Assessing the Technical Feasibility of the Pathways: Simulating the Hourly Grid Dispatch for India

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Introduction to Lawrence Berkeley National Laboratory

Managed by the University of California for the United States Department of Energy

Lawrence Berkeley National Laboratory

13 — Nobel Prizes
13 — National Medal of Science recipients
4,200 — Employees
200 — Site acreage

- **Dedicated to solving the most pressing scientific problems facing humankind**
  - Basic science for a secure energy future
  - Science of living systems to improve the environment and energy supply
  - Understanding and control of matter and energy in the universe
  - Translation to applied energy programs
- **Build and safely operate world-class scientific facilities**
- **Train the next generation of scientists and engineers**

Motivation: Assessing the technical feasibility of a pathway

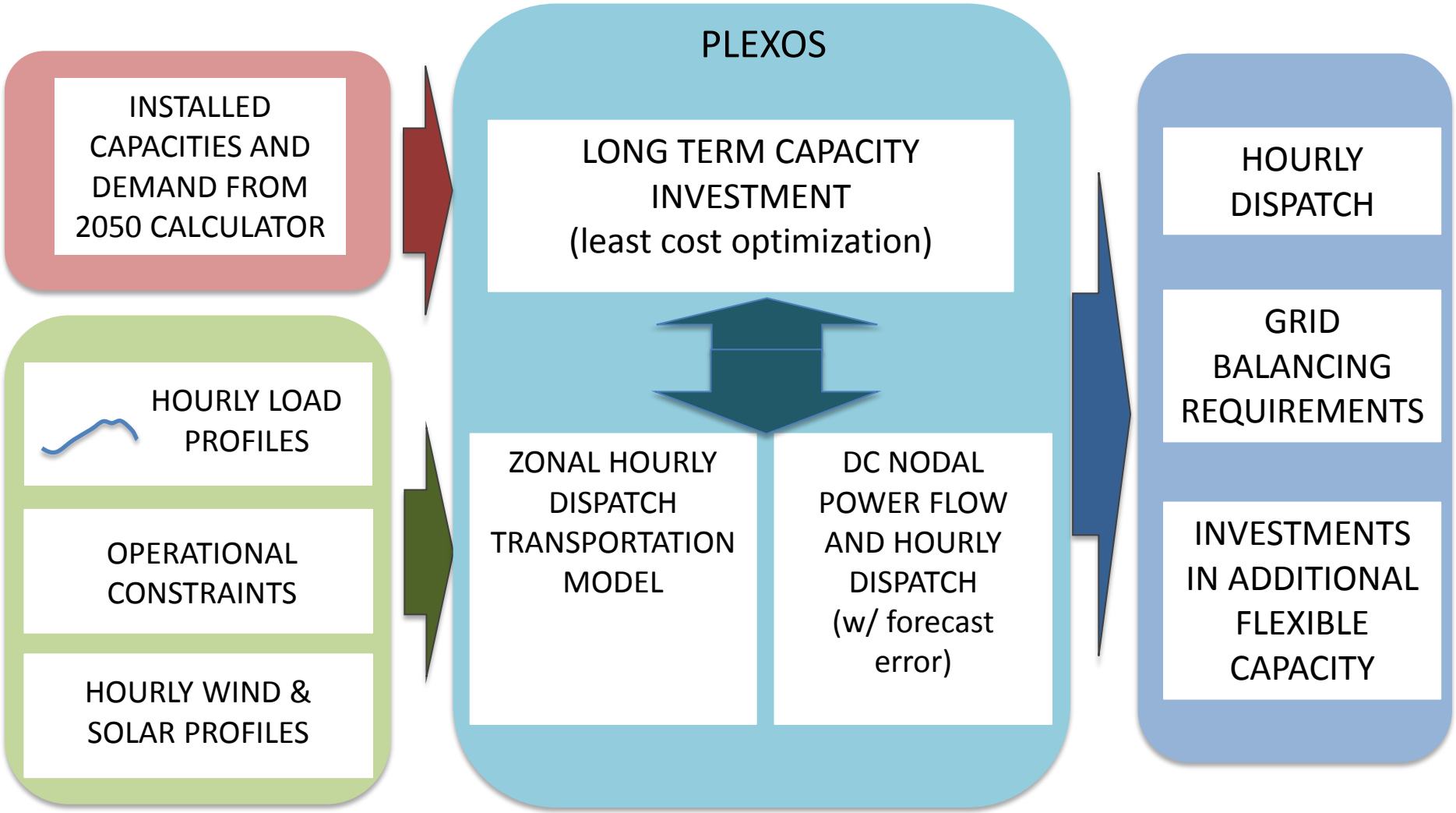
- For example, is a pathway targeting 80% renewable energy technically feasible?

- If not, what are the additional flexibility requirements?
  - How far can low cost options such as demand response go ?
  - Should the country invest in gas turbines or storage ?

