THE ENERGY CHALLENGE IN A WARMING WORLD

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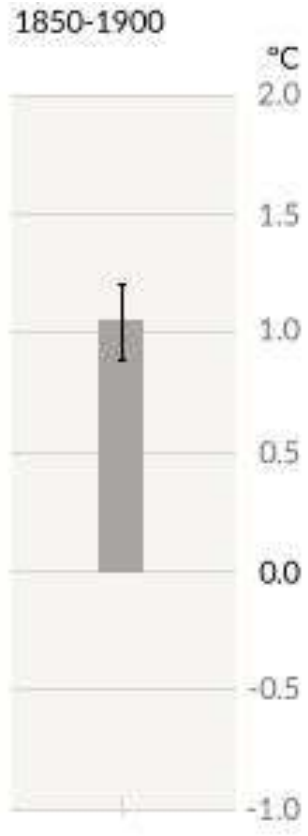
A Warming World



Warming about ~1.07 deg. C from pre-industrial average

IPCC, AR6, WG-I

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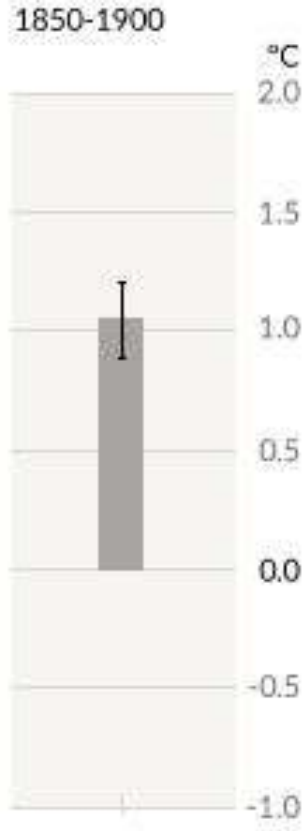

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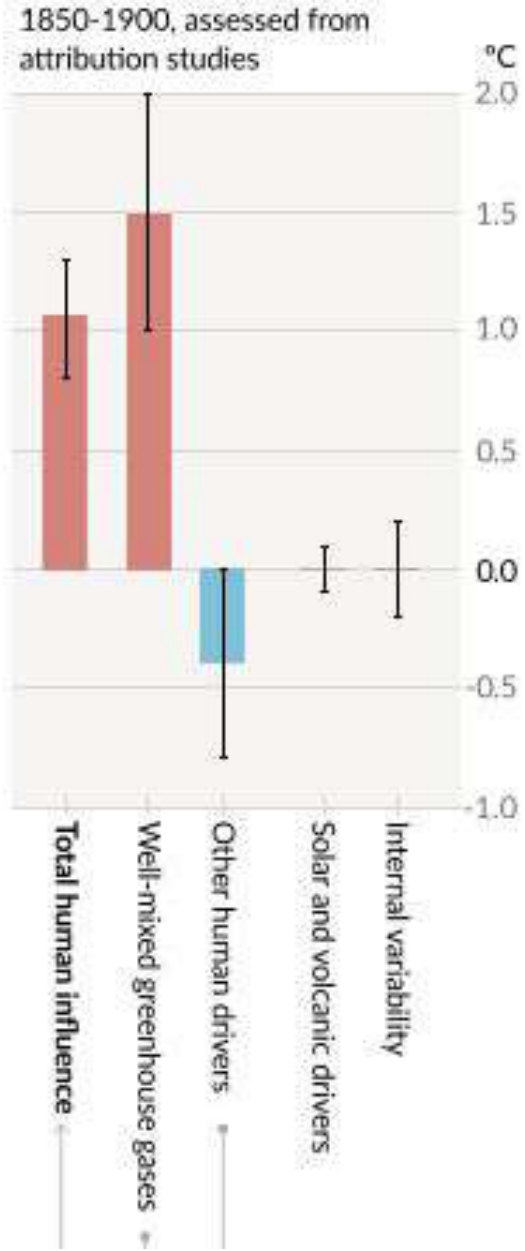

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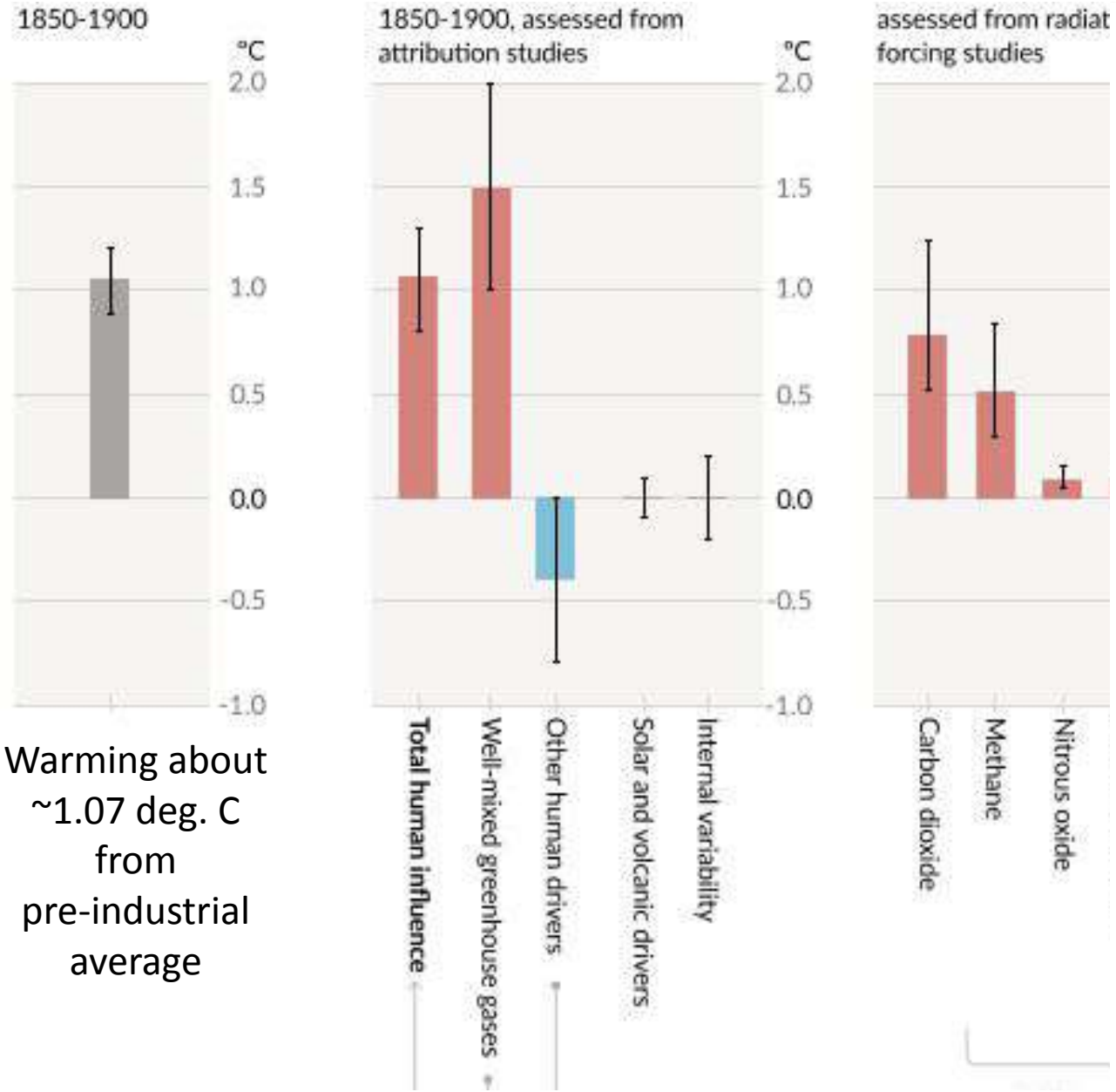

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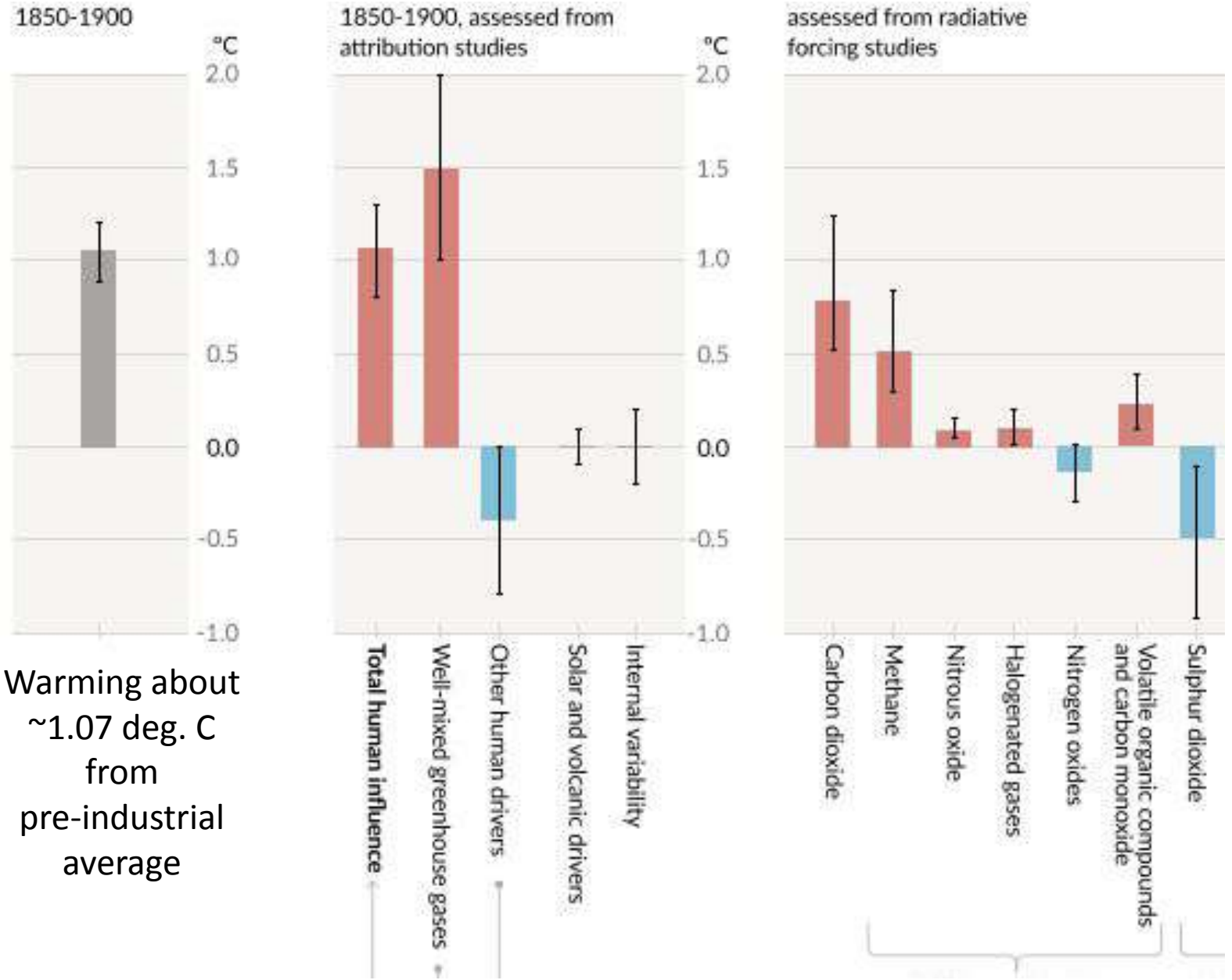

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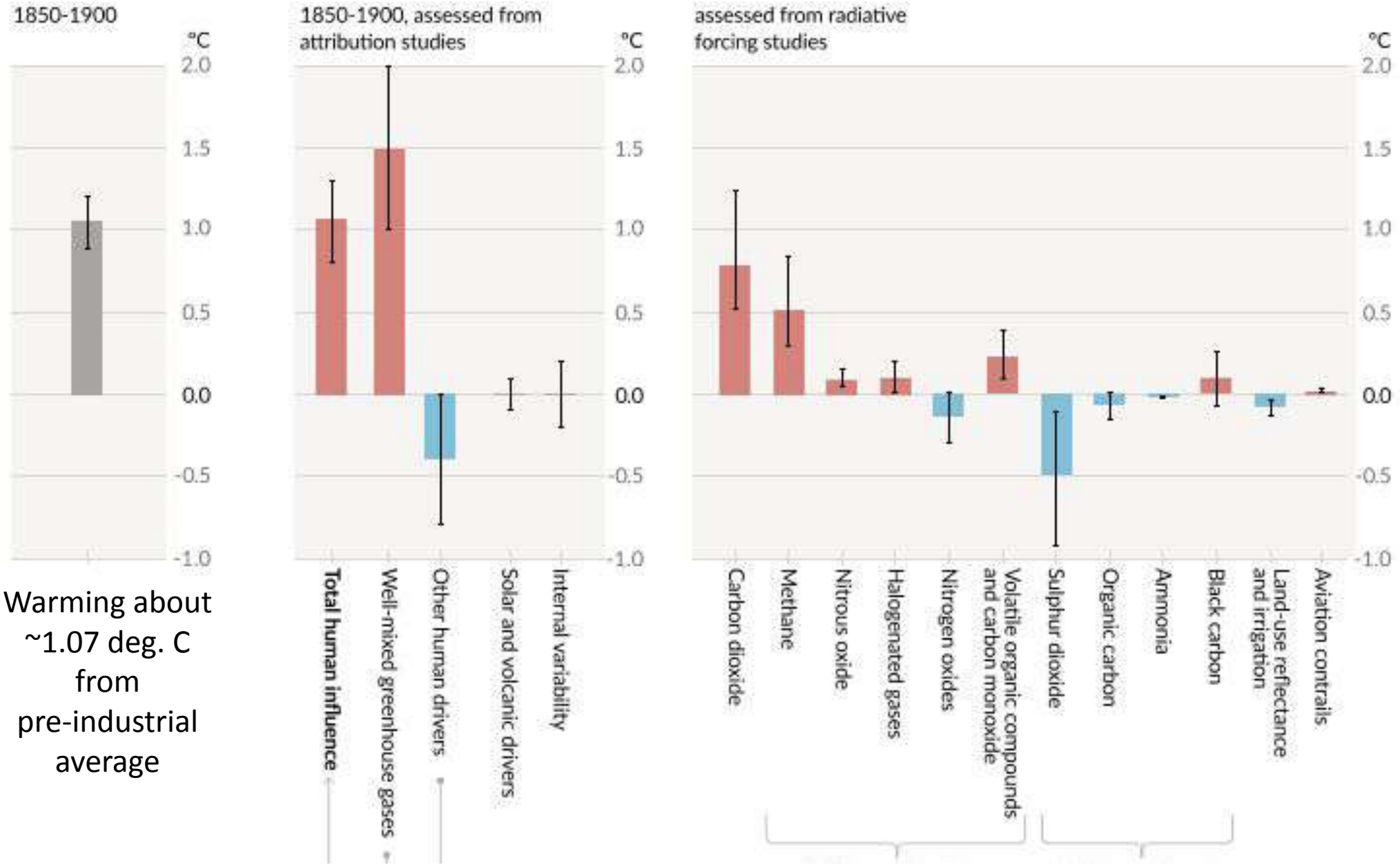


