Carbon-Aware Workload Scheduling for Sustainable Data Centers

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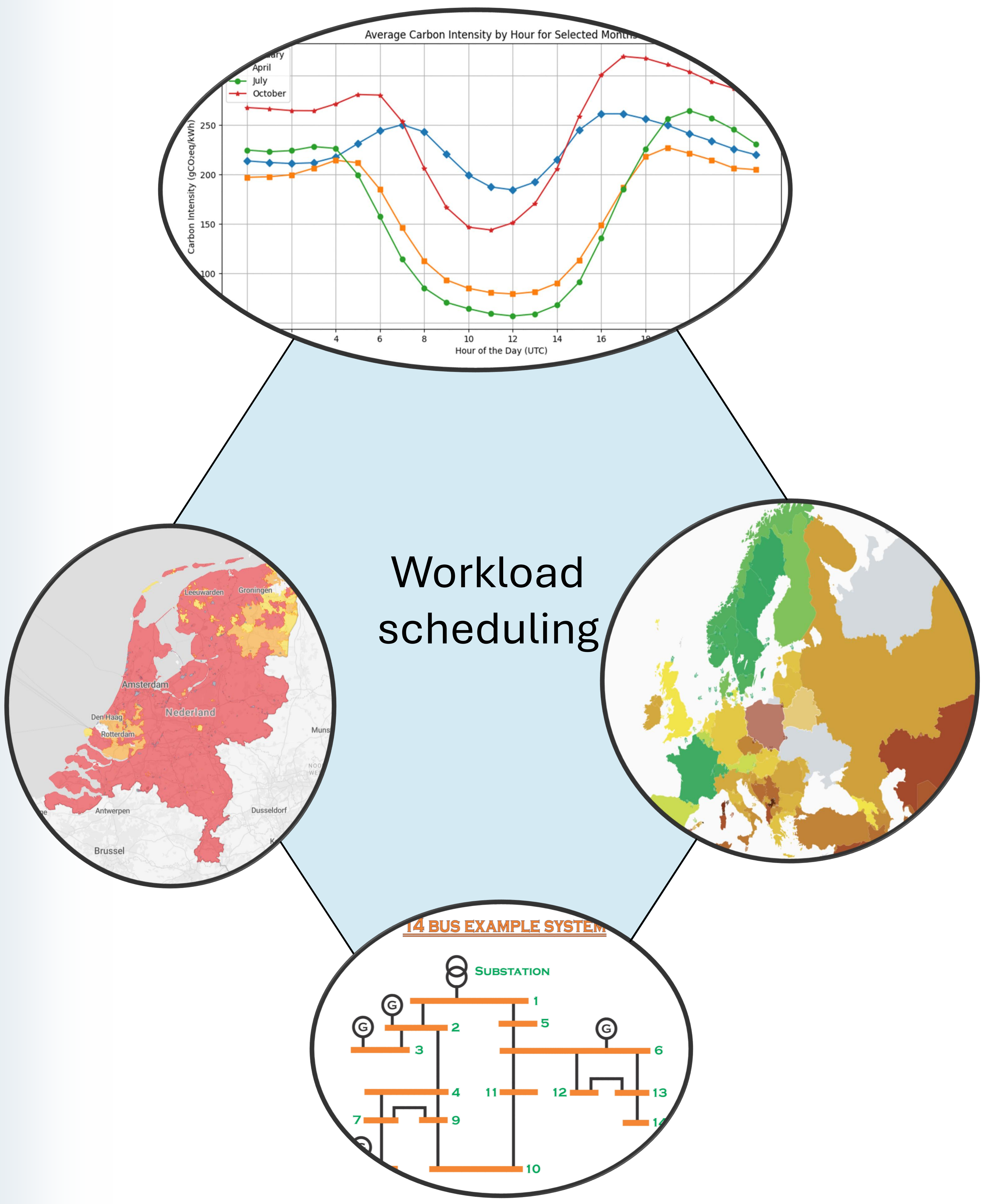
Why It Matters

- Data centers are responsible for a rapidly growing share of global electricity demand and CO_2 emissions.
- The rise of AI and large language models accelerates this trend.
- Most prior studies focus on data center facilities without considering their impact on the broader energy system.
- True sustainability goes beyond data centers. It requires an energy system-wide perspective that includes grid operations.
- Workload shifting enables data centers to move or delay computing tasks across time and locations to match periods or regions with low-carbon electricity, reducing overall energy system emissions.

