Rethinking Energy Transitions

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Overview

Decarbonisation or low-carbon development?

The role of electricity

Kerala’s resource constraints and energy consumption

Regional cooperation and equitable resource use

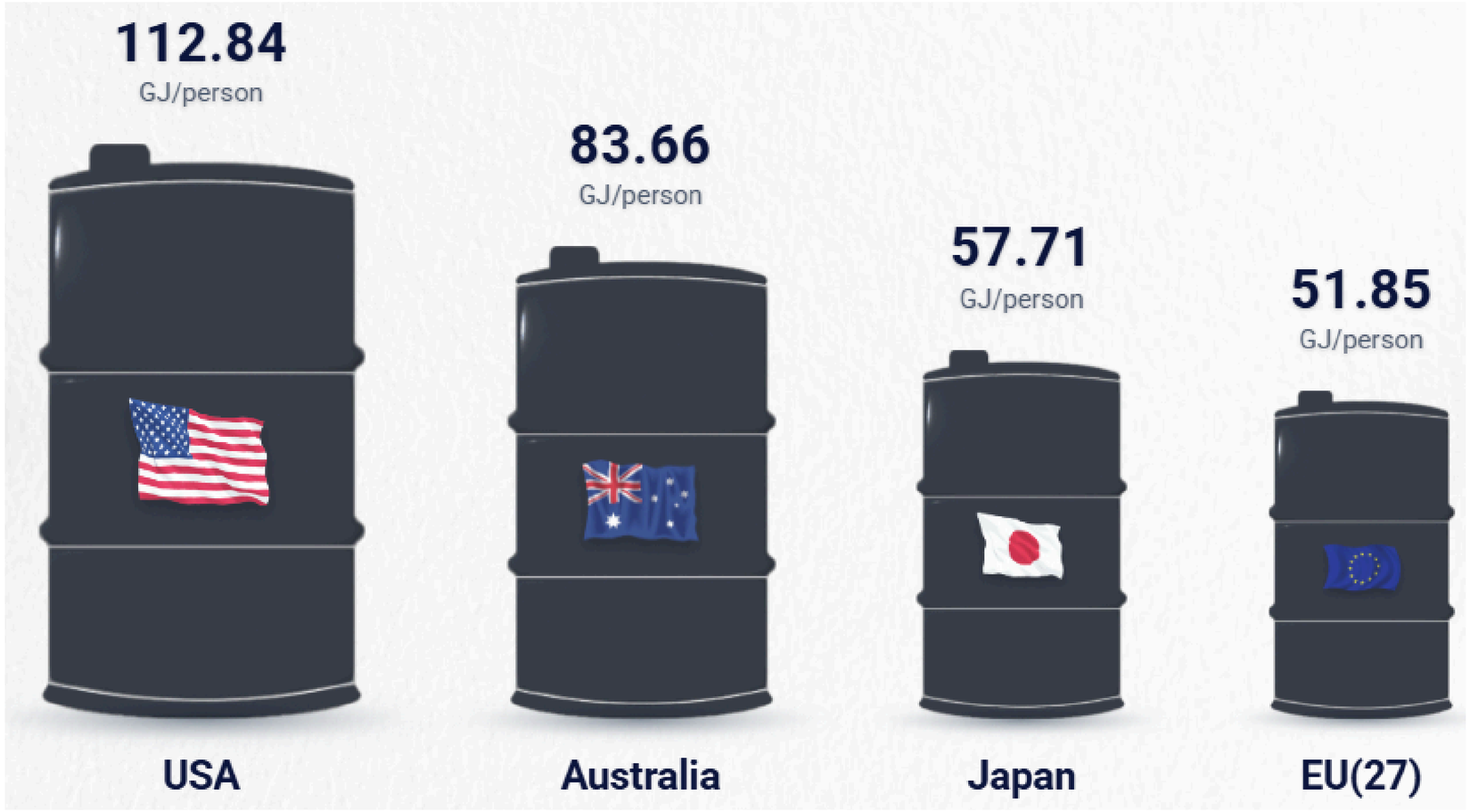
Strategies for the near and long terms

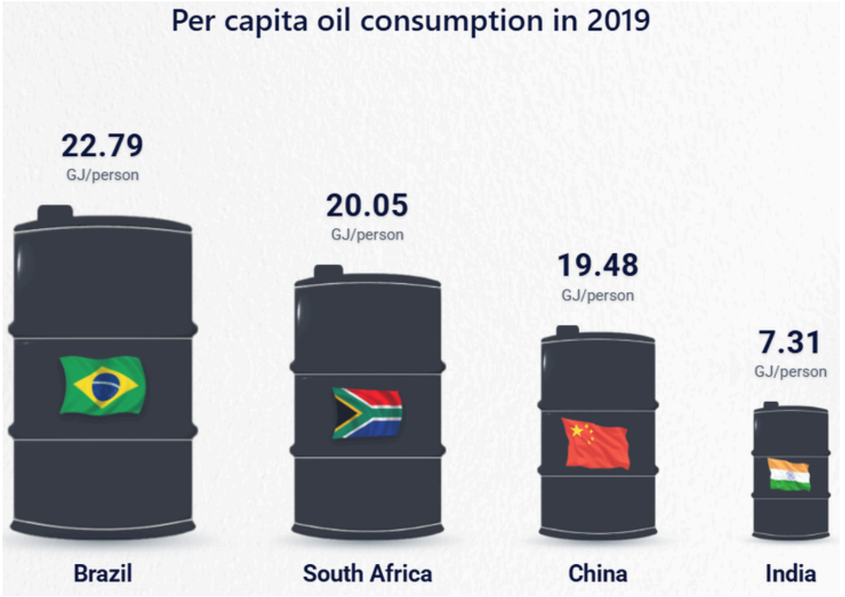
How carbonized are we?