Warming about ~1.07 deg. C from pre-industrial average

IPCC, AR6, WG-I

Other important advances…

Science clear since before AR5: **Increase in global temperatures proportional to the global cumulative emissions**

To limit warming since the pre-industrial period, cumulative emissions must stay within a **Global Carbon Budget**

Global cumulative emissions determine the global temperature that will be reached – ***not the timing of net-zero***

ANNEX I: EMISSIONS AND FAIR SHARE OF POPULATION

By 2019, Annex 1 countries had emitted more than

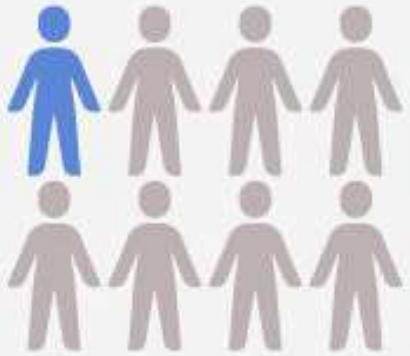
>60%

of global emissions

However in 2019, Annex I countries constituted only

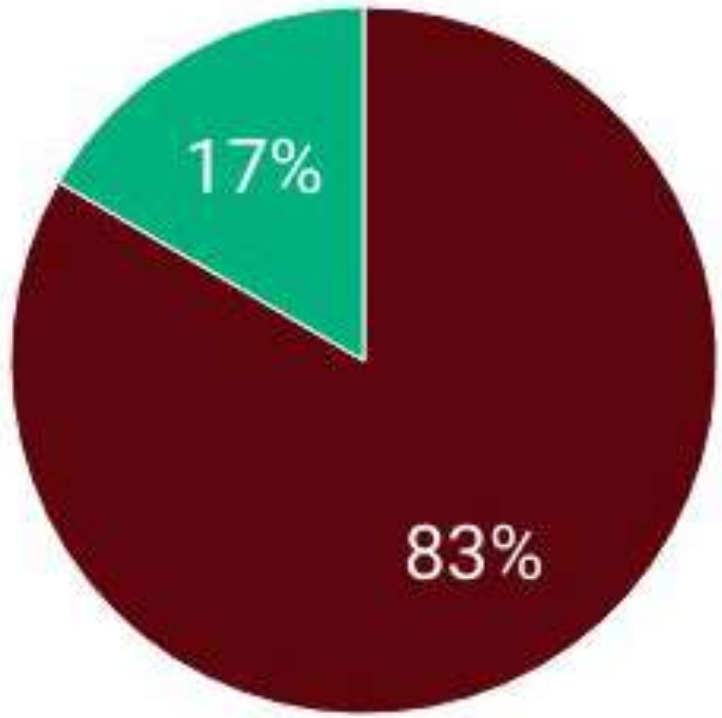
17%

of the global population



Historical Cumulative Emissions

~1.07 deg. Warming



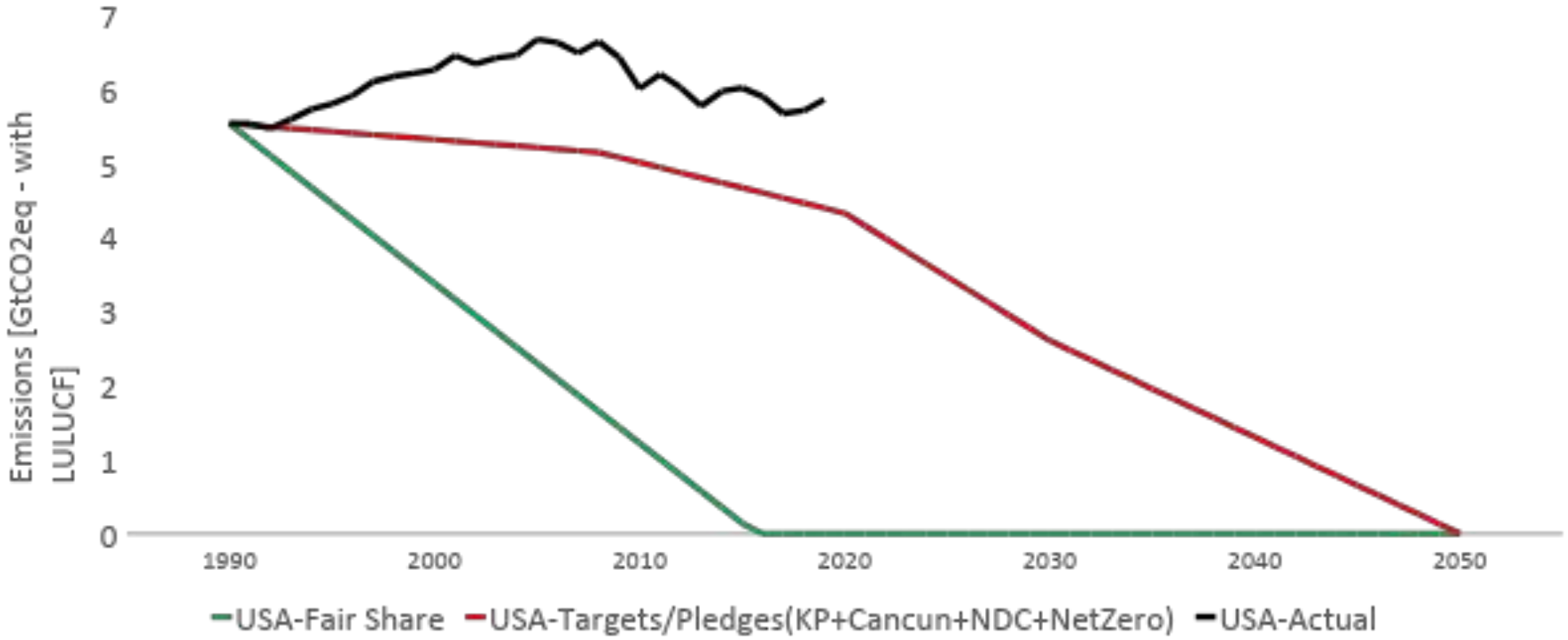
1.5°C- 50% Probability

Total:
3,016

Past Cumulative Emissions (1850-2019)

Remaining Carbon Budget to Limit Temperature Rise below a Specific Target (2020-Global Net Zero)

Illustration: Inaction by the US - Climate leader or laggard?



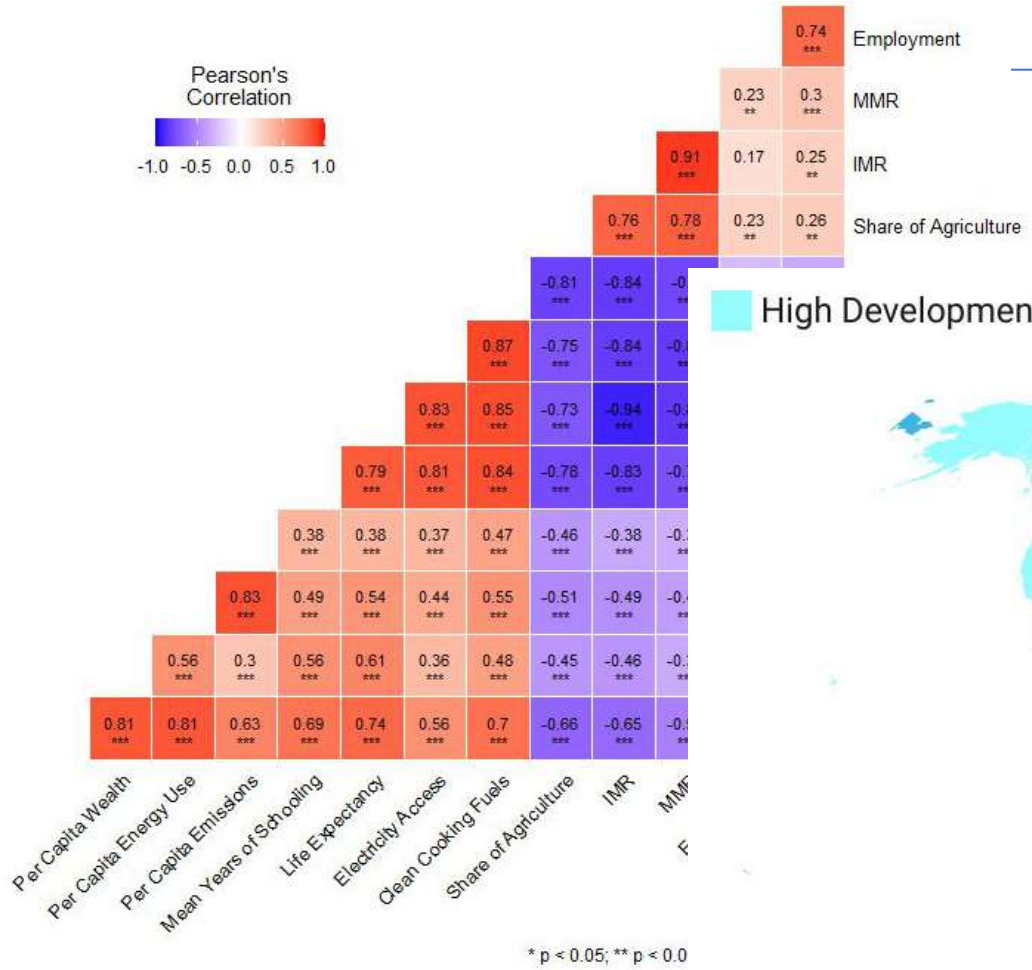
Differences in Historical Responsibility Linked to Energy Access and Poverty

A large section of the Global South faces perpetual energy poverty.

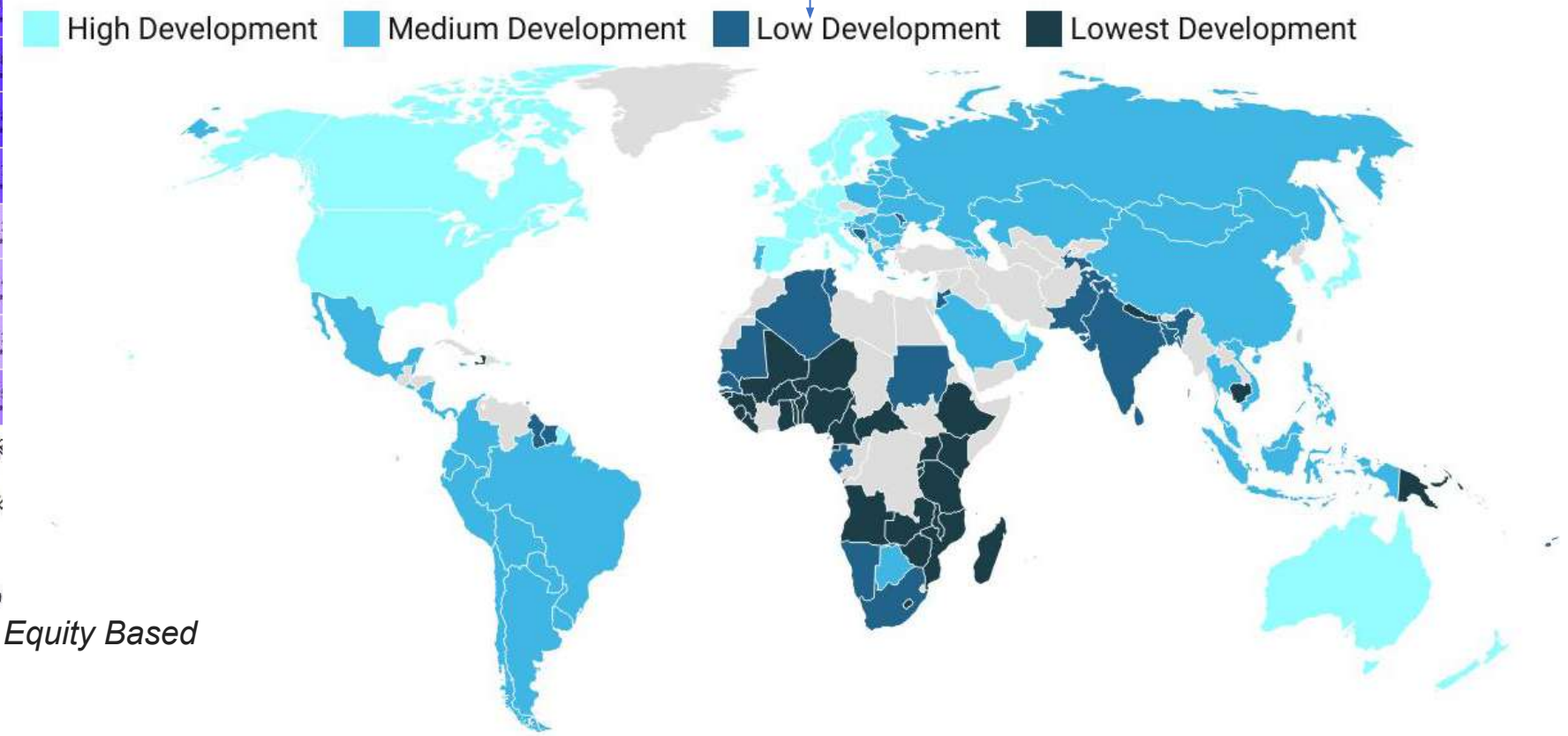
There are stark differences in energy access and use – across countries.

