India Smart Utility Week 2023

Master Class on

Energy Transition to NET ZERO Power Systems

28th February 2023

Understanding What Net-zero Means – Globally and Nationally

Presented by

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• Overview

• Everyone wants net-zero…what does that mean?

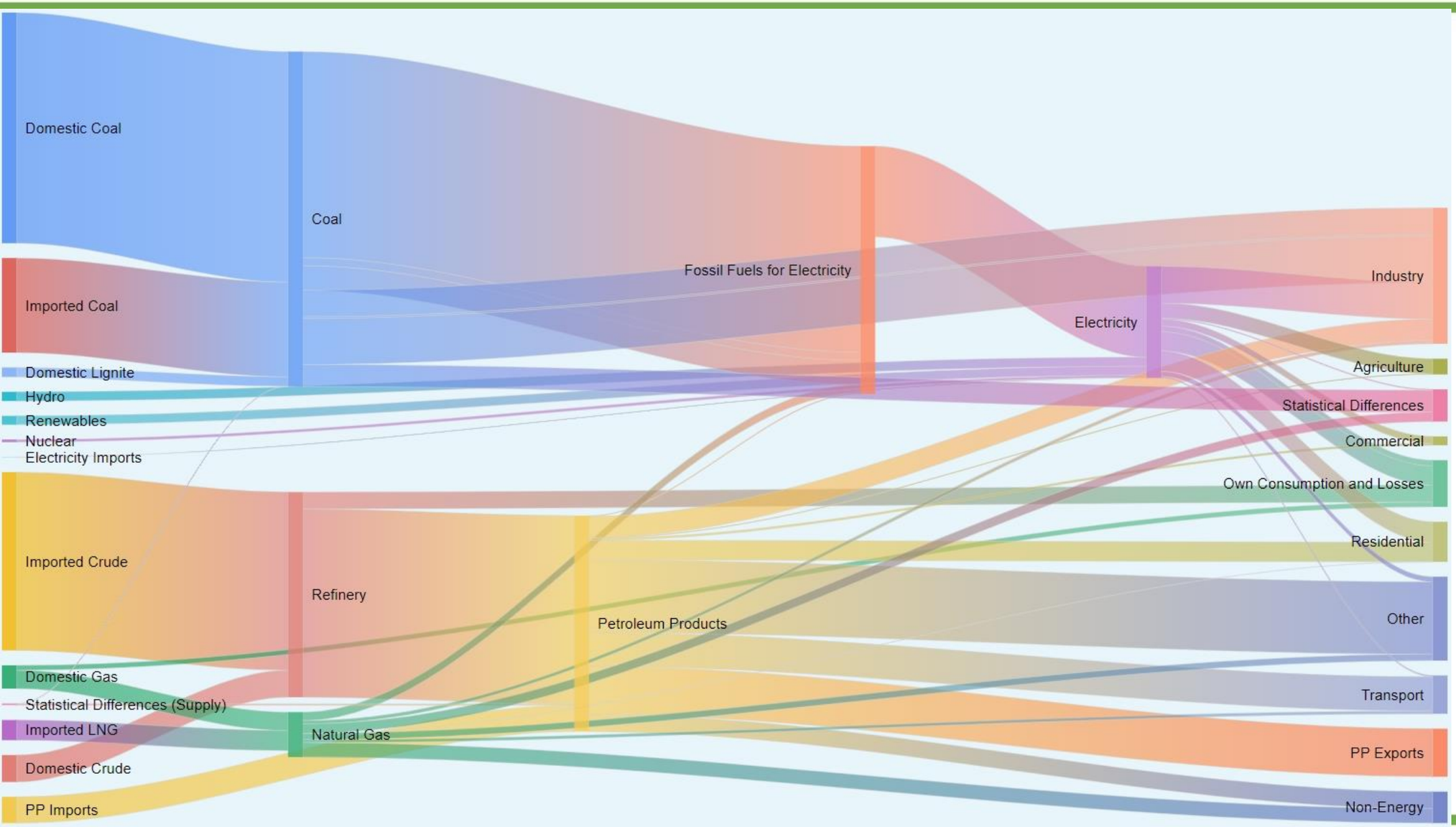
- Net-zero has captured the global imagination…
  - What does it mean? What does it mean for India?
- What *should* we be doing?
- Innovation and India's options

