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

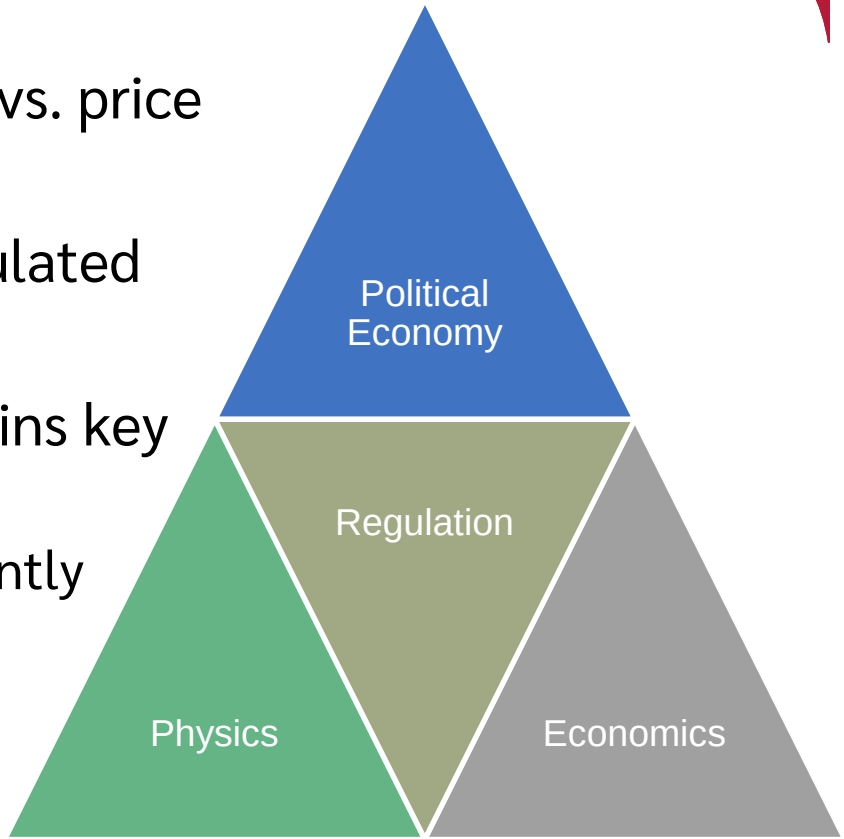
BUT THE TIME CONSTANTS VARY, by country and by application

Realities of electricity

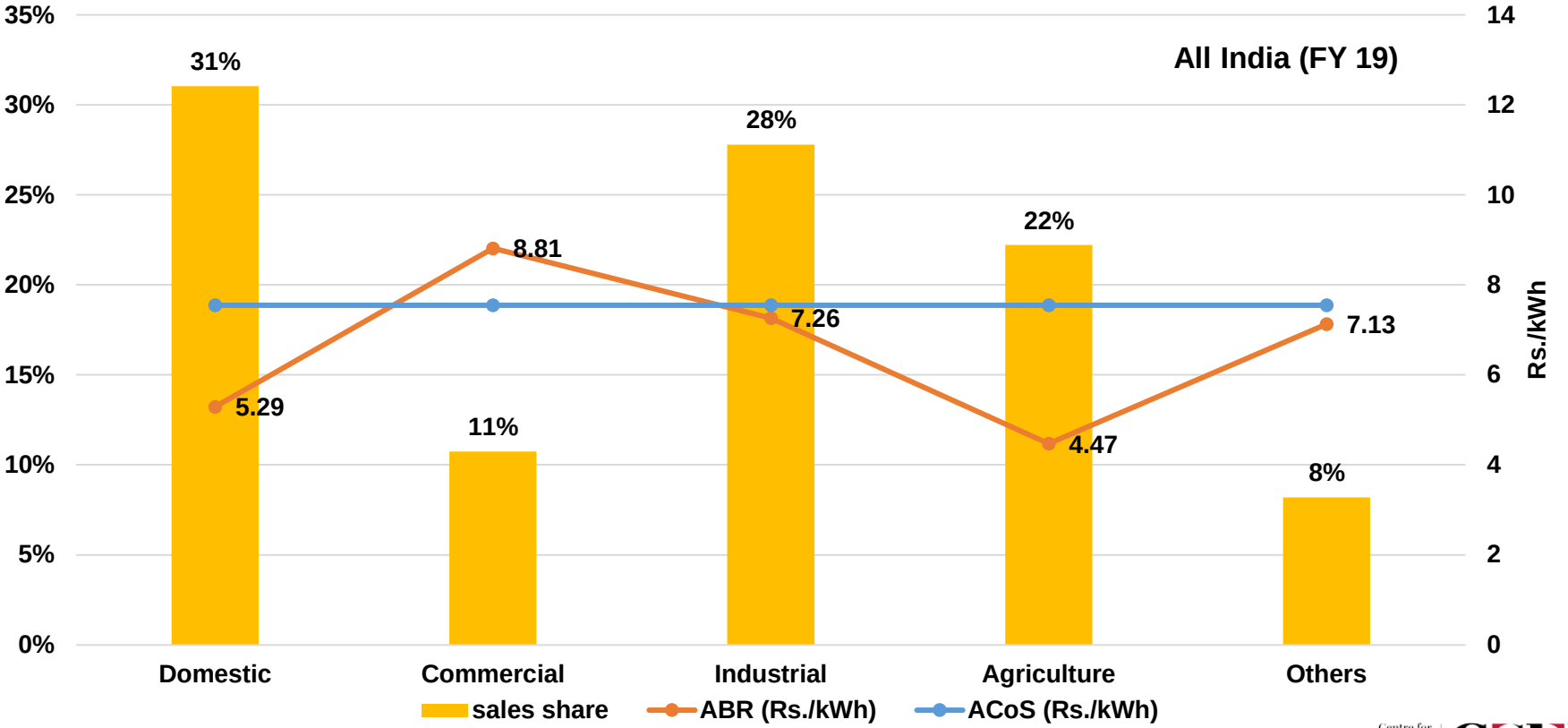
- Most important form of energy for India and many LDCs
  - Low heating demand
  - Limited personal transportation use thus far
- India: Coal dominates supply by far
  - Even with no new coal plants**, in 2030 half of electricity is still coal
- The AC grid is an enormous *coupled* system
  - Real-time 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

