Emissions Aware Distributed Storage Scheduling

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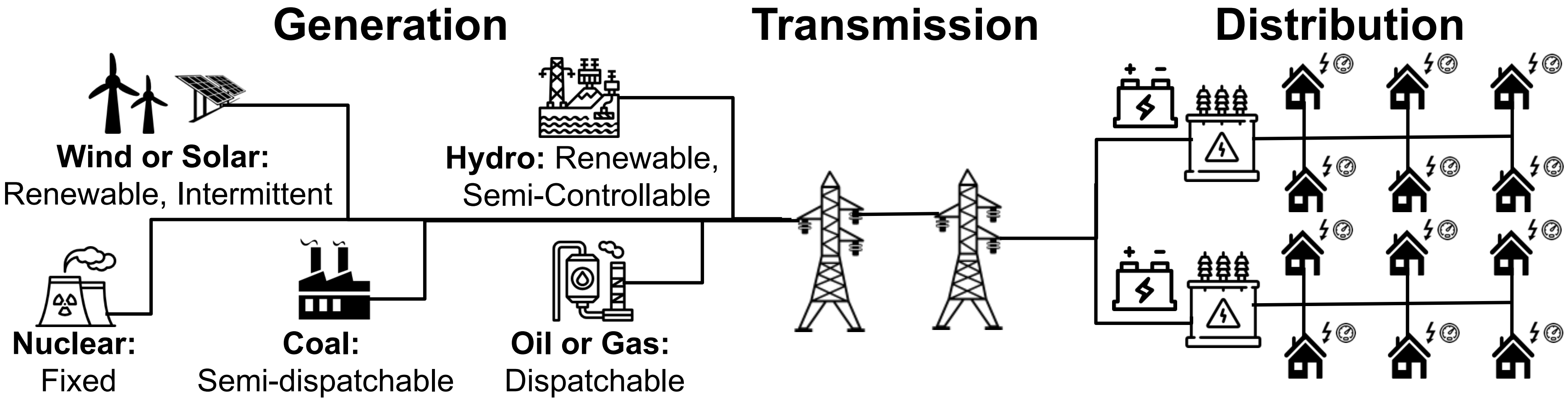
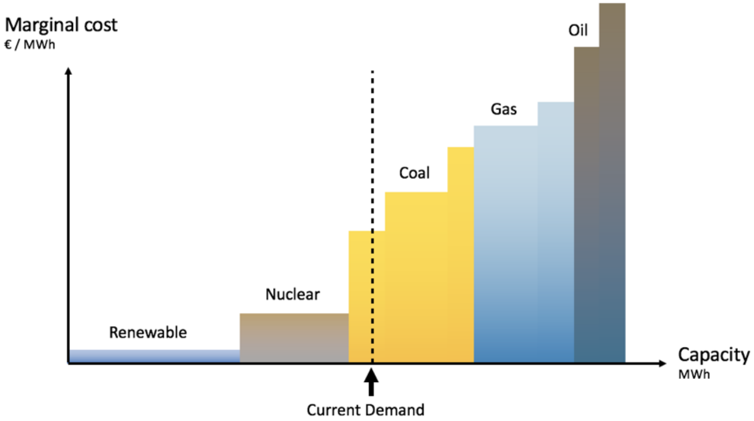
Motivation: Enabling Greener Grid Operations

- Grid Operations -> **Supply-Demand** balance
  - **Diverse Fuel Mix:** Varying **operating constraints, greenhouse emissions, prices**
  - **Smart Grid:** Distributed storage for grid resilience