Per capita coal consumption in 2019

How carbonized are we?

Per capita oil consumption in 2019





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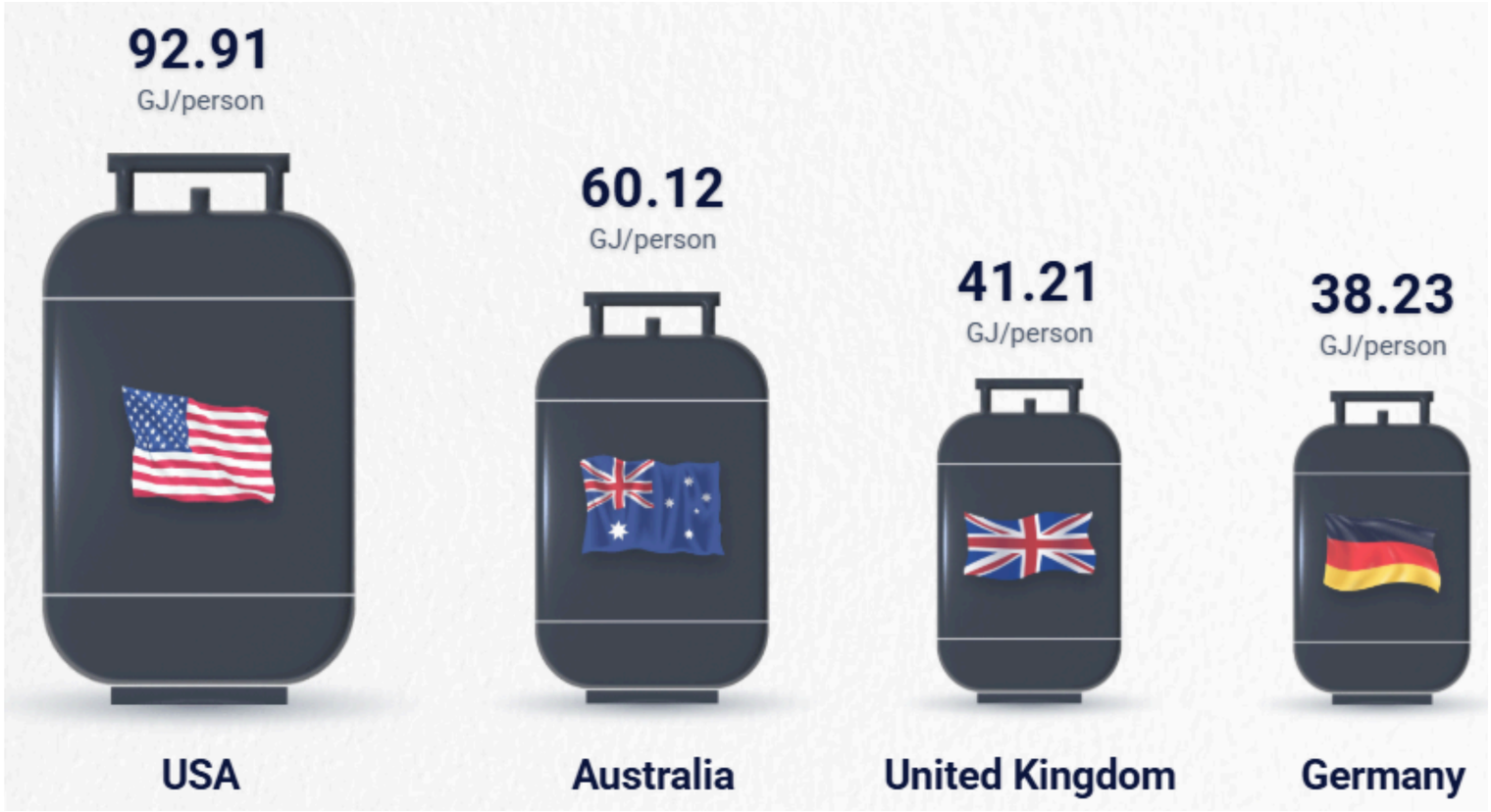
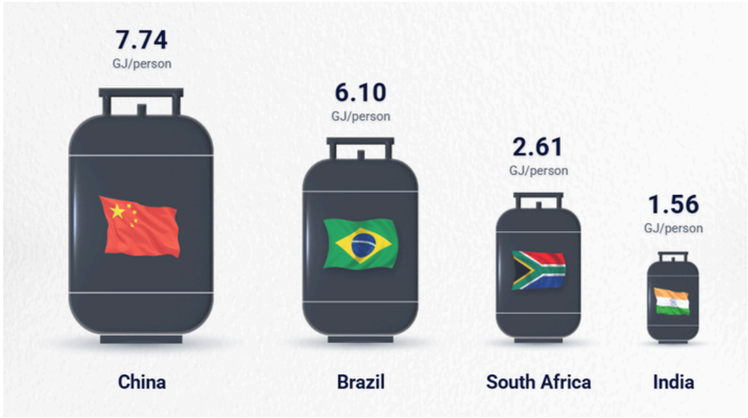
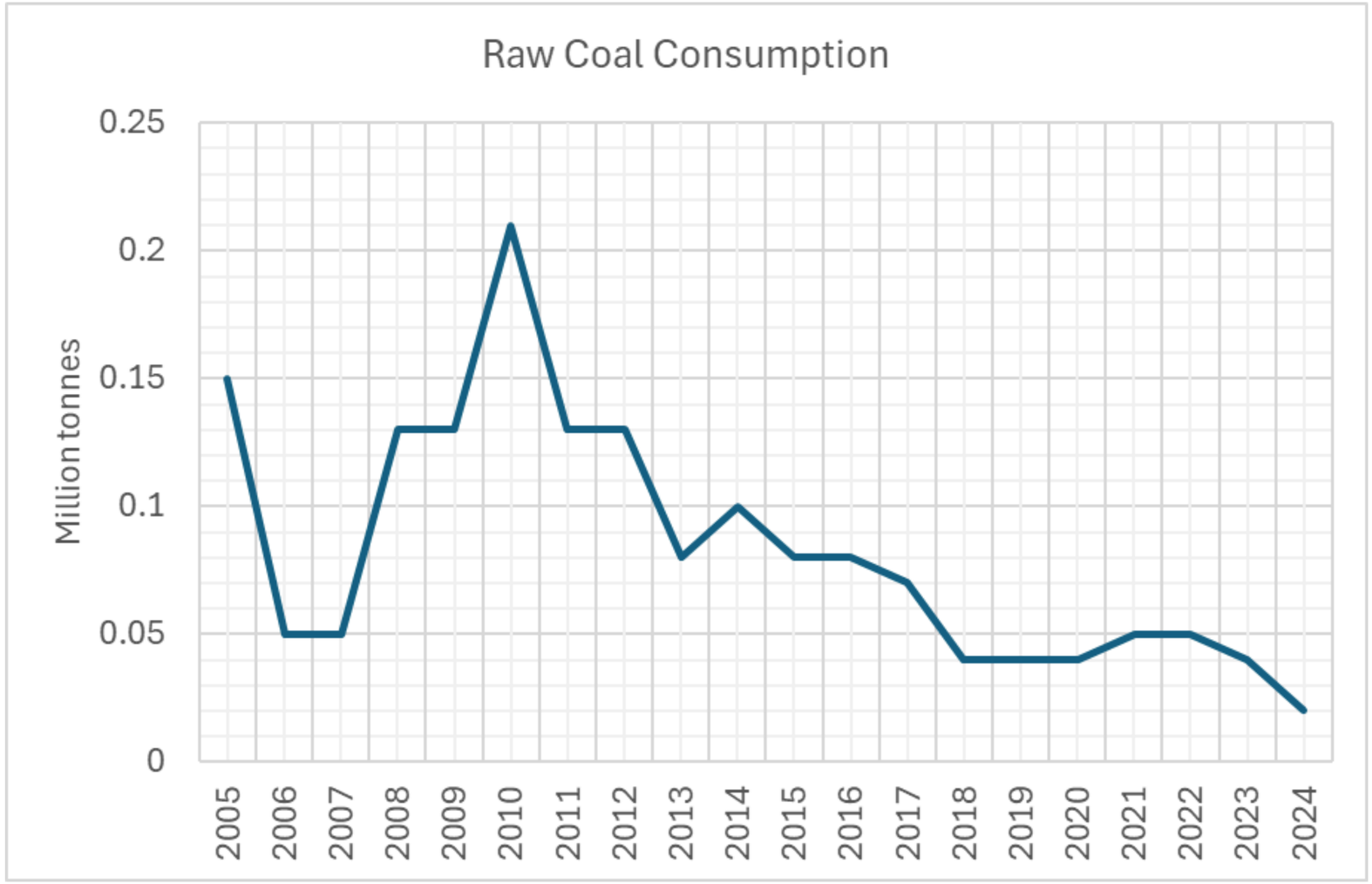




