



Solar Market Overview for Affordable Housing

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October 17, 2017

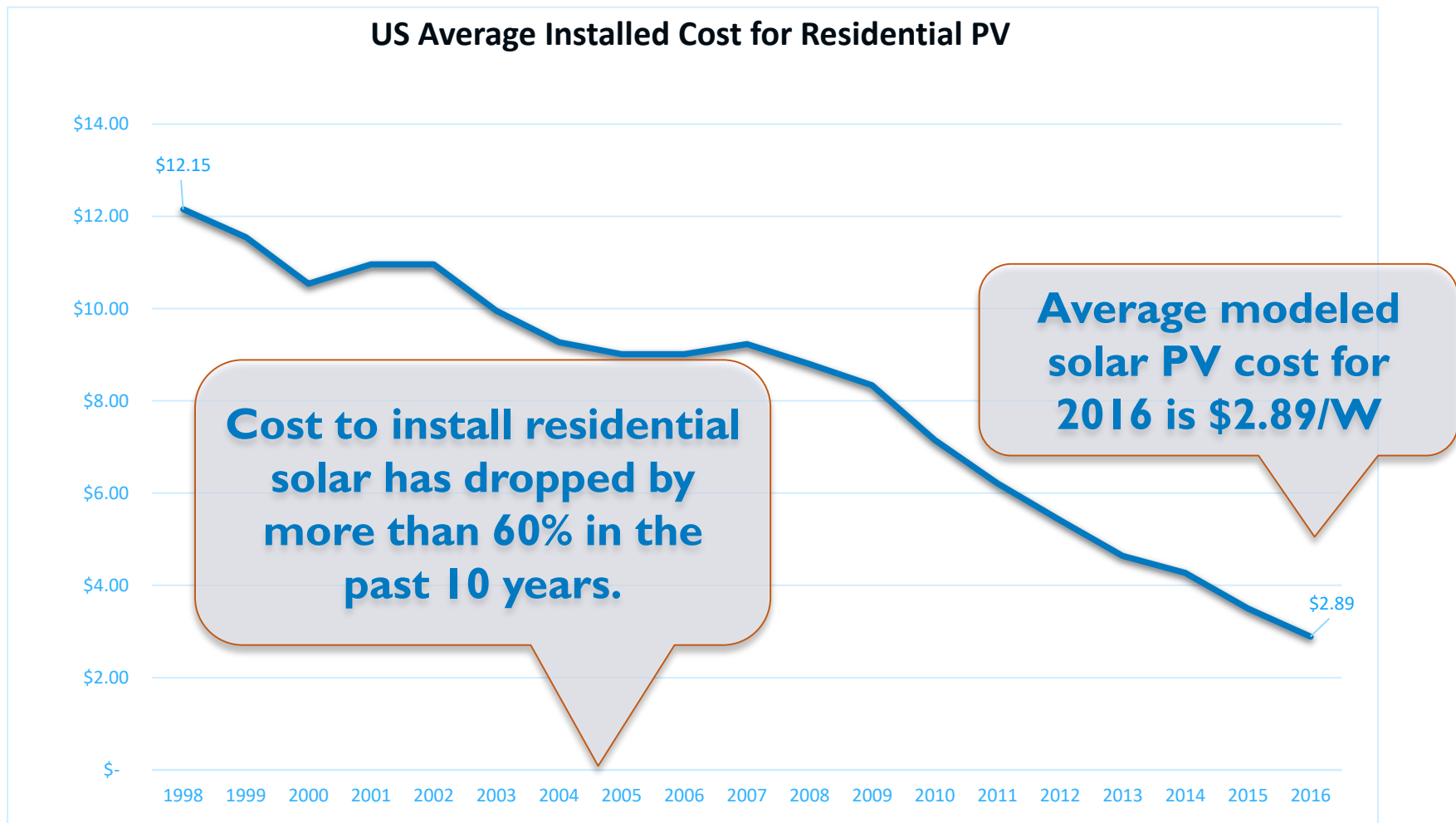
Agenda

- Market Update
 - PV Cost Trends
 - Technology
 - Solar Trends for Single and Multifamily Housing
 - Regulatory Considerations
 - Incentives
 - Common Solar Financing Structures



PV Cost Trends

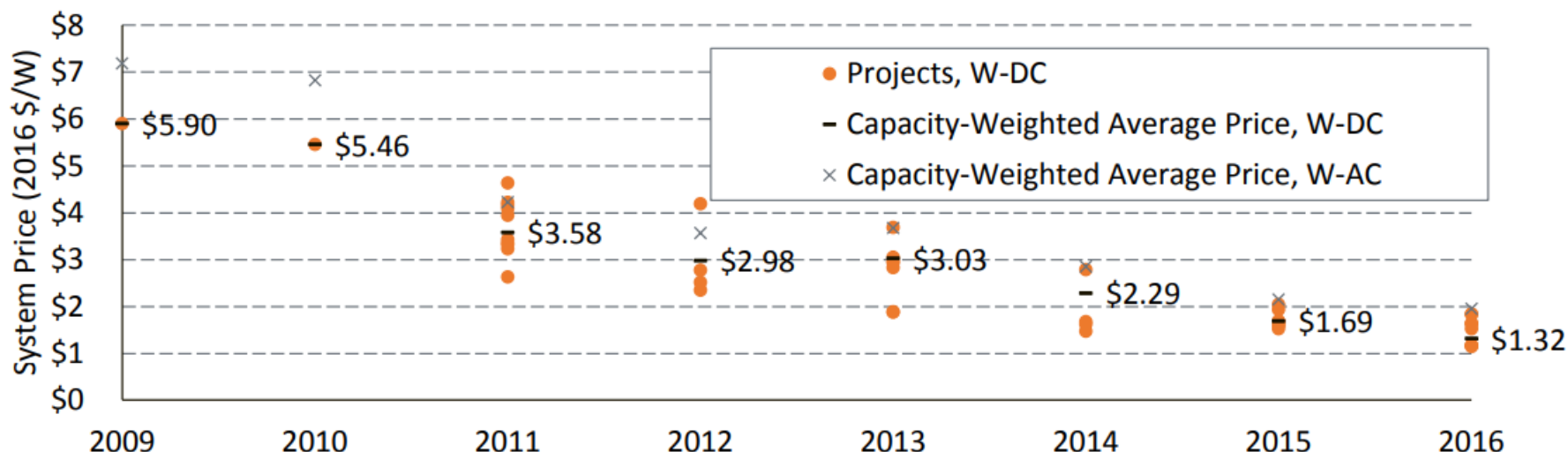
Solar Growth and Declining Costs



Source: Solar Energy Industry Association (SEIA)



Utility-owned PV Pricing (>5 MW)

