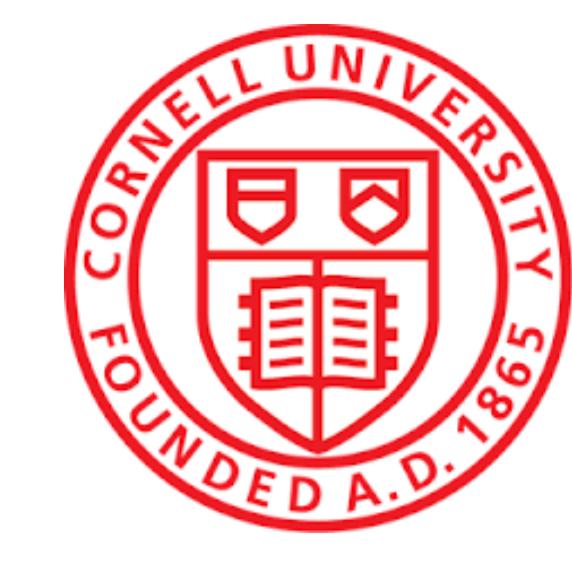


# Unveiling the hidden costs of China Southern Power Grid's decarbonization



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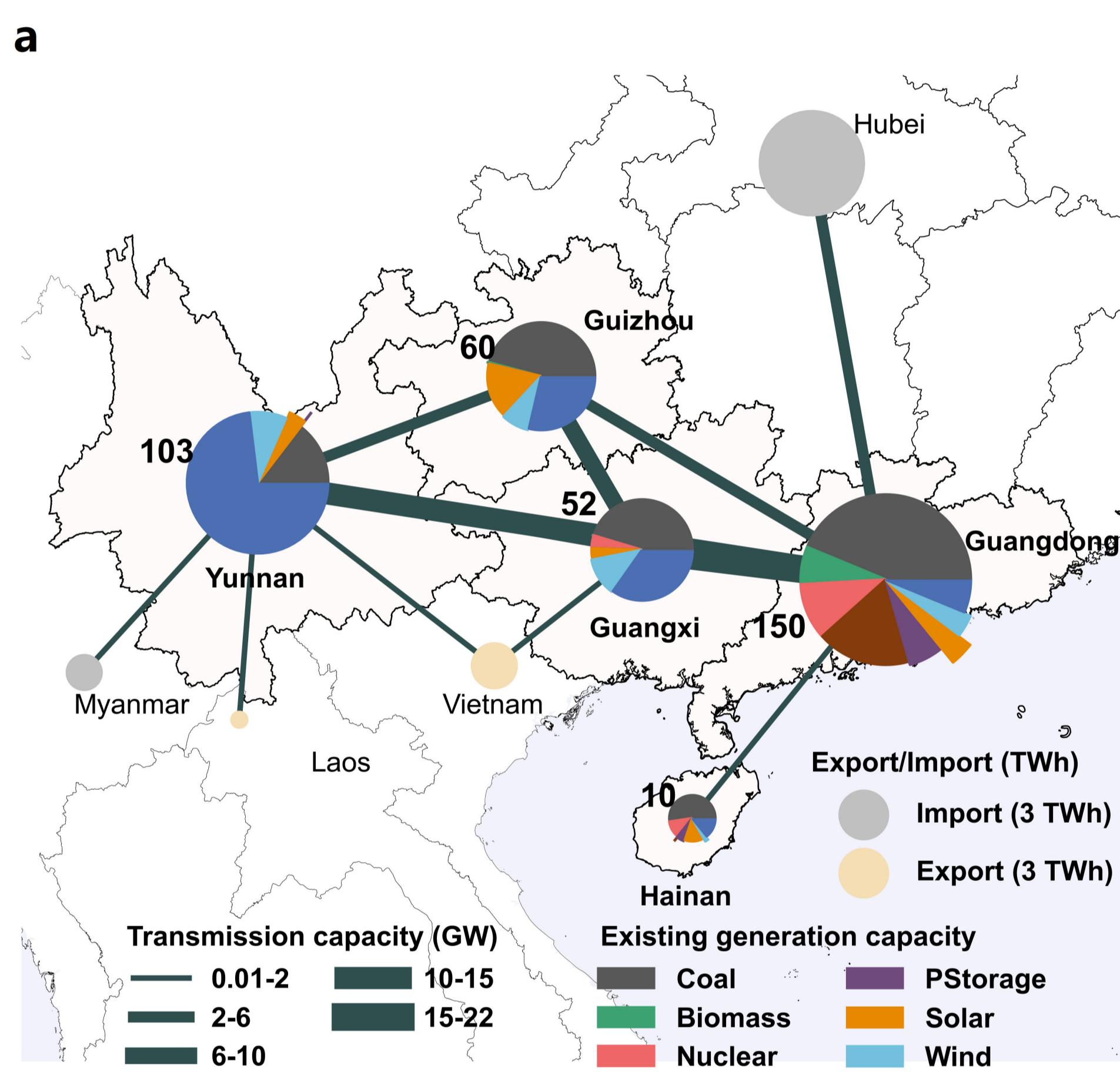
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## 1. Background

