Energy in the Built Environment

CASE STUDIES OF ULTRA-LOW ENERGY BUILDINGS IN THE PACIFIC NORTHWEST

2016 PNWER ECONOMIC LEADERSHIP FORUM, BOISE IDAHO

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Pacific NorthWest Economic Region

Overview

- → Roadmap to Resilient, Ultra-Low Energy Buildings
- → Case Studies
  - → Summary of results
  - → Examples of case studies
  - → Common design features
- → Conclusions/Recommendations

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Benefits from Addressing Energy in Buildings

- → Affordability
  - → Reduced energy costs to consumers
- → Comfort
- → Healthfulness
- → Lower carbon emissions

- → Durability
- → Resilience to extreme weather events and natural hazards
- → Increased market value

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PNWER Roadmap to Resilient, Ultra-Low Energy Buildings

→ **A document** that will seek endorsement by legislators and private sector leaders from 10 PNWER jurisdictions

→ **Goal** is to catalyze new energy-efficiency legislation to achieve the desired benefits and specific targets for the year 2030

→ **Provides**:

- › Information and analysis
- › Metrics, targets, timelines
- › Policy best practices
- › Market-driven solutions

→ **Includes <u>case studies</u>** of new and retrofitted buildings that demonstrate best practices throughout the PNWER

RDH Making Buildings Better

CICFI COUNCIL OF ICF INDUSTRIES

FORTIS BC™

CONSTRUCTION CENTER OF EXCELLENCE

BRITISH COLUMBIA BC Ministry of Energy and Mines

Case Study Methodology

→ Case selection criteria:

- Ultra-low energy (net-zero) new buildings
- Resilient design *and* design replication potential
- 'Deep' energy retrofits of existing buildings
- Must have 2+ years of real utility data

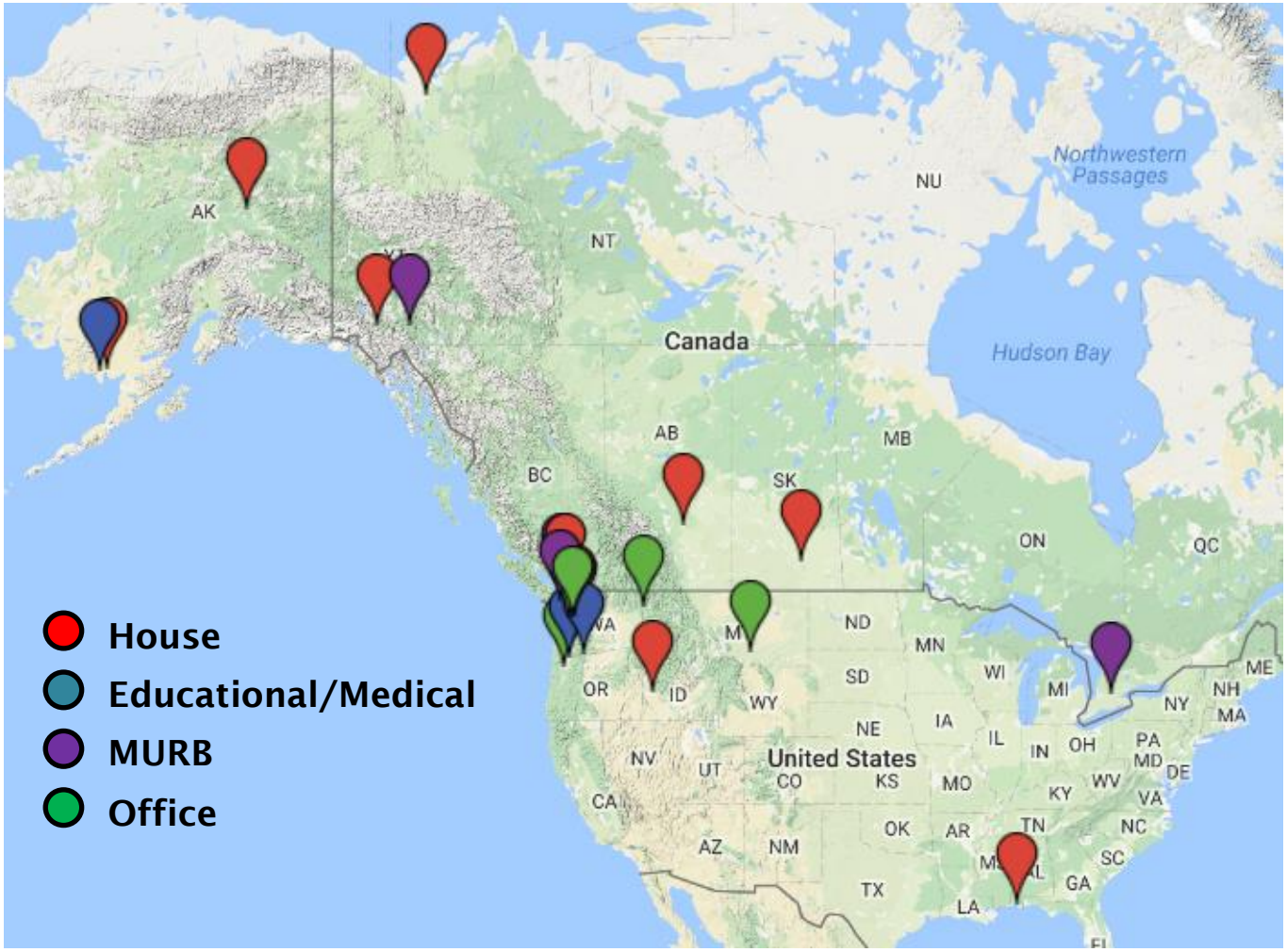
→ Collection of cases

- NBI Database, NEEA, regional utilities
- Interviews with owners and/or design team

→ Baselines for analysis

- Energy (New): DOE Prototype Building Models ASHRAE 90.1 2013
- Energy (Retrofit): CBECS, RECS, SHEU, SCIEU - energy surveys
- Costs: RS Means

