Role of Artificial Intelligence (AI) in Power System Planning and Operation

Dr. Sohail Khan, Associate Professor,
Sino-Pak Center for AI,
Pak-Austria Fachhochschule:
Institute of Applied Sciences and Technology (PAF-IAST)
Haripur, Pakistan

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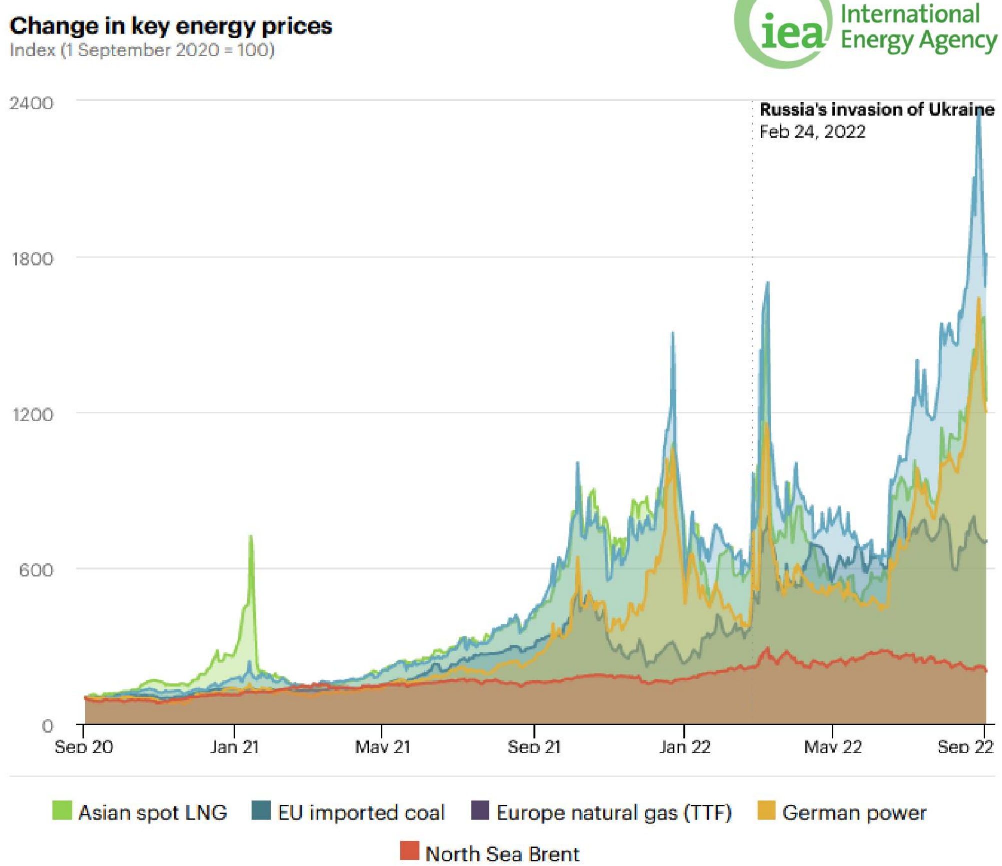
All Details @ https://emesk.github.io/talks/2023-talk-1

The Global Energy Challenge

The global energy challenge is the increasing demand for energy and the need to reduce greenhouse gas emissions to combat climate change.

Exacerbated by global crisis



The Global Energy Challenge

- The global temperature has increased by 1.1°C since the pre-industrial period, and it is projected to reach **1.5°C between 2030 and 2052** if current trends continue. (source: IPCC)
- The United Nations estimates that by 2030, climate disasters could cost the global economy **$54 trillion in economic losses**. (source: UN)
- In 2020, **the United States** alone experienced **22 climate disasters** that each caused over $1 billion in damages, resulting in a **total cost of $95 billion**. (source: NOAA)
- According to the World Bank, over **143 million people in Sub-Saharan Africa, South Asia, and Latin America could be displaced** by climate change by 2050. (source: World Bank)

