

# The Costs of Building to the Energy Step Code for Part 9 Buildings

A summary of the BC Energy Step Code Metrics Research Report

**REMI CHARRON**

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**MAY 30, 2018**

**ENERGY**  
**STEP**CODE  
BUILDING BEYOND THE STANDARD

# Acknowledgements

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→ BC Housing

→ City of New Westminster

→ BC Hydro

→ City of Vancouver

→ FortisBC

→ Province of BC

→ Acknowledgement is extended to all those who participated in this project as part of the project team or funding partners, or as external contributors or reviewers, including representatives from

→ Architectural Institute of BC

→ BCIT

→ Canadian Home Builders Association

→ City of Richmond

→ City Green Solutions

→ E3 Eco Group

→ Engineers and Geoscientists of BC

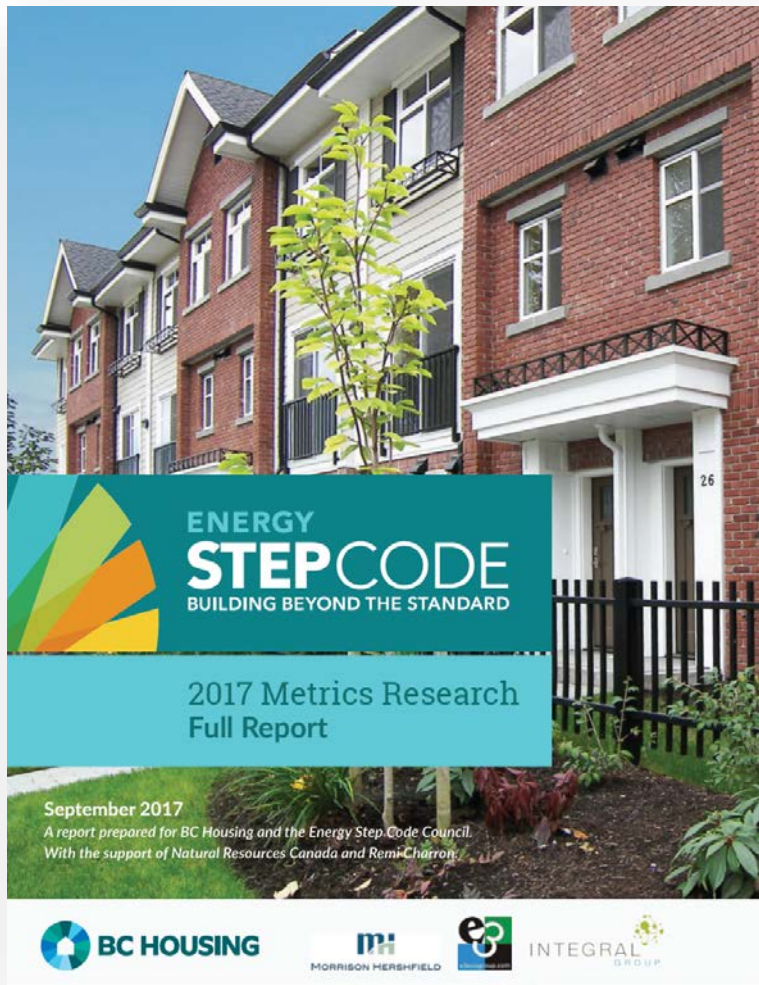
→ Integral Group

→ Travelers Canada

→ UBC

→ Urban Development Institute

# Performance Ranges to Meet Step Code



→ Data from BC Housing *Metrics Study*

- › Cost optimization of bundles of energy upgrades
- › Found “cheapest” way to comply with Step Code
- › Optimized for both:
  - Incremental Capital Cost
  - Net Present Value

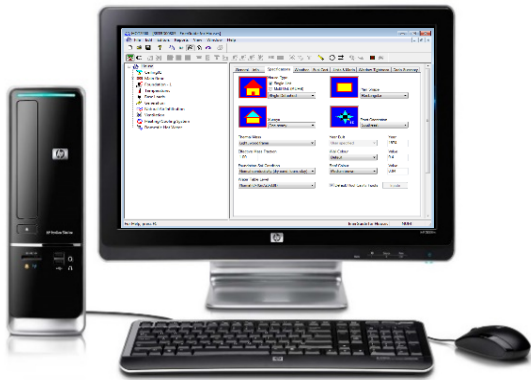
→ Data from 7 wood-frame archetypes

→ Provides a range of most cost-effective options to meet each Step

# Optimization – To Whose Benefit

Optimization	Low ICC	High NPV	Low GHGs
<b>Who benefits</b>	Builder / Developer	Occupant / Owner	Society & Government Environment
<b>Benefits</b>	Lower up-front costs	Lower operating costs	Lower emissions
<b>Typical ways to achieve step</b>	Higher performance mechanical over enclosure	Gas equipment (low cost fuel), High enclosure over mechanical	Electric equipment (low emission fuel), Highest efficiency equipment (e.g. heat pump), high performance enclosure

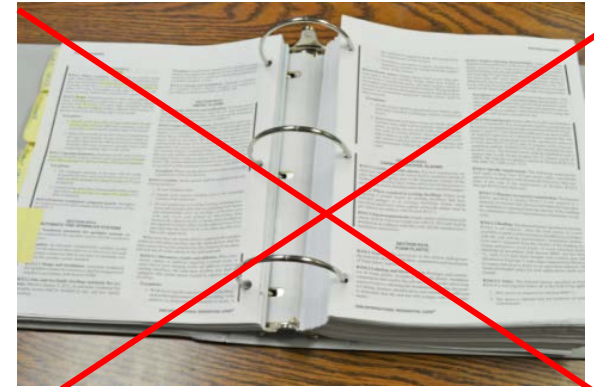
# BC Energy Step Code = Performance Compliance



Energy Modeling



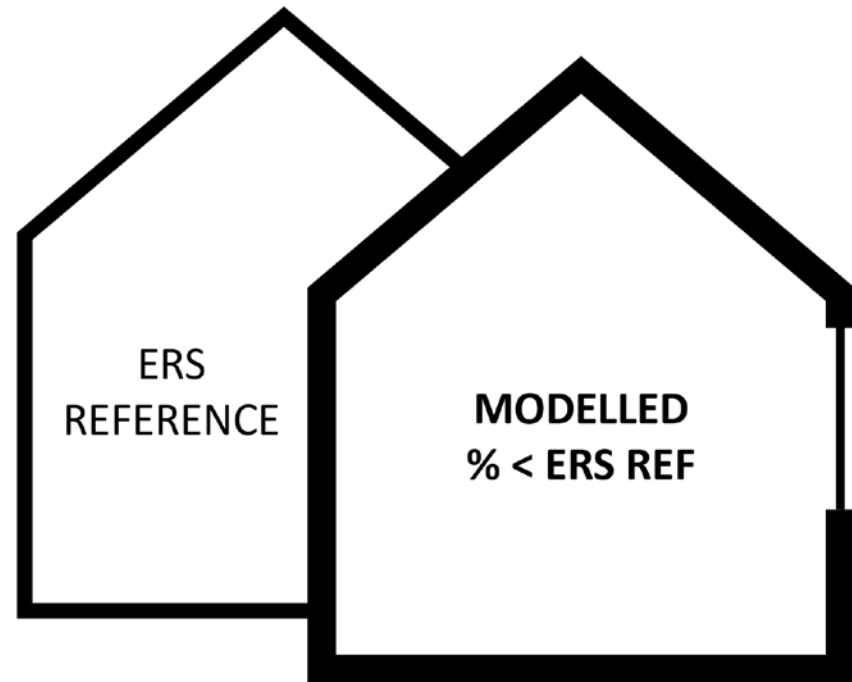
Air-Tightness Testing



No More Prescriptive Requirements

# Metrics Study Only Examined MEUI – It Did not Examine ERS Rating % Lower Than Reference House

- Limitation of the Metrics Study
- Over-estimated cost impact for small single family archetype

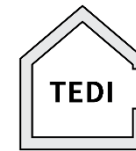
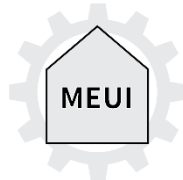
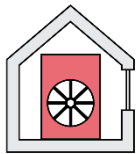


# What are the New Targets?

## Performance Requirements

### Part 9, Climate Zone 4

Base on BCBC Table 9.36.6.3.A.



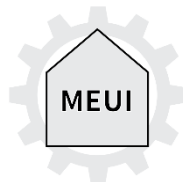
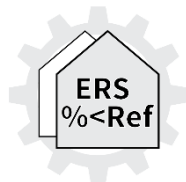
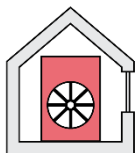
		ERS%<REF not less than 0% OR Conform to BCBC Subsection 9.36.5.					
		kWh/m <sup>2</sup> /yr		kWh/m <sup>2</sup> /yr		W/m <sup>2</sup>	
1	N/A						
2	3.0	-10%	OR	60	45	OR	35
3	2.5	-20%	OR	45	40	OR	30
4	1.5	-40%	OR	35	25	OR	25
5	1.0	N/A		25	15	OR	10

# What are the New Targets?

## Performance Requirements

### Part 9, Climate Zone 5

Base on BCBC Table 9.36.6.3.B.



