



# ***Roadmap to Resilient, Ultra-Low Energy Buildings in the Pacific Northwest***

2017 PNWER Annual Summit

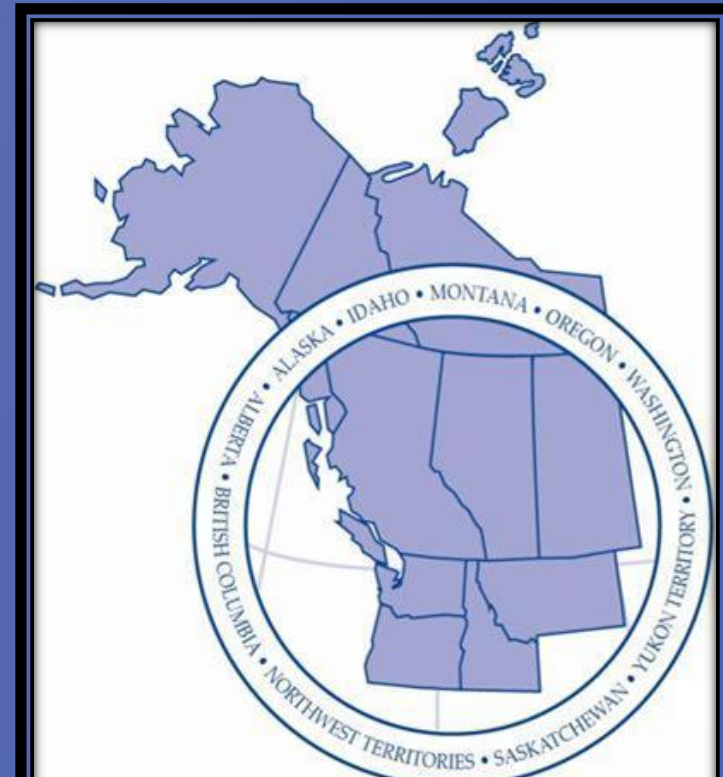
Portland Oregon

July 24<sup>th</sup>, 2017

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# Overview

- Value Proposition
- Roadmap to Resilient, Ultra-Low Energy Buildings
- Case Studies
- PNWER-wide Benefits Assessment
- Future Work





# Value Proposition

# Benefits from Addressing Energy in Buildings

- Investment and Jobs
- Improved affordability
- Reduced carbon emissions
- Improved occupant healthfulness and comfort
- Improved building durability and resilience



# Investment and Jobs

→ Pacific Coast Collaborative – West Coast Clean Economy Report

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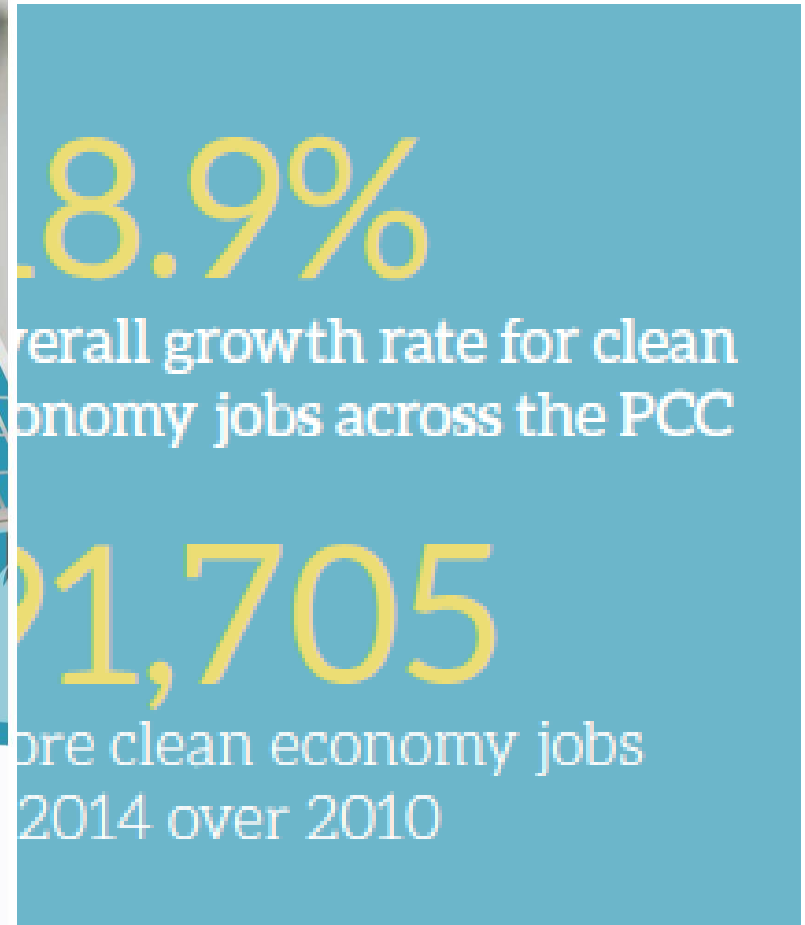
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# Investment and Jobs – Oregon