• Disclaimers and Guidance

• All views are those of the author

- This talk is an inter-disciplinary lens on Greenhouse Gas (GHG) emissions, spanning energy and electricity systems
- The focus should be on trends and big picture, not a specific number
  - But the details matter!
- More details can be found at CSEP's website and publications

Introduction: Electricity isn't all energy



Source: NITI Aayog (EDM)

Total energy:

Primary Energy: 733.6 MTOE

End-use" 410.3

- **Net-zero – what are we talking about?**
- **To keep global mean temp. rise in check, we have to limit GHG emissions = fall to zero**
- The UN Conferences on climate change, COP, had a strong focus on "net-zero" last year (Glasgow, COP26)
  - India joined the global list of pledges, promising net-zero by 2070
- Many countries offered earlier, e.g., China 2060, and many OECD countries 2050 or sometimes sooner
- The IPCC headline is that to stay within 1.5°C rise, the world has to zero by 2050
  - Let's ignore what else we have to do for now…

- **Problems with net-zero**
- **Net-zero won't be sufficient…and may be greenwashing**

  - Simultaneity of zero?
    - 2050 zero for the world cannot mean zero for everyone at the same time
    - But this means high emitters must zero before 2050
  - What does "Net"?
    - Financial offsets are mostly accounting tricks
    - Carbon Dioxide Removal (CDR) is really expensive at best
    - Land-use offsets have their own challenges and limits

• Problems with net-zero (cont.)

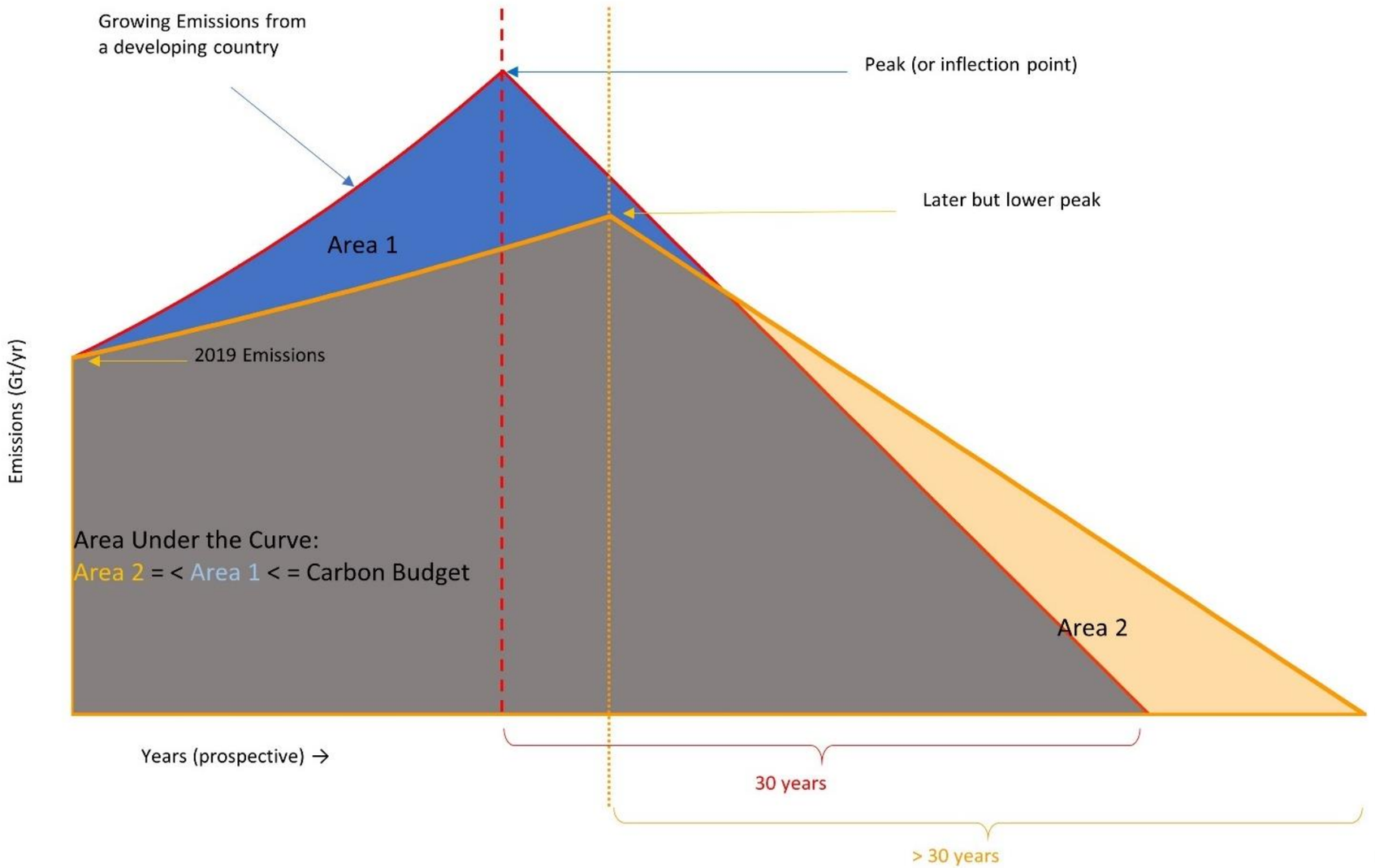
• Only cumulative emissions matter…not date of "zero"