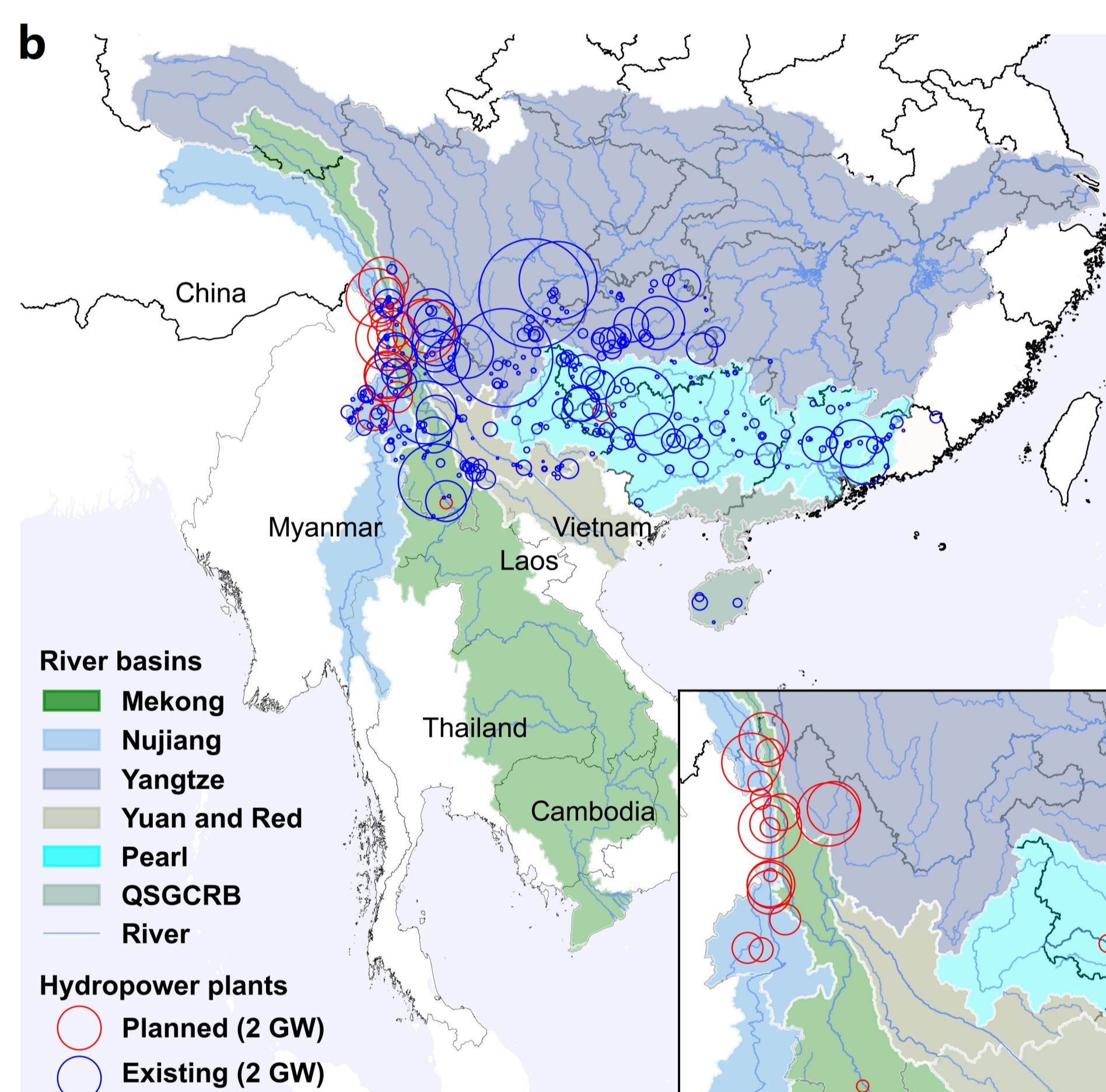
The **China Southern Power Grid (CSPG)** is China's one of two wide-area synchronous grids (panel a). The CSPG already serves a total of almost 300 million customers, with an annual electricity demand projected to increase from 1,177 TWh in 2020 to 2,579 TWh in 2060.