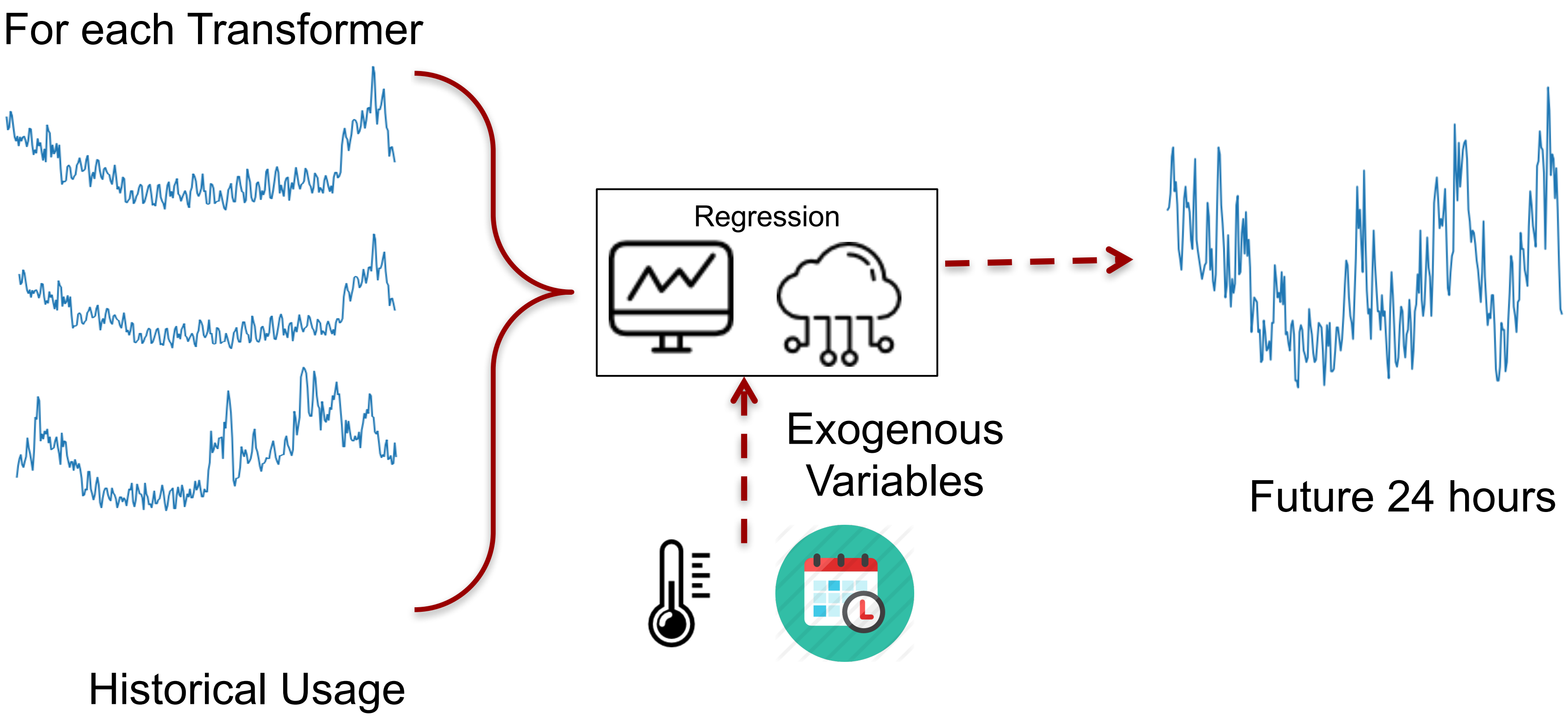
Can we use energy storage to make a greener grid?

Problem Formulation



- **Problem:** Distributed Scheduling of storage to reduce carbon emissions
- **Algorithm:**
  - **Load forecasting:** Use Historical Transformer Level load data to forecast the future
  - **Storage Scheduling:** Optimal scheduling of storage to minimize carbon emissions

Algorithm – Predicting Transformer-level Energy Usage (1)



Algorithm – Scheduling storage charge/discharge (2)

- Prepared a linear programming formulation for scheduling storage
- **Objective:** Minimize Carbon Emissions
- **Constraints:**
  - Energy balance
  - Grid Constraints: Transformer flow etc.
  - Battery Constraints: Amount of Discharge, Capacity, Rate of Charging/Discharging