		ERS%<REF not less than 0% OR Conform to BCBC Subsection 9.36.5.					
		kWh/m <sup>2</sup> /yr		kWh/m <sup>2</sup> /yr		W/m <sup>2</sup>	
1	N/A						
2	3.0	-10%	OR	90	60	OR	55
3	2.5	-20%	OR	75	50	OR	45
4	1.5	-40%	OR	45	40	OR	40
5	1.0	N/A		25	15	OR	10

# Study Details



# Modelled Energy Conservation Measures

Component	Options	# of choices
Airtightness ACH	3.5 ACH, 2.5 ACH, 1.5 ACH, 1.0 ACH, 0.6 ACH	5
Wall R-Value	R16, R18, R22, R24, R30, R40, R50, R60	8
Under-slab R-Value	R11, R15, R20, R40	4
Foundation Wall R-Value	R11, R17, R20, R25	4
Exposed Floor R-Value	R27, R29, R35, R40	4
Ceiling/Roof R-Value	R40, R50, R60, R70, R80, R100	6
Window Option & U-Value	Double (1.8), double (1.6), double (1.4), high gain triple (1.2), low gain triple (1.2), triple (1.0), high performance triple (0.8)	7
Domestic Hot Water (DHW) System	Electric & gas tank, 2 x gas tankless, heat pump (electric)	5
Drain Water Heat Recovery	None, 30%, 42%, 55% (recovery efficiencies)	4
Space Heating	Gas 92% & 95% AFUE, gas combo, Cold Climate ASHP (electric), Baseboard (electric)	5
Ventilation Heat Recovery	None, 60%, 70%, 75% & 84% SRE	5
<b>Total Number of Possible Combinations</b>	<b>53,760,000</b>	

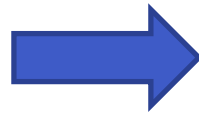
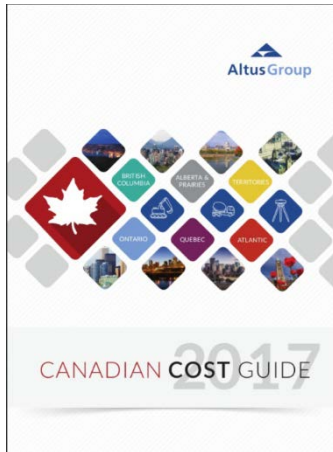
# Heat Pump Water Heater



- Study considered integrated unit with heat pump combined with tank
- Essentially takes heat from basement to heat hot water.
- Lowers MEUI but increases TEDI
- Split system with heat pump outside would be best.

Performance tested at CCHT twin houses in Ottawa, report at:  
[www.cmhc-schl.gc.ca/odpub/pdf/68220.pdf](http://www.cmhc-schl.gc.ca/odpub/pdf/68220.pdf)

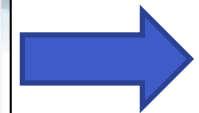
# Validating the Costs – Part 9



Altus 2017 Canadian Cost Guide +  
NRCan LEEP program

Additional validation from local experts:

- Builders
- Energy Advisors
- Quantity Surveyors



# Archetypes Modelled

Archetype	Details
• MURB (10 units)	1,654m <sup>2</sup> , 1,780ft <sup>2</sup> /unit, 3 storey over underground parkade
• Row House (6 units)	957m <sup>2</sup> , 1,720ft <sup>2</sup> /unit, 3 storey over underground parkade
• Quadplex	513m <sup>2</sup> , 1,382ft <sup>2</sup> /unit, 3 storey over underground parkade
• Large SFD	511m <sup>2</sup> , 2 storey with basement
• Medium SFD	237m <sup>2</sup> , 2 storey with basement
• Small SFD*	102m <sup>2</sup> , single storey on heated crawlspace

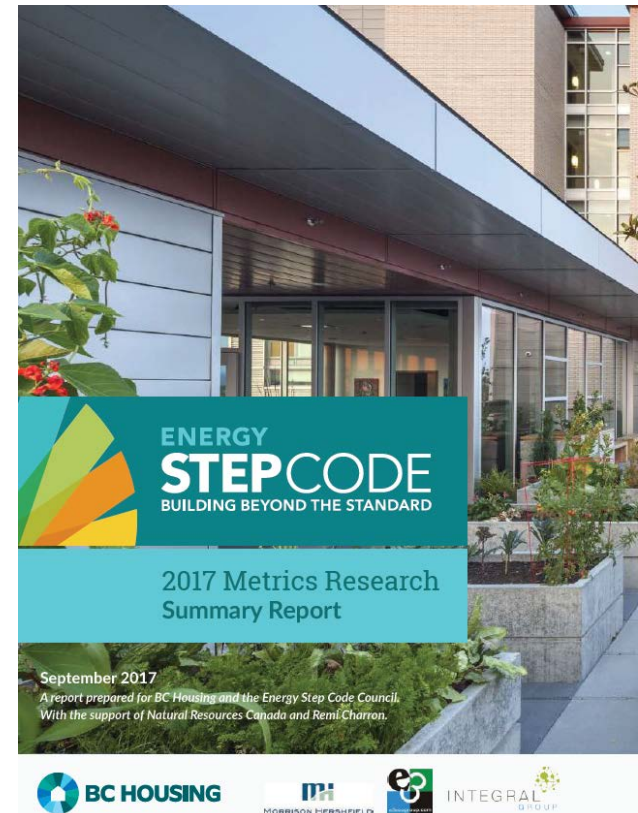
*\*single family dwelling*

# Overall Results



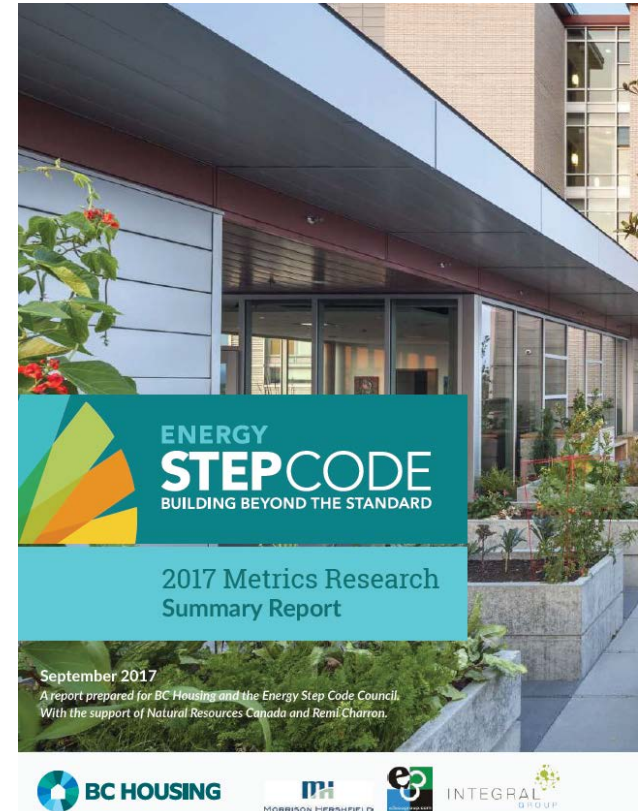
# Findings from the Costing Study – Lower Steps

- Buildings can achieve Step Code for less than 2% construction premium
  - Even less for some multi-family building types
- Costs are lowest for affordable building types (eg apartments)
  - Simple architecture is naturally efficient
- Cheaper for very large single family homes than stand-alone coach houses
  - Interior space: surface area of envelope



## Findings from the Costing Study – Upper Steps

- Upper steps are more expensive as they may require non-conventional building practices and specialty materials
  - Thermal breaks for balconies
  - High performance windows
  - Attachment of thick exterior insulation
- Most building types can achieve Net Zero Ready (ie up to 80% better energy performance) for less than 5% construction premium
- Design choices can further reduce costs – but were not incorporated into the study



## Putting costs in context ...

- **<1%** Industry preferred level of intervention of step code
- **1-2%** Typical cost incremental for last two code updates, demonstrated to have no measurable impact.
- **2-5%** May require some short term incentives

<1%

1-2%

>2%

# Lower Step Costing Results – Part 9 Buildings

Climate Zone 4 (Lower Mainland, South Vancouver Island)

	10 Unit Multi-Family (1780 ft <sup>2</sup> )	6-Unit Townhouse (1720 ft <sup>2</sup> )	Medium Single Family Dwelling (2550 ft <sup>2</sup> )
<b>Step</b>			
<b>1</b>	<b>0.1%</b>	<b>0.2%</b>	<b>0.2%</b>
<b>2</b>	<b>0.3%</b>	<b>0.4%</b>	<b>0.2%</b>
<b>3</b>	<b>0.3%</b>	<b>1.1%</b>	<b>0.8%</b>

# Lower Step Costing Results – Part 9 Buildings

## Climate Zone 5

	10 Unit Multi-Family (1780 ft <sup>2</sup> )	6-Unit Townhouse (1720 ft <sup>2</sup> )	Medium Single Family Dwelling (2550 ft <sup>2</sup> )	Small Single Family Dwelling (1100 ft <sup>2</sup> )
<b>Step</b>				
<b>1</b>	<b>0.1%</b>	<b>0.2%</b>	<b>0.2%</b>	<b>0.4%</b>
<b>2</b>	<b>0.3%</b>	<b>0.5%</b>	<b>0.0%</b>	<b>0.8%</b>
<b>3</b>	<b>0.3%</b>	<b>0.5%</b>	<b>0.0%</b>	<b>2.4%</b>

## Step 2 – Prescriptive Requirements + 3.0 ACH

	Metric	CZ4 Requirement	CZ 4 Results	CZ5 Requirement	CZ 5 Results
Small SFD	% Better	10%	2.2%	10%	2.8%
	MEUI	60	98.9	90	112.7
	TEDI	<b>45</b>	<b>41.0</b>	<b>60</b>	<b>54.4</b>
	PTL	35	53.8	55	66.2
Medium SFD	% Better	10%	4.4%	10%	1.9%
	MEUI	60	63.2	<b>90</b>	<b>73.5</b>
	TEDI	<b>45</b>	<b>36.9</b>	<b>60</b>	<b>46.7</b>
	PTL	<b>35</b>	<b>28.5</b>	<b>55</b>	<b>36.0</b>
Large SFD	% Better	10%	-15.2%	10%	-16.3%
	MEUI	60	63.2	<b>90</b>	<b>72.2</b>
	TEDI	<b>45</b>	48.8	<b>60</b>	<b>57.5</b>
	PTL	<b>35</b>	<b>27.2</b>	<b>55</b>	<b>34.2</b>

**Code minimum** med and large SFDs can meet **Step 2 targets** in **Zone 5**

**PTL:**

→ easy for large SFD

→ hard for small SFD

## Step 3 – Prescriptive Requirements + 2.5 ACH

	Metric	CZ4 Requirement	CZ 4 Results	CZ5 Requirement	CZ 5 Results
Small SFD	% Better	20%	3.5%	20%	4.2%
	MEUI	45	97.5	75	111.1
	TEDI	40	39.9	50	52.9
	PTL	30	53.1	45	65.0
Medium SFD	% Better	20%	6.6%	20%	4.5%
	MEUI	45	61.8	75	71.5
	TEDI	40	35.6	50	44.9
	PTL	30	27.7	45	34.8
Large SFD	% Better	20%	-12.5%	20%	-13.0%
	MEUI	45	61.7	75	70.2
	TEDI	40	47.5	50	55.6
	PTL	30	26.4	45	32.9

**Code minimum** med. and large SFDs can meet **Step 3 targets** in **Zone 5**

Large SFD meets **Step 3**, yet consumes 13% **more** than Reference House!

