BUILDINGENERGY BOSTON

Systems Thinking for Resilient Homes, Communities and Organizations

James Moriarty (Sustainable Comfort)

Curated by Stephen Stuart (Sullivan County Office of Sustainable Energy)

Northeast Sustainable Energy Association (NESEA) | March 19, 2024

SUSTAINABLE COMFORT

Systems Thinking

Resilient Homes, Communities and Organizations

James Moriarty
Vice President

Learning Objectives

- Use systems thinking language and structures
- Use of systems analysis and energy modeling to inform design decisions
- Where and how to implement systems and feedback loops into the design process
- Building a company structure informed by systems flow

Content Structure

- What is Systems Thinking?
  - Stocks and flows
  - Understanding boundary conditions
  - Be aware of interrelationships, and connections
  - Leverage points and exponentials

- Case Study – 145 Warren St
  - Need for low carbon housing
  - Community needs
  - House as a System

Why
Thinking in Systems

- A system is an interconnected set of elements that is coherently organized in a way that achieves something. Contains:
  - Elements
  - Interconnections
  - Function or purpose

- “A system is more than the sum of it’s parts”

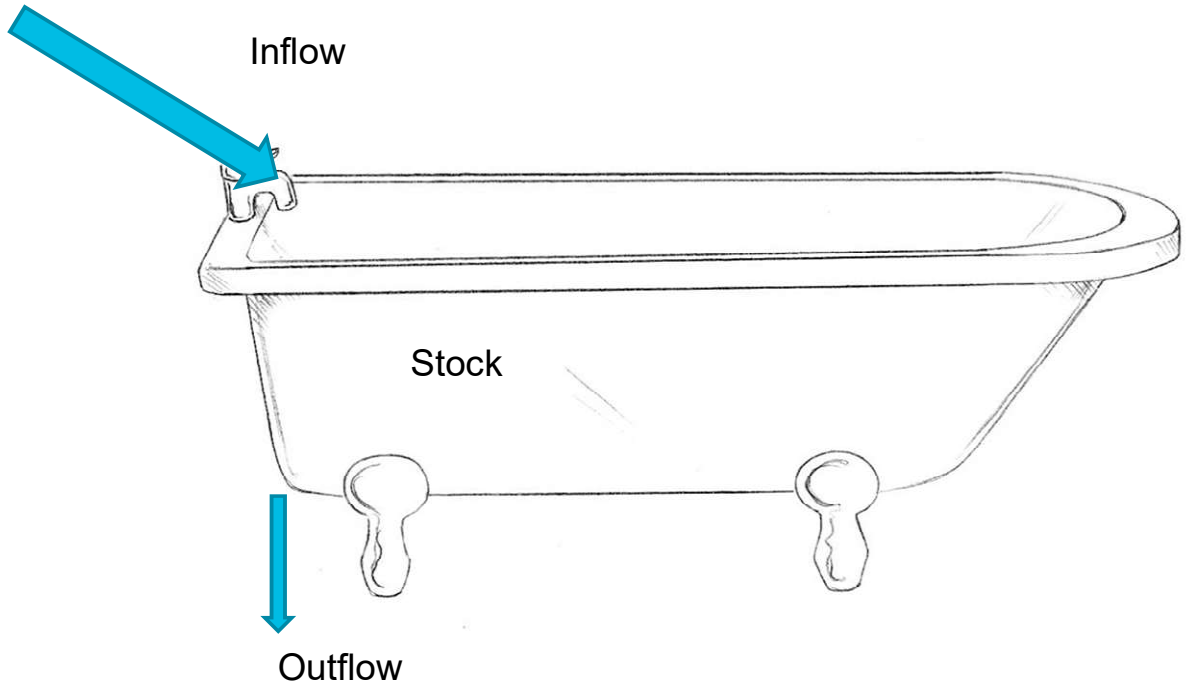
- “The least obvious part of a system, **its function or purpose**, is often the most crucial determinant of the system’s behavior. Interconnections are also critically important. Changing relationships usually changes system behavior. The elements, or parts of systems we are most likely to notice, are often (not always) least important in defining the unique characteristics of the system – unless changing an element also results in changing relationships or purpose.

Why
Thinking in Systems

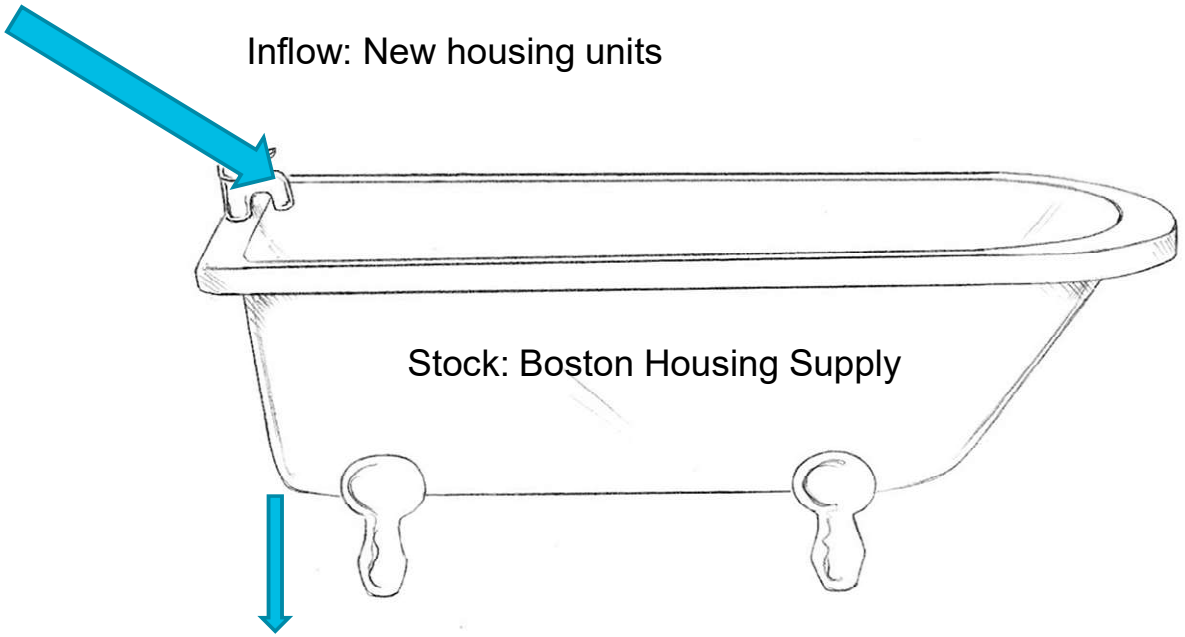
- Our industry is full of understanding, explaining, and modeling complex systems.
  - Building energy modeling
  - Hygro-thermal analysis
  - Moisture flow through wall assemblies
  - Human behavior impacts on energy performance

"The most marvelous characteristic of some complex systems if their ability to learn, diversity, complexify, evolve. The capacity of a system to make its own structure more complex is called self-organization. Self-organization is a common property of living systems, and we would do better at encouraging, rather than destroying, the self-organizing capacities of the systems of which we are a part."

Systems Thinking Example –Stocks and Flows



Systems Thinking Example – Housing Stocks and Flows



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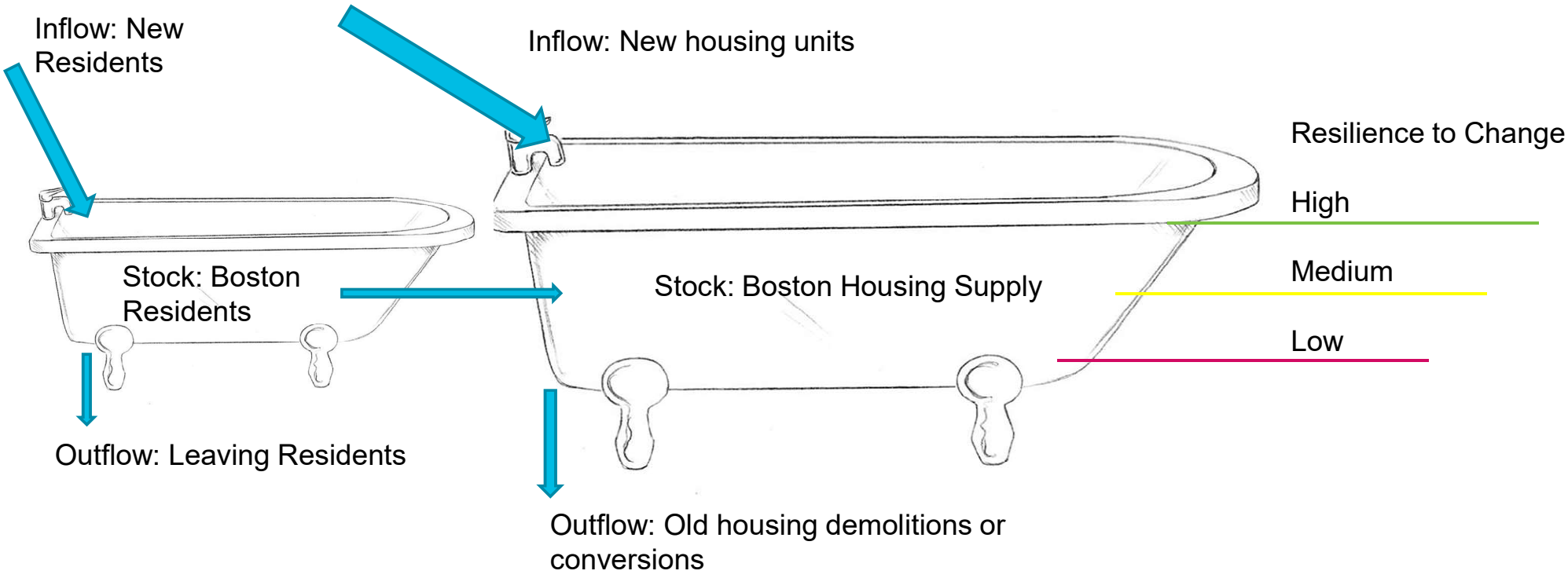

