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October 28, 2014

### MEMORANDUM

**TO: Power Committee**

**FROM: Charlie Grist and Massoud Jourabchi**

**SUBJECT: Seventh Plan Analysis Approach for Rooftop Solar Photovoltaic**

### BACKGROUND:

**Presenter:** Charlie Grist and Massoud Jourabchi

**Summary:** Staff will present the analytical approach for considering consumer-side solar photovoltaic (PV) energy resources in the Seventh Power Plan. A short summary of solar PV trends will be discussed. Initial findings will be presented.

Consumer-side solar PV includes rooftop installations on homes and businesses and other relatively small scale installations. Utility-scale solar photovoltaic resources will be addressed in a separate presentation.

The Seventh Plan analytical approach includes the following:

- Estimate system costs
- Forecast cost changes
- Forecast consumer adoption rates under business as usual assumptions
- Incorporate consumer adoption rates into load forecast
- Identify remaining potential as options for resource development
- Vet analysis with advisory committees

The world market for solar PV has expanded significantly since the Six Power Plan was developed in 2009, with installation capacity up 600 percent. However, in most countries the PV market is still largely driven by policy mandates rather than economics. US markets show growth patterns

similar to world markets but are at relatively low adoption rates. Adoption rates in the Pacific Northwest are far behind rates in California, Florida, and Arizona the leading states. Within the Northwest, Oregon has the most installations by far.

PV panel costs have fallen over 40 percent since 2009. Staff's initial estimate of the levelized cost of solar PV energy is \$200 to \$300 per MWh at today's costs, well above the cost of many other resources. Costs are forecast to fall to the \$100 to \$200 per MWh range by 2025. Staff's preliminary estimates of the regional resource potential of consumer-side solar PV range from 1000 to 4000 aMW.

Despite high costs, consumers have been adopting solar PV in small quantities. Estimated cumulative regional installations over the last ten years total about 80 MW of capacity. These installations produce approximately 9 aMW of energy. Staff is developing a model to forecast adoption rates based on historical PV adoption trends, forecast retail power rates and PV costs. This forecast will address energy and peak impacts of solar PV. Consumer-side solar PV potential not adopted and incorporated into the load forecast will be incorporated into the conservation supply curves.

The advisory committees will review staff's analysis plan and initial analysis this fall. The Demand Forecasting, Conservation Resources and Generating Resources advisory committees will take up the issue in November.

Relevance: Seventh Plan Development

Workplan: 1D. Prepare for Seventh Power Plan and Maintain Analytical Capability

Background: Six Plan costs estimates for residential consumer PV were well above \$200 per MWh.

# Rooftop Solar Photovoltaic Seventh Plan Approach to Analysis

**November 4, 2014**



# Outline

- **Approach for Seventh Plan**
- **Background**
- **Initial Findings**

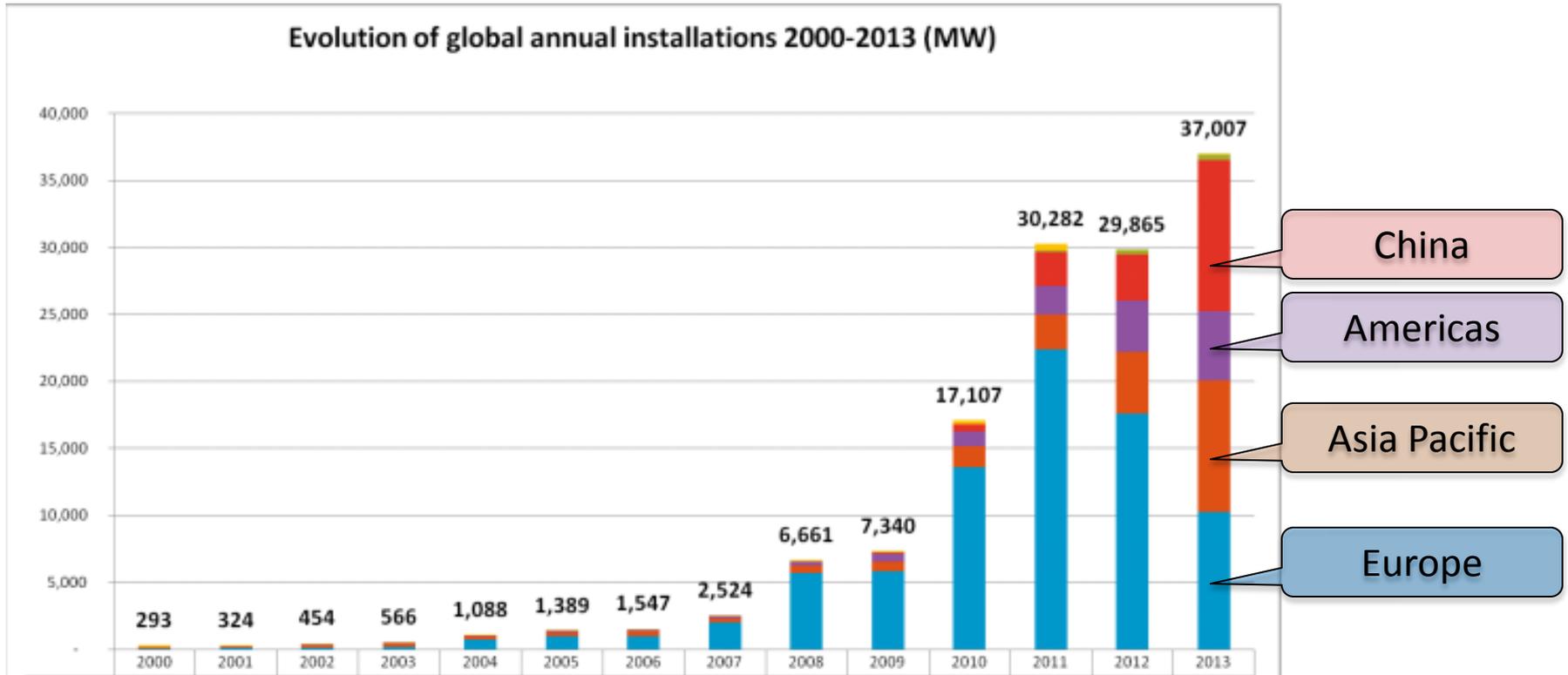
# Approach for Seventh Plan

- 1) Estimate Rooftop Solar PV System Cost
- 2) Forecast Changes in Cost & Performance
- 3) Forecast Status Quo Adoption Rate
- 4) Adoption of PV Reduces Load Forecast
- 5) Estimate Remaining Resource Potential
- 6) Remaining Potential Made Available to RPM
- 7) Vet Assumptions with Advisory Committees