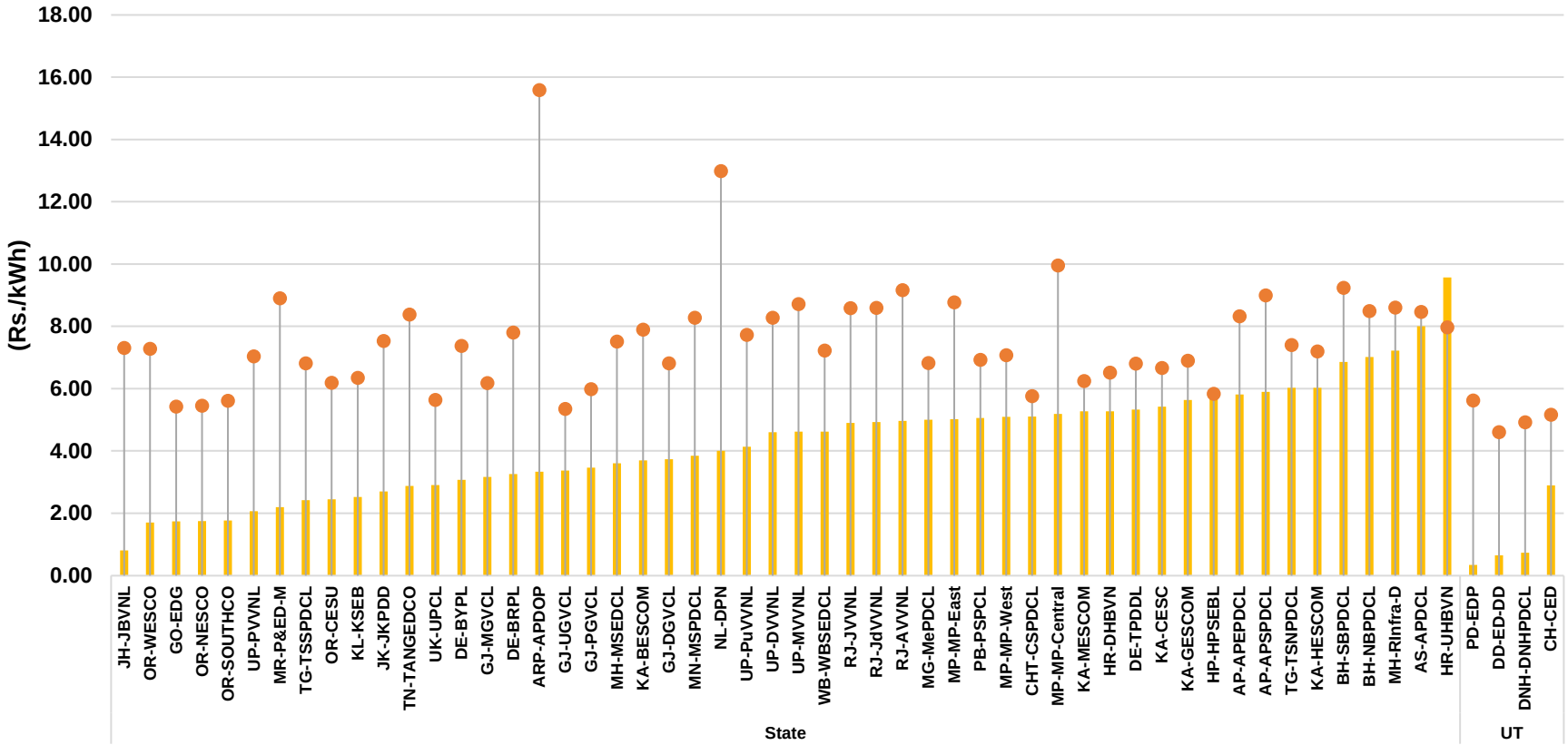


Segment-wise Billing, Cost & Volume



Source: PFC data

DISCOM Wise Agriculture ABR (FY-19)



Source : Compiled from SERC Tariff Orders (FY19)

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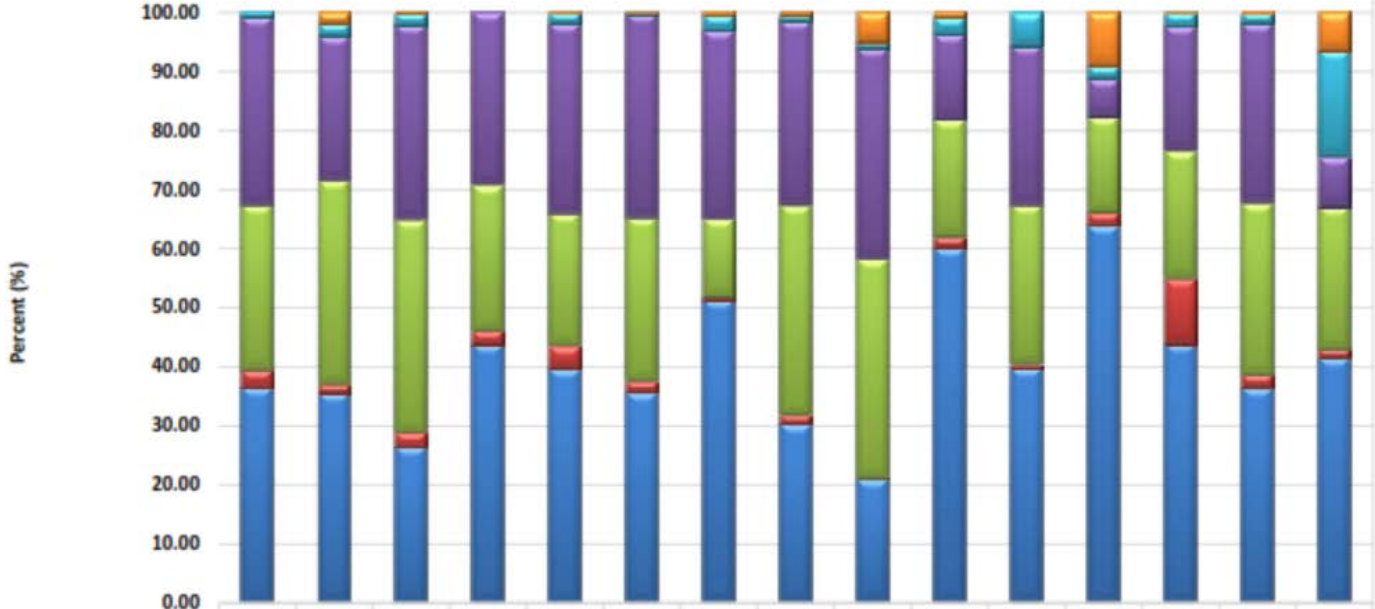
Realities of agriculture power pricing

- 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

	India	Pakistan	Nepal	Bangladesh
Share of usage	18.78%	9.72%	2.81%	4.13%
Actual Agric (GWh)	168,913	5,985	81.41	1,636
Total Consumption (GWh)	899,232	62,846	3,873	39,624

Category-wise % Shares in Electricity Consumption in various Countries -2016



	Australia	Canada	France	Germany	Italy	Japan	Korea	United Kingdom	United States	South Africa	Brazil	People's Republic of China	Russian Federation	European Union - 28	India
Non-specified (other)	0.00	1.92	0.19	0.00	0.09	0.03	0.42	0.36	4.97	0.78	0.00	9.10	0.03	0.15	6.45
Agriculture/forestry	0.83	2.11	1.94	0.00	1.86	0.29	2.68	1.09	1.08	2.93	5.65	2.11	2.30	1.75	18.01
Commercial and public services	31.78	24.37	32.96	29.27	32.07	34.38	31.79	31.23	35.72	14.46	26.98	6.43	21.11	30.39	8.46
Residential	27.94	34.58	36.03	24.66	22.48	27.84	13.30	35.53	37.03	19.90	27.06	16.27	21.65	29.03	24.11
Transport	2.97	1.46	2.44	2.27	3.90	1.82	0.52	1.54	0.28	1.79	0.53	2.19	11.09	2.29	1.48
Industry	36.48	35.55	26.44	43.80	39.60	35.64	51.30	30.25	20.93	60.13	39.78	63.90	43.82	36.39	41.48