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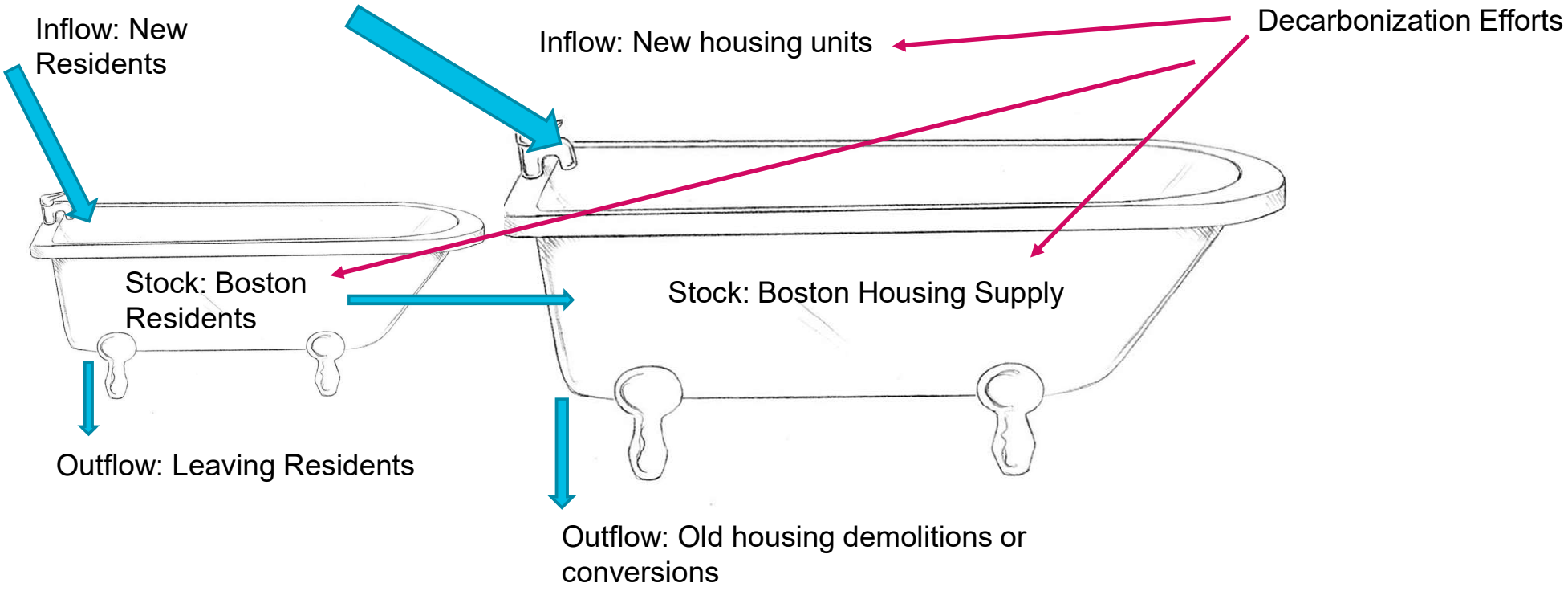
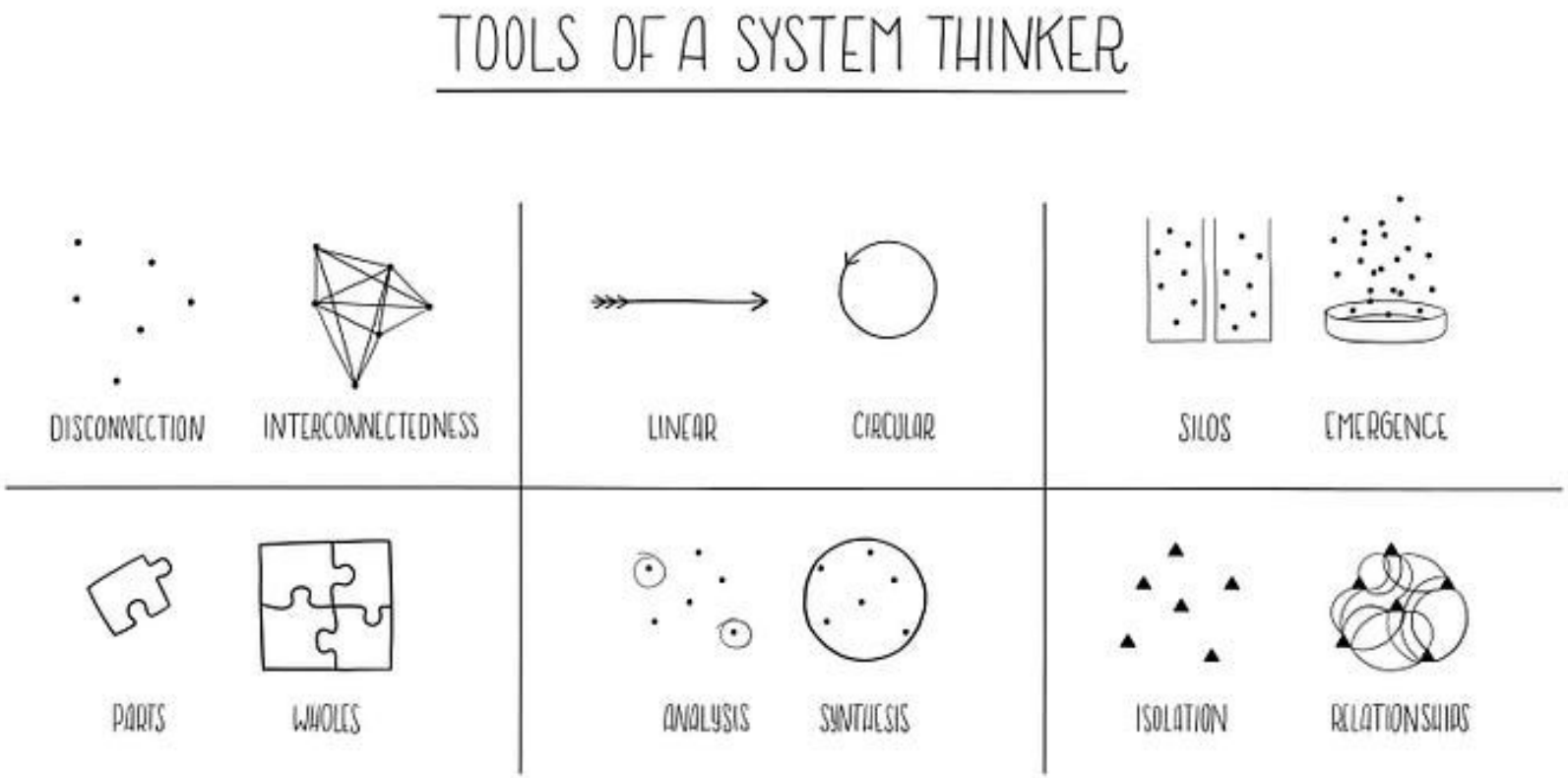
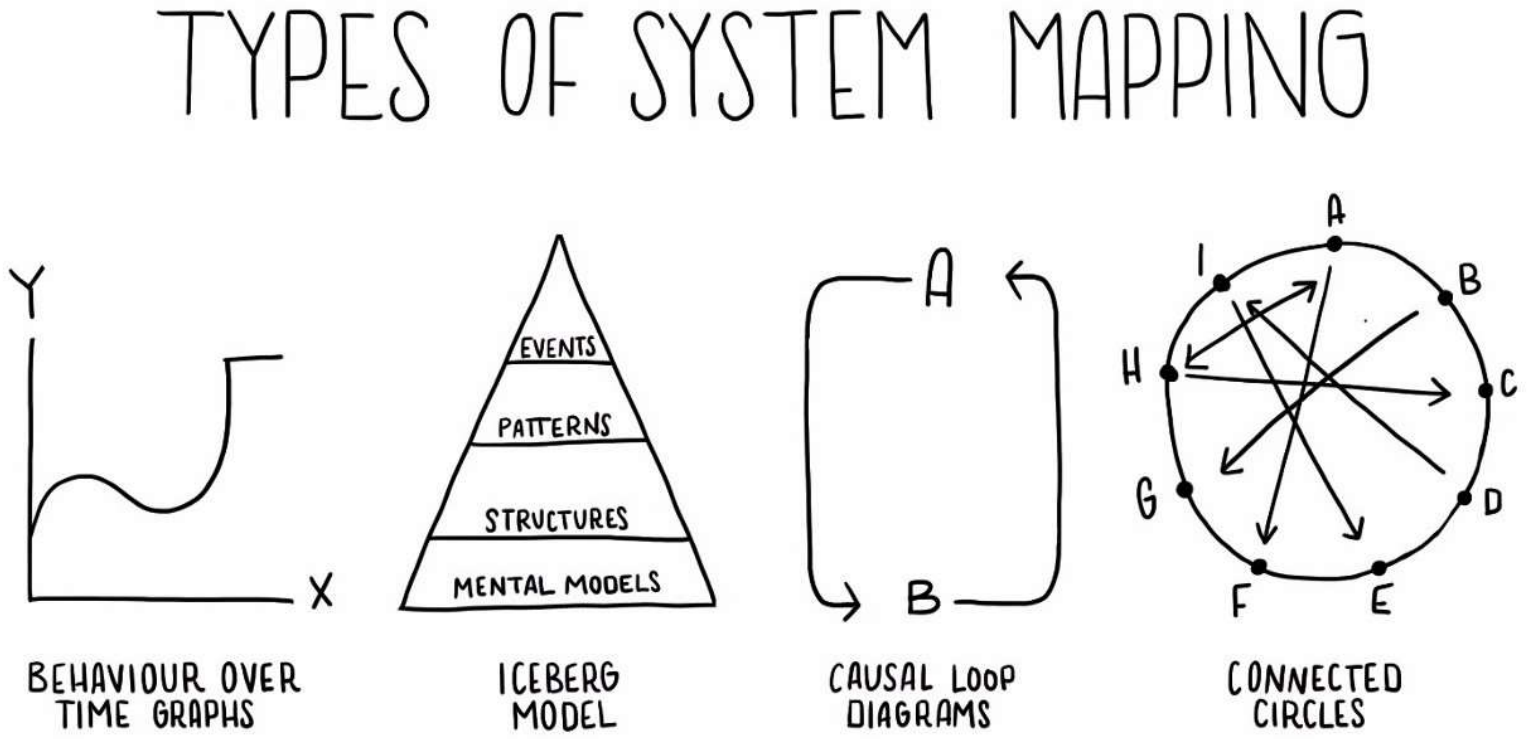