# Background Solar PV

- **It's a global market**
- **Modest consumer uptake in PNW**
- **Recent uptick in PNW adoption**
- **Solar PV costs falling**
- **Other trends: Ownership & financing**

# A World Market

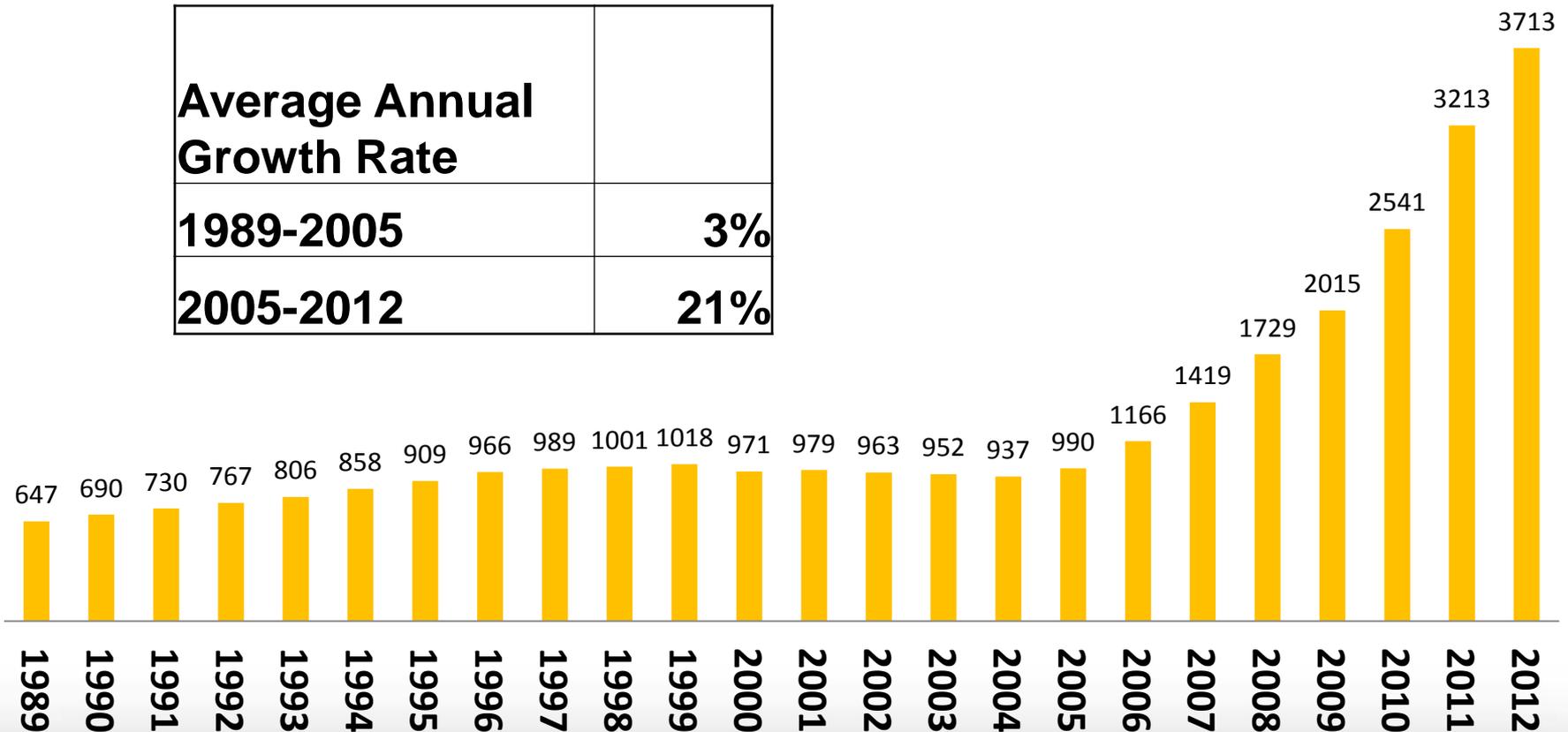


Source: European Photovoltaic Industry Association,  
Global Market Outlook 2014-2018

# PNW Regional Energy Production by Rooftop Solar (Trillion Btu)

Source EIA : State Energy Data System

<b>Average Annual Growth Rate</b>	
<b>1989-2005</b>	<b>3%</b>
<b>2005-2012</b>	<b>21%</b>



By 2012 over 10,000 Utility Customers Installed 66 MW  
of PV Capacity (MW)  
Selling back about 1 MWa of Power

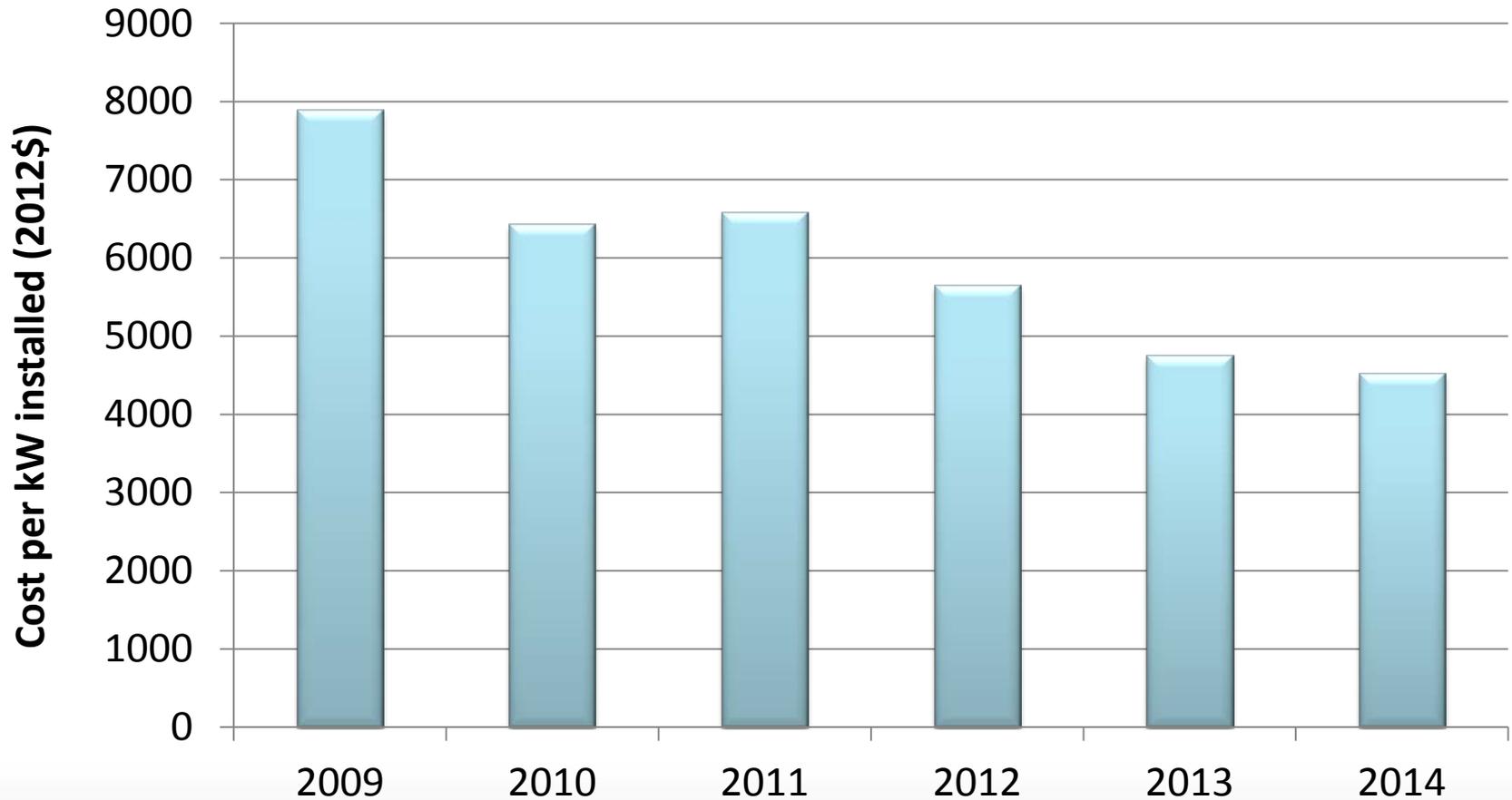
	<b>Net Metering Customer Count</b>	<b>Capacity Installed (MW)</b>	<b>MWh of Power Sold back to utility</b>
<b>Idaho</b>	349	2	2
<b>Montana</b>	1,010	4	122
<b>Oregon*</b>	6,269	43	8,687
<b>Washington</b>	3,222	17	932
<b>Region</b>	10,850	66	9,742

