Moving Towards 100% Renewable Power Goals

Sean Gallagher
Vice President, State Affairs
Solar Energy Industries Association
December 7, 2018
Agenda

• Quick Overview of the Solar Industry
• Why are we talking about 100% Renewables?
• Capabilities and Characteristics of Renewables
• Flexibility
  • Grid Level
  • Demand flexibility
  • Market Reform
Who We Are

About SEIA – the national trade association for the solar industry
Who We Represent

SEIA Members represent every aspect and vertical within the solar industry

Manufacturers
Installers
Project Developers
...and many more!
Over the last ten years, the U.S. solar industry has grown at an average rate of 59% each year.
An American Economic Success Story

The solar workforce has grown by 168% since 2010

In 2016, 1 out of every 50 new jobs in the U.S. was a solar job
Geographic Snapshot

TOP 10 STATES (MW)
1. California – 22,777
2. North Carolina – 4,491
3. Arizona – 3,613
4. Nevada – 2,658
5. Texas – 2,624
6. New Jersey – 2,526
7. Massachusetts – 2,226
8. Florida – 1,943
9. Utah – 1,627
10. Georgia – 1,556
Falling Prices Drive Growth

• The solar industry’s rapid growth is largely due to declining prices. PV prices have fallen 80% in the last decade and 52% over the last 5 years alone.
By 2022, there will be 100 gigawatts of solar installed in the U.S. That’s the equivalent of 35 coal power plants.

Our conservative estimates show there will be an average of 15 GW installed every year.
Why are we talking about 100% Renewables?
• **Solar Messaging Survey** around utilities and competition.
  • There is strong support for a 50% RPS (71% of voters)
  • Only 56% **trust their utility** to offer the best product at the best price
  • Three quarters of voters think utilities should use more solar energy
  • Fully 77% think **solar plus storage** can replace fossil fuels
  • More than two-thirds of voters want utilities to make fuel choice based on an open competitive process.
100 percent renewables is a wildly popular goal

The core of the industry’s dilemma is captured in this slide (on the left is the industry perspective):

**our truth**

100% RE goals have a direct impact on how we’re able to serve our customers. 100% RE is not technically feasible, nor does it make practical sense.

**their truth**

100% RE goals sound great. This is a step in the right direction. We need more renewable energy to protect the environment.

“**It is a lofty and worthwhile ideal that may not be feasible right away, but we can strive for it.**”

– Survey Open End Response

Utilities don’t think it is wise or feasible to go 100 percent renewables. But the public loves it. And I mean loves it. Check out these numbers from the opinion survey:

<table>
<thead>
<tr>
<th>74%</th>
<th>think we should use solar “as much as possible”</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
<td>agree that “In the near future, we should produce 100% of our electricity from renewable energy sources such as solar and wind”</td>
</tr>
</tbody>
</table>

“Renewable energy is never depleted, it’s always there. Easily sourced and easily replaced.”

– Minneapolis

“We need to get off fossil fuels.”

– Phoenix

EEI Polling 2018

Do you think the movement that's been joined by a number of companies, cities, counties, and towns around the country that have made commitments to 100% renewable energy is...

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>34%</th>
<th>53%</th>
<th>87%</th>
</tr>
</thead>
<tbody>
<tr>
<td>With 10% Bill Increase</td>
<td>24%</td>
<td>32%</td>
<td>56%</td>
</tr>
<tr>
<td>With 30% Bill Increase</td>
<td>13%</td>
<td>38%</td>
<td>51%</td>
</tr>
<tr>
<td>Post-test</td>
<td>25%</td>
<td>57%</td>
<td>82%</td>
</tr>
</tbody>
</table>

Very good idea
Pretty good idea

Fortune 100 Companies are Going Solar

- Top 25 Corporate users, led by Target, have installed more than 1 GW of total solar capacity
- They are choosing solar because it saves them money
- Clear and consistent financing options are critical to grow this market: C-PACE can help

147.5
Megawatts (MW) installed

300
Installations

Factoid
Target has added nearly 70 MW of solar so far in 2016—more than any other U.S. retailer and all but 10 states
New Governors Ran on Clean Energy

New Governors May Bring Gigawatts’ Worth of Renewable Additions Across America

Capacity additions aren’t guaranteed, but analysts see “a tremendous amount of upside potential.”