How We Tackle the Problem

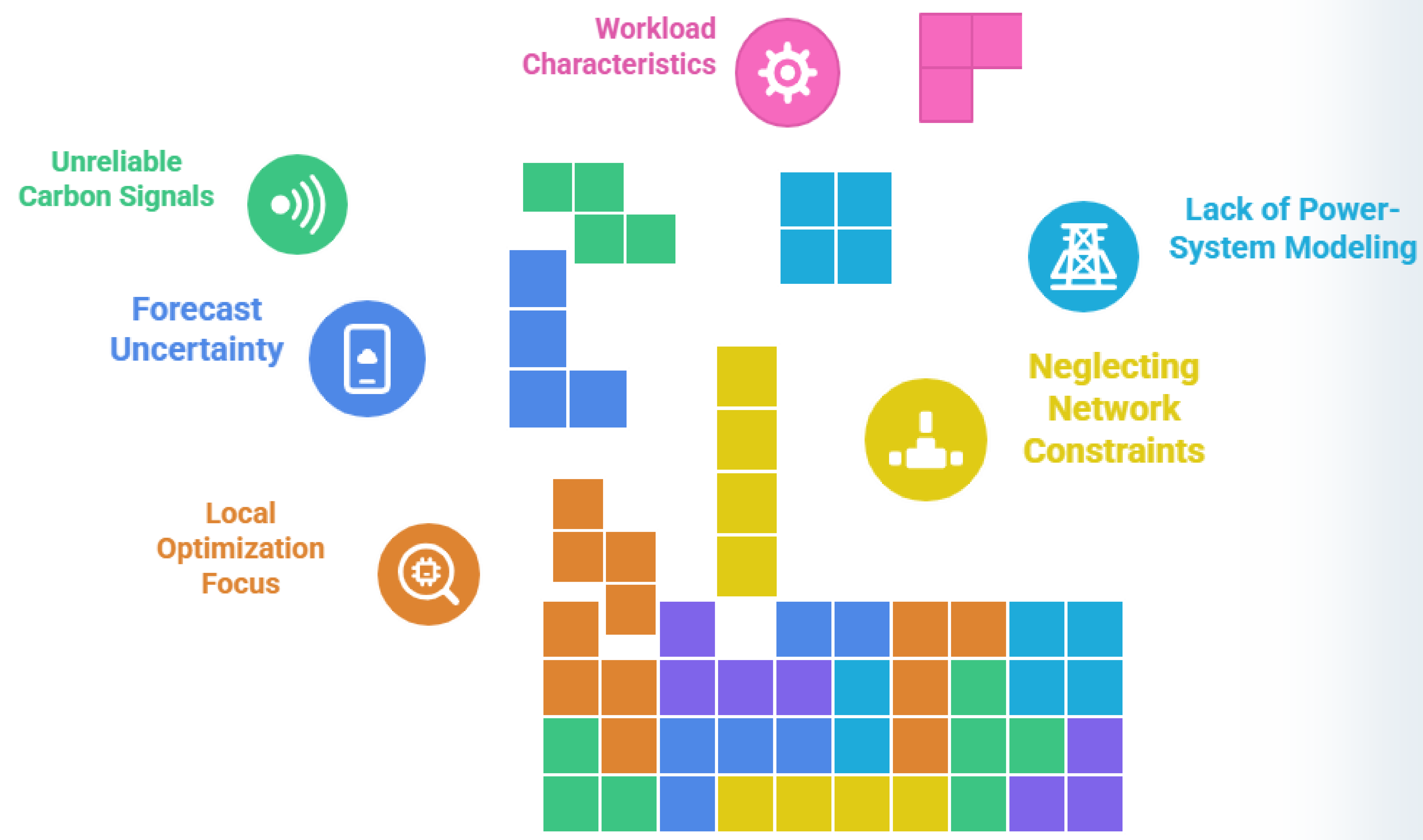
- We treat data-center scheduling as part of the power system, not an isolated IT task.
- Our approach links computing demand with real-time grid conditions such as congestion and renewable curtailment.
- We aim for energy system-wide decarbonization, not just local emission reduction.
- We use grid-aware scheduling and carbon metrics that reflect the true marginal impact of workload shifts.



What Makes Workload Scheduling Hard?