Regional Re-classification

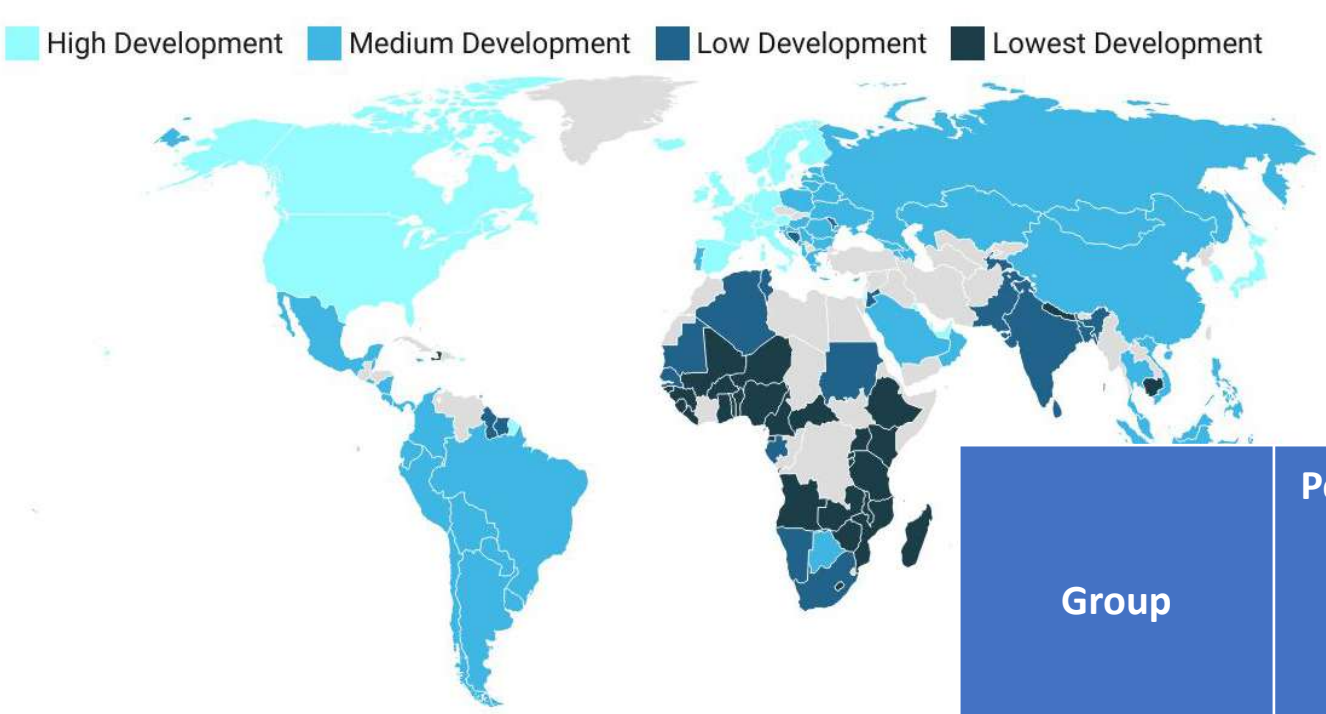
- 4 country groups based on 13 developmental variables



PC Analysis → K-means clustering



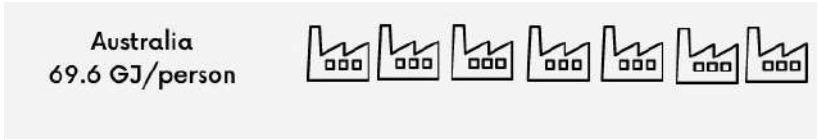
Ranjan, A. and Kanitkar, T., (2023). Energy Equity Based Climate-Compatible Futures



Group	Percentage of Global Population (%)	Share of global GNI (%)	Average per capita energy use (GJ)	Average per capita GHG emissions (tCO2eq.)
G1: High Development	14	44	300	18
G2: Medium Development	39	40	88	7
G3: Low Development	35	14	32	4
G4: Least Development	12	2	7	2

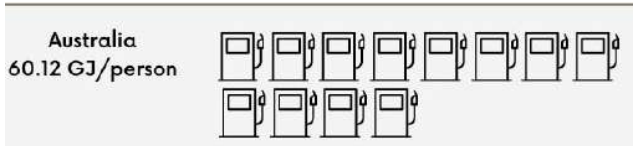
Ranjan, A. and Kanitkar, T., (2023). Energy Equity Based Climate-Compatible Futures

Coal Consumption (2019)

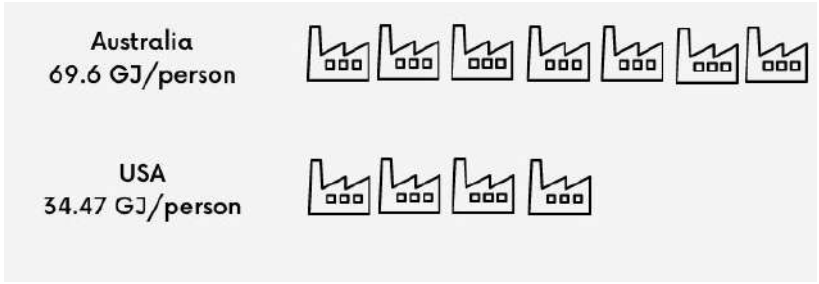


Oil Consumption (2019)

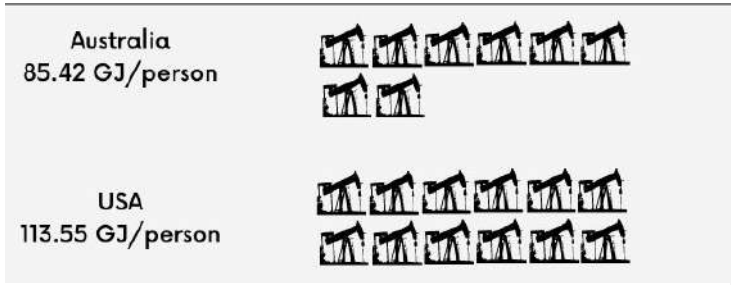
Gas Consumption (2019)



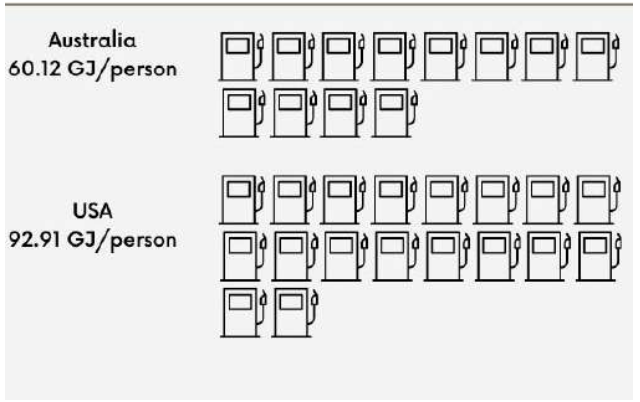
Coal Consumption



Oil Consumption



Gas Consumption



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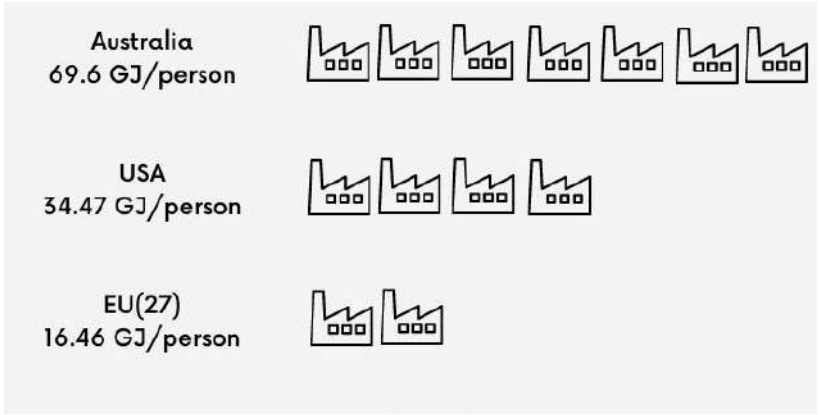

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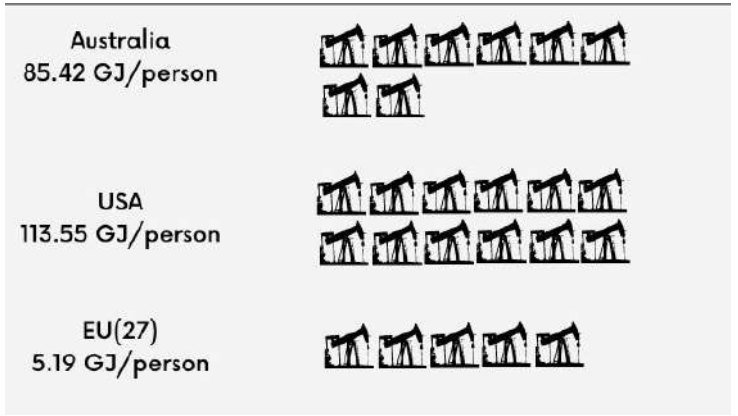

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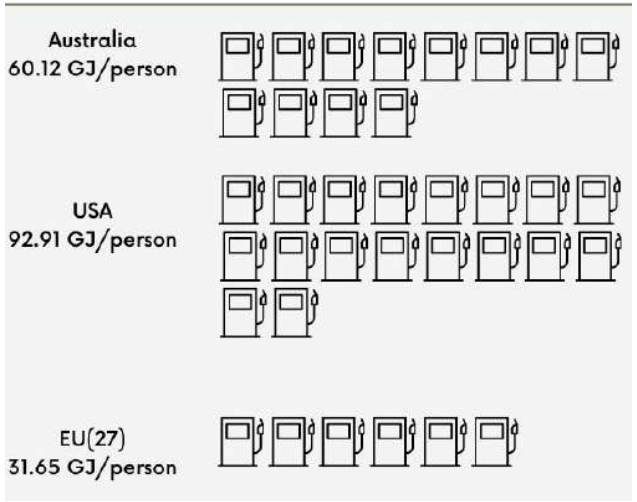
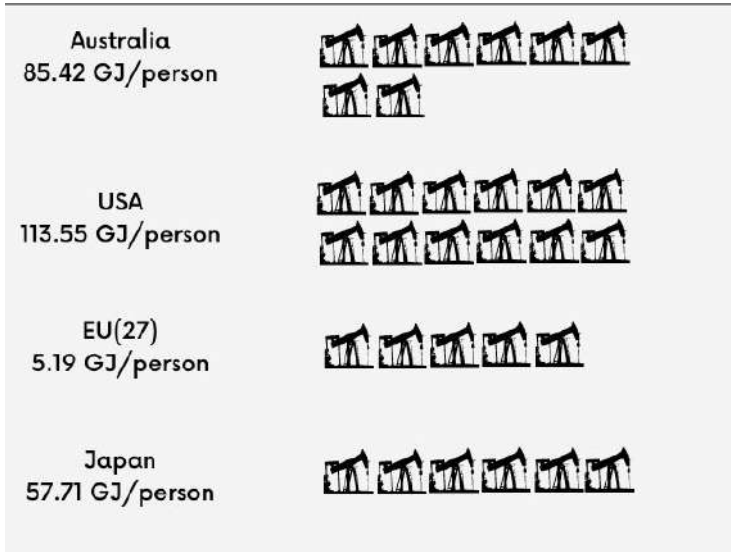


Coal Consumption

Oil Consumption



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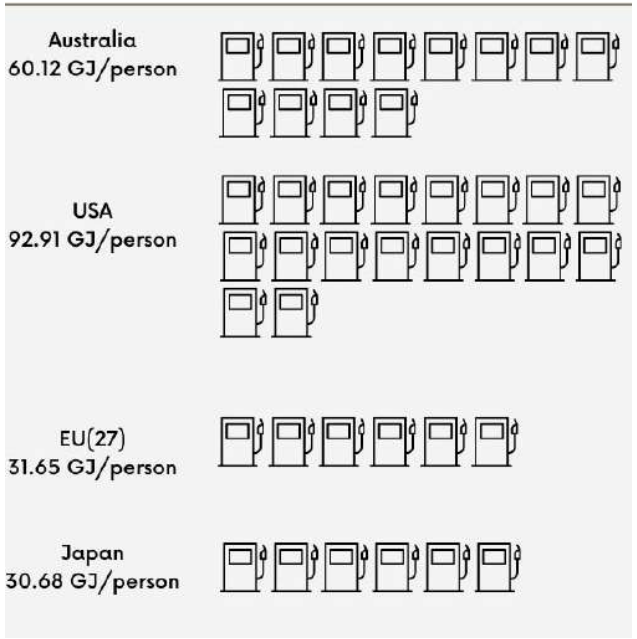