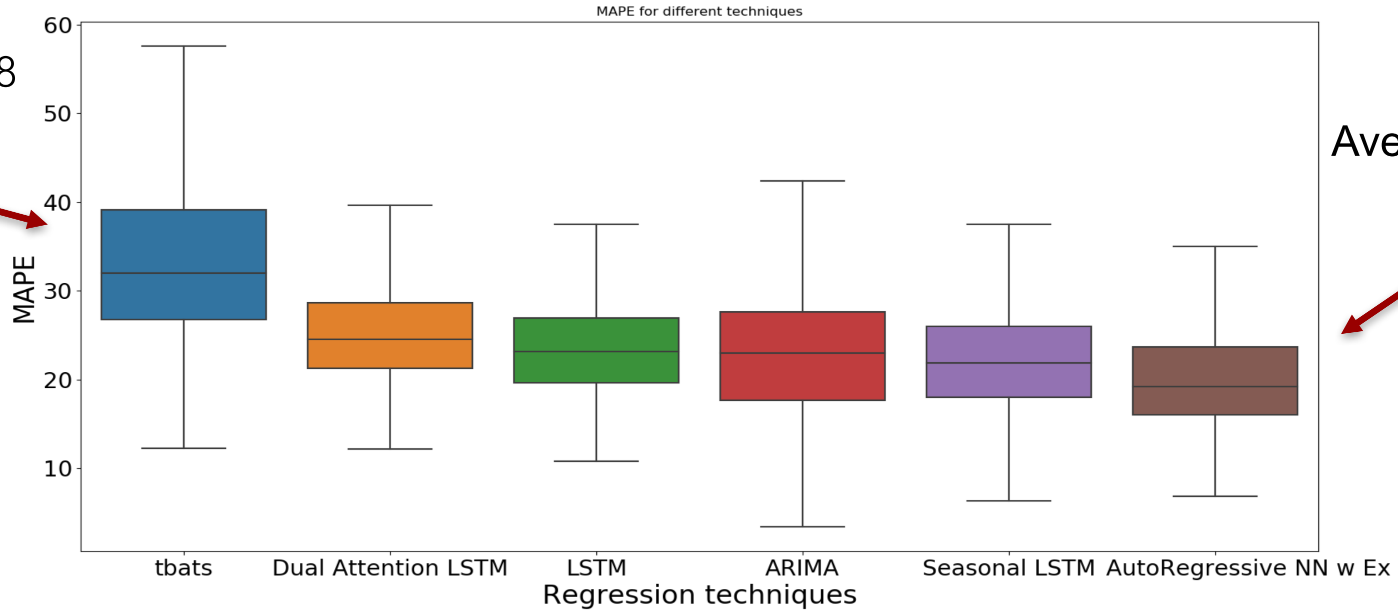
Evaluation Methodology

- **Dataset:** City-wide utility dataset from the New England region
  - Overall 10263 smart meter measuring electricity usage
  - Overall 1050 transformers serving these meters

- **Regression:**
  - Baseline Techniques – ARIMA, TBATS
  - State-of-the-art Techniques – Per-time LSTM, Dual Attention LSTM, Seasonal LSTM
  - Our Technique – Autoregressive Neural Network with Exogenous Variables
  - Train:Test split – 1 year : 1 year (Sliding Evaluation)
  - Granularity – 5 minute (288 values in a day)

Comparison of Regression Techniques

Average=32.18



Average=19.54

Autoregressive Seasonal Neural Network outperforms other state of the art techniques

Related Work

- Modeling grid energy consumption:
  - Lee et al. (ACM eEnergy 2017), Iyengar et al. (ACM SIGKDD 2018), Richardson et al. (Elsevier Renewable and Sustainable Energy Reviews 2013), Veit (ACM eEnergy 2014)
- Past work focussed on predicting prices:
  - Bunn et al. (Proceedings of the IEEE 2000), Conejo et al. (IEEE Power Systems 2005), Sahay et. al. (IEEE INDICON 2013)
  - We converted predicting - prices (2nd Order Chaos) to fuel mix (1st Order Chaos)
- Use of energy storage
  - Lawder et al. (IEEE Volume 102 2014), Koutsopoulos et al. (ACM eEnergy 2011)
  - We used a distributed battery storage scenario

Conclusion: Current status and deliverables

- Completed
  - Improved the state-of-the-art energy load prediction (regression)
  - Prepared linear programming-based formulation for energy storage operations
- To do
  - Evaluate the performance of the linear programming formulation
  - Preparing a stochastic optimization-based formulation for energy storage
- Final deliverable
  - Submit the work to a conference/workshop

Thank You

A Charge in Time Saves Nine:
Case for greenhouse emissions-aware energy usage

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