Transformational Times

CSULB Engineering Distinguished Lecture Series
Renewable Energy Solutions…
Batteries Not Included

Jennifer Didlo
President, AES Southland

October 20, 2016
We are in a time of massive transformation of our electricity infrastructure

The way we make electricity, the way we use electricity and what we use it for is forever changing.

Customer choice and access to cost competitive renewable energy is a Game Changer
Federal government implements Clean Power Plan (CPP) Green house Gas reductions

- Clean Air Act gives Federal EPA authority to establish carbon dioxide emission performance rates for all existing & new US power plants

- National performance standards are used to calculate state-specific goals that reflect each state’s mix of affected electricity generating units
  - In California, compliance has been achieved through Carbon cap & Trade program and the Renewable Portfolio Standard
Most states have either a mandatory or voluntary renewable portfolio standard

State-level renewable electricity standards are a leading driver of wind, solar, and other renewable development in the United States. Twenty-nine states and the District of Columbia have renewable electricity standards in place, 17 of which have set targets at 20 percent or greater. Another eight states have voluntary targets for renewable electricity.
In combination with Federal & State programs, renewable energy cost is rapidly declining making it the largest growing new capacity.

<table>
<thead>
<tr>
<th>Power Plant Type</th>
<th>Cost $/kW-hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>$0.095-0.15</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>$0.07-0.14</td>
</tr>
<tr>
<td>Nuclear</td>
<td>$0.095</td>
</tr>
<tr>
<td>Wind</td>
<td>$0.07-0.20</td>
</tr>
<tr>
<td>Solar PV</td>
<td>$0.125</td>
</tr>
<tr>
<td>Solar Thermal</td>
<td>$0.24</td>
</tr>
<tr>
<td>Geothermal</td>
<td>$0.05</td>
</tr>
<tr>
<td>Biomass</td>
<td>$0.10</td>
</tr>
<tr>
<td>Hydro</td>
<td>$0.08</td>
</tr>
</tbody>
</table>

Adapted from US DOE\(^2\)

Source: US Department of Energy Annual Energy Outlook 2015

> 68% Wind + Solar in 2015

Source: GTM Solar Market Insights, Q1 2016
Daily Net Load is no longer stable and predictable – but what’s so complicated about that?

Source: CAISO Duck Curve 2016 – CAISO web site
The problem is two fold...

The belly…

and the ramp
Renewable Integration is NOW, not 2020

Source: CAISO Duck Curve 2016 – CAISO web site

March 2015
3 hour ramp
13,800 MW

May 2015
Net Load
11,700 MW
AES has more than 8 years of operational experience with Battery based Energy Storage around the world

Battery systems are providing tremendous benefits to our electricity systems

Uses:
- Capacity Release
- Firming wind generation
- Energy time shifting
- Grid stabilizing
- Optimizing existing infrastructure

In our utilities and competitive markets

Both as projects and product sales
Contains Forward Looking Statements

300 MW right here in Long Beach providing critically located energy storage for local capacity, 4 hour energy and fast acting grid stabilizing services.
Thank you