How carbonized is Kerala?

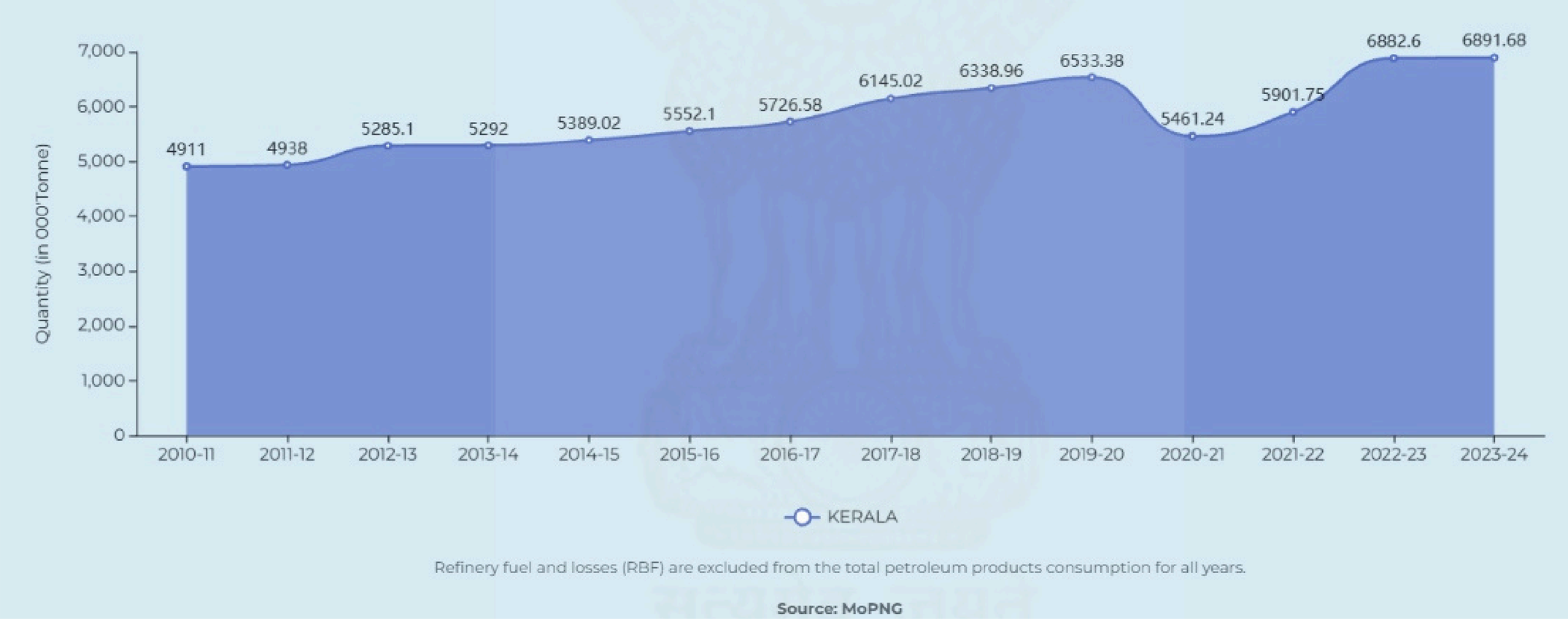
Direct Coal Consumption - Kerala

- Negligible primary coal consumption
- Mostly by the pulp and paper and cement industries
- 0.0015% of national consumption