Map of 22 Case Studies



Average energy savings:

Houses –**64 %**
Educational –**76 %**
MURBs –**50 %**
Offices –**84 %**

Average GHG emission reductions across all buildings:

-70% CO_2-equiv

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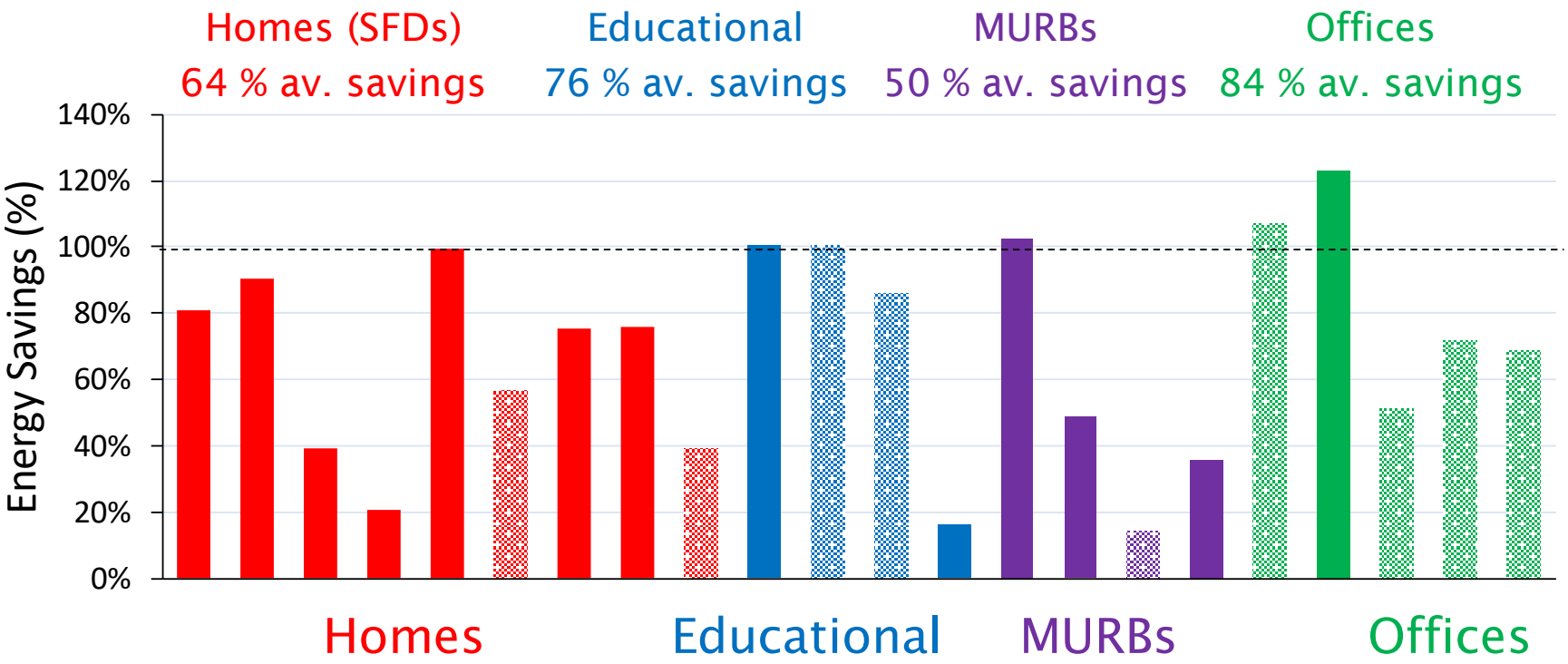
Type	New/Retrofit	Case Study Buildings	City	State/Prov	Climate Zone	Year Completed
Homes	New	Factor 9 Home	Regina	SK	7	2007
		Discovery 3 House	Red Deer	AB	7	2008
		Hutshi House	Haines Junction	YK	8	2013
		Northern Sustainable House	Inuvik	NWT	8	2013
		Harmony House	Burnaby	BC	5C	2013
		Alaska home	Dillingham	AK	8	2012
		Alabama home*	Fairhope	AL	2A	2013
	Retrofit	BC Livesmart home	Vancouver	BC	5C	2014
		Idaho home	Boise	ID	6B	2011
Educational/ Medical	New	Bertschi School	Seattle	WA	4C	2011
		OHSU CLSB	Portland	OR	4C	2014
	Retrofit	Hood River M.S.	Hood River	OR	5B	2010
		UAF BBC Applied Science	Dillingham	AK	8	2014
MURBs	New	zHome	Issaquah	WA	4C	2012
		Ingram Houses	Whitehorse	YK	8	2010
		Dorset St*	Waterloo	ON	6A	2006
	Retrofit	Belmont Building	Vancouver	BC	5C	2012
Offices	New	Bullitt Center	Seattle	WA	4C	2013
	Retrofit	Painter's Hall	Salem	OR	4C	2010
		Home on the Range	Billings	MT	6B	2006
		Rice Fergus Miller Office	Bremerton	WA	4C	2011
		Beardmore	Priest River	ID	6B	2009

*Outside the PNWER

Resilience Features (non-energy benefits)

Extreme weather	Rain, drought, wind, heat/cold
Seismic resistance	(no cases went above code)
Water savings	Low-flow fixtures, rainwater collection, landscaping
Improved acoustics	Sound insulation
Comfort	Thermal, spatial, mental
Community benefits	Public access, improved neighborhood
Transportation	Access to public transit, biking (showers)
Indoor air quality	Low VOC materials, duct considerations
Other health measures	Access to parks
Environmental benefits	Sustainable materials, waste reduction