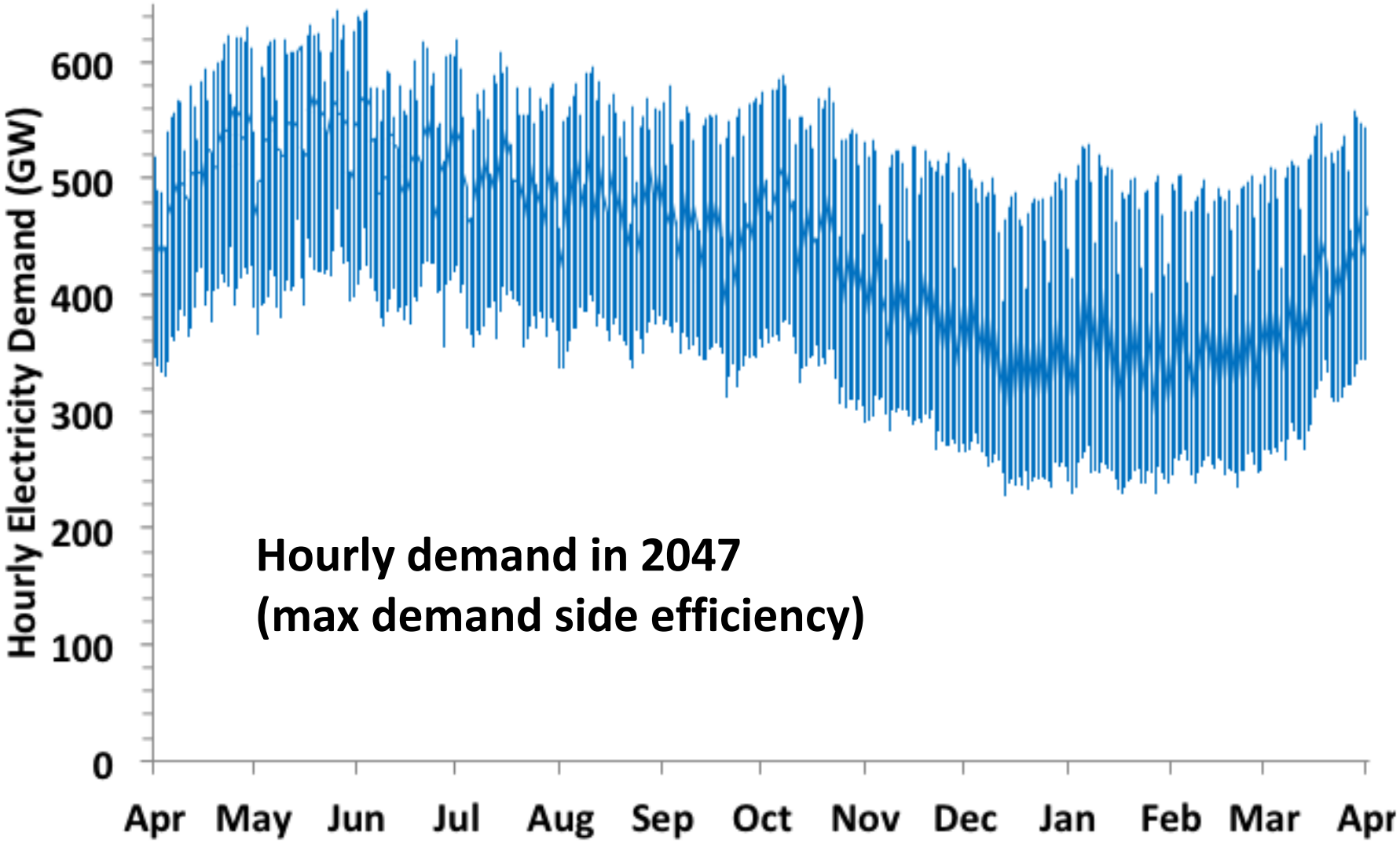
- What are the impacts on system operations ?
  - E.g. forecasting, optimizing the existing dispatch

- What are the key policies that need to be in place ?
  - E.g. intra-day/real-time/ancillary services market etc.

Modeling Framework for India

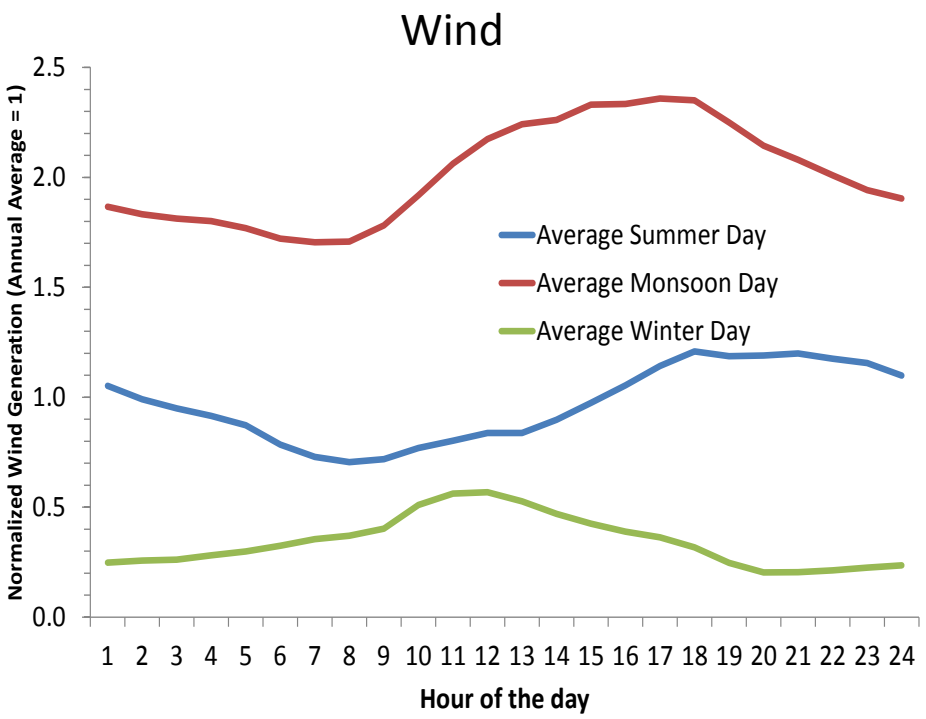


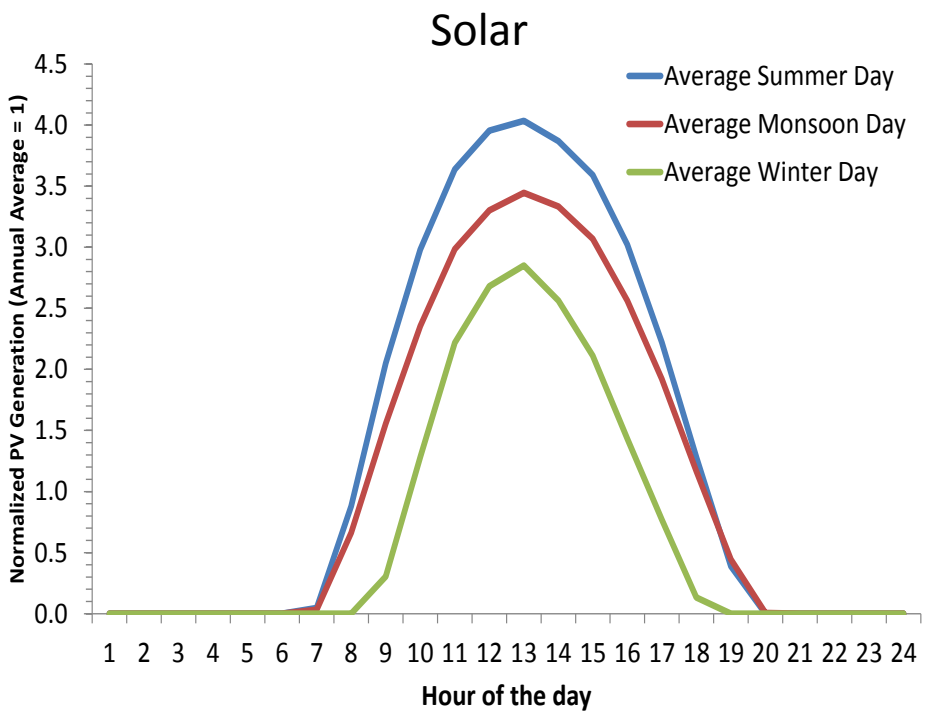
Hourly demand is modeled for each pathway considering the demand side efficiency options