→ 11% overall growth from 2010 to 2014

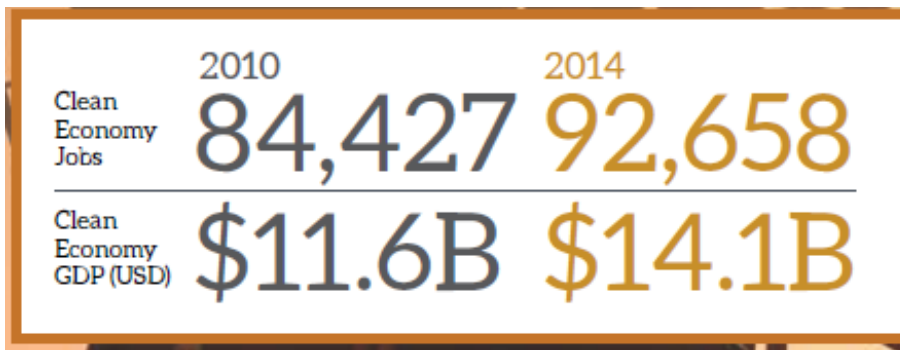
	2010	2014
Clean Economy Jobs	43,519	48,321
Clean Economy GDP (USD)	\$5.6B	\$7.0B

## Top 10 Segments

Public Sector (Federal, State, Local)	8,007
Green Architecture & Construction Services	6,601
Public Mass Transit & Rail	5,932
Sustainable Forestry Products	4,518
Recycling & Reuse	3,224
Hydropower	2,388
Organic Food & Sustainable Farming	2,301
Waste Management & Treatment	1,999
Solar Photovoltaic	1,761
Education & Training	1,381

# Investment and Jobs – Washington State

→ 10% overall growth from 2010 to 2014

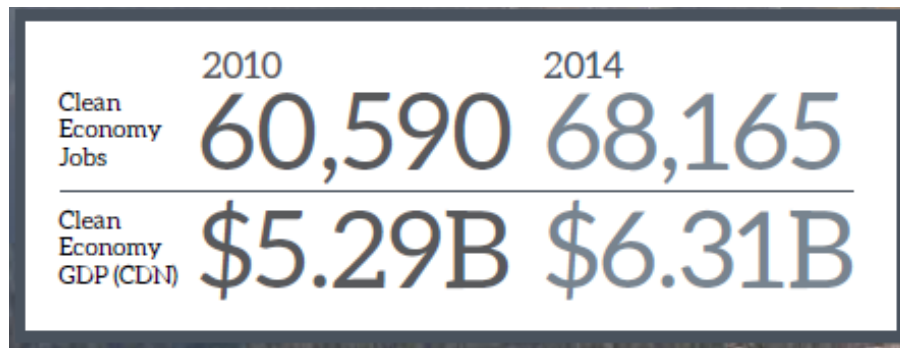


## Top 10 Segments

Public Mass Transit & Rail	14,511
Green Architecture & Construction Services	13,683
Organic Food & Sustainable Farming	10,245
Public Sector (Federal, State, Local)	8,414
Hydropower	6,789
Recycling & Reuse	6,123
Remediation	5,673
Waste Management & Treatment	4,631
Sustainable Forestry Products	3,482
Professional Energy Services	2,929