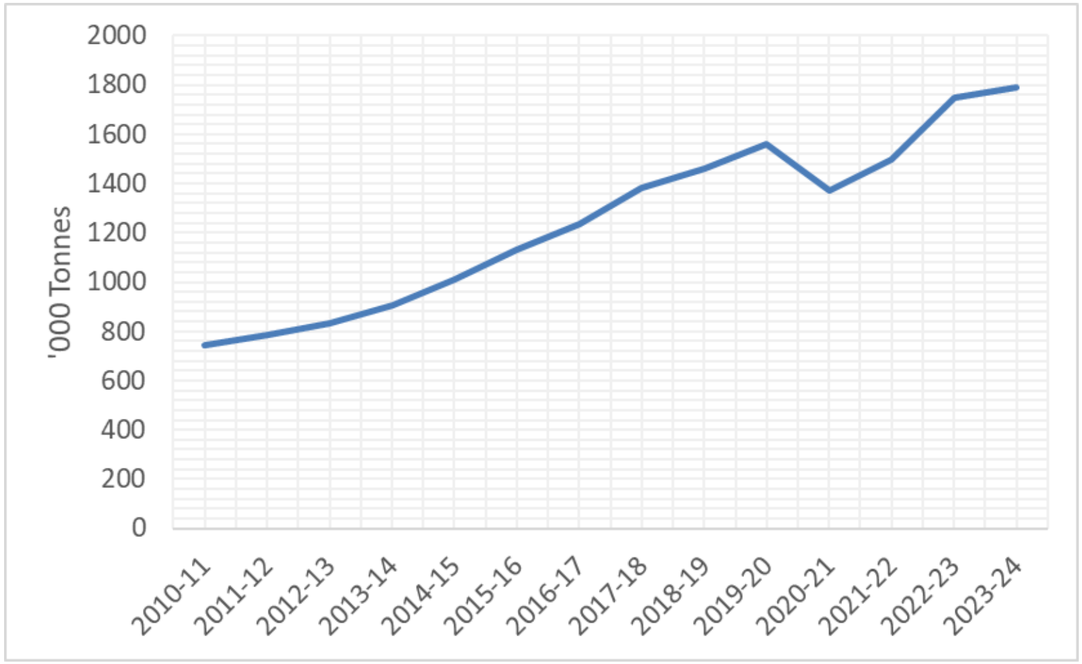


Oil - Kerala

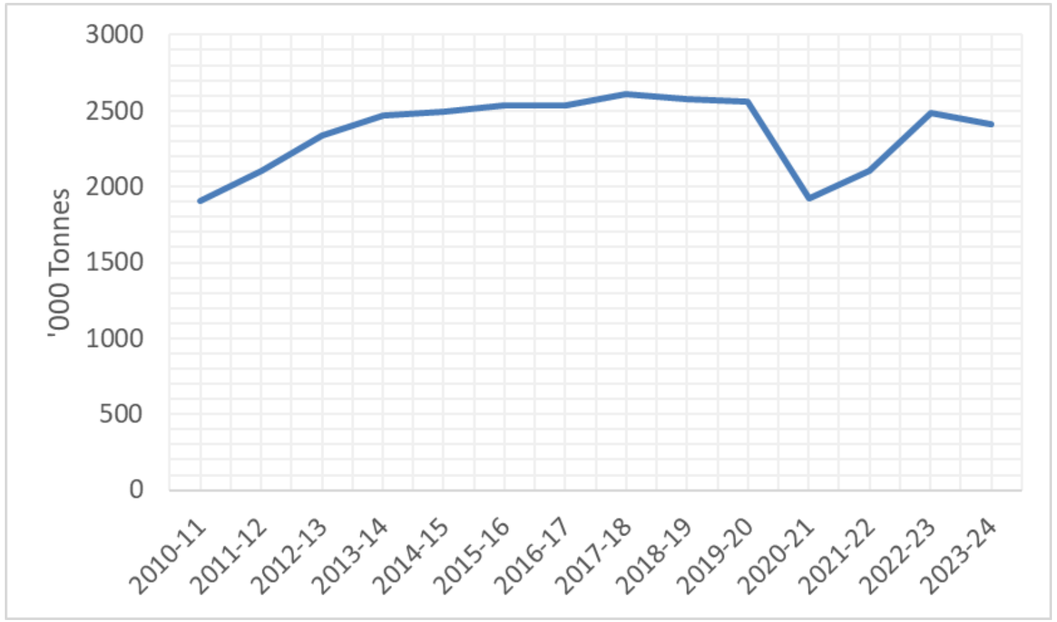
- Consumption = 6.9 mmt (~3% of All India consumption)
  - Mostly in the transport and domestic sectors



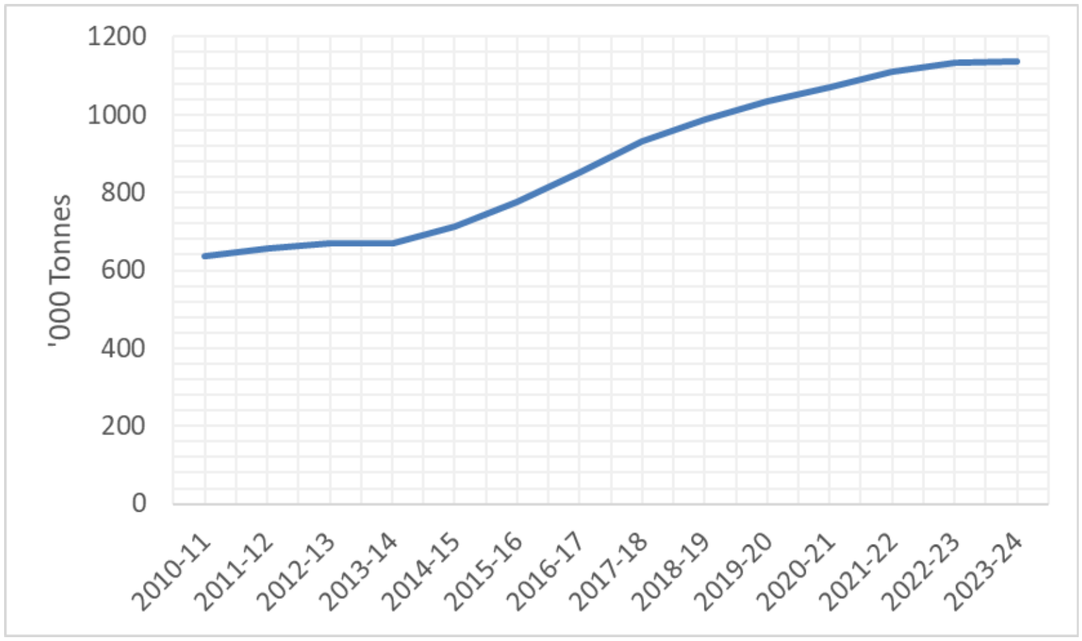
Petrol



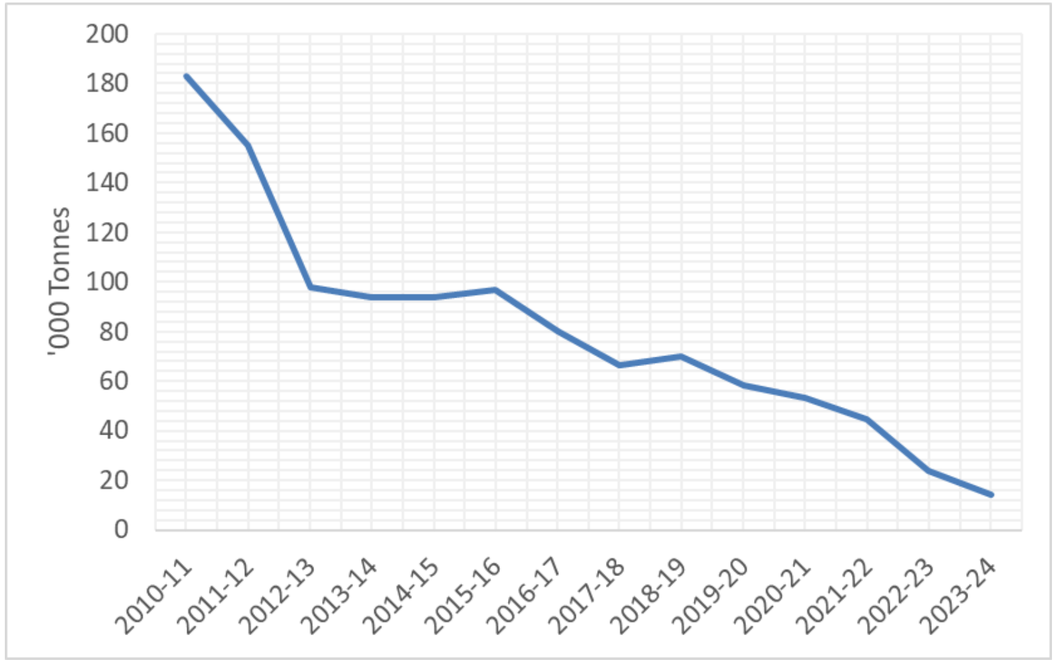
Diesel/HSD



LPG



Kerosene



Energy demand (beyond, but including electricity)

India’s per capita energy consumption	India’s per capita electricity consumption	Per capita electricity consumption in Kerala
○ 26 GJ (global average is 75 GJ)	○ 1400 kWh (global average is 3300 kWh)	○ 600 kWh ○ Less than half of national average, mostly driven by domestic consumption (50%)

So what does a “transition” mean?

