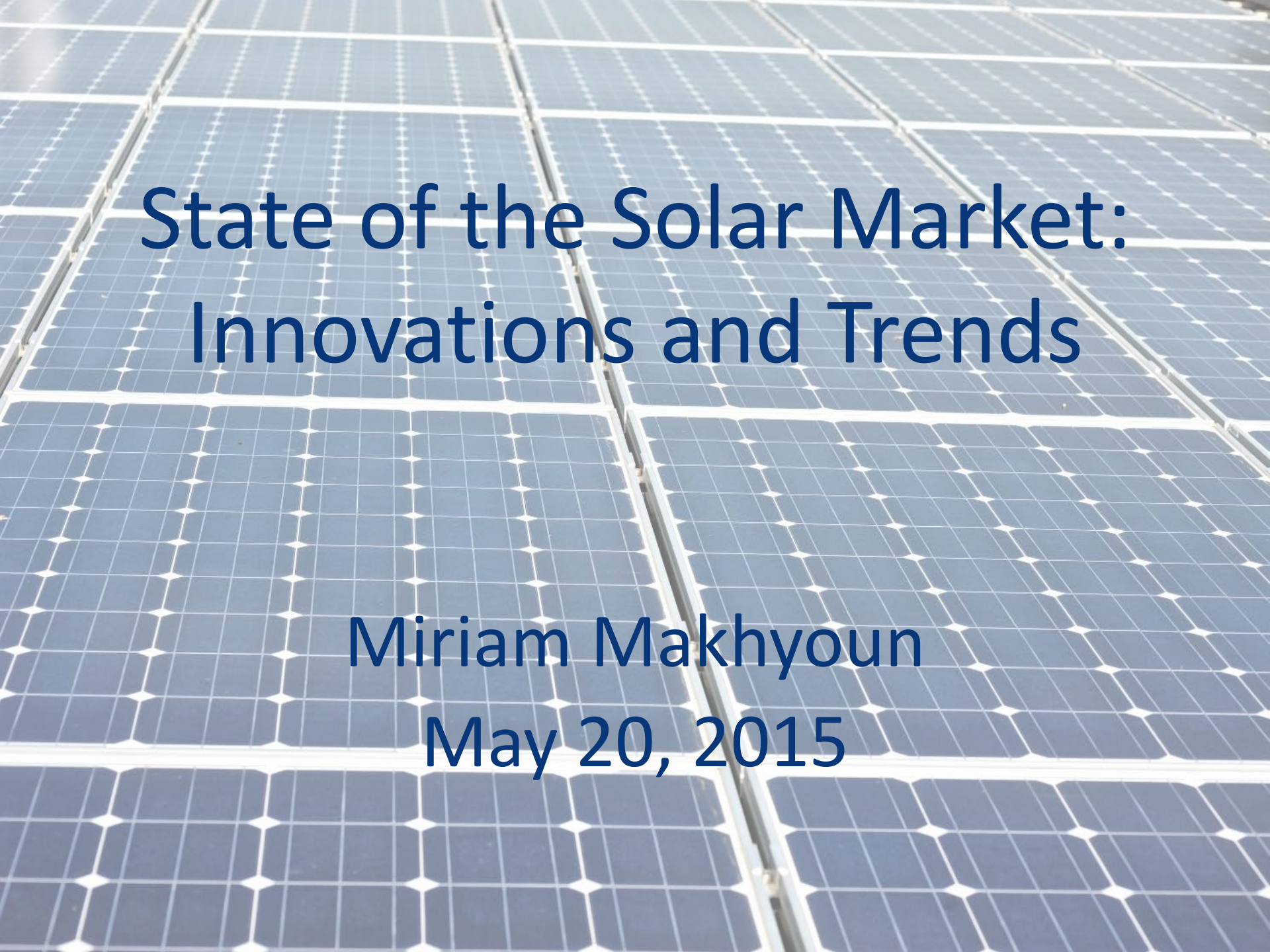


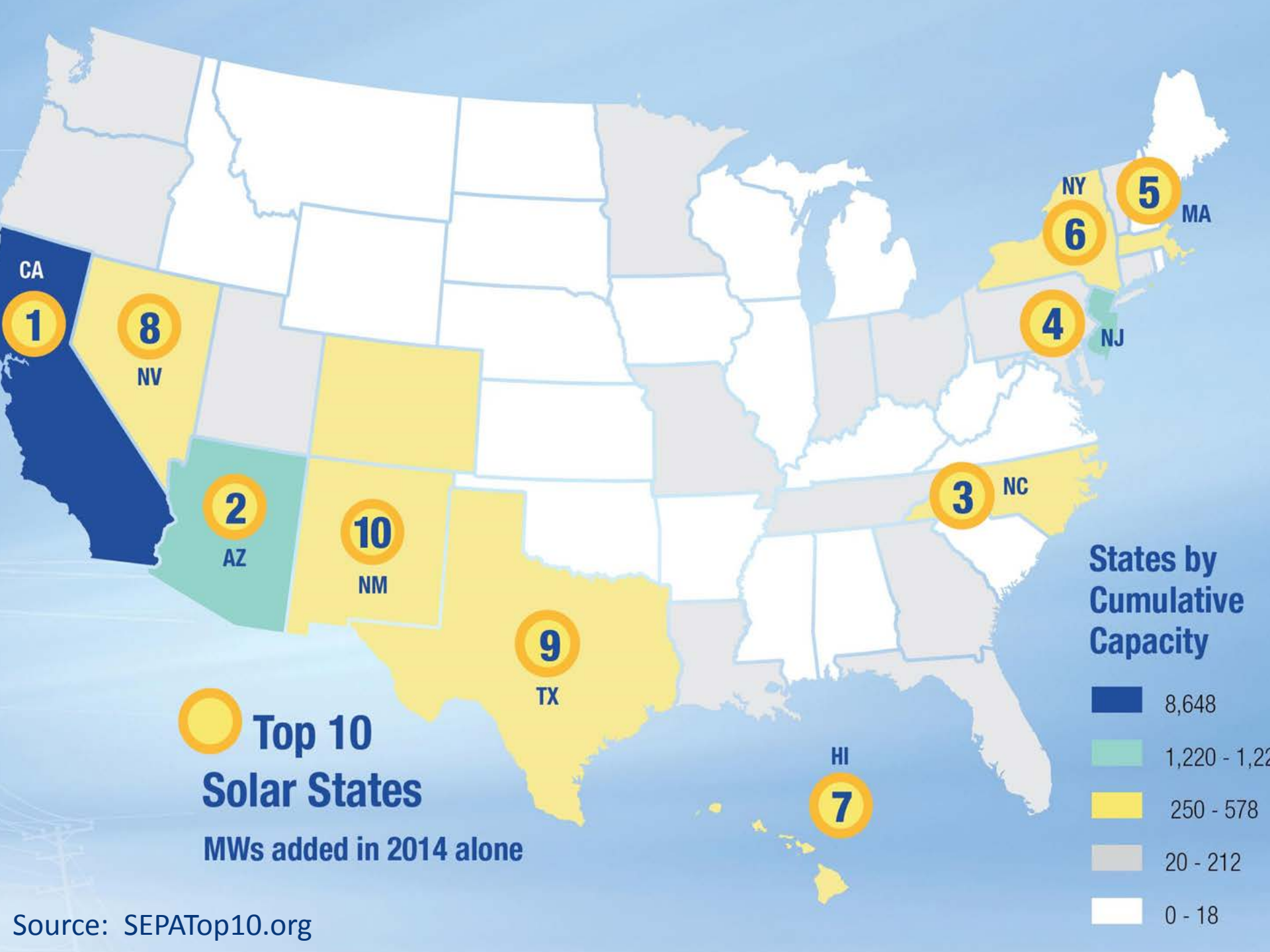
State of the Solar Market: Innovations and Trends