- How much is emitted in total – cumulative?
  - Area under the curve – See Tongia (2021): Flatten-the-curve
- Unfair to low emitters
  - Even if high emitters zero by 2050, their cumulative emissions would be more than any reasonable apportionment of even the REMAINING carbon budget (giving them a pass for historical emissions)

- **High Emitters aren't doing enough**
- **E.g., UK, best G20 nation, is viewed as green**

- UK lowered fossil CO2 emissions from 1990 to 2019 by 35%
  - That's only <1.2% year, vs. 3.33% needed to zero in 30 years
- UK's reduction wasn't just growth of renewable energy (RE)
  - It had a one-time shift from coal to gas – is that universally applicable?
  - UK also grew its embedded (imported = "not accounted") carbon
    - 11% in 1990 to 42% by 2020

• Let low emitters: “Flatten the Curve”



A tail should be allowed as it would be cost-effective assuming they tackle low-hanging fruit up front (lower their present rate “r”)

LET THE HIGH EMITTERS PAY DOWN THE LEARNING CURVE FOR GREEN H, CCUS, DIRECT AIR CAPTURE, ETC.

- **The rich can't wait**
- **High emitters must aggressively decline, without offsets**

- But even assuming they can decline within, say, 30 years, we can calculate how much they would stay within (or bust) their carbon budget
- Tongia (2021) has a framework to calculate "N" = years until one has to start the decline
  - Low emitters: N = positive
  - High emitters: N = 0 (if avg.) or negative

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• Time remaining to still stay within CO2* Budget as per the Area Under the Curve framework (selected countries)

	Per capita fossil CO2 emissions 2019	2019 3-year average YoY emissions trend (as extrapolated)	Years as-is then 30 years decline to stay within 1.5° rise carbon budget	Years as-is then 30 years decline to stay within 2° rise carbon budget
UAE	28.92	0.69%	-21.3	-13.6
USA	15.09	-0.49%	-18.0	-7.3
Canada	14.87	1.15%	-17.9	-7.1
Russia	10.51	0.64%	-15.6	-2.8
Japan	8.85	-1.99%	-21.8	-0.7
S. Africa	8.18	0.59%	-13.7	0.8
Germany	8.19	-3.88%	-13.7	2.2
China	6.85	2.45%	-12.2	2.8
WORLD	4.43	1.24%	-7.8	11.2
UK	5.73	-2.35%	-10.5	14.2
France	4.59	-1.37%	-8.2	19.1
Bangladesh	0.65	9.96%	9.9	22.0
India	1.82	3.43%	3.1	24.1
Brazil	2.09	-0.66%	2.6	64.1

Dr.