### Expected decarbonization pathway:

- Carbon neutrality to be reached by 2060
- Planned retirement of coal plants
- Exploitation of wind and solar resources
- 32 GW of new hydropower capacity to be deployed primarily on transboundary river basins (panel b)



Graphical representation of the CSPG generation and transmission fleet operated in 2020.

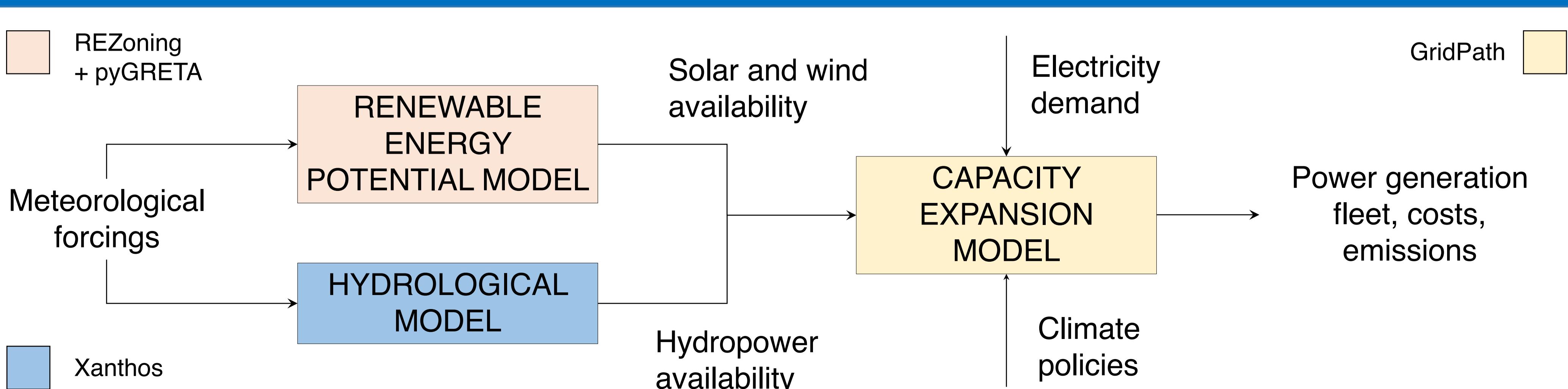


River basins supporting the CSPG. The inset provides a more detailed illustration of the planned dams.

## 2. Research questions

- What are the land requirements for achieving carbon neutrality?
- What is the amount of additional hydropower that is needed to support the decarbonization of the CSPG?
- How does protecting transboundary river basins impact decarbonization pathways and land requirements?