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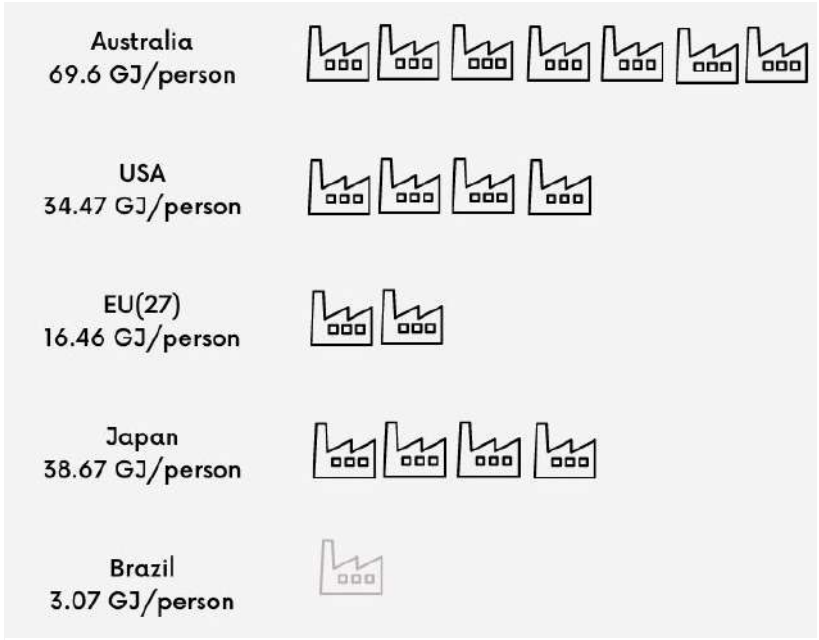

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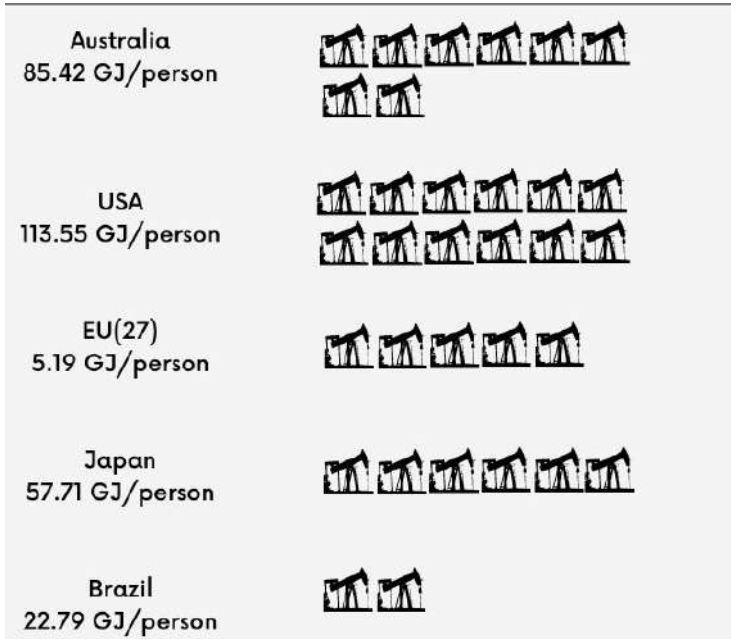

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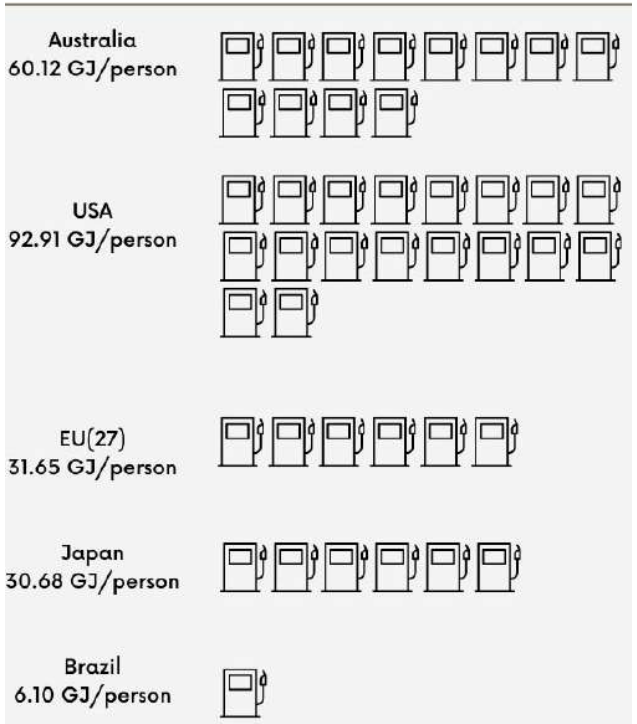

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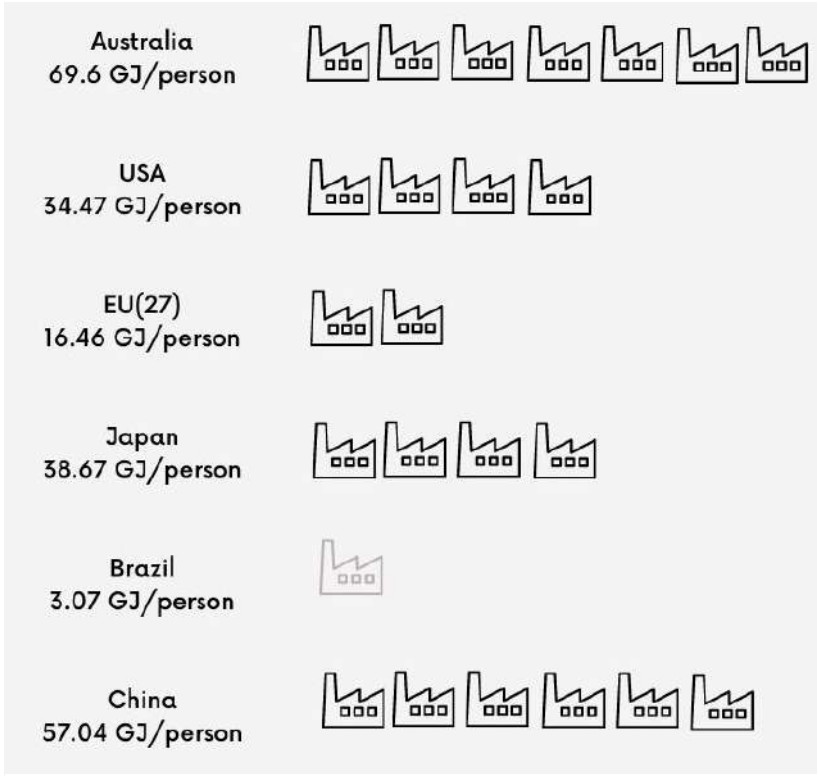

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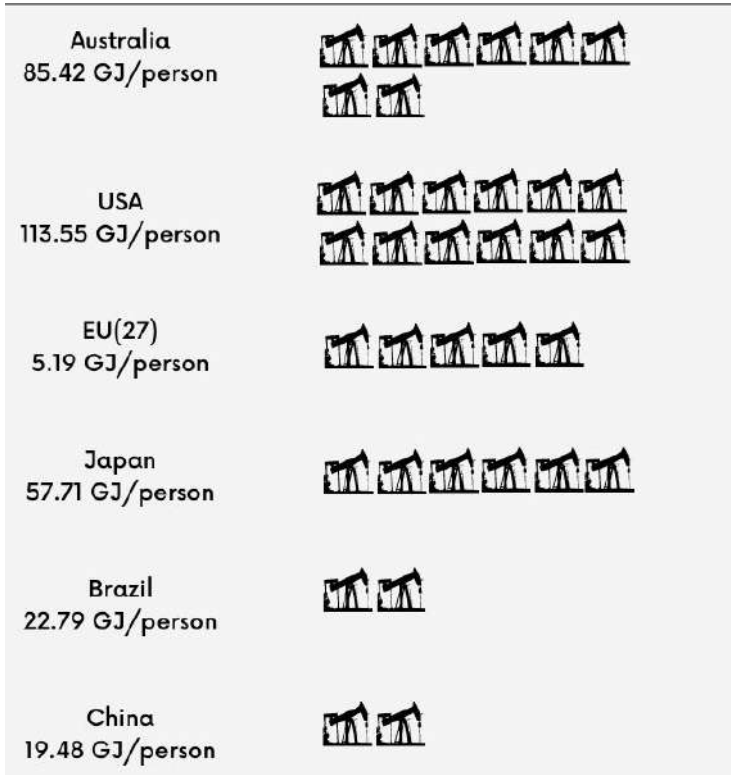

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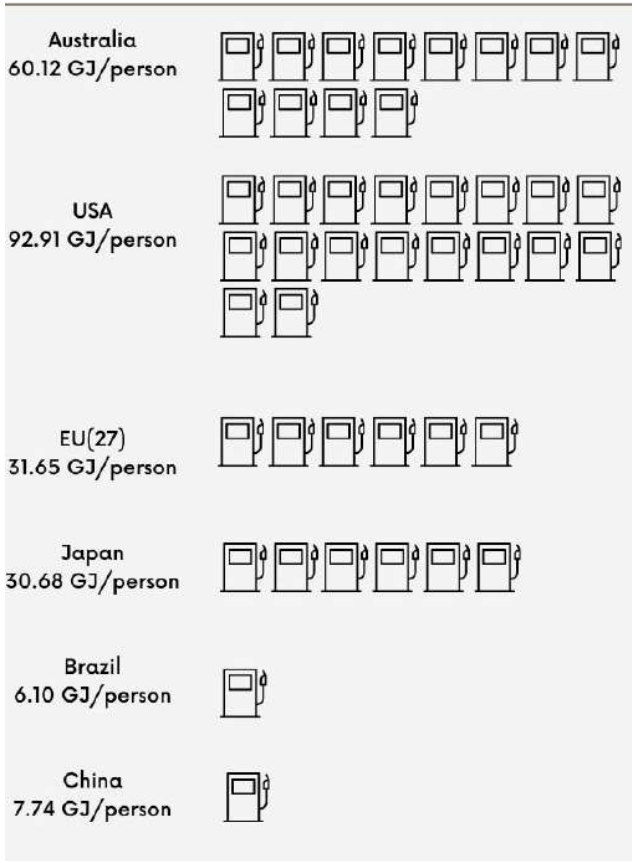

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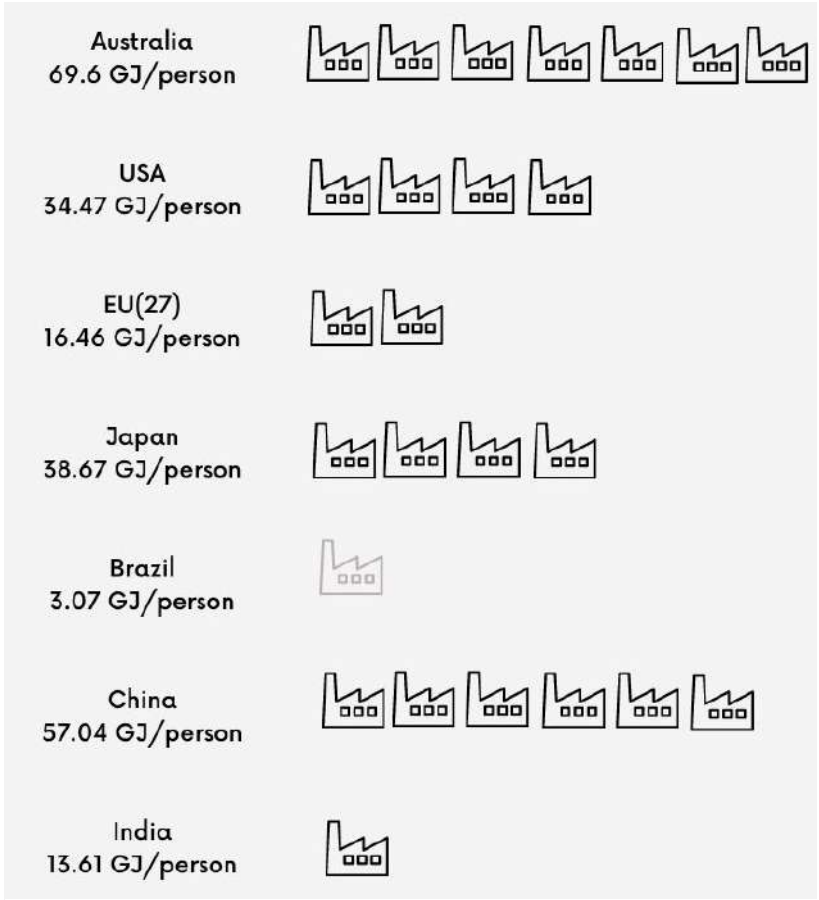