Thinking in Systems to Drive Change

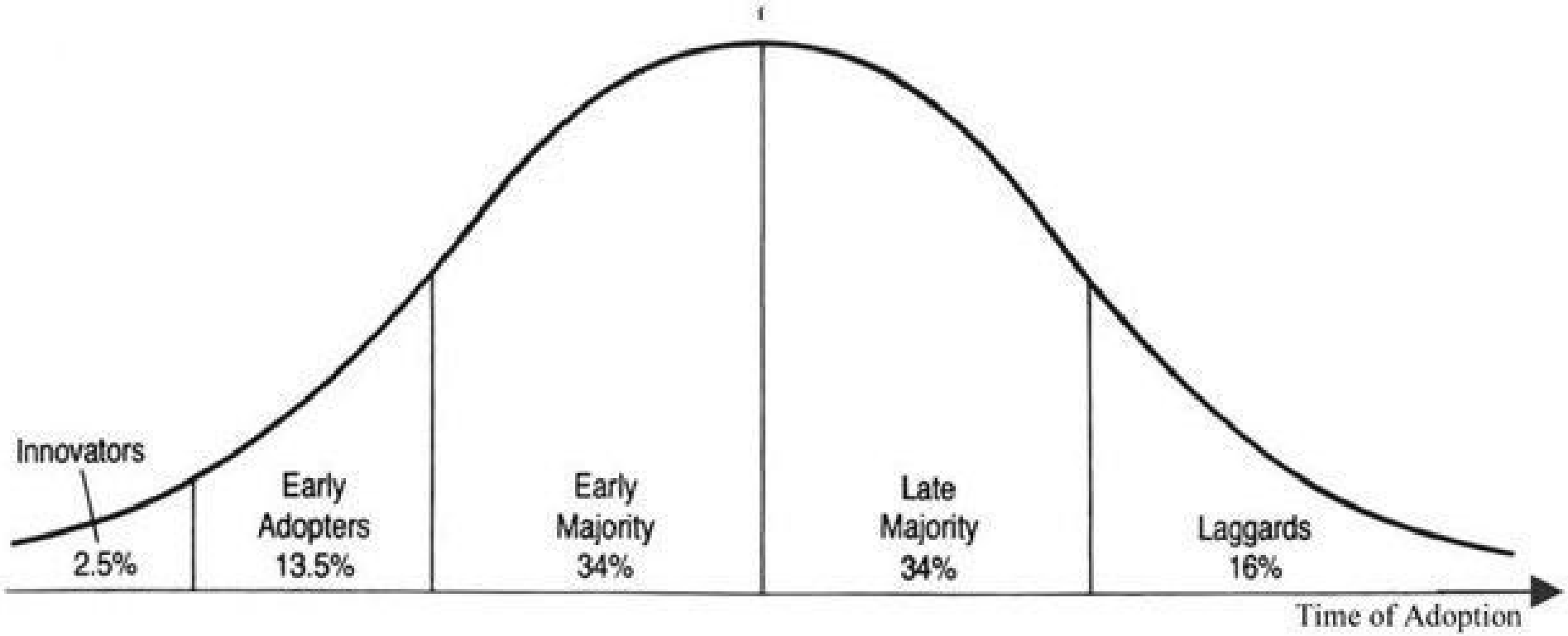


Thinking in Systems to Drive Change

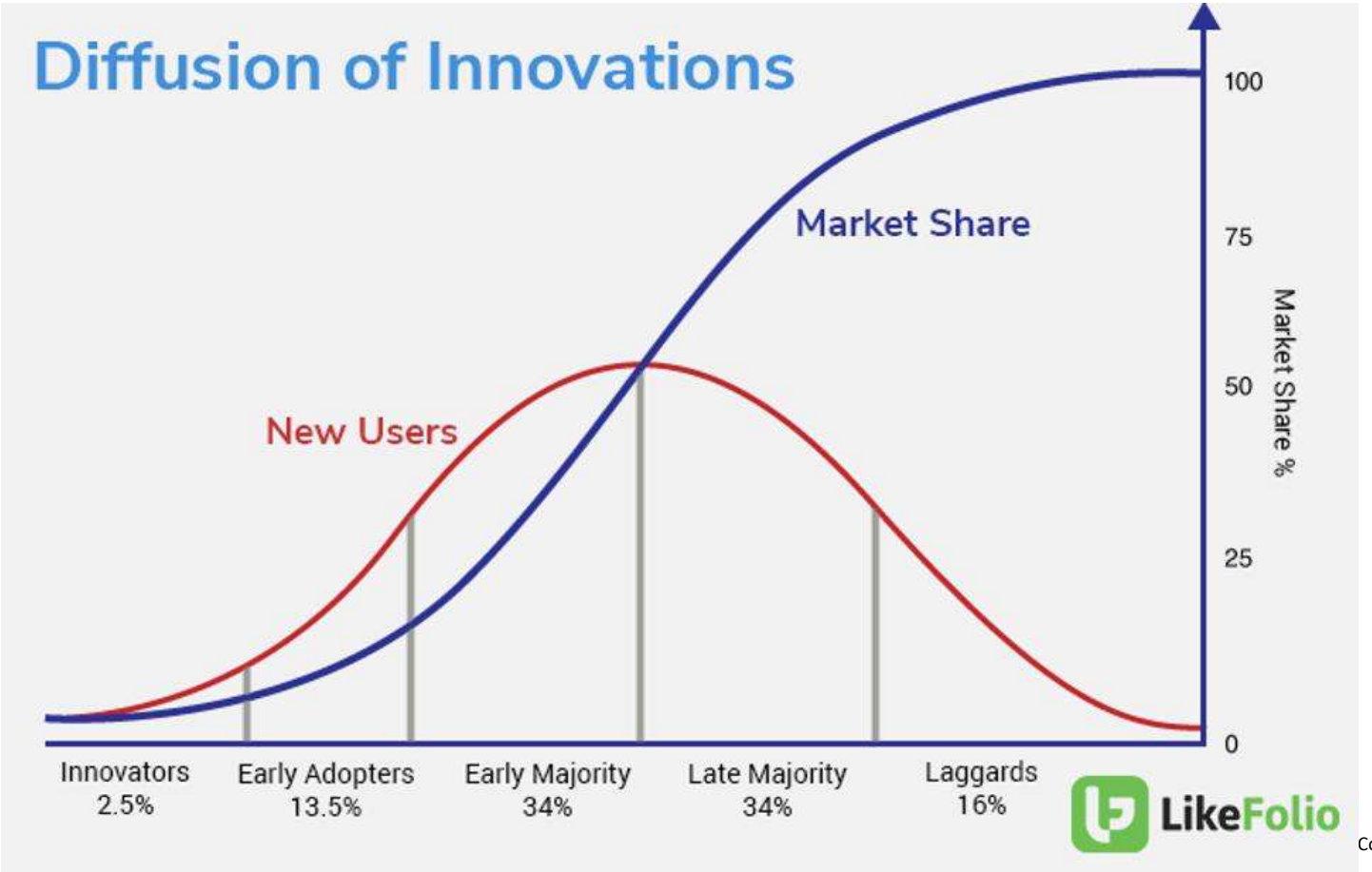


DISRUPT DESIGN

Thinking in Systems to Drive Change

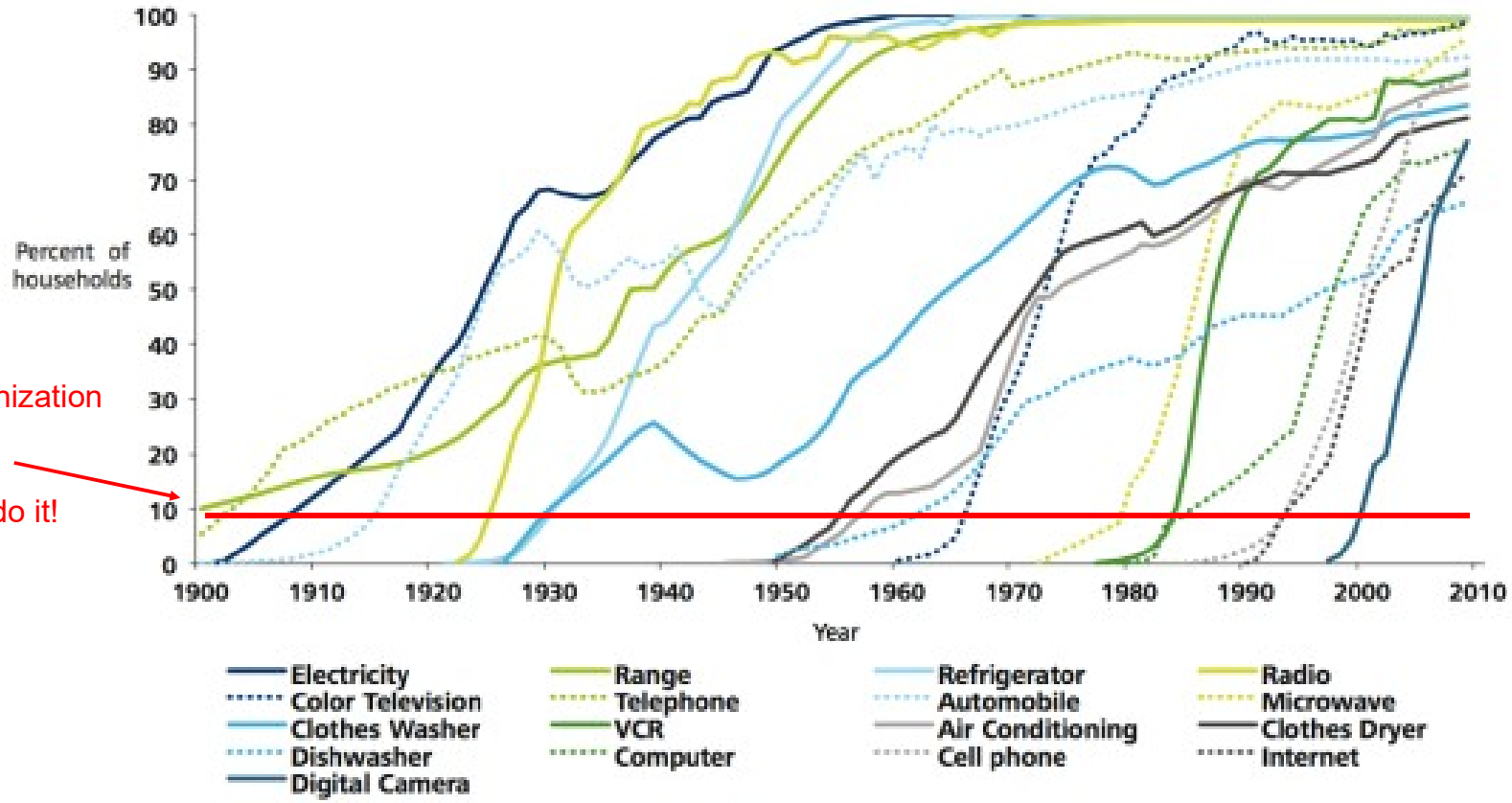


Why - Thinking in Systems



Dealing with Exponential Adoption

Figure 15: US historical adoption curves for new technologies

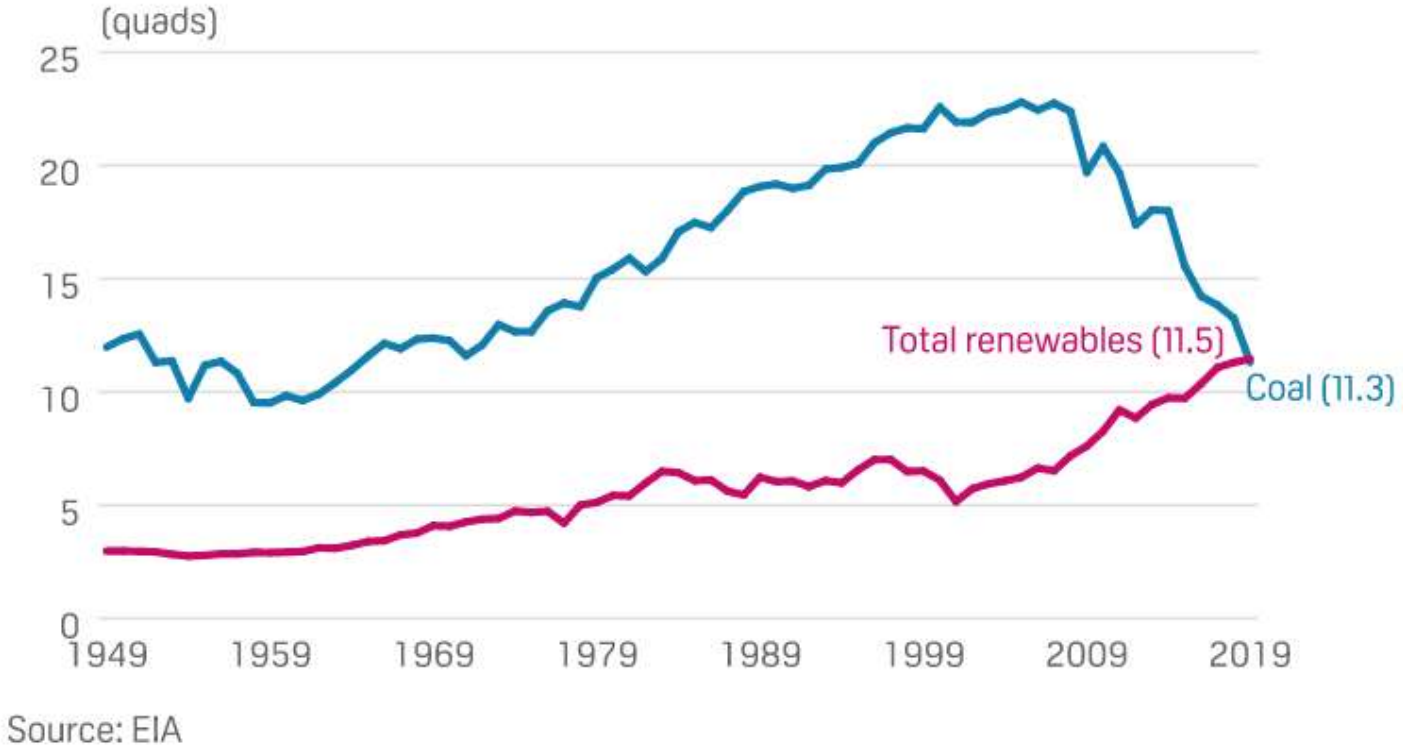


Source: W. Michael Cox, founding director, O'Neil Center for Global Markets and Freedom; US Census Bureau