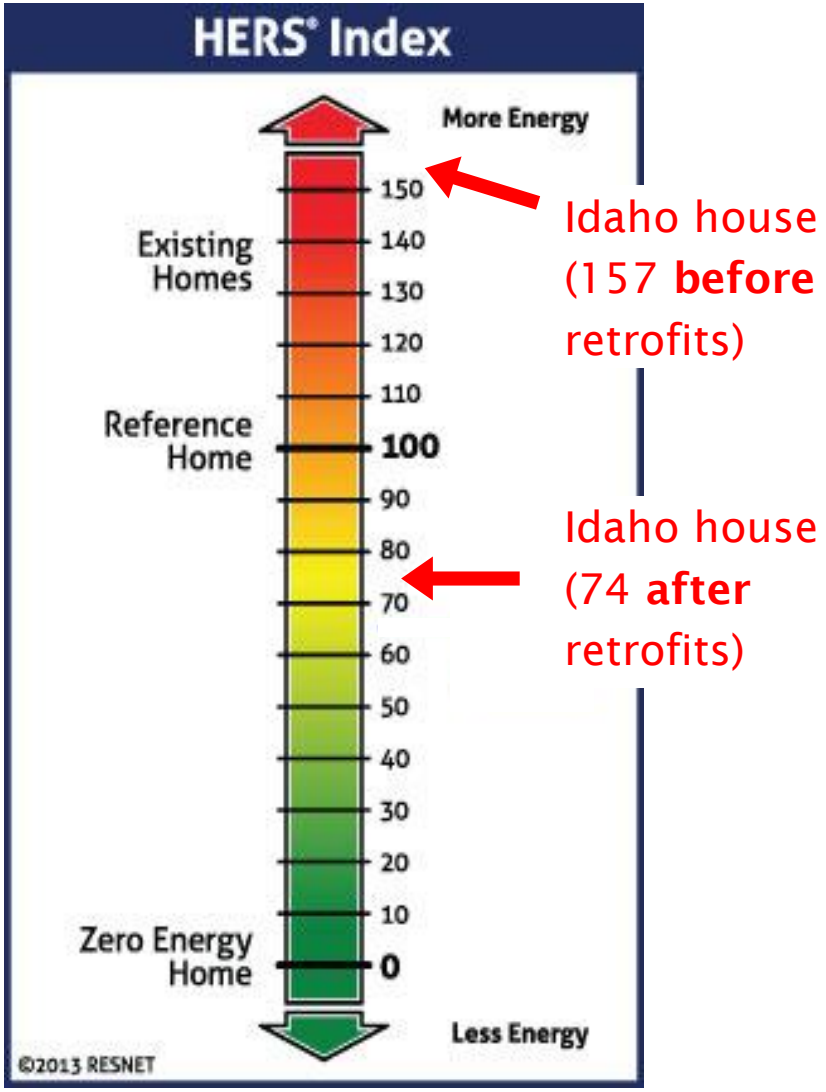
Energy Savings of Case Studies



Home Energy Rating System (HERS) challenges

Case Study: **Idaho home**

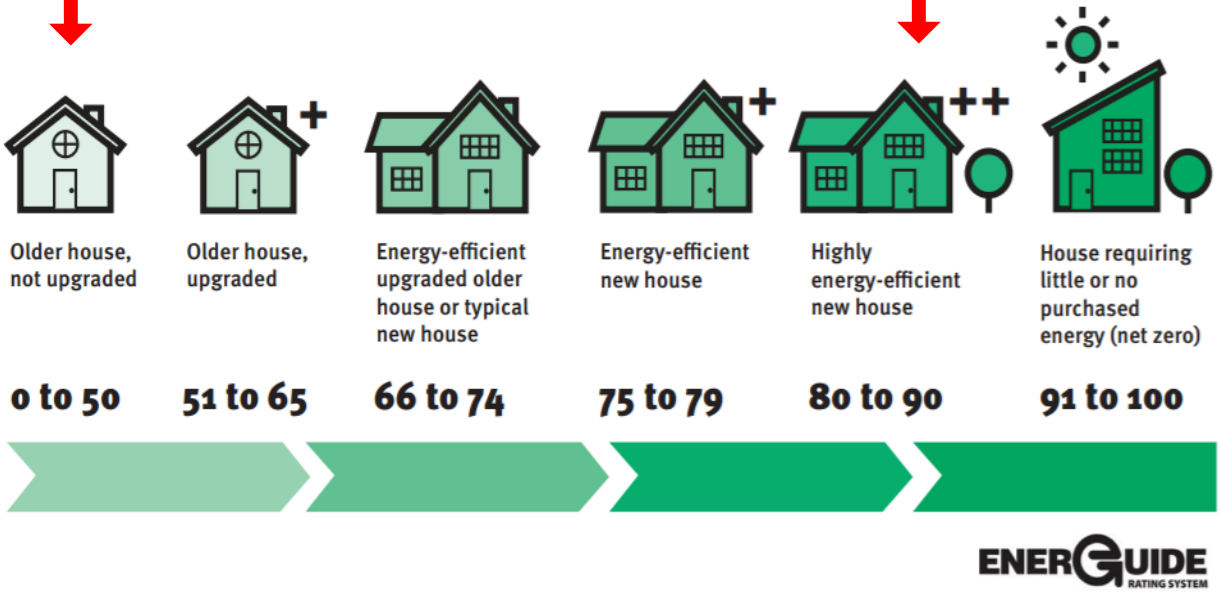
- → HERS index = 74
  - › Should be 26% better than average home
- → **Yet measured energy consumption was still 89% higher than average**
- → Why does HERS not reflect real energy consumption?
  - › Prescriptive approach
  - › No plug loads or occupant behaviour analysis
  - › Program does not verify with measured utilities



EnerGuide for Homes – more challenges

LiveSmart house
(20 **before** retrofit)

LiveSmart house
(88 **after** retrofit)



Case Study:
LiveSmart BC house

EnerGuide 88
(post-retrofit)