AI and Energy Efficiency

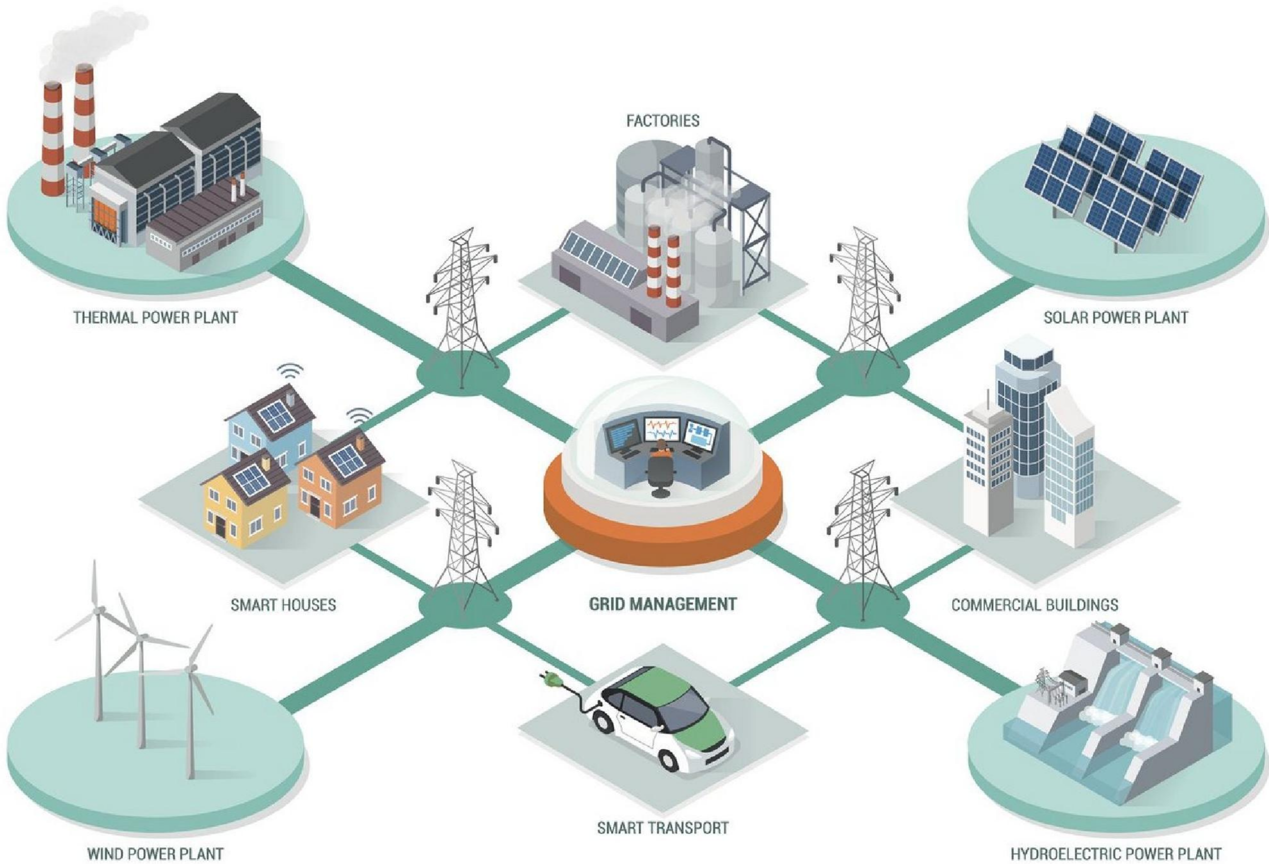
- **The ability to use less energy to perform the same task**
- How AI can improve energy efficiency in **buildings**, **transportation**, and **industry**?
- Examples of AI applications in energy efficiency: smart thermostats, predictive maintenance, and energy management system

AI and Energy Efficiency

- According to a study by the American Council for an Energy-Efficient Economy (ACEEE), **AI-enabled energy management systems in commercial buildings can reduce energy consumption by up to 20%.** (source: ACEEE)
- A report by the International Energy Agency (IEA) found that AI can help reduce global energy demand by **10-15% by 2040** through improved energy efficiency in buildings, transportation, and industry. (source: IEA)

AI and Renewable Energy Usage

Renewable energy, such as solar, wind, and hydropower, is a critical component of reducing greenhouse gas emissions and achieving net-zero emissions targets.