Decarbonization is here!

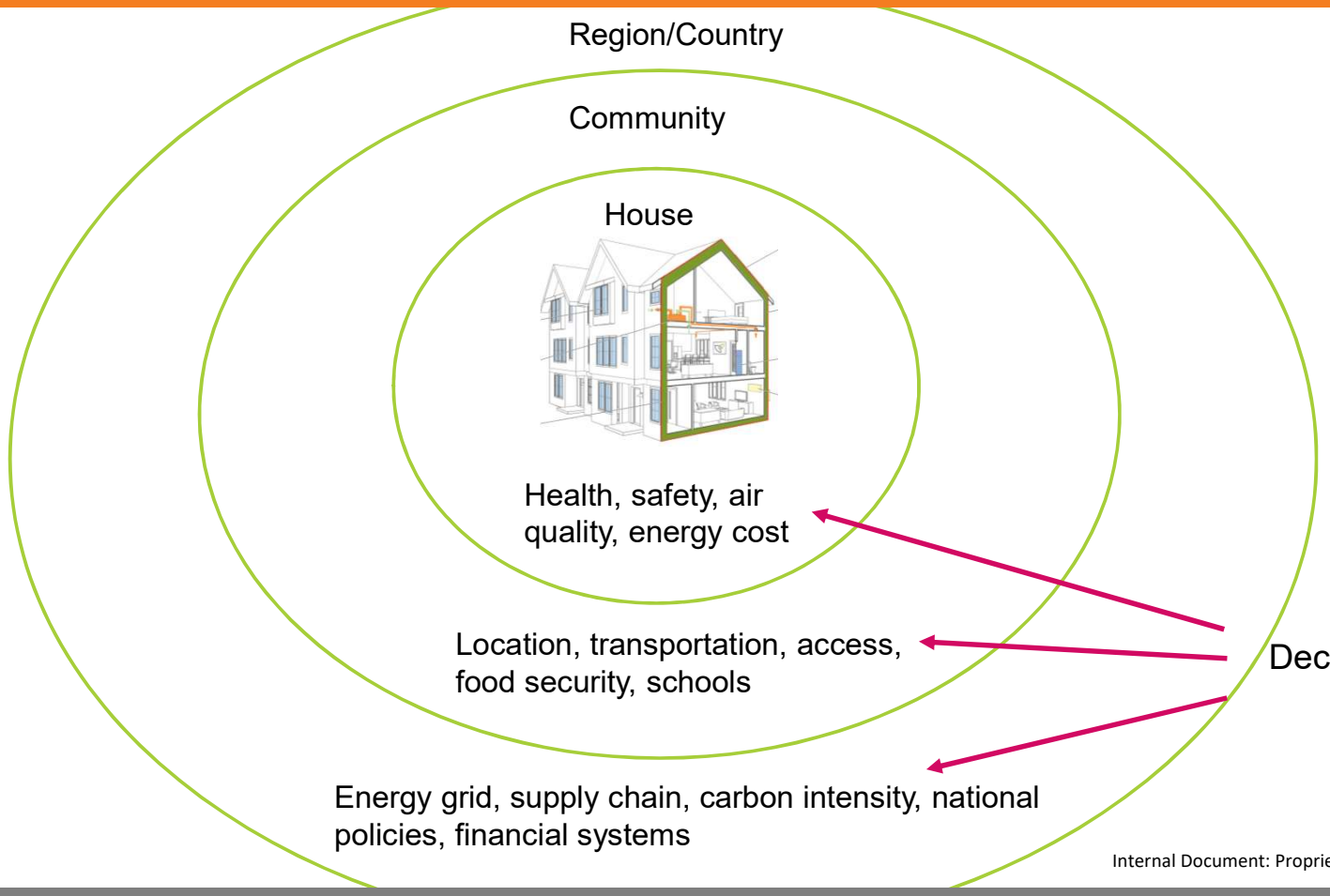
We can do it!

Enhancing Exponential Adoption of Clean Energy



Source: EIA

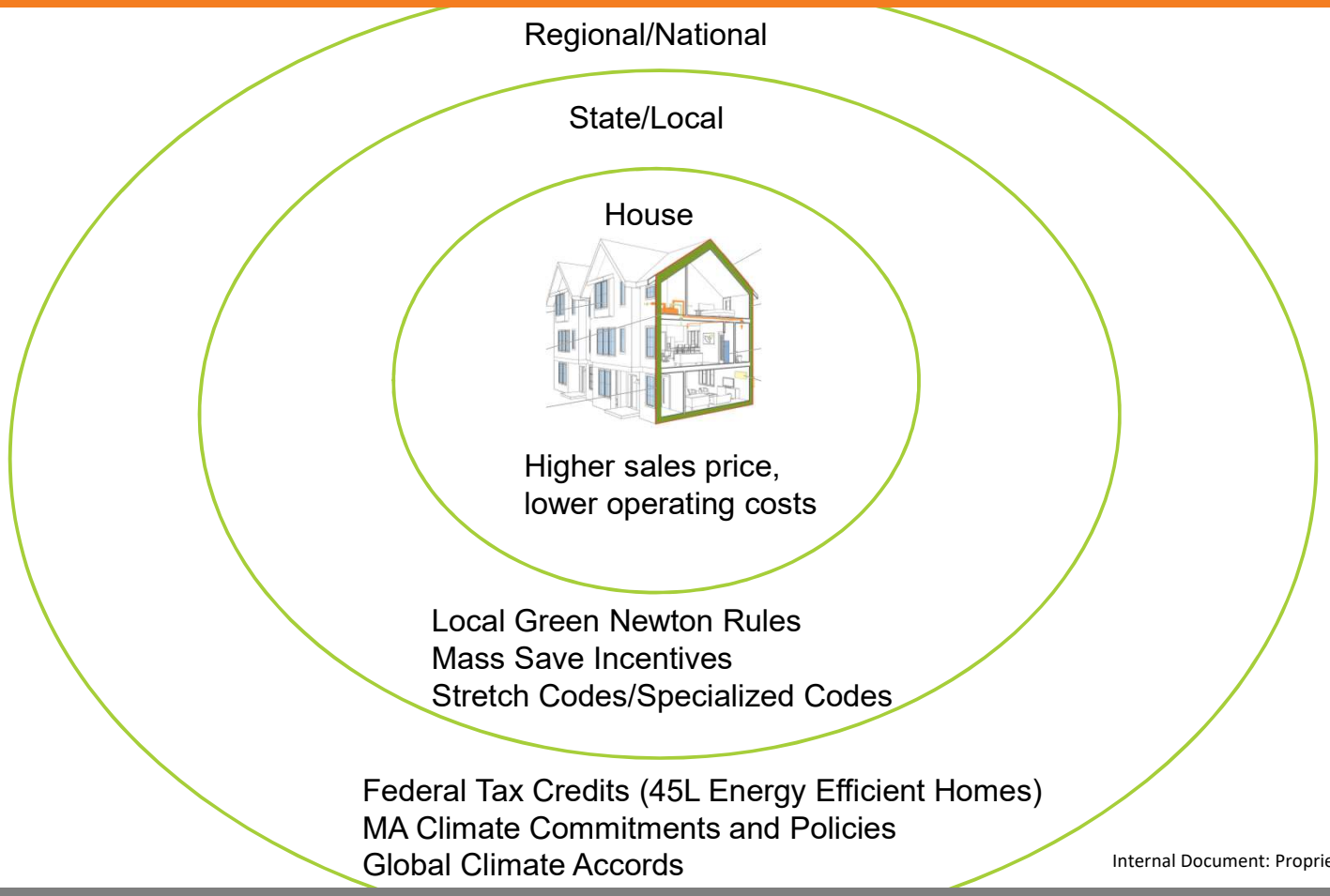
Systems Boundaries



145 Warren St, Newton MA

Case Study

Leverage Goals at Each Scale

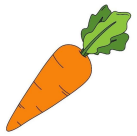


Regional and National
Newton, MA

State Commitment to **Zero Emissions** by 2050 to align with Paris Climate Accord