# Lowest Cost Design for Steps 2 and 3 – Small Single Family



→ Small SFD

1,100 ft <sup>2</sup> SFD	Step 2 Vancouver	Step 3 Vancouver	Step 2 Summerland	Step 3 Summerland
Walls	16	16	18	16
Attic	50	60	50	60
Slab Insulation	11.1	11.1	11.1	11.1
Foundation	11.3	11.3	11.3	11.3
Windows/Do ors	1.6	1.2	1.2	1.2
Heating	Baseboard	Baseboard	Baseboard	Baseboard
HRV/ERV	0%	60%	None	60%
DHW	Tankless	.67EF NG Tank	.67 EF NG Tank	.67 EF NG Tank
Airtightness	2.5	2.5	2.5	2.5

Step 2 requirement is 3.0 ACH, used 2.5 ACH as 3.0 ACH not modeled in Metrics study

# Lowest Cost Design for Steps 4 and 5 – Small Single Family



→ Small SFD

1,100 ft <sup>2</sup> SFD	Step 4 Vancouver	Step 5 Vancouver	Step 4 Summerland	Step 5 Summerland
Walls	22		22	
Attic	70		60	
Slab Insulation	11.1		11.1	
Foundation	11.3		11.3	
Windows/Do ors	1.0	Not achieved	1.2	Not achieved
Heating	Baseboard		Baseboard	
HRV/ERV	84%		70%	
DHW	Heat Pump		Heat Pump	
Airtightness	1.5		1.0	

# Lowest Cost Design for Steps 2 and 3 – Medium Single Family



→ Medium SFD

2,550 ft <sup>2</sup> SFD	Step 2 Vancouver	Step 3 Vancouver	Step 2 Summerland	Step 3 Summerland
Walls	16	18		16
Attic	40	40		40
Slab Insulation	0	0		0
Foundation	16.9	11.3	Too Easy. Step 3 is the minimum step achieved.	11.3
Windows/Doors	1.8	1.8		1.8
Heating	Baseboard	Baseboard		Baseboard
HRV/ERV	None	70%		None
DHW	Instant	Heat pump		Elec. Tank
Airtightness	2.5	2.5		2.5

Step 2 requirement is 3.0 ACH, used 2.5 ACH as 3.0 ACH not modeled in Metrics study

Climate Zone 5 Has Easiest Targets

# Lowest Cost Design for Steps 4 and 5 – Medium Single Family



→ Medium SFD

2,550 ft <sup>2</sup> SFD	Step 4 Vancouver	Step 5 Vancouver	Step 4 Summerland	Step 5 Summerland
Walls	24	24	24	40
Attic	40	40	60	100
Slab Insulation	0	11.1	0	0
Foundation	11.3	19.6	11.3	25
Windows/Do ors	1.6	1.2	1.6	1.2
Heating	Baseboard	Baseboard	Baseboard	Baseboard
HRV/ERV	60%	70%	None	70%
DHW	Heat pump	Heat pump	Heat pump	Heat pump
Airtightness	1.5	0.6	1.0	0.6

# Including the % Better for Small House

→ Climate Zone 4



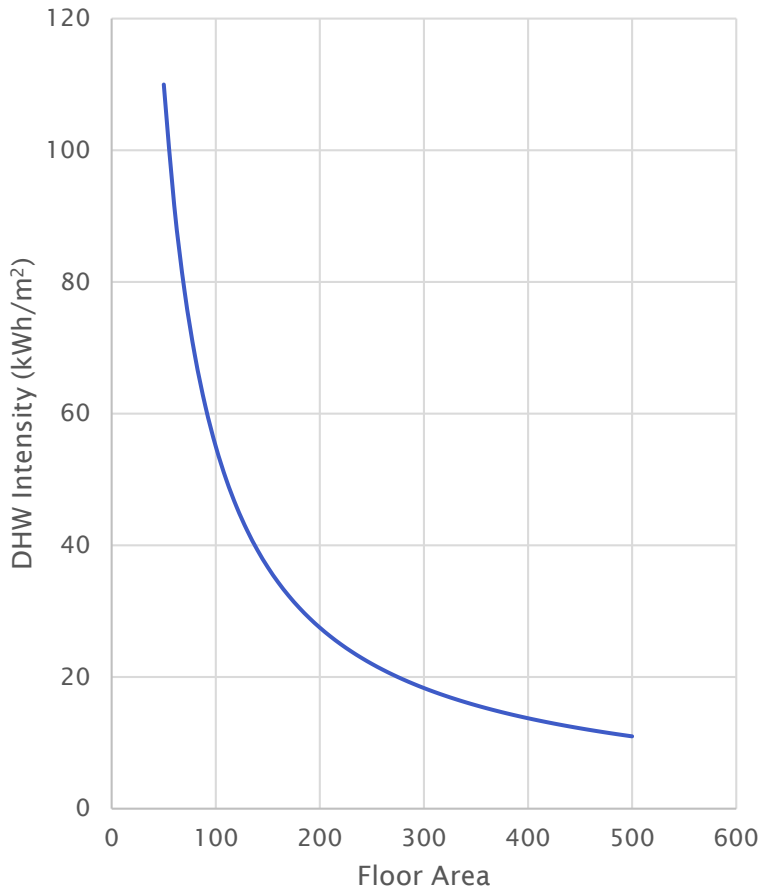
VS



	2,550 ft <sup>2</sup> SFD	Prescriptive 9.36	Medium House Step 3	Small House Step 3 - MEUI	Small House Step 3 – 20% ERS
Walls	R-16		R-18	R-30	R-16
Attic	R-40		R-40	R-100	R-60
Slab Insulation	11.1		None	R-11	R-11
Foundation wall	R-11		R-11	R-11	R-11
Windows/Door s	U <sub>SI</sub> -1.8		U <sub>SI</sub> -1.8	Triple U-1.2	Triple U-1.2
Heating	Base furnace (92%)		Electric Baseboard	Baseboard	Baseboard
HRV/ERV	None		70%	60%	60%
DHW	Code		Heat Pump	Heat pump	0.67 EF NG Tank
Airtightness	3.5 ACH50		2.5 ACH50	2.5 ACH50	2.5 ACH50

# Impact of DHW Load on Small Houses

Impact of Building Size on Energy Intensity of Hot Water Load



- The modelled hot water load is the same for all house sizes
- In Climate Zone 4, with a natural gas tank, it equals 5,500 kWh
- This constant load impacts smaller homes disproportionately
- For small houses, % Better than ERS is more appropriate

# Steps 2 and 3 of Large Single Family House



→ Large SFD

5,500 ft <sup>2</sup> SFD	Step 2 Vancouver	Step 3 Vancouver	Step 2 Summerland	Step 3 Summerland
Walls	16	16	Too Easy. Step 3 is the minimum step achieved.	16
Attic	50	50		40
Slab Insulation	0	0		0
Foundation	11.3	11.3		11.3
Windows/Doors	1.8	1.8		1.8
Heating	Baseboard	Heat pump		92% furnace
HRV/ERV	70%	70%		None
DHW	Tankless	Tankless		Elec. Tank
Airtightness	2.5	2.5		2.5

Step 2 requirement is 3.0 ACH, used 2.5 ACH as 3.0 ACH not modeled in Metrics study