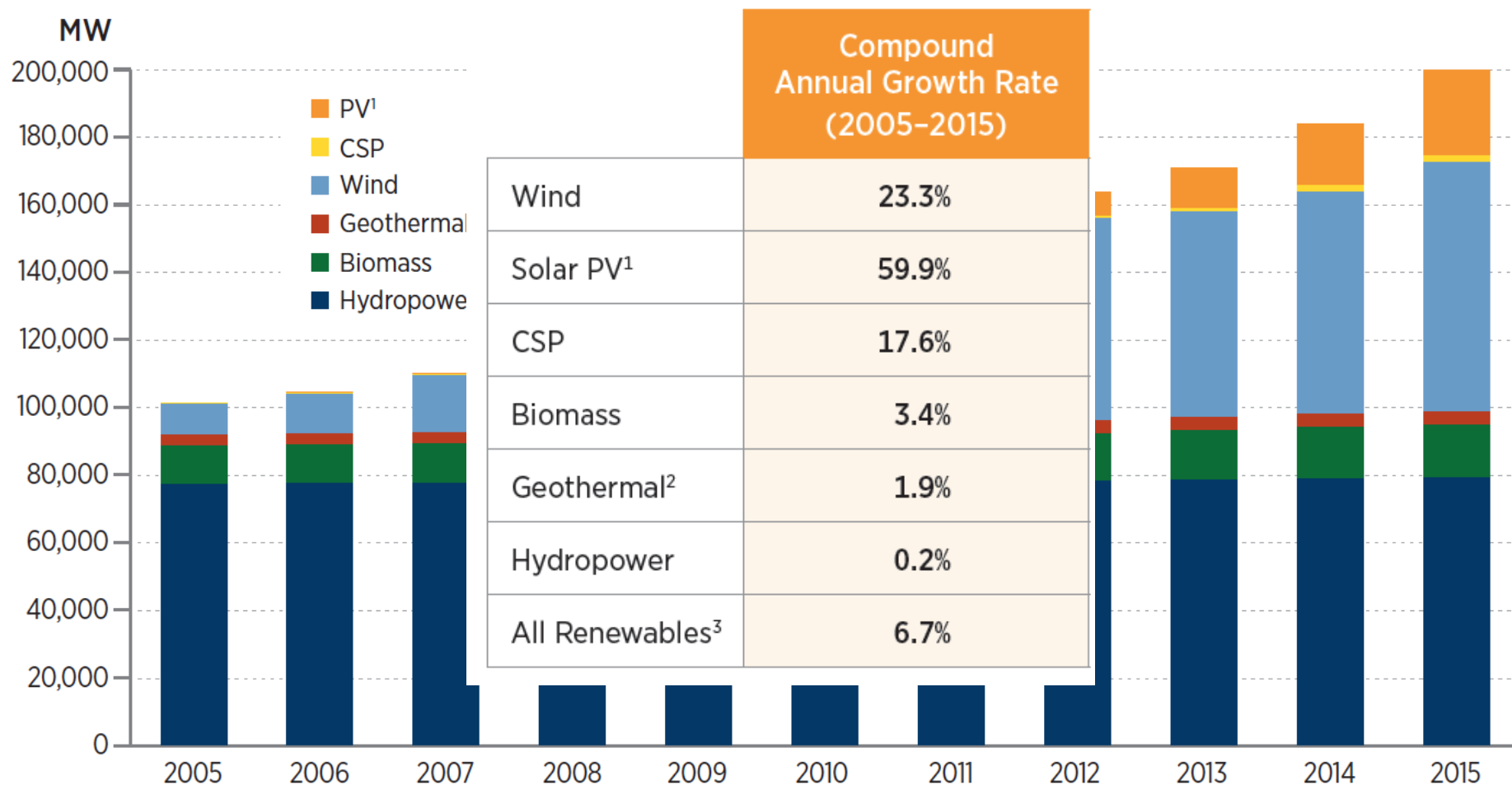


- In the above system price data set for nine regulated utilities the capacity weighted average price of a utility-owned PV system fell 78% to \$1.32/W_{DC} (\$1.95/W_{AC}) between 2009 and 2016.
 - The capacity weighted average system price fell 22% from 2015 to 2016
- From 2015 to 2016 PV system prices in Watts-AC fell slower than they did in Watts-DC because of an increase in inverter loading ratio, from roughly 1.3 to 1.5.
 - With cheaper modules, it is may be more economical to add more modules per inverter.
- The majority of utility-scale systems are owned by IPPs, which have PPAs with utilities. PPA pricing, while not in lock-step with system pricing, generally followed the same trends.
 - From 2010 to 2016 the generation-weighted average PPA price for utility-scale systems placed in service in that year fell 64%; from 2015 to 2016 PPA prices dropped 33% for systems placed in service in that year.
 - Systems should have much lower PPA pricing in the near future. as the average price for a PPA signed in 2015 was around \$40/MWh, or 30% lower than PPAs for systems installed in 2016.

Note: data sample consists of 42 projects with 1.2 GW-DC of capacity

Sources: FERC Form 1 Filings from the following utilities: Arizona Public Service; Florida Power & Light; Duke Energy Progressive; Georgia Power; Indiana Michigan Power Company; Kentucky Utilities; Pacific Gas & Electric; Public Service of New Mexico; Southern California Edison. PPA pricing from "Utility-Scale Solar 2015" (Bolinger and Seel 2016).

U.S. Renewable Generation Capacity Growth

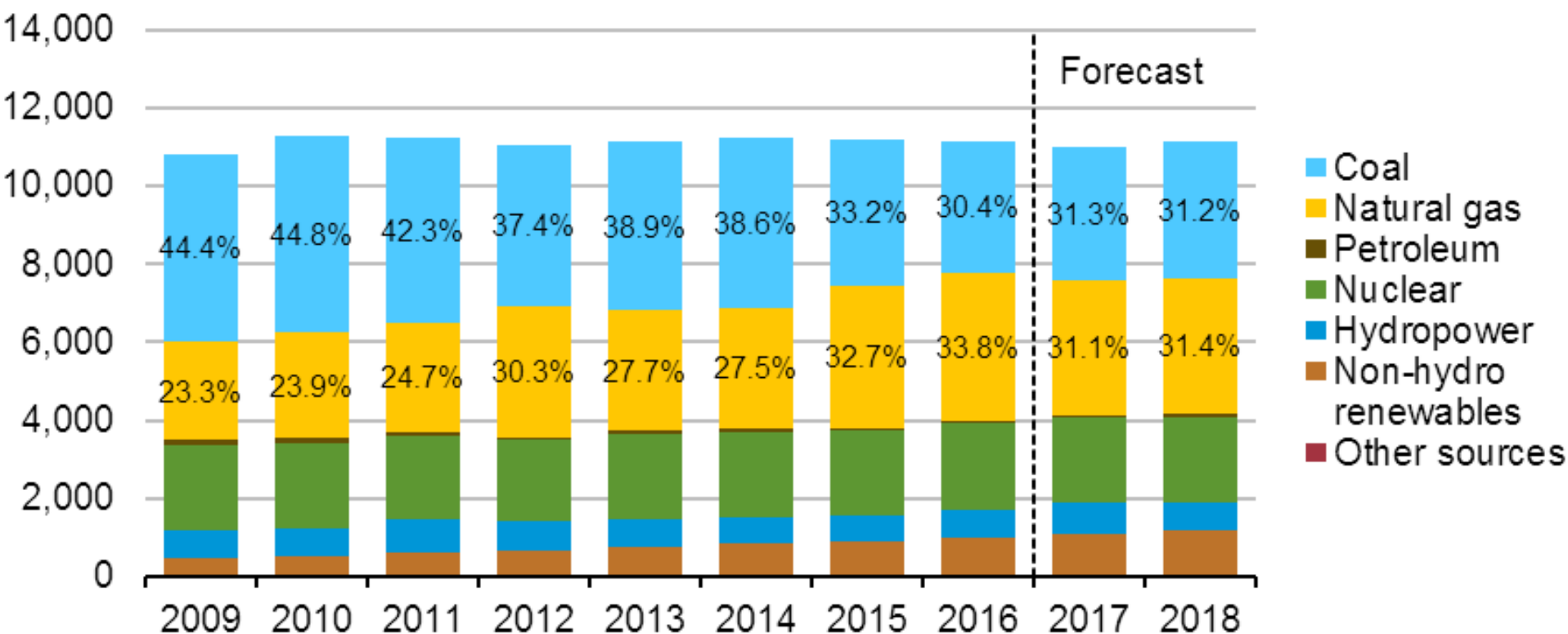


U.S. Electricity Generation by Fuel



U.S. electricity generation by fuel, all sectors

thousand megawatthours per day

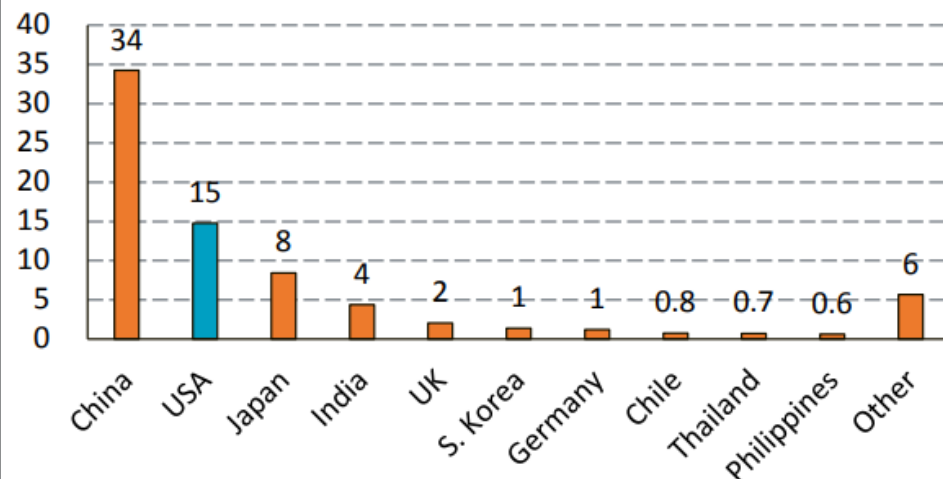


Note: Labels show percentage share of total generation provided by coal and natural gas.