Renewable Energy Profiles (Only Averages Shown)

Spatially resolved renewable energy profiles were constructed using actual generation and satellite (DNI/GHI) data



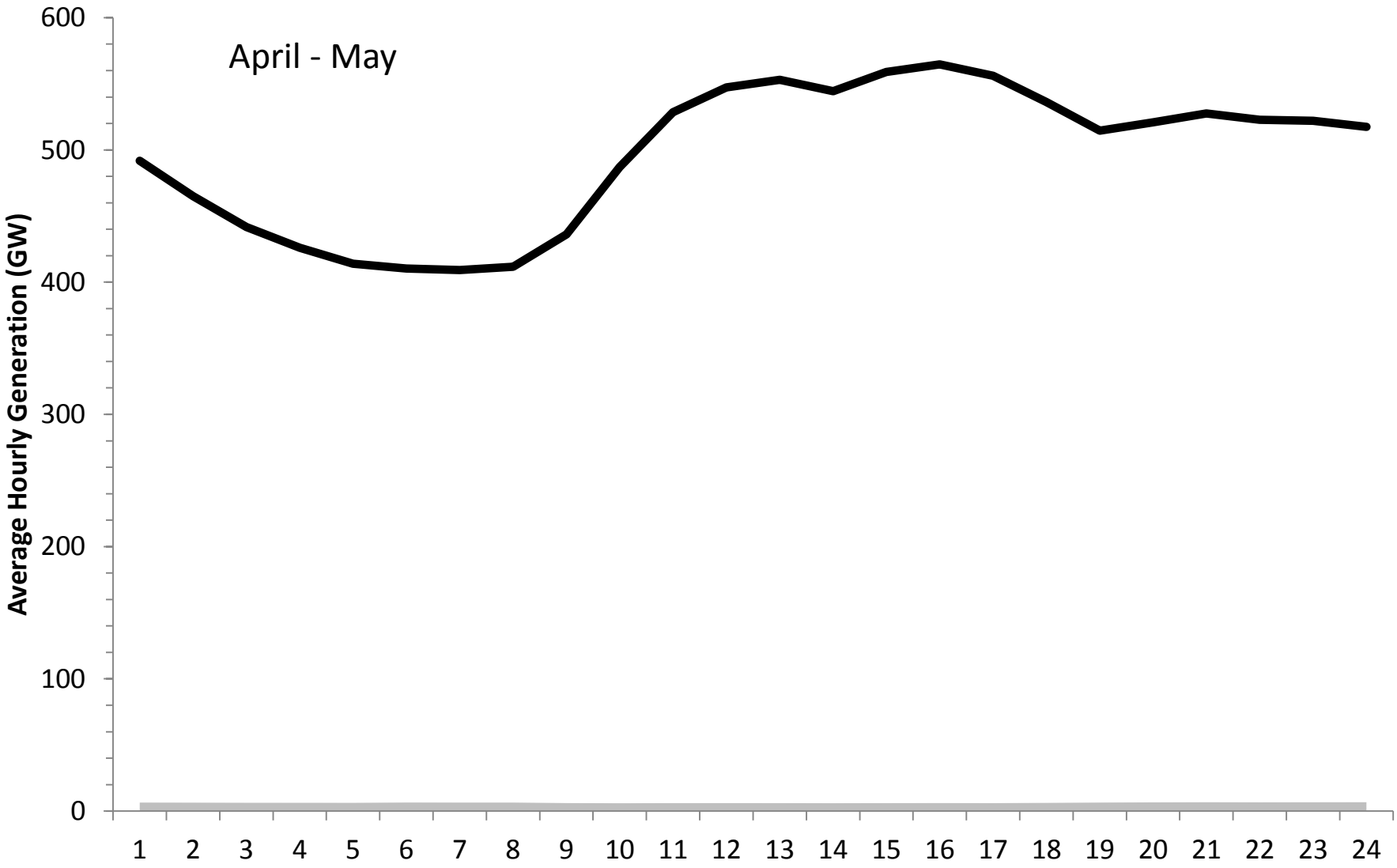


We modeled four key pathways from India's 2050 calculator

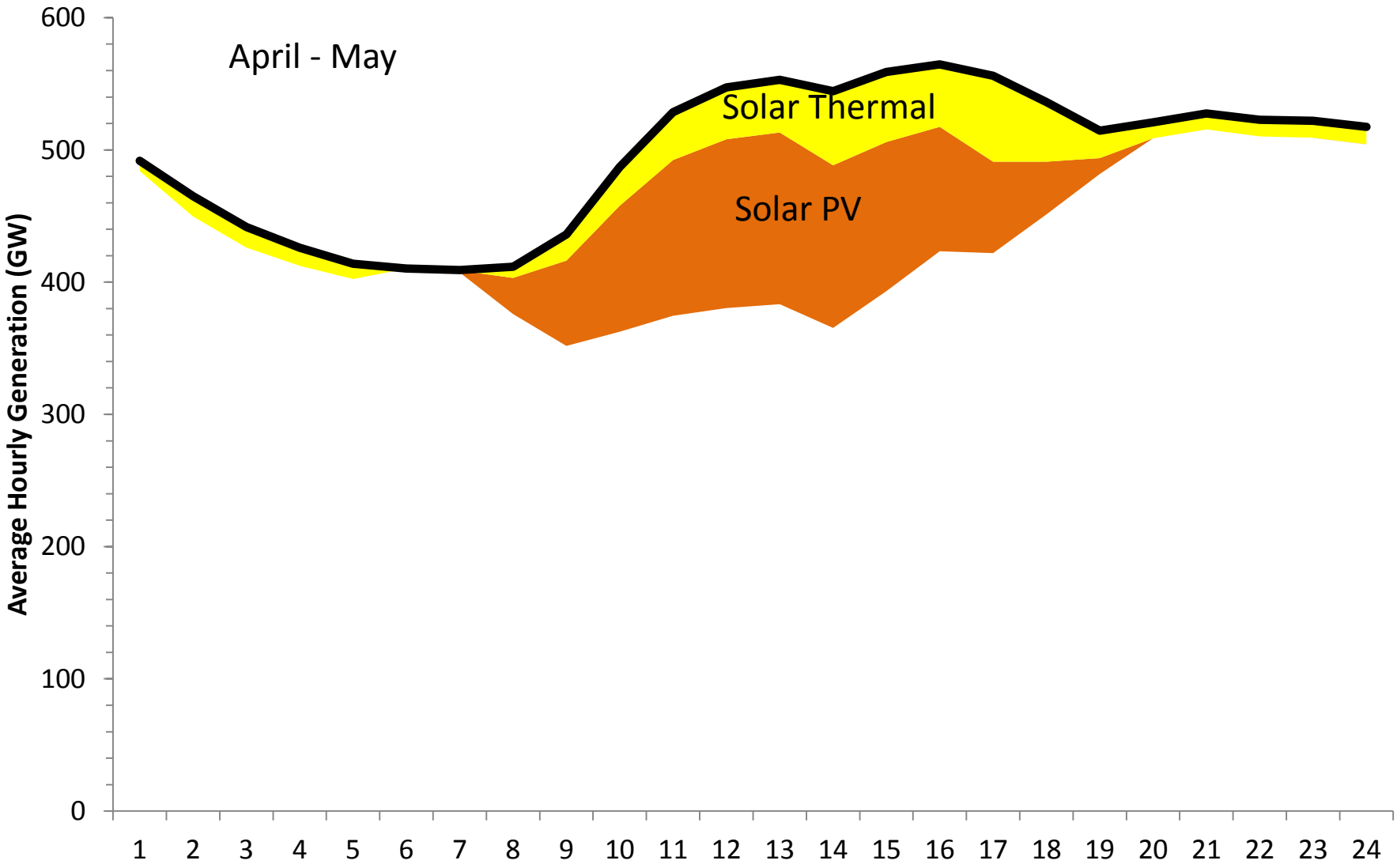
In this presentation, I will focus on two of them