AI for Transforming Energy Grids of Future

Many more …

How AI Contribute to the areas of Innovation

- Ref: [G-PST Research Agenda 2021]

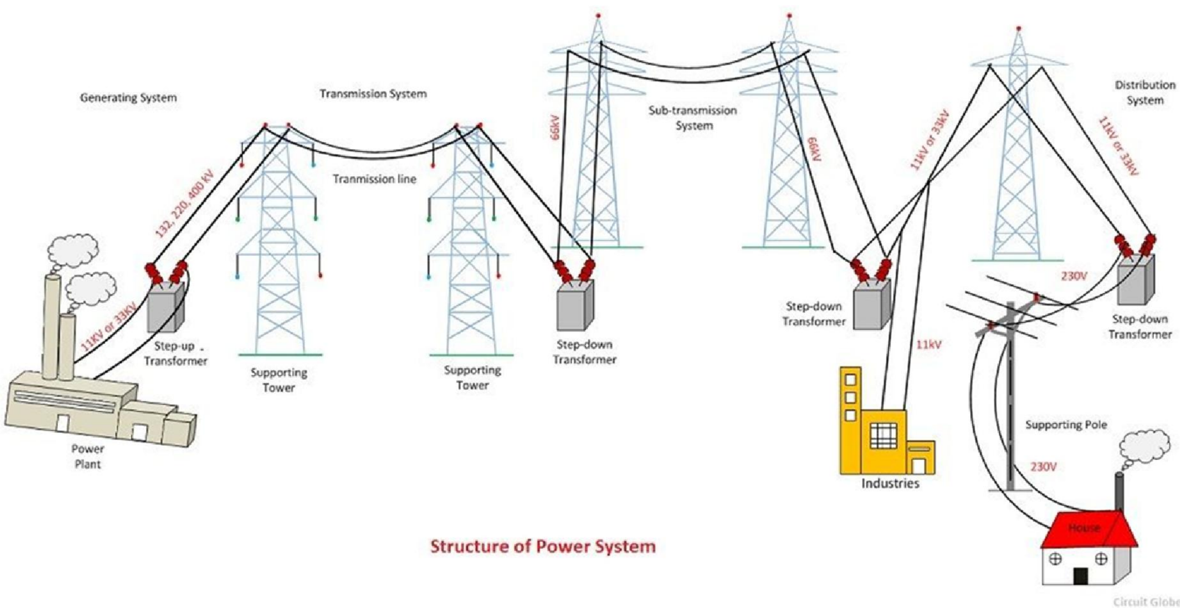
Research Program	Description
Inverter Design	Development of capabilities, services, design methodologies and standards for IBRs.
Stability Tools & Methods	Development of new tools and methods, as well as modifications or supplements to existing tools and methods, required to ensure reliability, security, and stability in power systems.
Control Room of the Future	Development of new technologies and approaches for enhanced real-time visibility and analysis in power system operator control rooms.
Planning	New planning metrics, methods, and tools to capture the characteristics and influence of a changing resource mix.
Restoration & Black Start	Creating new procedures for black starting and restoring a power system with high or 100% IBR penetrations.
Services	Quantifying the technical service requirements of future power systems to maintain the supply-demand balance reliably and at least cost.

AI for Optimal Power Flow

1.Data Availability:
1. Challenge in collecting significant historical power system data.
2. Real-world data often limited, sensitive, and subject to privacy concerns.

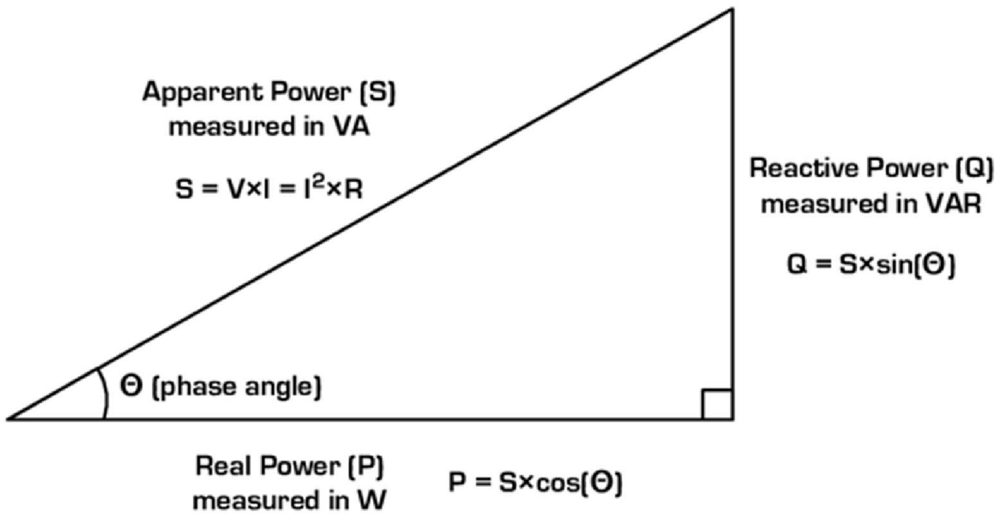
2.Model Complexity:
1. Neural network representation requires careful consideration of architecture, input, and output.

