Decarb Lunch Series

zebx

Powered by zeic

The Cost of Zero Carbon Development

Mon May 27, 2024,
from 12- 1pm PST
Free Webinar I zebx.org

CITY OF VANCOUVER

BC Hydro
Power smart

ZERO EMISSIONS INNOVATION CENTRE

zeic 'S **BUILDING** DECARBONIZATION TEAM

B2E

NearZero

BC Retrofit ACCELERATOR

CLF Carbon Leadership Forum British Columbia

zebx

ULI British Columbia

ULI GREENPRINT
NET ZERO IMPERATIVE

bosa properties

Guidance in Decision Making for Large-Scale Multi-Family Residential Developers

From condominium homes to rental apartments to commercial spaces, Chard Development has completed over 1.3 million square feet of residential and commercial development and delivered close to 1,400 homes in Metro Vancouver and Greater Victoria.

We are proud to be a catalyst for growth and positive forward momentum. After 30 years, and while our portfolio continues to grow, one thing remains the same. We make good on our promises and stand proudly behind the product we deliver.

Elenore on Fifth
Vancouver, BC – 2020

Juliet
Victoria, BC - 2008

Yates on Yates
Victoria, BC - 2020

34 W7
Vancouver, BC – 2019

Ellsworth
Vancouver, BC - 2018

1050 Yates

Victoria, BC

Located in the Harris Green neighbourhood of Victoria at the intersection of Cook and Yates street, 1050 Yates will bring close to 500 purpose-built rental homes with market-leading amenities and a street-facing public plaza for the community.

CHARD

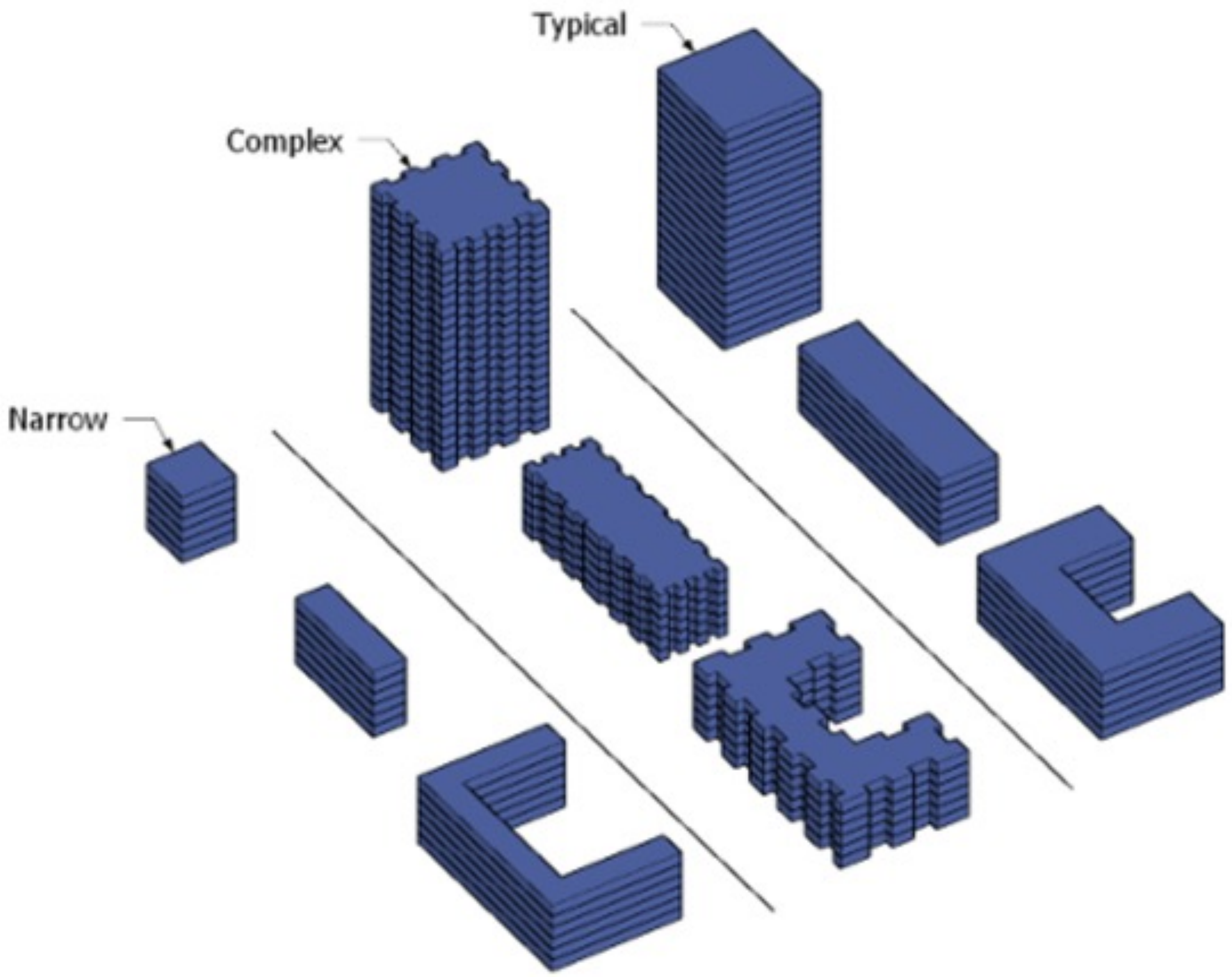

CHARD
COOK

Context

Why we commissioned the study

Building Shape (Form/Massing) affect energy usage

Key metric – VFAR (vertical surface to floor area ratio)



We make decisions quickly and we needed better data!

Energy use & what we've been building...

Last 2 decades – merchant development (condos)

- Energy usage targets – code, LEED, etc.
- Long-term operating costs part of the equation?
- Business case for better enclosure?

  Higher cost -> increase sales price -> project risk

Today – new income producing properties (purpose-built rental)

- Net operating income – energy usage = operating costs = some control
- Building shape matters (form and massing)