Source: EIA 861 annual Utility Net metering data

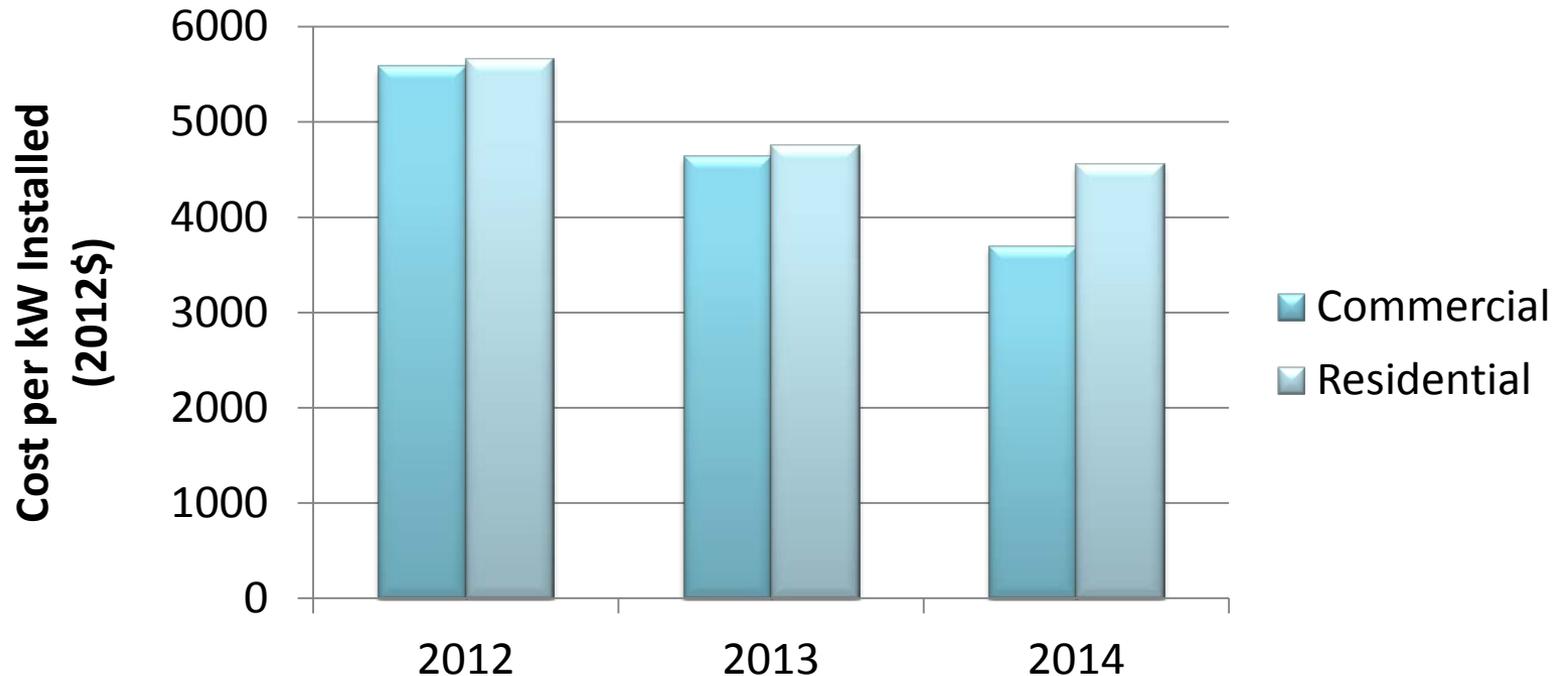
\*OPUC's reports that by 2013 about 8000 customers in Oregon are on net-metering.