# Steps 4 and 5 of Large Single Family House

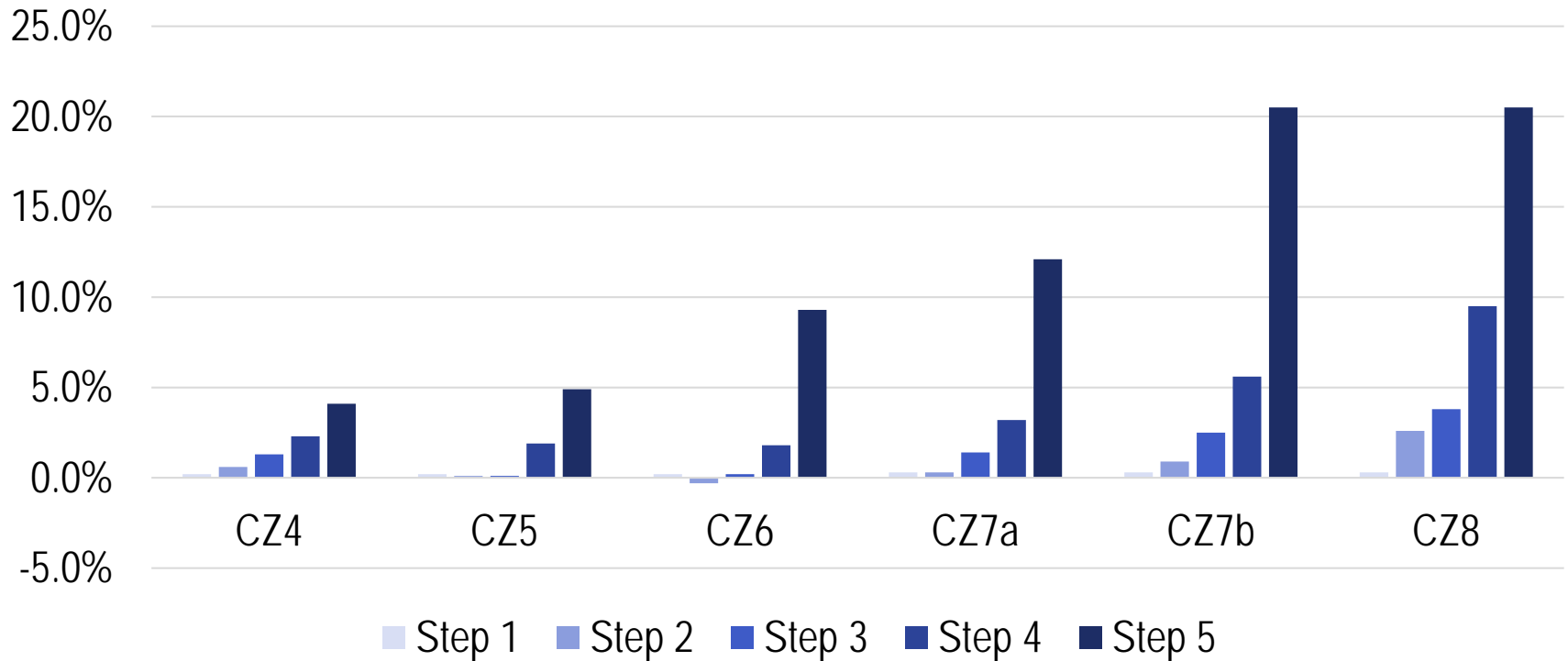


→ Large SFD

5,500 ft <sup>2</sup> SFD	Step 4 Vancouver	Step 5 Vancouver	Step 4 Summerland	Step 5 Summerland
Walls	16	40	16	60
Attic	40	70	40	70
Slab Insulation	0	0	0	20
Foundation	11.3	16.9	11.3	16.9
Windows/Doors	1.8	1.2	1.8	0.8
Heating	Heat pump	Heat pump	Heat pump	Baseboard
HRV/ERV	84%	70%	84%	84%
DHW	Elec. Tank	Elec. Tank	Elec. Tank	Elec. Tank
Airtightness	1.5	0.6	1.5	0.6

# BC Housing *Metrics Study*

## Medium SFD



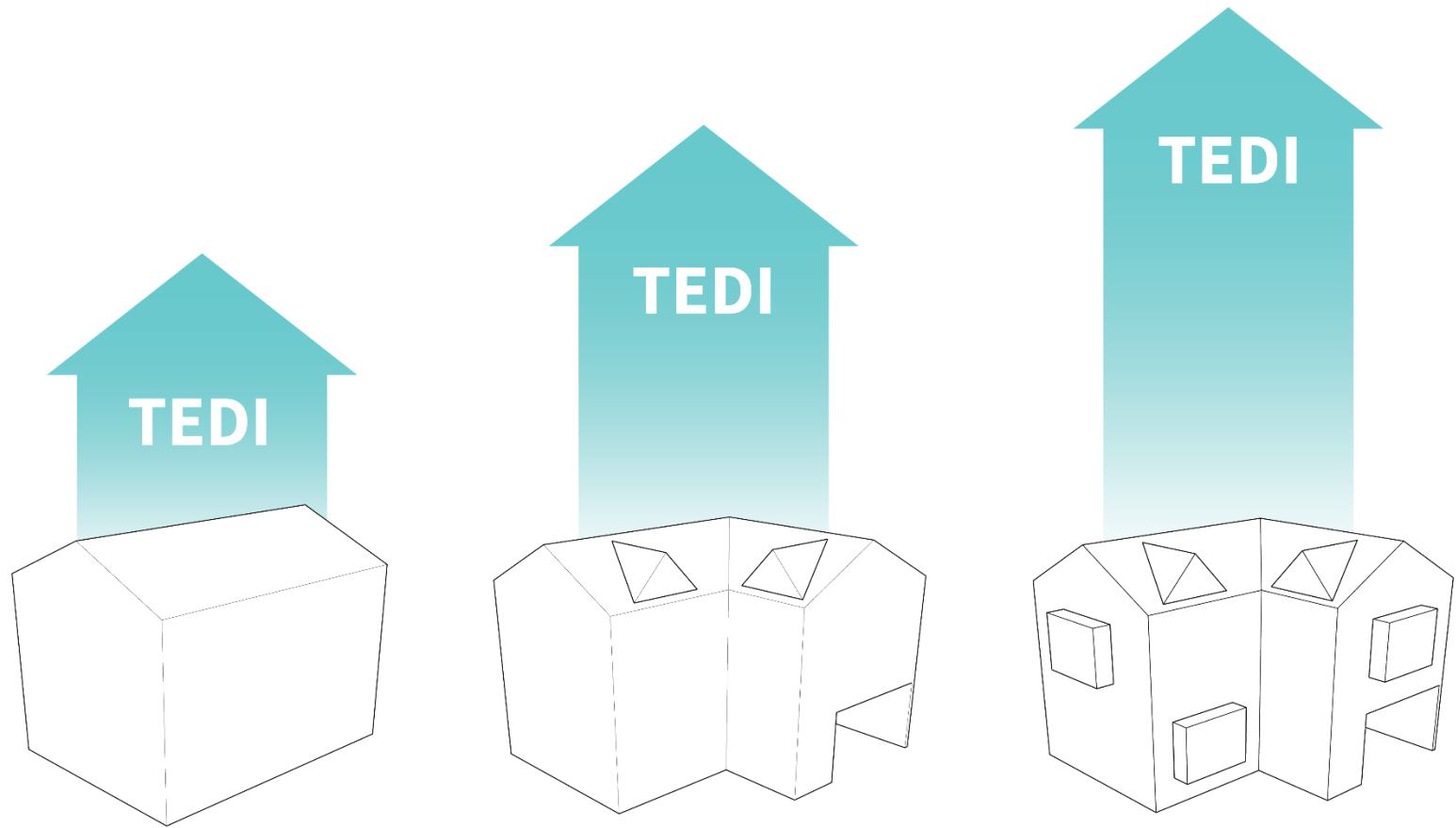
→ Example results from Metrics Study

→ Percent cost premium versus BCBC

# Building Enclosure Results

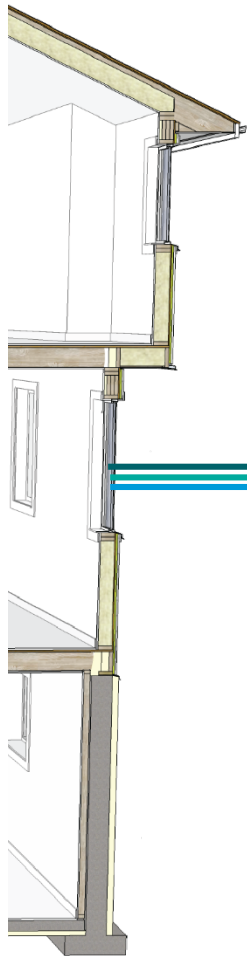


# Form Factor and Articulation Impact on TEDI



Surface Area/Volume Ratio

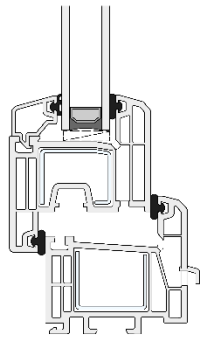
# Windows: Wide Range of Targets Across Steps & Zones



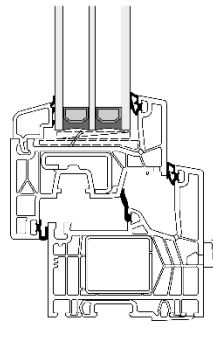
<b>1</b>	USI-1.8 (U-0.32)
<b>2</b>	USI-1.8 to USI-1.2 (U-0.32 to U-0.21)
<b>3</b>	USI-1.8 to USI-0.8 (U-0.32 to U-0.14)
<b>1</b>	USI-1.8 to USI-1.6 (U-0.32 to U-0.28)
<b>2</b>	USI-1.8 to USI-0.8 (U-0.32 to U-0.14)
<b>3</b>	USI-1.8 to USI-0.8 (U-0.32 to U-0.14)
<b>1</b>	USI-1.6 to USI-1.4 (U-0.32 to U-0.25)
<b>2</b>	USI-1.8 to USI-1.2 (U-0.32 to U-0.21)
<b>3</b>	USI-1.8 to USI-0.8 (U-0.32 to U-0.14)