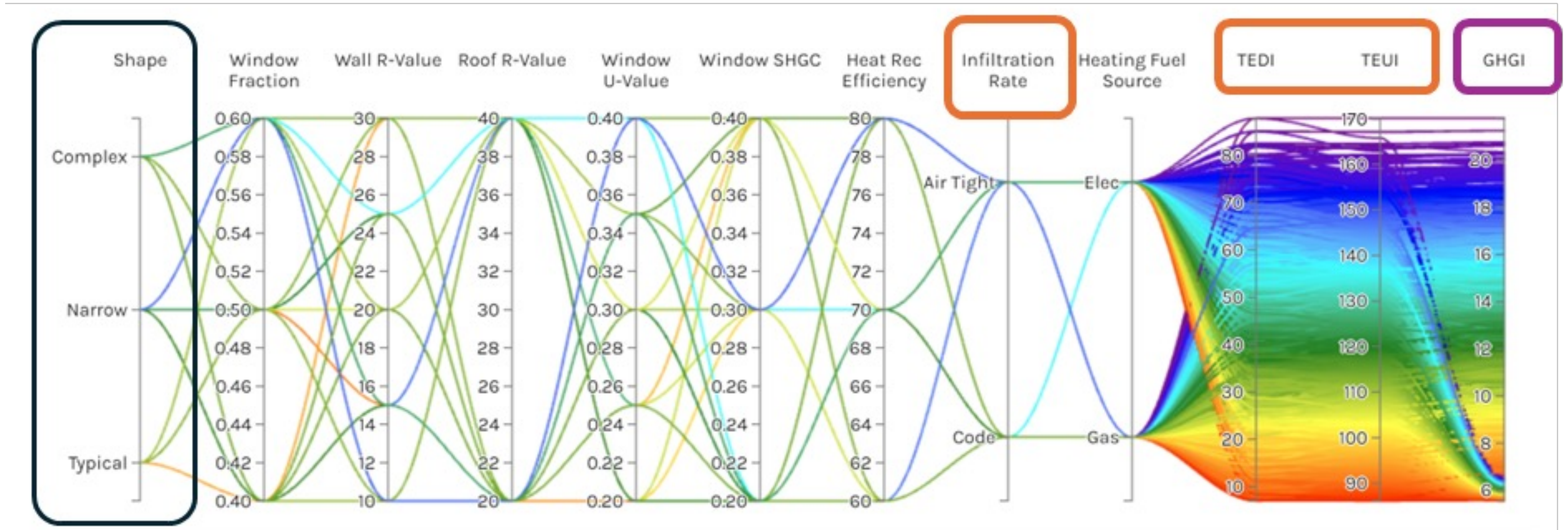
CHARD

Parametric Energy Modeling

An existing useful tool

Energy step code

Zero Carbon Step Code



Shape	Window Fraction	Wall R-Value	Roof R-Value	Window U-Value	Window SHGC	Heat Rec Efficiency	Infiltration Rate	Heating Fuel Source	TEDI	TEUI	GHGI
Typical	0.4	10	20	0.2	0.2	60	Air Tight	Elec	20.44	98.75	5.79
Typical	0.4	10	20	0.2	0.2	60	Air Tight	Gas	20.44	99.64	8.89
Typical	0.4	10	20	0.2	0.2	60	Code	Elec	25.63	103.75	5.85
Typical	0.4	10	20	0.2	0.2	60	Code	Gas	25.63	104.9	9.88
Typical	0.4	10	20	0.2	0.2	70	Air Tight	Elec	17.87	96.17	5.76

- Free, online, great starting point
- Work with a few key consultants early
- Operational & Embodied Carbon
- Costs not currently attached

Cost Index Tool

New, for high-level planning

CHARD

Energy/Zero Carbon Code, Costing Information

Table 4: Energy and Zero Carbon Step Code Results of the Case Study Building

		Mechanical Systems		
		Natural Gas	Mixed Fuel	Electrified
Building Enclosure & Demand Reduction	Standard Design	~~Does not meet step code requirements~~	Step 2 EL-2	Step 2 EL-4
	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
	High Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

Table 5: Cost Index Tool

		Centralized Natural Gas Systems	Decentralized Mixed Fuel Systems	Centralized Electrified	Decentralized Electrified		
					Option 1	Option 2	Option 3
Step 2		Baseline	0.89 0.75 | 0.94	0.95 0.99 | 0.94	Not included in analysis		
		Baseline	1.07	0.95			
Step 3		1.03 1.0 | 1.04	0.93 0.75 | 1.0	1.0 0.99 | 1.0	1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
		0.93	0.99	0.91	0.87	1.07	0.98
Step 4		1.14 1.11 | 1.15	0.99 0.85 | 1.0	1.05 1.09 | 1.04	Not included in analysis		
		0.78	0.84	0.86			

Schematic Design Information

Table 2: Case Study Building Enclosure & Demand Reduction Options

	Standard Design	Enhanced	High Performance	Passive House Performance
Wall Performance including thermal bridging	R-10	R-15	R-20	R-25
Window Wall frame and spandrel performance	Standard	High Performance	Passive House	Passive House
Glazing	Double	Double	Double	Triple
Airtightness	Standard	Standard	Standard	Passive House
HRV Efficiency	70%	70%	80%	85%

Table 3: Case Study Building Mechanical System Options

	Natural Gas	Mixed Fuel	Centralized Electrified	Decentralized Electrified
Heating	Central Natural gas high efficiency condensing boiler serving 4-pipe hydronic fan coil units (FCUs)	Electric Baseboard Heaters (EBBH)	Centralized air-source Heat pumps with Electric Boiler backup, serving 4-pipe FCUs	**Option 1:** Ductless mini-split heat pumps **Option 2:** EBBH **Option 3:** Combined HRV/Heat Pump Unit
Cooling	Central Water-cooled chiller serving 4-pipe hydronic FCUs	Suite-level Packaged Terminal Air Conditioners (PTAC)		**Option 1:** Ductless mini-split heat pumps **Option 2:** PTAC **Option 3:** Combined HRV/Heat Pump Unit
Domestic Hot Water	Central Natural gas high efficiency condensing boiler	Central Natural gas high Efficiency Condensing boiler	Central Electric boiler	Central Electric boiler

THE COST OF ZERO CARBON DEVELOPMENT

NAVIGATING DEVELOPMENT WITH THE ZERO CARBON STEP CODE

MADDY KENNEDY-PARROTT
NEIL NORRIS

RDH BUILDING SCIENCE
CHARD
BC Hydro Power smart
zebx

PROJECT BACKGROUND

What combinations of mechanical and enclosure systems are suitable in BC?

How will typical project capital costs be impacted?

What are the changes in operational costs to consider for long term ownership?

How to assess the financial impact of code and policy changes on projects that are already designed, to consider potential changes before breaking ground for construction?

Table 1: Zero Carbon Step Code Targets for Part 3 Residential Occupancies

Emission Level	Carbon Performance (Carbon Reduction)	GHGI Limit (kgCO2e/m2/Year)
EL-1	Baseline	Report Design Only
EL-2	Moderate	7.0
EL-3	Strong	3.0
EL-4	Net-Zero	1.8

CASE STUDY BUILDING

CLOSE TO 500 RENTAL UNITS
4 COMMERCIAL RETAIL UNITS
8000SF AMENITY SPACE
15- & 25- STOREY TOWERS
37% WINDOW TO WALL RATIO
24% SPANDRELS, 39% WALLS