# Installed Cost Falling

## Energy Trust of Oregon Program Data



# Commercial Costs Lower than Residential



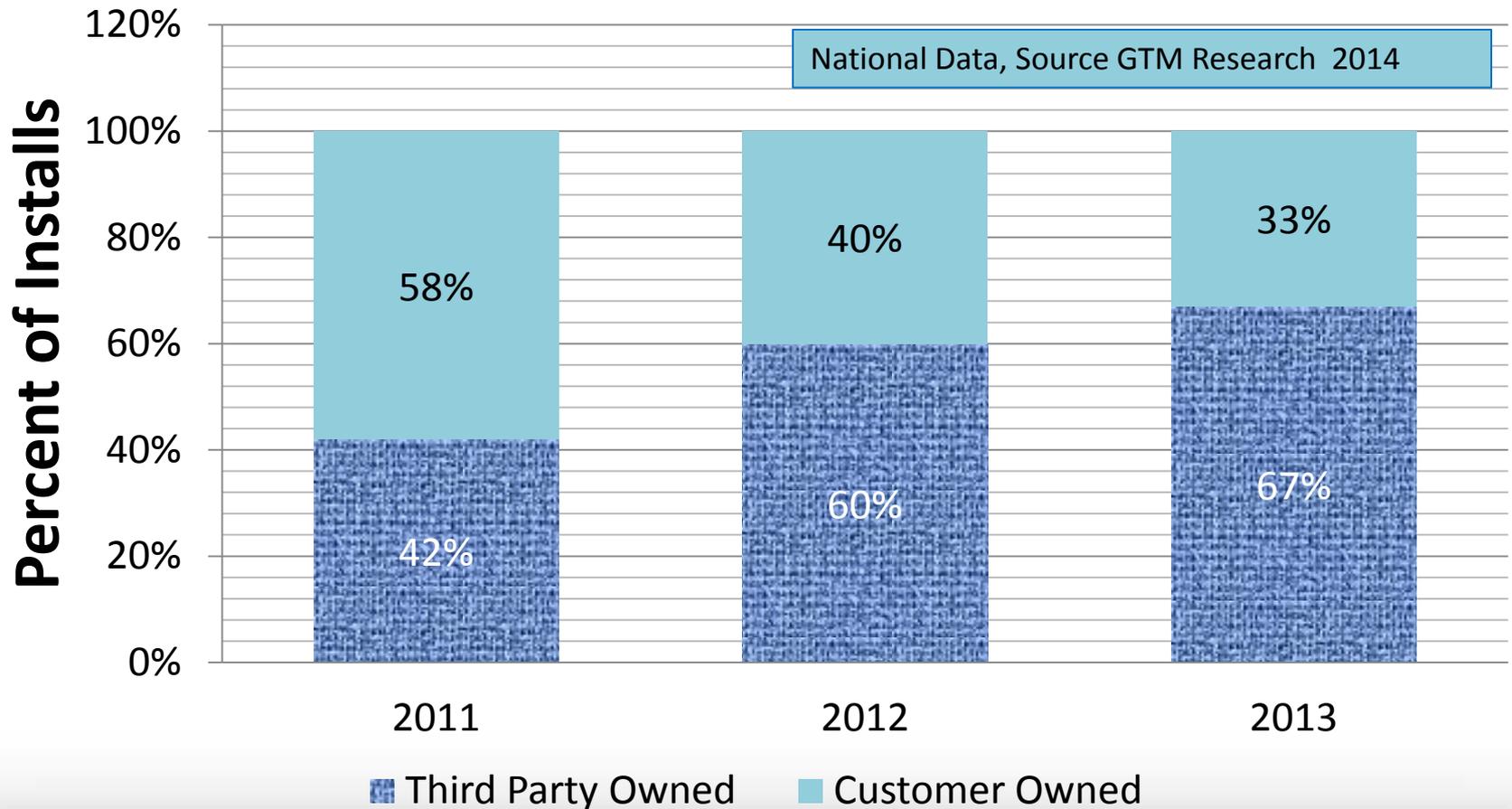
- Residential costs drop 20% since 2012
- Commercial costs drop by one-third since 2012

# Average Residential Size Going Up (Energy Trust of Oregon Data)

- **2012 = 4.2 kW**
- **2014 = 5.3 kW**



# Third-Party Leasing Overtakes Customer-Owned Residential Solar



# Emerging Ownership & Financing Options

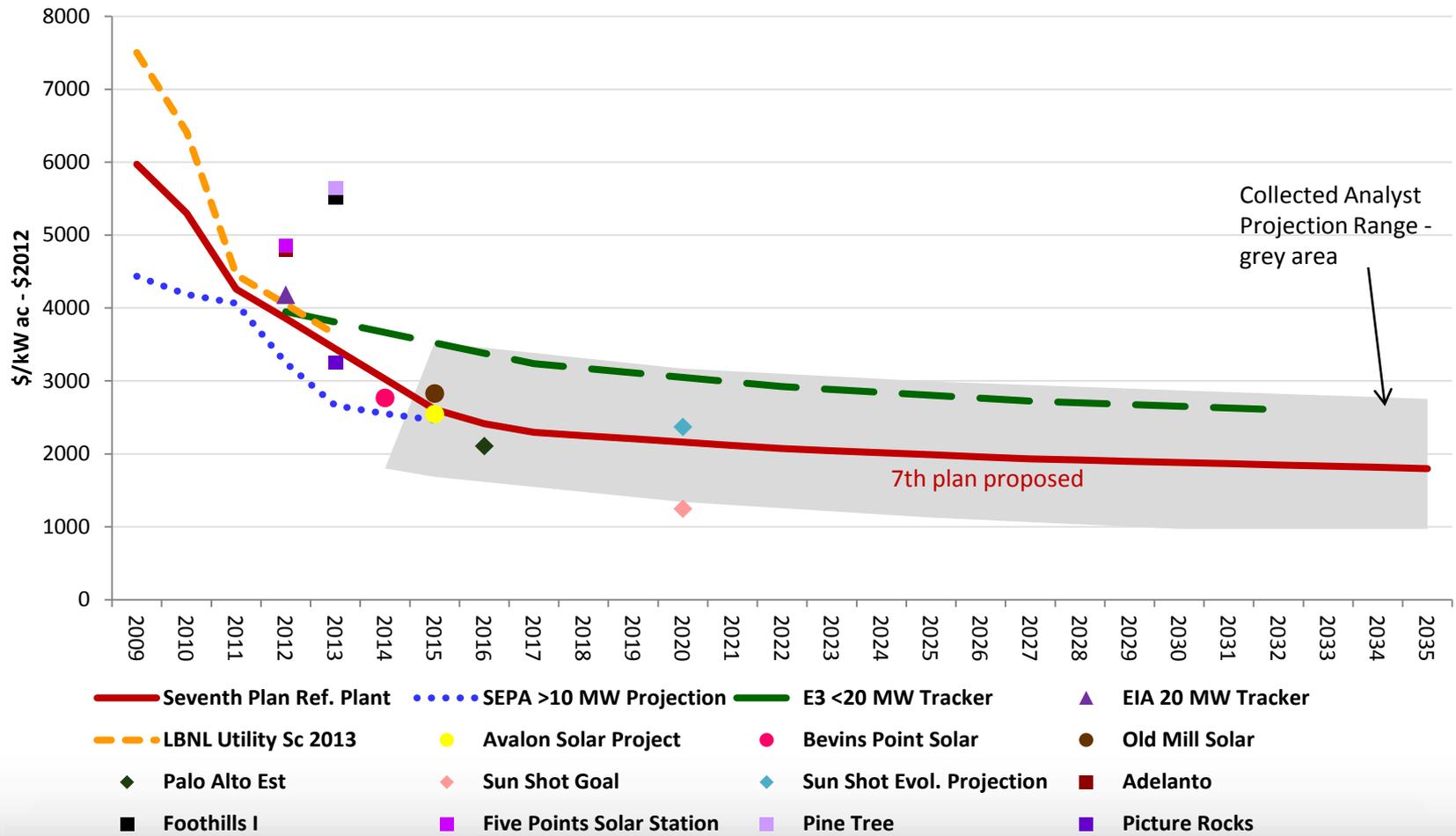
Consumer interest in solar PV has generated new approaches, financing & ownership arrangements

