Solar 101

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Agenda

- Introduction
- Section 1: Solar Technology
- Section 2: PV Siting and Performance
- Section 3: Solar on the Grid
- Section 4: Solar Markets & Financing
  
  10 Minute Break

- Section 5: Solar Market Trends
- Section 6: Key Federal and State Policies
- Section 7: Opportunities and Challenges Looking Forward
SEPA’s Mission

To facilitate the electric power industry’s smart transition to a clean energy future through education, research, standards, and collaboration.

SEPA’s work is guided by four key pathways
About SEIA

The Solar Energy Industries Association (SEIA®) is the driving force behind solar energy and is building a strong solar industry to power America through advocacy and education. As the national trade association for the U.S. solar energy industry, which employs more than 242,000 Americans, we represent all organizations that promote, manufacture, install and support the development of solar energy. SEIA works with its 1,000 member companies to build jobs and diversity, champion the use of cost-competitive solar in America, remove market barriers and educate the public on the benefits of solar energy.
WHO
ARE
YOU?
Solar Technology
Terminology

**Power = Voltage x Current**
- Measures instantaneous draw of an electrical load, or the output capacity of a generator
  - Watt (W)
  - Kilowatt (kW)
  - Megawatt (MW)

**Energy = Power x Time**
- Sustained delivery of a certain amount of power
  - Megawatt-hour (MWh)
  - Kilowatt-hour (kWh)

**Direct Current (DC) and Alternating Current (AC)**
Photovoltaic Panels

Source: Revision Energy
Photovoltaic System

Frame
Glass
Encapsulant
Solar Cells
Encapsulant
Backsheet
Junction Box

Source: DuPont

Solar Panels
Mounting System
Utility Grid
Inverter

Source: GoGreenSolar
Types of PV Panels

Monocrystalline  Polycrystalline  Thin Film
Solar Thermal Energy

Concentrated Solar Power (CSP)

Source: U.S. Department of Energy

Solar Water Heating

Source: U.S. Department of Energy
Questions?
PV Siting and Performance
**PV Array Orientation & Tilt**

![Diagram of PV array orientation and tilt]

<table>
<thead>
<tr>
<th>Pitch Angle</th>
<th>Location</th>
<th>Annual Savings*</th>
<th>Approx. Cost of Electricity ($/kWh)</th>
<th>Avg. Annual Solar Radiation (kWh/m²*2/day)</th>
<th>Estimated Electricity from a 5kW System** (kWh)</th>
<th>Production Ratio***</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°</td>
<td>New York</td>
<td>$1,094</td>
<td>$0.18</td>
<td>4.46</td>
<td>6,075</td>
<td>1.22</td>
</tr>
<tr>
<td>5°</td>
<td>New York</td>
<td>$979</td>
<td>$0.18</td>
<td>4.02</td>
<td>5,438</td>
<td>1.09</td>
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<tr>
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<td>Washington, D.C.</td>
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<td>$0.14</td>
<td>4.69</td>
<td>6,323</td>
<td>1.26</td>
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<tr>
<td>5°</td>
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<td>$798</td>
<td>$0.14</td>
<td>4.26</td>
<td>5,703</td>
<td>1.14</td>
</tr>
</tbody>
</table>

* Annual electric bill savings (cost of electricity x electricity produced)  
** Assumes on 80% derate factor, 180 degree azimuth, array tilt -equal to state's latitude  
*** Production ratio (electricity produced/size of system)

Source: EnergySage
Tracking Systems

Single Axis

Dual Axis
Solar Energy as a Resource
Project Development Phases

1. Design
   - Siting
   - Financing
   - Engineering

2. Development
   - Real Estate
   - Permitting
   - Construction

3. Operation
   - Commissioning
   - Monitoring
   - O&M
   - Decommissioning
Questions?
Solar on the Grid
# The Traditional Grid

<table>
<thead>
<tr>
<th>Generation</th>
<th>Transmission and Distribution</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Generating Station</td>
<td>2 Step up Transformer</td>
<td>4 Step down Transformer</td>
</tr>
<tr>
<td>2 Step up Transformer</td>
<td>3 Transmission Transformer</td>
<td>5 Subtransmission Customer</td>
</tr>
<tr>
<td>3 Transmission Transformer</td>
<td>4 Step down Transformer Transformer</td>
<td>6 Customers</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Energy
In Front of and Behind the Meter
Renewable Generation Growth

U.S. annual renewable generation, by fuel type

- Solar
- Wind
- Hydro
- Other renewables

U.S. annual net generation, wind

U.S. annual net generation, solar

Source: U.S. Energy Information Administration, Electric Power Monthly
Duck Curve

Electric power demand from March 31, 2012 – CAISO
Source: U.S. Department of Energy
Questions?
Solar Markets
Residential Solar Photovoltaic (PV)