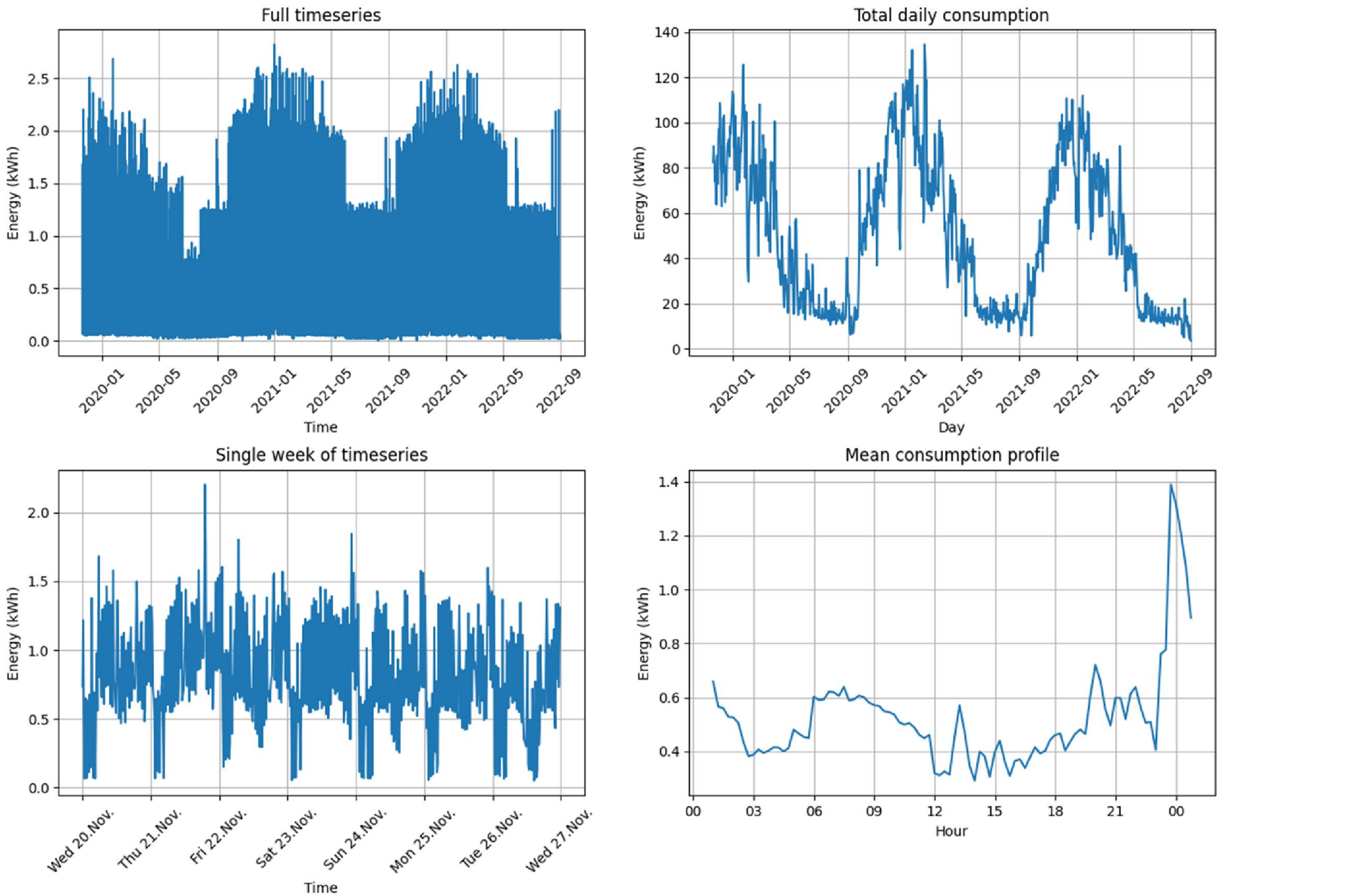
3.Generalization:
1. Neural network model may have limitations in adapting to unseen conditions.
2. Consistent performance across various scenarios is essential.
3. Ensuring robustness and reliability beyond the training set is a critical consideration.