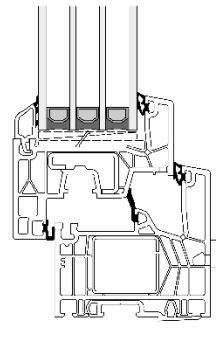
# High Performance Windows & Glazing



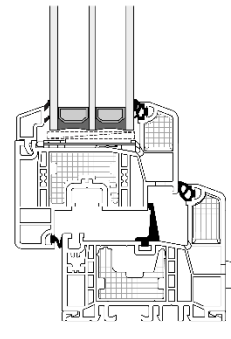
Double Glazed



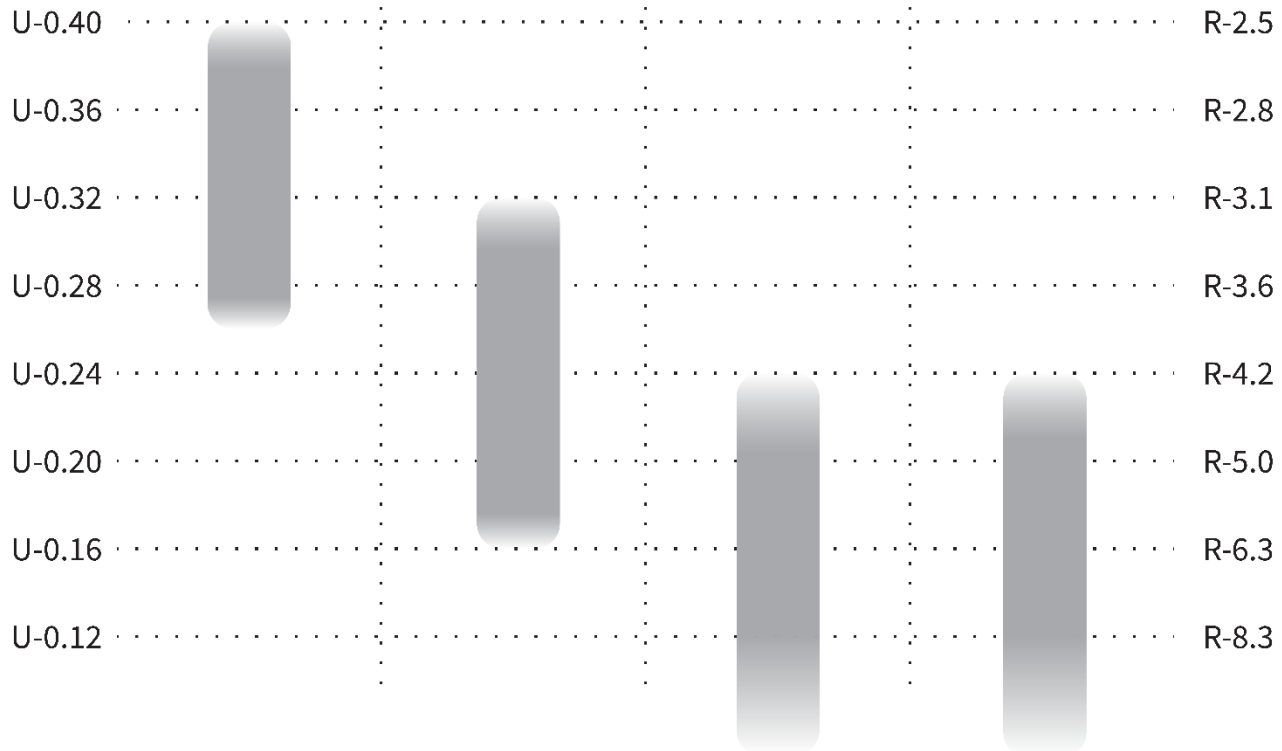
Triple Glazed



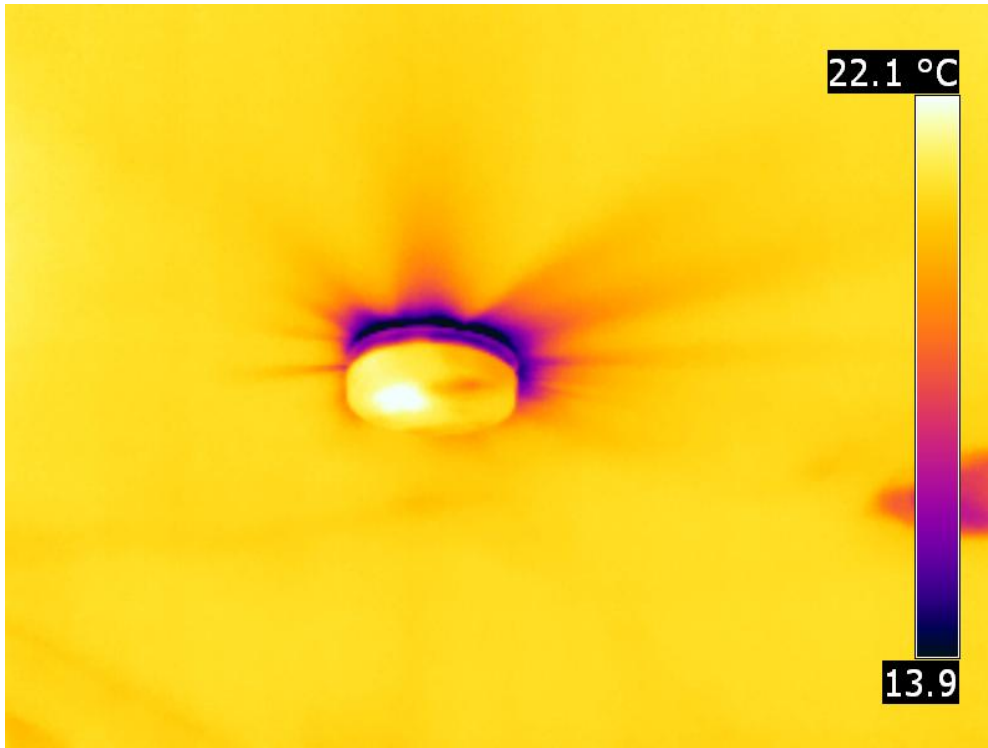
Quad Glazed



PH/Insulated



# Airtightness Targets



# Airtightness Targets



Airtightness	
1	3.5 ACH <sub>50</sub>
2	2.5 to 1.5 ACH <sub>50</sub>
3	2.5 to 1.5 ACH <sub>50</sub>



Airtightness	
1	3.5 ACH <sub>50</sub>
2	2.5 to 1.5 ACH <sub>50</sub>
3	2.5 to 1.0 ACH <sub>50</sub>



Airtightness	
1	3.5 ACH <sub>50</sub>
2	2.5 to 1.5 ACH <sub>50</sub>
3	1.5 to 0.6 ACH <sub>50</sub>