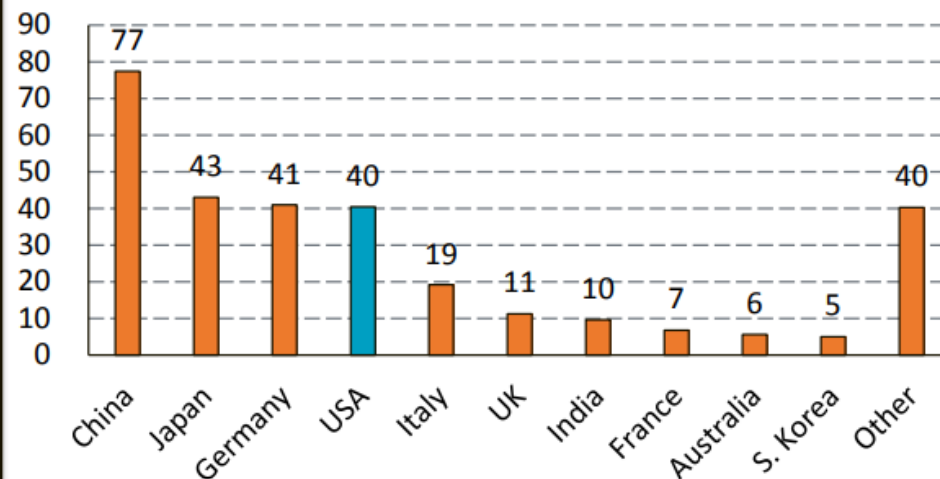
Source: Short-Term Energy Outlook, July 2017.

Top Ten PV Markets by Country

Annual Installations in 2016 (GW-DC)



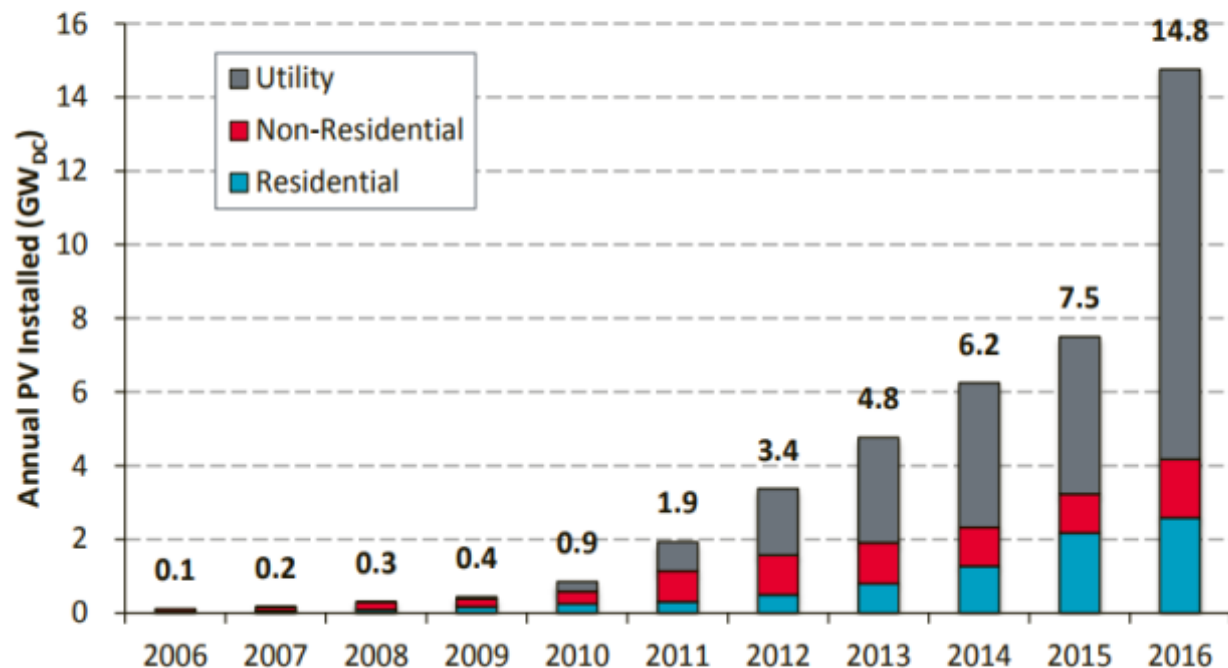
Cumulative Installations thru 2016 (GW-DC)



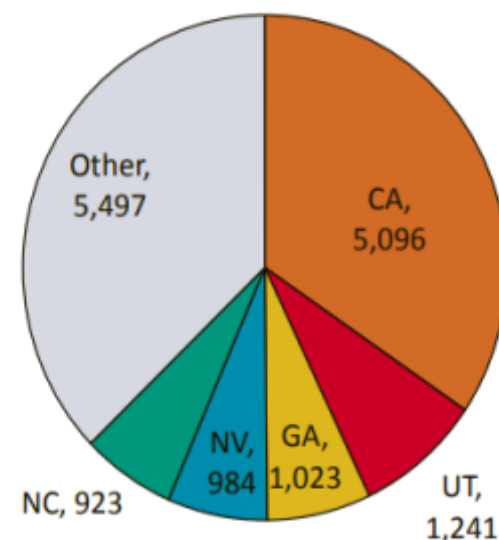
- At the end of 2016, global PV installations reached 299 GW_{DC}, up from 225 GW_{DC} in 2015.
 - An annual increase of 74 GW_{DC}
 - In 2001, there was only 1 GW of cumulative installations; the industry has thus grown by a factor of 298.
- Globally, the United States installed the second most PV capacity in 2016 and is now one of the top four markets in cumulative capacity—including CSP, it is nearing the second largest global solar market.
- The top ten markets represented 92% of annual PV installations in 2016.
 - China represented 46% of annual global installations in 2016.
- Despite a large concentration of installs in a few markets, many new markets are expanding around the world
 - From 2012 to 2016, Asian countries (other than China, Japan, and India) installed 8.6 GW, African countries installed 2.1 GW and South American countries installed 1.8 GW.

U.S. Installation Breakdown

U.S. PV Installations by Market Segment



U.S. PV Installations by State (MW_{DC}), 2016



- The United States installed 14.8 GW_{DC} of PV in 2016, 40.4 GW total
 - 2016 PV installations were larger than 2014 and 2015 combined, or all PV installations before 2014 combined
 - Utility-scale PV installations represented 72% of 2016 annual installations; however, the residential and non-residential markets also grew by 19% and 50% respectively, y/y.
- In 2016, the top 5 states represented 63% of the market—22 states installed more than 100 MW, 9 states had more than 1 GW of cumulative PV capacity.

The Cost of Not Being Resilient

2017 Hurricane Season – Power Outages Costing Lives

For the first time since 2005 the U.S. has had four major hurricanes make landfall on the mainland.



Hurricane Harvey

Hurricane Harvey

Category 4

Aug 25



2017

Aug

Sep

Oct

Nov

Dec

2018

2018

Image Credit –Left to Right

http://a.abcnews.com/images/US/hurricane-harvey-ht-jpo-170901_4x3_992.jpg

https://static.dezeen.com/uploads/2017/09/houston-flooded-hurricane-harvey-urban-design_dezeen_hero-852x479.jpg

http://a.abcnews.com/images/US/hurricane-harvey-01-ap-mt-170829_4x3_992.jpg

Impacted Texas Gulf Coast

- winds over 130mph,
- 50 inches of rain,
- 1.5 ft of flood waters,
- 136,000+ buildings impacted
- Death Toll = 88



Hurricane Irma

Hurricane Irma Category 4 and 5

Sept 10



2017

Aug

Sep

Oct

Nov

Dec

2018

2018

Image Credit –Left to Right

<http://www.miamiherald.com/news/nation-world/world/americas/article177687526.html>

http://www.aljazeera.com/mitems/imagecache/mbdxxlarge/mitems/Images/2017/9/11/63c351a3c66d411f8c96fad716e93fd2_18.jpg

Impacted Caribbean (Category 5) and Florida (Category 4)