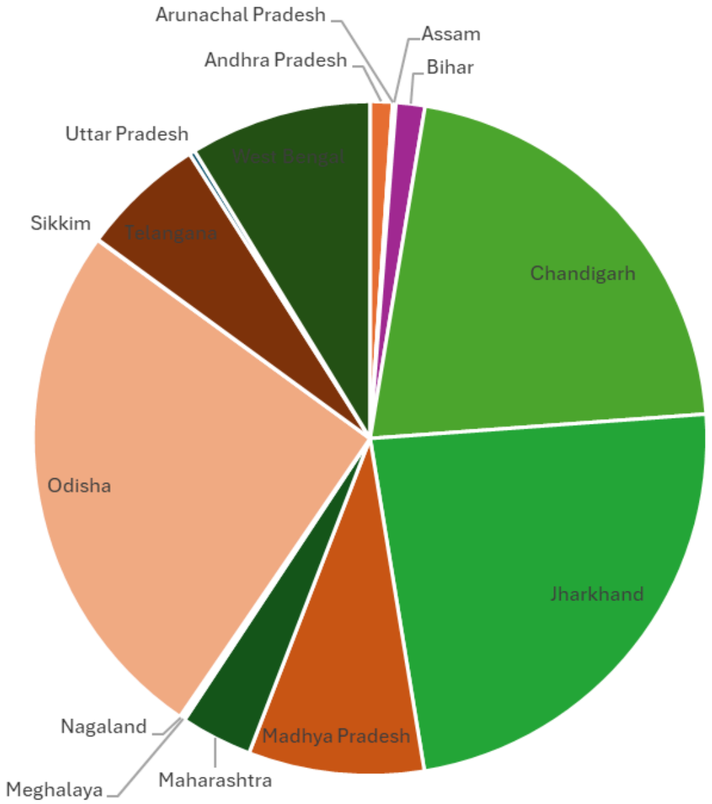
Energy growth needed to fuel industrial and infrastructure growth as well as modernisation

Consumption must **increase** not decrease

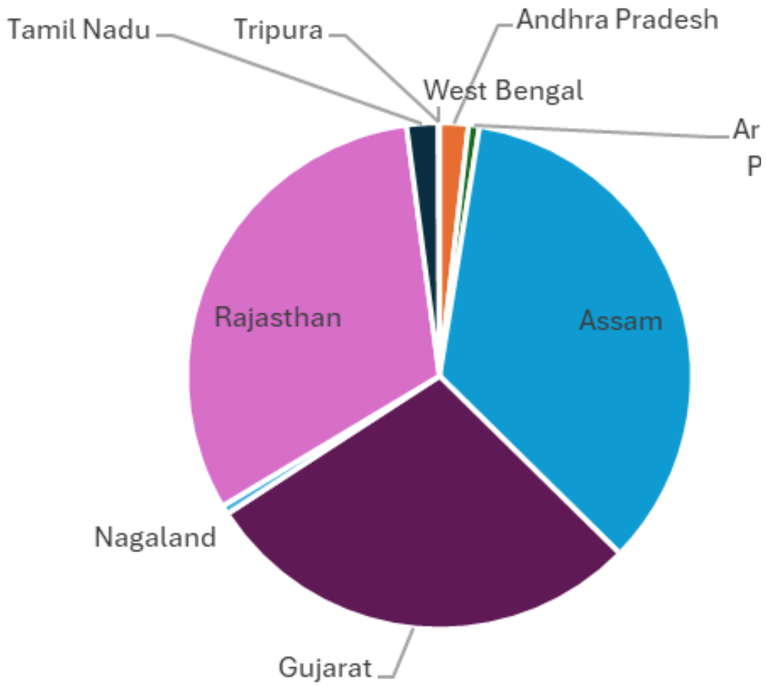
How does Kerala envision growth in industry? – what are the opportunities in the energy sector?