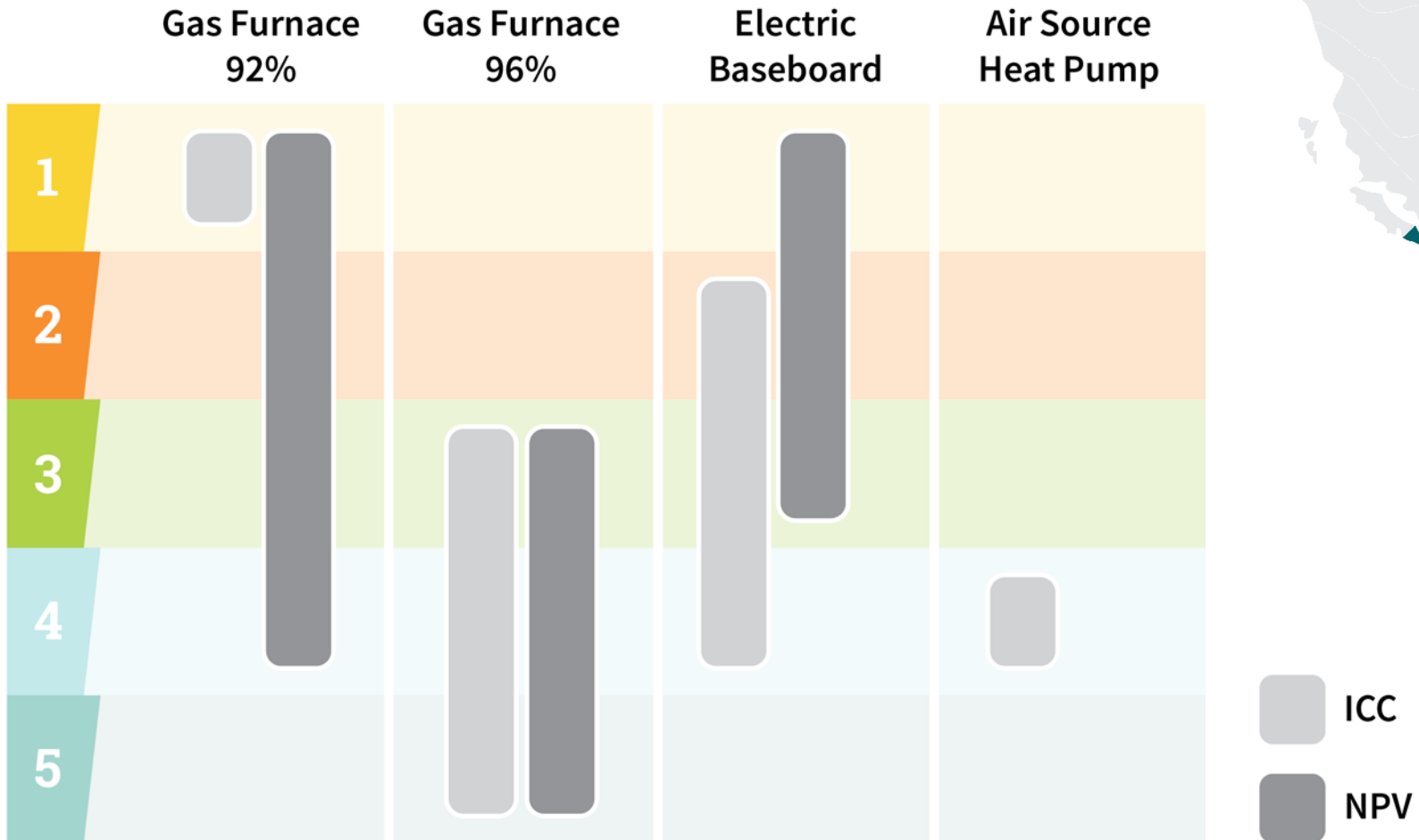
# **Mechanical System Results**



# Mechanical System Selection and Step Code Targets

## - Optimal Heating System

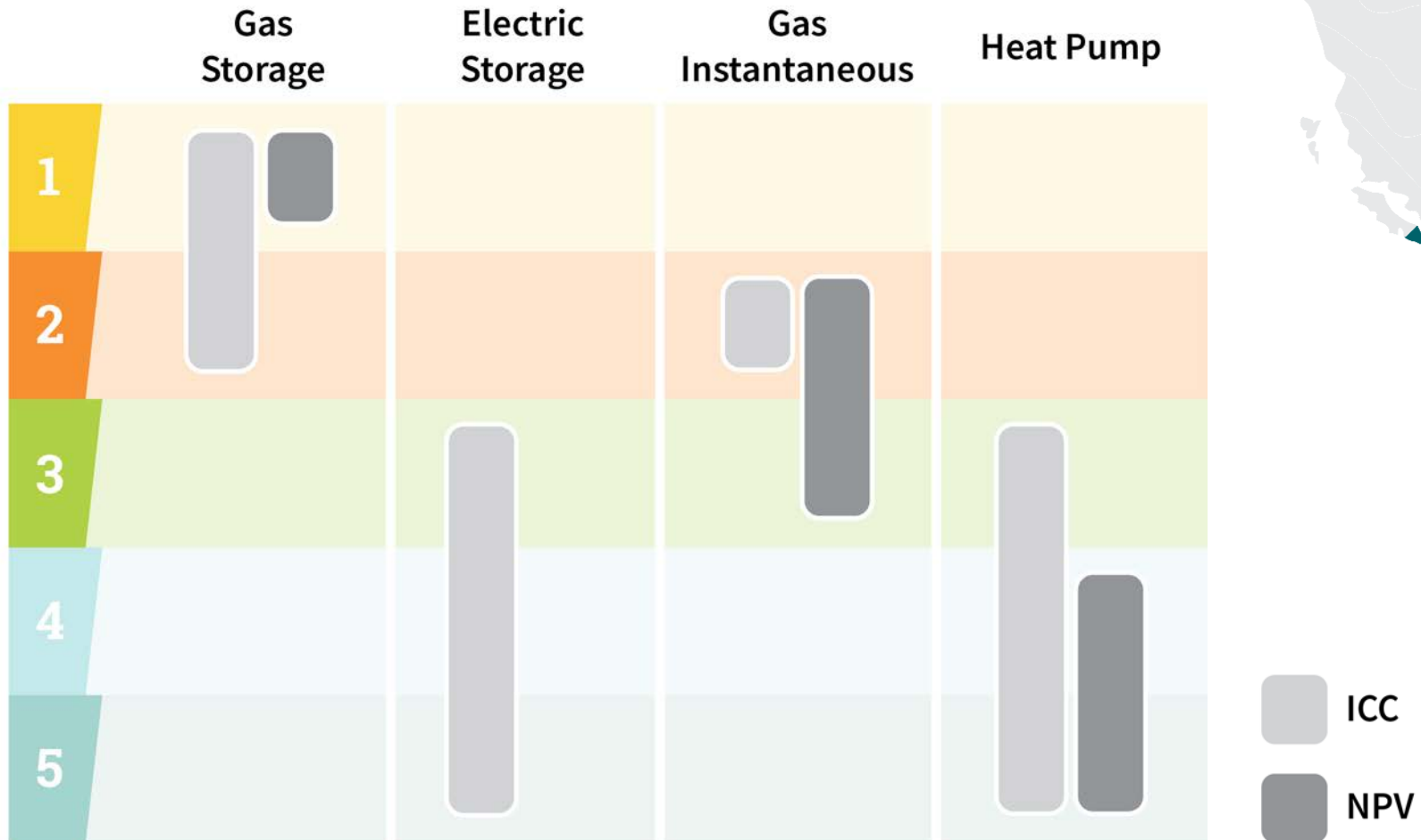
Part 9 - Climate Zone 4



# Mechanical System Selection and Step Code Targets

## - Optimal Hot Water System

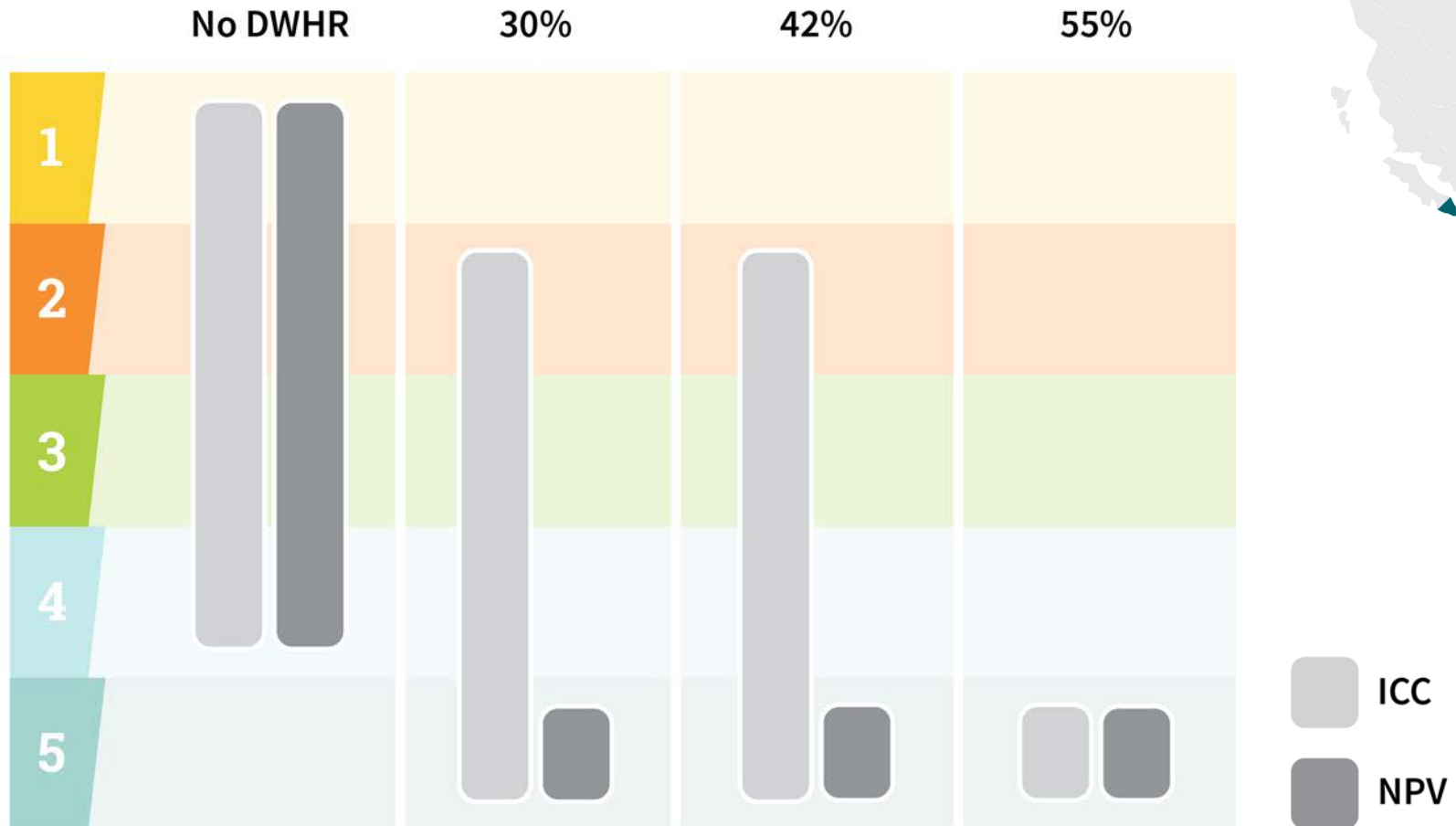
Part 9 – Climate Zone 4



# Mechanical System Selection and Step Code Targets

## - Use of DWHR?

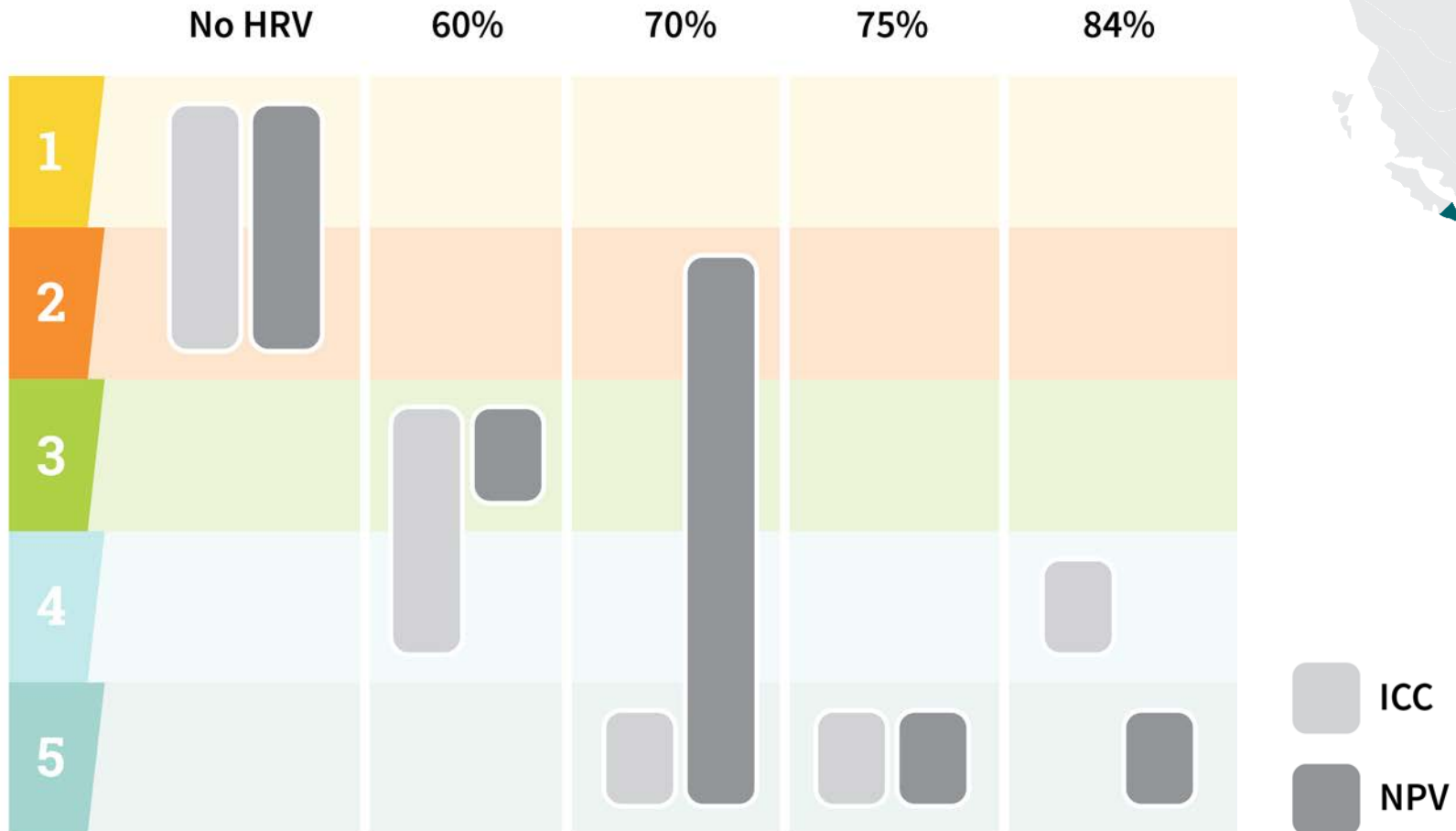
Part 9 – Climate Zone 4



# Mechanical System Selection and Step Code Targets

## - HRV Efficiency

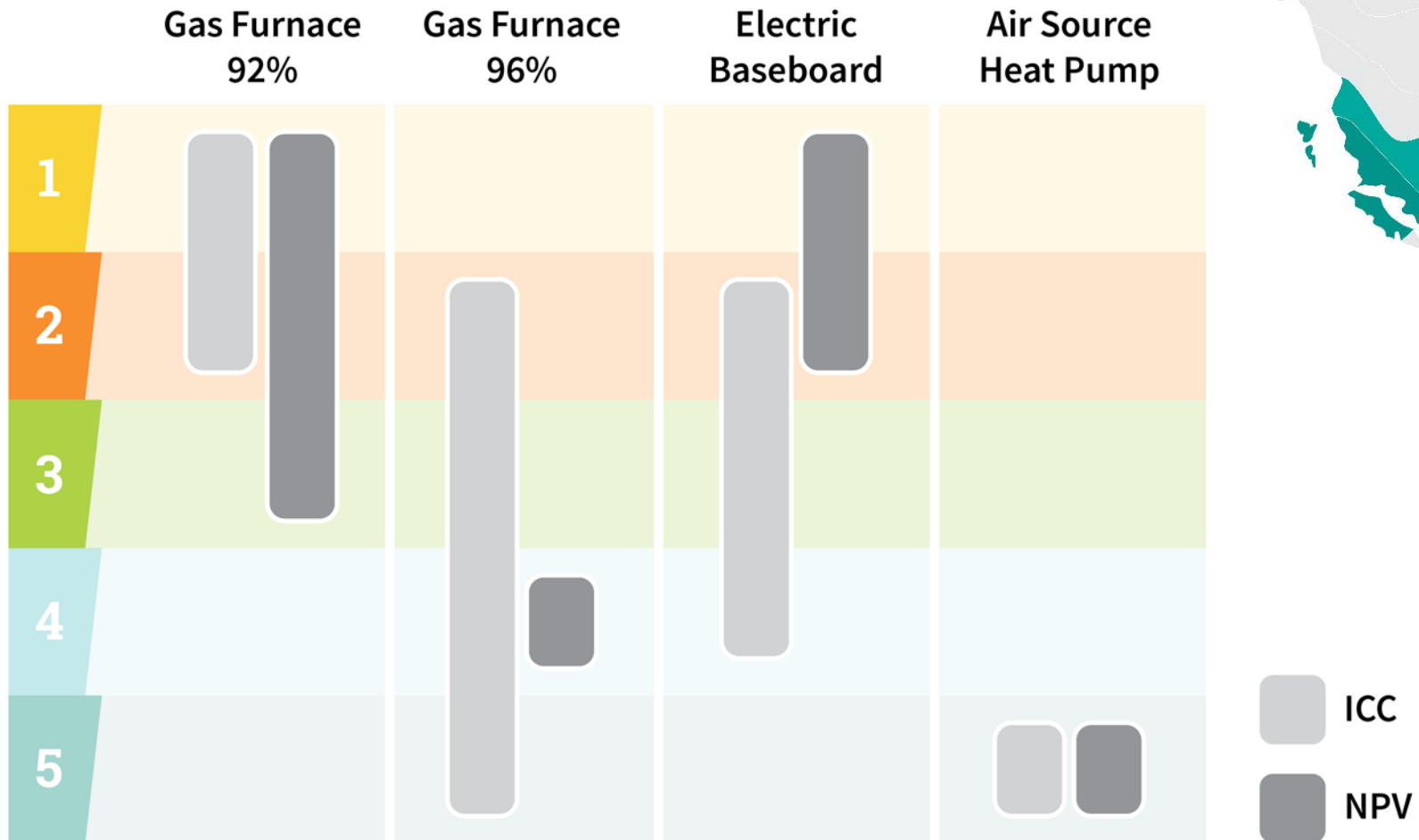
Part 9 - Climate Zone 4



# Mechanical System Selection and Step Code Targets

## - Optimal Heating System

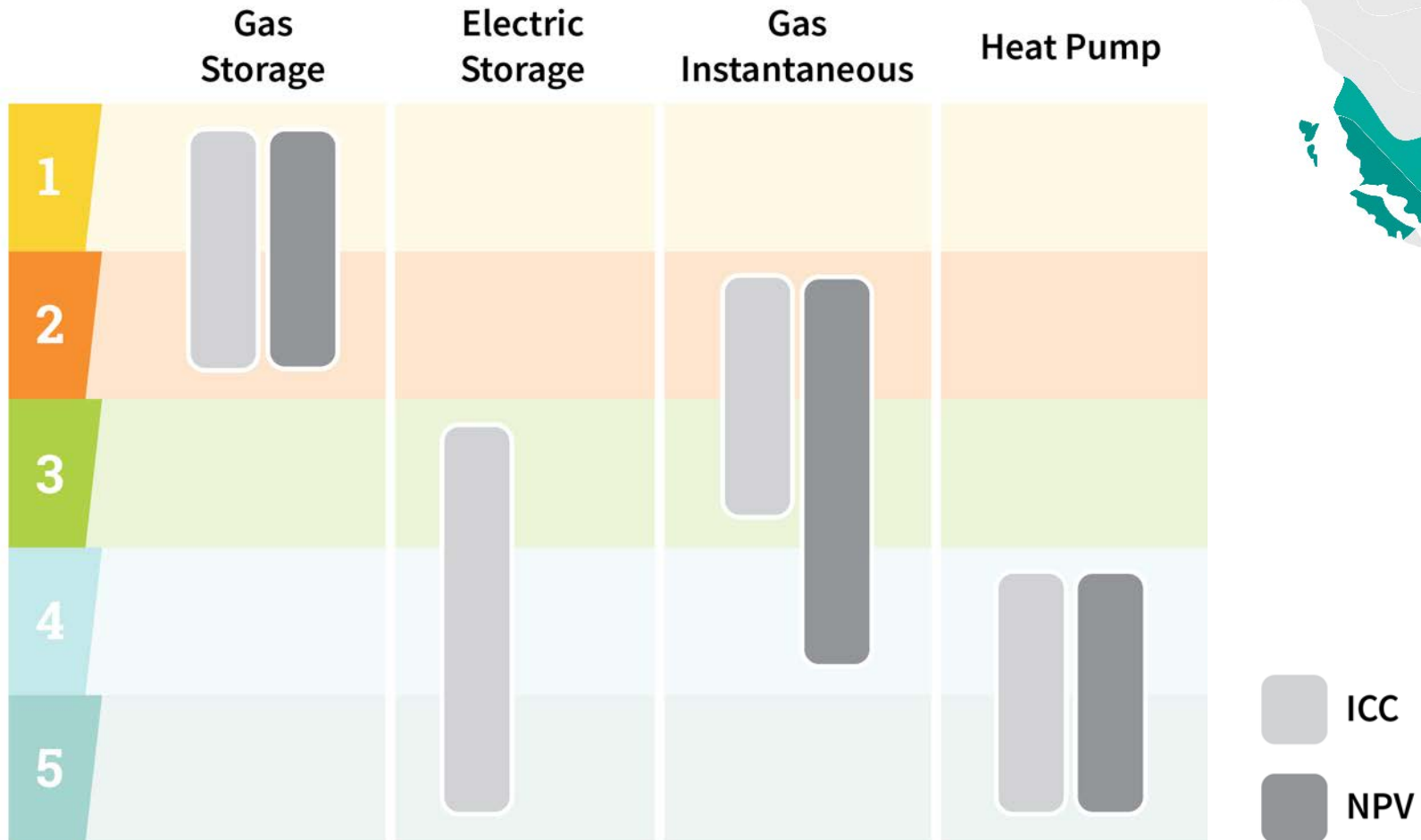
