Understanding electricity in the context of solar irrigation

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There are multiple transitions (transformations) underway

• It’s NOT just about “decarbonization”
• Move away from liquid fossil fuels in transportation
  • EVs
  • Gas (?interim)
  • Hydrogen (?green hydrogen)
• Grid of the future
  • More decentralized
  • Digital
• Changing role and power of consumers
  • Flexible
  • Prosumers
• Rise of Markets

BUT THE TIME CONSTANTS VARY, by country and by application
Realities of electricity

• Most important form of energy for India and many LDCs
  • Low heating demand
  • Limited personal transportation use thus far
• India: Coal dominates supply by far
  • Even with no new coal plants**, in 2030 half of electricity is still coal
• The AC grid is an enormous coupled system
  • Real-time balancing: Supply = Demand + Losses
• History: economies of scale → centralization
• India’s older problem of raw deficit is over
  • Older solution to all problems was “more supply”
  • Need is kW (capacity) at the right time, not kWh (energy) per se
Reality is a complex intersection

- We tend to think in terms of quantity vs. price
  - Are prices = ~cost?
- The system used to be costs-plus regulated
  - Now growing use of “markets”
- But **social welfare redistribution** remains key part of regulations
  - Different consumers are viewed differently
  - There are also supply-side distortions
    - Externalities of fossil fuels
    - Support for RE
Segment-wise Billing, Cost & Volume

Source: PFC data
DISCOM Wise Agriculture ABR (FY-19)

Source: Compiled from SERC Tariff Orders (FY19)
Realities of agriculture power pricing

• The prices shown are as per REGULATOR
  • Farmers may pay less thanks to subsidies by the state(s) – often free
  • Subsidies after tariffs are not captured or easily compiled (PFC data only show the billing)
    • Avg. Cost of Supply (ACos): 7.55 Rs./kWh
    • Total ABR without subsidy: 4.98 Rs./kWh
    • Total ABR with subsidies: 6.13 Rs./kWh (PFC Data); ~6.18 per tariff order compilations

• Bad equilibrium
  • Utilities lose money for each kWh “sold”
  • Farmers have little incentive to be efficient
  • Utilities inflate agricultural consumption as it’s mostly unmetered
    • Hide other losses
    • Get revenues from states
### FY 2014-15 Agriculture Electricity Consumption

<table>
<thead>
<tr>
<th></th>
<th>India</th>
<th>Pakistan</th>
<th>Nepal</th>
<th>Bangladesh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of usage</td>
<td>18.78%</td>
<td>9.72%</td>
<td>2.81%</td>
<td>4.13%</td>
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<tr>
<td>Actual Agric (GWh)</td>
<td>168,913</td>
<td>5,985</td>
<td>81.41</td>
<td>1,636</td>
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<tr>
<td>Total Consumption</td>
<td>899,232</td>
<td>62,846</td>
<td>3,873</td>
<td>39,624</td>
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</table>
Category-wise % Shares in Electricity Consumption in various Countries -2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Non-specified (other)</th>
<th>Agriculture/forestry</th>
<th>Commercial and public services</th>
<th>Residential</th>
<th>Transport</th>
<th>Industry</th>
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<tbody>
<tr>
<td>Australia</td>
<td>0.00</td>
<td>0.83</td>
<td>31.78</td>
<td>27.94</td>
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<td>24.37</td>
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<td>24.66</td>
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<tr>
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<td>0.00</td>
<td>29.27</td>
<td>23.07</td>
<td>2.27</td>
<td>43.80</td>
</tr>
<tr>
<td>Italy</td>
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<td>1.86</td>
<td>32.07</td>
<td>22.48</td>
<td>3.90</td>
<td>39.60</td>
</tr>
<tr>
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<td>0.29</td>
<td>34.38</td>
<td>27.84</td>
<td>1.82</td>
<td>35.64</td>
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<td>Korea</td>
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<td>31.79</td>
<td>13.30</td>
<td>0.52</td>
<td>51.30</td>
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<tr>
<td>United Kingdom</td>
<td>0.36</td>
<td>1.09</td>
<td>31.23</td>
<td>35.53</td>
<td>1.54</td>
<td>30.25</td>
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<tr>
<td>United States</td>
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<td>35.72</td>
<td>37.03</td>
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<td>14.46</td>
<td>19.90</td>
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<tr>
<td>Brazil</td>
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<td>5.65</td>
<td>26.98</td>
<td>27.06</td>
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<td>People’s Republic of China</td>
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<tr>
<td>Russian Federation</td>
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<td>30.39</td>
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<td>41.48</td>
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Source: - International Energy Agency (IEA) except India
The promise of solar agricultural use

• No battery required (unlike supply-side solar general options)
  • Agric. demand can be shifted
• Old C.W. – off peak is middle of the night
  • If we apply concept of “net demand”, off-peak will soon be mid-day
• But the long term value of RE? As RE rises
  • Marginal value declines
  • Marginal cost of integration rises

*Giving solarized water doesn’t change this much (only shows up as negative demand)*
Time of Day matters: Last week India hit record demand...in the AM thus far

- RE helps but after a point (future), will dip into coal output
- RE Contribution to the evening peak is low
  - For non-windy months, can be ~3% of evening peak

Source: NLDC Data
This is "load met" (MW)
3 different models of Solarizing agriculture

• Where do you put the solar?
  • Anywhere, via feeder control – Karnataka model
  • Feeder level – Maharashtra model
  • At the edge – (earlier) Rajasthan model

• The other key differences boil down to who owns it, in/out energy at what terms, and thus who benefits?
  • Feed in tariffs are very contentious
  • “self use” is insufficient to price and size
Issues and Hurdles

• The solar has to be grid interactive
  • Not just if its insufficient but also for when it’s surplus
  • How do you right size it?

• Is this a conflation of wholesale vs. retail?
  • We are changing an ongoing subsidy into a one-time capex subsidy

• Will all farmers benefit, or only the elite?
  • Minority of farmers are the ones who enjoy free/cheap power

• Crop choice distortions are already there
Closing Thoughts

• India’s grid is in changing and must in a few years (ignore COVID)
  • Temporary surplus of coal capacity (~doubled FY11-16)
  • High RE targets – initial target can be absorbed without much storage
• Is it fair to compare solar procurement vs. retail prices? (ignore pricing distortions)
• Need to improve signalling
  • Time of Day pricing
  • Wires and infra costs (Fixed vs. Variable)
  • Price to recognize edge-based disruption
    • “Paying customers” are the ones who will “leave the grid”
      • Open Access
      • RE
      • (soon) Storage, peer-to-peer
“The Future is already here – it’s just not evenly distributed”

- William Gibson