→ But… energy consumption is still 55% worse than average

BC LiveSmart house and Idaho house both improved dramatically from their pre-retrofit energy consumption → included in study

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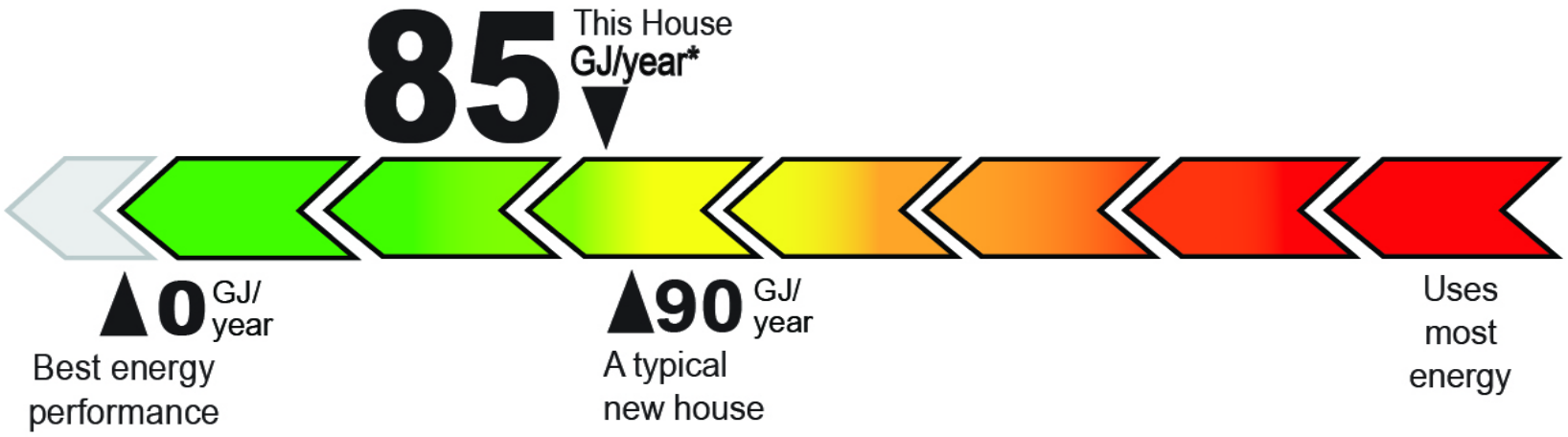
New – EnerGuide Gigajoules/Year Scale

→ **Progress**: A new EnerGuide rating system in Canada has been adjusted to better reflect the reality of houses' energy bills

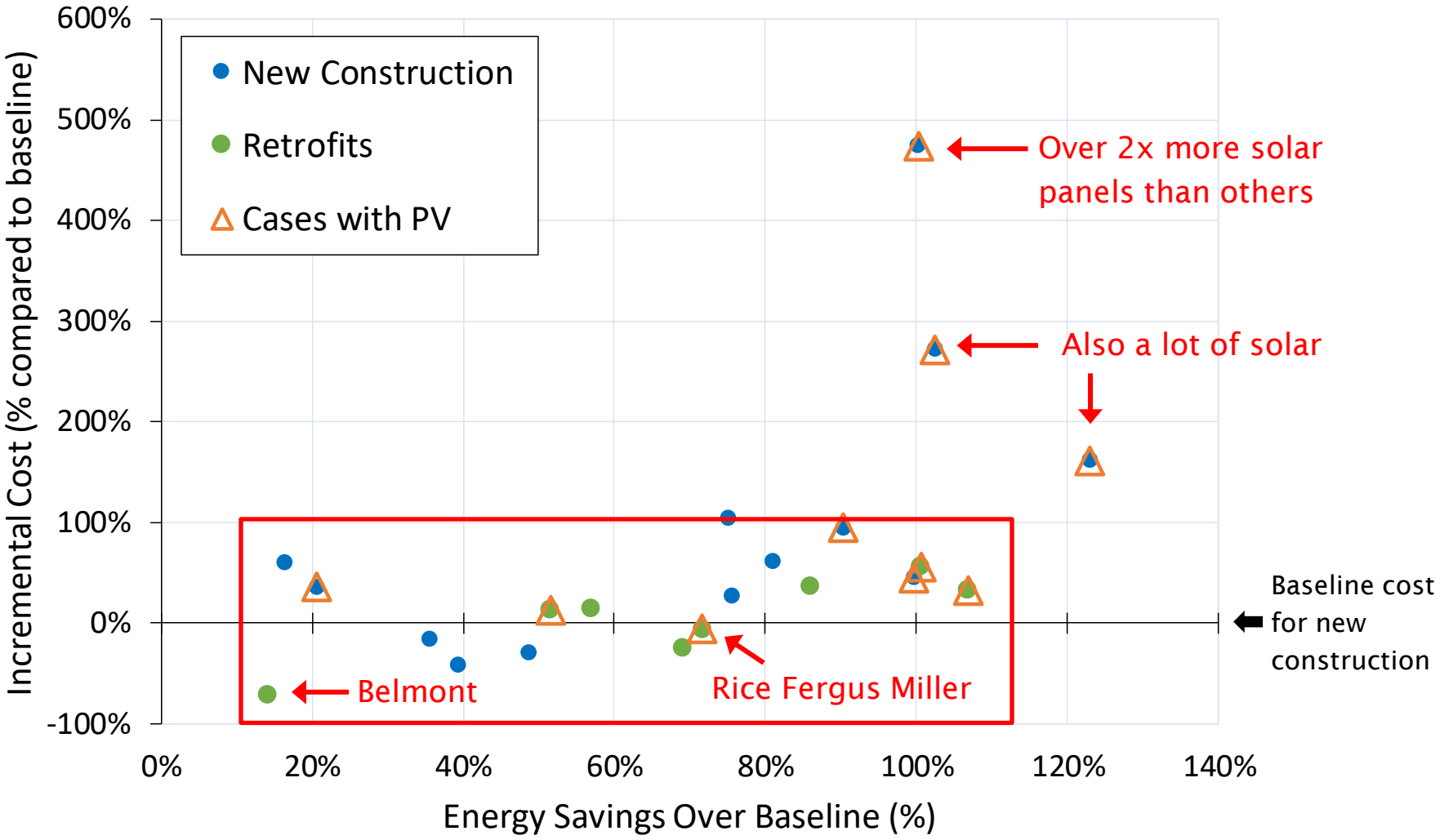
→ Uses GJ/year scale:



→ New scale is much less arbitrary

→ But still no measurement and verification of modeled data

Construction Cost Increase vs Energy Savings



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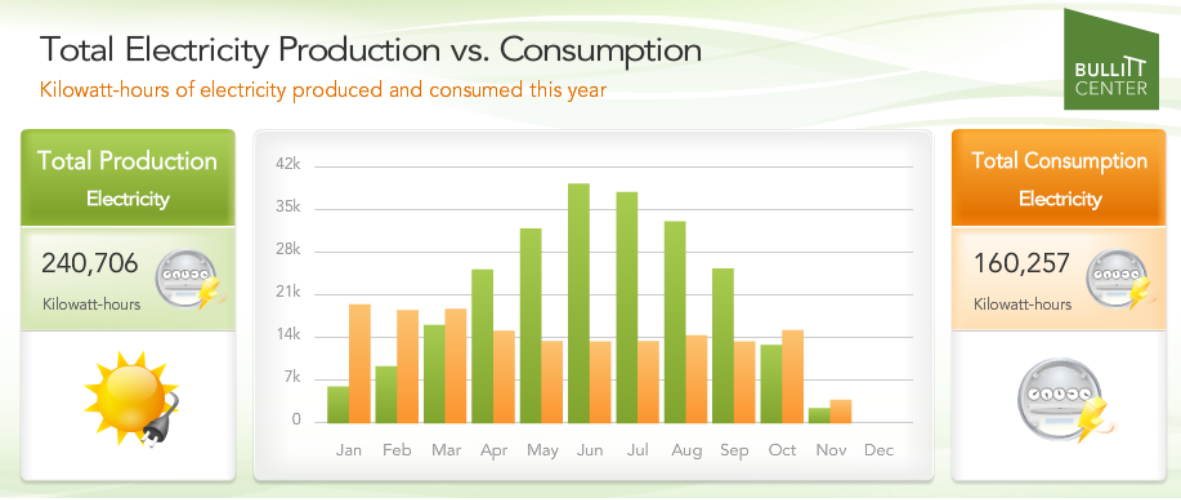
Case Example 1: The Bullitt Center

- → Net positive energy
  -7 kBtu/ft²/yr
- → **Jurisdiction**: Washington
- → **Building Type**: Office
- → **Construction Type**: New
- → **Construction Year:** 2013
- → **Ratings**: Living Building Challenge Certified

LIVING BUILDING CHALLENGE℠

Case Example 1: The Bullitt Center

Strategy	Create a new paradigm for 21st century buildings
HVAC	No heating under typical conditions, backup ground source heat pump serves radiant floor system
Walls	Exterior insulated walls, exterior blinds for solar shading
Windows	Automated controlled by CO_2, temp., RH, wind, and rain conditions, with manual override



Building Dashboard®

- → Net Zero Water
- → Building life cycle
- → Irresistible stair
- → Internal cap & trade
- → U of W's IDL collects performance data

Case Example 2: Hood River Middle School

- → **Jurisdiction**: Oregon
- → **Building Type**: Educational
- → **Construction Type**: Retrofit
- → **Original construction**: 1927
- → **Retrofit completed**: 2010
- → **Site description**: Rural, old bus storage barn
- → **Ratings**: Living Building Challenge Net Zero Energy Certified, LEED Platinum

HPD Magazine

LIVING BUILDING CHALLENGE

U.S. GREEN BUILDING COUNCIL
LEED PLATINUM
2010

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Case Example 2: Hood River Middle School

Strategy	Fuse sustainable design with teaching curriculum
HVAC	Ground source heat pump and radiant floors PV preheats winter air, river water cooling in summer
Walls	Insulated concrete forms (ICF)
Windows	Triple glazed windows with wood frames Deciduous vines provide seasonal solar shading

ILFI

- → Rainwater collection minimizes potable water demand by 89%
- → PV → Net Zero
- → Greenhouse for food production and teaching

Case Example 3: Single-family home

→ **Jurisdiction**: Alaska

→ **Building Type**: House

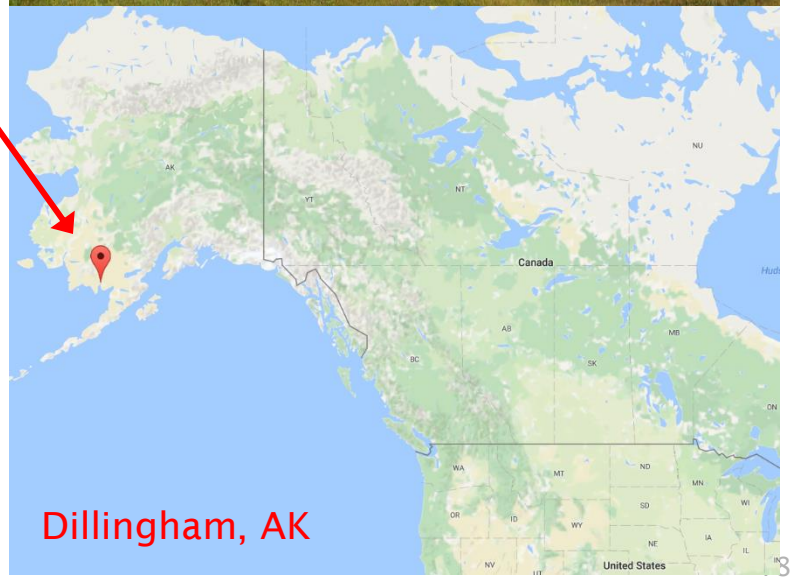
→ **Construction Type**: New

→ **Original construction**: 2011

→ **Site description**: Remote

→ **Ratings**: World Record Academy recognition for *Tightest Residential Building*