Where are the resources? How much is in Kerala

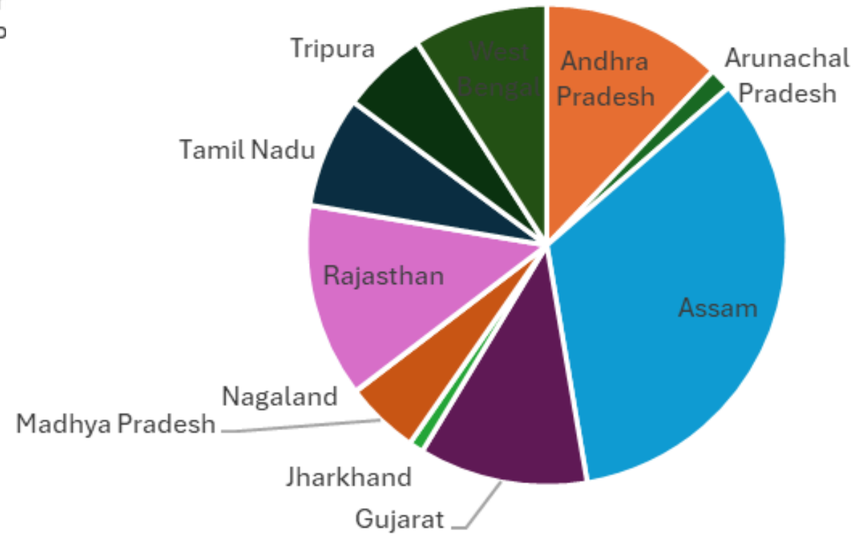
Coal – 0% in Kerala



Oil – 0% in Kerala



Gas – 0% in Kerala



- Solar Potential (large-scale land mounted)
  - 6-12 GW (depends on land availability)
  - <1 % of all India potential (0.37%)
  - Rooftop potential…

- Wind
  - 2.3-2.6 GW (based on hub height) – does not include offshore
  - <1% of all India potential (0.23%)

- Hydro
  - Large hydro – 2.4 GW (2% of all India potential)
  - Small hydro – 647 MW (3% of all India potential)

Other resource potentials in Kerala - geographic

Geographic potential not enough to determine actual realizable potential

- How ready are states to generate AND to consume RE?
  - Generation Readiness Index (GRI): An index measuring a state's technical, infrastructural, and institutional capacity to produce RE.
  - Consumption Readiness Index (CRI): An index measuring a state's economic, social, and systemic ability to absorb and sustain RE.
- A study based on 18 indicators
  - Resource potential, infrastructure & institutional capacity, basic service infrastructure, economic capacity, and system performance

Venkataramana, N. T., Kanitkar, T., Ramadesigan, V., & Banerjee, R.. ***A Framework for Equitable State-Level Renewable Energy Target Allocation in India***. *Energy (Under review)*.

Where does Kerala stand?

- **GRI = 0.07** (slightly above the national average)
  - Baseline infrastructure, capacity to exploit geographic potential, moderately above national average. But resource potential itself is low. Land availability is a constraint.

- **CRI = -0.08** (slightly below the national average)
  - Demand pattern is restrictive, i.e. very little demand that can be “shifted”, industrial load is less, economic capacity is average

Venkataramana, N. T., Kanitkar, T., Ramadesigan, V., & Banerjee, R.. ***A Framework for Equitable State-Level Renewable Energy Target Allocation in India***. *Energy (Under review)*.

Comparison against readiness-adjusted target

- **Deployment Gap:** The difference between actual generation and generation-readiness capability
- **Uptake Gap:** The difference between actual consumption and consumption-readiness capability.

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Does Kerala have a gap?

- Kerala has a deployment surplus of 7% in 2023-24
  - State generates more RE than its readiness-adjusted expectation
- However, Kerala has an uptake shortfall of 6.6%
  - State is consuming less RE than its readiness-adjusted potential
- Is focusing on within-state deployment necessary?
  - Interstate transmission charges, other cost burdens

Venkataramana, N. T., Kanitkar, T., Ramadesigan, V., & Banerjee, R.. ***A Framework for Equitable State-Level Renewable Energy Target Allocation in India***. *Energy (Under review)*.

How much to generate/procure?

- How does one understand the **role of hydro** in target setting
  - MoP target - 43% of all energy from RE includes hydro
  - Many other studies focus on non-hydro RE (CSTEP, WWF, Govt. of Kerala)

- Kerala must leverage the role of its high hydro capacity – especially important for grid integration of RE

Venkataramana, N. T., Kanitkar, T., Ramadesigan, V., & Banerjee, R. (2025). ***Optimizing renewable energy integration pathways: Inter-regional coordination and storage in India's power sector.*** *Applied Energy, 394, 126134.*

Comparison of scenarios for 2030

Metric	BAU (24.7% Non-Hydro)	MoP (43.33% Incl. Hydro)
New Capacity: Coal (GW)	0.5	1.3
New Capacity: Wind (GW)	2.3	0
New Capacity: Solar (GW)	4.2	0.5
New Capacity: Battery (GW)	0.2	0
Total System Costs (₹ Billion)	**531**	**321**
Annual Emissions ($MtCO_2$)	11	17

- Kerala can use its legacy hydro projects to effectively meet MOP targets in the near term
- There is **no economic justification** to build new solar and wind in the near term *to meet RE targets*

- With the RPO constraint satisfied, model optimizes for the cheapest remaining firm capacity: Coal

- However, to secure this in the context of increasing constraints on new coal capacity outside Kerala, regional cooperation becomes imperative