Pathway	*Peak Demand*	*RE Capacity*
Energy Security (Max Effort)	645 GW	436 GW (30%)
Minimum Emissions	645 GW	990 GW (60%) minus ~5% curtailment

Max Energy Security Pathway – Average Summer Day



Max Energy Security Pathway – Average Summer Day



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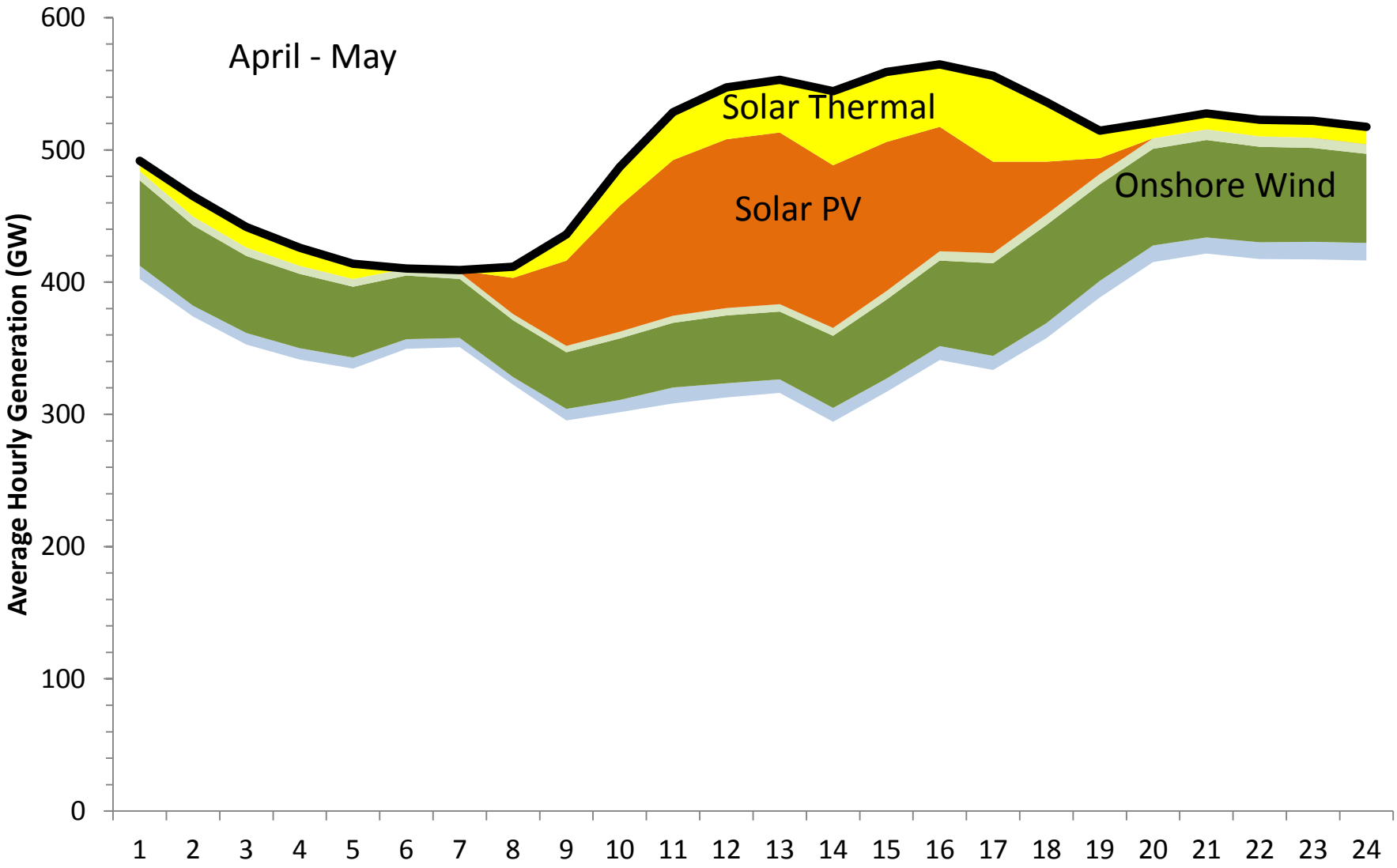