METHODOLOGY

01. Typical Step Code Compliance Modelling

→ Real project

→ Compliant Step Code model

→ Standardized inputs

  → City of Vancouver Energy Modelling Guidelines

02. Parametric Modelling

→ 6 Mechanical Systems

  → Chosen for analysis

  → Main driver for parametric study

→ Modify compliant model using chosen mechanical systems

  → Tweak enclosure performances to meet targets

  → Resulted in 4 unique “bundles” of enclosure performance

→ Resulted in 12 compliant models

  → 9 for interactions between ZCSC and ESC

  → 3 to review decentralized electrification

MECHANICAL SYSTEMS

	NATURAL GAS	MIXED FUEL	CENTRALIZED ELECTRIFIED	DECENTRALIZED ELECTRIFIED
HEATING	CONDENSING BOILER FAN COIL UNITS	ELECTRIC BASEBOARDS	AIR-SOURCE HEAT PUMPS FAN COIL UNITS	MINISPLITS ELECTRIC BASEBOARDS HRV/HEAT PUMP
COOLING	WATER-COOLED CHILLER FAN COIL UNITS	PTAC UNITS	AIR-SOURCE HEAT PUMPS FAN COIL UNITS	MINISPLITS PTAC UNITS HRV/HEAT PUMP
DOMESTIC HOT WATER	CONDENSING BOILER	CONDENSING BOILER	ELECTRIC WATER HEATERS	ELECTRIC WATER HEATERS

MECHANICAL SYSTEMS

	NATURAL GAS	MIXED FUEL	CENTRALIZED ELECTRIFIED	DECENTRALIZED ELECTRIFIED
HEATING	CONDENSING FAN COIL U			MINISPLITS BASEBOARDS EAT PUMP
COOLING	WATER-COOLED FAN COIL U			ISPLITS C UNITS EAT PUMP
DOMESTIC HOT WATER	CONDENSING	BOILER		RIC WATER HEATERS

PASSIVE COOLING STRATEGIES CAN BE DIFFICULT TO IMPLEMENT EFFECTIVELY

MOST PROJECTS END UP WITH AT LEAST SOME ACTIVE COOLING

LOAD REDUCTION:
ENCLOSURE & HEAT RECOVERY

<table>
<tr><th></th><th>STANDARD</th><th>ENHANCED</th><th>HIGH PERFORMANCE</th><th>PASSIVE HOUSE</th></tr>
<tr><td>WALL PERFORMANCE
INCLUDES THERMAL BRIDGING</td><td>R-10</td><td>R-15</td><td>R-20</td><td>R-25</td></tr>
<tr><td>WINDOW WALL
FRAME AND SPANDREL PERFORMANCE</td><td>STANDARD</td><td>HIGH PERFORMANCE</td><td colspan="2">PASSIVE HOUSE</td></tr>
<tr><td>GLAZING</td><td colspan="3">DOUBLE</td><td>TRIPLE</td></tr>
<tr><td>AIRTIGHTNESS</td><td colspan="3">STANDARD</td><td>PASSIVE HOUSE</td></tr>
<tr><td>HRV EFFICIENCY</td><td colspan="2">70%</td><td>80%</td><td>85%</td></tr>
</table>

ASSUMPTIONS

Capital Costs

- Based on real multi-family projects if possible
- Otherwise based on commercially available estimating software
- Enclosure:
  - Primarily windows, insulation, cladding attachment
  - Does not include cladding, doors, roofing, balcony, waterproofing
- Mechanical:
  - Systems as described
  - Does not include plumbing, DHW piping/fixtures, automation & controls, or fire protection

Operational Costs

- Electricity costs:
  - Residential rate within suites
  - Commercial rate for centralized systems and/or common area energy use
  - $0.0975-$0.1078 per kWh
- Natural gas costs:
  - Commercial rate estimated based on peak load
  - $7.58 - $8.25 per GJ
- Carbon Taxes
  - $170/tonne of CO_2e emissions
  - Based on projections from the Federal 2030 Emissions Reductions Plan
- Maintenance costs not included

Energy Modelling Inputs

- MUA, Amenity, Retail Spaces remained unchanged for all models
  - Only residential systems were modified

LIMITATIONS

High-Level "Back of the Envelope" Analysis

- → Results will vary by project
- → Not all mechanical systems included
- → Detailed costs & energy compliance is building specific
- → This tool is for high-level decision making, not detailed costing or energy compliance

Lessons learned are still applicable to large-scale multi-family buildings on a wider scale and will provide useful insights about modifying designs

RESULTS

<table>
<tr><th colspan="2" rowspan="2">ENERGY & CARBON CODE COMPLIANCE</th><th colspan="3">FUEL TYPE</th></tr>
<tr><th>NATURAL GAS</th><th>HYBRID</th><th>ELECTRIFIED</th></tr>
<tr><th rowspan="4">ENVELOPE & HRV</th><th>STANDARD</th><td>~~DOES NOT MEET STEP CODE REQUIREMENTS~~</td><td>STEP 2
EL-2</td><td>STEP 2
EL-4</td></tr>
<tr><th>ENHANCED</th><td>STEP 2
EL-1</td><td>STEP 3
EL-2</td><td>STEP 3
EL-4</td></tr>
<tr><th>HIGH-PERFORMANCE</th><td>STEP 3
EL-2</td><td>STEP 4
EL-2</td><td>STEP 4
EL-4</td></tr>
<tr><th>PASSIVE HOUSE</th><td>STEP 4
EL-2</td><td>STEP 4
EL-2</td><td>STEP 4
EL-4</td></tr>
</table>

<table>
<tr><th colspan="2" rowspan="2">COST INDEX TOOL</th><th rowspan="2">CENTRALIZED NATURAL GAS SYSTEMS</th><th rowspan="2">DECENTRALIZED MIXED FUEL SYSTEMS</th><th rowspan="2">CENTRALIZED ELECTRIFIED</th><th colspan="3">DECENTRALIZED ELECTRIFIED</th></tr>
<tr><th>MINI-SPLITS</th><th>BASEBOARDS / PTAC</th><th>INTEGRATED HRV HEAT PUMP</th></tr>
<tr><th rowspan="6">TARGET ENERGY STEP</th><th rowspan="2">2</th><td>BASELINE</td><td>0.89
0.75 | 0.94</td><td>0.95
0.99 | 0.94</td><td colspan="3" rowspan="2">N/A</td></tr>
<tr><td>BASELINE</td><td>1.07</td><td>0.95</td></tr>
<tr><th rowspan="2">3</th><td>1.03
1.0 | 1.04</td><td>0.93
0.75 | 1.0</td><td>1.0
0.99 | 1.0</td><td>1.11
1.38 | 1.0</td><td>0.93
0.76 | 1.0</td><td>0.97
0.89 | 1.0</td></tr>
<tr><td>0.93</td><td>0.99</td><td>0.91</td><td>0.87</td><td>1.07</td><td>0.98</td></tr>
<tr><th rowspan="2">4</th><td>1.14
1.11 | 1.15</td><td>0.99
0.85 | 1.0</td><td>1.05
1.09 | 1.04</td><td colspan="3" rowspan="2">N/A</td></tr>
<tr><td>0.78</td><td>0.84</td><td>0.86</td></tr>
</table>

<table>
<tr><td colspan="2">Capital Cost Index</td></tr>
<tr><td>Mechanical Cost Index</td><td>Envelope Cost Index</td></tr>
<tr><td colspan="2">Operational Cost Index</td></tr>
</table>