Miriam Makhyoun

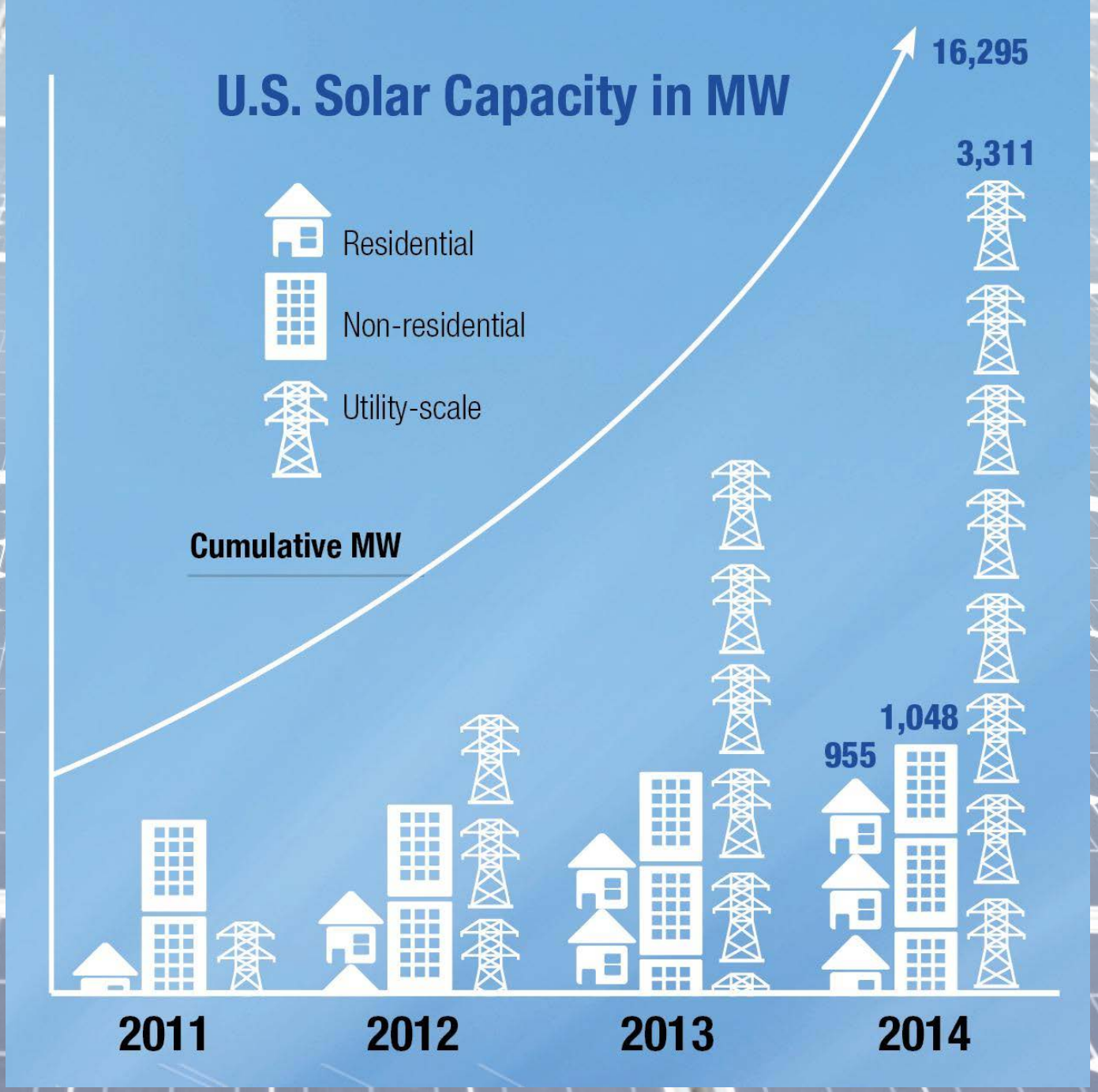
May 20, 2015

Presentation Agenda

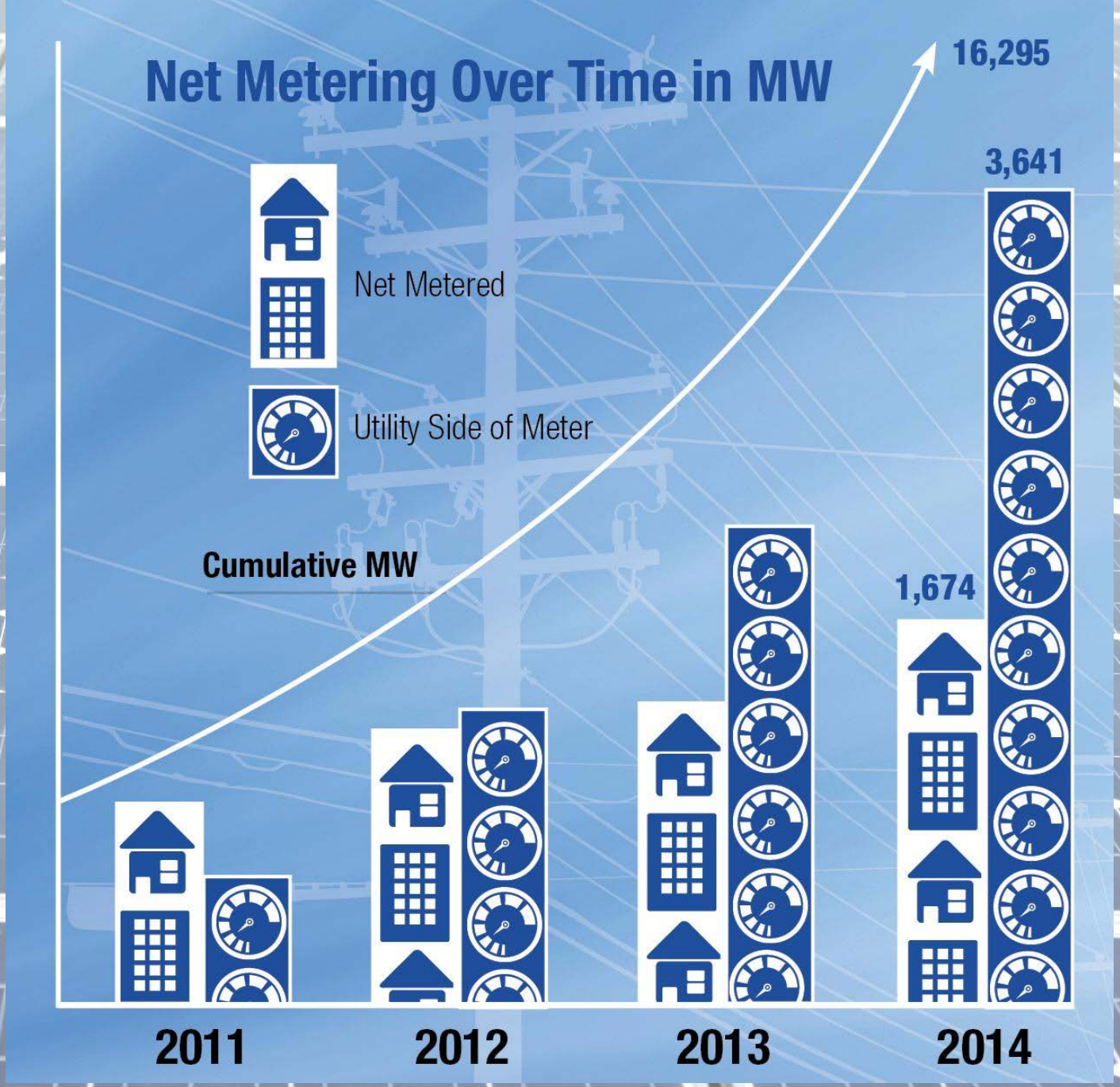
- How much solar was installed in 2014?
- What market segments saw the most growth?
- Solar Technologies (storage, inverters, forecasting)
- Rate restructuring
- Value of solar tariffs
- Fixed charges
- Current Price Points for Solar Energy Technologies
- Community Solar and Utility Rooftop Ownership



Source: SEPATop10.org

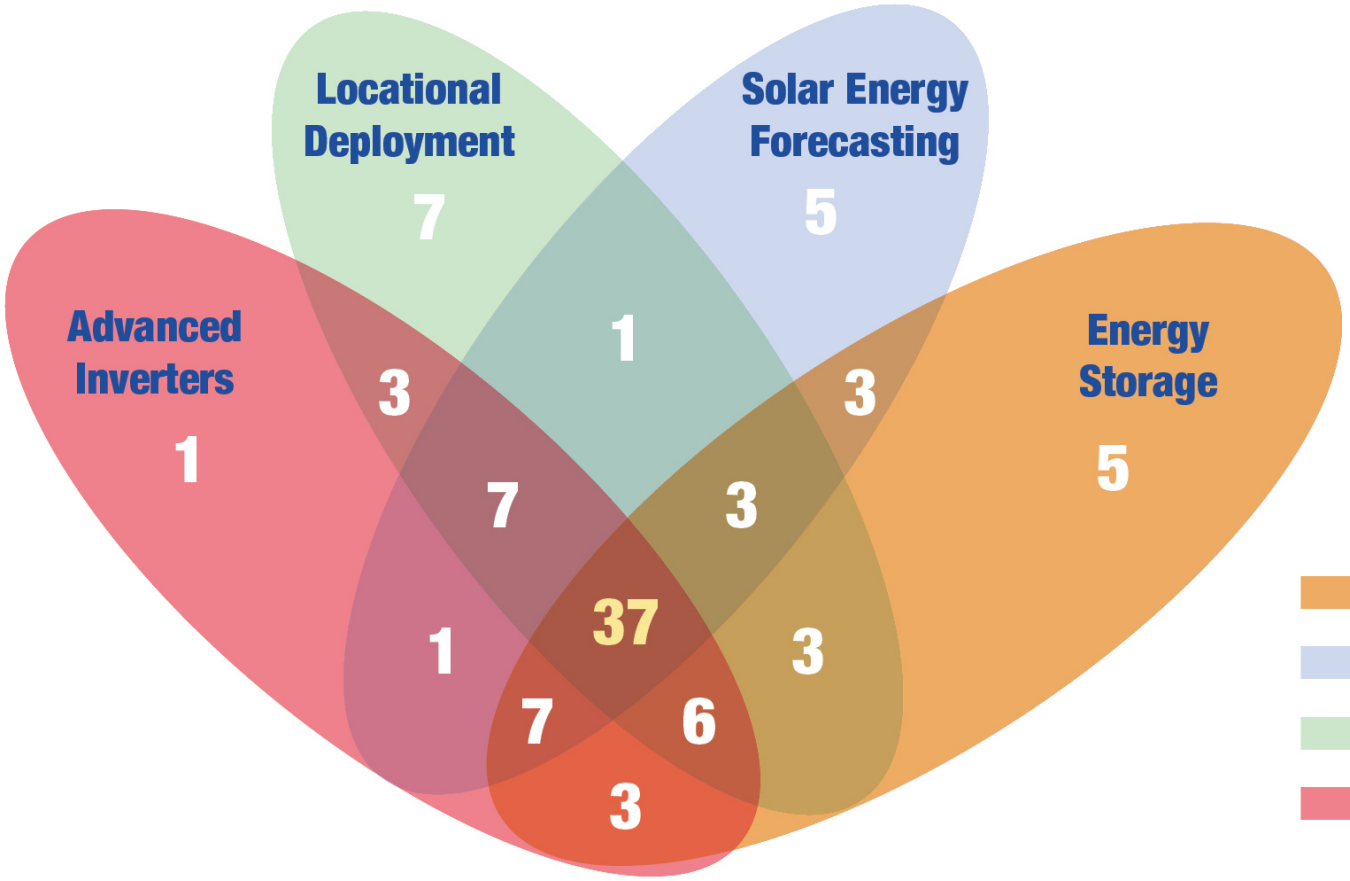


Source: SEPATop10.org



Source: SEPATop10.org

Grid Integration Strategy

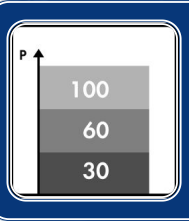


Energy Storage: 67
Solar Energy Forecasting: 64
Locational Deployment: 67
Advanced Inverters: 65