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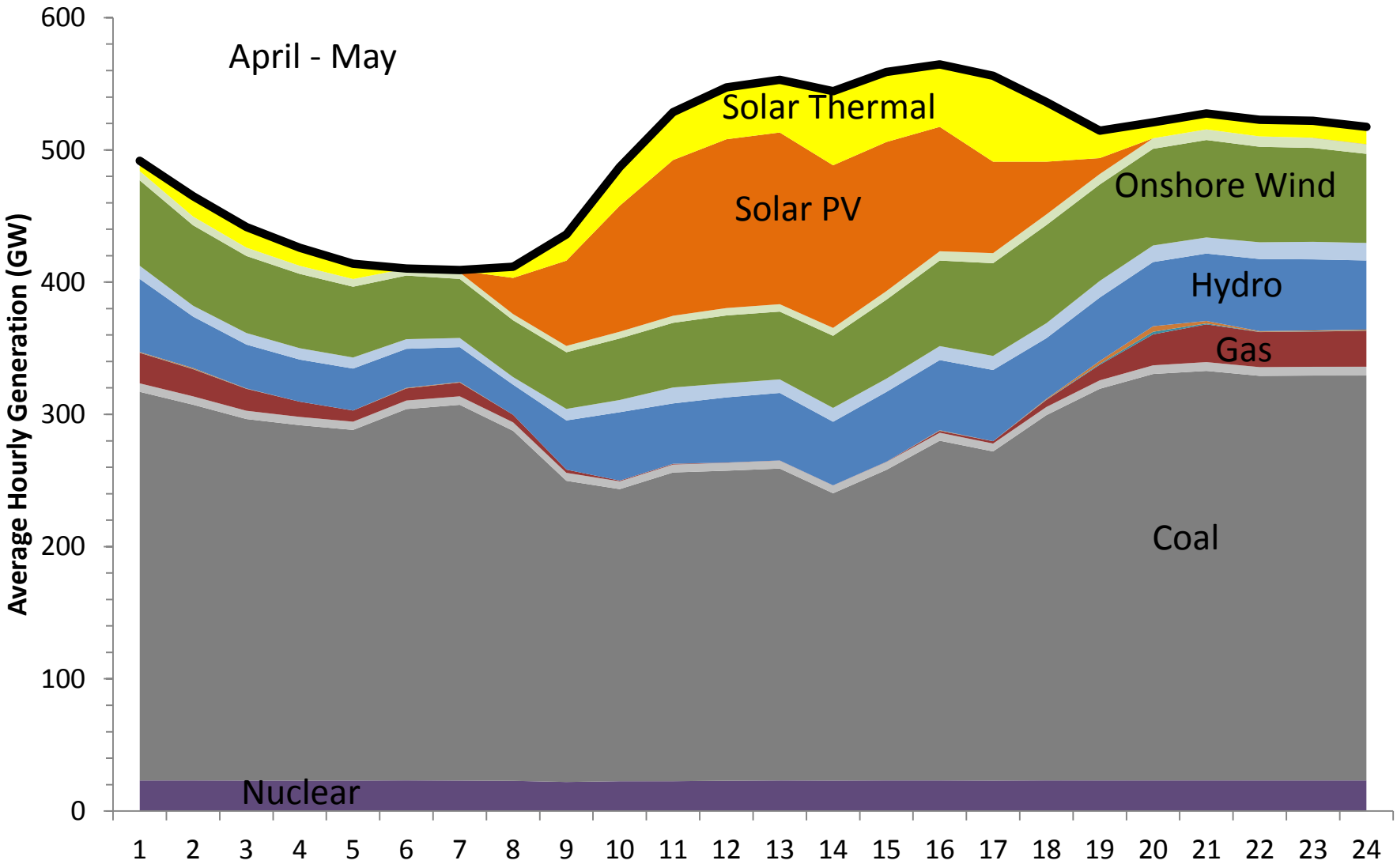
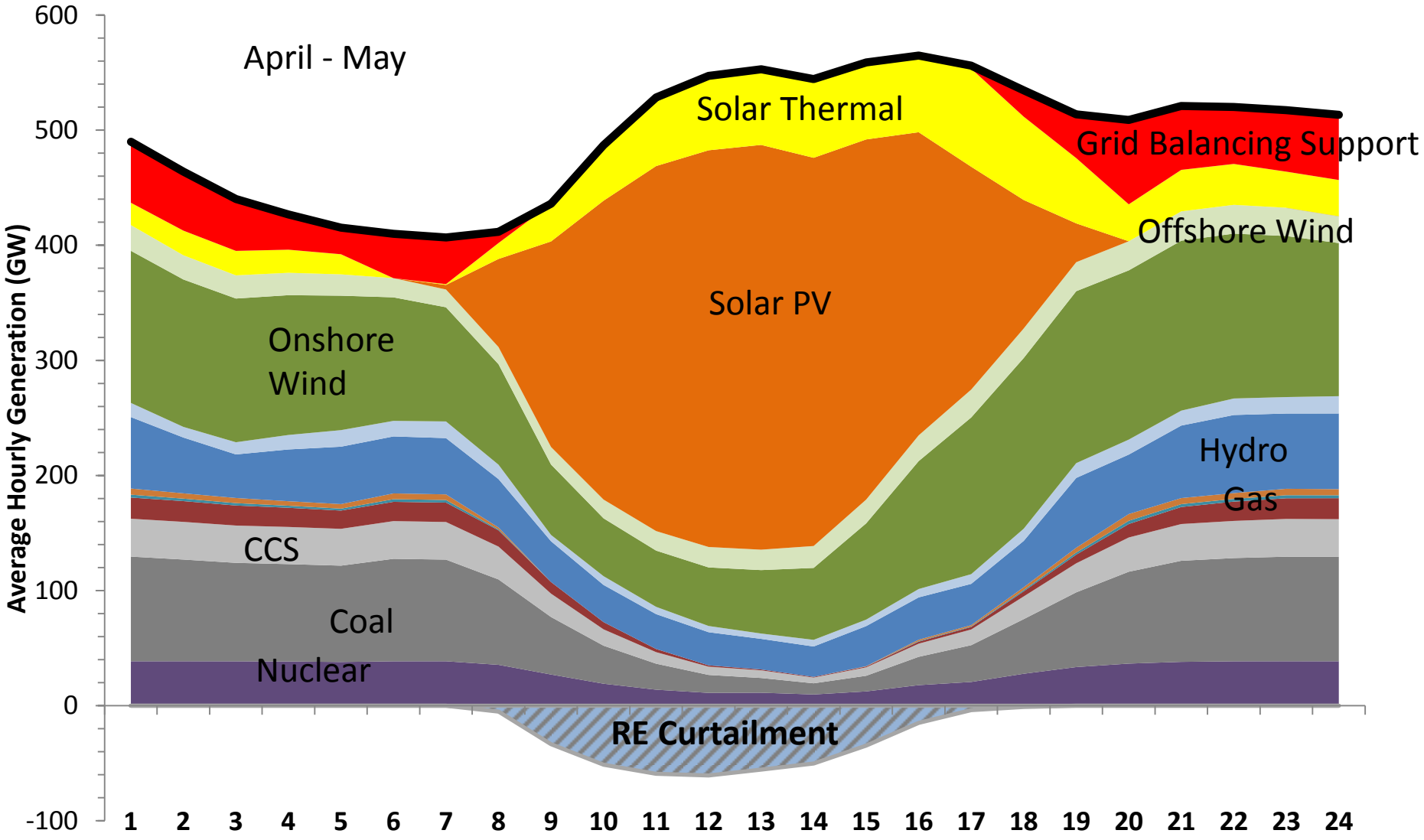
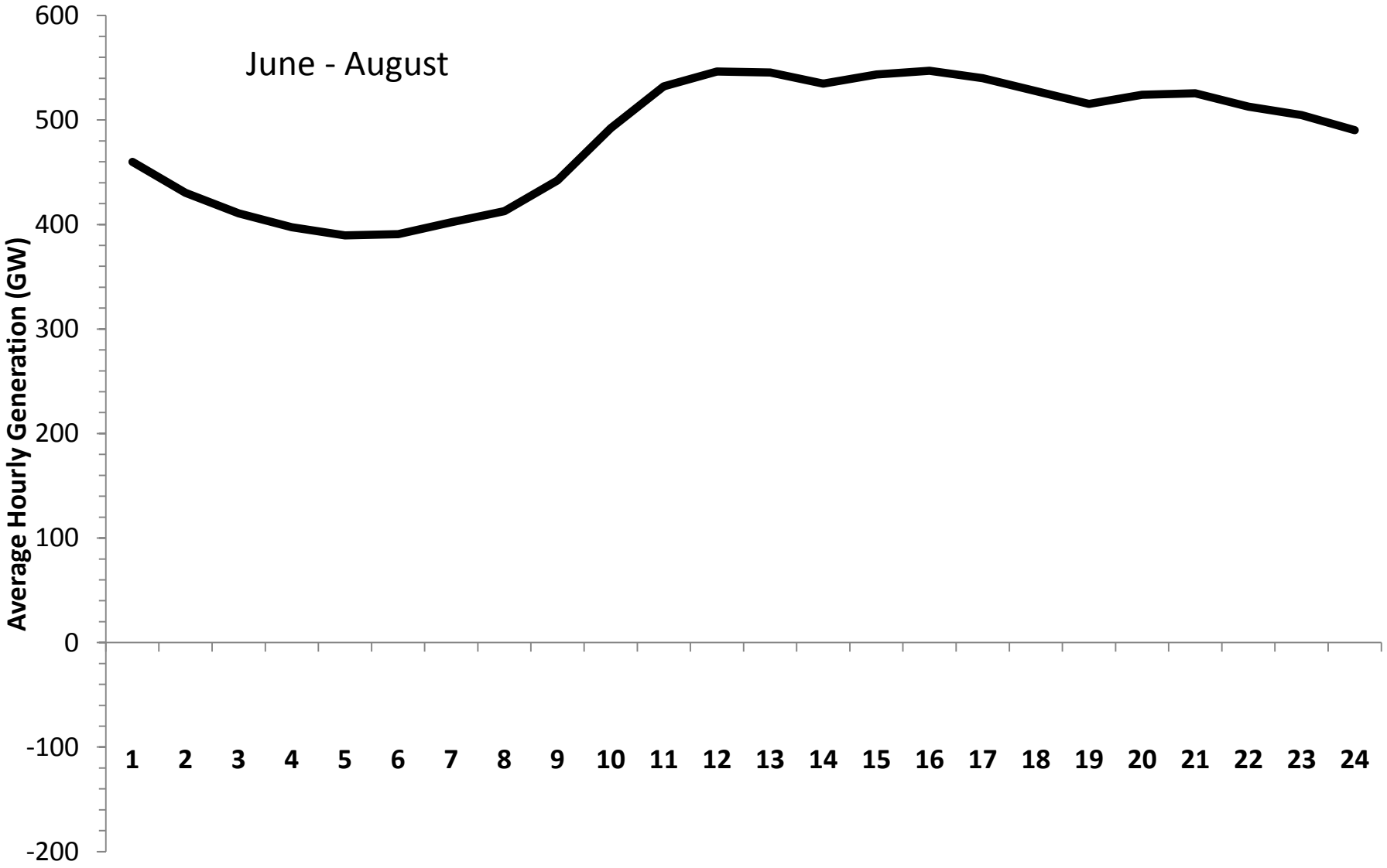