01 CODE COMPLIANCE

ENERGY & CARBON CODE COMPLIANCE		FUEL TYPE		
		NATURAL GAS	HYBRID	ELECTRIFIED
ENVELOPE & HRV	STANDARD	DOES NOT MEET STEP CODE REQUIREMENTS	STEP 2 EL-2	STEP 2 EL-4
	ENHANCED	STEP 2 EL-1	STEP 3 EL-2	STEP 3 EL-4
	HIGH-PERFORMANCE	STEP 3 EL-2	STEP 4 EL-2	STEP 4 EL-4
	PASSIVE HOUSE	STEP 4 EL-2	STEP 4 EL-2	STEP 4 EL-4

COST INDEX	CENTRALIZED NATURAL GAS	DECENTRALIZED MIXED FUEL	CENTRALIZED ELECTRIFIED	DECENTRALIZED ELECTRIFIED		
				MINISPLITS	BASEBOARDS / PTAC	INTEGRATED HRV HEAT PUMP
				N/A		
				1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
				0.87	1.07	0.98
				N/A		

01 CODE COMPLIANCE

COST INDEX	Centralized Natural Gas	Decentralized Mixed Fuel	Centralized Electrified	Decentralized Electrified		
				Minisplits	Baseboards / PTAC	Integrated HRV Heat Pump
				N/A		
				1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
				0.87	1.07	0.98
				N/A		

ENERGY STEP 2:

ENERGY & CARBON CODE COMPLIANCE		Fuel Type		
		Natural Gas	Hybrid	Electrified
Envelope & HRV	Standard	~~Does not meet step code requirements~~	Step 2 EL-2	Step 2 EL-4
	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
	High-Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

01 CODE COMPLIANCE

ENERGY STEP 3:

ENERGY & CARBON CODE COMPLIANCE		Fuel Type: Natural Gas	Fuel Type: Hybrid	Fuel Type: Electrified
Envelope & HRV	Standard	Does not meet step code requirements	Step 2 EL-2	Step 2 EL-4
Envelope & HRV	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
Envelope & HRV	High-Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
Envelope & HRV	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

COST INDEX

Centralized Natural Gas	Decentralized Mixed Fuel	Centralized Electrified	Decentralized Electrified: Minisplits	Decentralized Electrified: Baseboards / PTAC	Decentralized Electrified: Integrated HRV Heat Pump
			N/A		
			1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
			0.87	1.07	0.98
			N/A		

01 CODE COMPLIANCE

COST INDEX	CENTRALIZED NATURAL GAS	DECENTRALIZED MIXED FUEL	CENTRALIZED ELECTRIFIED	DECENTRALIZED ELECTRIFIED		
				MINISPLITS	BASEBOARDS / PTAC	INTEGRATED HRV HEAT PUMP
				N/A		
				1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
				0.87	1.07	0.98
				N/A		

ENERGY STEP 4:

ENERGY & CARBON CODE COMPLIANCE		FUEL TYPE		
		NATURAL GAS	HYBRID	ELECTRIFIED
ENVELOPE & HRV	STANDARD	~~DOES NOT MEET STEP CODE REQUIREMENTS~~	STEP 2 EL-2	STEP 2 EL-4
	ENHANCED	STEP 2 EL-1	STEP 3 EL-2	STEP 3 EL-4
	HIGH-PERFORMANCE	STEP 3 EL-2	STEP 4 EL-2	STEP 4 EL-4
	PASSIVE HOUSE	STEP 4 EL-2	STEP 4 EL-2	STEP 4 EL-4

01 CODE COMPLIANCE

COST INDEX	Centralized Natural Gas	Decentralized Mixed Fuel	Centralized Electrified	Decentralized Electrified		
				Minisplits	Baseboards / PTAC	Integrated HRV Heat Pump
				N/A		
				1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
				0.87	1.07	0.98
				N/A		

EMISSION LEVEL 2:

Energy & Carbon Code Compliance		Fuel Type		
		Natural Gas	Hybrid	Electrified
Envelope & HRV	Standard	~~Does not meet step code requirements~~	Step 2 EL-2	Step 2 EL-4
	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
	High-Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

01 CODE COMPLIANCE

EMISSION LEVEL 4:

ENERGY & CARBON CODE COMPLIANCE		Fuel Type		
		Natural Gas	Hybrid	Electrified
Envelope & HRV	Standard	~~Does not meet Step Code requirements~~	Step 2 EL-2	Step 2 EL-4
	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
	High-Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

COST INDEX	Centralized Natural Gas	Decentralized Mixed Fuel	Centralized Electrified	Decentralized Electrified		
				Mini-splits	Baseboards / PTAC	Integrated HRV Heat Pump
				N/A		
				1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
				0.87	1.07	0.98
				N/A		

01 CODE COMPLIANCE

ENERGY & CARBON CODE COMPLIANCE		Fuel Type		
		Natural Gas	Hybrid	Electrified
Envelope & HRV	Standard	Does not meet step code requirements	Step 2 EL-2	Step 2 EL-4
	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
	High-Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

- **Natural gas systems rely on load reduction**
- **EL-2 is achievable for fully natural gas systems targeting upper energy steps, but…**
- **EL-2 is the performance ceiling when major systems that use natural gas**
- **Electrified systems achieve EL-4**

TAKEAWAYS

01 CODE COMPLIANCE

02 COST IMPLICATIONS

ENERGY & CARBON CODE COMPLIANCE		Fuel Type: Natural Gas	Fuel Type: Hybrid	Fuel Type: Electrified
Envelope & HRV	Standard	~~Does not meet Step Code requirements~~	Step 2 EL-2	Step 2 EL-4
Envelope & HRV	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
Envelope & HRV	High-Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
Envelope & HRV	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

COST INDEX TOOL		Centralized Natural Gas Systems	Decentralized Mixed Fuel Systems	Centralized Electrified	Decentralized Electrified: Minisplits	Decentralized Electrified: Baseboards / PTAC	Decentralized Electrified: Integrated HRV Heat Pump
Target Energy Step	2	Baseline	0.89 0.75 | 0.94	0.95 0.99 | 0.94	N/A		
		Baseline	1.07	0.95			
	3	1.03 1.0 | 1.04	0.93 0.75 | 1.0	1.0 0.99 | 1.0	1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
		0.93	0.99	0.91	0.87	1.07	0.98
	4	1.14 1.11 | 1.15	0.99 0.85 | 1.0	1.05 1.09 | 1.04	N/A		
		0.78	0.84	0.86			

Capital Cost Index	
Mechanical Cost Index	Envelope Cost Index
Operational Cost Index	

EXAMPLE 1

Project has already been designed according to a historically typical proforma: natural gas heating & DHW systems.

Project must meet Step 2 energy target per local Energy Step Code adoption.

The AHJ has recently implemented requirements to meet the ZCSC EL-4.

The project must pivot to meet the AHJ’s new operational carbon requirements.

