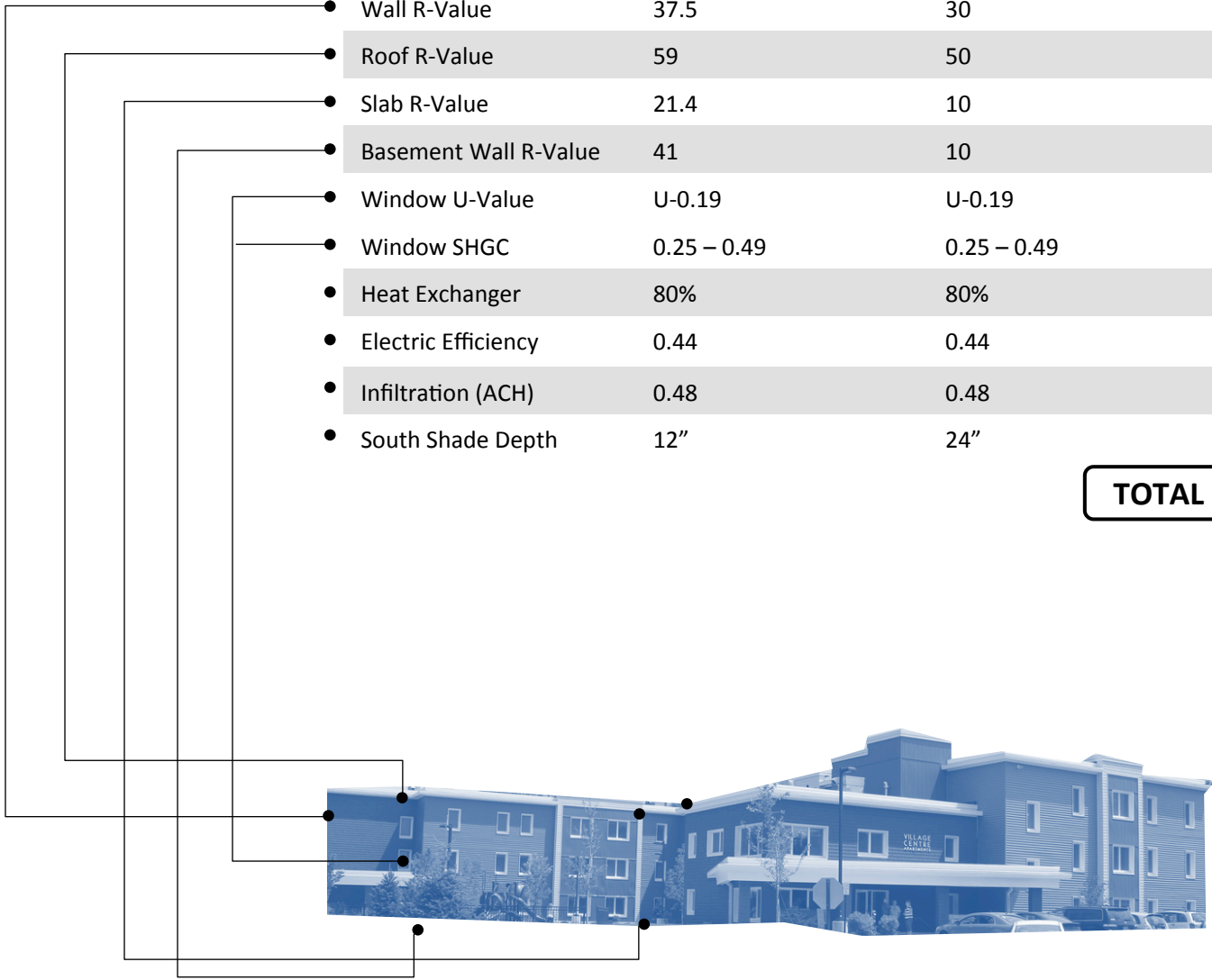
Item	Quantity	Unit	Price	Total
2x4	100	Linear Feet	1.50	150.00
2x6	100	Linear Feet	2.00	200.00
2x8	100	Linear Feet	2.50	250.00
1/2" CDX Sheathing	100	Sq. Yds.	1.00	100.00
2.6" Insulation	100	Sq. Yds.	1.00	100.00
4.1" Insulation	100	Sq. Yds.	1.50	150.00
2.6" T at window/door returns	100	Linear Feet	1.00	100.00
18" Floor Rim Joists - Basement	100	Linear Feet	1.00	100.00
18" Floor Rim Joists - Elevated	100	Linear Feet	1.00	100.00
20" Roof Rim Joists	100	Linear Feet	1.00	100.00
5.5" Cellulose	100	Sq. Yds.	1.00	100.00
5.5" Cellulose Dry Pack	100	Sq. Yds.	1.00	100.00
7.25" Cellulose Dry Pack	100	Sq. Yds.	1.00	100.00
12" Cellulose Dry Pack	100	Sq. Yds.	1.00	100.00
2" Foundation Insulation	100	Linear Feet	1.00	100.00
2.5" Foundation Insulation	100	Linear Feet	1.00	100.00
4" Foundation Insulation	100	Linear Feet	1.00	100.00
<b>Subtotal Costs</b>				<b>1,500.00</b>
<b>Add-ons at 10%</b>				<b>150.00</b>
<b>Total Cost or Cost Increase</b>				<b>1,650.00</b>
<b>Percent Increase over Baseline</b>				<b>11%</b>



COMPONENT	DESIGN VALUE	OPT. VALUE	COST
• Wall R-Value	37.5	30	\$70,070
• Roof R-Value	59	50	\$10,795
• Slab R-Value	21.4	10	
• Basement Wall R-Value	41	10	\$31,000
• Window U-Value	U-0.19	U-0.19	-
• Window SHGC	0.25 – 0.49	0.25 – 0.49	-
• Heat Exchanger	80%	80%	-
• Electric Efficiency	0.44	0.44	-
• Infiltration (ACH)	0.48	0.48	-
• South Shade Depth	12"	24"	TBD

**TOTAL \$111,865**

*1.5 % of first cost*



## NEXT STEPS

- Simplify workflow (user friendly)
- Continue in-house testing to validate results
- Solicit feedback from key user-groups
- Define business model
- Bring to market

### *Current Parameters*

- *Window U-value*
- *Window SHGC*
- *Wall, Roof, and Underground Opaque R-values*
- *Heat Exchanger Efficiency*
- *Heat Exchanger w/cfm*
- *Shade depth*



**Thornton Tomasetti**

**Thanks!**

- Florian Antretter [florian.antretter@ibp.fraunhofer.de](mailto:florian.antretter@ibp.fraunhofer.de)
- Kris Dane, [Kdane@Thorntontomasetti.com](mailto:Kdane@Thorntontomasetti.com)
- Colin Schless, [Cschless@Thorntontomasetti.com](mailto:Cschless@Thorntontomasetti.com)