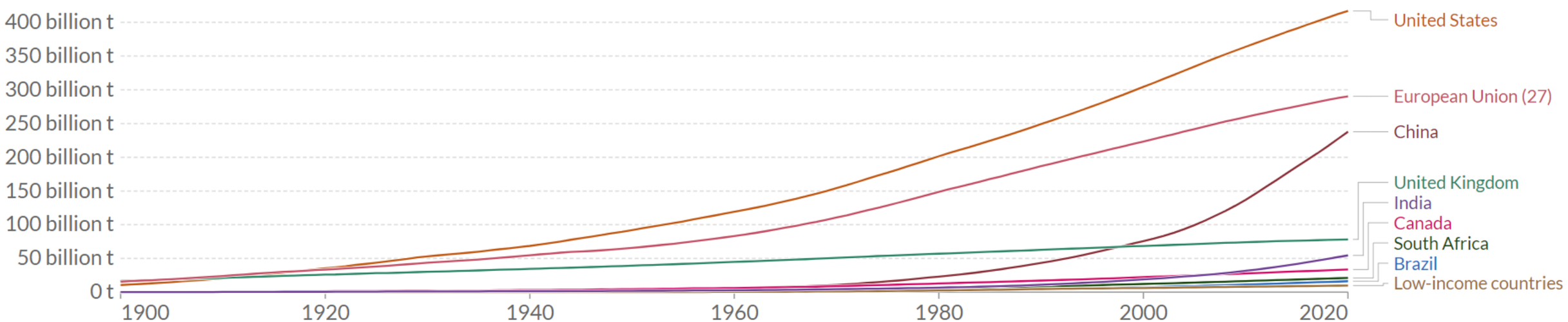
- **Sad Reality: 1.5°C rise was always tough**
- **But we have to remember the causes**

Cumulative CO_2 emissions

Cumulative emissions are the running sum of CO_2 emissions produced from fossil fuels and industry since 1750. Land use change is not included.

Our World in Data

Add country | Relative change



Source: Our World in Data based on the Global Carbon Project

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

• India's "high" coal use in context

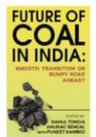


Table 1.1: Global snapshot of coal, 2019: Top 10 Producers / Consumers

	Production (million tonnes [MT])	Consumption (MT)	Per capita coal consumption (kg)	Estimated average calorific value (kcal/kg)	Converted per capita coal energy consumption (GJ)	Share of primary energy from coal
China	3,846	3,936	2,826	4,958	59	57.6%
India	756	966	714	4,021	12	47.7%
United States	640	507	1,553	5,340	35	12.0%
Germany	134	244	2,941	2,257	28	17.5%
Russia	440	174	1,202	4,991	25	12.2%
South Africa	254	161	2,789	5,655	66	70.6%
Indonesia	610	138	516	5,894	13	38.2%
Poland	112	115	6,284	3,975	105	44.7%
Kazakhstan	115	93	2,442	4,307	44	53.9%
Australia	507	69	2,751	6,199	71	27.8%
Colombia	82	9	180	6,871	5	13.4%
Rest of world	632	1,937	505	3,678	8	12.4%
Total World	8,129	7,658	1,009	4,925	21	27.0%

Source: Coal and Energy data from BP Statistical Review of World Energy 2020. Consumption data in tonnes calculated from energy (exajoules as listed via respective conversion as per production data, which was listed in both energy and tonnes). Population data taken from UN.[2] Only Indian consumption data are as per Ministry of Coal FY2018-19 official data.

Calorific values are calculated estimates, with uncertainty due to variance in the breakdown of imported coal by calorific value. A low share of primary energy from coal suggests high carbon emissions from other sources but specific alternatives to coal vary by country.

Per capita natural gas/yr.
[thousand CUF]

Russia	107.2
USA	84.9
UK	38.6
Germany	35.3
Japan	34.1
Nigeria	3.7
India	1.3

source: Worldometer data

- **China offers some insights**
- **Both cleanest and dirtiest country energy-wise**