- \$50billion in damages in Florida
- Miami-Dade County had ~730,000 without power
- ~6 million across the state without power
- Death Toll = 75



Hurricane Maria

Hurricane Maria

Category 4

Sept 20



2017

Aug

Sep

Oct

Nov

Dec

2018

2018

Impacted Puerto Rico and the Caribbean

- ~\$60billion in damages
- Crippled 95% of communications networks in Puerto Rico
- Millions without food, water and power
- Death toll = 48



Image credit: L-R

<https://www.gannett-cdn.com/-mm-/460bb6af77d3b531031308f37e47261e0cbe0f1/c=689-0-4783-3078&r=x404&c=534x401/local/-/media/2017/10/03/USATODAY/USATODAY/636426185590734256-XXX-10022017-Yabucoa-Puerto-Rico-Hurricane-Maria-homes08.JPG>

<https://timedotcom.files.wordpress.com/2017/00/puerto-rico-hurricane-maria-aftermath1.jpg?quality=95>

Hurricane Nate

Image credit: L-R
http://media.npr.org/assets/img/2017/10/08/gettyimages-858867316-2_wide-4902ecc18daa341687b2275ef812ea0ce19928e1-s900-c85.jpg
<https://thenypost.files.wordpress.com/2017/10/hurricane-nate-embed.jpg?quality=90&strip=all&w=662&strip=all>
https://www.reviewjournal.com/wp-content/uploads/2017/10/9388995_web1_9388995-ba8cf5fd3d024196a53f0a8259f257c3.jpg

Hurricane Nate Category 1

Oct 8



2017

Aug

Sep

Oct

Nov

Dec

2018

2018

Impacted Gulf Coast States

- Alabama Power reported Sunday afternoon that more than 63,000 customers were without power.
- Mississippi Power said 3,716 of its customers were without power, while in Louisiana, 332 homes were affected.
- Death Toll in Central America = 45 (2 in U.S.)



Wildfires

Image Credit: The Mercury News/Bay Area News:
<http://www.mercurynews.com/2017/10/10/pge-power-lines-linked-to-wine-country-fires/>

Northern California Fires



2017

Aug

Sep

Oct

Nov

Dec

2018

2018

Impacted Wine Country

- 102,000 PG&E customers were without power.
- 3,500 structures were burned.
- Death toll: 35



Disaster Recovery at NREL: Deeper Dive



Image Sources:

<http://www.reuters.com/article/us-storm-sandy-hurricane-idUSBRE89N16J20121030>

<http://www.serve.gov/site-page/sandy>

Camden County MUA: <http://www.ccmua.org/>

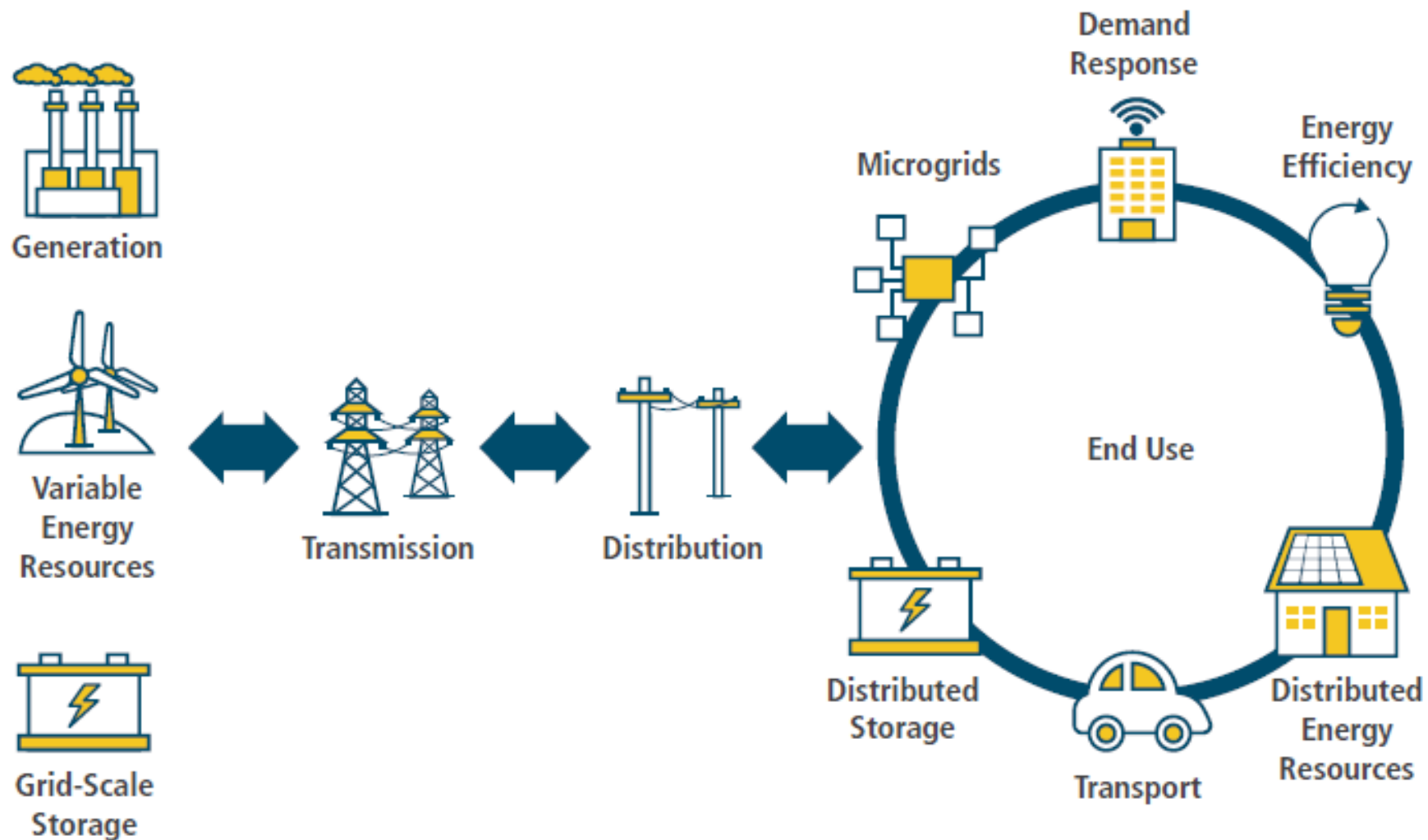
WHAT IS RESILIENCE?

“the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through **adaptable and holistic planning and technical solutions**”.

www.nrel.gov/tech_deployment/resilience-planning-roadmap/

Electricity System Overview

Figure S-3. Emerging 21st-Century Electricity Two-Way Flow Supply Chain



Quadrennial Energy Review , 2016

The background consists of several overlapping triangular and quadrilateral shapes in various shades of blue, ranging from a deep navy blue to a light sky blue. The shapes are arranged in a way that creates a sense of depth and movement, with some shapes appearing to recede into the background while others come forward.

Technology

District Net Zero Housing (NZH) and Net Plus Housing



Battery Storage

Photovoltaics

Solar Hot Water

Thermal Storage

Commercial Buildings

Affordable Housing

Mixed-Use Buildings

District Geothermal Heating and Cooling

Combined Heat and Power

Wind Turbines

Residential Buildings

Biomass and Waste-to-Energy

Microgrids

Landfill Gas

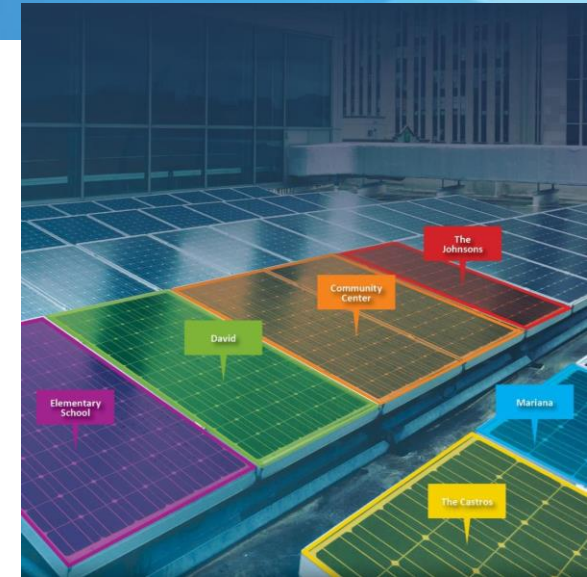
Dispatchable Loads

Cook County Community Solar Project



- Local Benefits Analysis published (8/17)
- 15 Replicable Case Studies – most plan to pursue installation. Website for cases, financials etc.
- Final Report – Findings:
 - For potential site owners
 - For policy / regulatory process