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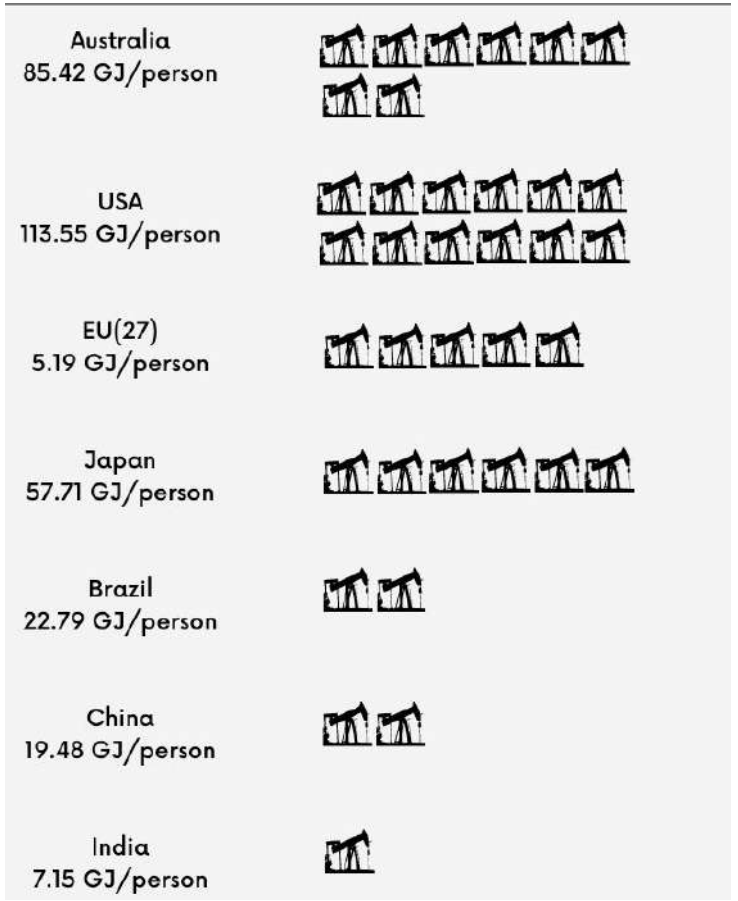

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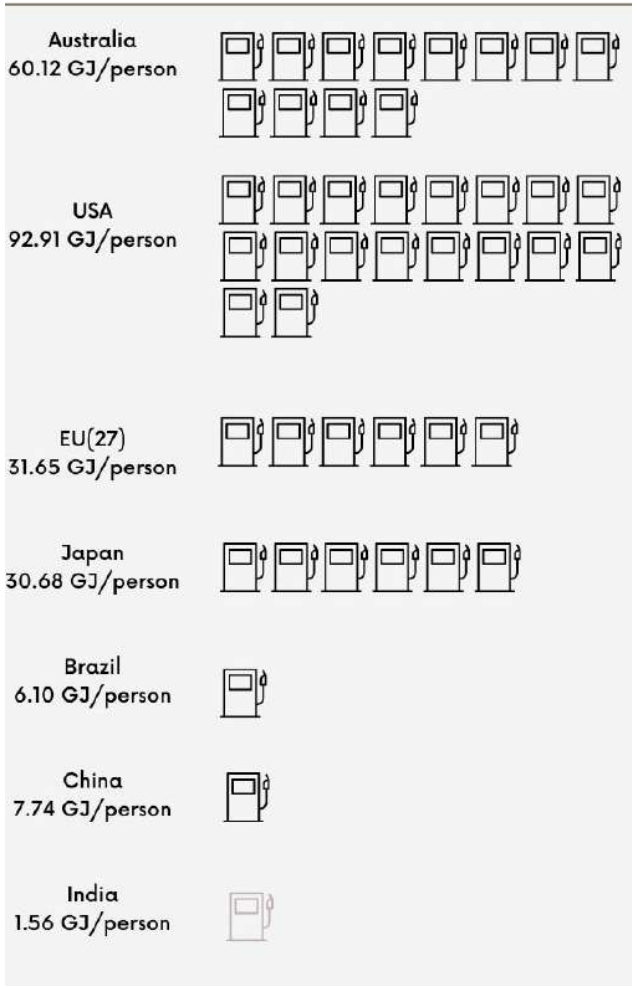

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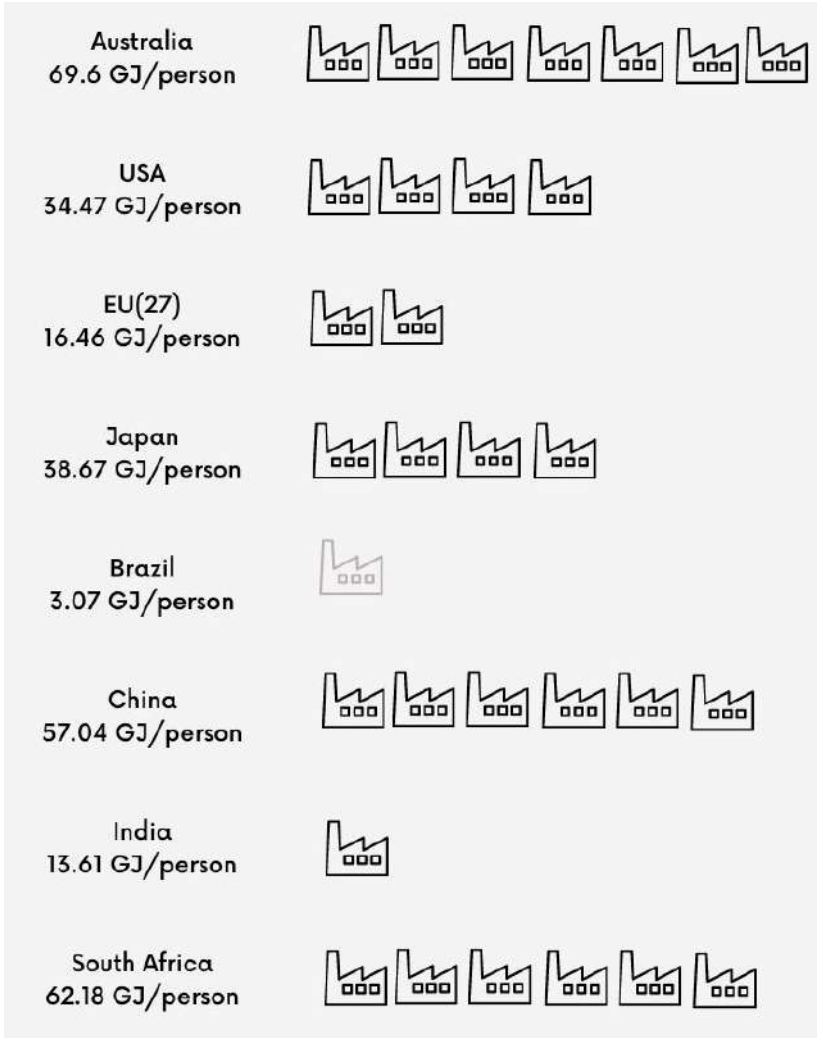

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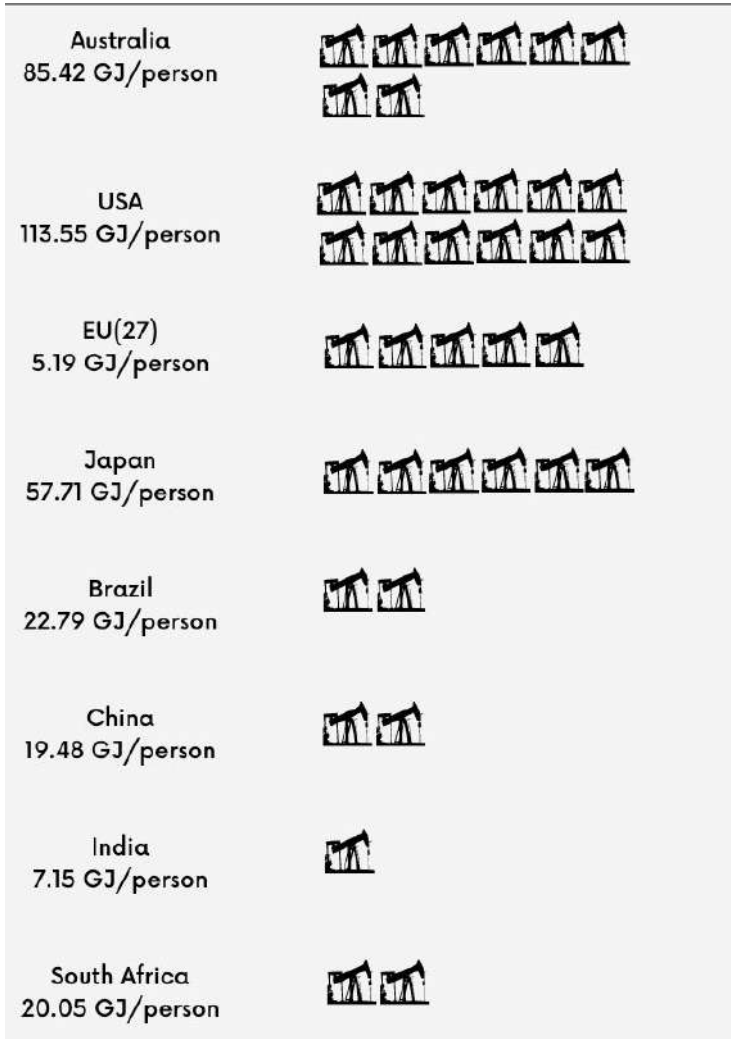
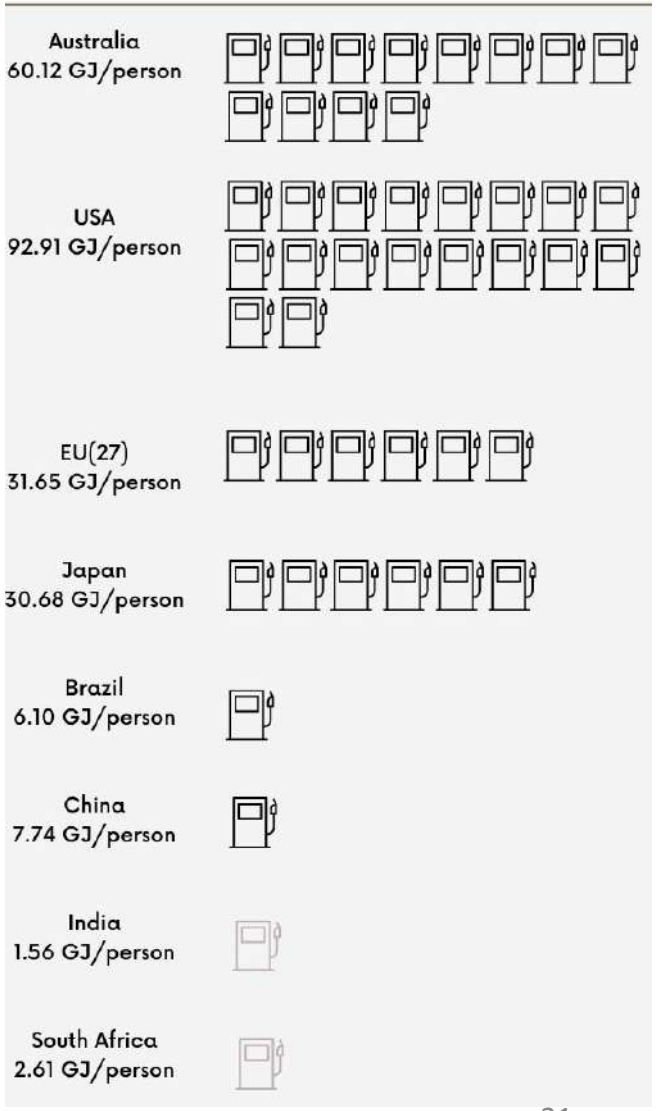
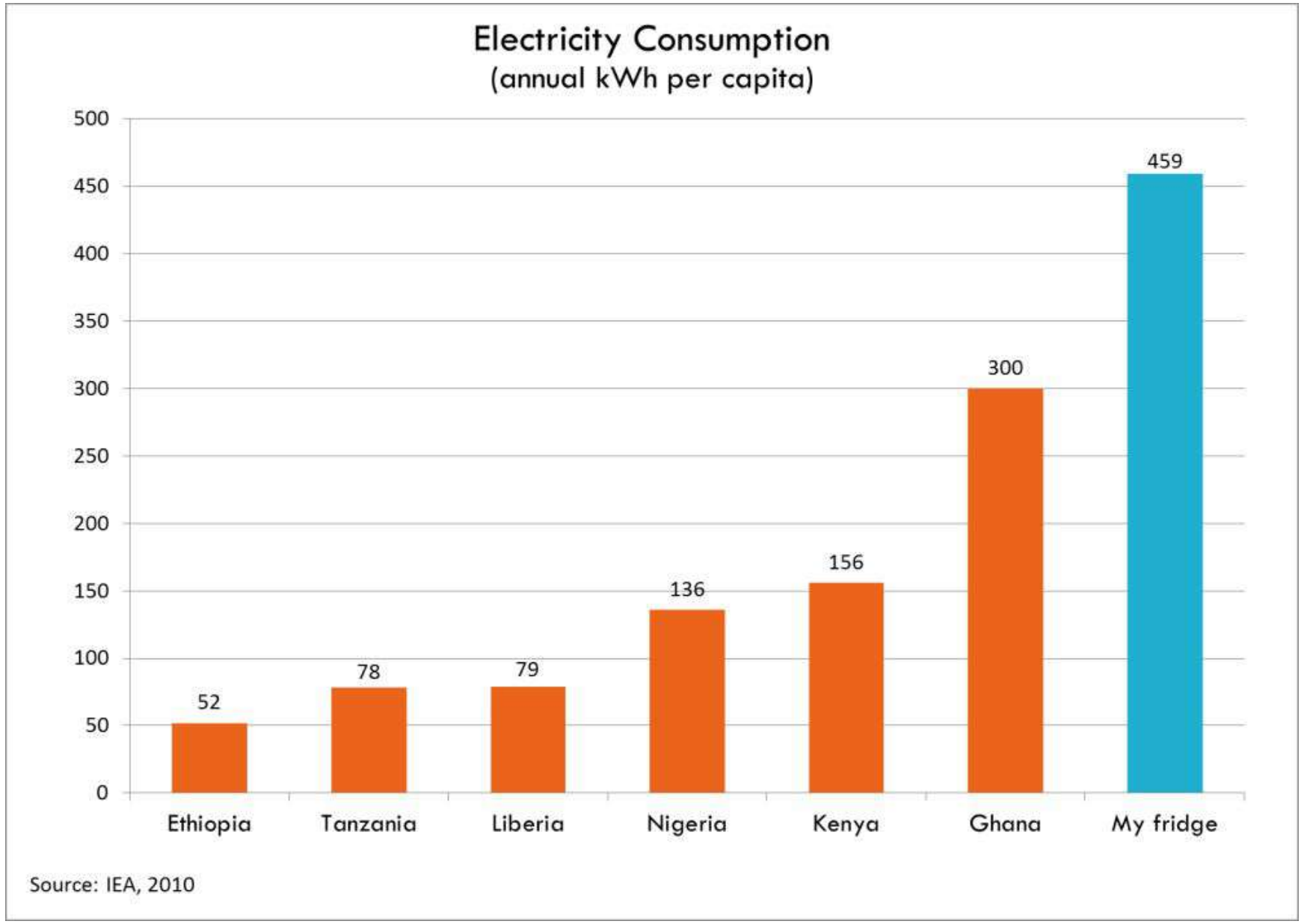