→ **Champion**: Tom Marsik



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Case Example 3: Single-family home

Strategy	Small 590 ft², airtight, use passive design principles
HVAC	HRV, heat pump water heater, electric space heater is barely needed (internal heat from occupants, lighting etc.)
Walls	28" thick walls, air sealed
Windows	Triple-pane, argon-filled, two low-E coatings, with fiberglass frames

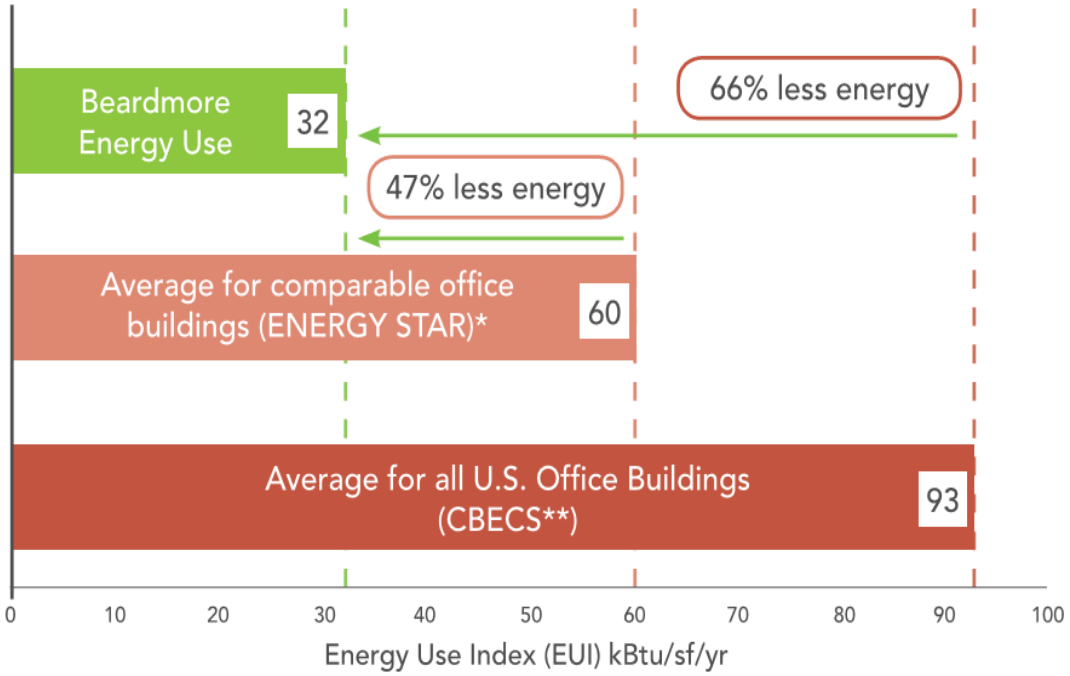
- → 0.05 ACH_{50} air tightness
  - → A specialized tool was needed to measure it!
- → When it's 0 ˚F outside, it's still 50 ˚F inside (without heating)
- → Solar-ready

Case Example 4: The Beardmore

- → **Jurisdiction**: Idaho
- → **Building Type**: Office
- → **Construction Type**: Retrofit
- → **Original construction:** 1922
- → **Retrofit completed**: 2009
- → **Site description**: Existing historical building
- → **Ratings**: LEED Gold and National Register of Historic Places
- → **Champion**: Brian Runberg

Case Example 4: The Beardmore

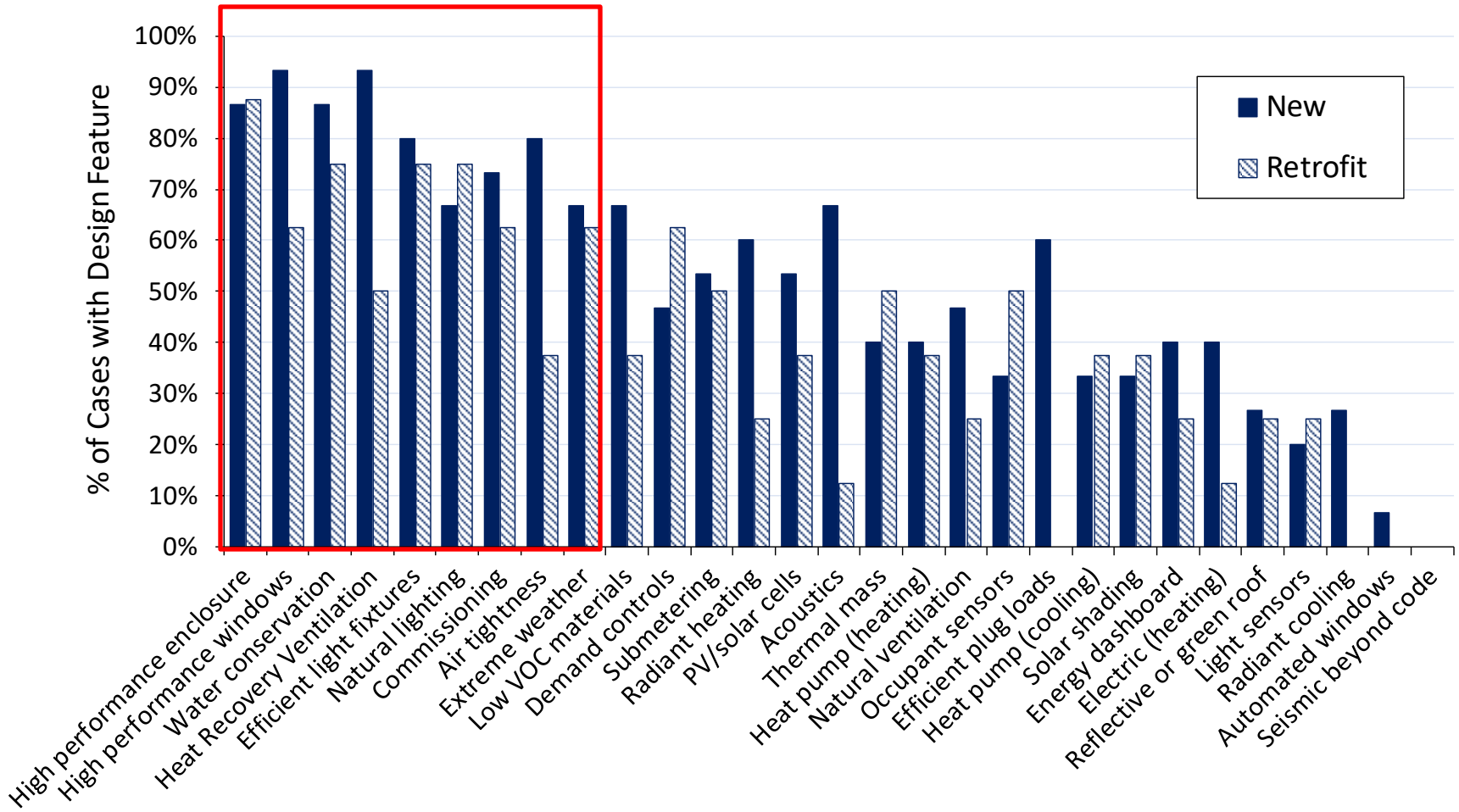
Strategy	Reach LEED Gold while maintaining Historical Register
HVAC	Rooftop heat pumps with economizer controls
Walls	Increased insulation to exterior walls and roof
Windows	Original wood frames, + low-E coating, additional glazing placed inside to protect historic transom detail