Project end date: Sept. 30, 2017



What's At Stake:



Jobs:

10,070 construction-period jobs and 177 permanent jobs



Environment:

Reduction of 3.28 Million Metric Tons of CO2 equivalent harmful greenhouse gases

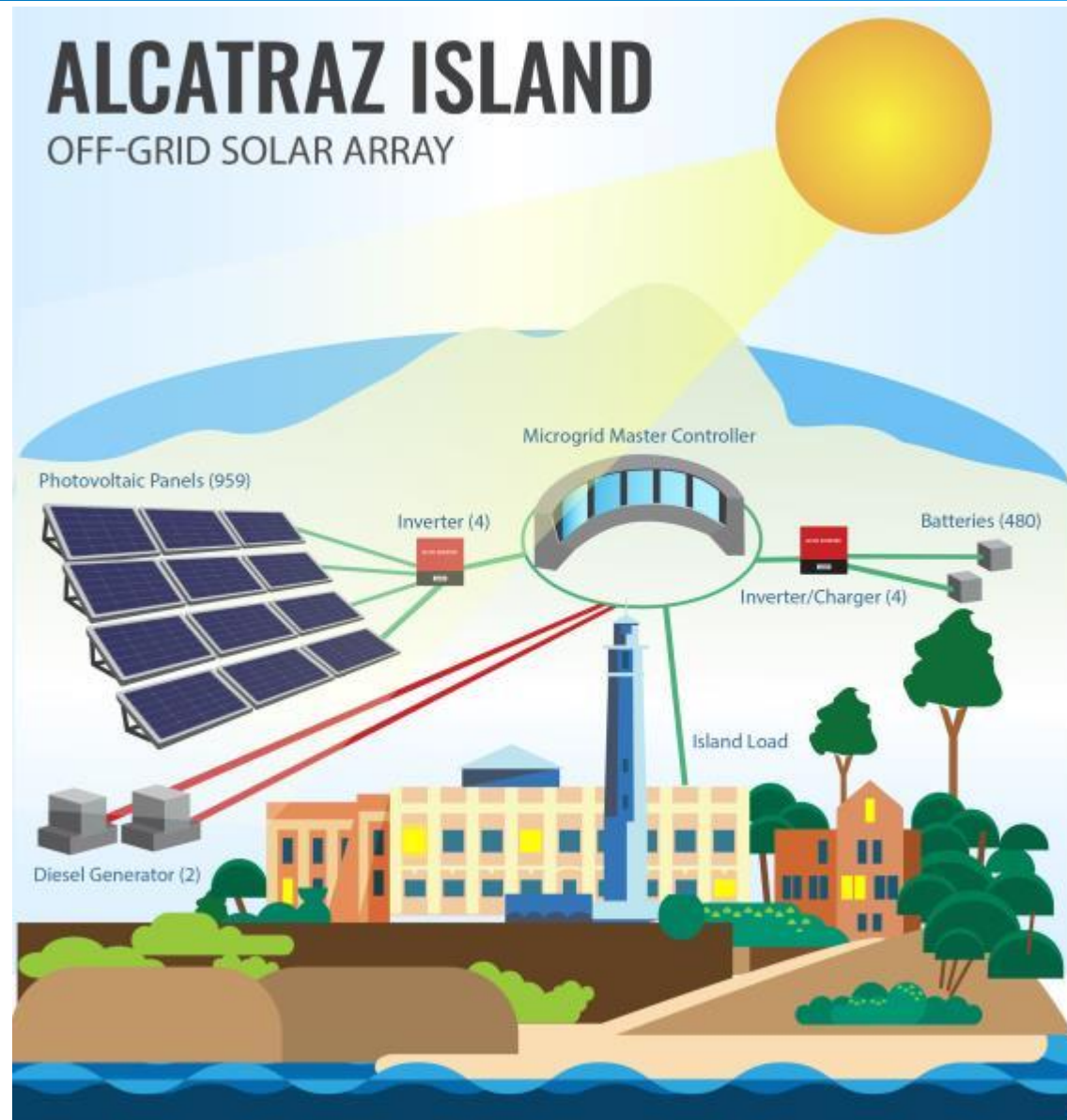


Savings:

\$1.01 Billion in electric bill savings to subscribers (over 25 year project life, in 2016 dollars)

Microgrids with Storage

- Inverters convert direct current power from solar to alternating current power compatible with the island's utility system.
- Other inverters reverse that conversion for battery charging.
- When solar goes to sleep, the batteries discharge through their inverters.
- If solar batteries are low, diesel generators automatically back up power to the user, and recharge battery bank until there is enough charge to sustain the island load by itself.
- Result: Island uses 50% of previously diesel powered generation.
- Microgrid controller device optimizes solar first, then storage, then diesel if necessary.



Sterling, Massachusetts Municipal Adopts Solar + Storage

Payback = 7 Years

Savings = \$400,000/year

CESA Video – 9:39

<https://www.youtube.com/watch?v=w3lt2lwLCm4&feature=youtu.be>

Solar Trends for Affordable Single and Multifamily Housing

Top Financing Options for Owner-occupied Homes

- LIHEAP/WAP
 - Colorado Rooftop Solar Program
- Direct Cash Incentives
 - California Single-family Affordable Solar Housing
- On-bill Financing
 - Ouachita Cooperative in Arkansas
- Loans
 - Massachusetts' Solar Loan Program
- Third-party Leasing/ESA
 - PosiGen in Connecticut



Top Financing Options for Multi-family Housing Providers

- Capital Refinancing
 - Anecdotal evidence
- Third-party Leasing/PPA & Energy Service Agreements
- LIHEAP/WAP
- On-bill Financing
- PACE
 - California has launched a Low-income PACE pilot:
 - <https://thinkprogress.org/new-program-will-support-clean-energy-and-efficiency-for-low-income-residents-a24198304245/>



NREL has developed a variety of world-class tools that can be used to model urban mixed-use developments

- OpenStudio/EnergyPlus
- Renewable Energy Optimization (REopt) tool
- REopt Lite
- Campus Modeling Tool (CMT)
- Subdivision Energy Analysis Tool (SEAT)
- Urban Opt -Urban Renewable Building And Neighborhood Optimization tool