## 3. Modelling framework



## 4. Experimental setup

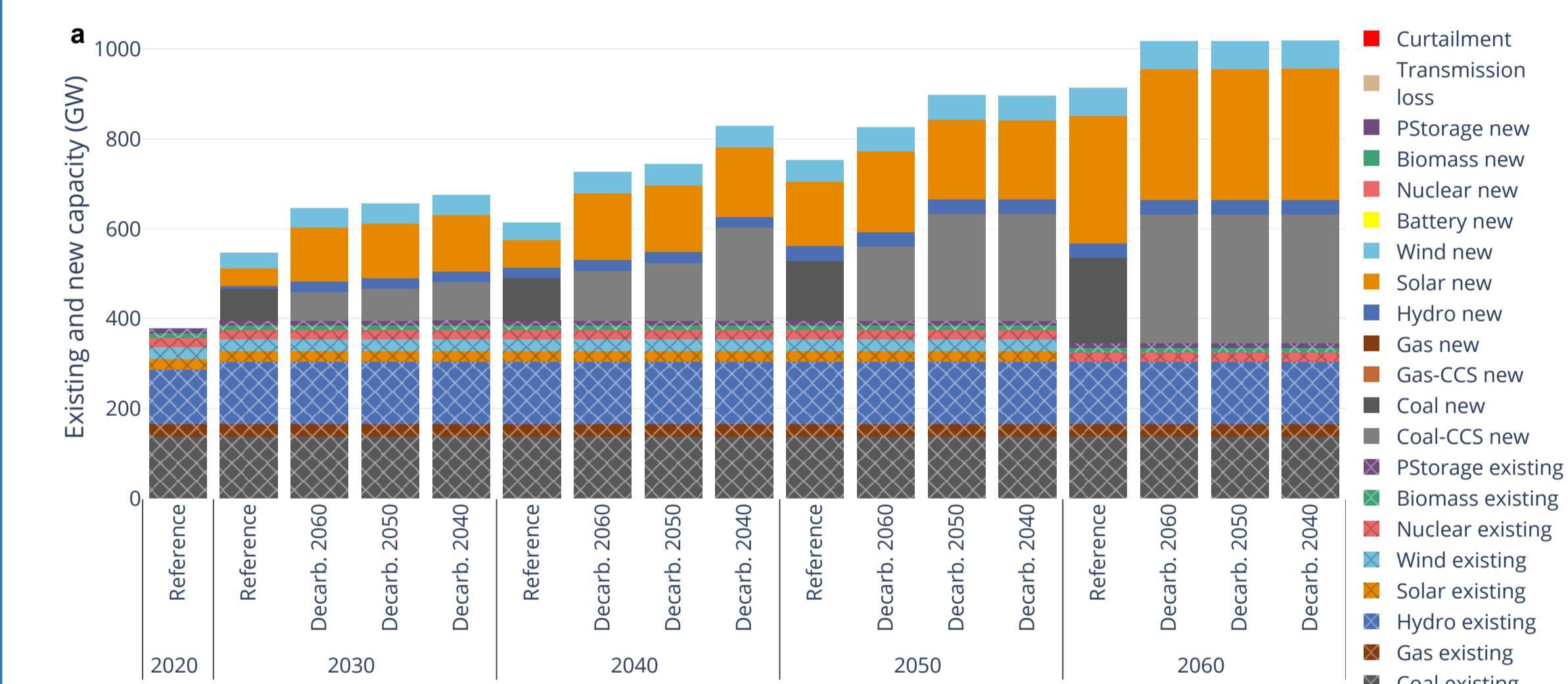
Capacity expansion plans are carried out over the period **2020-2060**. In the Reference scenario, we assume that carbon-neutrality targets are not imposed; an assumption that allows us to estimate the costs associated to the decarbonization of the CSPG.

Name	Carbon neutrality	Transb. hydro*	Available renewable capacity (GW)		
			Hydro	Solar	Wind
Reference	No target	Y	32.34	340	94
Decarb. 2060	By 2060	Y	32.34	340	94
Decarb. 2050	By 2050	Y	32.34	340	94
Decarb. 2040	By 2040	Y	32.34	340	94

\*We include additional scenarios to explore the impact of climate change on hydropower availability as well as different policies for transboundary water management.

## 5. Results

The pledge of reaching carbon neutrality by 2060 may be feasible, but:

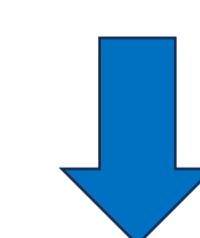


Power generation fleet over the period 2020-2060.