# Investment and Jobs – British Columbia

→ 13% overall growth from 2010 to 2014

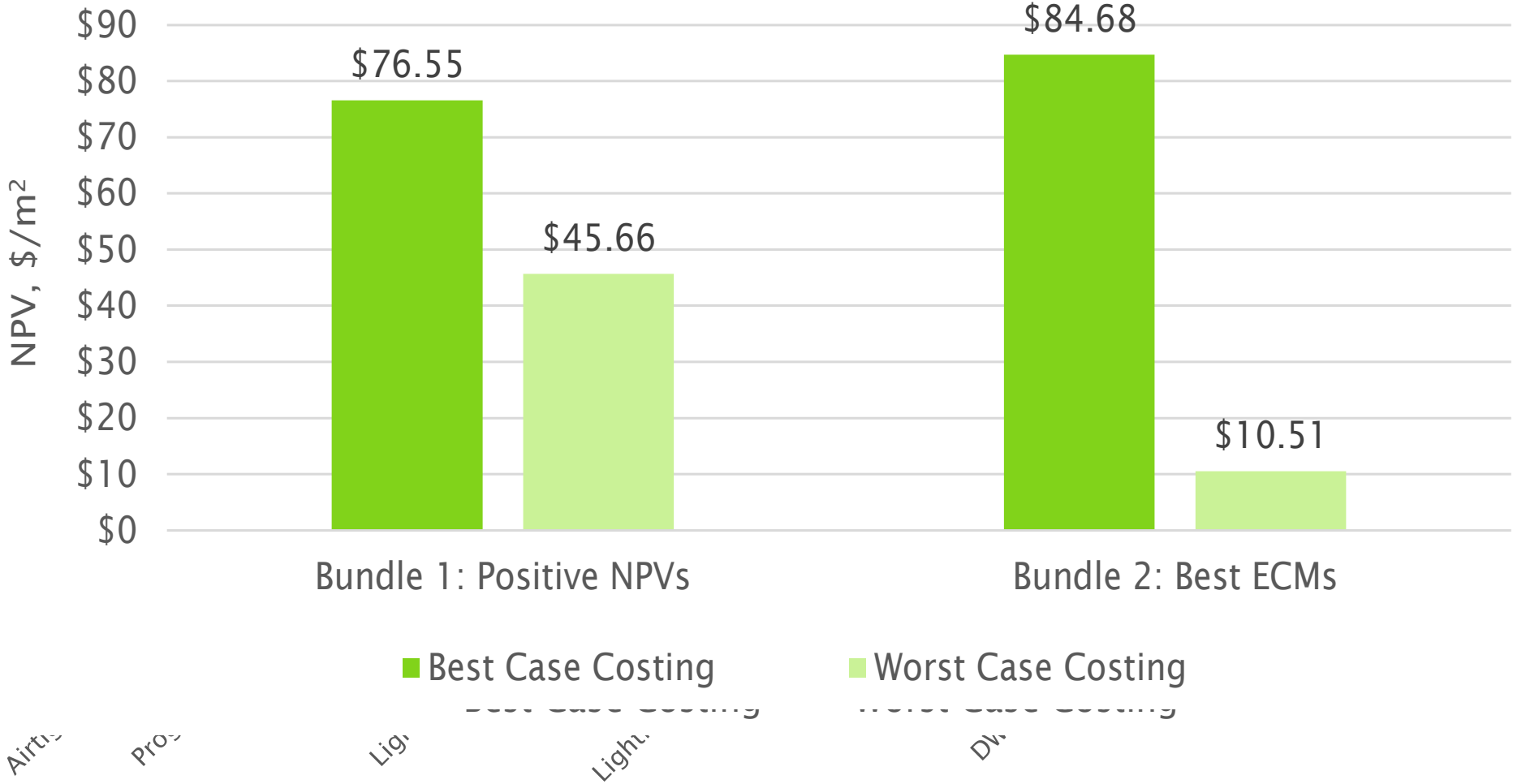


## Top 10 Segments

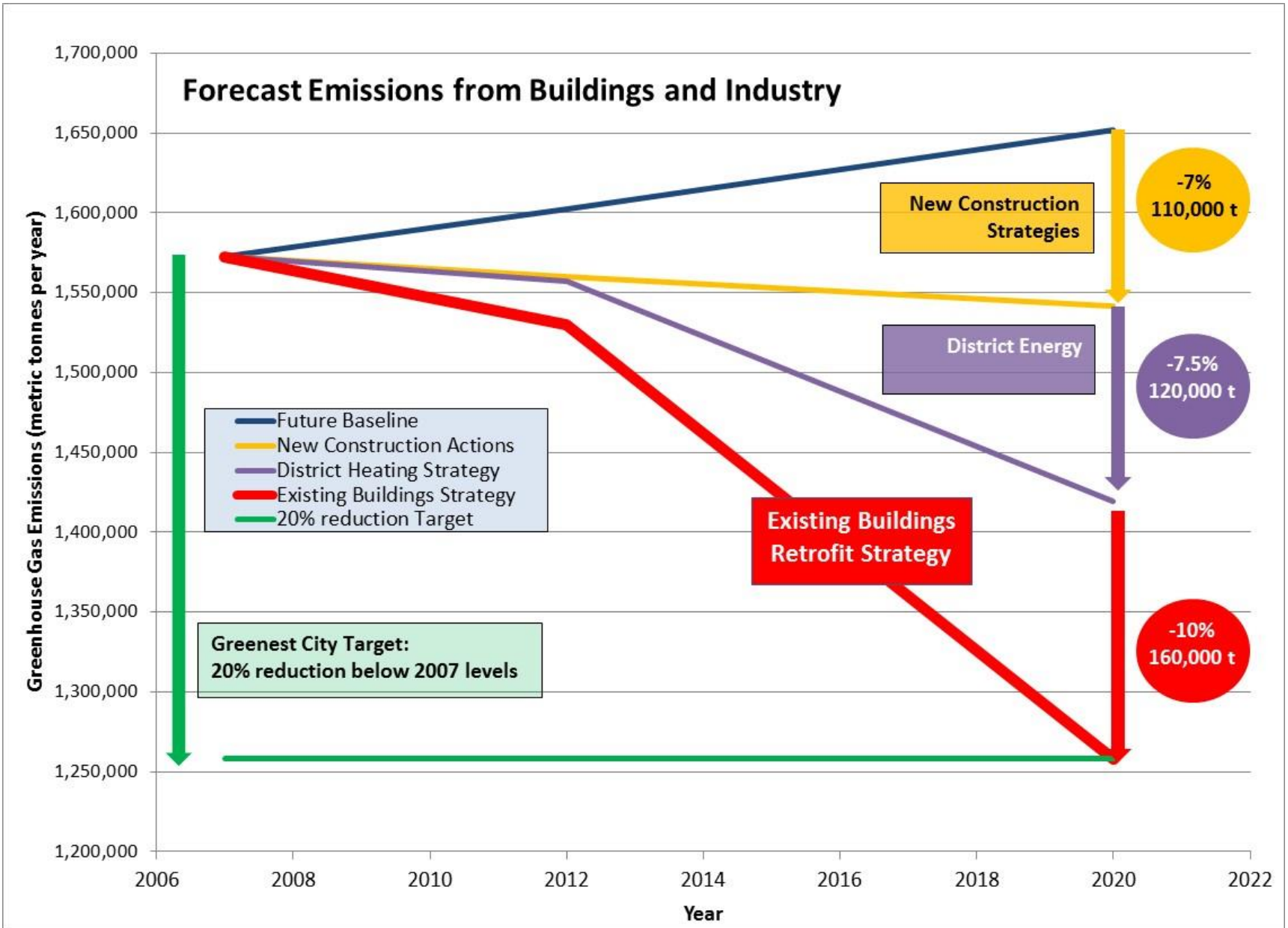
Public Mass Transit & Rail	12,246
Green Architecture & Construction Services	11,698
Hydropower	8,821
Sustainable Forestry Products	6,166
Recycling & Reuse	3,660
Education & Training	3,645
Waste Management & Treatment	3,259
Public Sector (Federal, Provincial, Local)	2,827
Smart Grid	2,518
Professional Energy Services	2,308