**Coming Soon:
URBANopt**

Urban Renewable
Building
And
Neighborhood
Optimization tool

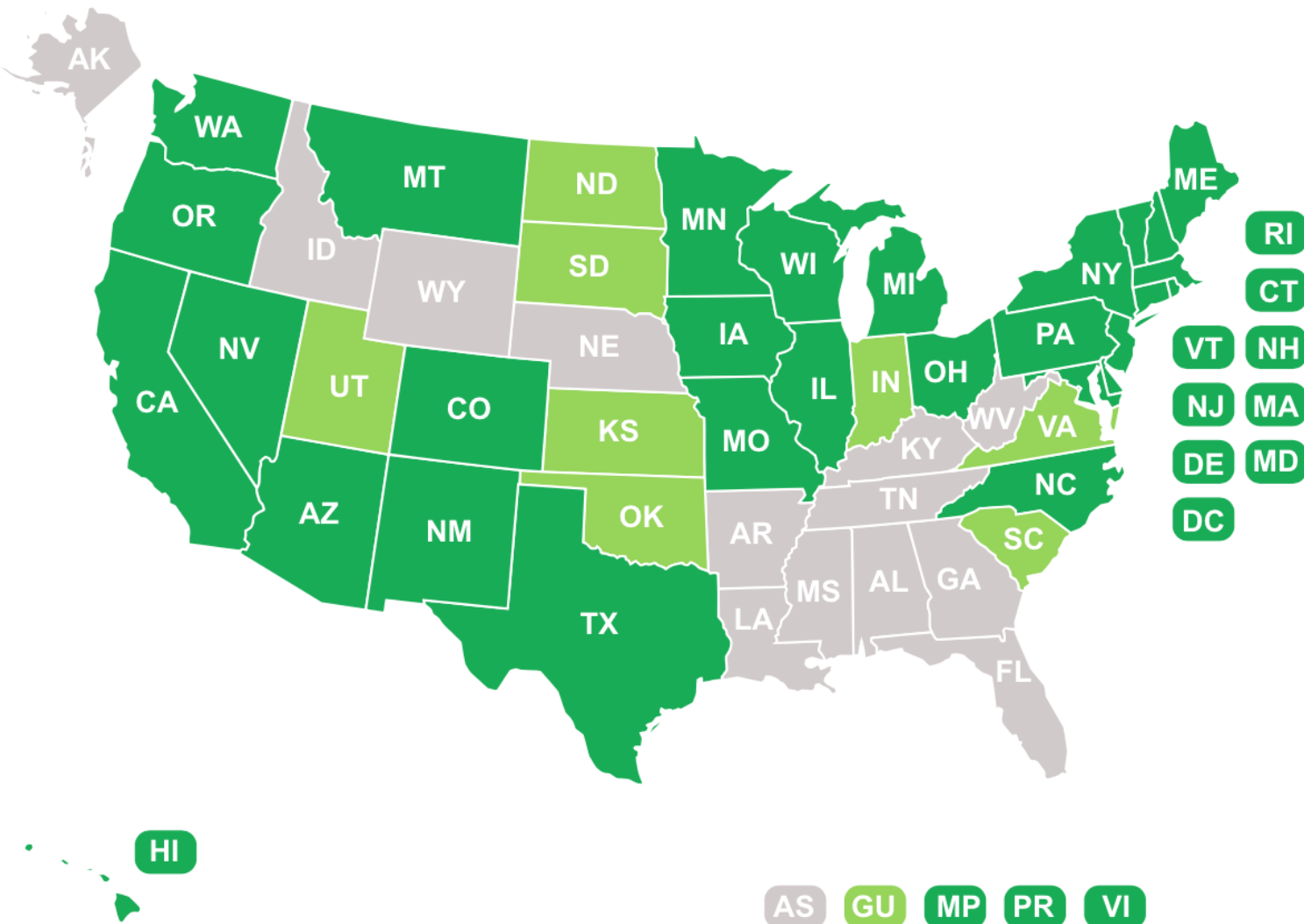


Regulatory Trends & Considerations

State Renewable Portfolio Standards (RPS) and Goals

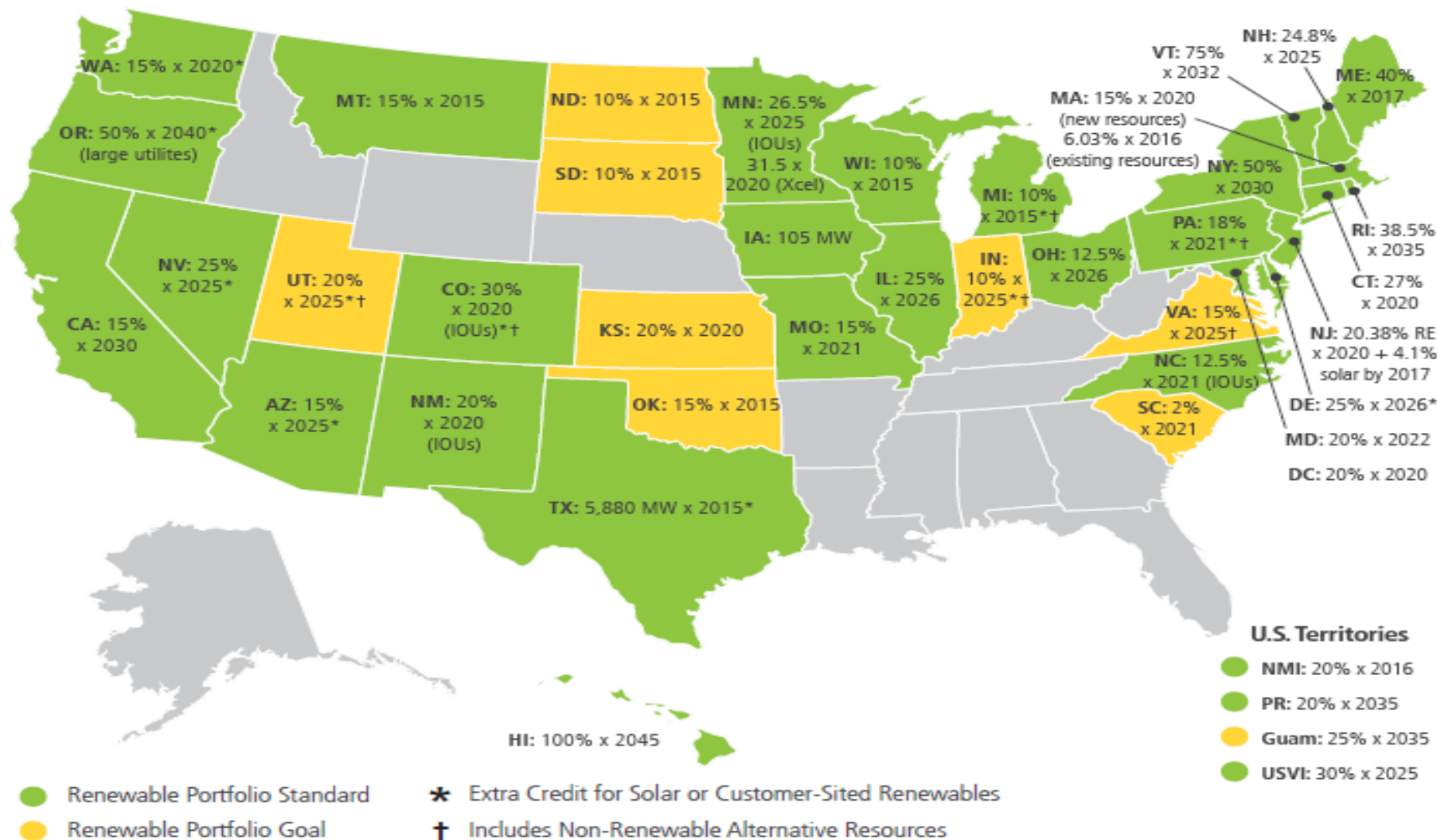
States and territories with Renewable Portfolio Standards

States and territories with a voluntary renewable energy standard or target



Renewable Portfolio Standards and Goals

Figure 3-5. State RPS Policies, August 2016⁴⁸

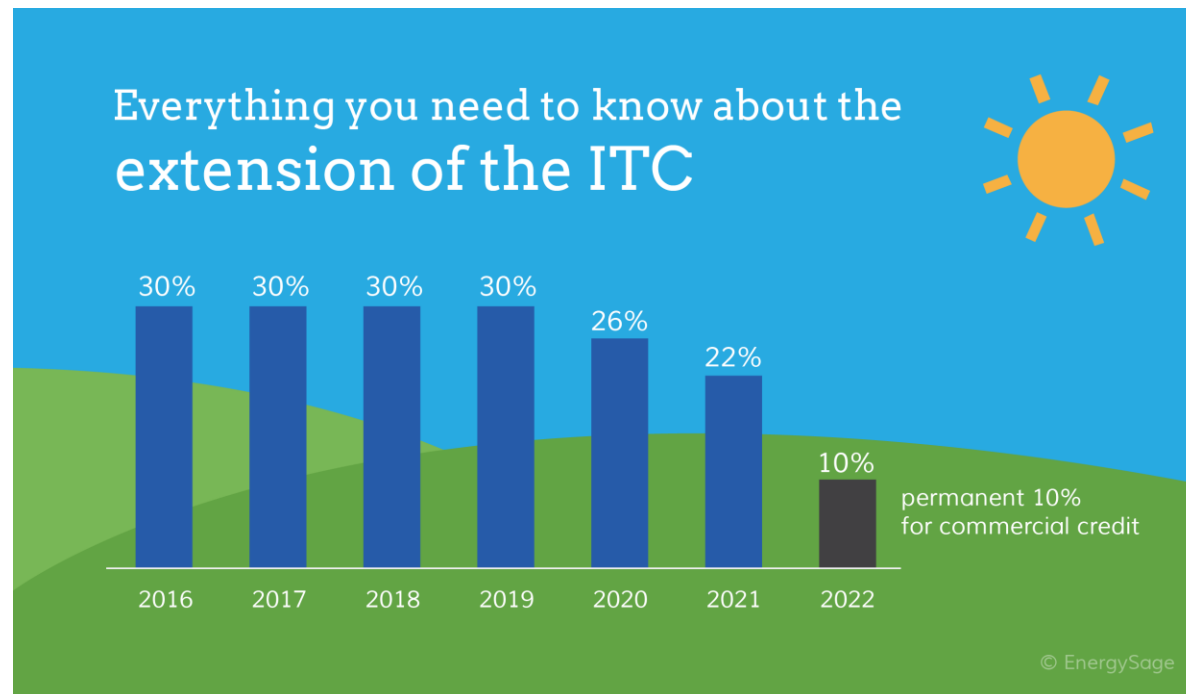


Twenty-nine states and the District of Columbia have an RPS, and an additional eight states have a renewable portfolio goal; some include extra credit for solar or customer-sited renewables or include nonrenewable alternative resources. The RPS or renewable portfolio goals are key drivers of renewable energy growth.