- Community Solar
- Special Purpose Entities
- Solar-Specific Banks
- Lease Options
- Utility-Sponsored Models
- Bulk Purchasing



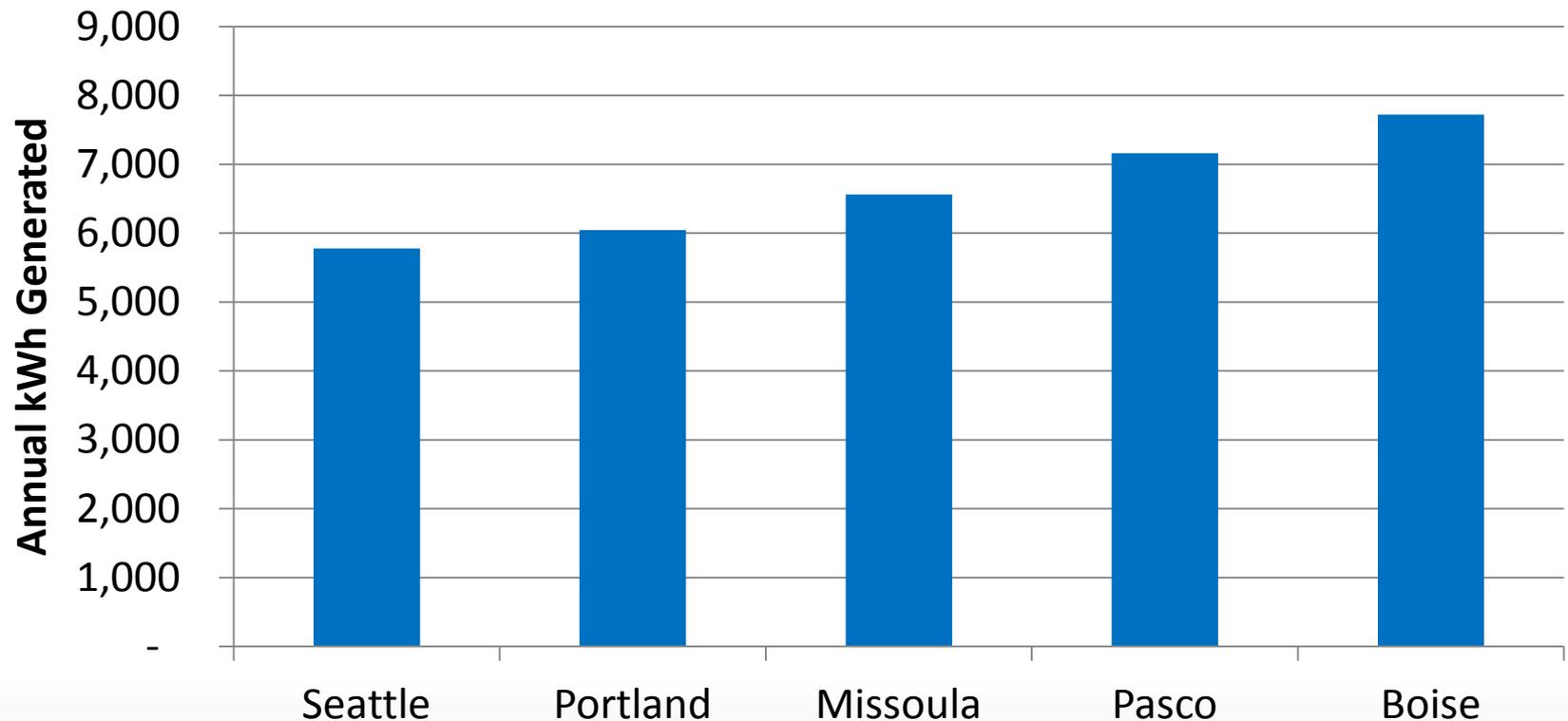
# Many Forecasts Indicate Cost Declines

## Utility Scale Solar PV Capital Cost Estimate - \$/kWac



# Location Matters: More Sun Means More Energy Produced

Annual kWh Generated for a 5.3 kW Residential System



# Cost of PV Energy

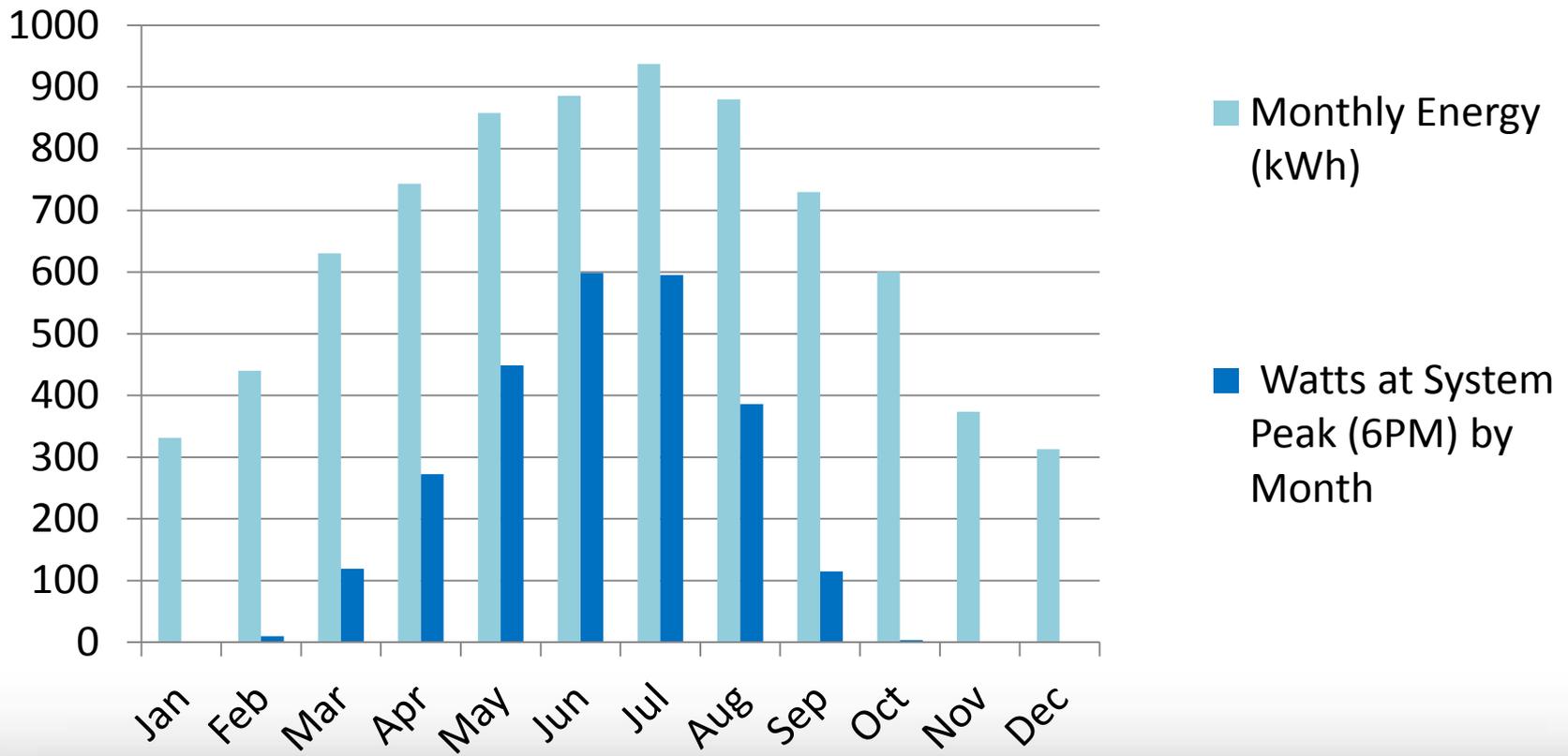
## Levelized Cost \$/MWh (2012\$)