# Improved Affordability

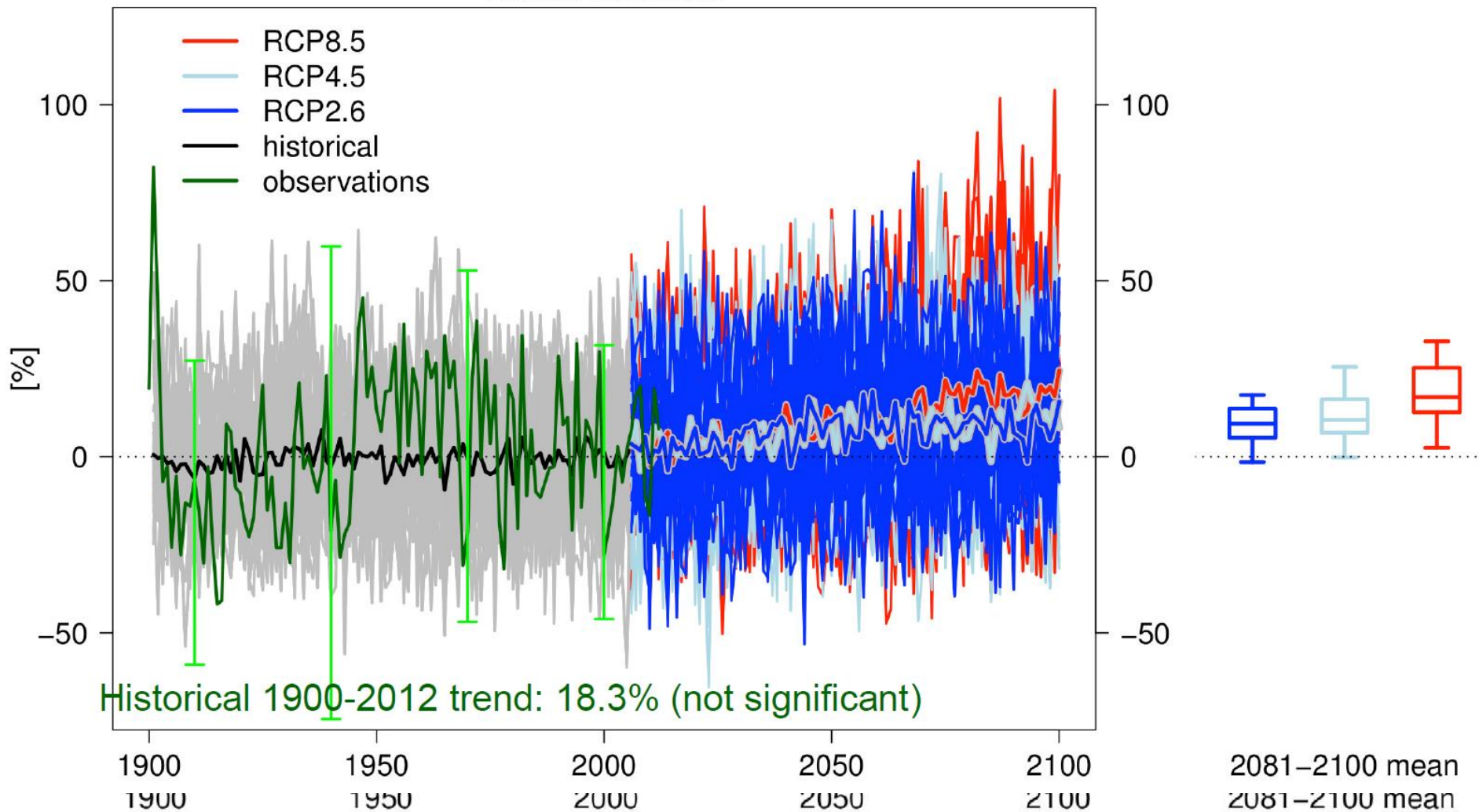


# Reduced Greenhouse Gases



# Winter (DJF) Precipitation

Precipitation change relative to 1986-2005





# Roadmap Background

# 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 inform energy-efficiency legislation to achieve the desired benefits and specific targets for the year 2030
- **Provides:**
  - › Market data and analysis
  - › Policy best practices
  - › Metrics, targets, timelines
  - › Market-driven solutions
- **Includes case studies** of new and retrofitted buildings that demonstrate best practices throughout the PNWER