- → LED lights with night setback and occupancy sensors
- → Commissioning, including air tightness testing
- → Solar-ready

NBI, BetterBricks

Common Design Features



Most common high performance design features for new and retrofit buildings

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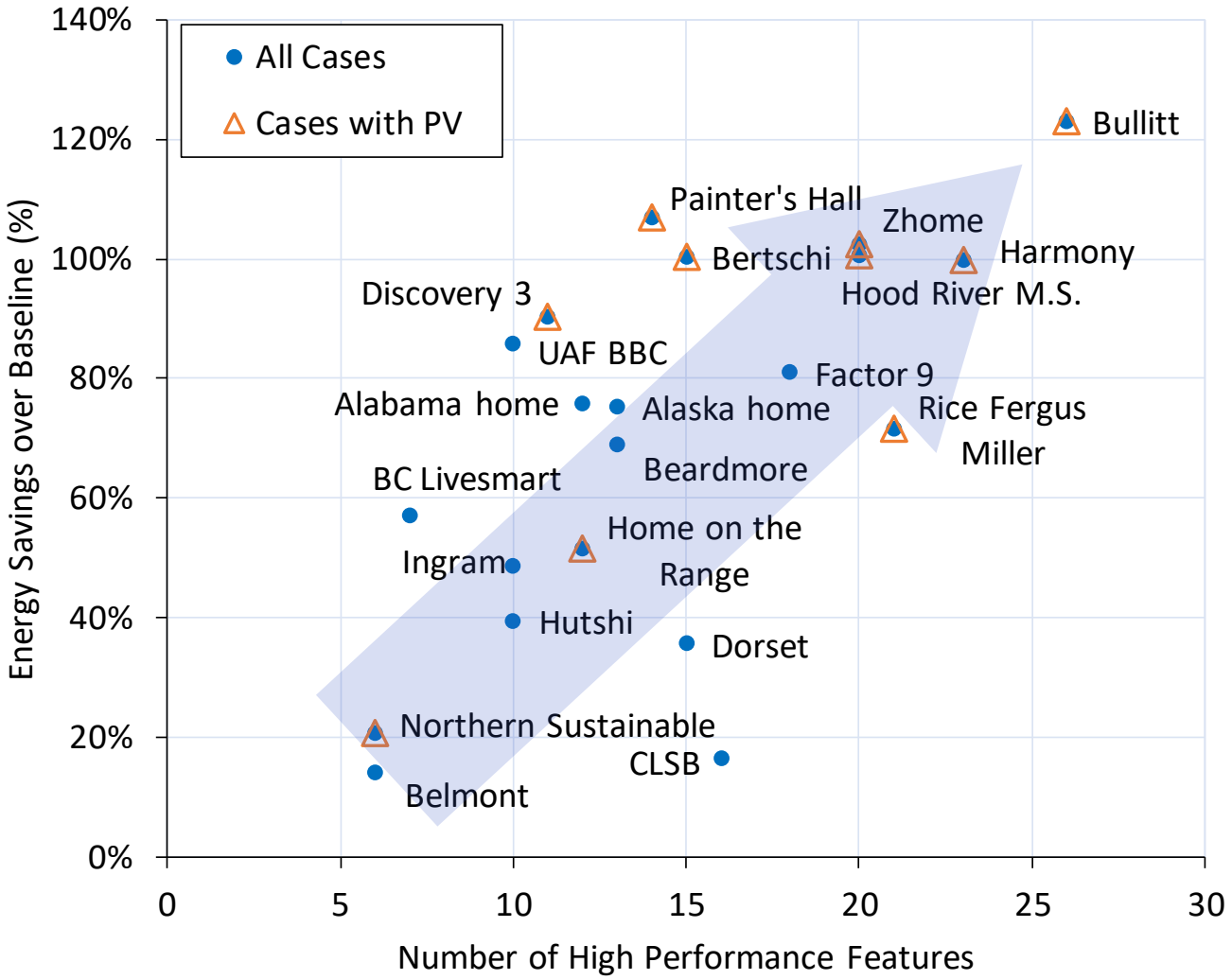
High Performance Features = Energy Efficiency



Unique Design features

Beardmore: DIY Rainwater Collection and Filtration

→ Lined old boiler room with pool liner and filter layers

→ Supplies all WC toilets+sinks

Collaborative Life Science Building: Waste Reduction

→ Paperless!