…Often overlapping technologies

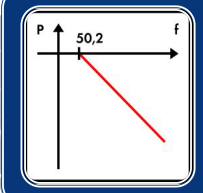
Source: SEPATop10.org

Advanced Inverters



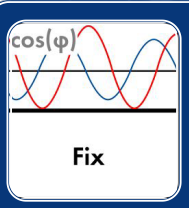
Remote Dispatch

- Ability to control PV generation to a specified % of nominal power



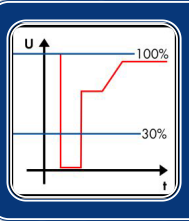
Over Frequency Response

- Ability to automatically reduce active power with frequency deviations



PF Control Mode

- Ability to supply/absorb reactive power during PV operation
- Ability to control Power Factor



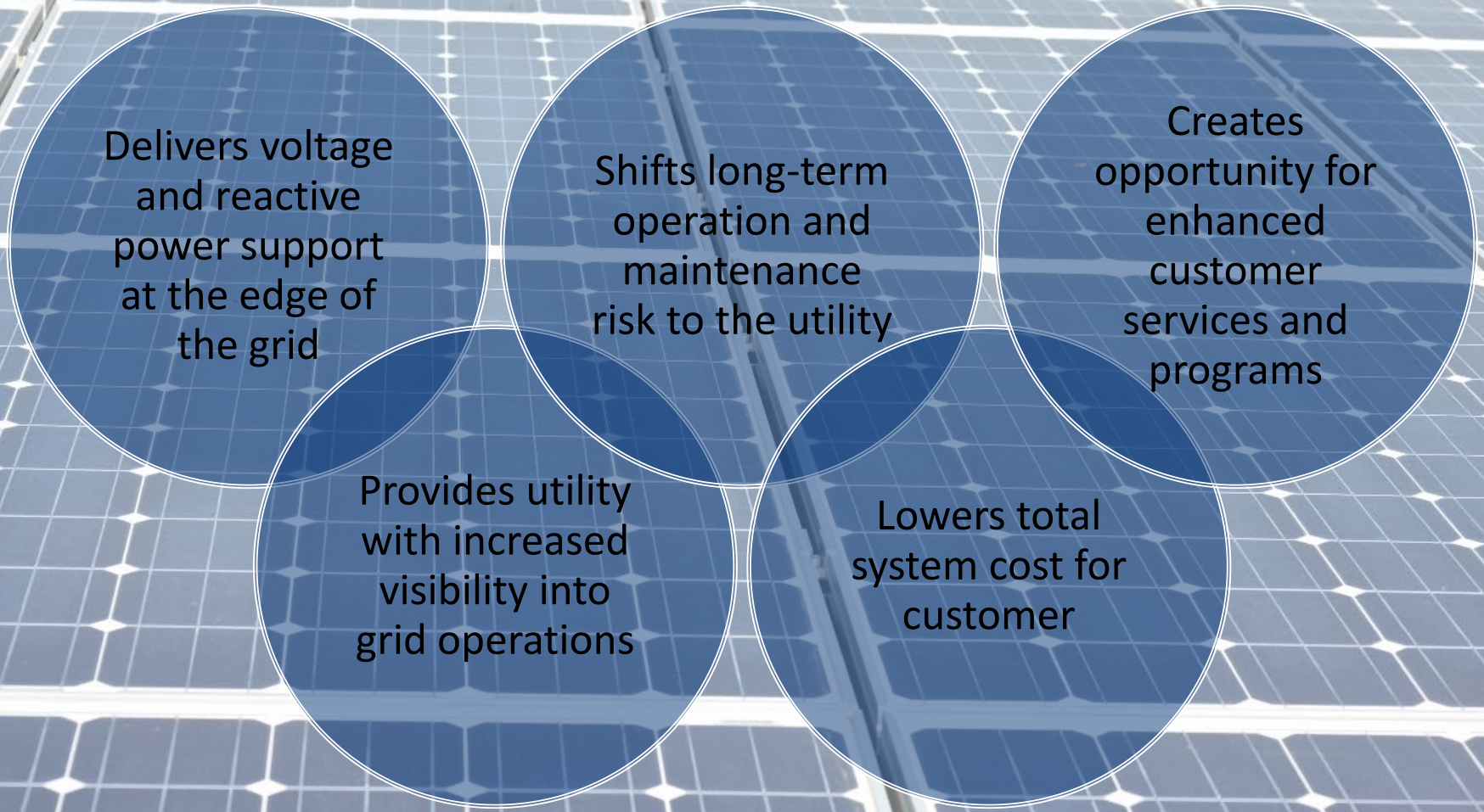
Fault Ride-Through

- Ability to supply reactive current during fault ride-through period

- Significant promise in this technology
- Grid-reactive settings currently leveraged in Germany
- Potential for remote settings and controls on the horizon
  - Challenges on two-way communications still being researched

Source: German Association of Energy and Water Industries (BDEW) Guidelines

Advanced Inverter Ownership Rationale

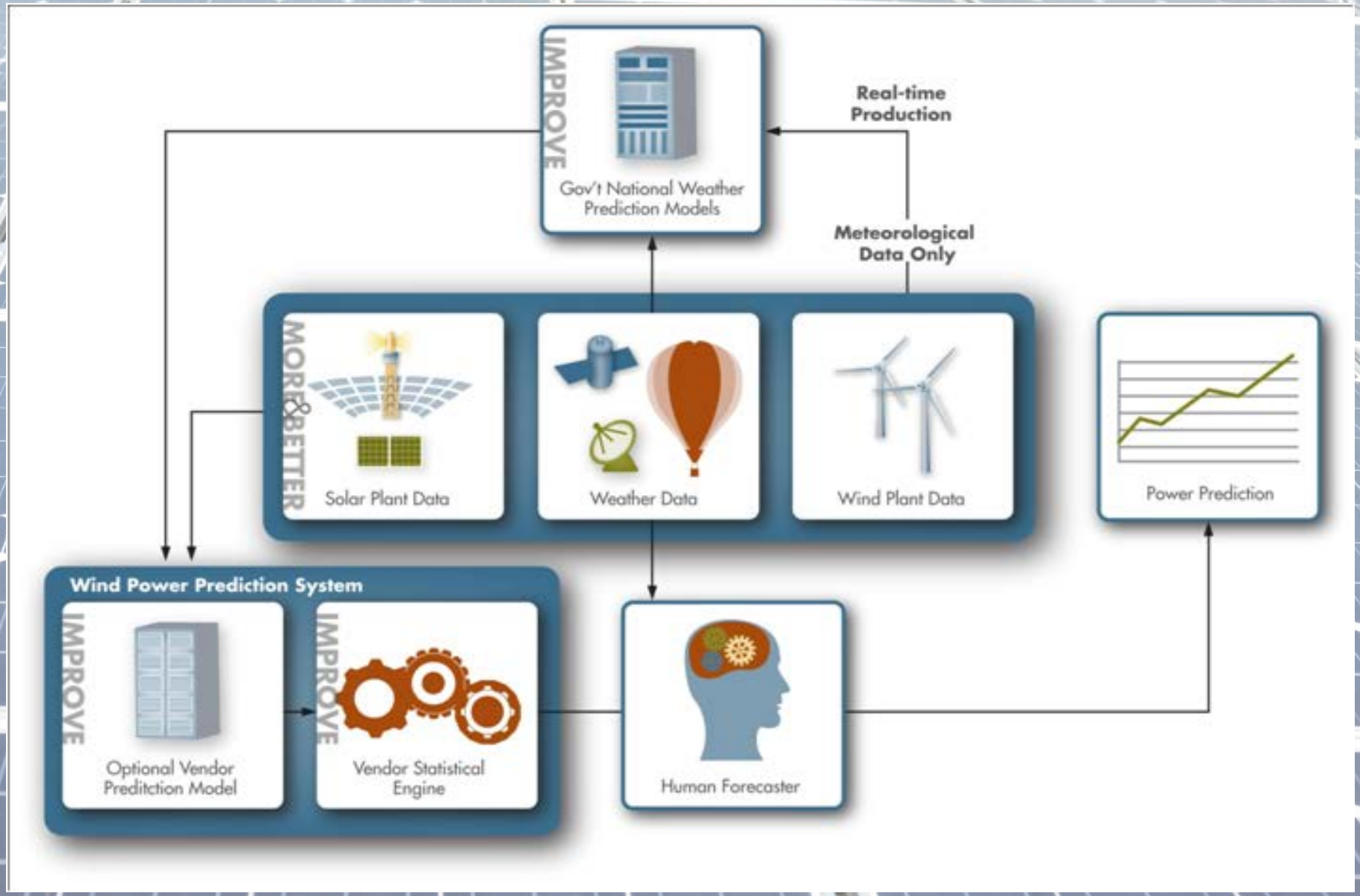


Energy Storage Applications by Technology

	ELECTRIC ENERGY TIME SHIFT	ELECTRIC SUPPLY CAPACITY	ELECTRIC SUPPLY RESERVE CAPACITY-SPINNING	FREQUENCY REGULATION	RELIABILITY & QUALITY	RENEWABLES CAPACITY FIRMING	VOLTAGE SUPPORT
Advanced Lead Acid Battery	●		●	●		●	●
Lithium Ion Battery	●	●	●	●	●	●	●
Lithium Iron Phosphate Battery	●			●		●	●
Sealed Lead Acid Battery	●				●	●	
Sodium Sulfur Battery	●	●	●	●	●	●	●
Vanadium Redox Flow Battery	●	●	●		●	●	●

Source: Makhyoun, SEPA, 2014

Solar Energy Forecasting



Forecasting Inputs

1.Actual input history from EMS (solar/wind generation)

2.Calendar variables

1.Time of day

2.Day of the week

3.Season

4.Previous day/hour/interval weather

5.Holidays

6.Sunrise/Sunset

Actual and Forecast Weather:

1.Temperature

2.Dew point

3.Wind speed and direction

4.Cloud coverage

5.Irradiance

6.Barometric pressure


Solar Market Overview

Drivers for DG Market Growth

Core DG growth drivers:

Fundamental Economics

- Upward pressure on utility costs/rates
- Declining PV costs (60%/3 yrs)

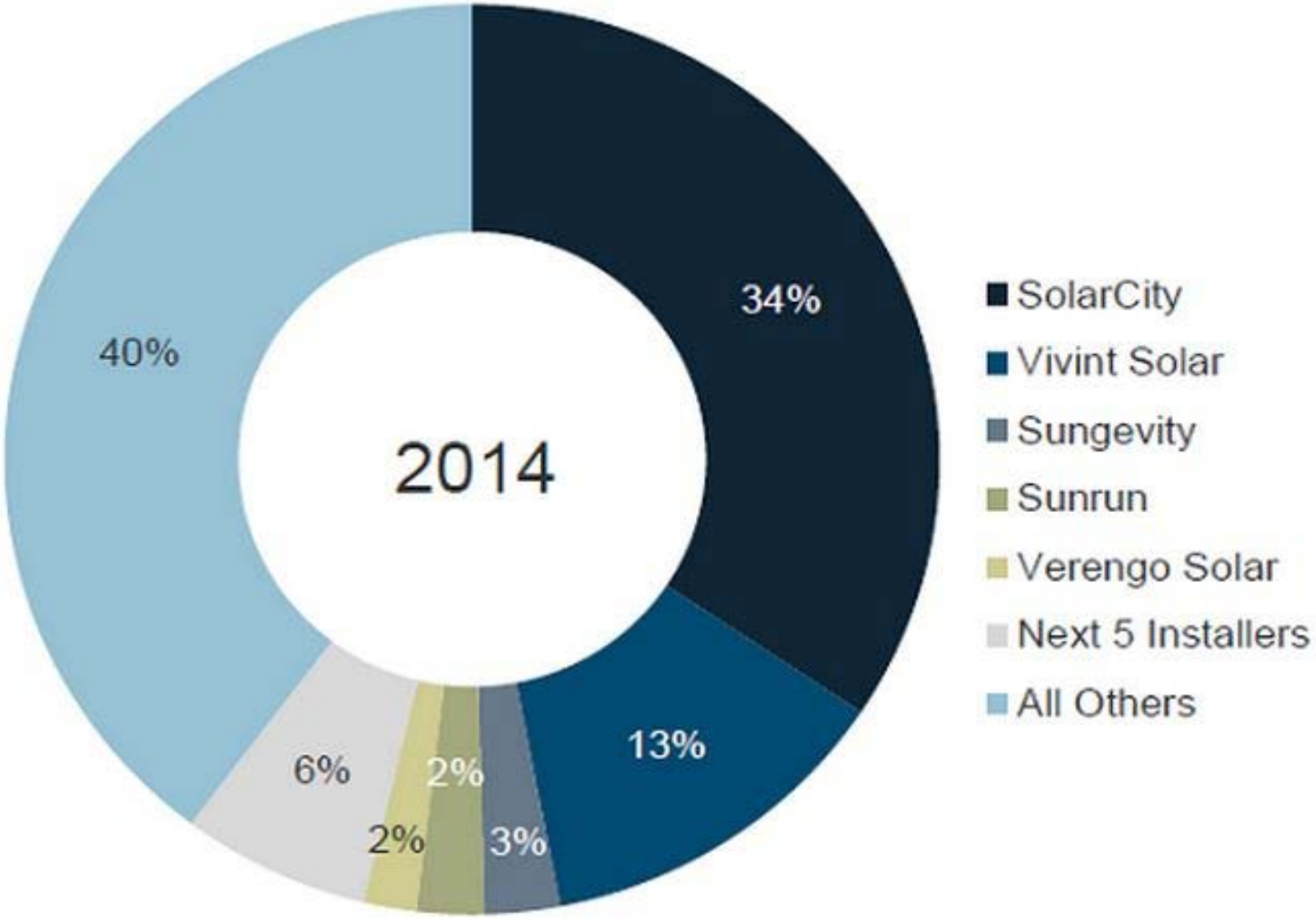
Policy

- State Renewable Energy Standards
- Net Metering
- Federal Incentives (ITC/MACRS)

Consumer Preference

- Innovation in customer financing (leases &PPAs)
  - Leveraging cost of capital to turn ROI to cash flow
  - Securitization & public funding
- Increasing demand by customers for choice

Third-Party Sales



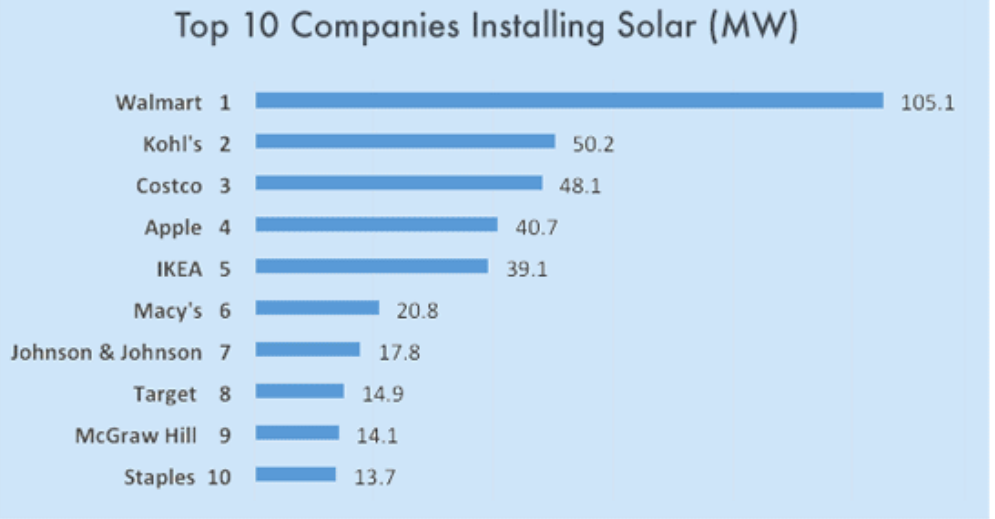
Source: U.S. PV Leaderboard, Q1 2015

DG Growing Among C&I Customers

Despite rates that contain less subsidy

- 569 MW currently installed at over 1,000 locations by top 25 corporate solar users
- Apple recently reached agreement to buy 130 MW from First Solar
  - $848M transaction
  - Largest solar procurement deal for a non-utility; nearly triples Apple's stake in solar

Fact: Since 2012, top U.S. companies have ramped up their solar capacity by more than 100 percent.