Part 9 – Climate Zone 5&6



# Mechanical System Selection and Step Code Targets

## - Optimal Hot Water System

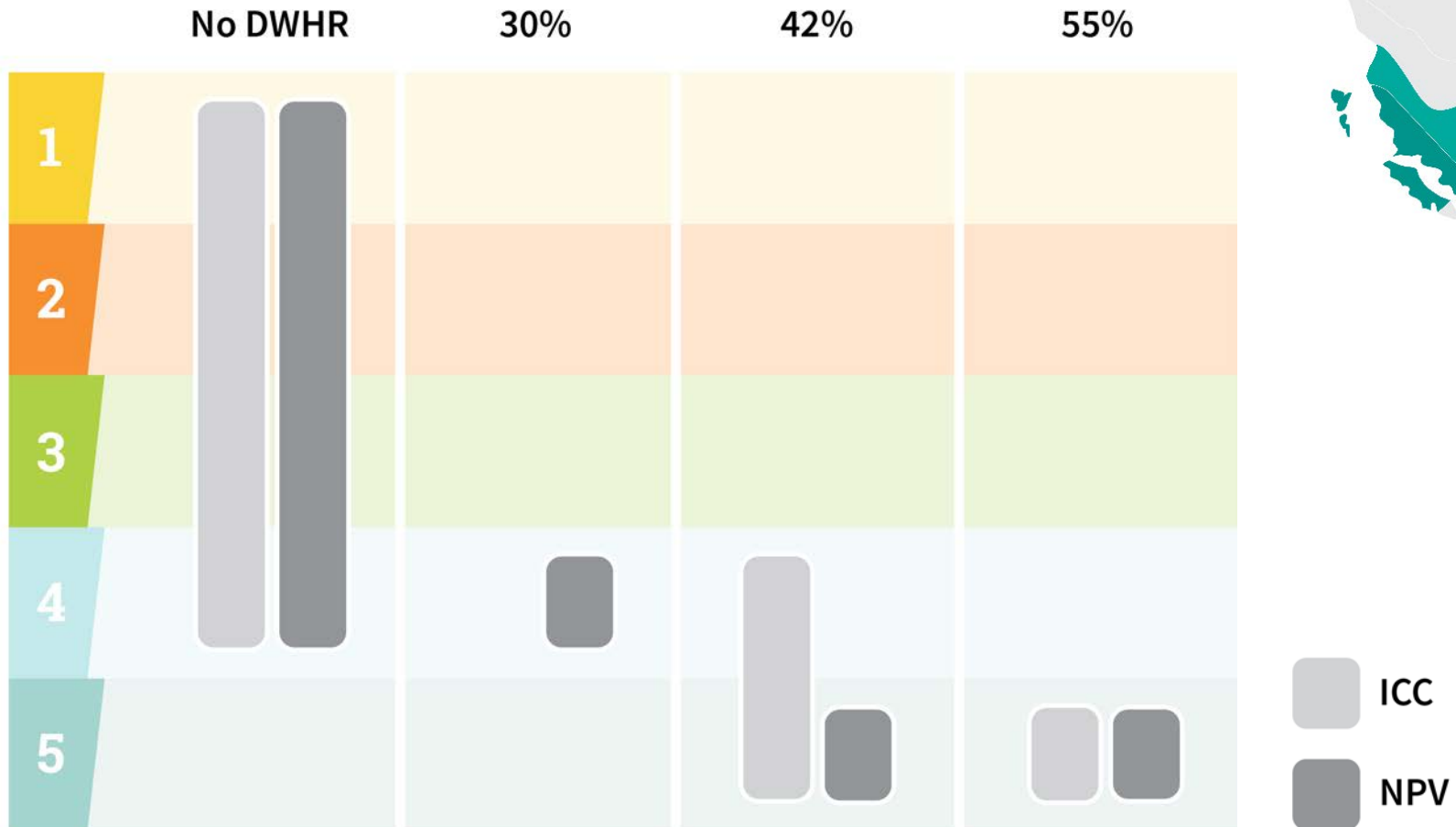
Part 9 – Climate Zone 5&6



# Mechanical System Selection and Step Code Targets

## - Use of DWHR?

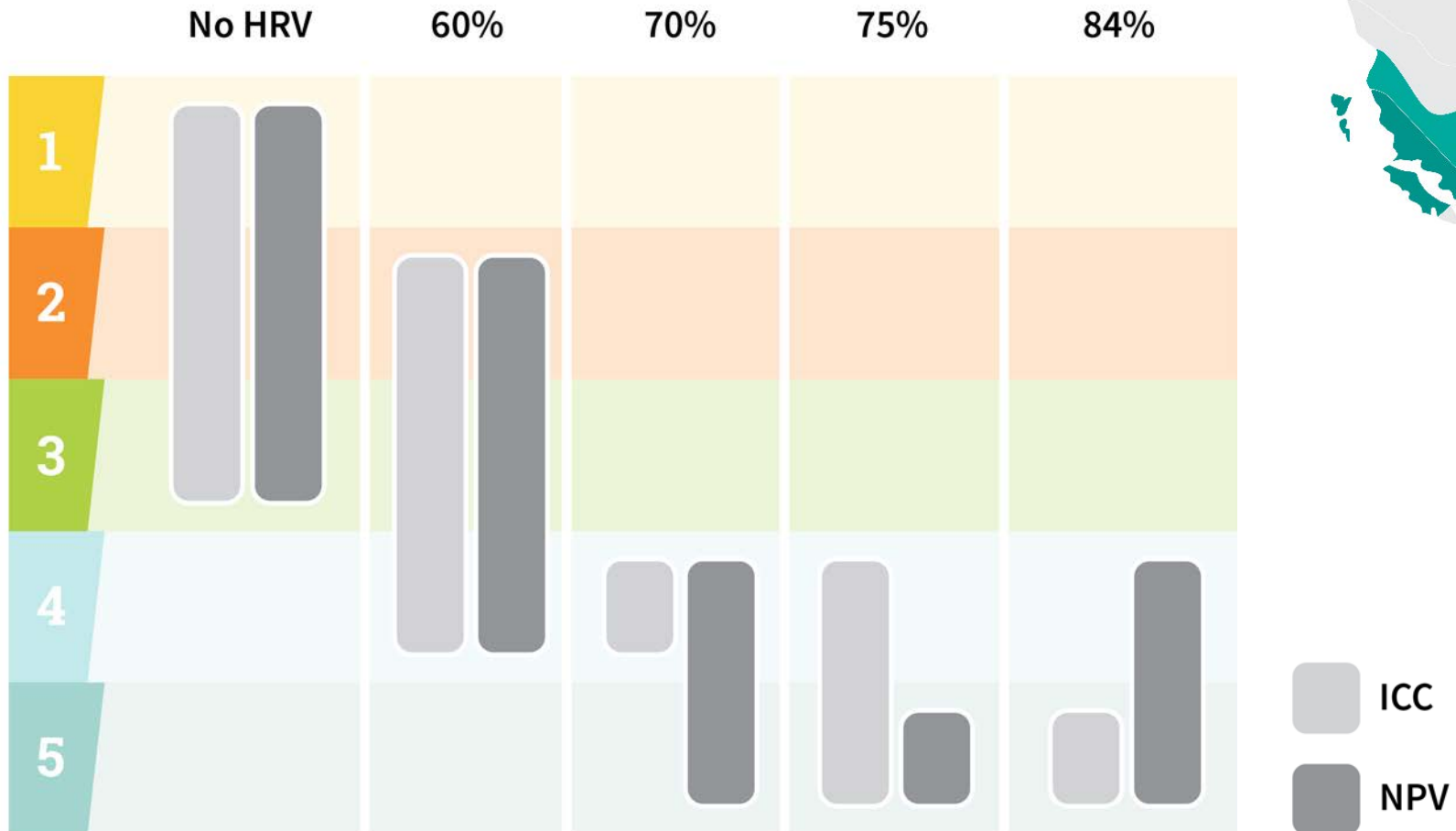
Part 9 – Climate Zone 5&6



# Mechanical System Selection and Step Code Targets

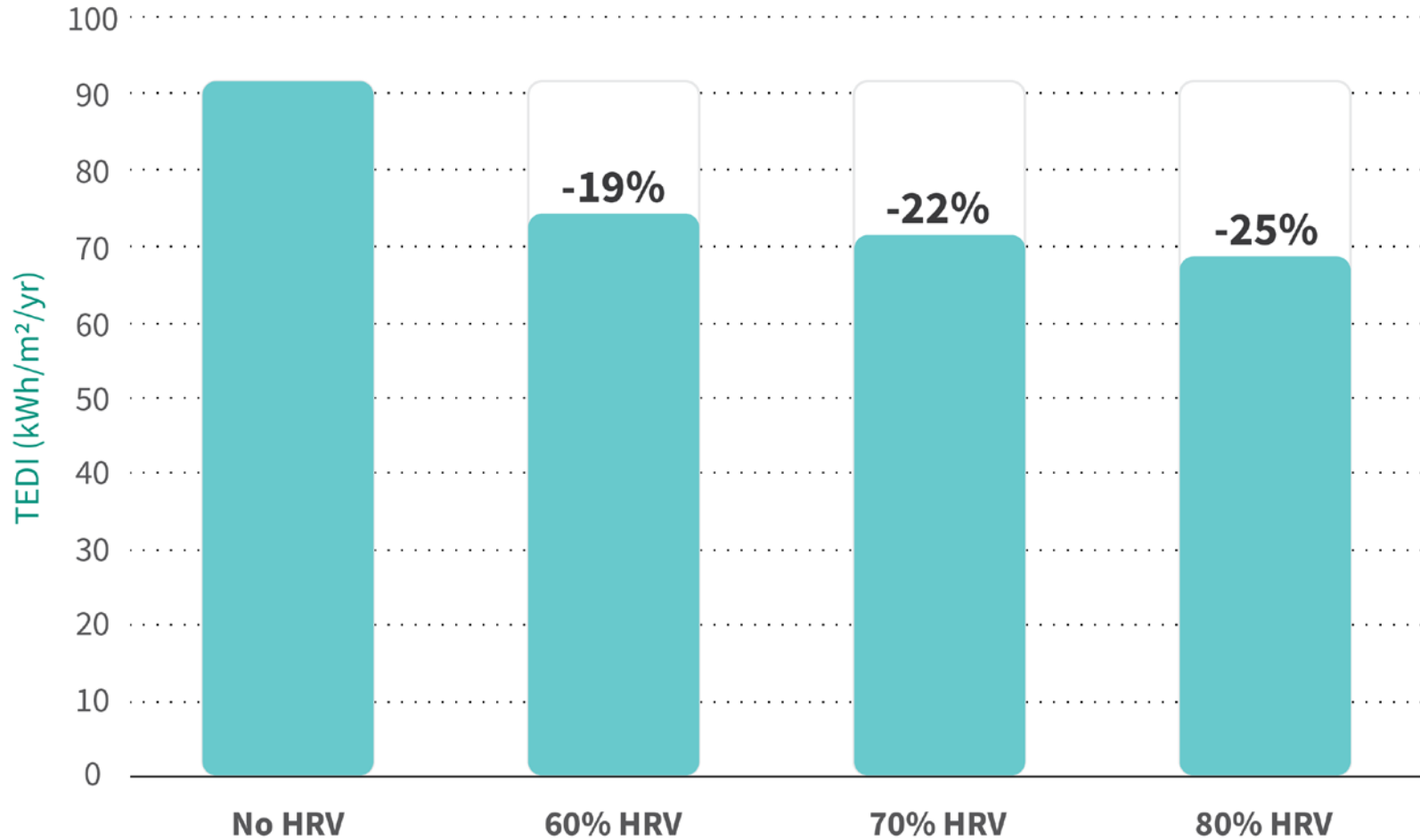
## - HRV Efficiency

Part 9 - Climate Zone 5&6



# Example of HRV Efficiency Impact on TEDI

## Medium SFD, Climate Zone 4



# Ongoing Work

- Looking to update targets to address issues found during Metrics Study
  - Adjust TEDI and MEUI to have proportional increases in energy across the whole province
  - Provide additional allowance for MEUI for small houses

# Additional Resources



# Additional Resources

Visit:

→ [www.energystepcode.ca](http://www.energystepcode.ca)

→ [www.bchousing.org/research-centre](http://www.bchousing.org/research-centre)



Coming in early 2018:

→ *Design Guide to the BC Energy Step Code*

→ *Builder Guide to the BC Energy Step Code*

The image features a decorative vertical line on the left side, colored in a teal shade. To the right, there is a large, abstract graphic composed of several overlapping, fan-shaped segments. These segments are colored in a gradient from light yellow at the bottom to dark teal at the top, with intermediate colors of orange, green, and light blue. The segments are arranged in a way that they appear to radiate from a common point on the right edge of the frame.

# Discussion