Incentives

Factors Impacting Economics

- 30% ITC extended through Dec. 31, 2019
- Future solar trade case could impose tariff on foreign PV panels and increase system costs



Reference: <http://news.energysage.com/congress-extends-the-solar-tax-credit/>

Database of State Incentives for Renewables & Efficiency

Website for Incentives:
<http://www.dsireusa.org/>

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IN YOUR CITY



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Find Policies & Incentives by State

Solar Financing Structures

Solar Finance Structures

- Power Purchase Agreements (PPAs)
- Energy Services Agreements (ESAs)
- Community Solar Model
- LIHTC and Solar
- How corporate tax cuts may affect the market

Solar Developers Create Power Purchase Agreements

- On-site renewable power purchase agreements (PPAs) allow affordable housing agencies to fund on-site renewable energy projects with no up-front capital costs.
- Developers install renewable energy systems on multifamily properties. In exchange, agencies agree to purchase the power generated by the system.
- Developers can capture the tax credits as well as depreciation which can result in heavy tax relief for the first 6 to 8 years of the project

Power Purchase Agreement Economics –Sam Modeling

Power Purchase Agreement Economics

- Modeled as 20 year term and 7 year term with buy out in year 8
- Buy out modeled as Net Present Value (NPV) of PPA, O&M expense, and state and federal tax savings
 - Buy out in beginning of year 8 for 7 year PPA estimated at less than \$200k
- After year 7 **Housing Agency** takes over ownership, gets all electricity savings but also has to pay operating expense (O&M)

Scenario	REC Center PPA (\$1.85/Watt)	REC Center 7 Year PPA (\$1.85/Watt)
System size (kW)	305.7	305.7
1st Year PPA Rate	8.14 ¢/kWh	8.14 ¢/kWh
NPV (\$)	\$374,816	-

*Note: A PPA includes 30% Investment Tax Credit (ITC) and Modified Accelerated Cost Recovery (MACRS)

MACRS is a method of depreciation in which a business' investments in certain tangible property are recovered, for tax purposes, over a specified time period through annual deductions. Developers can take an additional 35% annually for depreciation, which usually tapers to zero at 7 to 8 years.

Estimated Buy Out and Electricity Savings

Category	High End	Low End
Estimated Buy Out at Year 8 (\$ NPV)	Less than \$200k	Less than \$200k
NPV of Electricity Cost Savings Year 1-10 (\$)	\$238,949	
NPV of Electricity Cost Sav Minus Operating Exp 8-20 (\$)	\$903,650	

Agency Purchase Economics – SAM Modeling

Scenario	REC Center Cash (\$1.85/Watt)	REC Center Cash (\$1.85/Watt) No Demand
System size (kW)	305.7	305.7
Net capital cost (\$)	\$564,267	\$564,267
Annual energy (kWh/yr)	436,095	436,095
Capacity factor (year 1)	16.3%	16.3%
Energy yield (year 1)	1,430 kWh/kW	1,430 kWh/kW
Levelized COE (nominal)	12.72 ¢/kWh	12.72 ¢/kWh
Net electricity savings with system (year 1)	\$66,571	\$40,341
Net demand savings with system (year 1)	\$26,230	\$0
Net present value (\$)	\$251,376	(\$110,481)
Payback period (yrs)	9.0 years	15.5 years

Annual Cost Savings Based on Weather File

Weather File	Annual Cost Savings (\$/yr)
TMY3	\$66,570
2014	\$71,872
2013	\$74,064
2012	\$70,439
2011	\$69,306

*Note does not include 30% ITC or MACRS

Community Solar Model

Cook County Business
Case Tool:
Elevate Energy

Community Solar Program Assumptions

Community Shared Solar Program	
System Life (years):	25
% of System Subscribed by Anchor Subscriber:	40%
Annual Subscriber Retirement/Acquisition Rate (%):	1.5%
Panel Price/Lease Escalator (%):	0%

Solar Project Financial Metrics	
Annual Energy & Demand Cost Increase:	2.00%
Subscriber NPV Discount Rate:	8.00%
Developer NPV Discount Rate:	6.00%

Financing Assumptions

Solar Project Financing Options		
	Developer	Subscriber
Percent of Costs Financed:	20%	50%
Interest Rate:	6%	8%
Financing Term (years):	0	5

Incentive Assumptions

Incentive	Input Unit	Input Value
Federal Investment Tax Credit (ITC):	% of qualified costs	30%
State/Local Generation Incentives, if Applicable:	\$/kWh	\$0.00
State/Local Capacity Subsidy, if Applicable:	\$/Watt	\$0.00
State/Local Lump Sum Incentive, if Applicable:	\$	\$0.00
SREC Value:	\$/SREC (MWh)	\$0.00
SREC Lifetime:	years	15
SREC Payout Schedule:	years	5
Tax Rate for MACRS Depreciation:	%	35%
Salvage Value:	% of system cost	0.00%

Administrative and Transactional Cost Assumptions

Subscriber Acquisition Assumptions	Input Unit	Input Value
Subscriber Acquisition Difficulty:	N/A	Moderate
Labor rate for Acquisition Activities:	\$	\$50
Labor Rate Escalator:	%	2%
Upfront Billing Software Costs:	\$	\$0
Ongoing Billing Software Licensing Costs:	\$/year	\$0

Key Assumptions

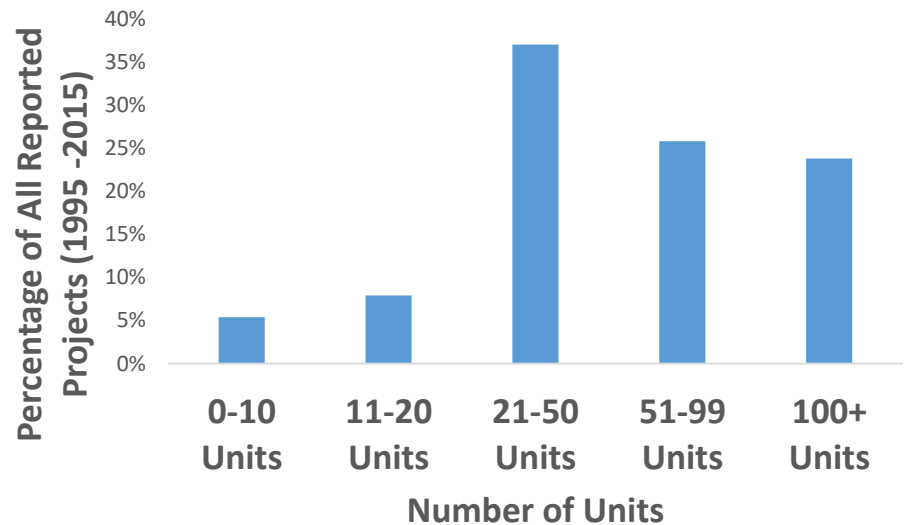
- 30% ITC
- 35% tax rate, for depreciation
- \$50/hr labor rate with 2% escalation for subscriber acquisition
- Annual site lease
 - \$2,500 per year assumed

Energy Services Agreement (ESAs) for Solar

- An Energy Services Agreement (ESA) or Company (ESCO) incurs the cost of implementing a range of energy conservation measures (ECMs)—which can include solar
- Upgrades are paid from the energy, water, and operations savings resulting from these ECMs.
- The ESCO and the agency negotiate to decide who maintains the ECMs.
- Payments to the contractor cannot exceed savings in any one year.
- These contracts are recommended for renewable energy projects only if energy-efficiency measures also are being performed.