	Cost in 2014	Cost in 2014 with Federal Tax Credit	Cost in 2024 without Federal Tax Credit
Boise (Residential)	\$204	\$151	\$144
Boise (Commercial)	\$165	\$121	\$115
Portland (Residential)	\$262	\$194	\$184
Portland (Commercial)	\$211	\$156	\$147

- Levelized Cost per MWh (2012\$)
- 25-Year Life
- 4% Discount Rate
- 5.3 kW System
- No Regional Act Credit
- Federal Tax Credit only to 2016
- O&M Cost & Inverter Replacement
- No Program Admin Costs

# NREL Solar Calculator Used to Shape Energy & Peak Impacts

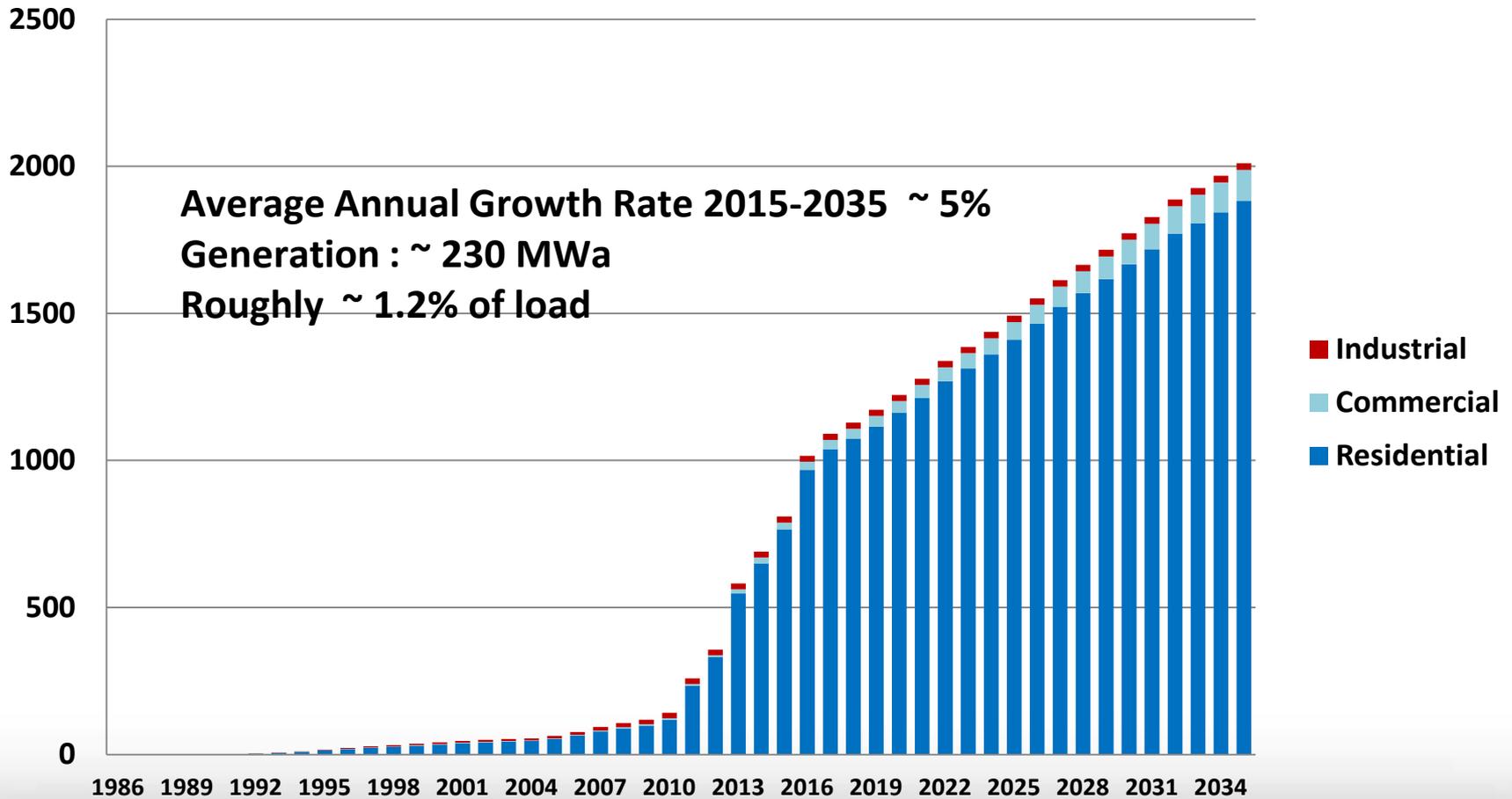
## Boise Energy & Peak Contribution



# Forecast Long-Term Adoption (Business as Usual Case)

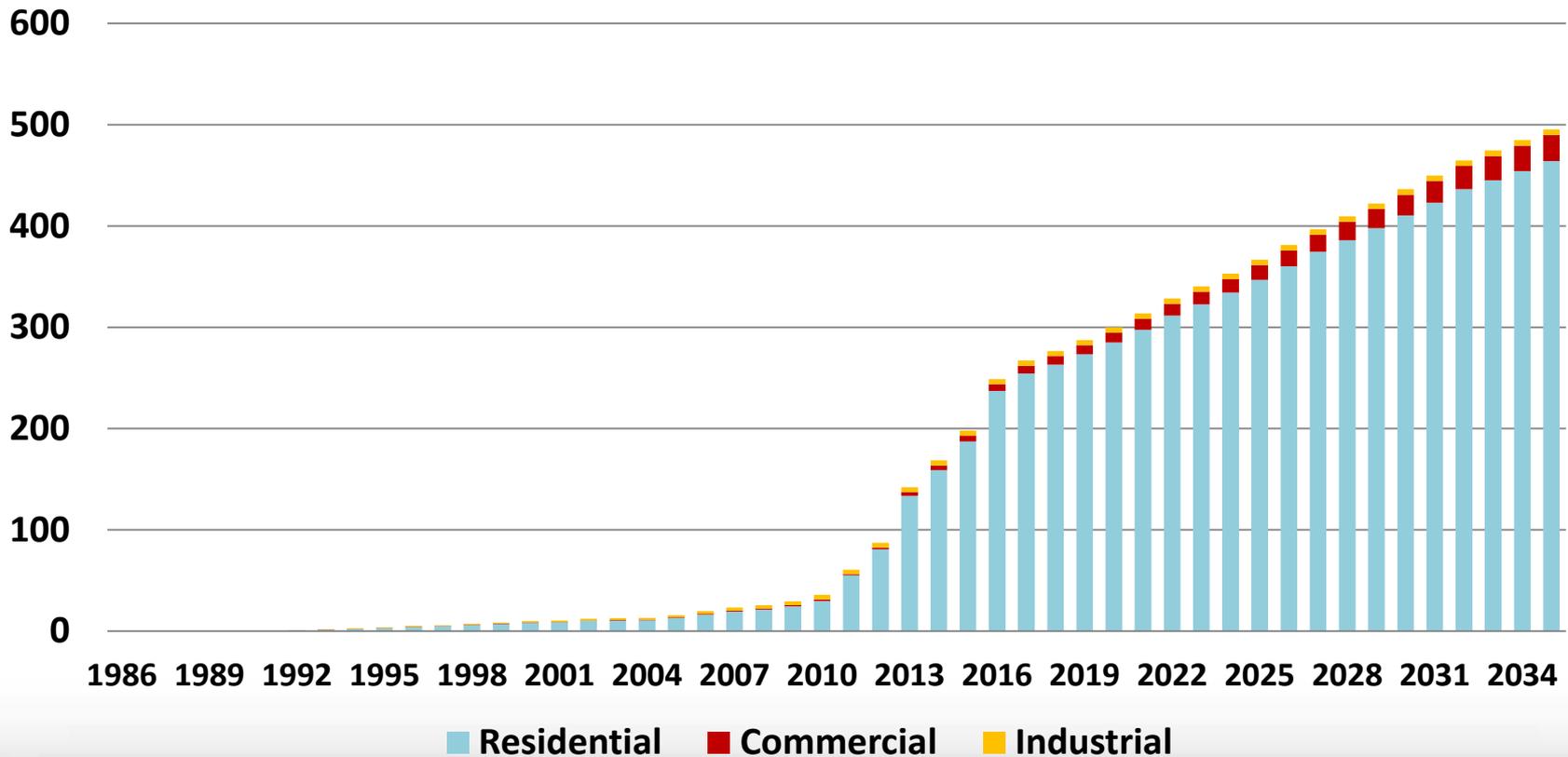
- Council's long-term load forecast model estimates consumer PV adoption rates
- Estimated for all sectors
  - Historical PV adoption trends (1985-2012)
  - Forecast retail power rates
  - Solar PV costs & performance
  - Both energy and peak impacts
- Forecast load reduced by forecast adoption of PV
  - Initial estimates: Consumer side-PV generation supplies 0.5-2.0% of regional electric load by 2035