BUDGETS

Mechanical:
$30M

Enclosure:
$30M

10y operating:
$5M

Total:
$65M

01 CODE COMPLIANCE

02 COST IMPLICATIONS

ENERGY & CARBON CODE COMPLIANCE		Fuel Type: Natural Gas	Fuel Type: Hybrid	Fuel Type: Electrified
Envelope & HRV	Standard	~~Does not meet Step Code requirements~~	Step 2 EL-2	Step 2 EL-4
Envelope & HRV	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
Envelope & HRV	High-Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
Envelope & HRV	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

COST INDEX TOOL		Centralized Natural Gas Systems	Decentralized Mixed Fuel Systems	Centralized Electrified	Decentralized Electrified: Mini-Splits	Decentralized Electrified: Baseboards / PTAC	Decentralized Electrified: Integrated HRV Heat Pump
Target Energy Step 2	Capital Cost Index	Baseline	0.89	0.95	N/A	N/A	N/A
	Mechanical | Envelope Cost Index		0.75 | 0.94	0.99 | 0.94			
	Operational Cost Index	Baseline	1.07	0.95			
Target Energy Step 3	Capital Cost Index	1.03	0.93	1.0	1.11	0.93	0.97
	Mechanical | Envelope Cost Index	1.0 | 1.04	0.75 | 1.0	0.99 | 1.0	1.38 | 1.0	0.76 | 1.0	0.89 | 1.0
	Operational Cost Index	0.93	0.99	0.91	0.87	1.07	0.98
Target Energy Step 4	Capital Cost Index	1.14	0.99	1.05	N/A	N/A	N/A
	Mechanical | Envelope Cost Index	1.11 | 1.15	0.85 | 1.0	1.09 | 1.04			
	Operational Cost Index	0.78	0.84	0.86			

Capital Cost Index	
Mechanical Cost Index	Envelope Cost Index
Operational Cost Index	

COST IMPLICATIONS OF DESIGN CHANGE

STEP 2 CENTRALIZED ELECTRIFIED	
0.95	
0.99	0.94
0.95	

Mechanical
0.99
Enclosure
0.94
Operational
0.95

Mechanical: $30 x 0.99 = $30M (no change)
Enclosure: $30M x 0.94 = $28.2M (-$1.8M)
Operating: $5M x 0.95 = $4.75M (-$0.25M)

INITIAL BUDGET

Mechanical:
$30M
Enclosure:
$30M
10y operating:
$5M
Total:
$65M

UPDATED BUDGET

Total:
$63M
Savings:
$2M

EXAMPLE 2

Project has been designed with electric baseboard heaters, PTAC units, and a natural gas DHW system.

Project must meet Step 3 energy target.

Project team has learned about a newly available incentive funding stream and would like to explore the implications of electrifying and complying with Step 4 energy targets.

BUDGETS

Mechanical:
$20M

Enclosure:
$30M

10y operating:
$5M

Total:
$55M

01 CODE COMPLIANCE

02 COST IMPLICATIONS

ENERGY & CARBON CODE COMPLIANCE		Fuel Type		
		Natural Gas	Hybrid	Electrified
Envelope & HRV	Standard	~~Does not meet Step Code requirements~~	Step 2 EL-2	Step 2 EL-4
	Enhanced	Step 2 EL-1	Step 3 EL-2	Step 3 EL-4
	High-Performance	Step 3 EL-2	Step 4 EL-2	Step 4 EL-4
	Passive House	Step 4 EL-2	Step 4 EL-2	Step 4 EL-4

COST INDEX TOOL		Centralized Natural Gas Systems	Decentralized Mixed Fuel Systems	Centralized Electrified	Decentralized Electrified		
					Mini-Splits	Baseboards / PTAC	Integrated HRV Heat Pump
Target Energy Step	2	Baseline	0.89 0.75 | 0.94	0.95 0.99 | 0.94	N/A		
		Baseline	1.07	0.95			
	3	1.03 1.0 | 1.04	0.93 0.75 | 1.0	1.0 0.99 | 1.0	1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
		0.93	0.99	0.91	0.87	1.07	0.98
	4	1.14 1.11 | 1.15	0.99 0.85 | 1.0	1.05 1.09 | 1.04	N/A		
		0.78	0.84	0.86			

Capital Cost Index	
Mechanical Cost Index	Envelope Cost Index
Operational Cost Index	

COST IMPLICATIONS OF DESIGN CHANGE

STEP 3 MIXED FUEL	
0.93	
0.75	1.0
0.99	

➡

STEP 4 CENTRALIZED ELECTRIFIED	
1.05	
1.09	1.04
0.86	

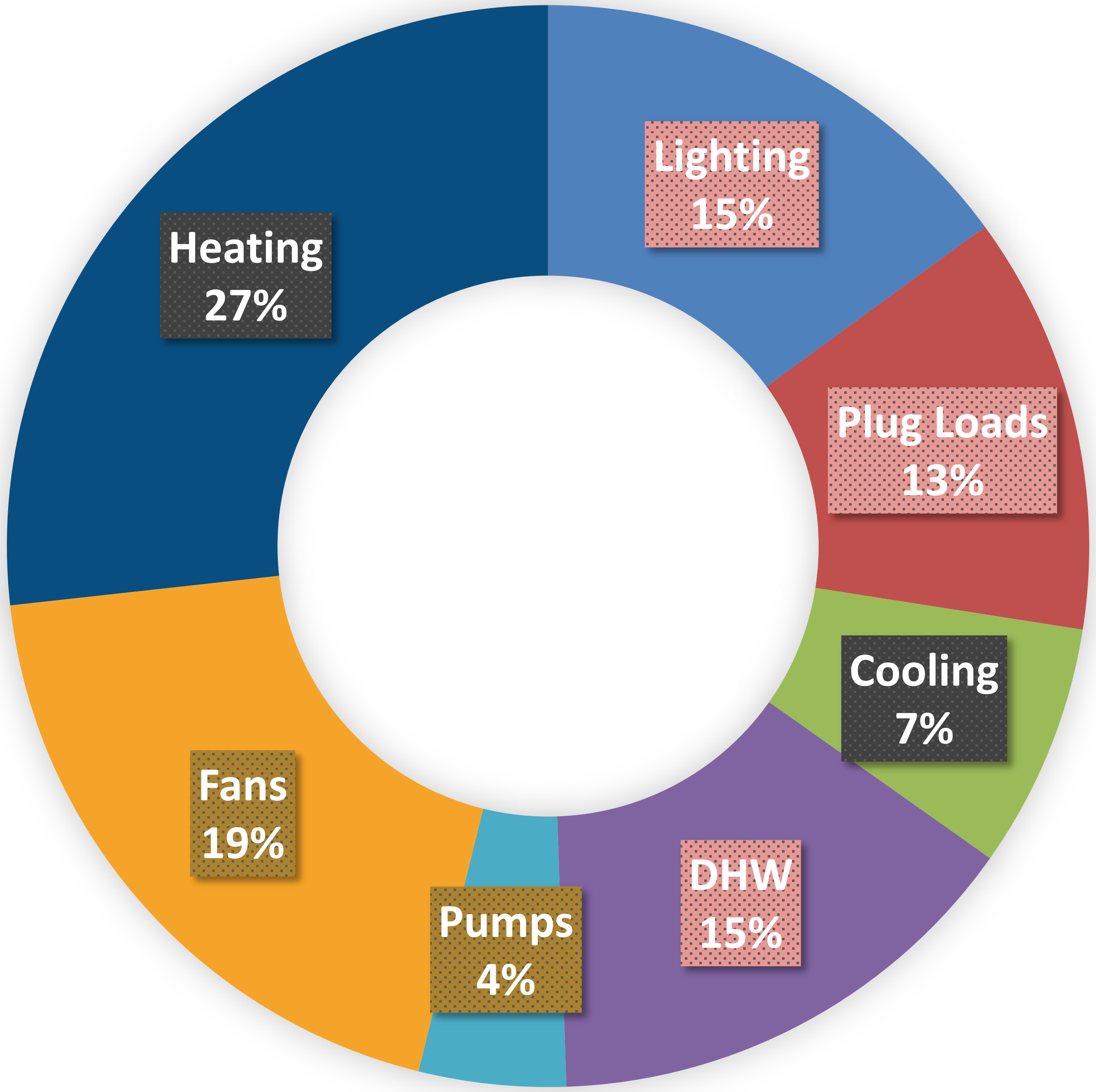
Mechanical: 1.09/0.75 x $20M = $29M (+$9M)
Enclosure: 1.04/1.0 x $30M = $31.2M (+$1.2M)
Operational: 0.86/0.99 x $5M = $4.3M (-$0.7M)

