Digital Business Models for the Future Electric Utilities

Transforming from the Old to the New in Energy Systems

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Pramod Jain, Ph.D.
Innovative Wind Energy, Inc.
pramod@i-windenergy.com
+1-904-923-6489
Agenda

• Drivers of Change
• Scenario for future of the grid
• Implications
• Concluding remarks
Drivers of Change: Falling Price for Onshore Wind, Solar PV and Storage

**Figure 1** Average prices resulting from auctions, 2010-16

- **Solar**
  - Saudi Arabia, 9/17: $17.9
  - Mexico, 11/17: $19.18
  - India, 1/18: $37.3

- **Wind**
  - Mexico, 11/17: $18.14
  - Brazil, 4/18: $20.23
  - India, 12/17: $37
  - Germany, 8/17: $50.3

- **Dispatchable Solar Plant - PV+Storage**
  - Kauai @13.9c/kWh (2017)
    - PV = 17 MW
    - Storage = 13 MW x 4 hours
  - Kauai @11c/kWh (late 2018)
    - PV = 28 MW
    - Storage = 20 MW x 5 hours
  - Tucson @4.5c/kWh (2019)
    - PV = 100 MW
    - Storage = 30 MW x 4 hours

- **Dispatchable**
- **Decentralize**
- **Defossilize**

Paris Climate Agreement—Focus on RE by Governments
### Drivers of Change: Future of Grid with RE+Storage

<table>
<thead>
<tr>
<th>Conventional thinking about RE</th>
<th>New RE⁺ (RE+Storage)</th>
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<tbody>
<tr>
<td>RE is variable and uncertain, therefore have to limit penetration</td>
<td>RE⁺ modulates output hence variability and uncertainty are reduced/eliminated</td>
</tr>
<tr>
<td>Fast ramping of RE causes frequency issues</td>
<td>RE⁺ modulates output, to reduce fast ramping</td>
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<td>RE requires higher reserves</td>
<td>RE⁺ reduces reserve requirement</td>
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<tr>
<td>RE causes higher cycling of conventional generation</td>
<td>RE⁺ modulates output</td>
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<td>When diurnal and seasonal profiles of RE do not match load, there is curtailment</td>
<td>RE⁺ provides the buffer</td>
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<td>RE causes poor utilization of transmission network</td>
<td>RE⁺ tactically located at nodes mitigates poor utilization</td>
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<td>RE causes large voltage swings in weak grids</td>
<td>RE⁺ manages voltage by providing reactive power</td>
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</table>
Which business models are sustainable in 5 to 10 years?

Main Hypothesis
1. LCOE of rooftop solar PV+* is below retail rate
2. LCOE of utility scale wind†, solar PV+ is below the cost of conventional generation
3. Customers shape the market/load
   – Objective: Reduce waste and reduce cost
   – How: IoT, EV, Solar PV+
4. Self generation by the most profitable customers
5. Grid defection by the most profitable customers

Implications:
1. Older policy mechanisms cannot be economically supported
   – Net-metering
   – Feed-in tariff for 20 years
   – Dispatch 100% RE when produced
2. Utility may lose ability to set prices and supply energy to customers reliably

*+ means including storage. Wind† means Wind+Storage
Imagine ...

We all are living in the Republic of Thoughtful People and Thoughtful Devices

**A Year After Trump’s Paris Pullout, U.S. Companies Are Driving a Renewables Boom**

By Brad Plumer

June 1, 2018

100% RE goals

2.78GW in 2017

2.48 GW in 1H 2018

Rooftop, Storage, EV …

Building Automation,

Thermal Storage …

Buy

Consume

Sell

Generate

Store
What to do?

Business as usual or its extensions will not work

New approach: Create business models to stop defections
A new business model: A digital utility

• Create a marketplace for customers to trade electricity
• **Dynamic pricing**—the grid operator publishes prices every minute for purchasing and selling electricity
• The broker (utility) keeps the spread
Dance between load and generation, orchestrated by dynamic pricing
Digital platform for ToP and ToD

- Amazon/ebay of electrons
- Manage/optimize the 5 tasks
  - Consume, Generate, Store, Sell, Buy
- Program appliances
- Lease/rent hardware
- O&M of hardware
- Buy/sell on spot market, options, futures
- Of course use conductors of utility for buying/selling, wheeling
- To dance in this market, platform provides dynamic pricing

Is my utility ready for this?
Dynamic pricing, proliferation of internet connected devices

The impact on load and generation

• Millions of appliances will make decisions about electricity consumption—loads that can be deferred will wait for lower price
• RE+ plants will make decisions about charging, discharging and supply to grid—generation waits for higher prices to supply
• Each entity is optimizing using its own criteria
  – Risk takers can make speculative bets
  – Risk averse entities use simple rules
  – No more duck curve
• Tight integration with transportation sector
What are the implications of Dynamic Pricing on System Operations and Customers?

- VRE with no storage will not be profitable
- Inflexible conventional plants will not be profitable
- Load Flexibility will payoff for customers
- Generation for self consumption and selling excess to maximize revenue (roll the dice)
- Utility scale wind+, solar+ plants would be paid to provide:
  - Governor-like response, Inertia, Voltage support
- Utility scale wind and solar plants have to send accurate forecasts frequently (every 15 minutes)
  - There have to be penalties for excess error
- System operations will require:
  - Very fast dispatching algorithms
  - Rapid AGC
Concluding Remarks

Utilities will be between a rock and a hard place:

- Old Business Model, AVOID this outcome: The economically better-off customers become self-sufficient, resulting in higher prices for folks who can least afford it
- New Business Model, IDEAL outcome: Lower energy prices for all, higher energy security and higher energy access

Each country needs to work with all stakeholders to design a business model/market system that yields the ideal outcome, based on

- Resource mix, geographic spread, marginal cost of electricity
- Size of system, reliability issues, transmission backbone
- Institutional capacity, market readiness