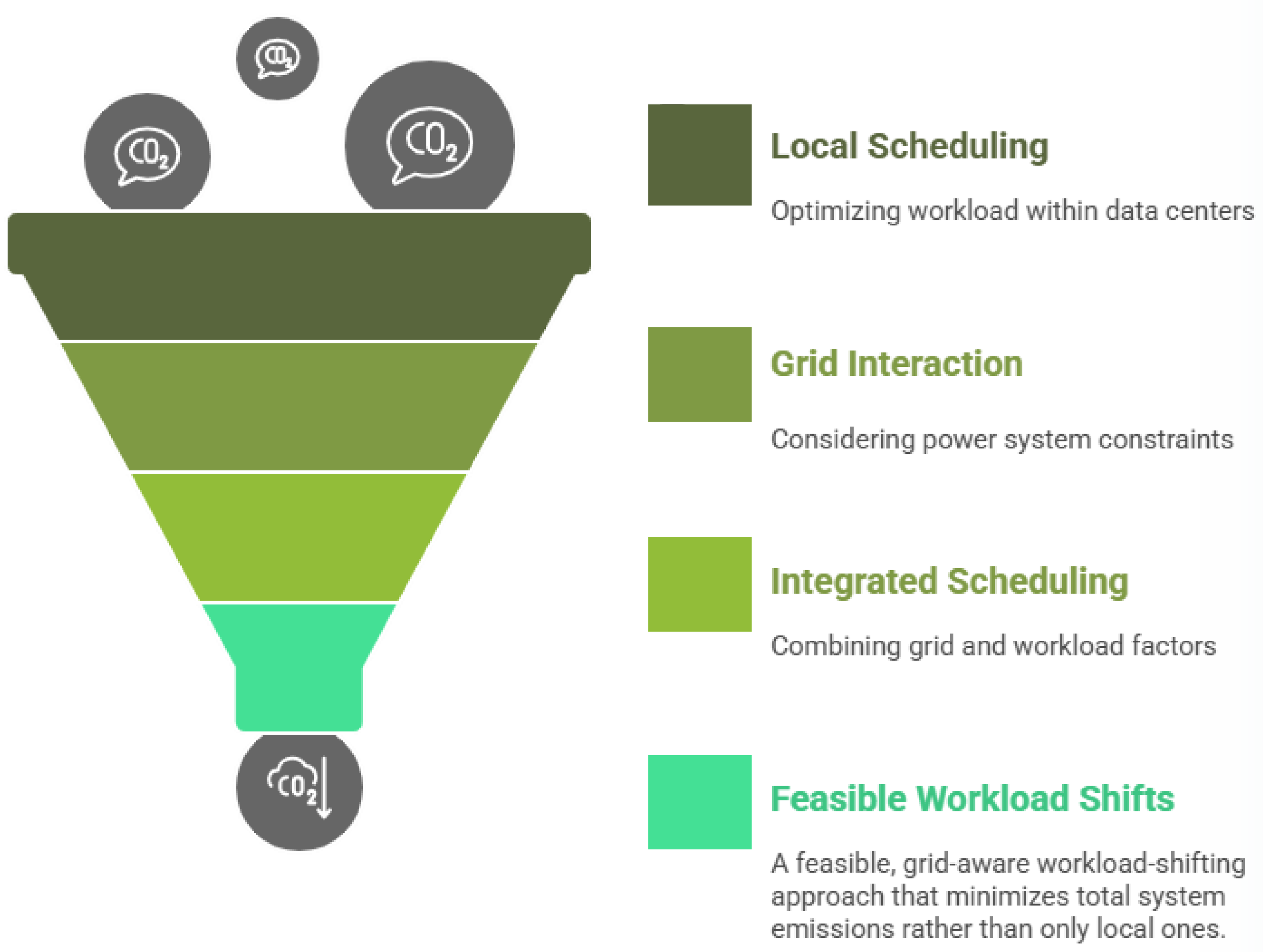
- Current approaches face several interconnected challenges:
  - Unreliable carbon signals that misrepresent true grid emissions.
  - Forecast uncertainty in renewable availability and demand.
  - Local optimization focus that ignores energy system-wide impacts.
  - Neglect of power grid constraints such as congestion and redispatch.
  - Lack of power-system modeling that links data-center operation to real grid behavior.

These limitations form the "missing pieces" preventing energy system-wide sustainability.



Our Roadmap Towards Greener Data Centers

- Achieve sustainability by linking data centers with the power grid as one integrated ecosystem and reduce total energy system-wide emissions.
- Align computing demand with clean electricity across time and location.
- Develop reliable carbon signals that capture grid dynamics and uncertainty.
- Develop a carbon-aware scheduler that integrates power-system constraints (e.g., power grid congestion, generators ramp limits, and renewable curtailment) and co-optimizes workloads with grid operations.



Achieving System-Wide Emission Reduction

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MISD Project

Contact Me!

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