UPDATED BUDGET

Total:
$64.5M
Additional Cost:
$9.5M

KEY TAKEAWAYS

THE TEUI PROBLEM



- → Lighting, Plug Load, DHW energy end-use
  - → Mostly standardized inputs
  - → Minor energy use reduction potential
- → Fan & pump energy use represents terminal unit energy end-use (FCUs, HRVs)
  - → Typically governed by airflow rates
  - → Minor energy use reduction potential
- → Cooling energy is not a major energy end-use
- → Heating energy end-use
  - → Largest building energy end-use
  - → Can be reduced by heating load reduction
  - → Can be reduced by improving system efficiency

THE TEUI PROBLEM

Natural Gas Boiler:
80-96%
Electric Baseboards:
100%

These efficiencies are comparatively low, and the ceiling for these systems. The only option for reducing energy use (TEUI) is through load reduction

Combined HRV/Heat Pump:
231%
Centralized ASHP:
300%
PTAC:
311%
Minisplits:
350%

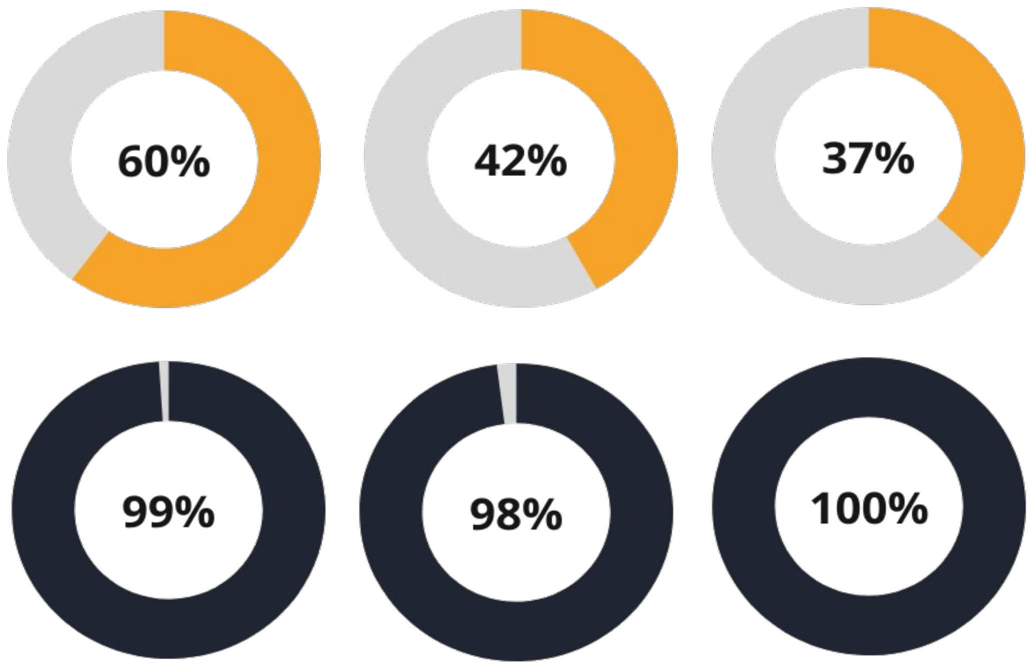
Efficiencies are estimates given typical COPs for heat pump systems

NATURAL GAS MODEL RESULTS

Step 2 | Step 3 | Step 4

TEDI MODEL VS. TARGET

TEUI MODEL VS. TARGET



TO MEET TEUI REQUIREMENTS,
TEDI SIGNIFICANTLY EXCEEDS TARGETS

HEAT PUMPS

- →High Efficiency Systems
  - → More flexibility for design changes
- →Provides Heating AND Cooling
  - → Other systems require additional cooling systems
    - → Natural gas: chiller
    - → Electric baseboards: PTAC

LOW-COST MECHANICAL SYSTEMS

→ **Compare low-cost mechanical systems (electric baseboard heater models) with higher-cost options**

COST INDEX TOOL		Centralized Natural Gas Systems	Decentralized Mixed Fuel Systems	Centralized Electrified	Decentralized Electrified: Minisplits	Decentralized Electrified: Baseboards / PTAC	Decentralized Electrified: Integrated HRV Heat Pump
Target Energy Step	2	Baseline	0.89 0.75 | 0.94	0.95 0.99 | 0.94	N/A		
		Baseline	1.07	0.95			
	3	1.03 1.0 | 1.04	0.93 0.75 | 1.0	1.0 0.99 | 1.0	1.11 1.38 | 1.0	0.93 0.76 | 1.0	0.97 0.89 | 1.0
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Capital Cost Index	
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LOW-COST MECHANICAL SYSTEMS

- → **Compare low-cost mechanical systems (electric baseboard heater models) with higher-cost options**
- → **Mechanical costs are significantly lower**

Cost Index Tool		Centralized Natural Gas Systems	Decentralized Mixed Fuel Systems	Centralized Electrified	Decentralized Electrified: Minisplits	Decentralized Electrified: Baseboards / PTAC	Decentralized Electrified: Integrated HRV Heat Pump
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Capital Cost Index	
Mechanical Cost Index	Envelope Cost Index
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LOW-COST MECHANICAL SYSTEMS

- → Compare low-cost mechanical systems (electric baseboard heater models) with higher-cost options
- → Mechanical costs are significantly lower
- → Operational costs are significantly higher at lower steps