Inflation Reduction Act & MA Incentives

45L Energy Efficient Home Tax Credits
Electrification Rebates and Incentives
Solar and Geothermal Tax Credits
Mass Save Incentive Programs

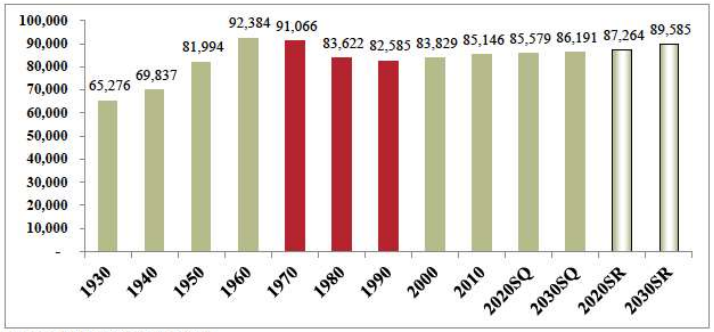


Massachusetts Programs and Policies

MA Net-Zero Policies
MA Stretch Codes and Specialized Codes
BERDO

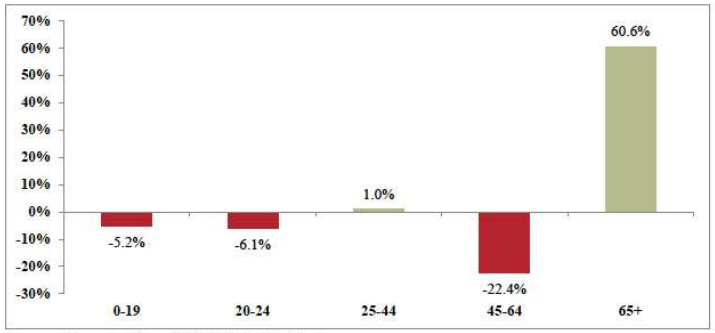
Community Needs – Housing near Transit

Figure 1: City of Newton Projected Population 1930 to 2030



Source: MAPC Projection Data

Figure 4: City of Newton Projected Population Change by Age Cohort 2010–2030 Status Quo Projection



Source: Computed from MAPC Projection Data

145 Warren Street

Add scores to your site

Newton Center, Newton, 02459

Commute to **Downtown Newton**

5 min | 20 min | 8 min | 28 min | View Routes

Favorite | **Map** | **Nearby Apartments**

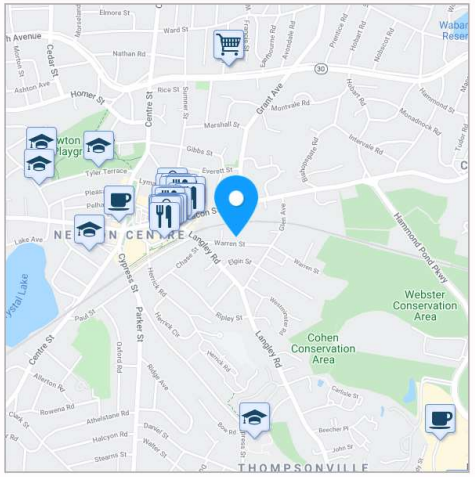
More about 145 Warren Street

Walk Score 77 — **Very Walkable**
Most errands can be accomplished on foot.

Transit Score 52 — **Good Transit**
Many nearby public transportation options.

Bike Score 58 — **Bikeable**
Some bike infrastructure.

About your score

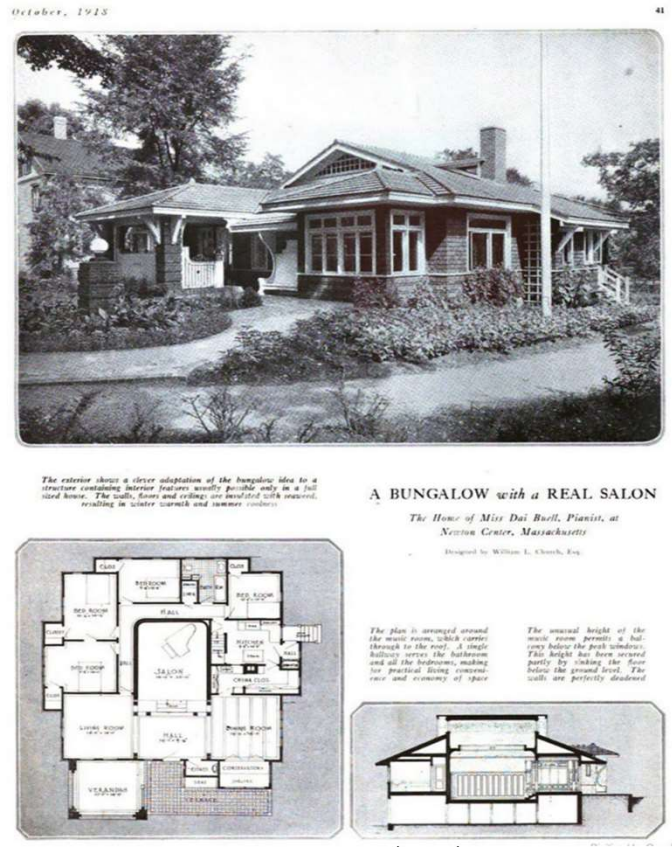


Community Needs – Housing near Transit

The Aloha Bungalow

October 1918 Home and Garden Magazine featured the home of Dai Buell

1 of 37 places in Newton on the historic registry.


October, 1918 41

The exterior shows a clever adaptation of the bungalow idea to a structure containing interior features usually possible only in a full sized house. The walls, floors and ceilings are insulated with seaweed, resulting in winter warmth and summer coolness

A BUNGALOW *with a* REAL SALON

The Home of Miss Dai Buell, Pianist, at Newton Center, Massachusetts

Designed by William L. Church, Esq.

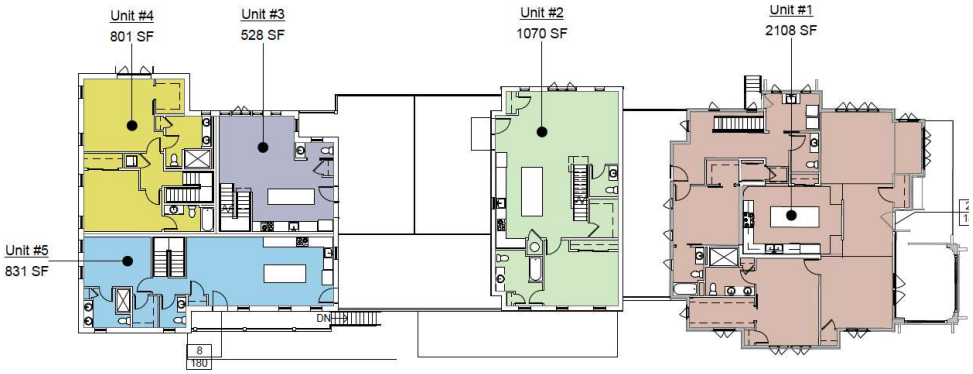
The plan is arranged around the music room, which carries through to the roof. A single hallway serves the bathroom and all the bedrooms, making for practical living convenience and economy of space

The unusual height of the music room permits a balcony below the peak windows. This height has been secured partly by sinking the floor below the ground level. The walls are perfectly deadened

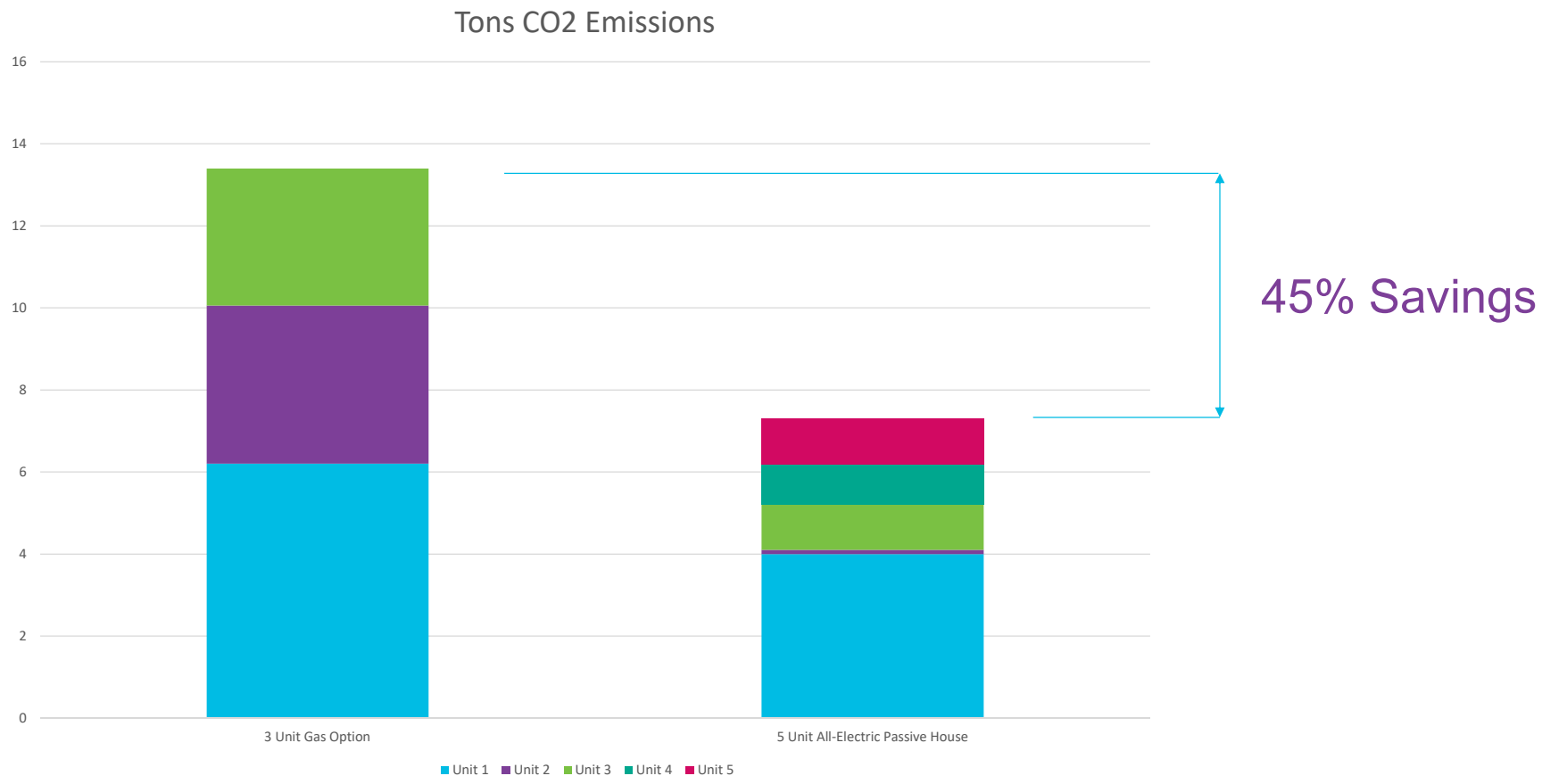
Development Options

3-Unit Concept

5-Unit Passive House Concept



Passive House Carbon Emissions Reduction



Community Scale
Newton, MA

Historic Preservation
Preserve the historic home and character of the area

Special Permit Process
Requests an increase in unit density on the rest of the property to provide more housing