# Preliminary -Projection of Roof-top Solar PV Generation (GWH)



# Preliminary- Roof-top Solar PV Generation Coincident with July System Peak

MW of July Peak Reduction

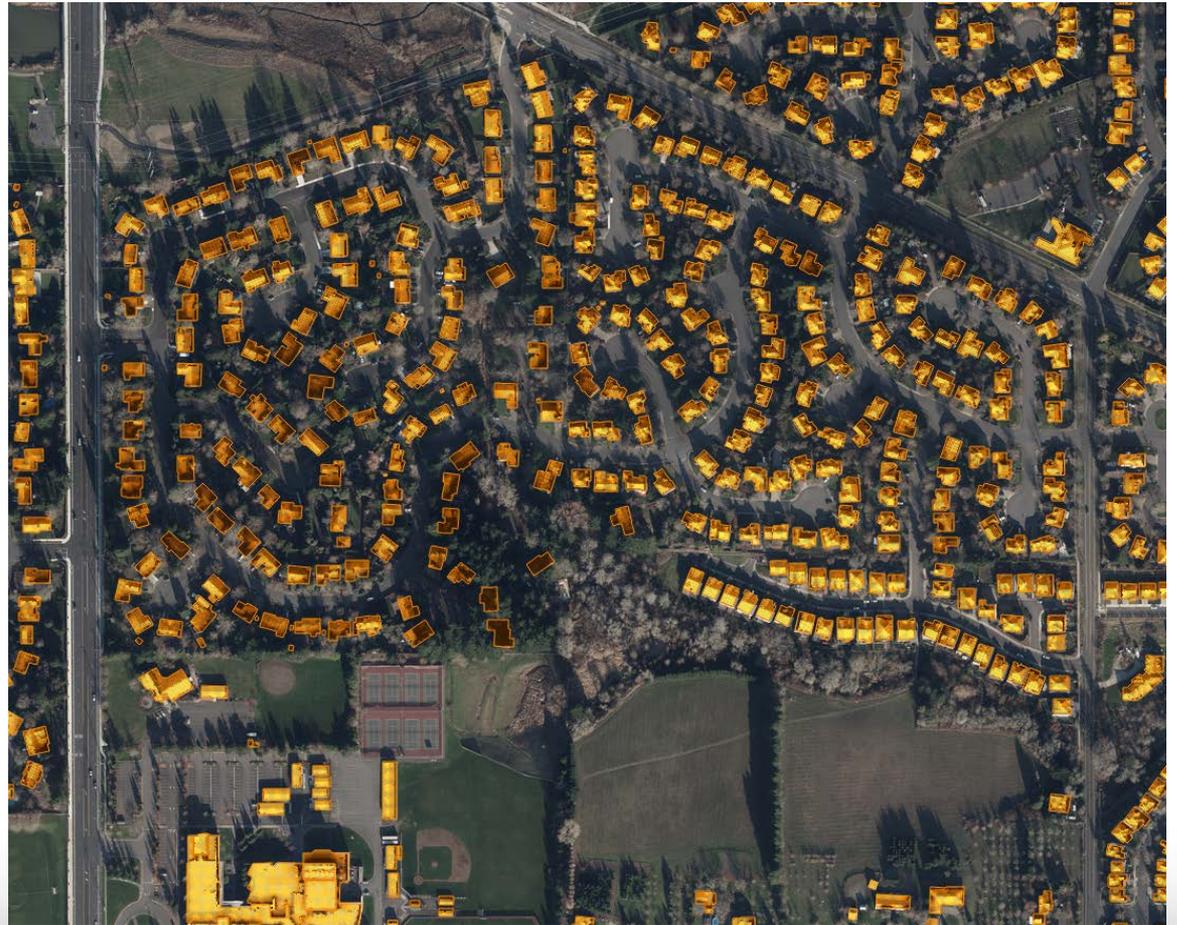


# Solar PV Not Adopted in Forecast Model Remains As Resource Option

- **Estimate Remaining Resource Potential**
  - Number of homes & businesses
  - Average capacity per home or business
  - Adjust for orientation & shading
  - Minus forecast adoption in load forecast
- **Cost per MWh Based on Forecast Cost**
- **Add to Supply Curves of Resource Potential**

# Estimating Potential Applications

- Most homes have some solar access
- Panels do not have to be on buildings



# Summary:

## Approach for Seventh Plan

- 1) Estimate Roof top Solar PV System Cost
  - Use recent cost data from Energy Trust of Oregon
  - By solar zone, residential & commercial applications
- 2) Forecast Changes in Cost & Performance
  - Use same cost curve decline as utility scale
  - Apply to rooftop prices
- 3) Forecast Long-term Adoption Rate of Rooftop Solar
  - Long-term forecast model based on historical adoption
  - Business as usual case
- 4) Estimate Remaining Resource Potential
  - Number of homes & businesses