<table>
<tr><th colspan="2" rowspan="2">COST INDEX TOOL</th><th rowspan="2">CENTRALIZED NATURAL GAS SYSTEMS</th><th rowspan="2">DECENTRALIZED MIXED FUEL SYSTEMS</th><th rowspan="2">CENTRALIZED ELECTRIFIED</th><th colspan="3">DECENTRALIZED ELECTRIFIED</th></tr>
<tr><th>MINI SPLITS</th><th>BASEBOARDS / PTAC</th><th>INTEGRATED HRV HEAT PUMP</th></tr>
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LOW-COST MECHANICAL SYSTEMS

- Compare low-cost mechanical systems (electric baseboard heater models) with higher-cost options
- Mechanical costs are significantly lower
- Operational costs are significantly higher at lower steps
- At higher steps, operational costs are comparable or less

What you save on baseboards is worth spending on enclosure

Cost Index Tool		Centralized Natural Gas Systems	Decentralized Mixed Fuel Systems	Centralized Electrified	Decentralized Electrified: Minisplits	Decentralized Electrified: Baseboards / PTAC	Decentralized Electrified: Integrated HRV Heat Pump
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Capital Cost Index	
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MIXED FUEL

- → Most cost-effective solution
  - → When maintaining natural gas for DHW
  - → In the context of current regulatory environment: while EL-2 still acceptable
- → Not appropriate when AHJs require EL-3 or higher
- → Appropriate for projects with electrical capacity limitations
  - → Northern communities upgrading electrical transmission/delivery

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DHW

- Natural Gas results in cheapest option
  - Capital costs AND operational costs
- Electric resistance is most expensive option to operate
  - May require electrical capacity upgrades to use
- CO_2 heat pumps potentially best of both worlds
  - Not included in analysis
  - Highest capital cost option, except if capacity upgrades are required for electrical resistance boilers
  - Gas is approximately 4x cheaper than electricity
  - CO_2 heat pumps are only 2.5x more efficient than gas, likely still more expensive to operate

EMISSION LEVEL 3

ENERGY & CARBON CODE COMPLIANCE		FUEL TYPE		
		NATURAL GAS	HYBRID	ELECTRIFIED
ENVELOPE & HRV	STANDARD	DOES NOT MEET STEP CODE REQUIREMENTS	STEP 2 EL-2	STEP 2 EL-4
	ENHANCED	STEP 2 EL-1	STEP 3 EL-2	STEP 3 EL-4
	HIGH-PERFORMANCE	STEP 3 EL-2	STEP 4 EL-2	STEP 4 EL-4
	PASSIVE HOUSE	STEP 4 EL-2	STEP 4 EL-2	STEP 4 EL-4

- → Somewhat extraneous in many situations
- → Electrified = EL-4
- → Gas for major systems = EL-2 at best
- → Backup natural gas systems may achieve EL-3
  - → Backup condensing boilers for coldest day peak loads, etc.

CENTRALIZED vs DECENTRALIZED

NO BEARING ON COMPLIANCE WITH ZCSC

ELECTRIFIED = EL-4

CAPITAL COSTS

WIDE RANGE OF DECENTRALIZED COSTS

COSTS OF CENTRALIZED ELECTRICAL SYSTEMS ADAPTING TO MARKET DEMAND

MAINTENANCE COSTS

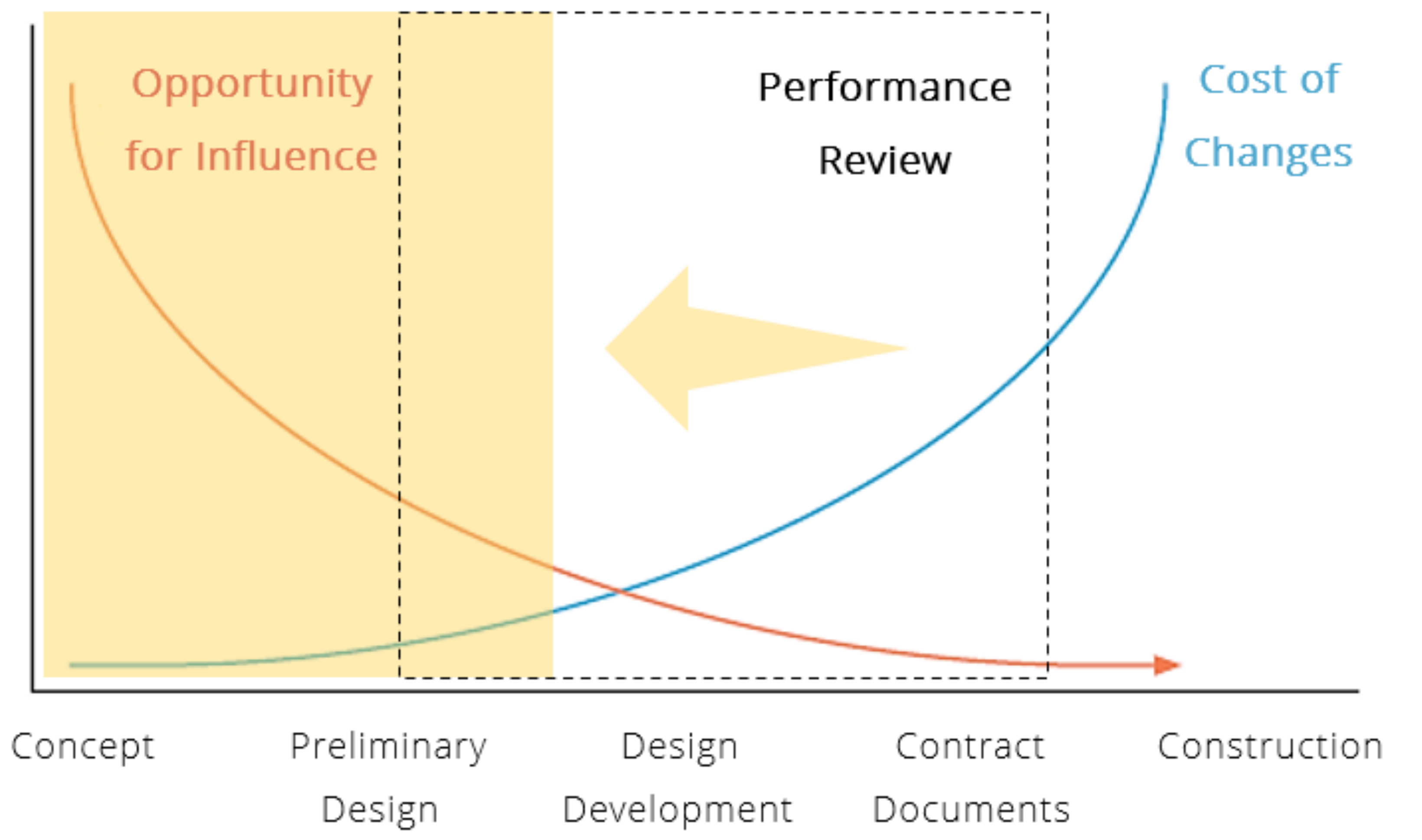
TYPICALLY LOWER FOR CENTRALIZED SYSTEMS

DESIGN FLEXIBILITY

DECENTRALIZED SYSTEMS OFFER MORE OPTIONS

EARLY-STAGE DECISIONS

- Parametric Modelling
  - Project-specific
  - After using tool to determine high-level viability
- Cost impacts of design changes
  - Additional consulting fees
  - Increase design and coordination time
- Diminishing returns at later stages of the design process