Considerations for Low Income Housing Tax Credit (LIHTC) Solar on Affordable Housing

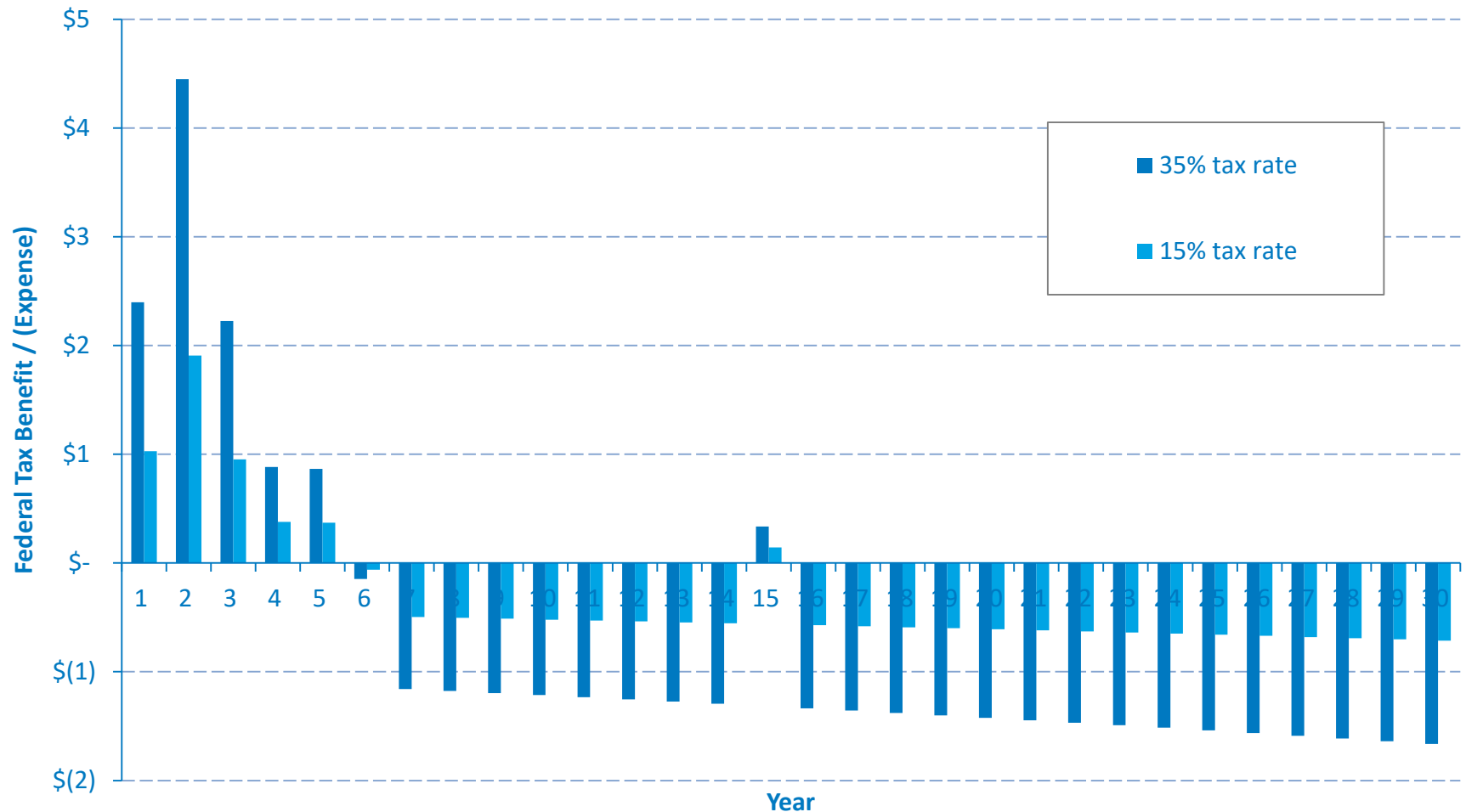
- LIHTC housing is NOT regulated by HUD
- Implementing state agencies manage this program
- HUD approval is not required for solar
 - Additional research may be needed to determine solar requirements on a state-by-state basis



LIHTC Housing Size Characteristics from 1995 – 2015

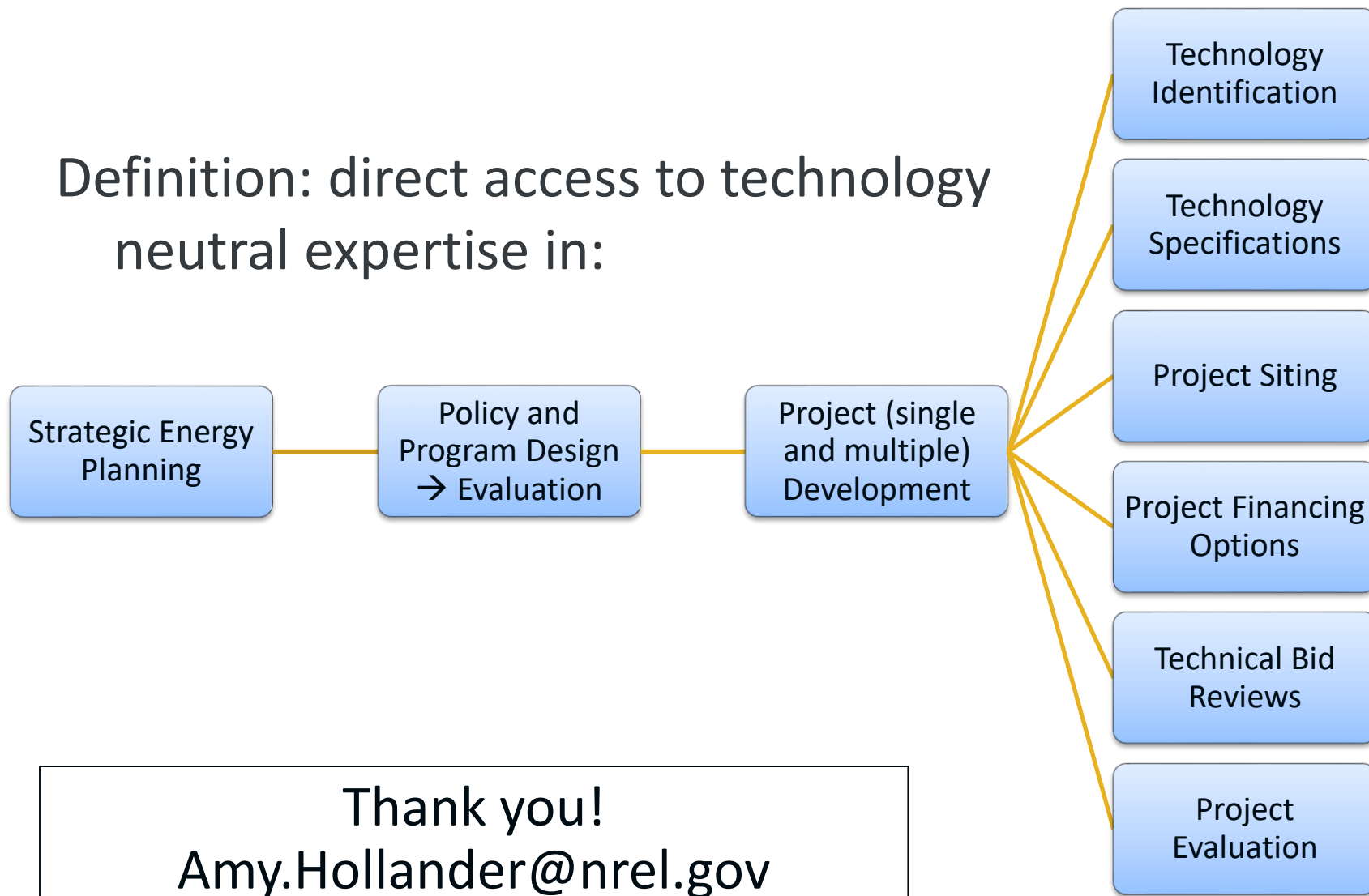
Tax Benefit to Investors May Change

Federal Tax Benefit/Expense Over Life of PV Project



Types of NREL Technical Assistance

Definition: direct access to technology neutral expertise in:



Thank you!
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QUESTIONS?

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720 KW

50 KW

1,156 KW

449 KW

408 KW

94 KW

524 KW

NREL PV Systems - South
Table Mesa Campus