  - Fraction applicable (adjust for orientation & shading)
  - Minus forecast market uptake
- 5) Add to supply curves by year for RPM

# End

# Extra Slides

# Typical Installed Cost

- Residential: \$20,000 - \$25,000 (4-5 kW)
- Commercial: \$50,000-\$200,000 (10-40 kW)
- Largest: \$22 million (5.7 MW)

- Incentives typically cut consumer costs in half
- Third-Party leased projects at no initial customer cost
- Provide 40-50% of residential electric needs



# What's Happening in Programs?

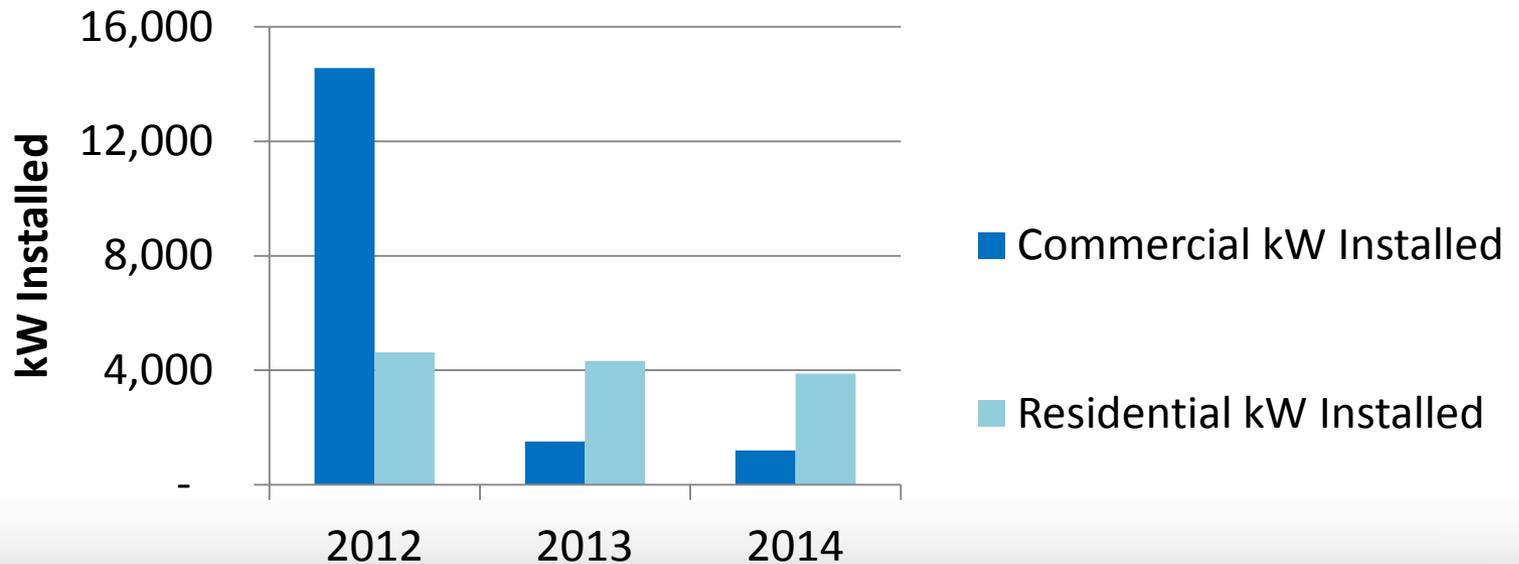
## Energy Trust of Oregon Program 2012-2014

- **ETO Incentives for Residential**
  - PGE: \$0.95/Watt, up to \$9500
  - PacifiCorp: 0.70/Watt, up to \$7000
  - Cash or Loan, or
  - Third-Party Leasing, fixed-term lease payment
- **Plus State Tax Credit**
  - Up to \$6000 per residence
- **Plus Federal Tax Credit**
  - 30% of cost through 2016



# Energy Trust Oregon 2012-2014 Total Installed Capacity 30 MW

- Residential: About 4 MW per year
- Commercial: About 1-2 MW per year
- Utility Scale: Occasional large projects
- Over 6000 systems installed since 2003, total 58 MW
- 20MW Residential, 22MW Commercial, 16 MW Utility Scale



# Solar Growth Not Uniform Across States

2012 Roof-top Solar Power Production (Trillion Btu)