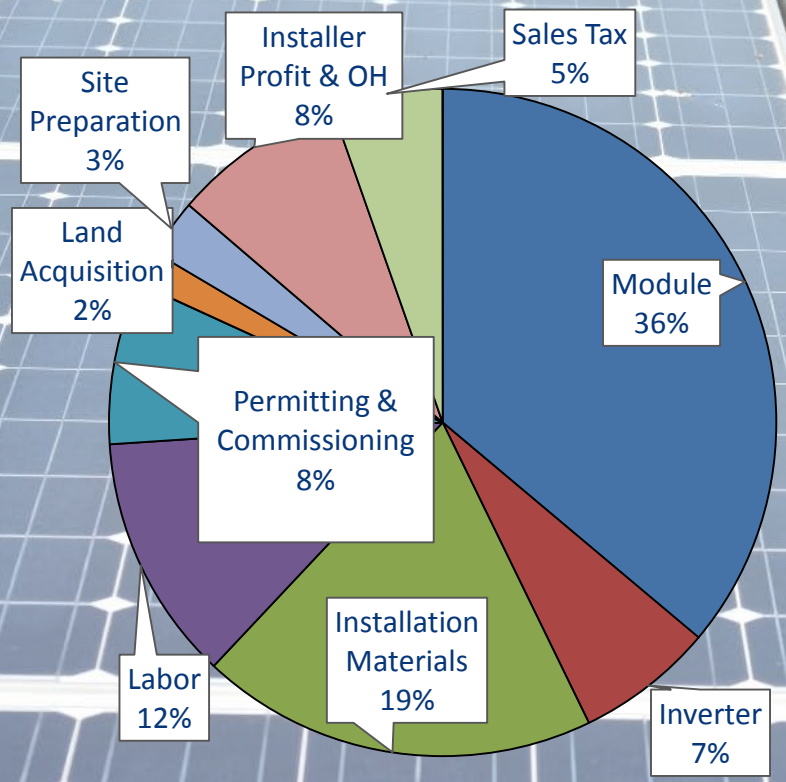
SEIA 2014 Solar Means Business Report


Pricing Update

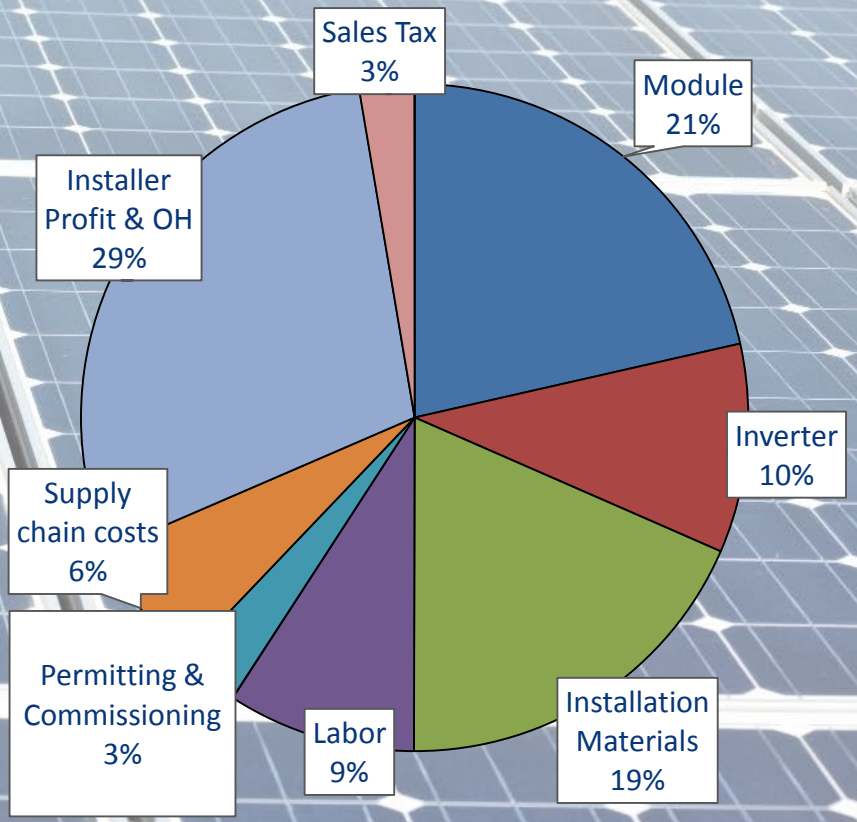
Sources of Cost

Economies of scale play a significant role in solar cost efficacy

Utility-Scale Fixed – $1.80/W



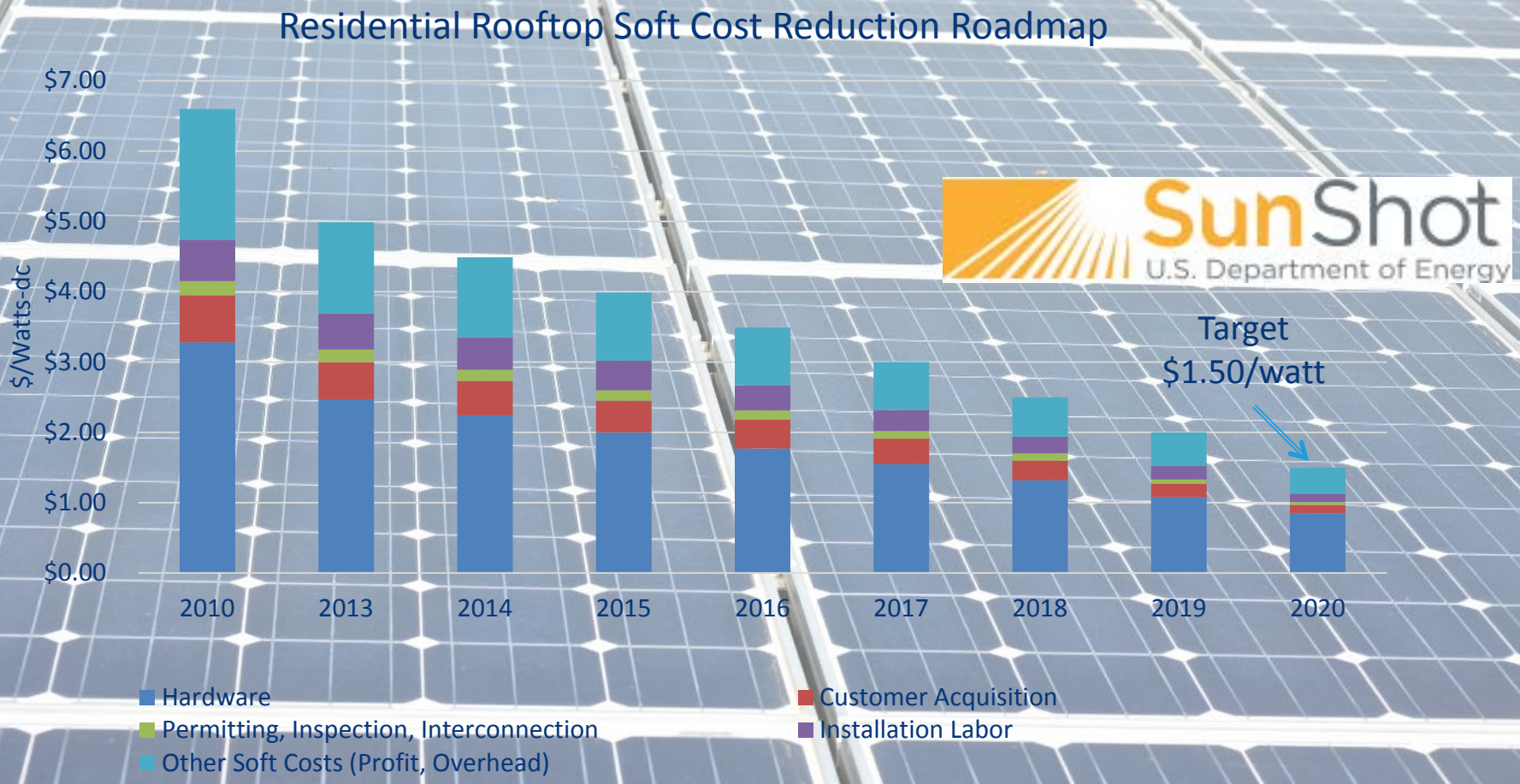
Residential Rooftop - $3.29/W



NREL/DOE "Q2/Q3 '14 Solar Industry Update" (October 31,2014)

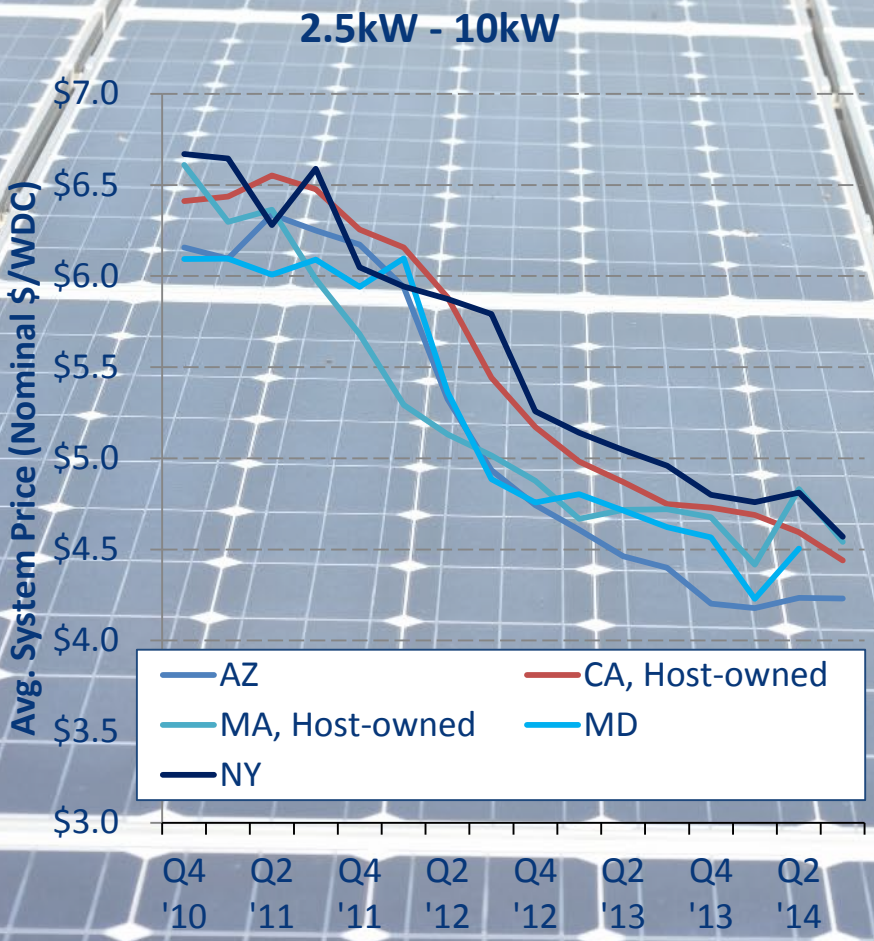
Cost Declines Key Focus of DOE

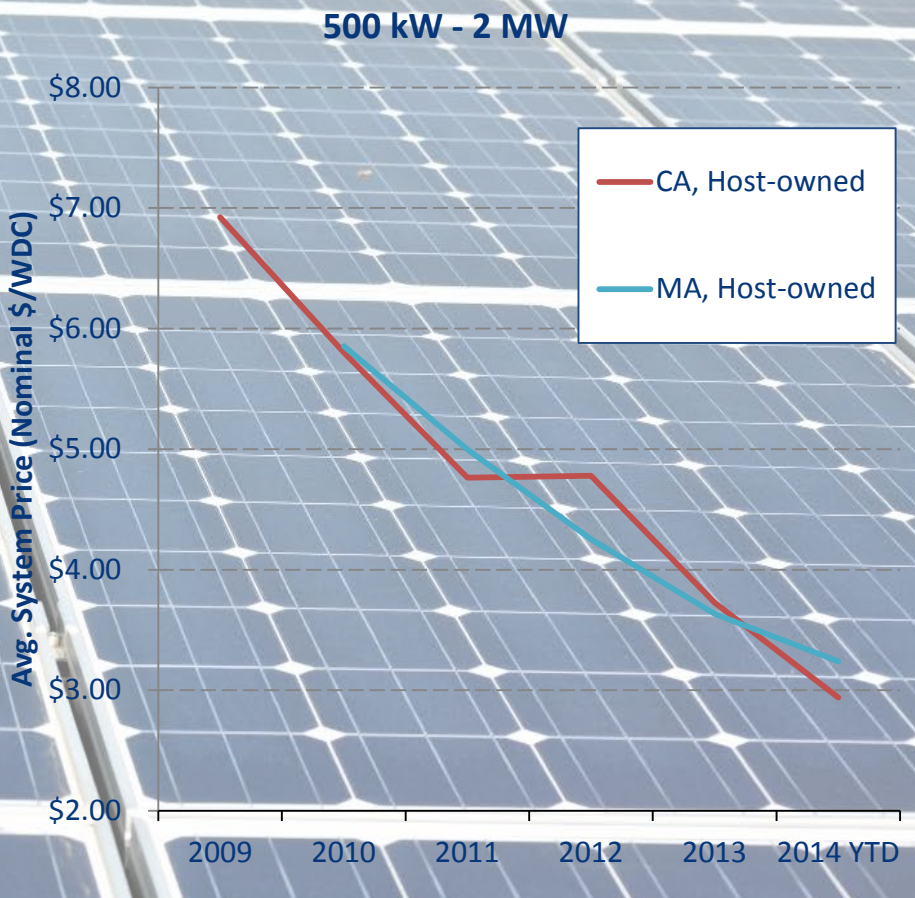
Residential solar costs are projected to continue cost declines to $1.50/watt in 2020