Gas Consumption





An American refrigerator uses more energy than average per capita energy consumption in 6 African nations

Source: Todd Moss, Centre for Global Development; https://www.cgdev.org/blog/my-fridge-versus-power-africa

And yet…

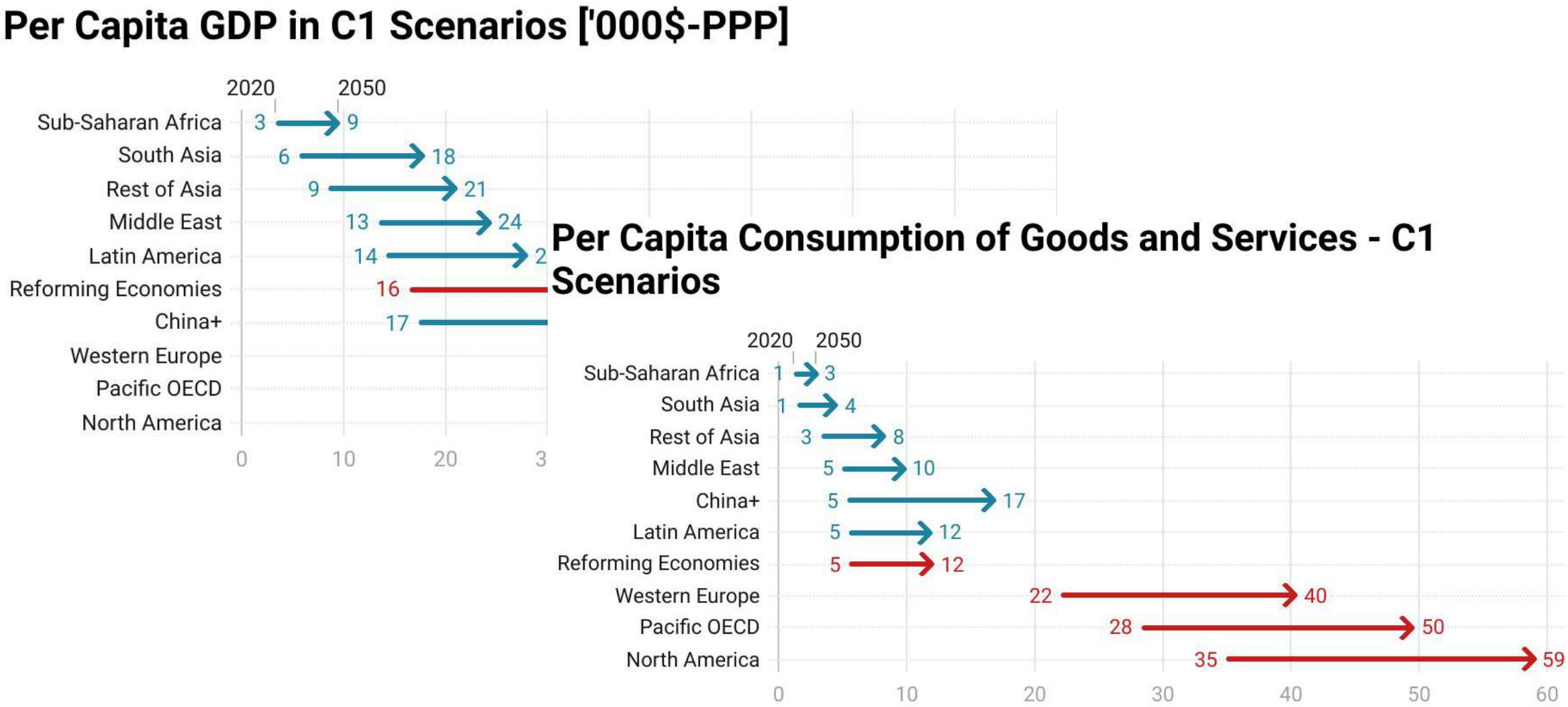
- These inequalities are sought to be perpetuated even in the future
  - Action by developed countries highly inadequate even after Rio, KP and PA
  - Constant shifting of goal posts
  - Higher burdens of developing countries
    - Model scenarios project unequal futures
    - Unequal futures are accepted matter-of-factly (What can we do…very little carbon space left)

Some examples

- We assessed
  - 556 emissions scenarios corresponding to 1.5 and 2 deg. C targets – Paris Agreement – and their underlying regional assumptions and outcomes.

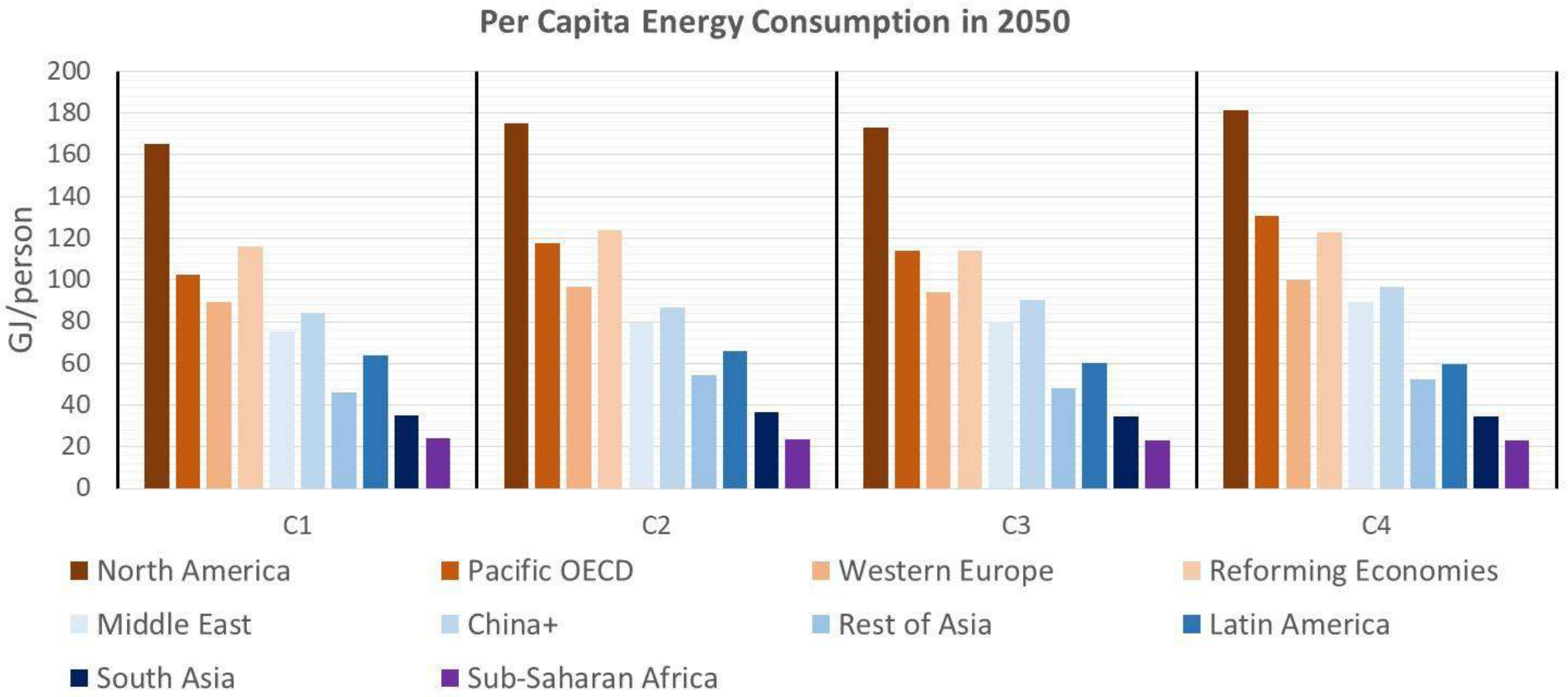
- Scenarios come from models (Integrated Assessment Models)
  - Heavily dependent on input assumption – neoclassical, no distributive justice,
    - Unjustified technology optimism coupled with unjustifiable economic pessimism

Highly unequal global outcomes: Economic Growth and Consumption in Developing Countries Severely Restricted



Kanitkar, T., Mythri, A., & Jayaraman, T. (2022). Equity Assessment of Global Mitigation Pathways in the IPCC Sixth Assessment Report.

Primary energy consumption (not just fossil fuel) restricted for developing countries



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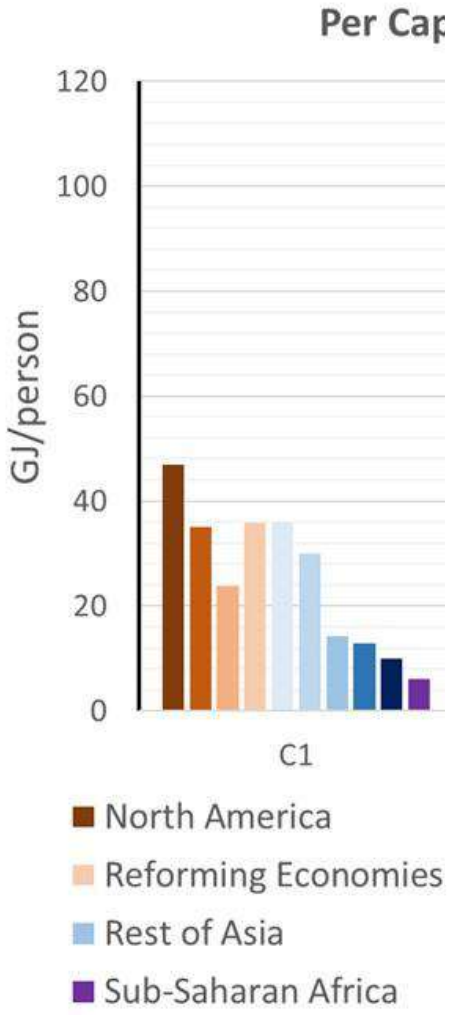
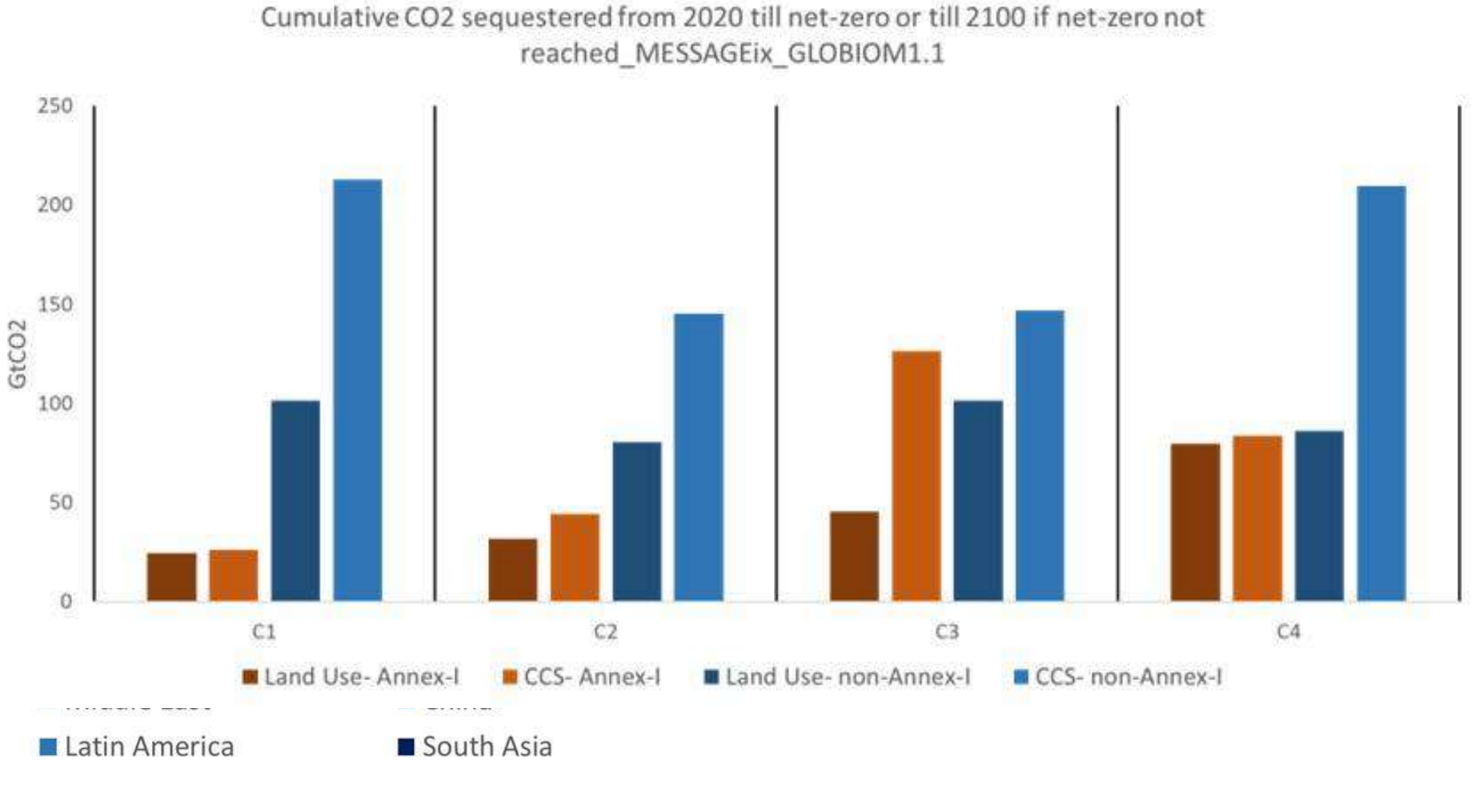
Higher fossil fuel consumption in developed countries vs. higher CO_2 sequestration in developing countries