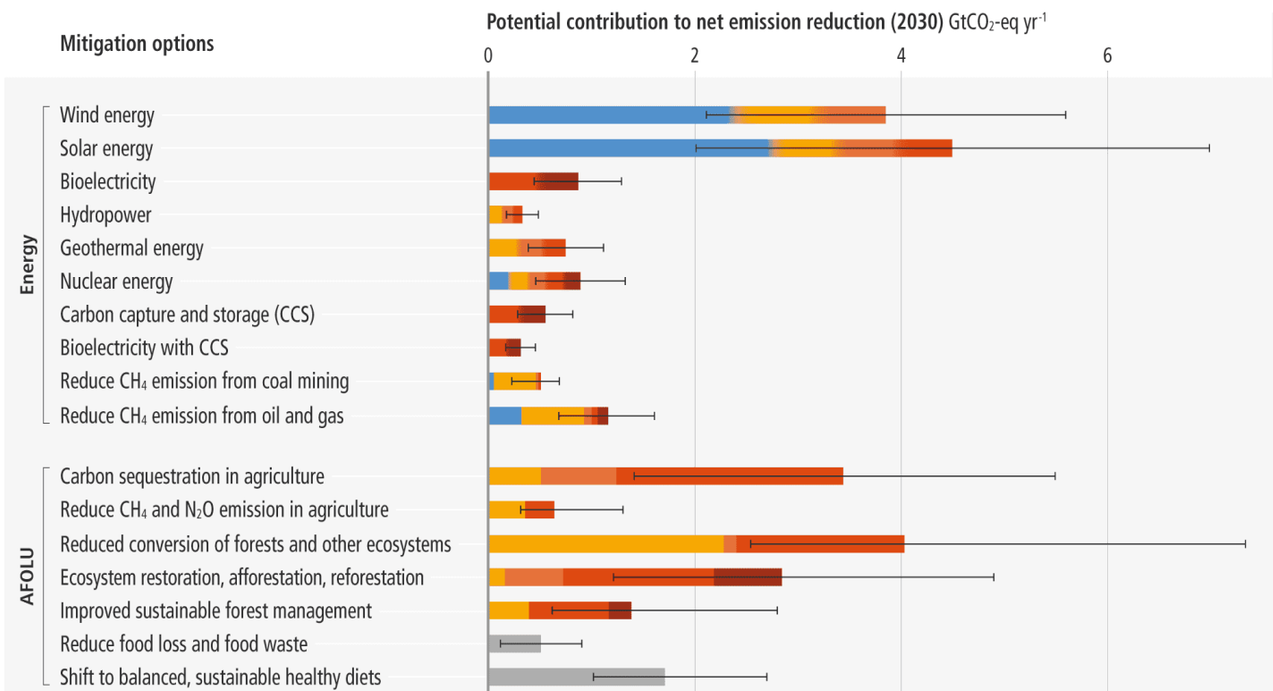
China is the global leader in the **mass production** of low carbon energy technologies