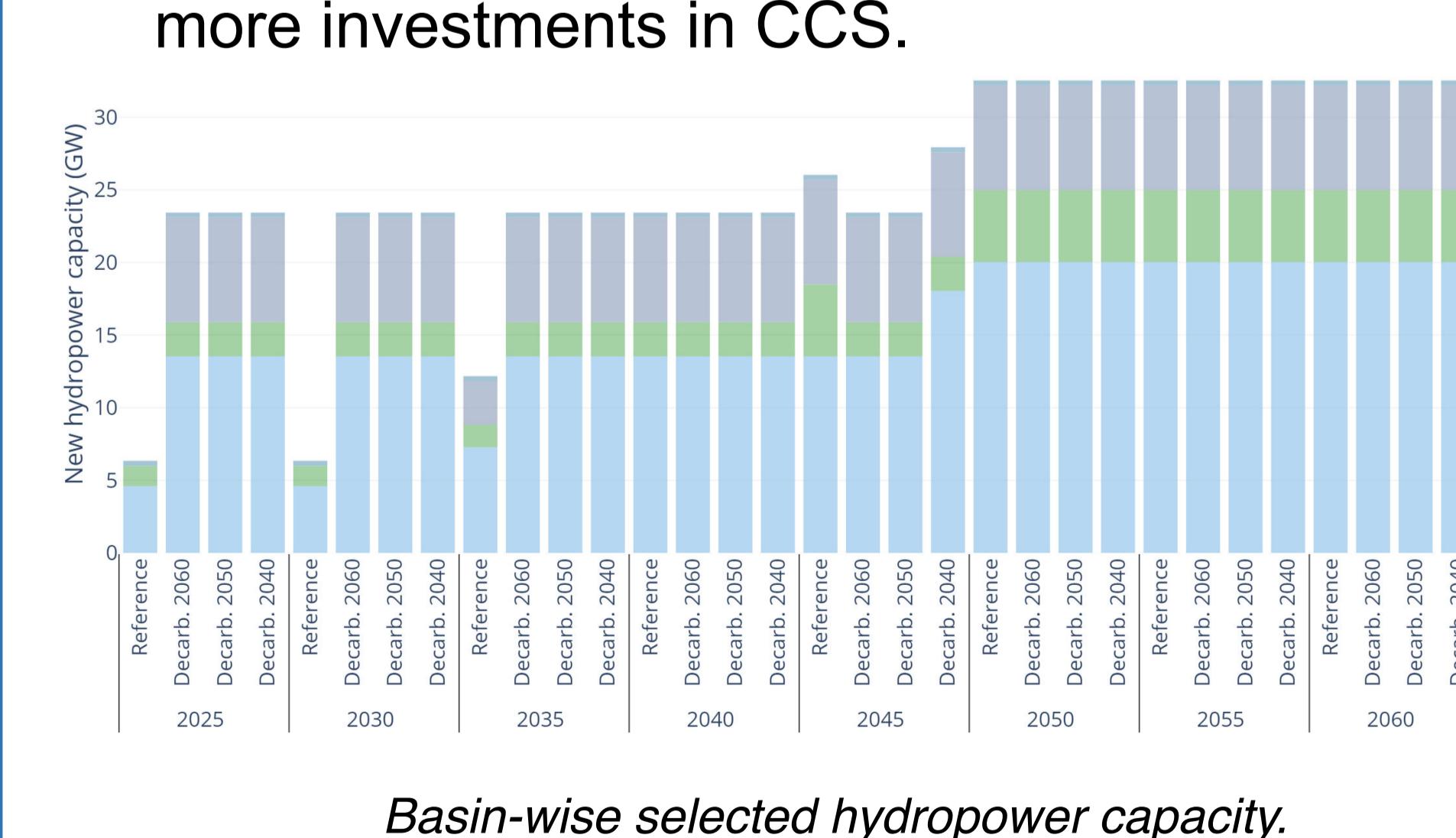
- **Hydropower plans would largely affect the Nujiang (Salween), one of the last free-flowing rivers of the region.**
- Limiting the construction of dams requires more investments in CCS.

▪ **A 100% transition to wind, water, and solar does not seem possible**, since carbon capture and storage (CCS) would likely play an important role.