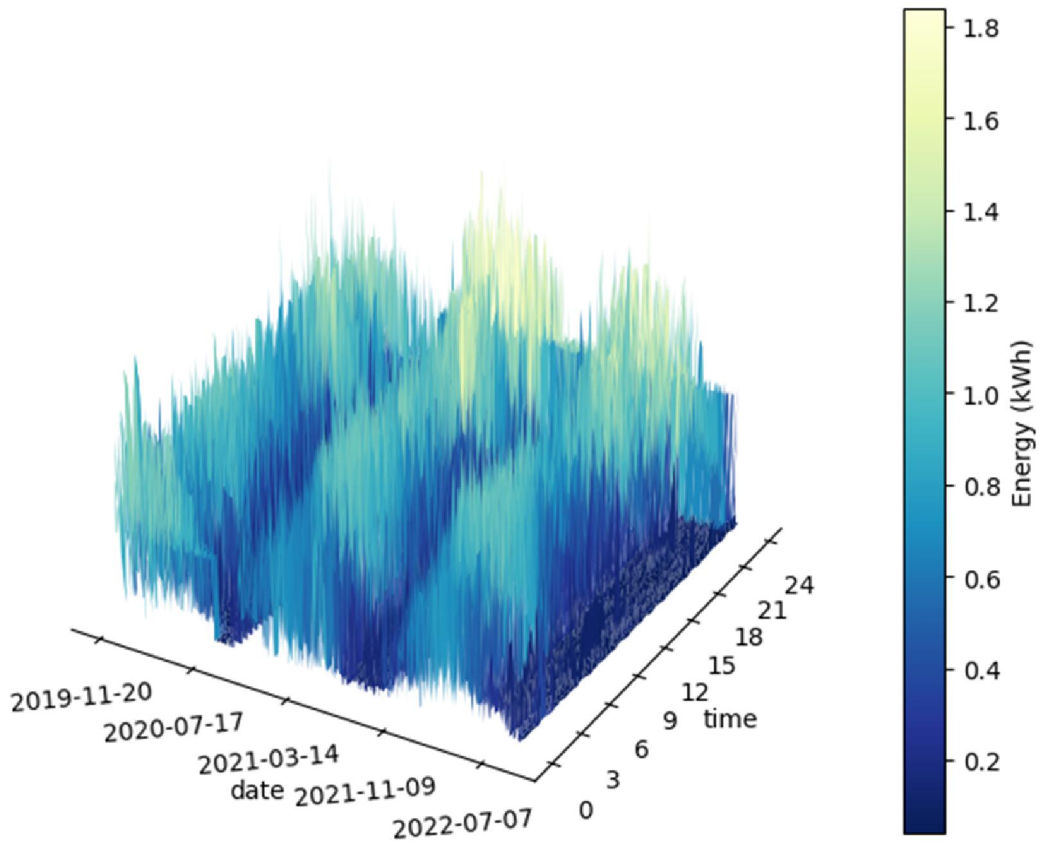
Smart Meter Data Analytics

Practical Use-Cases and Best Practices of Machine Learning Applications for Energy Data in the Residential Sector