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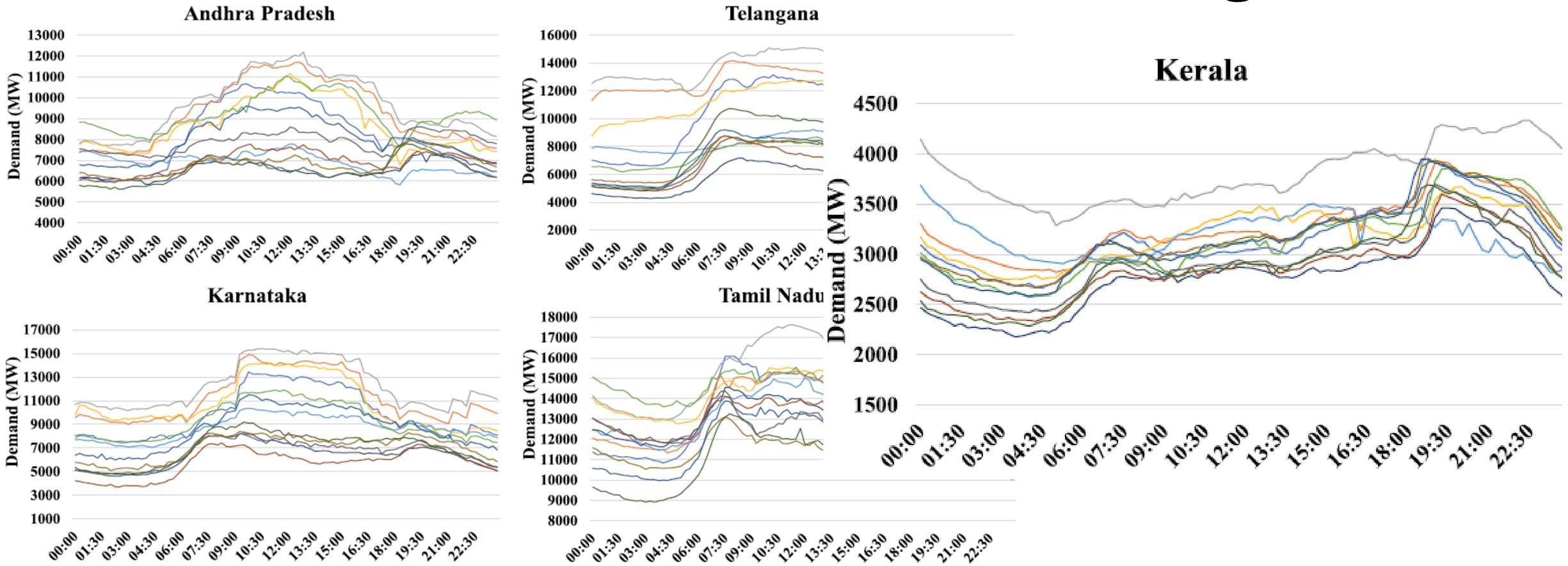
Narrative of ‘self-sufficiency’ has limitations

- Kerala has resource and land constraints – what self sufficiency is possible within these? And why?
- Increasing cooperation with other states the best route for low carbon development for all – regional resource planning provides opportunities

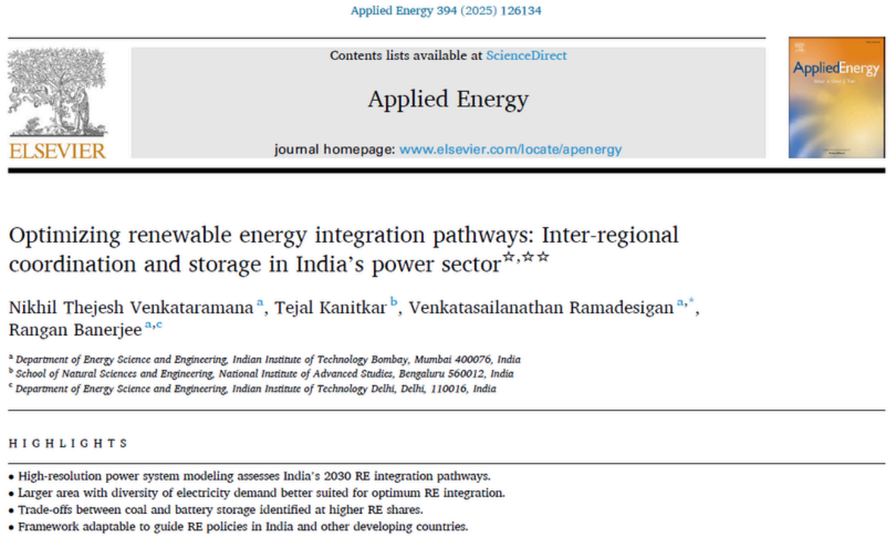
Advantage of load balancing



- Complementary demand profiles enable resource sharing, reducing reserve margins and facilitating renewable energy integration.
- For instance, midday agricultural peaks in Karnataka and Andhra Pradesh can be offset by stable residential loads in Kerala

Advantage of resource sharing

- Hydro capacities in Kerala and Karnataka can be used to enhance RE integration in regions with higher potential and lower land constraints – Telangana, Andhra Pradesh, and Tamil Nadu
- In the near term hydro+coal operations allow for lower system costs due to costs of BESS
- Cooperative compliance can enhance ambition – rethink logic of competitive power procurement



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Optimizing renewable energy integration pathways: Inter-regional coordination and storage in India's power sector☆,☆☆

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HIGHLIGHTS

- High-resolution power system modeling assesses India's 2030 RE integration pathways.
- Larger area with diversity of electricity demand better suited for optimum RE integration.
- Trade-offs between coal and battery storage identified at higher RE shares.
- Framework adaptable to guide RE policies in India and other developing countries.

In conclusion

- Rethink ‘transitions’ – the pre-condition for decarbonisation ..is carbonisation
  - Kerala is not carbonised
  - “Transition” must focus on improving well-being, energy access, employment

- Rethink pathways to enhance RE integration
  - Regional cooperation
  - Innovative agreements between states and regions
  - Cooperative federalism in practice

Thank you

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