EMMA FOEHINGER MERCHANT | NOVEMBER 21, 2018

The Energy 202: The nation just elected a bunch of governors who campaigned on clean energy

By Dino Granicioni
November 3

7 Incoming Governors Strongly Support Renewable Energy Goals

November 12th, 2018 by Steve Hanley

Solar, solar power, renewables, California Independent System Operator, smart grid, Jerry Brown

Arizona’s loss is several other states’ gain, however. Incoming governors in Connecticut, Maine, Colorado, Illinois, Nevada, New Mexico, and Oregon have all pledged to meet up their state’s renewable energy goals, according to a report by PV Magazine.

100% Goal in 5 States

Governors in 5 states included plans for 100% renewable energy in their campaign platforms.
Clean Energy Proposals – Newly Elected Governors

**Colorado**: Governor-elect Jared Polis has called for 100% renewable energy for the state by 2040, as well as the expansion of distributed energy resources like solar. The state currently has a 30% RPS by 2020 for investor-owned utilities.

**Illinois**: Governor-elect J.B. Pritzker aims to double the state’s 25% by 2025 RPS to 50% by 2025, and then again to 100% by 2050. This is significant, as Illinois passed the Future Energy Jobs Act (FEJA) in 2016 which will dramatically increase solar and wind in the state.

**Michigan**: Governor-elect Gretchen Whitmer supports 100% renewable energy by 2050. The state now has a 15% by 2021 RPS (passed under Republican Governor Snyder in 2016).

**Wisconsin**: Governor-elect Tony Evers has come out in support of a 100% by 2050 clean energy target for the state — a vast expansion from the state’s outdated, modest 10% by 2015 goal.

**Maine**: Governor-elect Janet Mills has called for 100% clean energy by 2050, as well as expanded distributed generation.

**Connecticut**: Governor-elect Ned Lamont supports 100% clean energy for the state by 2050, while the state now has a 48% by 2030 RPS goal, which was passed in 2018.

**Oregon**: Re-elected Governor Kate Brown supports 100% clean energy by 2050. Oregon’s RPS now requires that 50% of electricity comes from renewable energy sources by 2040.

**New Mexico**: Governor-elect Michelle Lujan has called for 80% renewable energy for the state by 2040, which would be a significant leap from the state’s current RPS goals — 20% by 2020 for investor-owned utilities and just 10% for electric cooperatives.

**Nevada**: Governor-elect Steve Sisolak supported Nevada’s successful 2018 ballot initiative that mandates 50% renewables by 2050, although this seems modest when considering the state’s existing 25% by 2025 RPS.

**Minnesota**: Governor-elect Tim Walz supports a 50% renewable energy goal for the state by 2030. Current mandated renewable energy targets vary by utility, up to 31.5% by 2020.
CONSUMERS ENERGY PROPOSES LONG-TERM PLAN, A CLEANER ENERGY FUTURE FOR MICHIGAN

Jun 13, 2018

Consumers Energy today announced it is seizing a once-in-a-generation opportunity to reshape Michigan’s energy future.

The company will file an Integrated Resource Plan (IRP) this week with the Michigan Public Service Commission (MPSC) that outlines the path to using zero coal while ensuring affordable and reliable energy for Michigan’s families and businesses. . . .

In-depth modeling analysis showed higher levels of energy efficiency and demand management programs and renewable energy are the best and most affordable way to meet customers’ needs in the future.

Under the IRP, demand response, energy efficiency, and grid modernization tools would take on more significant roles. . . . Consumers Energy also would add 5,000 megawatts of solar energy throughout the 2020s, along with wind and battery storage.


Michigan utility plans major shift from coal to solar in coming decades

June 13, 2018

The CEO of one of Michigan’s largest utilities says solar is a better long-term investment than new natural gas plants.

Consumers Energy, which previously announced plans to close its coal-fired power plants by 2040, said Wednesday that — unlike other Michigan utilities — it won’t seek to replace coal with new natural gas capacity.