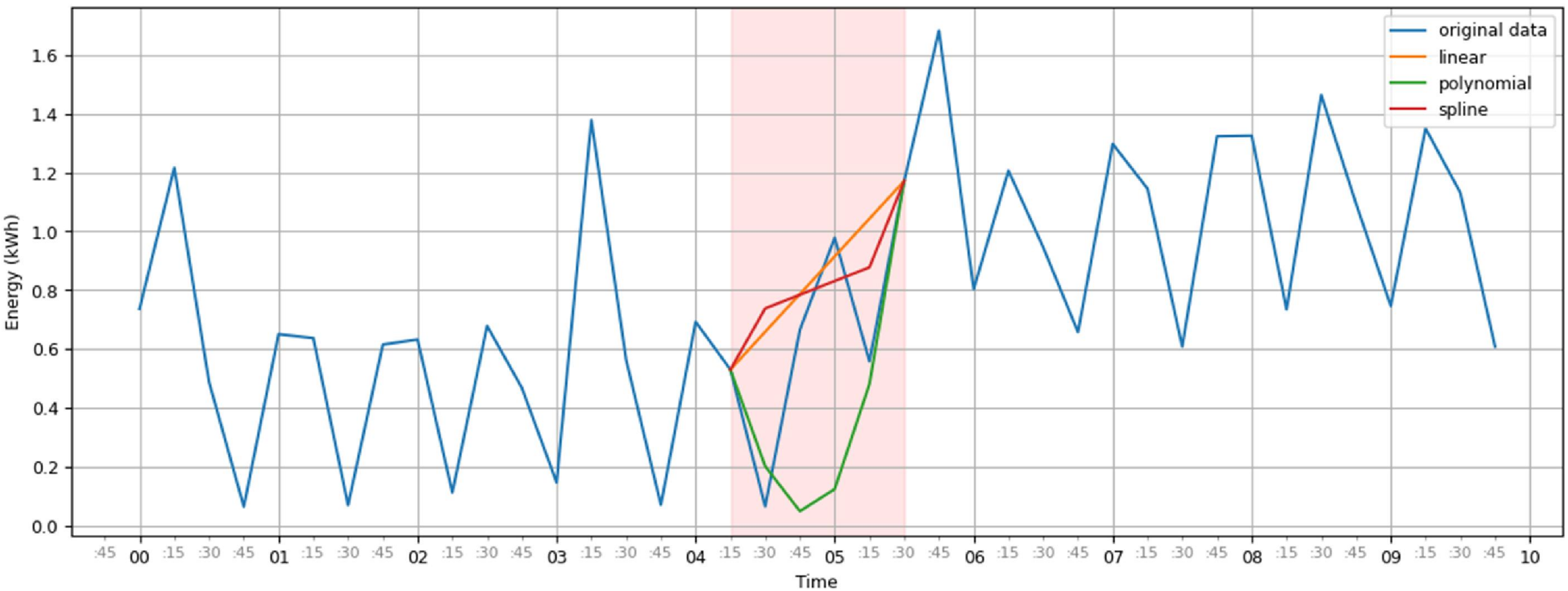



Full timeseries
Energy (kWh)
Time
Total daily consumption
Energy (kWh)
Day
Single week of timeseries
Energy (kWh)
Wed 20.Nov.
Thu 21.Nov.
Fri 22.Nov.
Sat 23.Nov.
Sun 24.Nov.
Mon 25.Nov.
Tue 26.Nov.
Wed 27.Nov.
Time
Mean consumption profile
Energy (kWh)
Hour