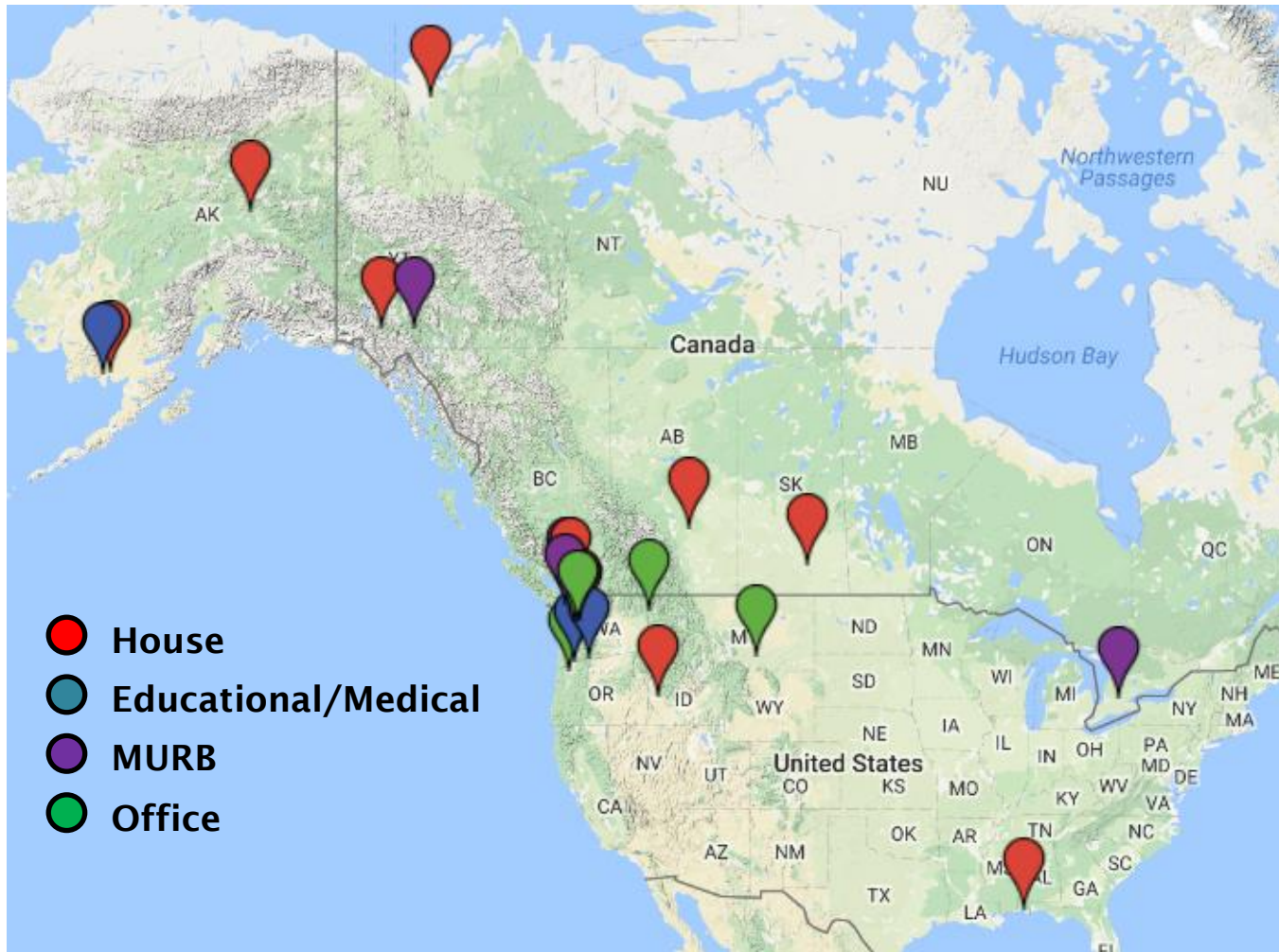
# Roadmap Progress

Task	Status
Policy review	Complete – PNWER 2013 Summit
Roadmap Launch and Terms of Reference	Complete – PNWER Summit and Economic Leadership Forum 2014
Case study analysis of energy savings and financial benefit	Complete – PNWER Summit and Economic Leadership Forum 2016
Extrapolation of energy savings and emission reductions	In progress – scoping at PNWER Summit 2017, results at Forum