- Typically rooftop installations on single or multi family residential properties
- Capacity: 1-15 kW (average 7 kW)
  - Sized to account for majority of yearly household electricity use (but not more than)
- Normally grid-connected
  - Uses net energy metering (NEM)
  - Residential entity is electricity off-taker
- Average cost: $2.87/watt
  - Average system cost: $20,000
- Finance Options
  - Third Party Ownership (Lease/PPA)
  - Debt Financing through installer
  - Self-financed
- 23% Market Share in 2018
Commercial and Industrial Solar Photovoltaic (PV)

- Roof or ground-mounted installations on commercial, industrial, government or non-profit properties
- Capacity: 1-5000+ kW (average 100 kW)
  - Sizes vary widely depending on project objectives
- Normally grid-connected
  - Uses net energy metering (NEM)
  - Commercial entity is electricity off-taker
- Average cost: $1.45/watt
  - Average system cost: ranges widely
- Finance Options
  - Third Party Ownership (PPA)
  - Debt Financing through installer
  - Self-financed
- 14% Market Share in 2018
Typically ground-mounted installations in a variety of open spaces (desert, brownfield, grassland, other reclaimed land)

- Capacity: 1+ MW (average 12 MW)
  - Can be as large as 500 MW
- Sells electricity on wholesale market
  - Utility or Independent Power Producer-owned
  - Electricity off-taker is utility or large corporate
- Average cost: $0.90/watt (fixed tilt)
  - Average system cost: ranges widely
- Finance Options
  - Multi-party arrangements
  - Debt, Equity, Tax Equity, Loan Guarantee
- 58% Market Share in 2018
Community Solar (PV)

- Ground-Mounted Installations on Greenfields or Brownfields
- Capacity: Generally 1 – 5 MW
  - Smaller or larger projects are possible depending on state regulations
- Utility-Led or Third-Party Led
  - Electricity from Project is sold to residential and commercial customers
  - Typically executed through PPA or virtual PPA
- Average cost: $1 - 2/watt
  - Hardware and installation cost profile similar to utility-scale
  - Customer acquisition and servicing increases all-in cost
- Finance Options
  - Multi-Party Arrangements (includes subscriber deposits)
  - Debt, Equity, Tax Equity
- 6% Market Share in 2018
Solar as an Economic Engine

Solar Industry Jobs by Sector

Number of Jobs

- Installation
- Manufacturing
- Sales & Distribution
- Operations & Maintenance
- Other

Years: 2010 to 2018

Data Source: SEIA
Solar Companies by Business Type

- Contractor/Installer: 43%
- Manufacturer/Supplier: 18%
- Other: 14%
- Project Developer: 7%
- Distributor: 7%
- Consultant: 6%
- Service Provider: 5%

Source: SEIA, National Solar Database
QUESTIONS?
10 Minute Break
Solar Market Trends
U.S. Solar Market Through Q2 2019

• Over 69 GW of total solar capacity now installed
  • Average Annual Growth Rate of 50% over last 10 years
  • Generates enough electricity to power over 13 million homes

• Solar generation offsets more than 78.7 million metric tons of CO2 emissions each year, equivalent to:
  • Taking 16.7 million vehicles off the road
  • Planting nearly 2 billion trees
  • Shuttering 20 coal power plants

• In 2018, a new solar project was installed in the U.S. every 100 seconds.
  • The solar market has grown from installing less than 1 GW annually 10 years ago, to more than 12 GW in 2019

• Over the next 5 years, the U.S. will install 81 GW, 61% more than was installed over the last 5 years
  • By 2021, there will be over 100 GW of solar installed in the U.S.

• There are now more than 2 million solar installations in the U.S.
  • After reaching 1 million in 2016, it took just over two years to reach 2 million, with 4 million expected by 2023
Growth in Solar led by Falling Prices

U.S. Solar PV Price Declines and Deployment Growth

Source: SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight
Solar is Price Competitive With All Other Technologies

Unsubsidized Levelized Cost of Energy for Select Technologies

Source: Lazard 12.0
Solar’s Share of New Capacity Has Grown Rapidly

Annual New Electric Capacity Additions

Source: SEIA/Wood Mackenzie
Power & Renewables; FERC
U.S. Solar Industry – a 50 State Market

Top 10 States

<table>
<thead>
<tr>
<th>State</th>
<th>Installed Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>25,773 MW</td>
</tr>
<tr>
<td>North Carolina</td>
<td>5,601 MW</td>
</tr>
<tr>
<td>Arizona</td>
<td>3,873 MW</td>
</tr>
<tr>
<td>Nevada</td>
<td>3,502 MW</td>
</tr>
<tr>
<td>Florida</td>
<td>3,337 MW</td>
</tr>
<tr>
<td>Texas</td>
<td>3,029 MW</td>
</tr>
<tr>
<td>New Jersey</td>
<td>2,911 MW</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>2,567 MW</td>
</tr>
<tr>
<td>New York</td>
<td>1,775 MW</td>
</tr>
<tr>
<td>Utah</td>
<td>1,671 MW</td>
</tr>
<tr>
<td>Georgia</td>
<td>1,571 MW</td>
</tr>
</tbody>
</table>