Green Newton Goals
Eliminate Fossil Fuel Use – All Electric/Carbon Neutral

Reduce Embodied Carbon – Materials Selection

Use of Passive House to increase efficiency

GreenNewton

NEWTON CLIMATE ACTION Official Partner

Green Newton seeks to promote efficient high-performance buildings

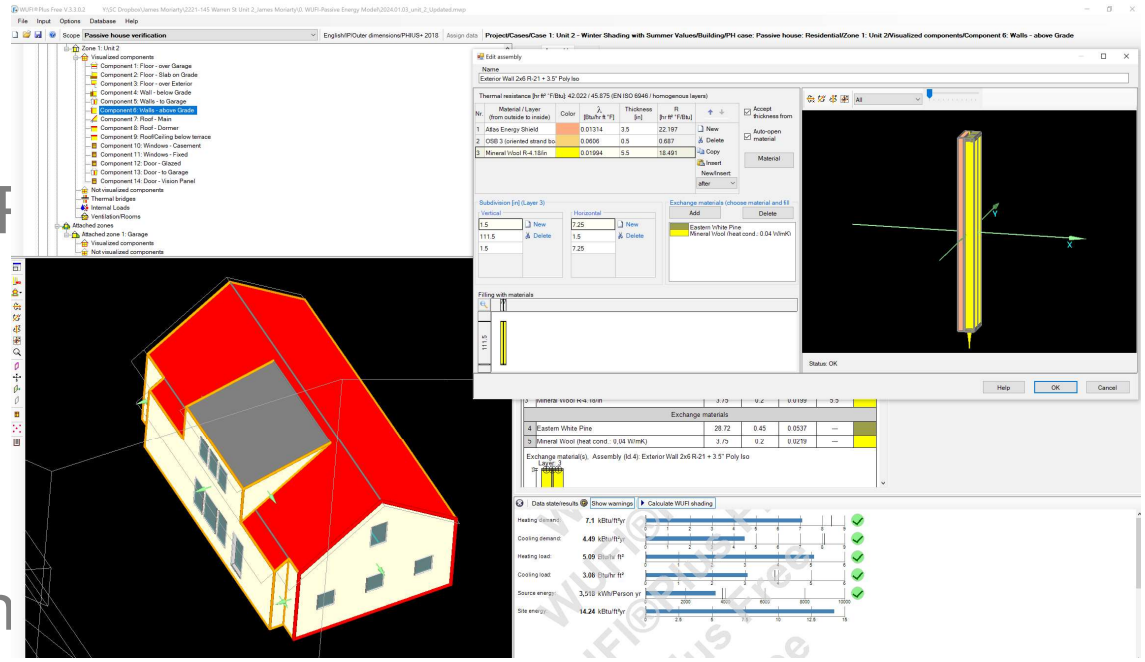
Optimize the Home Performance
Building Science Toolkit

Integrated Design Process

Energy Modeling
- Passive House – WUFI, PHP
- Homes – HERS Ratings

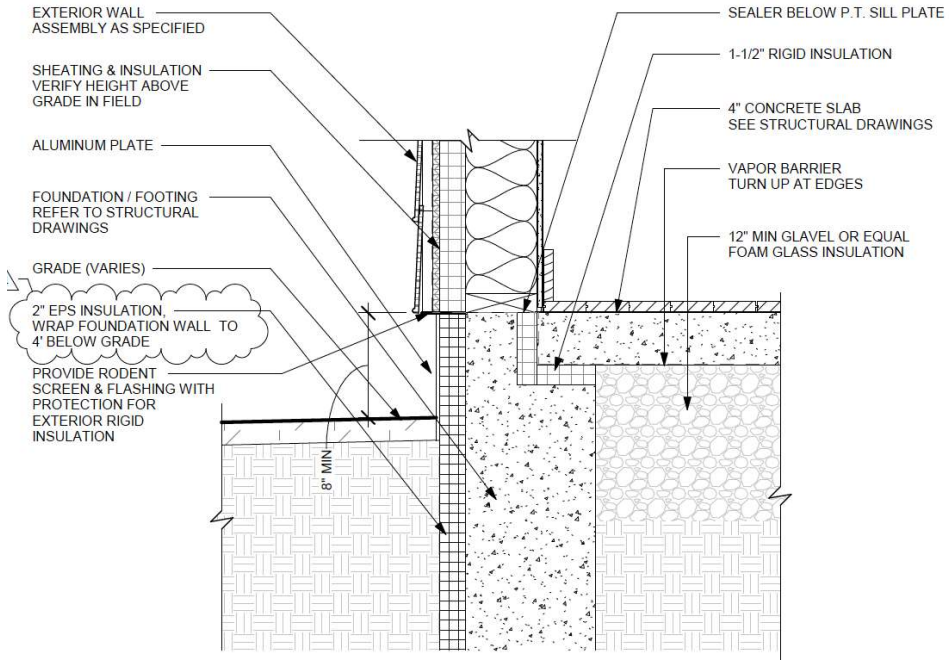
Inspections and Testing

Measurement and Verification



House as a System

Slab Insulation



12” Foam Glass Insulation – R-20

PROS

No foam under slab
Replaces gravel
Light weight product
Cost comparable to cutting rigid foam board

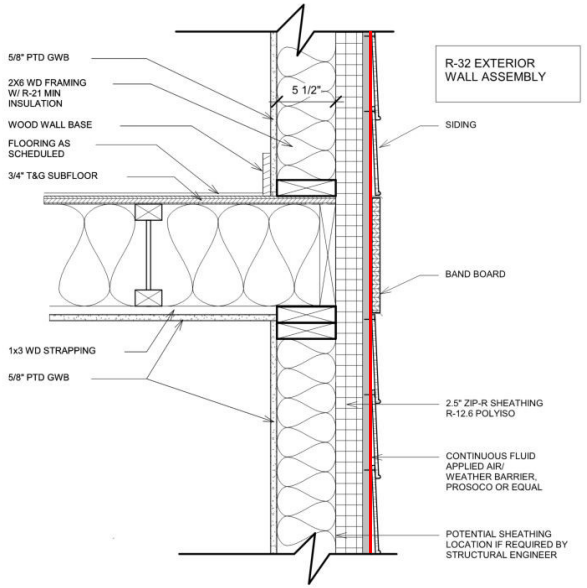
CONS

More expensive than gravel

Installation Process

Glavel Foam Glass

Exterior Walls – Units 3-5



2x6 Wall with ZIP-R Exterior Rigid – R-30

Installation Progress

PROS

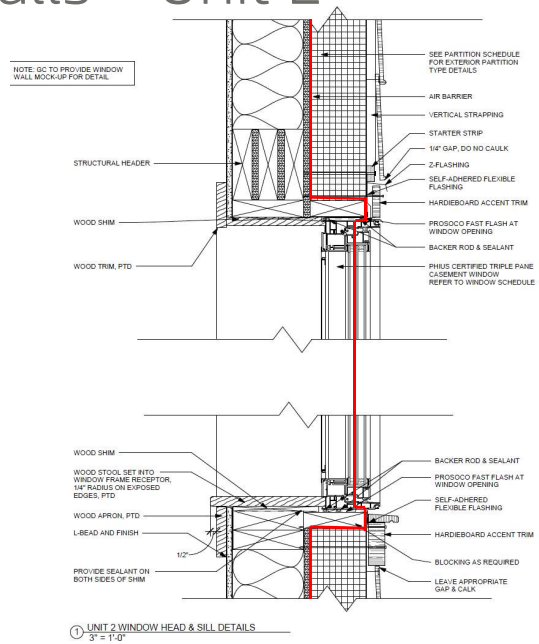
Reduced thickness insulation
Reduce thermal bridging
Primary air barrier at exterior

Recommend fluid applied air barrier at seams

CONS

Longer fasteners for additional rigid
Detailing around windows, corners and roof

Exterior Walls – Unit 2



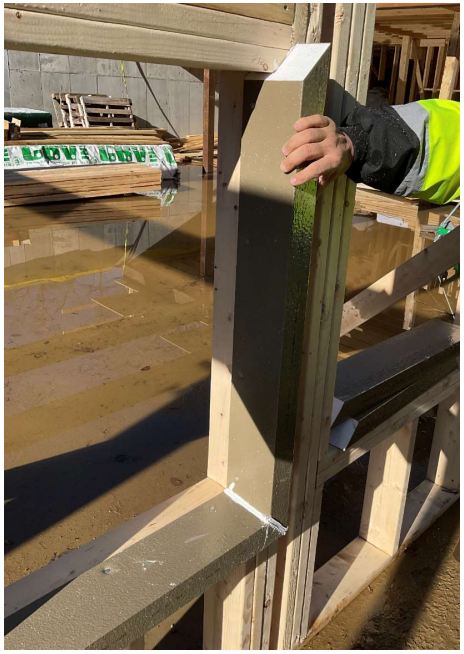
2x6 Wall with 4” Rigid Insulation – R-42