# Case Studies

# Case Studies – 22 and counting....



**Average energy savings:**

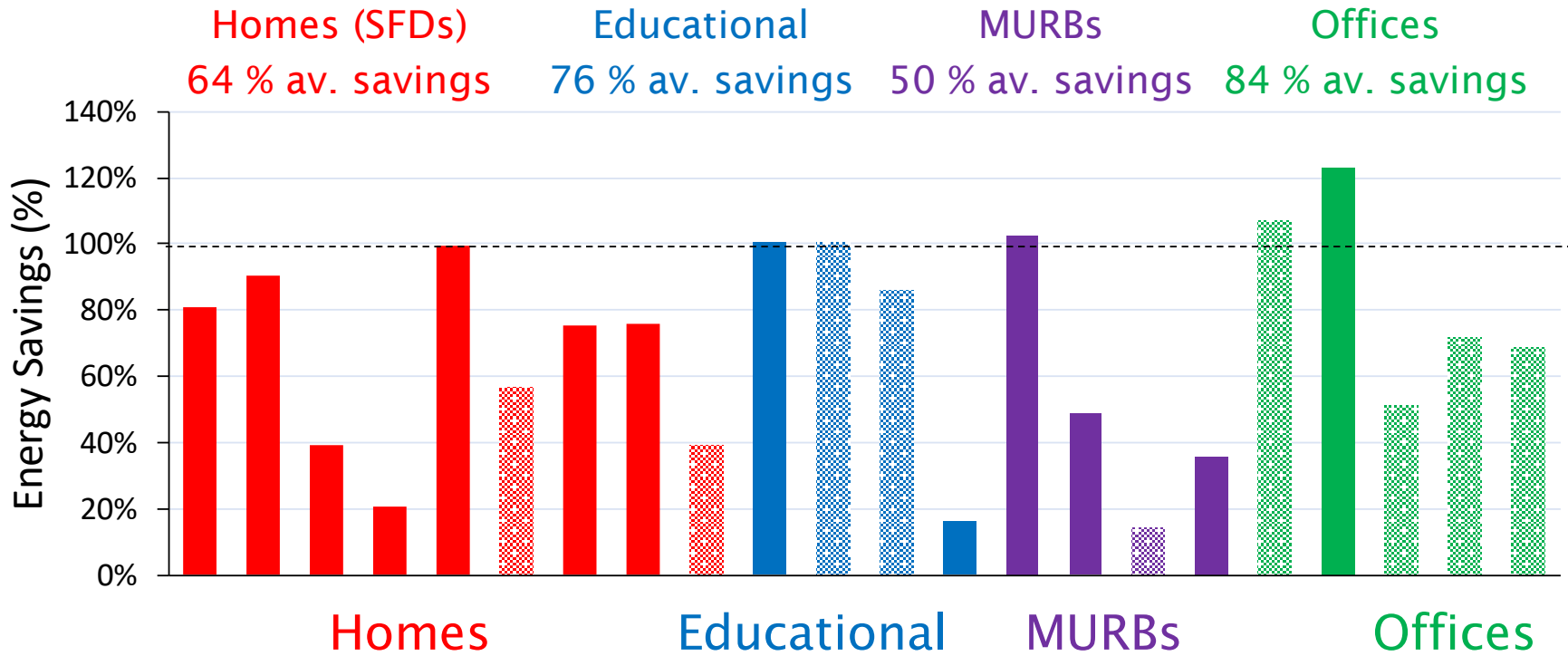
Houses -**64 %**  
Educational -**76 %**  
MURBs -**50 %**  
Offices -**84 %**



**Average GHG emission reductions across all buildings:**

**-70% CO<sub>2</sub>-equiv**



# Energy Savings of Case Studies



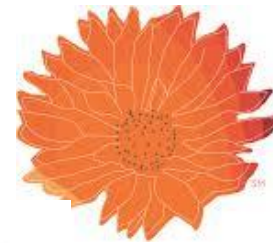
-  - Retrofit
-  - New Construction

# Oregon Case Study 1: 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



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# Case Study 1: Hood River Middle School

<b>Strategy</b>	Fuse sustainable design with teaching curriculum
<b>HVAC</b>	Ground source heat pump and radiant floors PV preheats winter air, river water cooling in summer
<b>Walls</b>	Insulated concrete forms (ICF)
<b>Windows</b>	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 Study 2: Collaborative Life Sciences Building, OHSU

- **Jurisdiction:** Oregon
- **Building Type:** Research/Health
- **Construction Type:** New
- **Original construction:** 2014
- **Site description:** OHSU Schnitzer Campus. Brownfield development site.
- **Ratings:** LEED Platinum



Image source: <http://lopressroom.com/viracon/aia-topten-2015>



## Case Example 2: Collaborative Life Sciences Building, OHSU

<b>HVAC</b>	Hydronic/radiant heating systems. Atrium and lab exhaust heat recovery. Energy efficient condensing boilers. Heat recovery chillers.
<b>Roof</b>	Three green roofs installed on areas of building
<b>Lighting</b>	Seasonal solar paths were analyzed to ensure design for optimal day lighting and solar shading



<http://www.ohsu.edu/news/clsb/>

- Potable water needs were reduced 60% through rainwater harvesting (90,000 gallon cistern) and greywater re-use in toilets
- >3 tons (85%) of construction waste diverted from the landfill



# **Region-wide Benefits Assessment**

# Region-wide Impact Assessment



- Forecast benefits and costs of implementing archetypes across the entire PNWER region by 2030
- *Benefits include:* Energy savings, GHG emission reductions, associated cost savings, resiliency, investment and job creation.
- Extrapolation of case study impacts in line with:
  - Current and future building stock and floor space by jurisdiction
  - Consideration of regional climates and energy mix by jurisdiction

# Example: BC Paper on Standards for Existing Buildings

		OPTION 1	OPTION 1B	OPTION 2
Cumulative Annual Electricity Savings	in 2025	2,800 GWh/yr (9,554,000 Mbtu/yr)	2,900 GWh/yr (9,895,000 Mbtu/yr)	3,000 GWh/yr (10,236,000 Mbtu/yr)
	in 2030	6,400 GWh/yr (21,380,000 Mbtu/yr)	7,100 GWh/yr (24,226,000 Mbtu/yr)	7,400 GWh/yr (5,250,000 Mbtu/yr)
Cumulative Annual Natural Gas Savings	in 2025	77 GWh/yr (263,000Mbtu/yr)	215 GWh/yr (734,000 Mbtu/yr)	470 GWh/yr (1,604,000 Mbtu/yr)
	in 2030	270 GWh/yr (921,000 Mbtu/yr)	880 GWh/yr (3,003,000 Mbtu/yr)	2,200 GWh/yr (7,507,000 Mbtu/yr)
Cumulative Annual GHG Savings	in 2025	0.04 Mt/yr	0.06 Mt/yr	0.11 Mt/yr
	in 2030	0.11 Mt/yr	0.20 Mt/yr	0.47 Mt/yr
Discounted Cumulative ICC (2017 \$)	in 2025	\$405 million	\$405 million	\$483 million
	in 2030	\$560 million	\$560 million	\$764 million
Discounted Cumulative NPV (2017 \$)	in 2025	\$123 million	\$138 million	\$234 million
	in 2030	\$175 million	\$205 million	\$439 million