Min Emissions Pathway - Average Summer Day



Min Emissions Pathway - Average Monsoon Day



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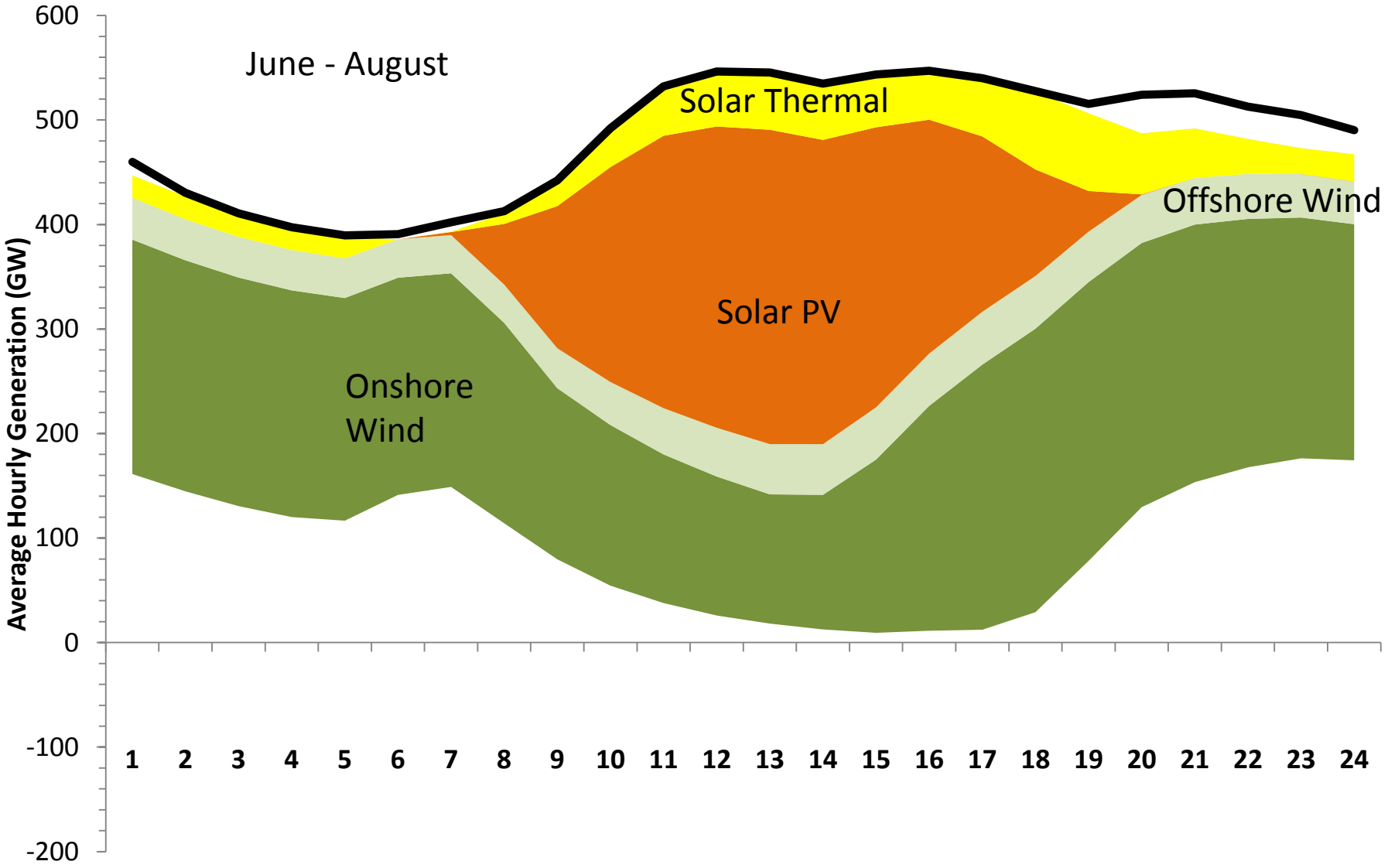

