Digital Business Models for the Future Electric Utilities

Transforming from the Old to the New in Energy Systems

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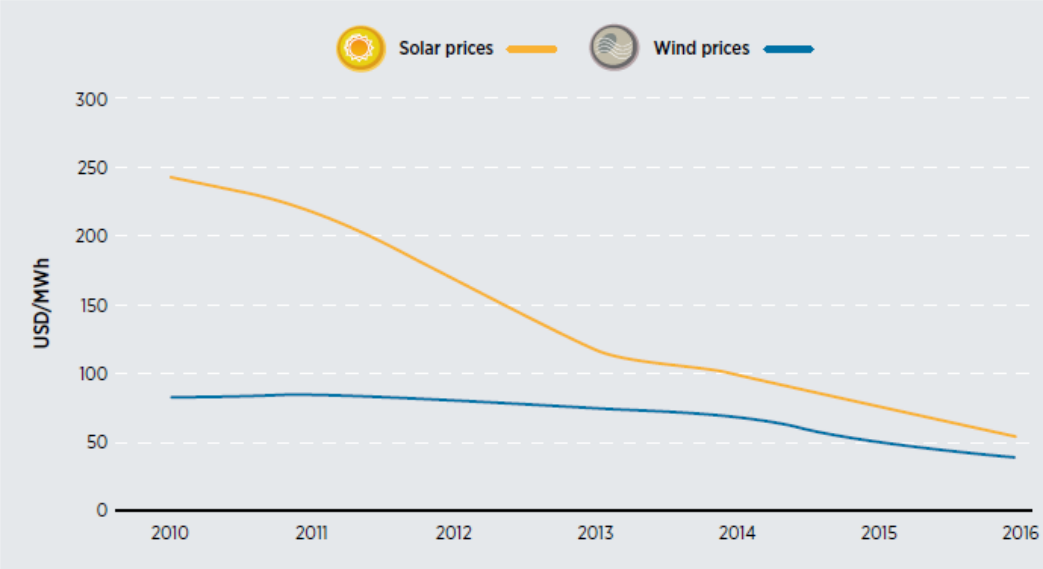
Agenda

- 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



Source: IRENA, 2017.

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

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

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

What to do?

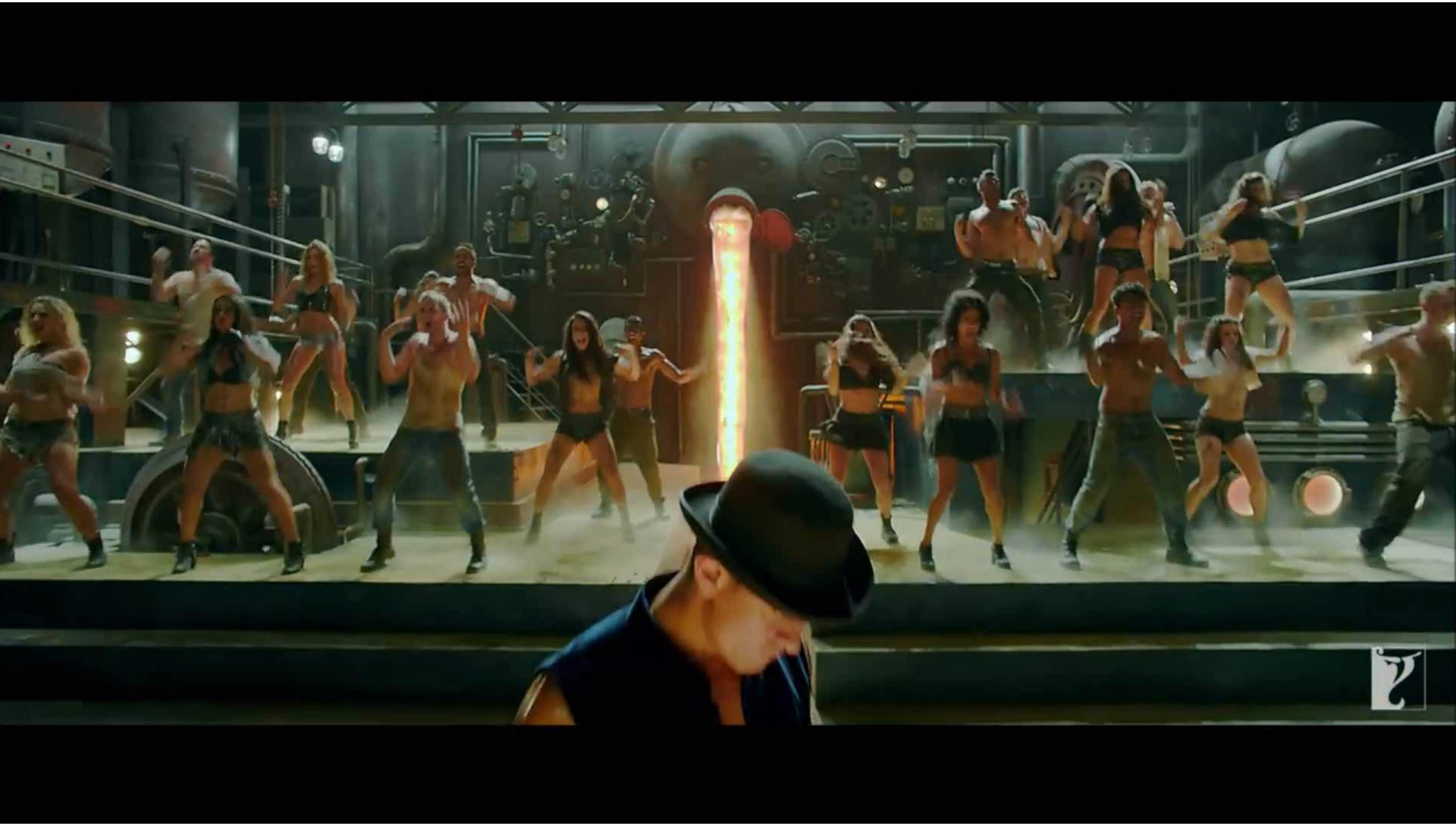
Business as usual or its extensions will not work