## Extrapolation Methodology

- Estimate the annual floor area for each building type
- Estimate the annual energy savings from case study results
- Extrapolate energy savings by constructing and retrofitting buildings to the performance levels of the PNWER case studies rather than common practices
- Estimate associated GHG savings through jurisdiction specific and region wide emissions factors
- The annual savings will be extrapolated over the 30-yr time horizon with staged implementation to estimate cumulative annual savings in key years

## Building Area

→ Building Retrofit Area = Total Area x Retrofit Rate

→ Building New Area = Total Area x New Build Rate

→ Existing Building Area (millions ft<sup>2</sup>)

Jurisdiction	SFH	Lowrise	Highrise	Educational	Office
AK	348	16	37	15	26
ID	772	35	83	52	51
OR	1875	84	201	81	141
MT	483	22	52	32	32
WA	3334	150	357	143	251
BC	2886	312	132	117	207
AB	2751	218	117	104	184
SK	654	50	32	28	50
YK	25	2	1	1	2
NWT	29	2	1	1	2

→ Source: 2011 SHEU, 2009 SCIEU, 2009 RECS, 2012 CBECS and population weighting for inter-region jurisdiction interpolation

## Building Area

→ Building Retrofit Area = Total Area x Retrofit Rate

→ Building New Area = Total Area x New Build Rate

→ Retrofit and Construction Rates

Type	Retrofit Rate	New Build Rate
SFH	1.0%	1.8%
Other	2.0%	1.3%

→ Retrofit Source: Building Energy Retrofit Potential in B.C. Pembina Institute, 2016., Olgay and Seruto, 2010. "Whole-Building Retrofits: A Gateway to Climate Stabilization", ASHRAE Transactions vol 116, part 2, 2010.

→ New Build Source: Extrapolation of 2012 SHEU and 2012 CBECS

# Annual Energy Savings

→ Savings = Baseline x % Savings from Case studies

→ Estimated Savings from Case Studies

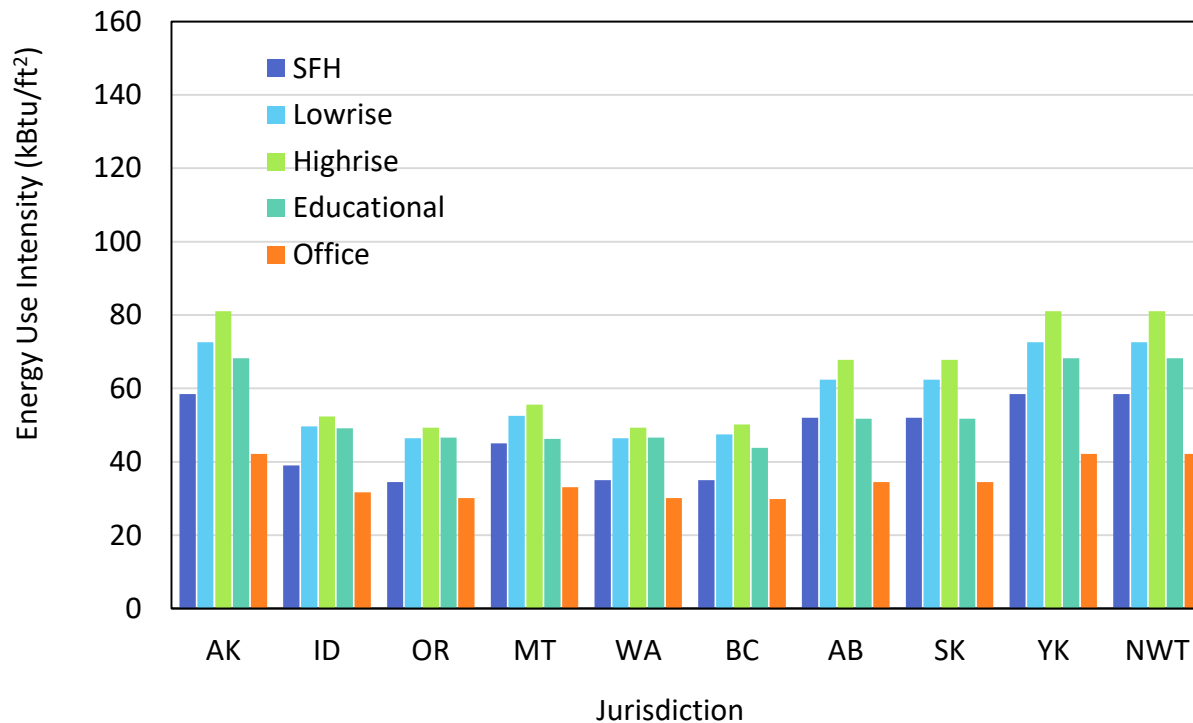
Type	Retrofit Savings	New Build Savings
SFH	50%	70%
Low-Rise	20%	60%
High-Rise	20%	60%
Educational	80%	60%
Office	65%	70%