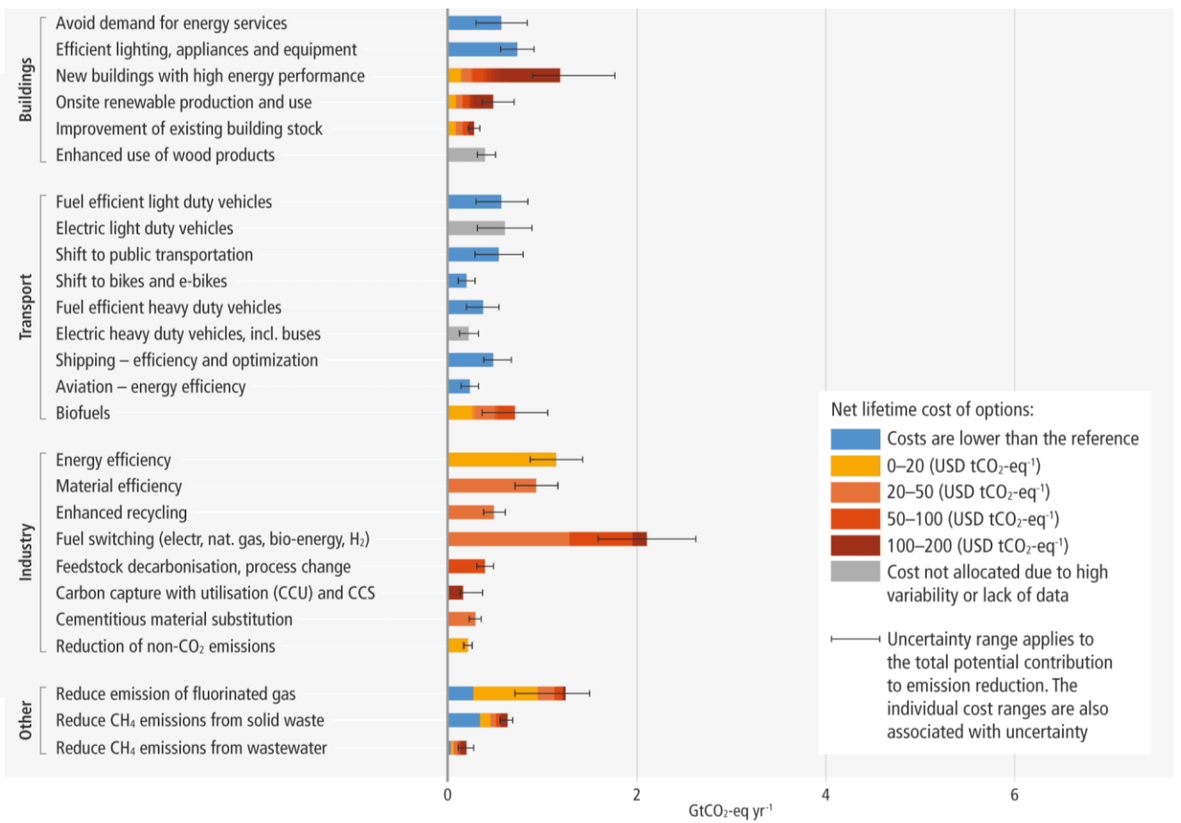
Solar Panels:	From 1% to 66% (2001-2018)
Wind Turbines:	1/3 of global supply (2018)
Electric Vehicles:	53% of global sales (2018)
Lithium-ion Batteries:	69% of global production (76% by 2025)
Nuclear Reactors:	From 45 to 88 plants by 2030

- **For India, short term action matters**
- **Most critical will be the power sector**
  - Electricity is the most growth (and ~half of present emissions) – but luckily easiest to decarbonize
  - There are several metrics that aren't the same:
    - Energy ≠ Capacity ≠ Peak Demand ≠ Real-Time balancing
  - Power Grid realities:
    - India has built up a temporary *capacity* surplus thanks to doubling coal capacity FY11-FY16
    - Most growth is RE = Variable RE (VRE) – without storage
      - Storage costs are still VERY high and projected to be so through 2030
    - Most modelling is on energy basis, or a few grid balancing studies (incl. CSEP, plus CEA, NREL, LBL, TERI, and state-level like Prayas, CSTEP).
      - There is enormous uncertainty on load and demand profiles (by time of day) – but we can start with energy as the key *exogenous* factor for planning
  - By ~2027 (+/-), the present surplus will exhaust, and Variable RE won't suffice
    - Will need firm power, maybe storage
    - More transmission
    - Grid re-design

• IPCC's AR6 Mitigation Report (SPM.Fig7)

Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.