PROS

Higher R-value
Protected air barrier
Primary air barrier protected in sheathing

CONS

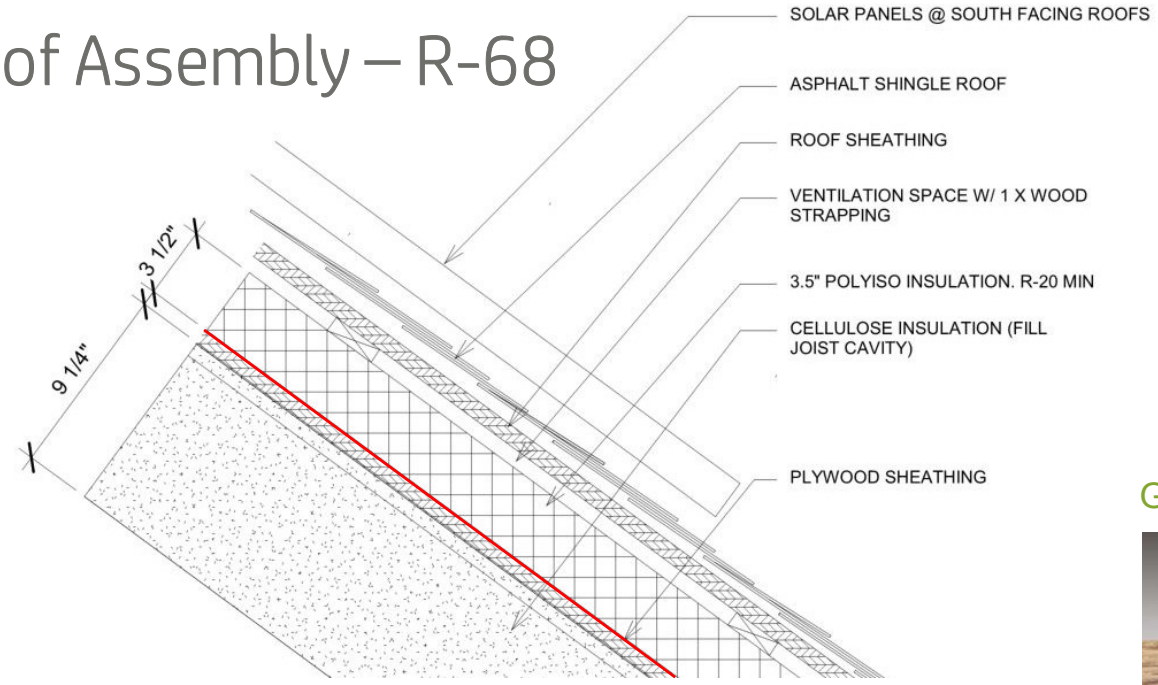
Strapping needed for siding
Foam is a higher emitting material



Window Installation

Thermal bucks eliminate thermal bridging at window blocking

Sloped Roof Assembly – R-68



Durability Considerations

PHIUS Guidelines for unvented framed roof assemblies with some insulation provided by air impermeable insulation are as follows:

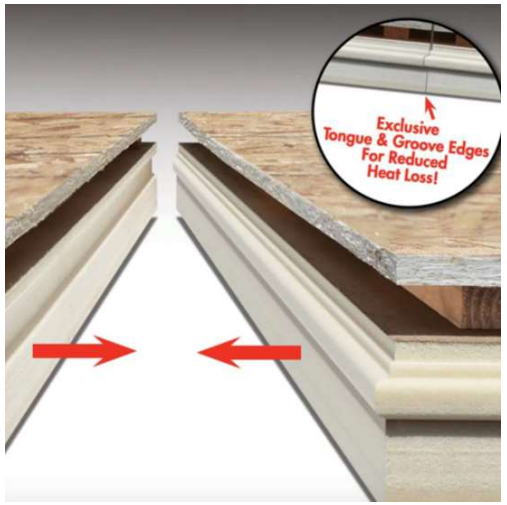
Outer air-impermeable insulation value >35% of total

A 2x10 rafter cavity with cellulose provides an R-34.

Continuous insulation must be R-19 or greater.

The proposed assembly with GAF ThremalCal® ventilation integrated insulated roof panels meets PHIUS moisture criteria and necessary R-value to meet thermal performance requirements.

GAF Thermacal-1



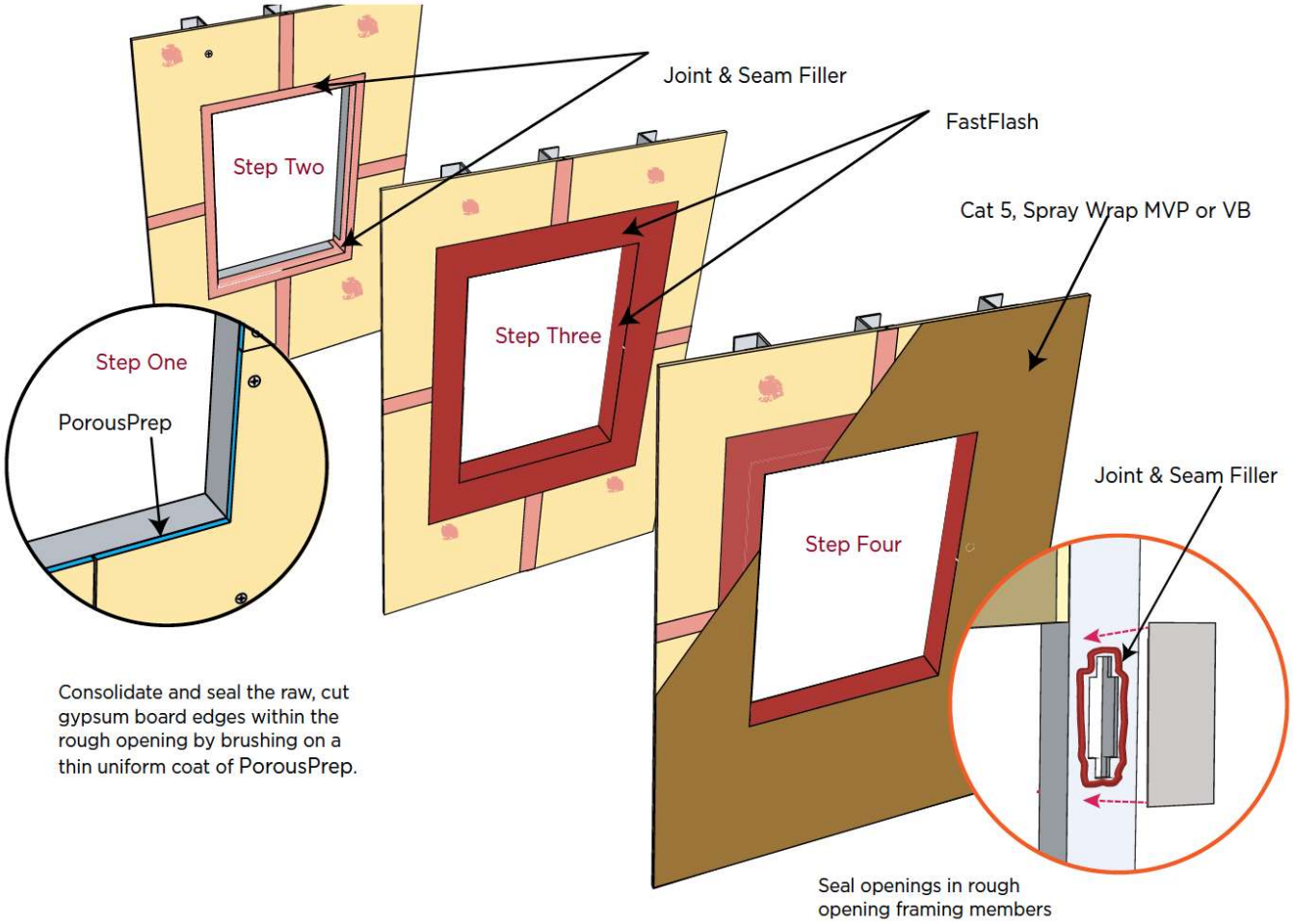
https://www.gaf.com/en-us/products/thermacal-1

Fluid Applied Air Barr

Continuous fluid applied air barriers for air and water protection.

Prosoco R-Guard product recommended for window flashing and primary air barrier.

Eliminates the need for Tyvek air and water barrier and dealing with tapes at any seams.



Heating, Cooling, and Ventilation

Minotair Pentcare

Primary Ventilation System

Distributes air across unit

Mitsubishi Mini Split

Supplemental heating/cooling

Main living area unit

Additional Program Certifications

Along with Phius 2021 Certification, the following programs are also required for indoor health and comfort:

EPA Indoor Air Plus
Energy Star Homes
DOE Net Zero Energy Ready Homes
Mass Save Incentives

Project Incentives

Incentives

- 45L Tax Credit $22,500
- MA All Electric incentive $75,000
- Solar Tax Credits $12,500 30% federal tax credit

~2% of construction costs in credits/incentives

MA All Electric

Home Type	Level 1	Level 2
Single family	$15,000	$25,000
2-unit dwelling	$17,500	$30,000
3-unit dwelling	$20,000	$35,000
4-unit dwelling	$22,500	$40,000

45L

Energy Star Pathway	Unit Incentive
Energy Star SFNH (Single family/townhomes)	**$2,500/unit**
Energy Star SFNH + DOE ZERH (Single family/townhomes)	**$5,000/unit**
Energy Star MFNC (Multifamily)	**$500/unit**
Energy Star MFNC + DOE ZERH (Multifamily)	**$1,000/unit**

Passive House Carbon Emissions Reduction

Carbon Rating & HERS® Certificate

Projected Report
Based on Plans

Rating Date:
Registry ID:
Ekotrope ID: bL7BEZe2

Carbon Index	HERS® Index
11	2

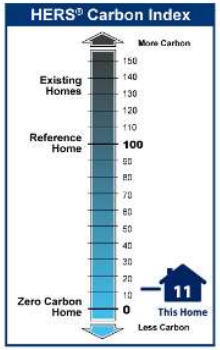
About these ratings:
Both ratings are relative performance scores. A lower Carbon Rating Index means fewer carbon emissions for a home. The lower the HERS Rating, the more energy efficient the home. For more Info:
www.resnet.us/about/resnet-carbon-rating-index
www.hers.com

Home:
145 Warren Street - Unit 2
Newton, MA 02458
Builder:

	CO_2e Emissions [tons/yr]	Annual Cost
Heating	0.7	$812
Cooling	0.1	$121
Hot Water	0.2	$212
Lights/Appliances	1.7	$2,134
Service Charges		$0
Generation (e.g. Solar)	-1.9	-$3,115
Total:	**0.8**	**$164**

Annual Savings*
8.4 Tons CO_2e
$10,825
*Relative to an average U.S. home

This home meets or exceeds the criteria of the following:



Home Feature Summary:

Home Type:	Single family detached
Model:	Unit 2
Community:	145 Warren
Conditioned Floor Area:	2,301 ft²
Number of Bedrooms:	3
Primary Heating System:	Air Source Heat Pump • Electric • 12.5 HSPF
Primary Cooling System:	Air Source Heat Pump • Electric • 19.5 SEER
Primary Water Heating:	Residential Water Heater • Electric • 3.55 UEF
House Tightness:	347.5 CFM50 (0.86 ACH50)
Ventilation:	83 CFM, 83 CFM • 86.32 Watts, 86.32 Watts • ERVERV
Duct Leakage to Outside:	10 CFM @ 25Pa (1.32 / 100 ft²)
Above Grade Walls:	R-43
Ceiling:	Vaulted Roof, R-66
Window Type:	U-Value: 0.16, SHGC: 0.45
Foundation Walls:	N/A
Framed Floor:	R-45

Rating Completed by:

Energy Rater: Kellie Murphy
RESNET ID: 3503214

Rating Company: Sustainable Comfort
55 Linden St Worcester, MA 01609
5087136680

Rating Provider: Sustainable Comfort
55 Linden St Worcester, MA 01609
5087136680

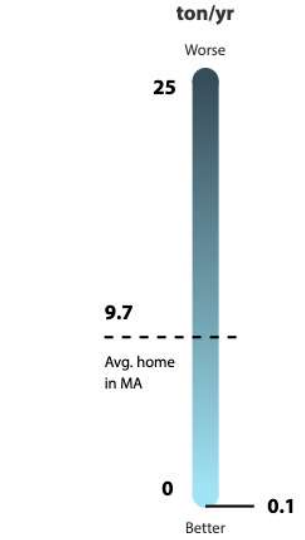
Kellie Murphy, Certified Energy Rater
Date: 3/6/24 at 11:33 AM

ekotrope

Ekotrope RATER - Version:4.2.0.3352
The Energy Rating Disclosure for this home is available from the Approved Rating Provider.
This report does not constitute any warranty or guarantee.

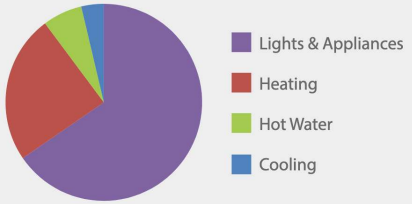
Home Carbon Footprint

This shows the estimated annual carbon emissions associated with your home and is based on your home's estimated total annual energy use. The lower the score, the less carbon pollution is released into the atmosphere.



Yearly Energy Costs*

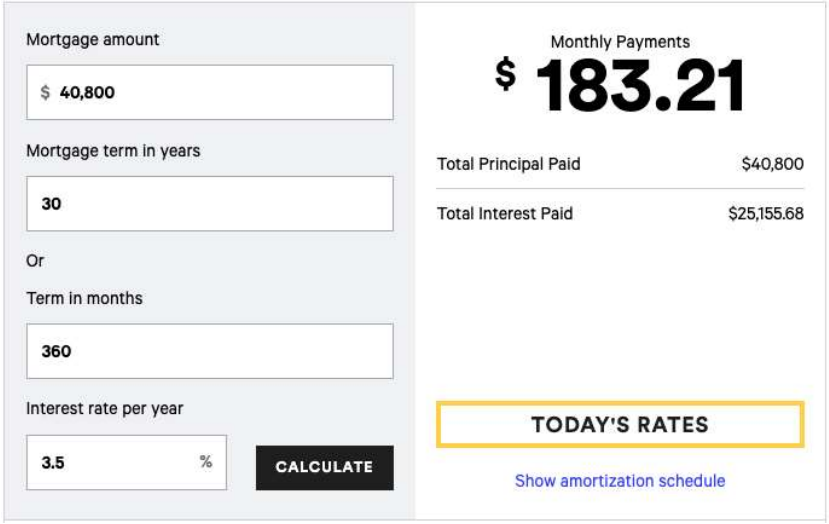
Total
$148



Utility Cost Comparison

Code Built Home: $2,524 per year
Passive House: $323 per year
Utility Cost Savings: $183 per month

Additional Mortgage Value: $40,800



Passive House Utility Cost – Example 2 Bedroom

Annual Energy Cost	
Electric	$323

Annual End-Use Cost	
Heating	$414
Cooling	$103
Water Heating	$101
Lights & Appliances	$941
Onsite Generation	-$1,321
Service Charges	$84
Total	$323

Code Built Home Utility Cost – Example 2 Bedroom

Annual Energy Cost	
Natural Gas	$843
Electric	$1,681

Annual End-Use Cost	
Heating	$810
Cooling	$90
Water Heating	$443
Lights & Appliances	$950
Onsite Generation	-$0
Service Charges	$230
Total	$2,524

Systems Thinking

Finding your own **“Why”**

Why is it so Important to me?

NESEA's Impact

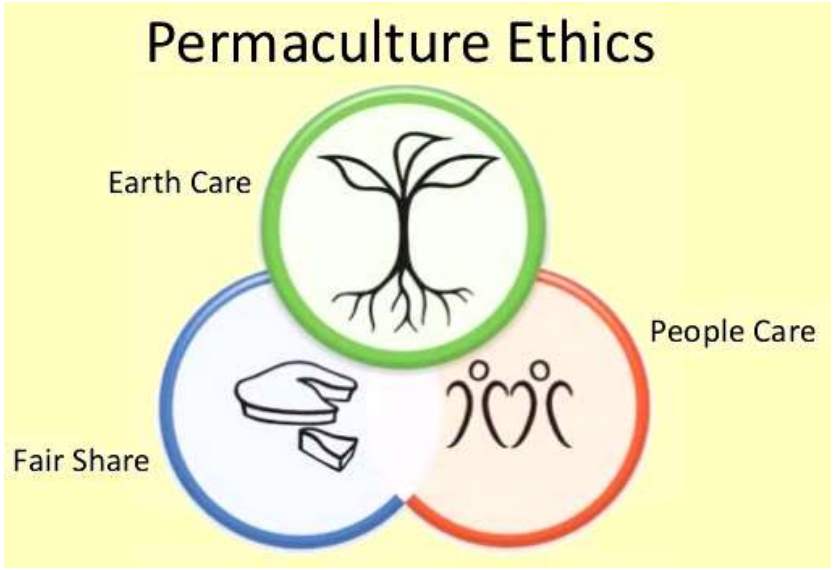
NESEA
NORTHEAST SUSTAINABLE ENERGY ASSOCIATION

Why has NESEA been so Important to me?
- Community of Practice
- Why of our Work
- Reflect, Motivate and Make a Difference!

NESEA Experience
- Current NESEA Board Member
- Kate Goldstein Emerging Leader Recipient

In

Personal


Permaculture Ethics
Earth Care
People Care
Fair Share


Before
BeforeAfter

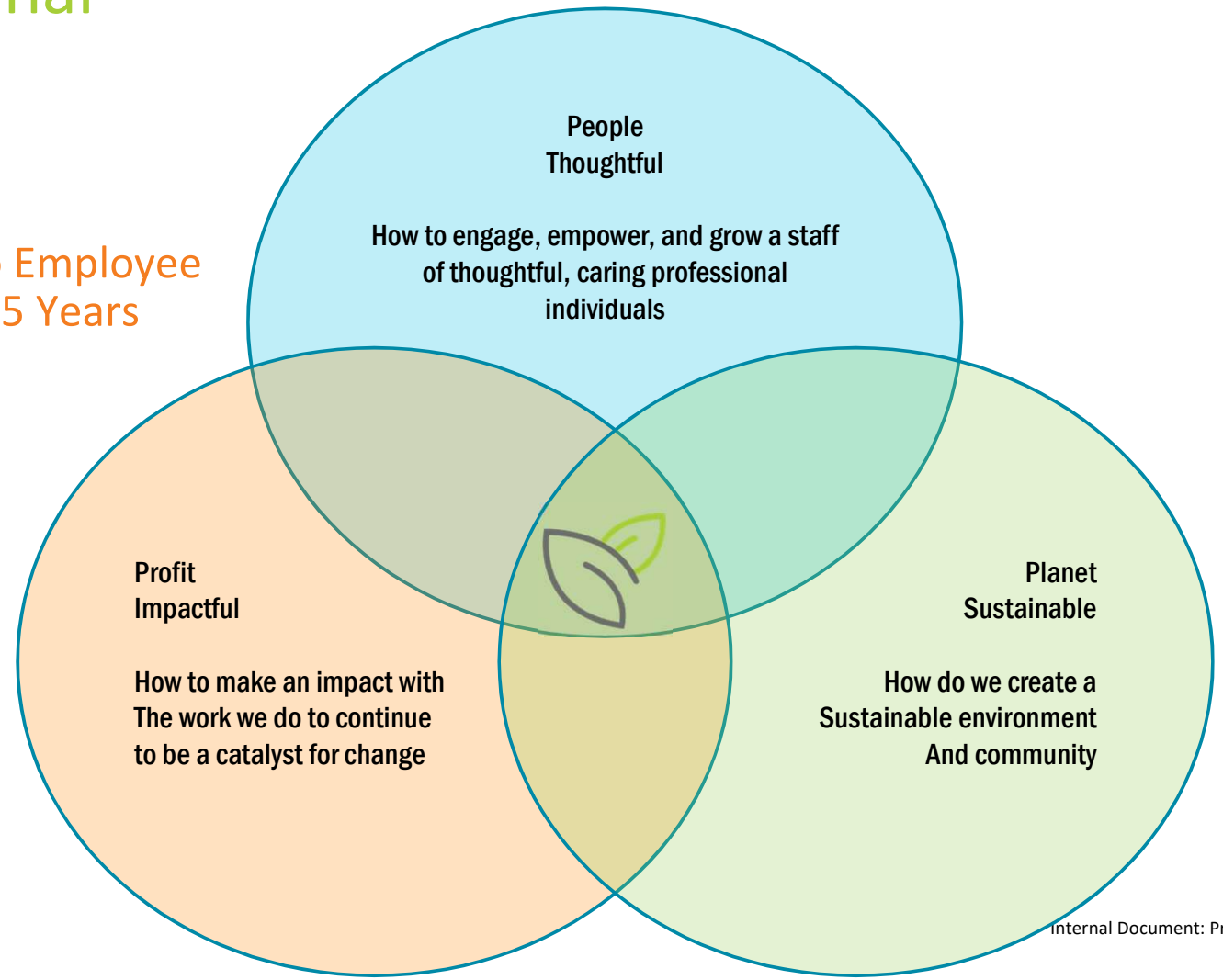

After

Professional

Professional

Mission: We work to create thoughtful, sustainable, impactful buildings.

Committed to Employee Ownership in 5 Years



Systems Thinking

Questions?