→ Note: the retrofit and new construction are relative to different baseline energy use

# Annual Energy Savings

→ Savings = Baseline x % Savings from Case studies

→ New Building Baseline, kbtu/ft<sup>2</sup>



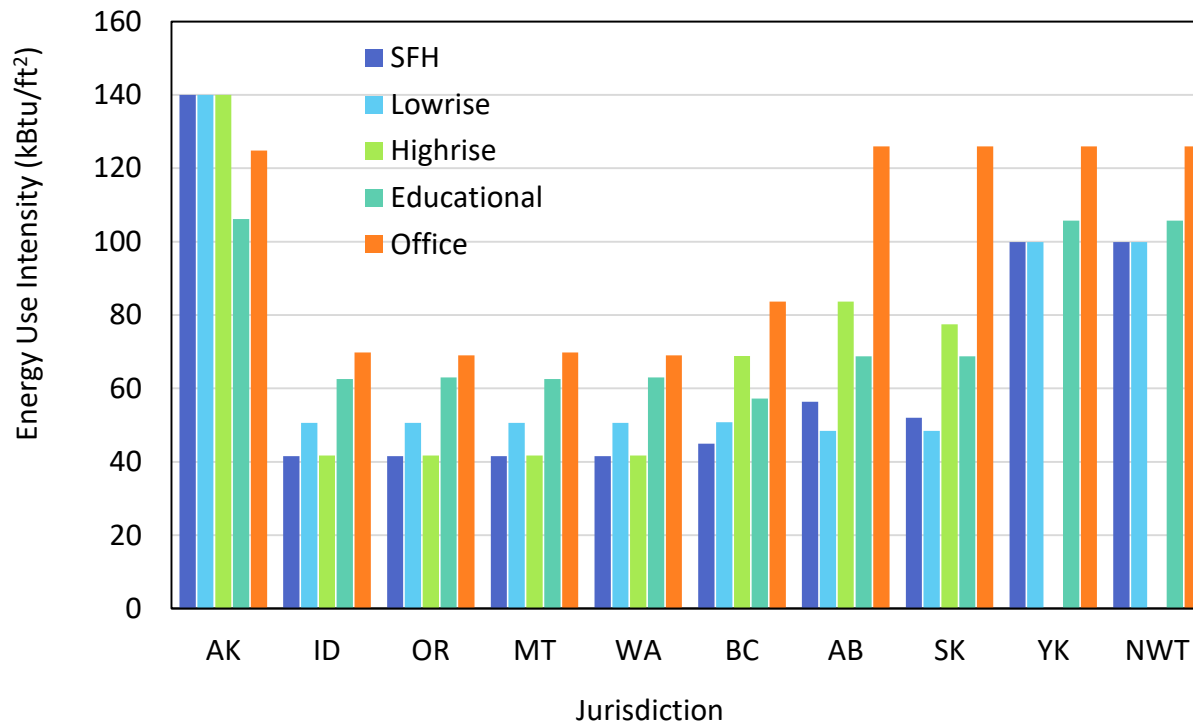
→ Data Source: PNNL Commercial and Residential Prototype Building Modeling results for ASHRAE 90.1-2013 and IRC 2012

→ Canadian data from representative US cities

# Annual Energy Savings

→ Savings = Baseline x % Savings from Case studies

→ Retrofit Building Baseline (Existing Buildings), kbtu/ft<sup>2</sup>



→ Data Source: 2011 SHEU, 2009 SCIEU, 2009 RECS, 2012 CBECS

# Emissions Reduction

→ Savings = Energy Savings x Emissions Factors

→ Jurisdiction Specific Emissions Factors, kg CO<sub>2</sub>e per kWh

Jurisdiction	Electricity	Natural Gas
AK	0.50	0.18
ID	0.05	0.18
OR	0.12	0.18
MT	0.59	0.18
WA	0.06	0.18
BC	0.01	0.18
AB	0.64	0.18
SK	0.71	0.18
YK	0.04	0.18
NWT	0.04	0.18

→ Potential to use regional emissions factor based on Western Electricity Coordinating Council factors (WECC)

## Future Work



- New Case Studies
- PNWER-wide projections for:
  - Energy use reduction
  - Greenhouse gas emission reduction
- Economic assessment
  - Energy savings, net benefit to society
  - Investment, jobs, economic diversification
- Jurisdiction specific analysis and extrapolation
  - Depends on partners, sponsorships
- Analysis of policy options and market-driven solutions
- White Paper



# Conclusions

- Ultra-low energy new construction and deep energy retrofits have been demonstrated throughout PNWER
- Energy savings can improve affordability for citizens, businesses and institutions
- Value proposition also includes jobs, GHG reductions, improved resilience
- Proposed “Roadmap” could be used to guide PNWER jurisdictions to achieve those objectives, while providing flexibility for policy approaches
- Partnership underway through PNWER Energy and Environment Working Group to complete research and prepare a White Paper

# Discussion

- Value Proposition
- Roadmap to Resilient, Ultra-Low Energy Buildings
- Case Studies
- PNWER-wide Benefits Assessment
- Future Work

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