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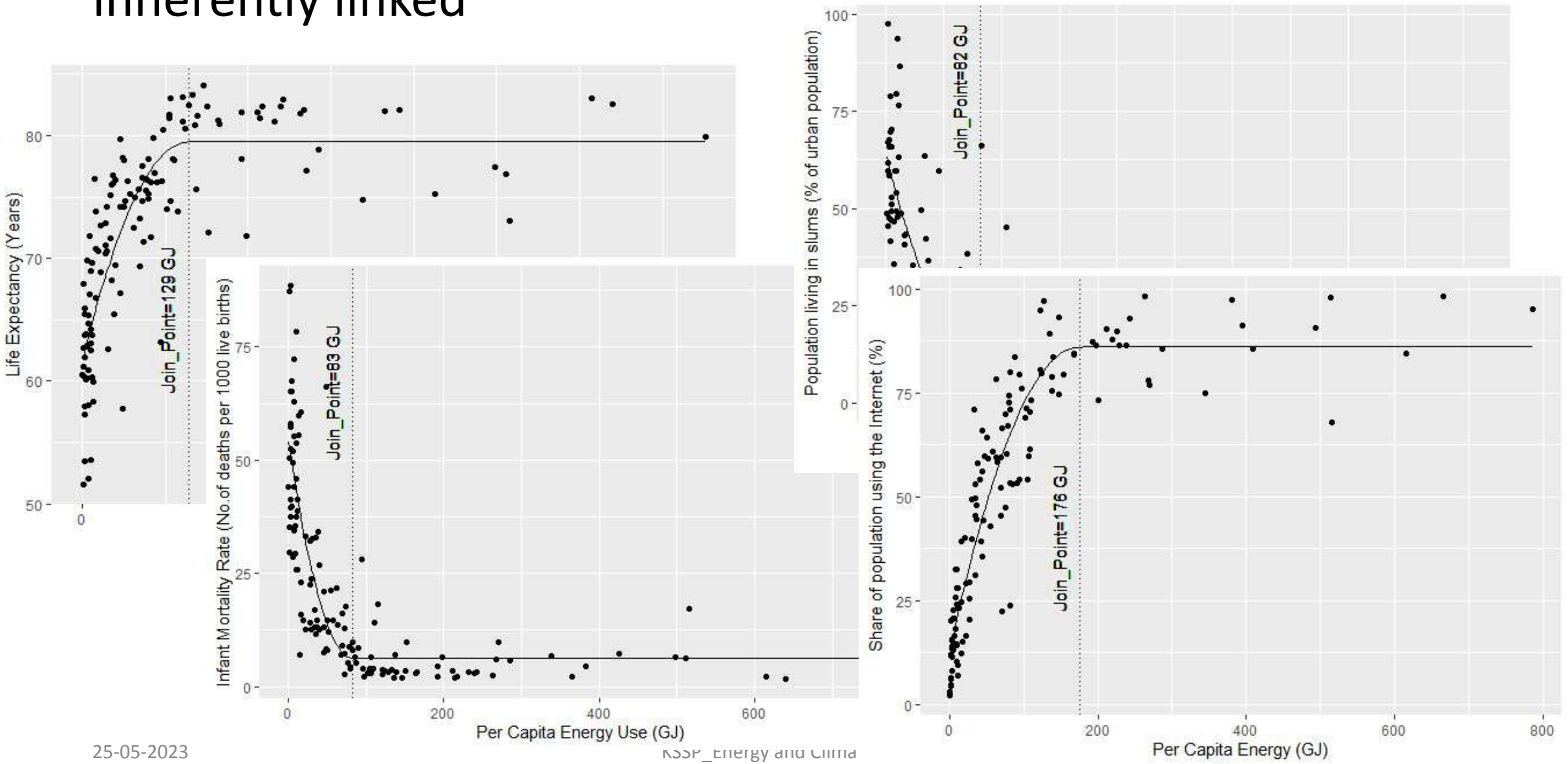
Climate justice matters because…energy and development inherently linked



Across 9 variables: Threshold for development – ~94 GJ, ~$28,000

Variables	Join Point (per capita energy, GJ)	Join Point (per capita GDP, PPP$)	Sample Size for 2016 (Out of 134 countries)
Life Expectancy (years)	129	39,200	134
Infant Mortality Rate ((No. of deaths per 1000 live births)	83	20,240	134
Maternal Mortality Rate ((No. of deaths per 100,000 live births)	35	12,790	134
Daily Calorie Intake (kcal/day)	141	45,990	129
Death rate from air pollution (per 100,000 people)	66	22,510	134
Mean years of schooling (years)	97	27,320	134
Share of population using internet (%)	176	45,310	134
Electricity Access (% population)	33	10,190	134
Share of urban people living in slums (%)	82	34,560	88
	94 (±15)	**28679 (±4179)**	

India □ 23 GJ, $5720

Lack of energy access has real material consequences

- Low access to modern energy, amenities, infrastructure, and services in India
  - > 42% have no access to modern cooking fuels (57% in rural India)
  - ~30% with no sanitation facility

- Women bear the brunt of this backwardness…
  - >33% girls over age of 6 have never attended school
  - ~34% rural women illiterate (as opposed to 18% rural men)
  - Only 41% of Indian women have more than 10 years of schooling
    - only 34% of rural women
  - > 66% women have never used the internet (43% men)
  - Adolescent fertility rate for women aged 15-19 years 43% (49% in rural India)

Equity in real material terms

- Climate justice not some vague concept but a real fight for a decent life for all while limiting global warming

- Uncritical acceptance of utopian discourses of sustainability (applied selectively to the Global South) undermine this fight

- The same hubris is extended to RE technology, without accounting for challenges……and yet…RE has many challenges: A brief example of Southern India