Non-Hardware ("Soft") Cost-Reduction Roadmap for Residential and Small Commercial Solar Photovoltaics, 2013-2020 (NREL, Aug 2013)

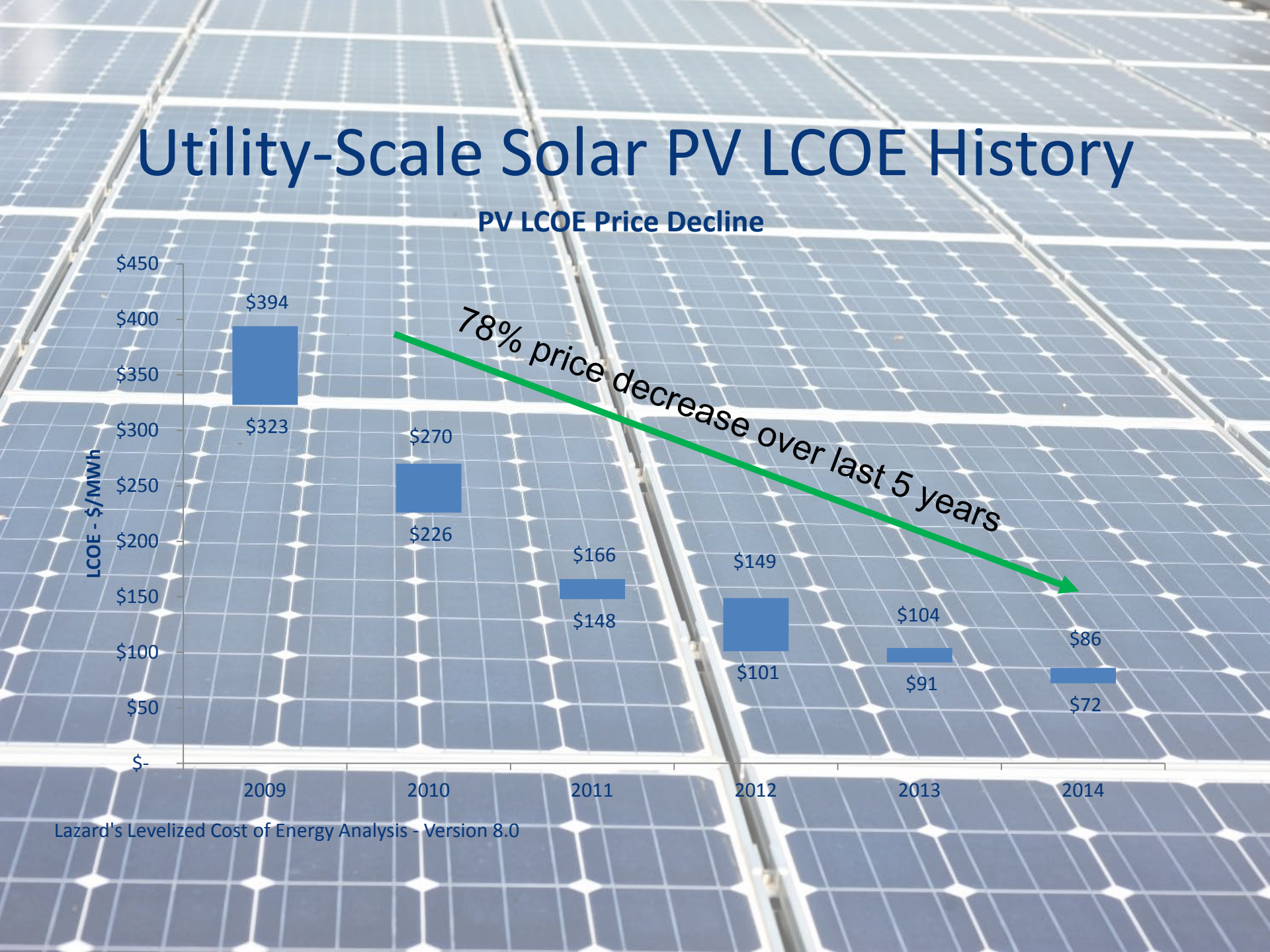
PV System Pricing Update – Distributed





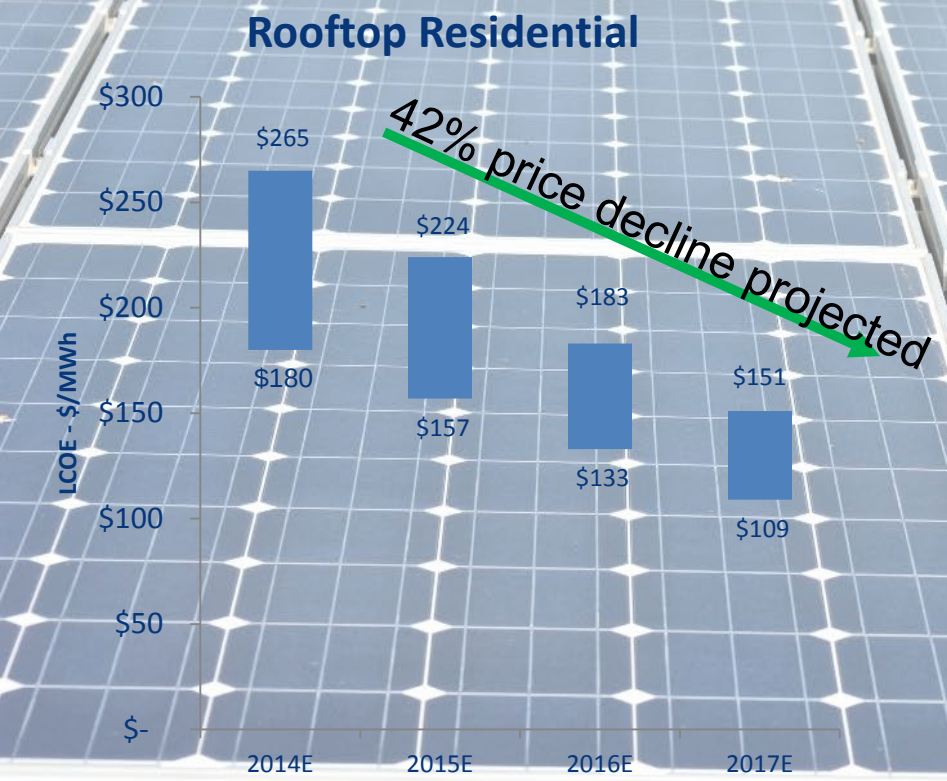
NREL/DOE "Q2/Q3 '14 Solar Industry Update" (October 31,2014)