New approach: Create business models to stop defections

A new business model: A digital utility

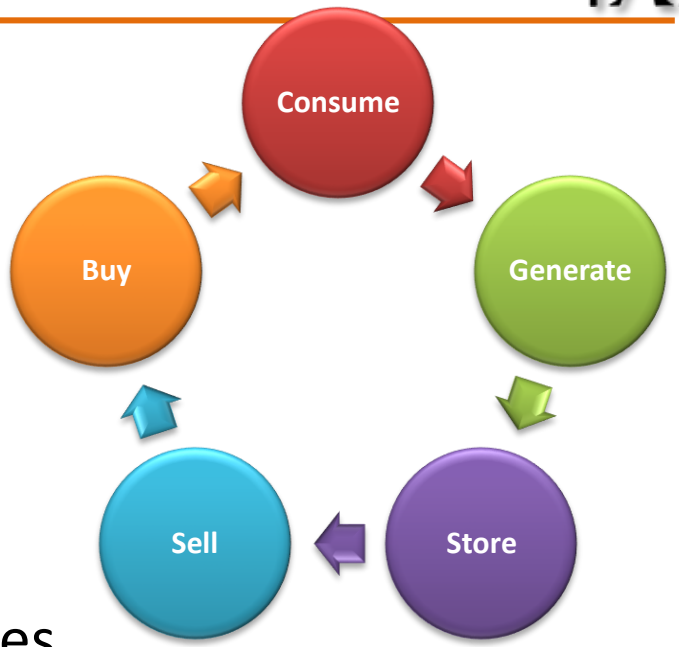
- Create a marketplace for customers to trade electricity
- **Dynamic pricing--the grid operator publishes prices every minute for purchasing and selling electricity**
- The broker (utility) keeps the spread

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

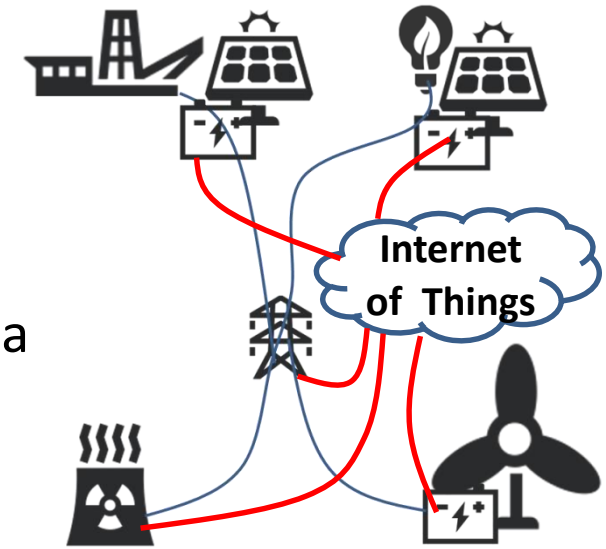


Is my utility ready for this?

Dynamic pricing, proliferation of internet connected devices

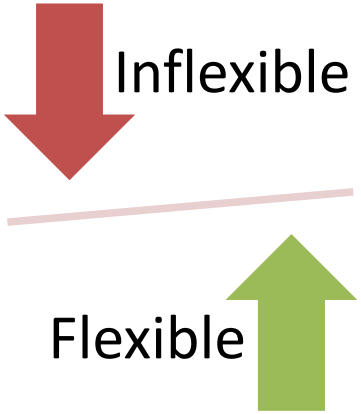
The impact on load and generation

- 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