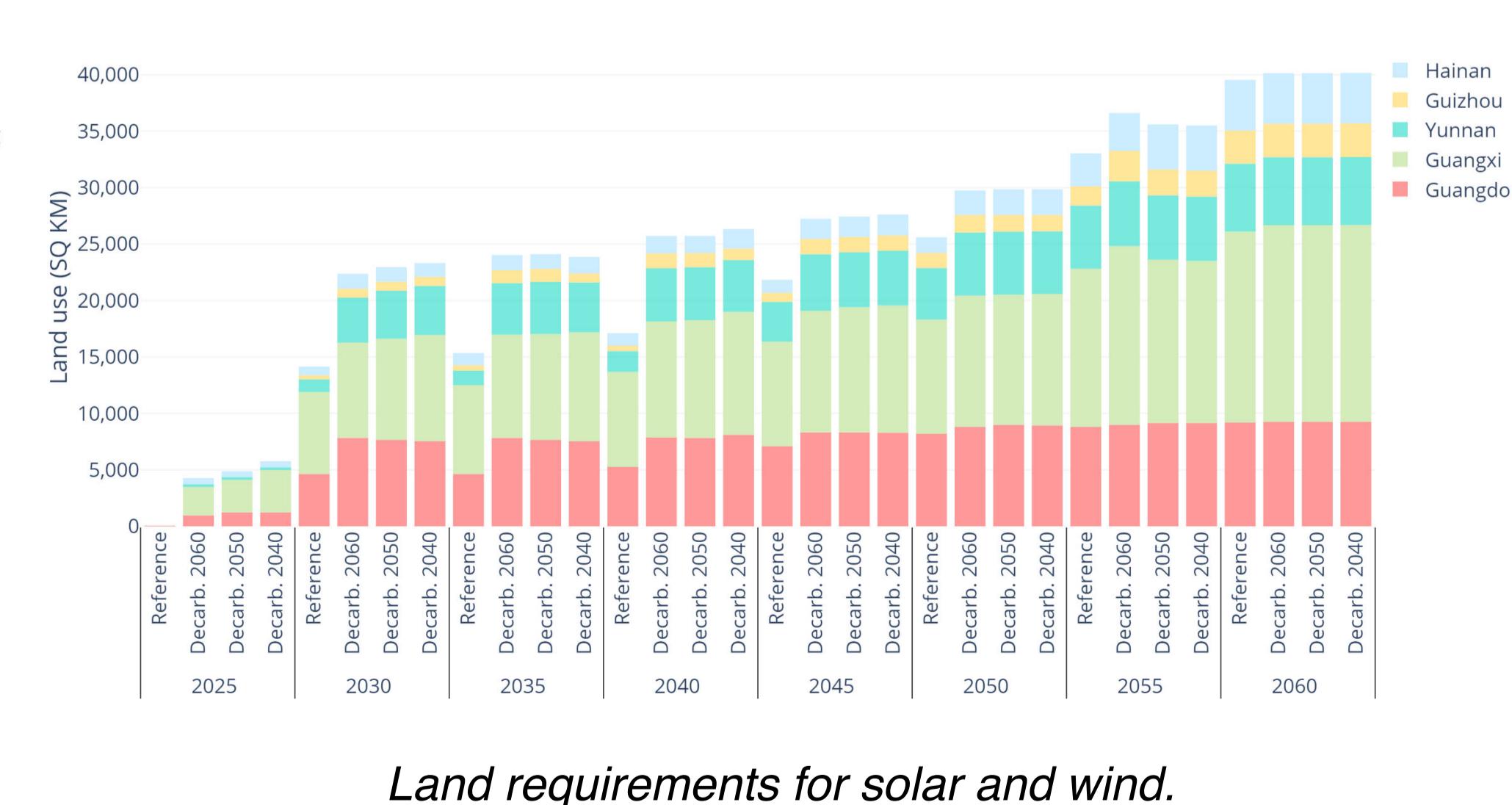
▪ Rapid investments in renewables are needed, with **major requirements for water and land resources**.



- **40,000 km<sup>2</sup> of land needed by 2060.**
- 90% of wind and solar resources are located in cultivated land, grassland, and shrubland.



Basin-wise selected hydropower capacity.



Land requirements for solar and wind.

## References

Jin X., Chowdhury K., Cheng C., Galelli S. The unintended consequences of decarbonizing the China Southern Power Grid, *Nature Sustainability*, under review.  
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