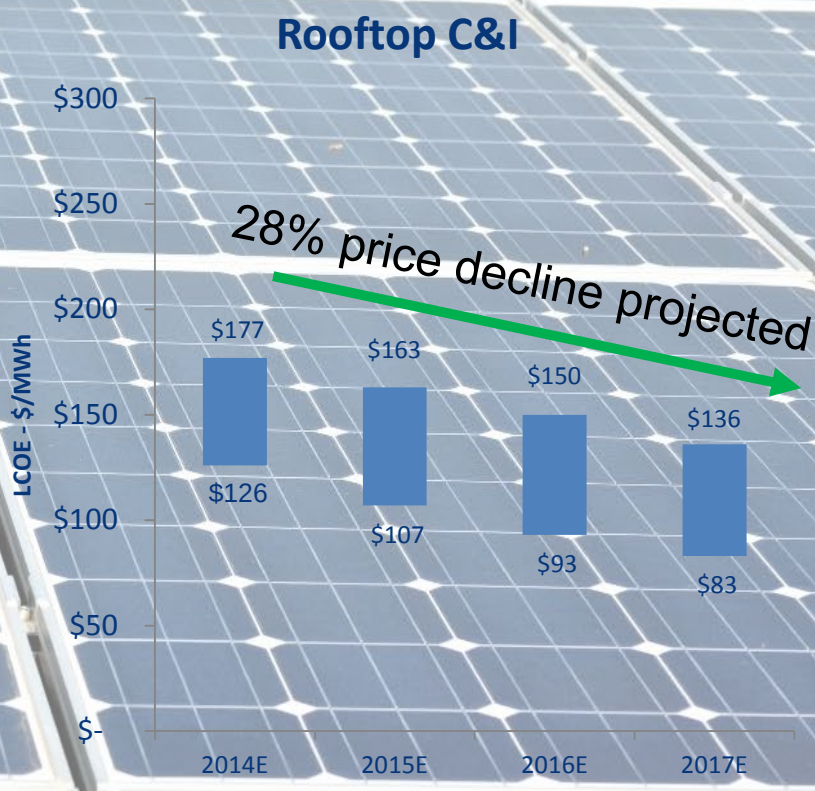
Utility-Scale Solar PV LCOE History



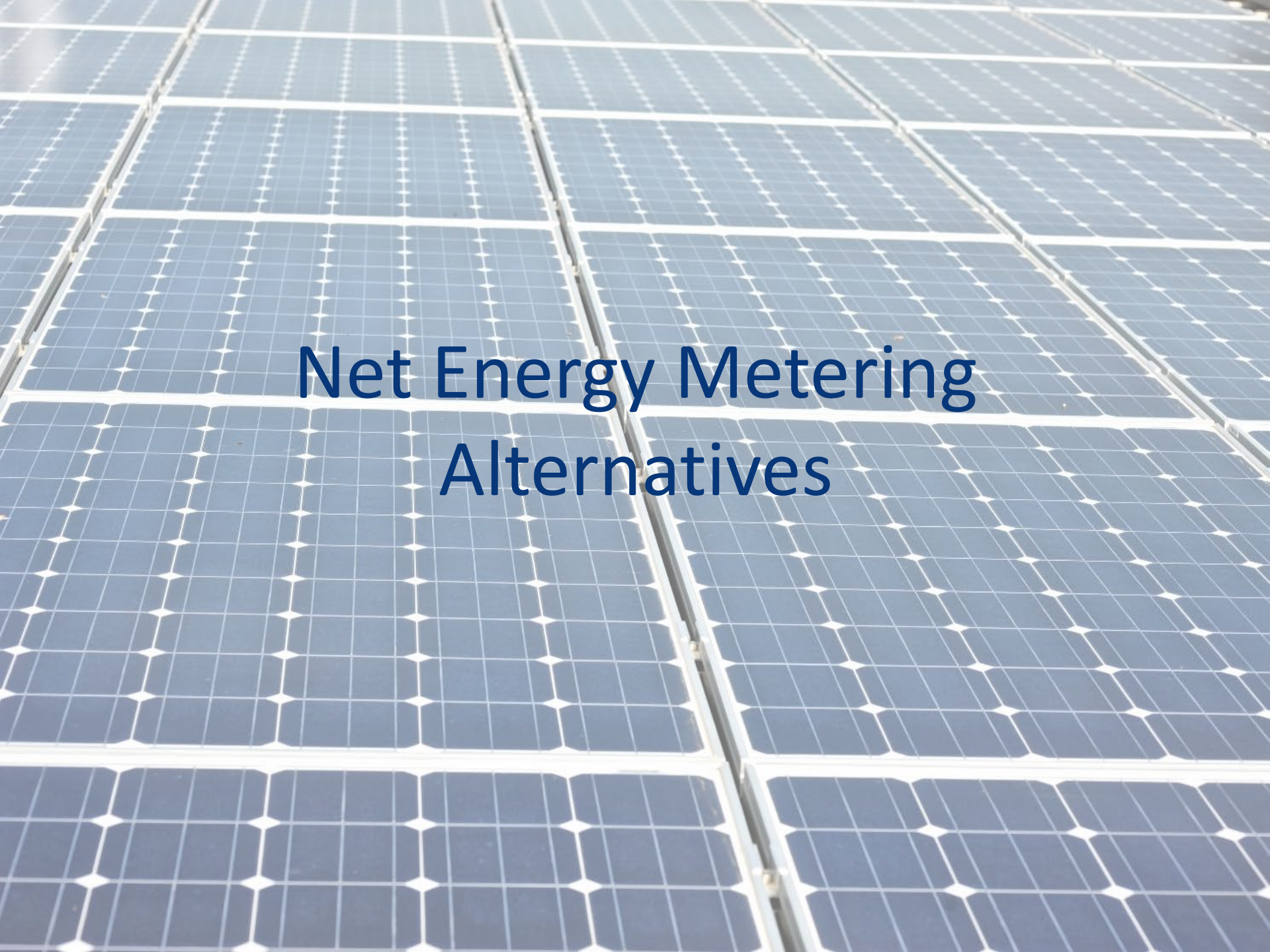
Lazard's Levelized Cost of Energy Analysis - Version 8.0

LCOE Forecast Comparison





Lazard's Levelized Cost of Energy Analysis - Version 8.0



Net Energy Metering Alternatives

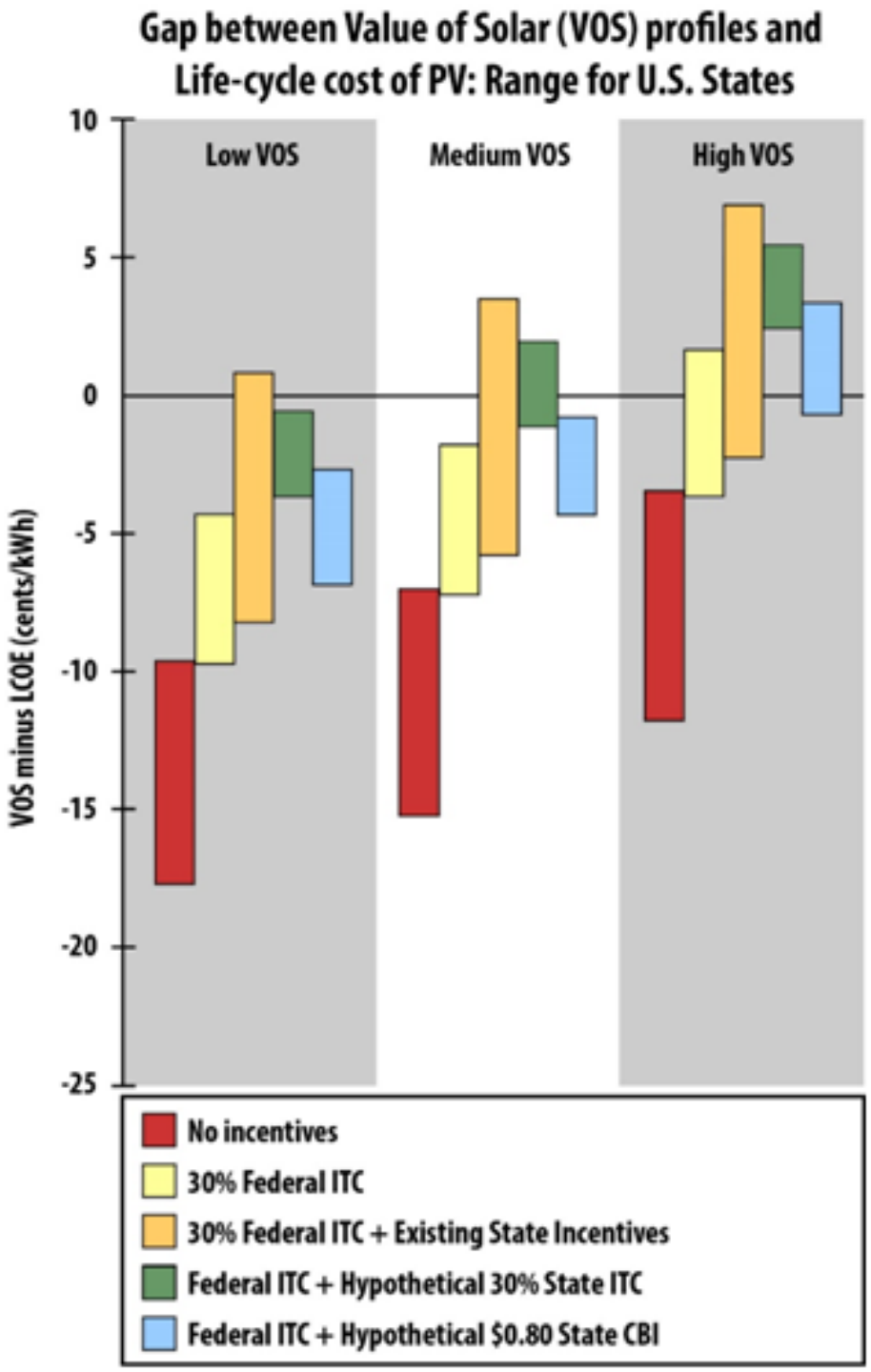
Addressing Solar DG Transaction

CAMP 1 — CAMP 2

Business as Usual | **Reforming the Solar Customer Transaction (NEM/rate reform)**

RATE CONSTRUCT

Single Transaction (Rate) Approach				Two or More Transactions (Rates)	
Apply NEM	Reform Existing Rates (all customers or solar only)			Solar Rate	Reform All Rates
MODEL					
Current Rates	Increased Fixed Charge and/or Minimum Bill	Demand Charge	Stand-by or Solar Charge	Independent Energy Sale and Solar Purchase Rates	Value of Services
ATTRIBUTES					
• Currently applicable rates result in an acceptable transaction • Solar penetration does not warrant action	• Add or increase basic service charge ($/month) • Raise minimum bill requirements ($/month)	• Add or increase customer fee for demand ($/kW/month)	• Charge for stand-by capacity, based on DG system size ($/kW/month or ($/kW/yr)	• Retain existing rates for services provided from utility to cust. • Establish second rate to purchase from customer	• Design rates to reflect itemized services from utility to cust. and from cust. to utility



Value of Solar

- Price-support Market (LCOE-PV > VOS Tariff
- Transitional Market (LCOE-PV ≈ VOS Tariff)
- Price-competitive Market (LCOE-PV ≤ VOS Tariff)

Source: NREL; SEPA, 2015

Emerging Discussions

Community Solar and Utility Rooftop Ownership

Utility-Owned Residential Rooftop Models

APS Rooftop Ownership

- Utility installed and owned rooftop PV
- 10 MW cumulative program size for about 1,500 customers
- Customers get a $30 monthly bill credit for 20 years (lease payment for rooftop real estate)
- Competitive process using local contractors
- Precedent – APS already has two rooftop ownership models in place (Flagstaff pilot project and Schools & Government)

Tucson Electric Power

- Utility owned rooftop PV
- 3.5 MW or about 600 customers
- Customers get a fixed monthly rate for 25 years
  - Flat monthly bill (e.g., $100)
  - Usage band of +/- 15% off of average historical consumption
- Competitive process using local contractors
- Strong interest already in program; first installations about to occur