Building a natural gas plant would risk stranding the company’s capital in a single asset, after which there would be “no turning back,” said Consumers President and CEO Patti Poppe. Instead, the company plans to bet on solar, which can be built incrementally as needed.

“We think we have the opportunity of a generation with this clean energy plan to reshape how energy is delivered to the state of Michigan,” Poppe said, noting an emphasis on smaller, more distributed generation. “This avoids big bets on large, new fossil fuel generation plants.”

Previously, as part of this IRP process, NIPSCO conducted an all-resources RFP for 600 MW of capacity.

The results showed that clean energy options, even in Indiana (i.e., one of the least progressive states in the country on energy policy), are now very affordable.

Here's NIPSCO's preferred plan.

Notably, it is planning for 1,348 MW of solar Unforced Capacity (UCAP) by 2028. It is not building any new natural gas. And it will reduce GHG emissions by 90% by 2030.
Xcel Energy Commits to 100% Carbon-Free Electricity by 2050

The utility’s ambitious plan could pre-empt a messy problem.

JULIA PYPER | DECEMBER 04, 2018

PacifiCorp shows 60% of its coal units are uneconomic

Dive Brief:

- PacifiCorp revealed that 13 of its 22 coal units are more expensive than alternative options, such as clean energy, when discussing its coal fleet as part of a two-day public stakeholder meeting Monday and Tuesday.

- The Berkshire Hathaway subsidiary used unit-by-unit analysis to calculate a net benefit or cost for taking the coal units offline by 2022,
Wind & Solar Are Lowest Cost New Resources

Lazard’s Levelized Cost of Energy Analysis – Version 12.0, November 2018

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Levelized Cost ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV - Rooftop Residential</td>
<td>$160</td>
</tr>
<tr>
<td>Solar PV - Rooftop C&amp;I</td>
<td>$81</td>
</tr>
<tr>
<td>Solar PV - Thin Film Utility Scale</td>
<td>$44</td>
</tr>
<tr>
<td>Onshore Wind</td>
<td>$29</td>
</tr>
<tr>
<td>Gas Peaking</td>
<td>$152</td>
</tr>
<tr>
<td>Nuclear</td>
<td>$112</td>
</tr>
<tr>
<td>Coal</td>
<td>$60</td>
</tr>
<tr>
<td>Gas Combined Cycle</td>
<td>$41</td>
</tr>
</tbody>
</table>

Additional highlights from LCOE 12.0:

The low end levelized cost of onshore wind-generated energy is $29/MWh, compared to an average illustrative marginal cost of $36/MWh for coal. The levelized cost of utility-scale solar is nearly identical to the illustrative marginal cost of coal, at $36/MWh. This comparison is accentuated when subsidizing onshore wind and solar, which results in levelized costs of energy of $14/MWh and $32/MWh, respectively.
Capabilities and Characteristics of Renewables
Grid Already Accommodates Large Penetration of Renewables

- 15 U.S. States already see solar & wind penetrations of 10% or above, with no reduction in reliability.

- Nationally, Solar & Wind represented 7% of total generation in 2016

- California:
  - 13% of total generation 2016
  - >50% of instantaneous generation March 2018
  - 14,000 MW 3-hour ramp
California is at 30% Renewables Today

Supply and renewables

- **25,743 MW** Current demand
- **8,502 MW** Current renewables
- **5,151 MW** Current solar
- **1,671 MW** Current wind