Source: SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight
Residential Market Continues to Diversify

Residential Solar PV Installations

Source: SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight
Community Solar, Corporate Procurement Boost Non-Residential Market

Non-Residential Solar PV Installations

Source: SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight
Utility-Scale Project Pipeline

U.S. Utility-Scale PV Pipeline

Operating: 38,972 Megawatts-DC
Contracted (PPA Signed): 29,257 Megawatts-DC
Announced (Pre-Contract): 56,649 Megawatts-DC

Under Construction: 8,655 Megawatts-DC

Source: SEIA/Wood Mackenzie
Power & Renewables U.S. Solar Market Insight
QUESTIONS?
Federal and State Policy
Solar Growth with the Investment Tax Credit

- 30% Tax Credit against Federal Income Tax
- Can be claimed on total system costs (materials and labor)
- Actually two separate credits
  - Section 25D (Residential)
  - Section 48 (Commercial)
Extending the ITC

- Extended in late 2015 at 30% through the end of 2019
  - Drops to 26% in 2020 and 22% in 2021
  - After 2021, Commercial credit drops to 10%, Residential credit expires
- Commence Construction language added
  - Projects must be placed in service before the end of 2023
- SEIA leading the push on new ITC Extension
  - Bill introduced that would extend 30% ITC five additional years, with phase down beginning in 2025
  - A 10 year extension would lead to 82 additional GW
International Trade

- China/Taiwan AD/CVD Cases (2012 & 2014)
  - Resulted in tariffs on imported cells and panels from China and later, Taiwan
  - Tariffs range widely depending on manufacturer
- Section 201 Case (2016 & 2017)
  - Resulted in tariffs on imported cells and panels from most countries
  - Tariff of 30% in Feb 2018, dropping 5 percentage points each year thru Feb 2022
  - 2.5 GW Quota for cells
- Aluminum and Steel Tariffs
  - Full impact TBD, but impact on solar is marginal
- Section 301 Tariffs
  - Minor impacts on additional solar goods, such as inverters
201 Impact on Price and Demand

- 201 Case announced in spring 2017, leading to increased demand for modules in U.S. and corresponding increase in price
- Prices continue to climb until resolution of case leads to market certainty and demand reductions
- Reduction in Chinese market subsidies pushes leads to module oversupply, and mitigates impacts of tariffs
- Tariffs continue to push domestic prices up relative to global prices
- 13% reduction in demand expected over 4 year tariff life
  - Mid term review in December 2019/January 2020

**Multicrystalline Module Prices**

- **Source:** Wood Mackenzie Power & Renewables
Net Metering (NEM)

- **Source**: Solar panels and wind turbines collect energy.
- **Inverter**: The inverter converts the electricity from direct current (DC) to alternating current (AC).
- **House**: The energy is used in your home, school, or business.
- **Utility Pole**: Distribution of excess energy through utility distribution system.
- **Meter**: The bidirectional meter indicates energy usage and excess energy produced.
Issues in NEM and Rate Design

• Public Utilities Commission
  • Determines rate design through periodic legal proceedings (Rate Case)

• Export Rate
  • Price at which consumer is compensated for electrons exported to grid
  • Traditionally set at Retail Rate ($/kWh)

• Demand/Fixed Charges
  • Flat charges used to offset utility infrastructure costs

• Time-of-Use Rates
  • Volumetric rates that vary depending on the time of day.
Utility-Scale Demand Drivers

- Renewable Portfolio Standards (RPS)
- Solar Renewable Energy Credits (SREC)
- Public Utility Regulatory Policies Act (PURPA)
- Community Choice Aggregators (California)
- Green Tariffs
Policy Miscellany

- Block Incentive Programs (NY, MA, IL)
  - SREC Markets
- Tax Incentives
  - Income (Personal and Corporate), Property and Sales Tax
- Codes and Standards
- Permitting
- PV Recycling
- Federal Agencies
  - DOE, Interior, EPA, FERC

![Residential Solar PV System Pricing](chart)

Source: Wood Mackenzie Power & Renewables
QUESTIONS?
Opportunities and Challenges
Looking Forward

- 17% growth expected in 2019 due primarily to growth in utility-scale market
- Growth across all market segments in 2020 and 2021 as projects aim to come online before full phase down of ITC
- DG Markets see biggest impact of ITC expiration in 2022, while utility-scale takes advantage of commence construction out to 2023
- By 2024, prices are low enough across all market segments to lead to modest growth, driven by the opening of new markets
Looking Forward

• Challenges
  • Future of DG Compensation
  • Diminishing returns at higher penetrations
  • Consumer Protection
  • Flat Electricity Demand
  • Customer Acquisition/Soft Costs

• Opportunities
  • Soft Costs
    • Australia Resi Costs: $1.50/watt
  • Storage
  • EVs/Electrification
  • Carbon Regulation
  • Coal Retirements
  • Finance
QUESTIONS?
Contact Us