RE Generation

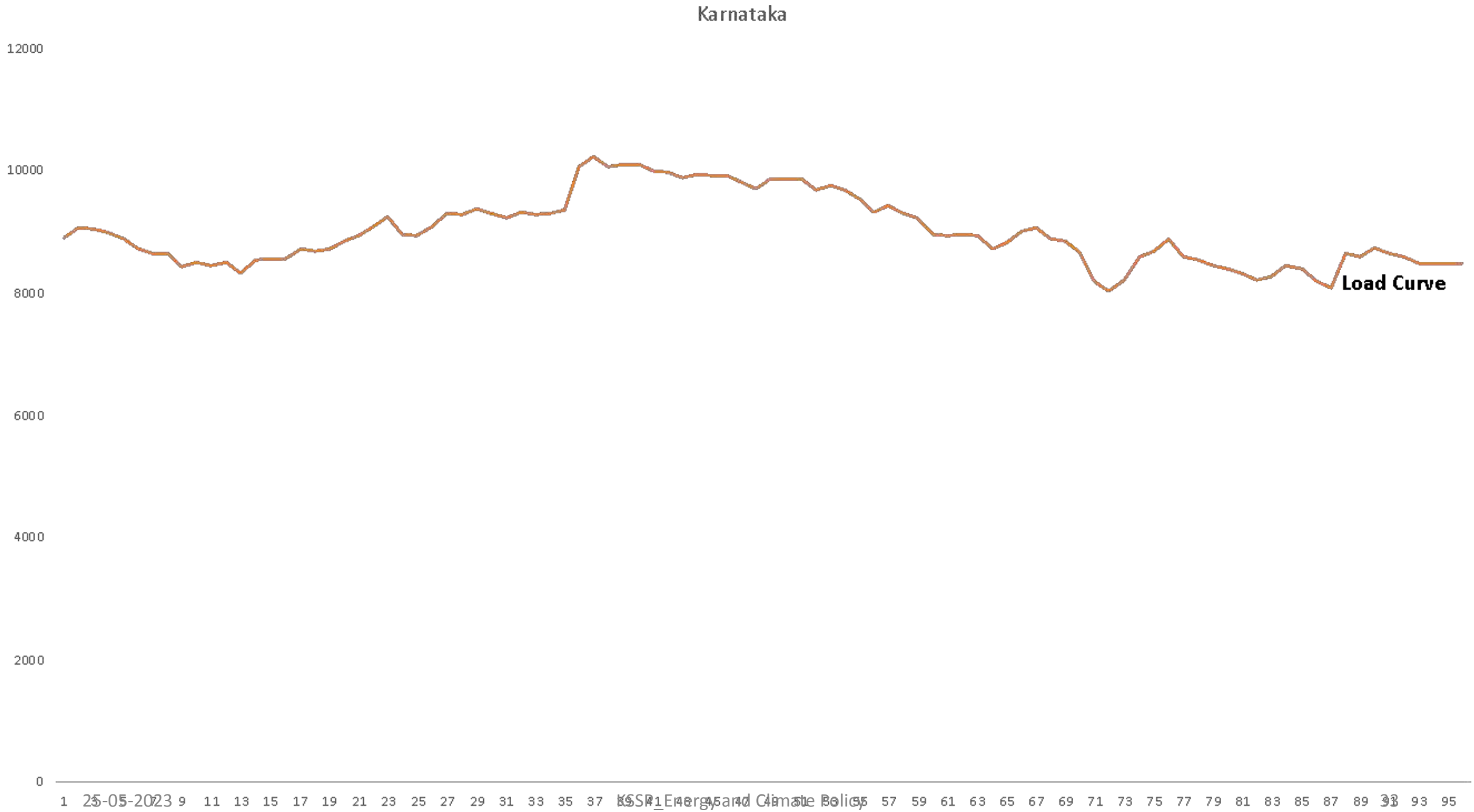
As of 3 November 2022

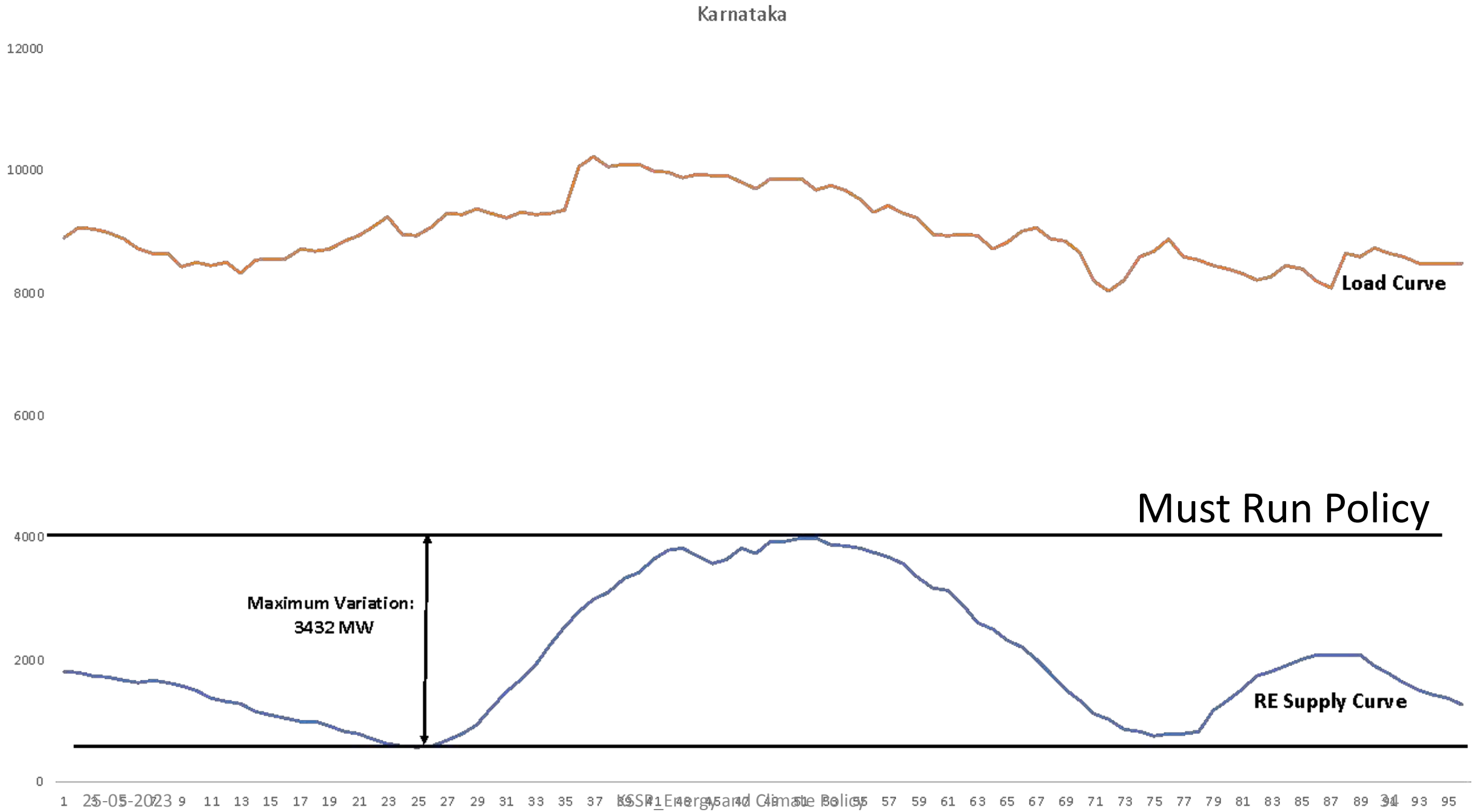
Total RE capacity - ~118 GW

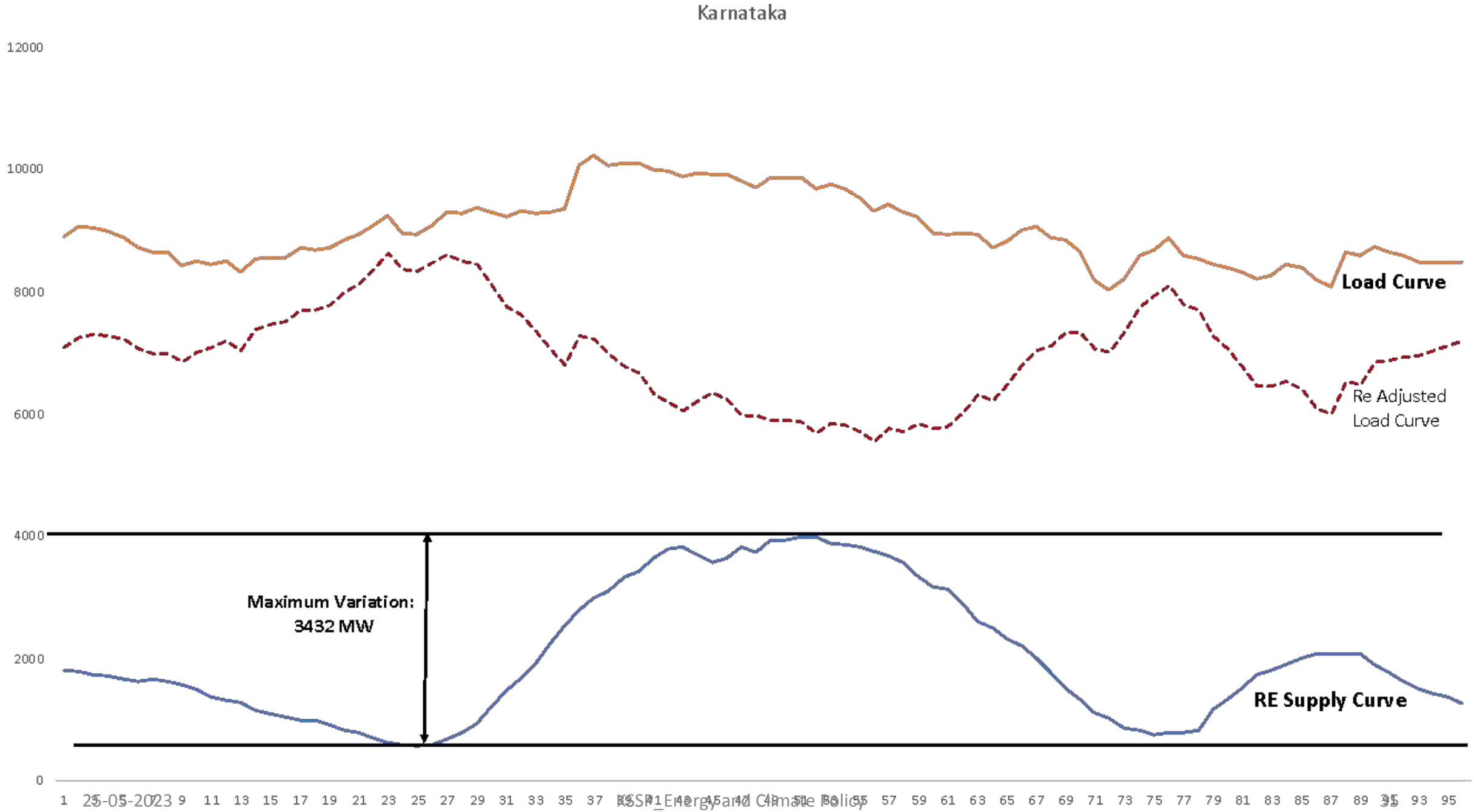
- **Solar 60.8**
- Wind 41.6
- Biomass 10.7
- SHP 4.8

- Non-fossil includes
  - LHP 46.8 and Nuclear 6.78

  Total Non-fossil 171 GW (~42%)


Karnataka
12000
10000
8000
6000
4000
2000
0
Load Curve
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95


Karnataka
12000
10000
8000
6000
4000
2000
0
Load Curve
Must Run Policy
Maximum Variation:
3432 MW
RE Supply Curve
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95


Karnataka
12000
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Load Curve
Re Adjusted
Load Curve
Maximum Variation:
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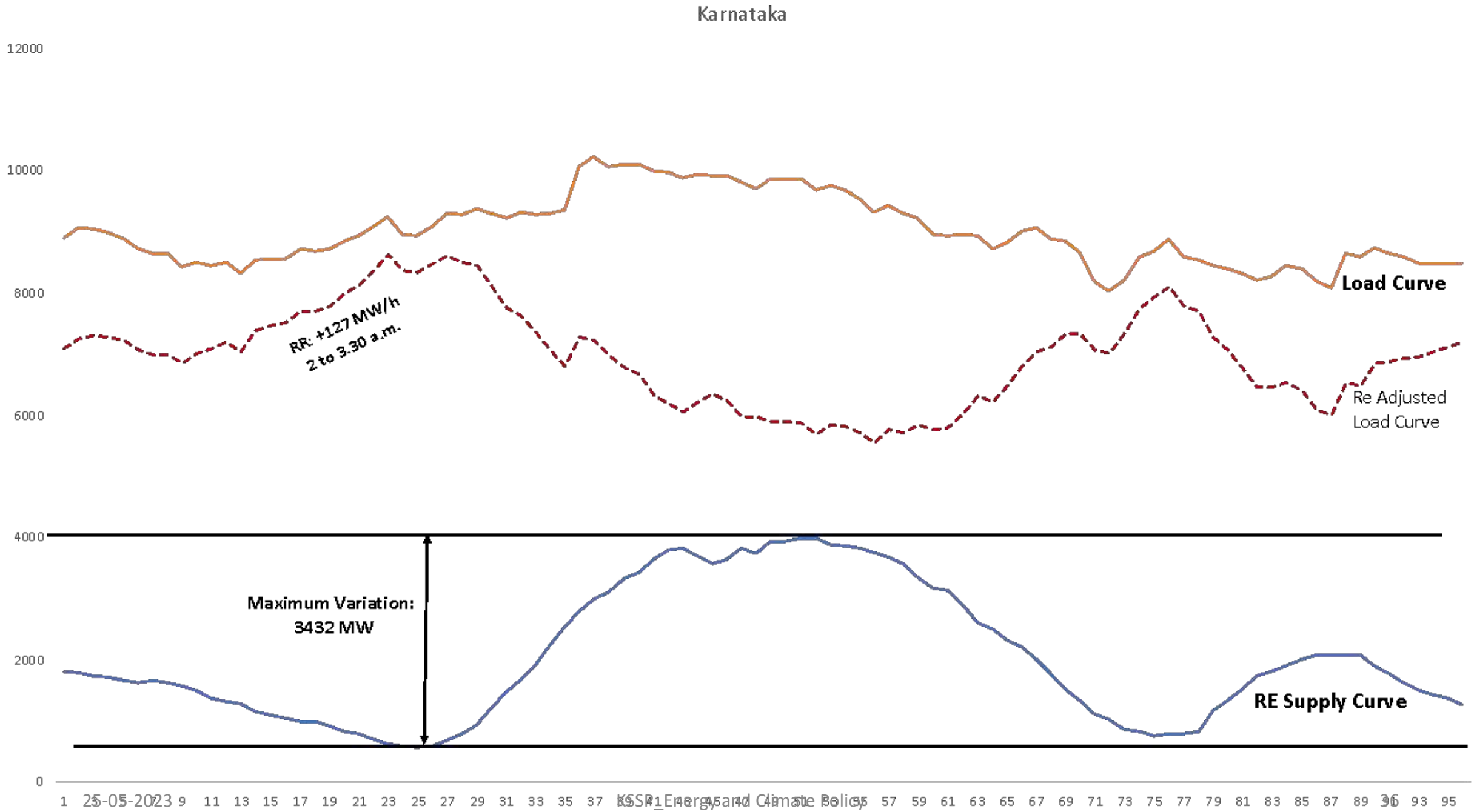
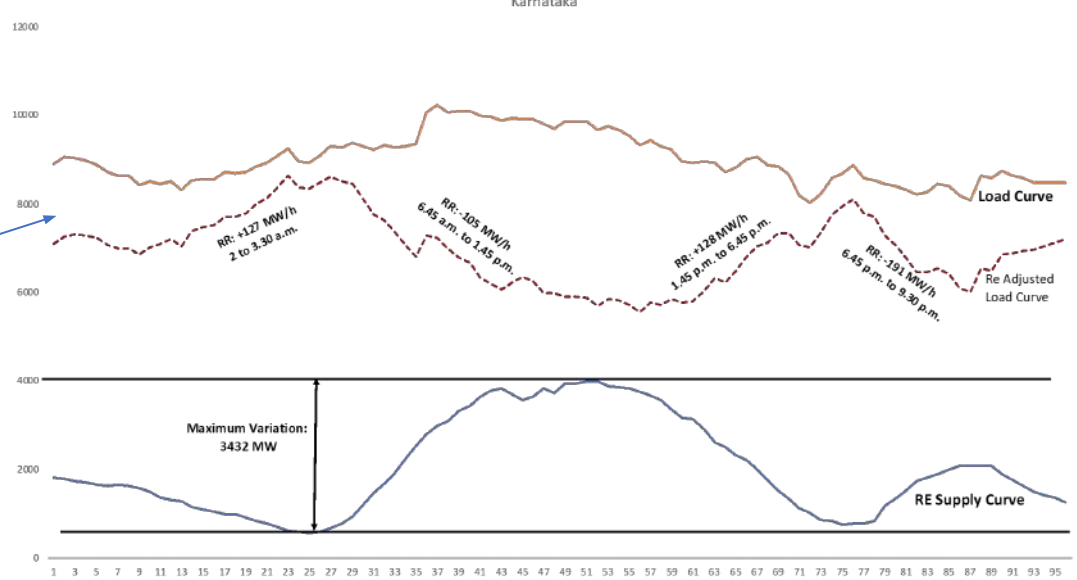
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95


Karnataka
12000
10000
8000
6000
4000
2000
0
Load Curve
RR: +127 MW/h
2 to 3.30 a.m.
Re Adjusted
Load Curve
Maximum Variation:
3432 MW
RE Supply Curve
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95

Not without Cost

Southern India (~50% of RE installed capacity)	Avoided Cost of Carbon ($/ton)	Total Financial Burden (Million USD)
Karnataka	1.91	227
Telangana	4.51	200
Tamil Nadu	1.92	286
Andhra Pradesh	2.92	350



Additional burden of grid integration of VRE

- ₵ 1.11/kWh: balancing cost
- ₵1.5/kWh: stranded capacity cost
- Totaling: ₵ 3.04/ kWh

Over and above a carbon tax (coal cess) of ~ $ 4.5/tCO2

High cost of energy

	Average Per Capita GNI ($/person/year)	Residential Electricity Charge (₵/kWh)	Industrial (₵/kWh)	Commercial (₵/kWh)
California (USA)	35046	19	12	15
Texas (USA)	29525	12	5	8
Karnataka(India)	2500	9 - 10	7 - 10	6 - 15
Tamil Nadu (India)	2800	6.5 - 9	6 - 9	6 - 11

Will new (cheaper) RE reduce costs?

Storage is a major concern- What are our options? – **Important for Kerala**

Important to safeguard the use of domestically available resources….

- **While still committing to use these responsibly**.... Unlike developed countries

- Mitigation: as much as feasible – **innovation necessary**.
  - But does not mean others can free ride on India's efforts

- Green development **a necessity**, not an "opportunity"

- How can India **leverage the limited carbon resource?** Securing agriculture, MSME, most vulnerable sectors and populations

- Also plan for **increasing adaptation burden** secure the means necessary to protect our people, due to inaction on climate change by others.

In Conclusion….

- **Science movements must prioritize the re-conceptualization of the climate question**
  - Not blindly follow a northern environmental narrative
  - A scientific study of society must foreground the building of a just and equitable future

- **In the quest for 0-emissions, let us not forget 0-hunger, 0-malnutrition, 0-unemployment, 0-homelessness**
  - How do we achieve futures that are not only free of drudgery but also prosperous, just, equitable, and environmentally sound?

- **Need a new scientific environmentalism**
  - As opposed to utopian/feudal/bourgeois environmentalism

Thank you

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