Total System Electric Generation

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>California In-State Generation (GWh)</th>
<th>Percent of California In-State Generation</th>
<th>Northwest Imports (GWh)</th>
<th>Southwest Imports (GWh)</th>
<th>California Energy Mix (GWh)</th>
<th>California Power Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>302</td>
<td>0.15%</td>
<td>409</td>
<td>11,364</td>
<td>12,075</td>
<td>4.13%</td>
</tr>
<tr>
<td>Large Hydro</td>
<td>36,580</td>
<td>17.8%</td>
<td>4,531</td>
<td>1,536</td>
<td>42,987</td>
<td>14.72%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>713,584</td>
<td>43.43%</td>
<td>40</td>
<td>9,765</td>
<td>90,315</td>
<td>33.67%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>17,926</td>
<td>8.69%</td>
<td>0</td>
<td>9,564</td>
<td>25,518</td>
<td>0.08%</td>
</tr>
<tr>
<td>Oil</td>
<td>38</td>
<td>0.02%</td>
<td>0</td>
<td>0</td>
<td>38</td>
<td>0.01%</td>
</tr>
<tr>
<td>Other (Petroleum Coke/Waste Heat)</td>
<td>409</td>
<td>0.20%</td>
<td>0</td>
<td>0</td>
<td>409</td>
<td>0.14%</td>
</tr>
<tr>
<td>Renewables</td>
<td>61,163</td>
<td>20.65%</td>
<td>12,592</td>
<td>10,609</td>
<td>94,684</td>
<td>20.00%</td>
</tr>
<tr>
<td>Biomass</td>
<td>6,927</td>
<td>2.26%</td>
<td>1,015</td>
<td>32</td>
<td>6,874</td>
<td>2.35%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>37,170</td>
<td>5.69%</td>
<td>23</td>
<td>937</td>
<td>12,705</td>
<td>4.35%</td>
</tr>
<tr>
<td>Small Hydro</td>
<td>6,413</td>
<td>3.11%</td>
<td>1,149</td>
<td>5</td>
<td>7,867</td>
<td>2.70%</td>
</tr>
<tr>
<td>Solar</td>
<td>24,331</td>
<td>11.79%</td>
<td>0</td>
<td>5,465</td>
<td>29,796</td>
<td>10.20%</td>
</tr>
<tr>
<td>Wind</td>
<td>12,807</td>
<td>6.34%</td>
<td>10,015</td>
<td>4,560</td>
<td>27,442</td>
<td>9.40%</td>
</tr>
<tr>
<td>Unspecified Sources of Power</td>
<td>N/A</td>
<td>N/A</td>
<td>22,385</td>
<td>4,632</td>
<td>27,017</td>
<td>0.26%</td>
</tr>
</tbody>
</table>

Source: CEC 1304 Power Plant Owners Reporting Form and SB 1368 Reporting Regulations

In-state generation is reported generation from units one megawatt and larger

www.seia.org
Grid Services from Modern Solar Projects

Regulation accuracy of the solar plant demonstration exceeded accuracy of conventional resources

<table>
<thead>
<tr>
<th>Events</th>
<th>Conventional Resource</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV response to high frequency</td>
<td>Compared to a combined cycle plant</td>
<td>✓</td>
</tr>
<tr>
<td>Solar PV response to high frequency</td>
<td>Compared to a hydro plant</td>
<td>✓</td>
</tr>
<tr>
<td>Solar PV response to low frequency</td>
<td>Compared to a hydro plant</td>
<td>✓</td>
</tr>
<tr>
<td>Solar PV ability to arrest frequency decline within the inertia response timeframe (Fast frequency response)</td>
<td>Compared to a hydro plant</td>
<td>✓</td>
</tr>
</tbody>
</table>

Source: http://www.caiso.com/Documents/UsingRenewablesToOperateLowCarbonGrid.pdf
Grid Services from Inverter-Based Resources

As technology changes, it becomes important to avoid placing unintentional limits that constrain the types of resources that can provide it.

Any resource that is capable of providing a grid service should not be prevented by reliability rules or market rules from doing so. Instead of binding technology type with grid service, the latter should be carefully defined so that individual resources can demonstrate their ability to provide the relevant service(s).

Not all resources will perform equally, and therefore grid service definitions should be constructed in such a way that resources can be distinguished; this also makes it possible for grid experts to assess whether there is a sufficient level of reliability services to avoid problems.


---

<table>
<thead>
<tr>
<th>Inverter-Based</th>
<th>Synchronous</th>
<th>Demand Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>Hydro</td>
<td>Wind</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Natural Gas</td>
<td>Solar PV</td>
</tr>
<tr>
<td>Storage/Battery</td>
<td>Coal</td>
<td>Storage/Battery</td>
</tr>
<tr>
<td></td>
<td>Nuclear</td>
<td></td>
</tr>
</tbody>
</table>

These services also contribute to frequency restoration, but are also considered essential reliability services on their own.