Source: - International Energy Agency (IEA) except India

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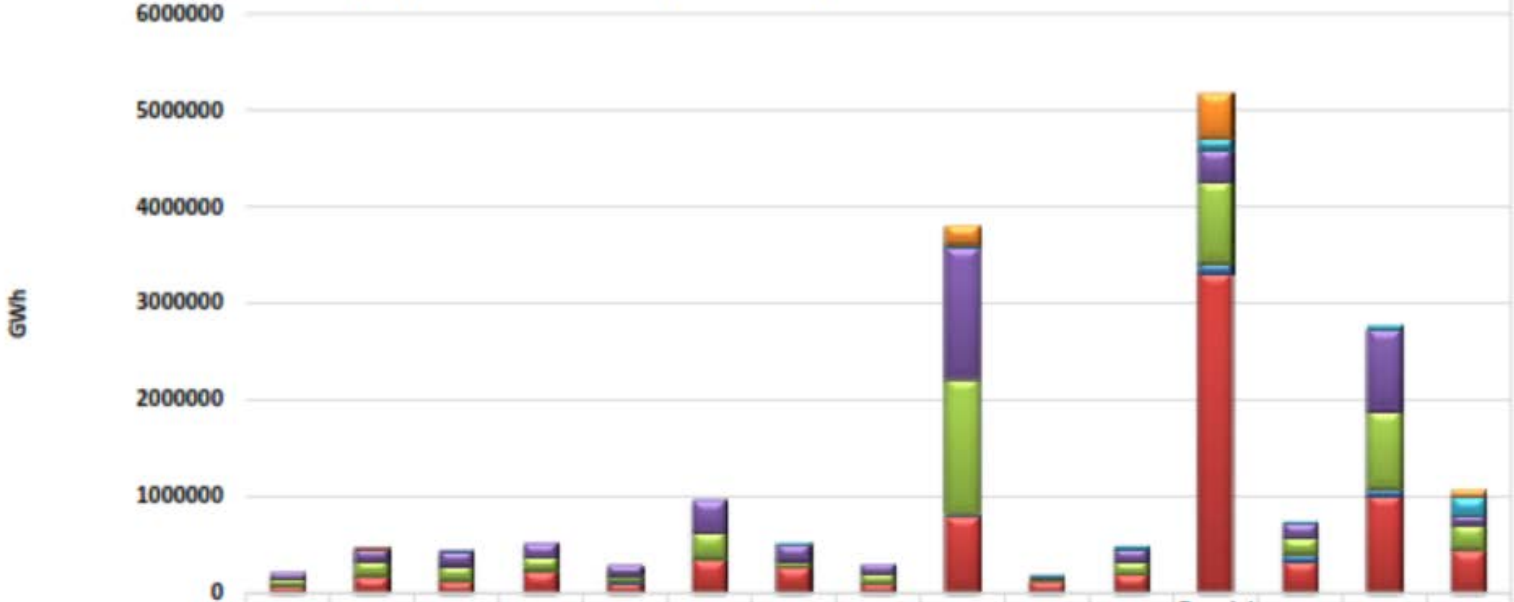
Category-wise Electricity Consumption in various Countries -2016



	Australia	Canada	France	Germany	Italy	Japan	Korea	United Kingdom	United States	South Africa	Brazil	People's Republic of China	Russian Federation	European Union - 28	India
Non-specified (other)	0	9133	822	0	254	315	2164	1106	189113	1507	0	471178	200	4223	68493
Agriculture/forestry	1756	10024	8602	0	5314	2816	13838	3317	41097	5649	27771	109191	17162	48781	191151
Commercial and public services	67331	115688	145797	151440	91736	332619	164422	94924	1360145	27890	132497	332949	157205	846126	89825
Residential	59189	164166	159396	127600	64304	269279	68775	107971	1409855	38375	132916	842060	161205	808214	255826
Transport	6284	6910	10784	11739	11162	17604	2689	4669	10605	3457	2584	113297	82569	63685	15683
Industry	77291	168756	116971	226598	113257	344716	265383	91916	796896	115940	195347	3308367	326343	1013148	440206

Source: - International Energy Agency (IEA) except

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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

Source: Underlying Data from MERIT India

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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