→ Saved ~$10M

→ Simultaneous, coordinated review

→ Also, salvaged old oil drilling pipes for foundation piles

The Importance of Champions

→ The energy-efficient case studies all have Champions

- → For example:
  - › Alaska home – Tom Marsik (UAF BBC Applied Science)
  - › Beardmore – Brian Runberg
  - › Bullitt Center – Denis Hayes, Chris Rogers, Chris Faul

→ Their roles include:

- → Leadership, inspiration, vision
- → Ambitious energy goals, targets (net zero buildings, etc.)
- → Overcoming barriers
  - › Work with city and other regulatory agencies

Conclusions/Recommendations

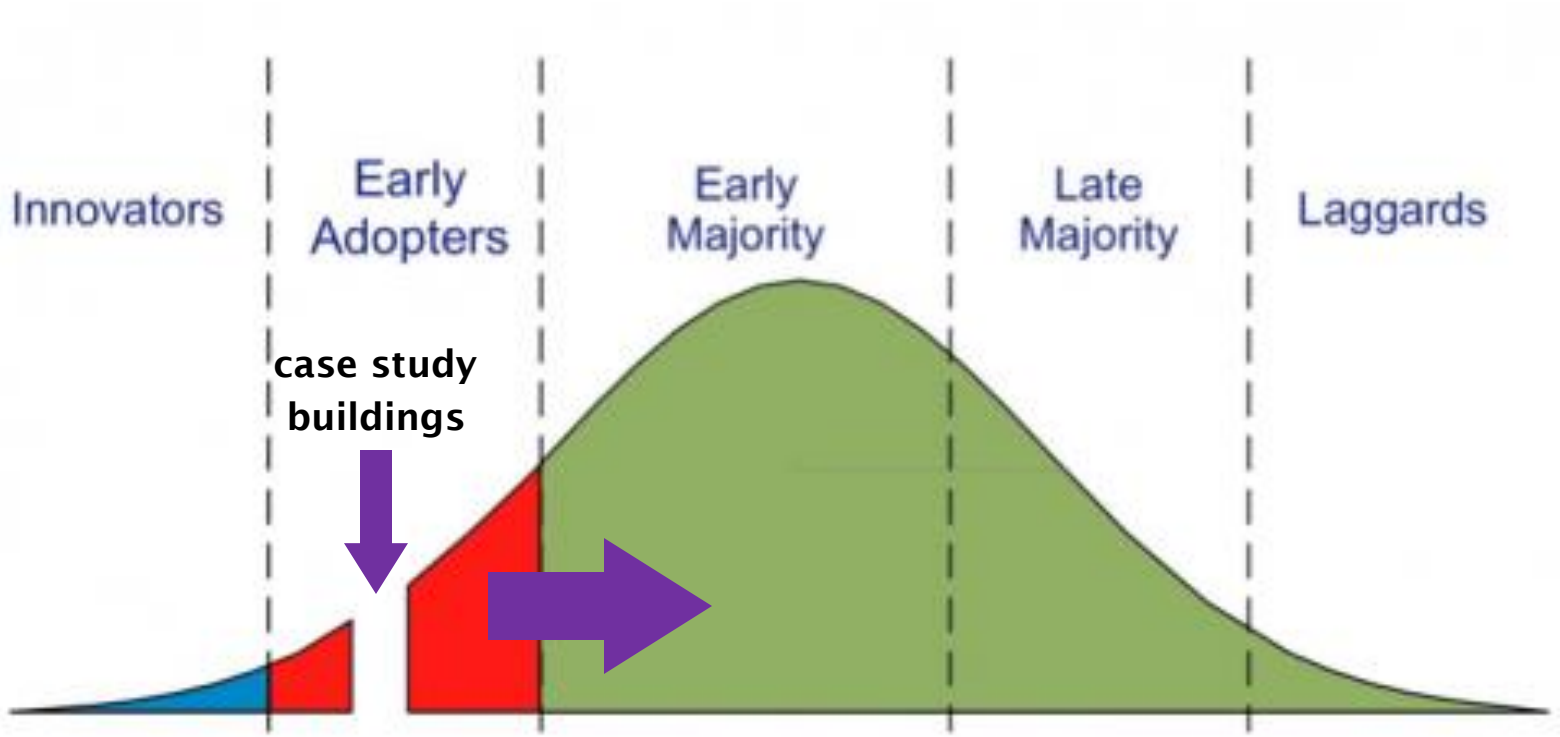
→ How to achieve energy efficiency in the built environment?

- Support champions!
- With an integrated design process (IDP), it doesn't have to cost more

→ Use common high performance design features:

Category	Top Design Features
Enclosure	High performance walls
	High performance windows
	Air tightness
Mechanical	Heat recovery ventilation
	Commissioning
Lighting	Efficient light fixtures
	Natural lighting (daylighting)
Resilience	Water conservation
	Extreme weather resilience

These Case Studies are Paving the Way



→ Follow the lead of the case study buildings, learn from their success

→ We are well-positioned to achieve energy-efficiency in the built environment

Future Work - Extrapolation

→ Use the case study analysis, extrapolate to entire PNWER

- → New construction rates from regional surveys
- → Retrofits will 'piggy-back' on regular renewal schedule

→ Projections for:

- → Jobs, economic benefits
- → Energy use reduction
- → Greenhouse gas emission reduction

→ Detailed analysis and extrapolation for some regions

- → Depends on funding partners, sponsorship

Questions

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