- Excellent
- Very Good
- Good
- Limited
- Incapable
You can’t get there from here without a paradigm shift

Today we are on the blue line and working towards the dashed blue curve. We don’t know what the green curve looks like or how to get there.

Debra Lew and Nick Miller, GE Energy Consulting and Hickory Ledge, 11/29/18
Flexibility and Market Reform
CAISO Records & Takeaways

On Sunday, February 18, 2018, the ISO experienced a minimum net-load of 7,149 MW @ 14:06

- 34-hr, 13,597 MW ramp met by:
  - Import – 62%
  - Hydro – 10%
  - Thermal – 28%

- Max renewables curtailed 1,905 MW
- Total curtailment was 9,070 MWh
- Max EIM Export was 2,338 MW
- Diablo Unit 2 was off-line
- One of the biggest challenges during low minimum net-load is the capability to commit internal resources to meet the evening ramp and other AS requirements
- Rely on imports on low net-load days to meet ramps

Increasing trend of renewable curtailment varies with seasonal and hydro conditions
Solar Dispatchability Reduces Thermal Commitments & Reduces Costs for Customers

- Enabling flexibility in dispatch creates more opportunities for solar to be curtailed, but less actual curtailment is observed.
- Curtailment can be minimized by allowing solar to provide needed grid services at key times.
- Dispatchability of solar enables the operator to commit fewer thermal power plants:
  - Minimum output requirement for thermal generation ($P_{min}$) reduced.
  - Quantity of solar delivered to the grid increased.
- Provision of balancing services from solar plants allows thermal generators to operate more efficiently by reducing the need for cycling and load following services, resulting in less fuel consumption and less curtailment.

Figure 3. Impact of 4-hour storage dispatch on net load on the peak demand day in 2011

Source: https://www.nrel.gov/docs/fy18osti/70905.pdf
Solar + Storage

- Storage-friendly language being included in various state NEM/rate design legislation
- Many new utility-scale solar projects are incorporating storage to better supply peak capacity/address duck curve
- What policy mechanisms are needed to advance solar + storage?
1.1 CONCLUSIONS AND RECOMMENDATIONS

This report concludes that market reforms are needed to ensure that electricity in the U.S. is reliable and affordable. Such reforms also are needed to accommodate an anticipated supply mix with high levels of renewable generation and to integrate all of the generation, storage and demand-side resources that contribute to reliable power system operation. The reforms we recommend will produce four highly beneficial features: markets that are flexible, fair, far, and free.

FLEXIBILITY refers to both the market and the power system. A flexible power system should be able to respond and adapt to changes in uncontrollable or non-dispatchable factors such as consumption (load), wind speed, solar insolation, other generator output deviations, forced generation outages and transmission disruptions. Modern grid response capabilities need to be faster and cover more megawatts than in the past. Fortunately, modern computing, communications, and control technology, including the fast controls of inverter-based resources, allow much faster response than was previously possible. The market design must also be flexible enough to serve a variety of alternate resource and load scenarios effectively without the need for drastic redesign.

A FAIR market will treat all customers and resources evenly and allow all the opportunity to succeed. Such a market will be designed around service requirements and performance capabilities and be fuel-neutral and technology-agnostic, without inappropriately advantaging or penalizing particular customers or resources. It will compensate based on objectively metered services delivered, rather than subjectively determined resource capabilities or attributes.

A FAR market will have a broad geographic span, to maximize the efficiency benefits of supply and demand diversity reducing variability of resources by netting them out against each other. It will expand deliverability options between resources and customers. System operator borders will operate seamlessly and RTOs will expand in their geographic scope.

A FREE market facilitates customer choice and does not raise barriers to market entry and exit. It should also support customers’, states’, and local authorities’ ability to act on choices about how to balance between goals such as least-cost, distributed versus centralized, environmental impact, local and in-state development, and other priorities.
Capabilities and Characteristics of Renewables