KEY DESIGN LEVERS

ENERGY & CARBON CODE COMPLIANCE		FUEL TYPE		
		NATURAL GAS	HYBRID	ELECTRIFIED
ENVELOPE & HRV	STANDARD	DOES NOT MEET STEP CODE REQUIREMENTS	STEP 2 EL-2	STEP 2 EL-4
	ENHANCED	STEP 2 EL-1	STEP 3 EL-2	STEP 3 EL-4
	HIGH-PERFORMANCE	STEP 3 EL-2	STEP 4 EL-2	STEP 4 EL-4
	PASSIVE HOUSE	STEP 4 EL-2	STEP 4 EL-2	STEP 4 EL-4

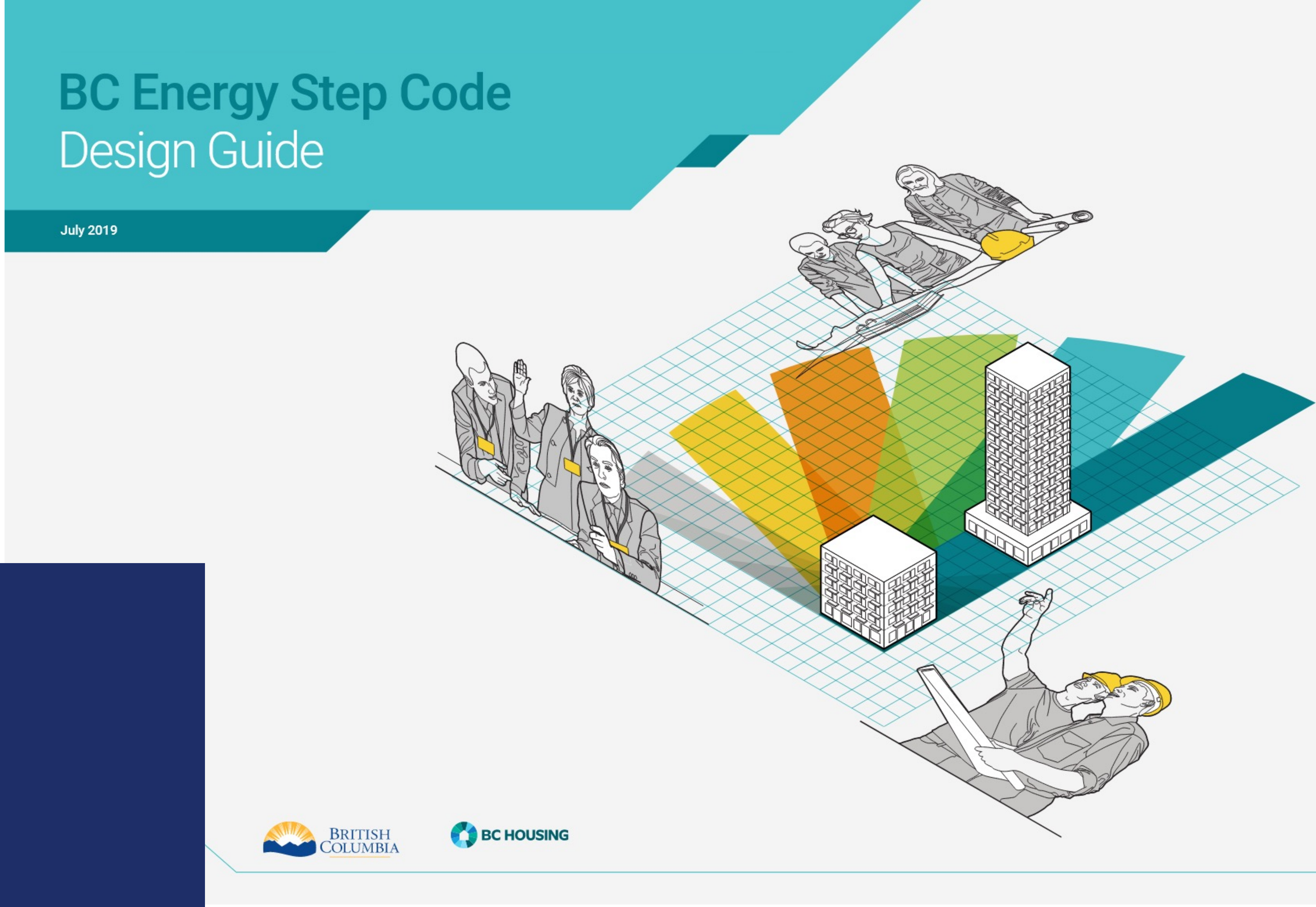
- → TEDI
  - → Envelope
  - → Ventilation
- → TEUI
  - → Mechanical System Efficiency
- → GHGI/Zero Carbon Step Code
  - → Fuel Type

ENERGY STEP CODE DESIGN GUIDE

Early design guidance already exists

- → Minimize heat loss
  - → Building form (VFAR)
  - → Assembly performances
- → Maximize gains
  - → Window layouts
  - → SHGC selection
- → Optimize ventilation
  - → HRVs & compartmentalization

Main focus is to reduce demand first



DISCUSSION + QUESTIONS

Read the full report at:
zebx.org

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RDH Building Science
@RDHBuildings

NearZero

Powered by zeic

Embodied Emissions

Stream 2

An applied research project for low-rise homes that minimize embodied emissions.

Utility Data

Stream 4

A ZEBx utility data collection initiative to determine the real emissions and energy profiles of BC homes.

nearzero.ca

Decarb Lunch Series

zebx

Powered by zeic

University of Victoria's Housing and Dining Complex

Thu Jun 13, 2024,
from 12- 1pm PDT
Free Webinar I zebx.org

NearZero: Reaching the Top Step

How are homeowners, builders and designers already reaching the highest step of emission reduction requirements? We found some of them from ZEBx's NearZero program, listen to them here.

Overview

Playbooks & Winners

Is BC Ready for Electrification? B2E w BC Hydro, Sep 2023

B2E, a program alongside ZEBx and part of the ZEIC family, collaborated with BC Hydro in Sep 2023 to help answer the question 'Is BC Ready for Electrification?'

Overview

B2E Resources

Life Cycle Assessment Process to Estimate Embodied Carbon in Buildings

From ZEBx's Net-Zero Energy-Ready Playbook Series

Overview

Read This Playbook

Planning Airtight Buildings

From ZEBx's Net-Zero Energy-Ready Playbook Series

Overview

Read This Playbook

Have any questions? +1 604-330-2017 info@zebx.org

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- Events & Demonstrations
- Specialized Programming

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