Confronting Myths about vRE Integration

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This Looks Scary

Output from a PV plant
This Looks Scary, Too

Each Day is a different color.

Megawatts

Hour
And this....

The duck curve shows steep ramping needs and overgeneration risk.

Sample Net Load – March 31, 2012

- ramp need ~13,000 MW in three hours
- overgeneration risk

(from the California Independent System Operator)
Can grids support high levels (>10-20% annually) of variable RE?

<table>
<thead>
<tr>
<th>Country</th>
<th>% Electricity from Wind</th>
<th>Balancing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>43% in 2015</td>
<td>Interconnection, flexible generation (including CHP), and good markets</td>
</tr>
<tr>
<td>Portugal</td>
<td>25% in 2013</td>
<td>Interconnection to Spain, gas, hydro, and good market</td>
</tr>
<tr>
<td>Spain</td>
<td>21% in 2013</td>
<td>Gas, hydro, and good market</td>
</tr>
<tr>
<td>Ireland</td>
<td>18% in 2013</td>
<td>Gas and good market</td>
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</tbody>
</table>

Many grids are operating with 20%–30% variable renewables.

Their experiences demonstrate that actions taken to integrate wind and solar are unique to each system, but do follow broad principles.
Can variable RE provide baseload power?

- Yes, variable RE can contribute to resource adequacy, but changes how we think of “baseload”
- In high RE systems, we want the balance of generation to be flexible, and not necessarily be designed to run like a traditional baseload unit

Figure credit: Keith Parks, Xcel Energy
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Figure credit: Keith Parks, Xcel Energy
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- In high RE systems, we want the balance of generation to be flexible, and not necessarily be designed to run like a traditional baseload unit
  - First plan to use all the available RE; determine when and where the RE is available
  - Plan what additional resources—and their characteristics—are needed to meet load

Figure credit: Keith Parks, Xcel Energy
Do individual renewable energy plants require backup by conventional plants?

- **Individual** plants do not require backup
  - Reserves are optimized at system level.

- Wind and solar could increase need for operating reserves.
  - But this reserve can usually be provided from other generation that has turned down
  - This reserve is not a constant amount (depends on what wind/solar are doing)
  - Many techniques are available to reduce needed reserves.

- Wind and solar can also provide reserves; in both directions when curtailed
Does RE require priority dispatch (must-run)?

- No, trend is toward treating RE like real power plants:
  - Visible
  - Schedulable
  - Dispatchable
  - Curtailable
  - Able to provide ancillary services
- Requires least-cost dispatch
- Address RE bankability separate from system operations

RE production costs at $0/MWh, so typically dispatched first to minimize operational costs
What impact does variable renewable energy have on grid stability?

Frequency stability

- Solution: RE will need to provide active power controls (synthetic inertia, governor response, automatic generator control)

- Example: Xcel (Colorado) requires new wind turbines to have AGC

Voltage stability: potential issue in small and/or weak systems, such as those with long, radial lines

Figure: Impact of wind power controls regulation, dispatch, and area control error

Source: Public Service Company of Colorado
How often does the wind stop blowing everywhere at the same time?

Source: ERCOT, WindLogics
Does variable renewable energy generation require storage?

- Storage is always useful, but may not be economic.

- Detailed simulations of power system operation find no need for electric storage up to 30% wind penetration (WWSIS, CAISO, PJM, EWITS).

- 50% wind/solar penetration study in Minnesota found no need for storage (MRITS, 2014)

- At higher penetration levels, storage could be of value.
  - Recent E3 integration study for 40% penetration in California: storage is one of many options.

Source: Adrian Pingstone (Wikimedia Commons)
How expensive is integrating variable renewable energy generation to the grid?

All generation (and load) has an integration cost:

• Any generator can increase cycling for remaining generation

• Conventional plants can impose variability and uncertainty costs

• Conventional plants can create conditions that increase need for system flexibility
  • Must-run hydropower and IPP contracts; thermal plants that cannot be turned down
  • Start-up times for coal require day-ahead scheduling, which is harder for wind

Frequently used options to increase flexibility

RELATIVE ECONOMICS OF INTEGRATION OPTIONS

Option costs are system-dependent and evolving over time
Frequently used options to increase flexibility

- Numerous options for increasing flexibility are available in any power system.
- Flexibility reflects not just physical systems, but also institutional frameworks.
- The cost of flexibility options varies, but institutional changes may be among the least expensive and evolving over time.