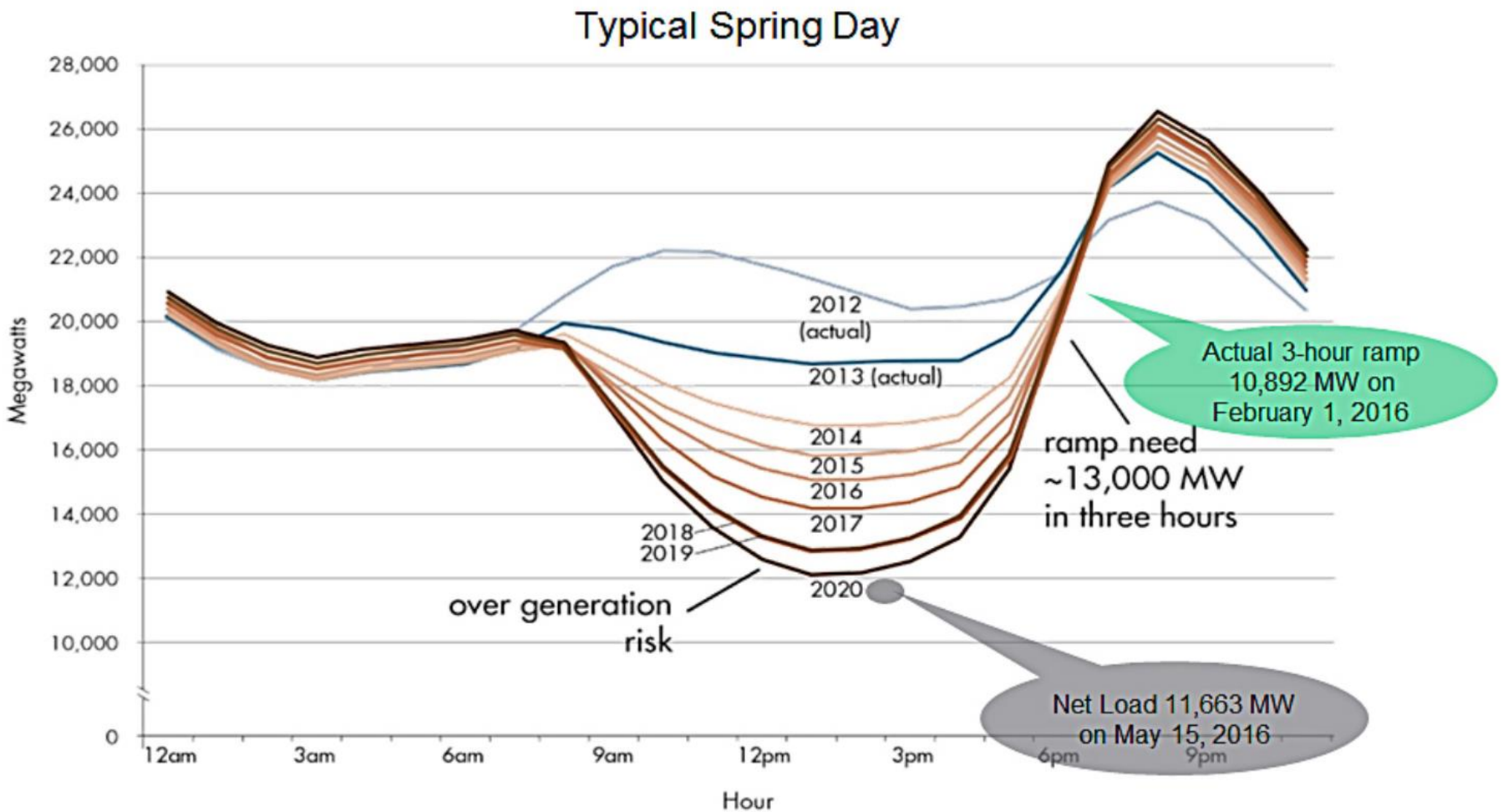




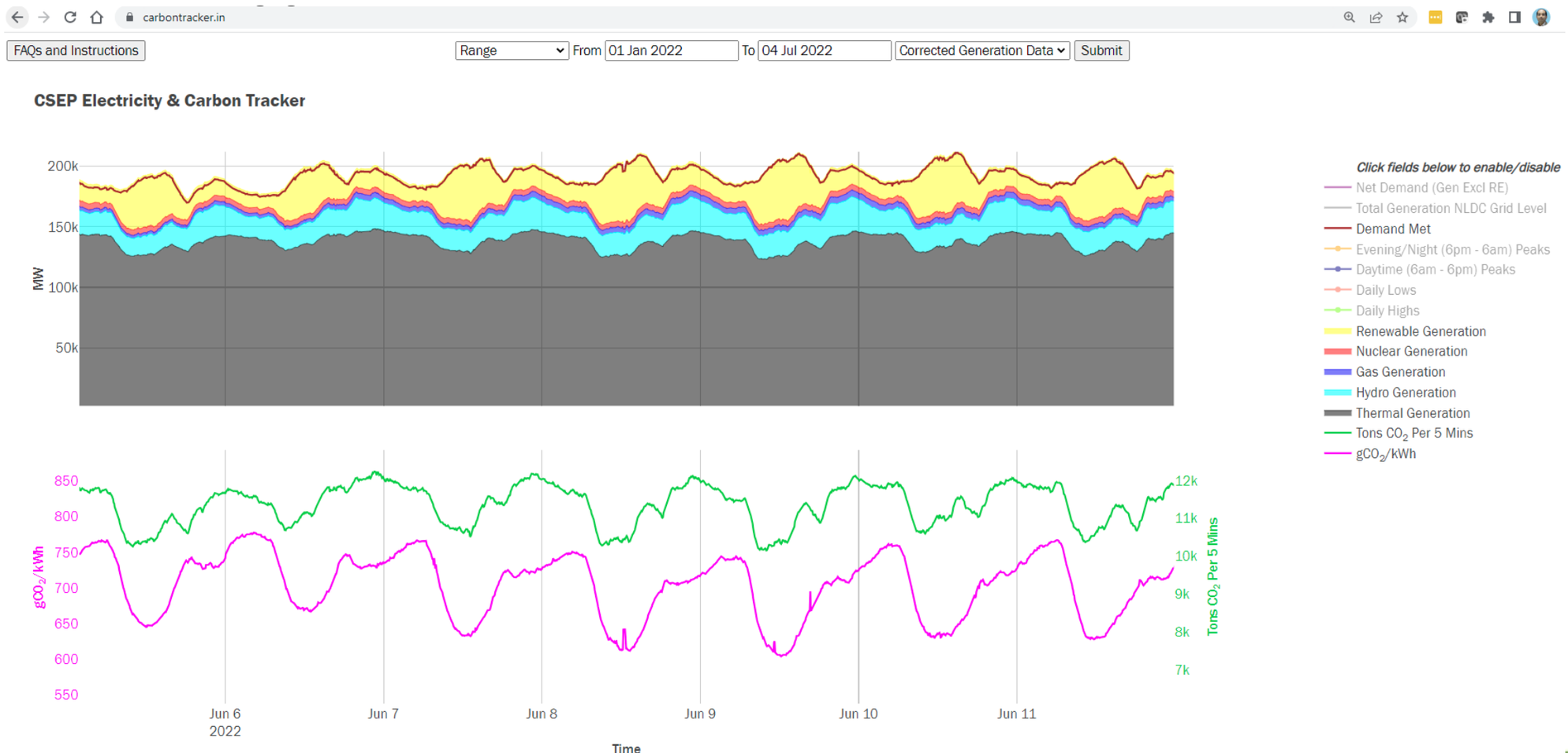
There WILL need to be a premium paid…

…and even then is it enough?

• CA-ISO's Famous Duck Curve (2014)



• Time of Day matters – Indian Snapshot



Source: Underlying Data from MERIT India

- **Future won't look like the Past**
- **Time of Day issues will only grow**
  - We have to recognize the need for (and value of) peaking power
    - We don't have Time of Day pricing for the most part, neither retail, nor even wholesale
  - As we grow to 450 GW RE, we WILL enter a world of "surplus"
  - Tongia (2022) showed that RE surplus will be seasonal, and "too much" RE isn't a cost-problem – problem is "net demand" (evening peak)
  - Storage is still very expensive
    - Levelized cost of energy (LCOE) is a very poor marker
      - Ignores system costs
      - Assumes daily "full use"

- **What are emissions for 100% electrified?**
- **Many users are proclaiming "100% solar" – without storage**

- How are they really carbon-free?
- Are they simply relying on "banking" aka offsets?
- Is this accurate?
- Will this scale?

- **What we need to update**
- **Managing an RE heavy grid will need changes**
  - REALITY – As RE grows:
    - Marginal cost increases
    - Marginal value declines
  - More Transmission
  - Better signalling for the right power – right time, right place, right characteristics, and right price
  - Changes to grid structure?
    - Today, PPAs mostly under state Load Despatch Centre
    - Tomorrow…lots to be figured out; saying “markets” isn’t enough
  - How we handle “socialization” and social welfare redistribution
    - We can’t keep subsidizing RE (e.g., rooftop solar capex, free ISTS, etc.)

- **Other changes and issues**
- **The scale we need is unprecedented**
  - We have simultaneous transitions
    - Decarbonization
    - Digitalization
    - Decentralization (and structural reforms, e.g., markets, prosumers, etc.)
  - We need a smarter grid
  - We have to up our manufacturing – we shouldn't be imports-only
  - We need to upskill our systems
  - We have to fix our DisComs

- **Thank you!**