Smart Meter Data Analytics



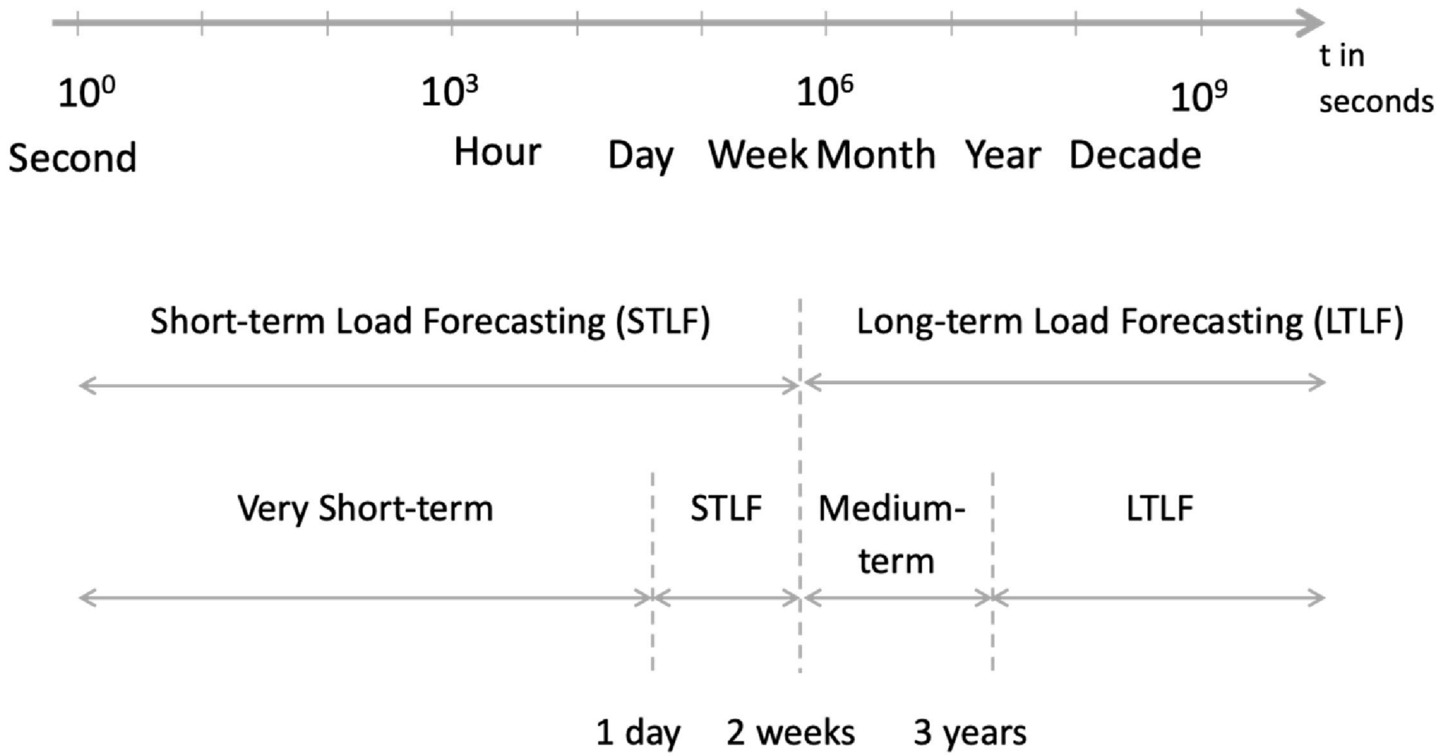
Smart Meter Data Analytics



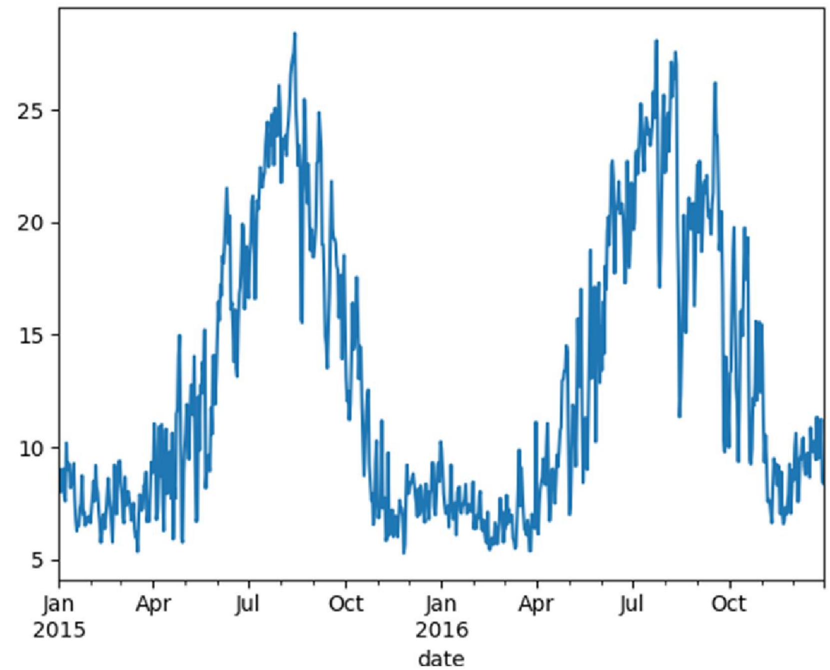
Estimating Emissions From Satellite Images with Computer Vision