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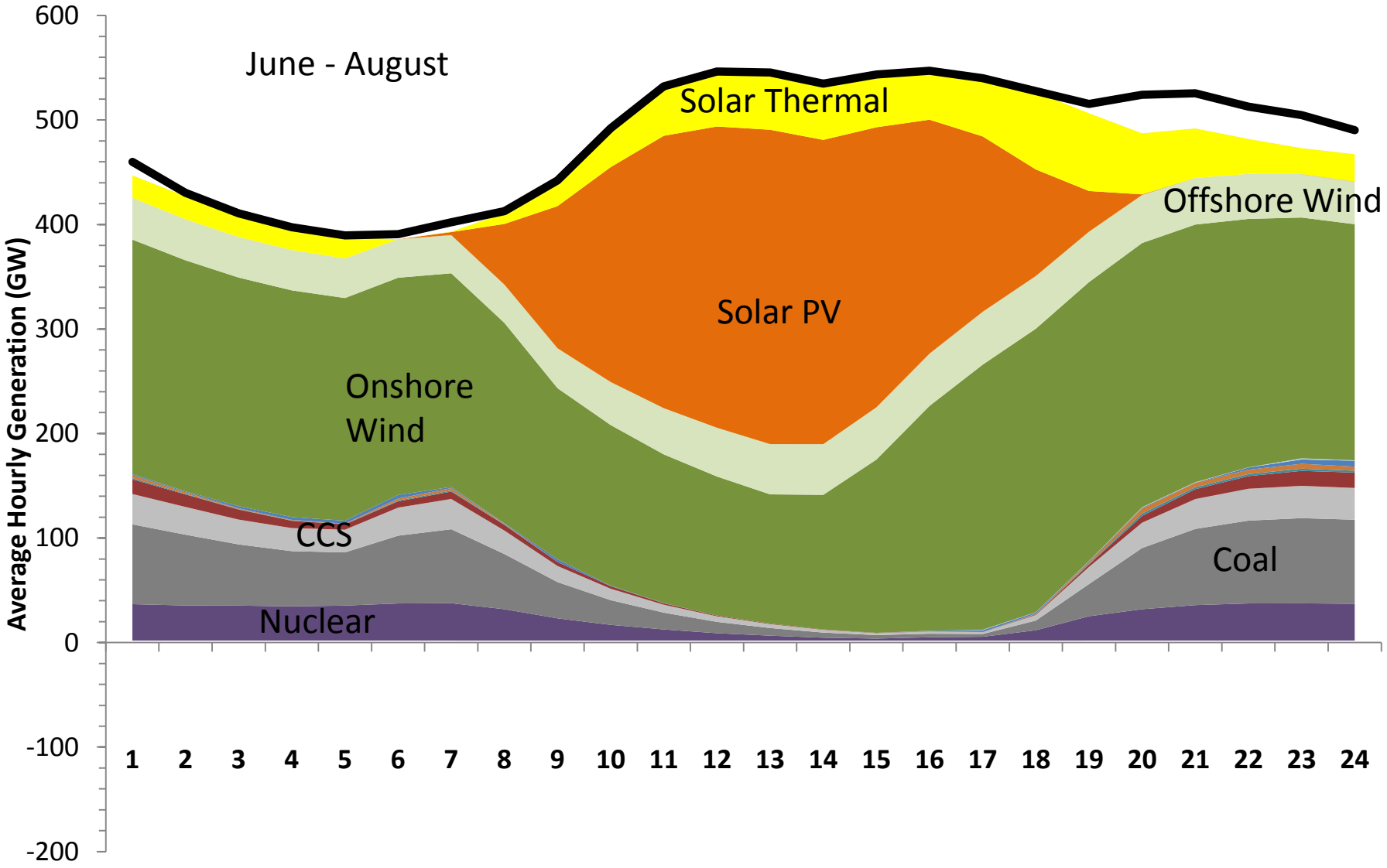
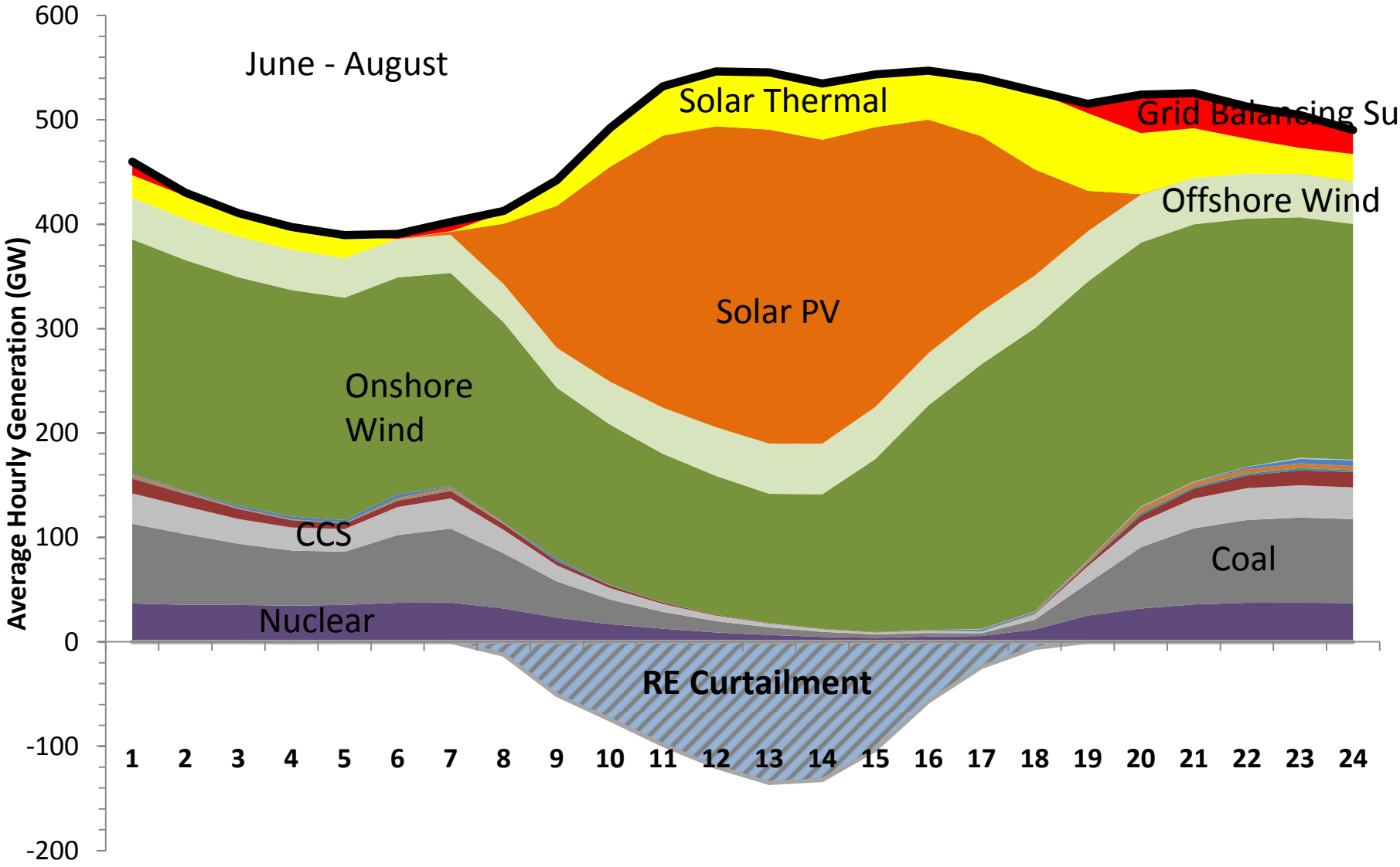
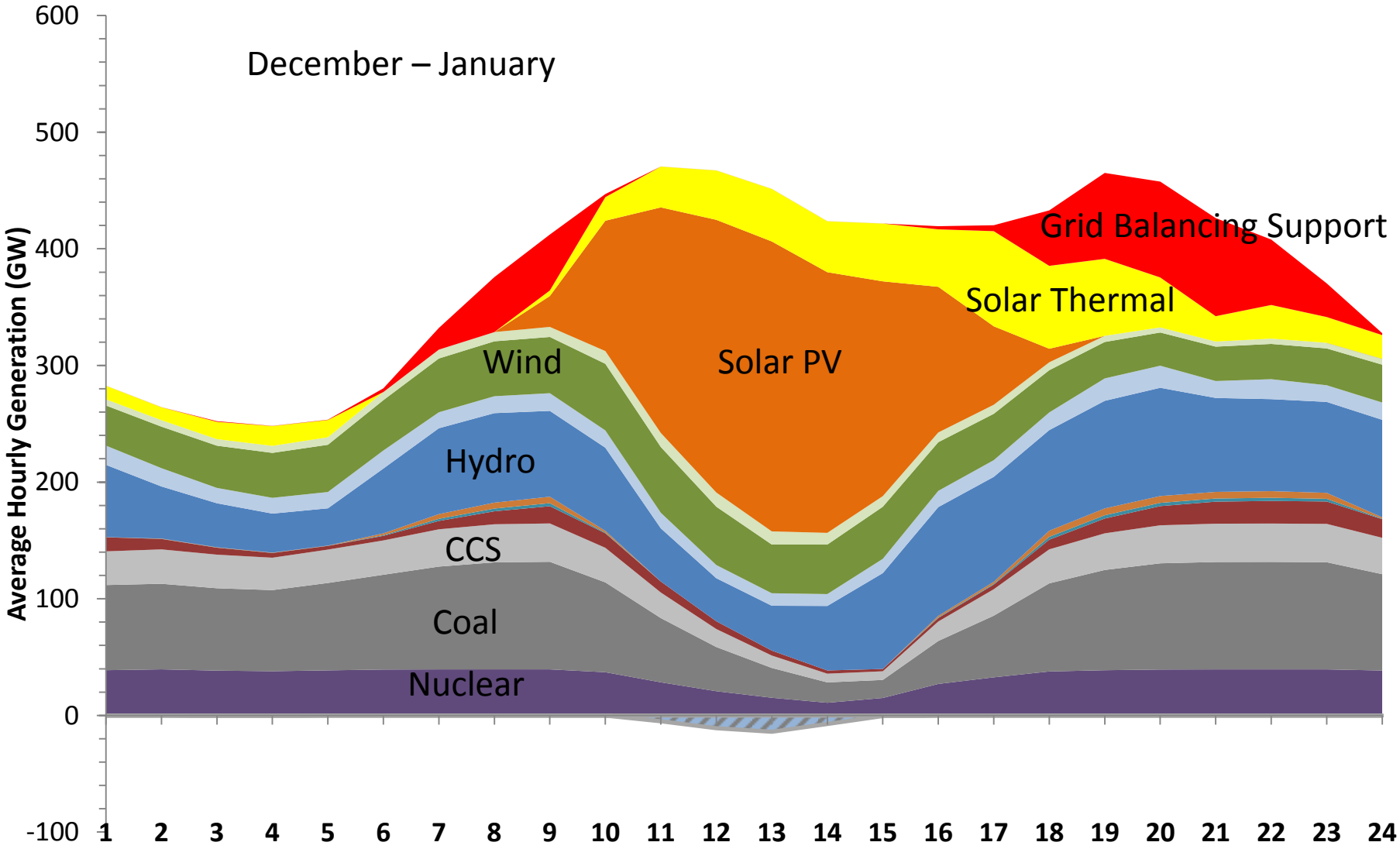


Min Emissions Pathway - Average Monsoon Day



Min Emissions Pathway - Average Winter Day



Key Takeaways

- The 2050 calculator offers great insights based on annual energy balance
- However, additional capacity investments for grid balancing may be necessary
  - E.g. India's Minimum Emissions Pathway = 100 GW
- Some form of daily/hourly balancing with good spatial resolution will make the results robust
  - Can be modeled outside the calculator with a static database of the grid simulation posted on the web e.g. India calculator V2
- Look forward to furthering the collaboration !

Thank You

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