How Community Solar Works

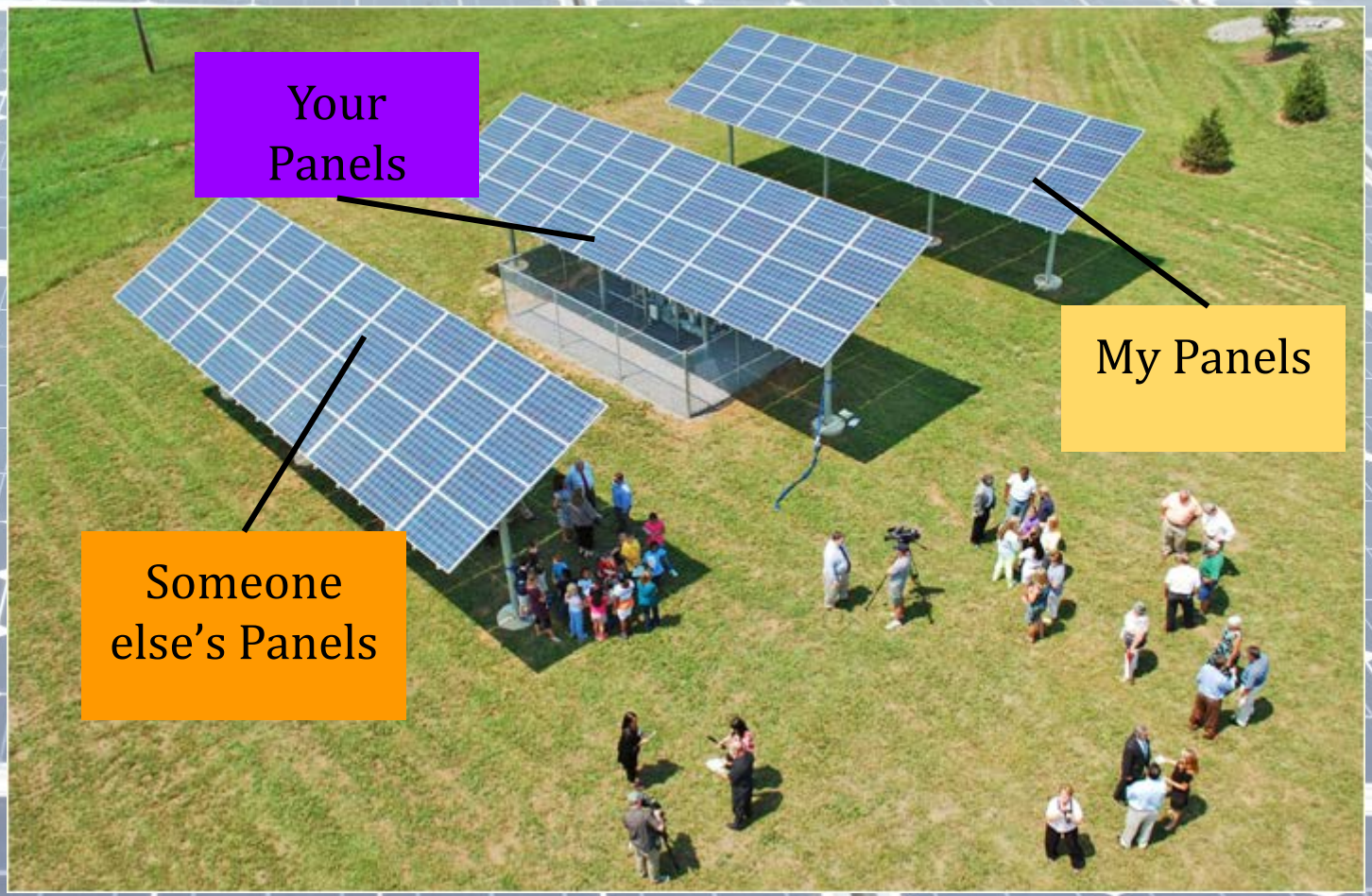


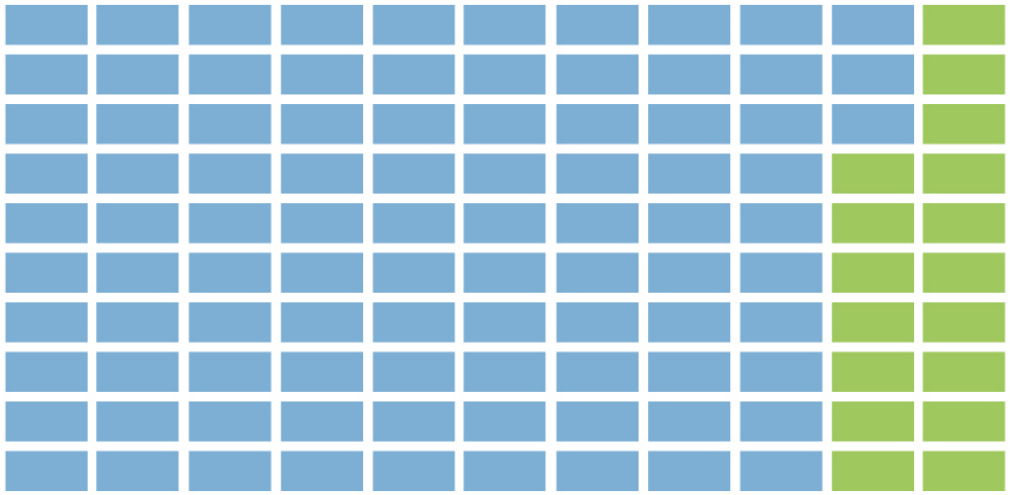
Photo: Duck River Electric Cooperative

Program Example:

Orlando Utilities Commission

- Offer: 1 kW blocks, up to 15 kW at $0.13/kWh fixed based on actual plant generation; net metered bill credit
  - Equates to $.025/kWh (residential) or $.015/kWh (commercial) more than current customer rates
- Phase 1 Supply: 400 kW
- Term: 25 years
- Performance risk: No guarantee
- Additional details:
  - Customers pay a $50 deposit (refundable after 2 years)
  - Fully subscribed in 6 days; active waiting list for Phase 2

What are Participants Buying?



Capacity Offering **74%**

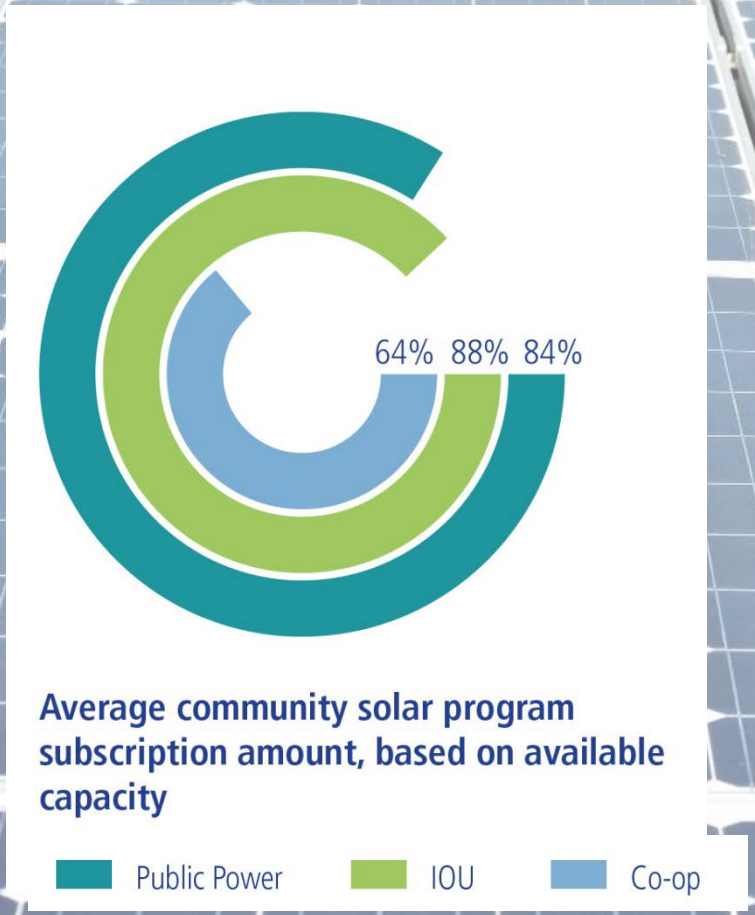
Rate Offering **17%**

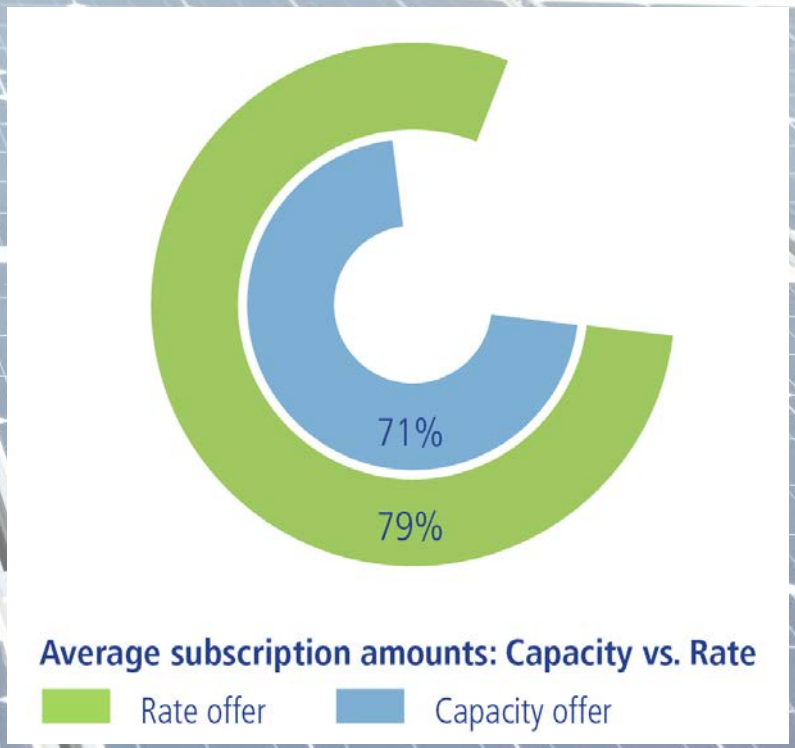
A breakdown of active and planned community solar program structures.

Capacity Offering	Rate Offering
Customer purchases or leases blocks of capacity – often in panel increments – and, in some cases, receives a virtual or simulated net metering rate	Customer purchases blocks of energy output, measured in kWh, at a predetermined and sometimes fixed rate, potentially offering a hedge against higher future utility rates

"Expanding Solar Access Through Utility-led Community Solar", SEPA (September 2014)

How Successful are They?





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