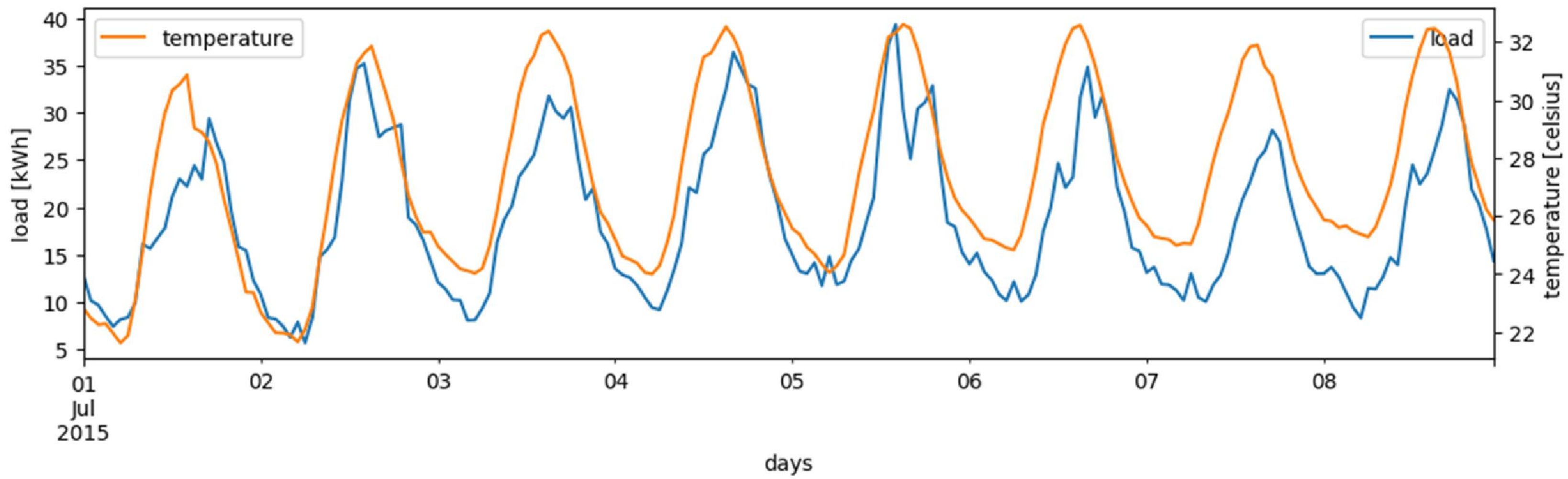
Estimating Coal Power Plant Operation From Satellite Images with Computer Vision

Building Load Forecasting with ML



Building Load Forecasting with ML





Electric Vehicles Integration in Energy System

Total CO2-Equivalent Life-Cycle Emissions from Commercially Available Passenger Cars

Production emissions → body and batteries

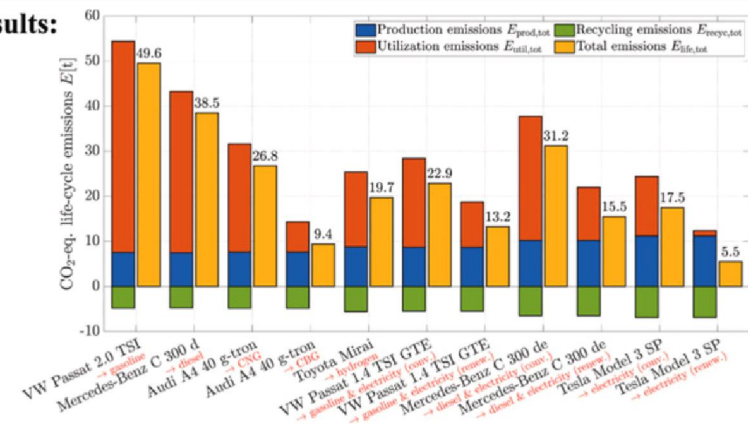
Utilization emissions → fuel and electricity

Recycling emissions → recycling and disposal

Database with 790 commercially available vehicle models

Evaluation and comparison of different powertrains and energy sources

Results:



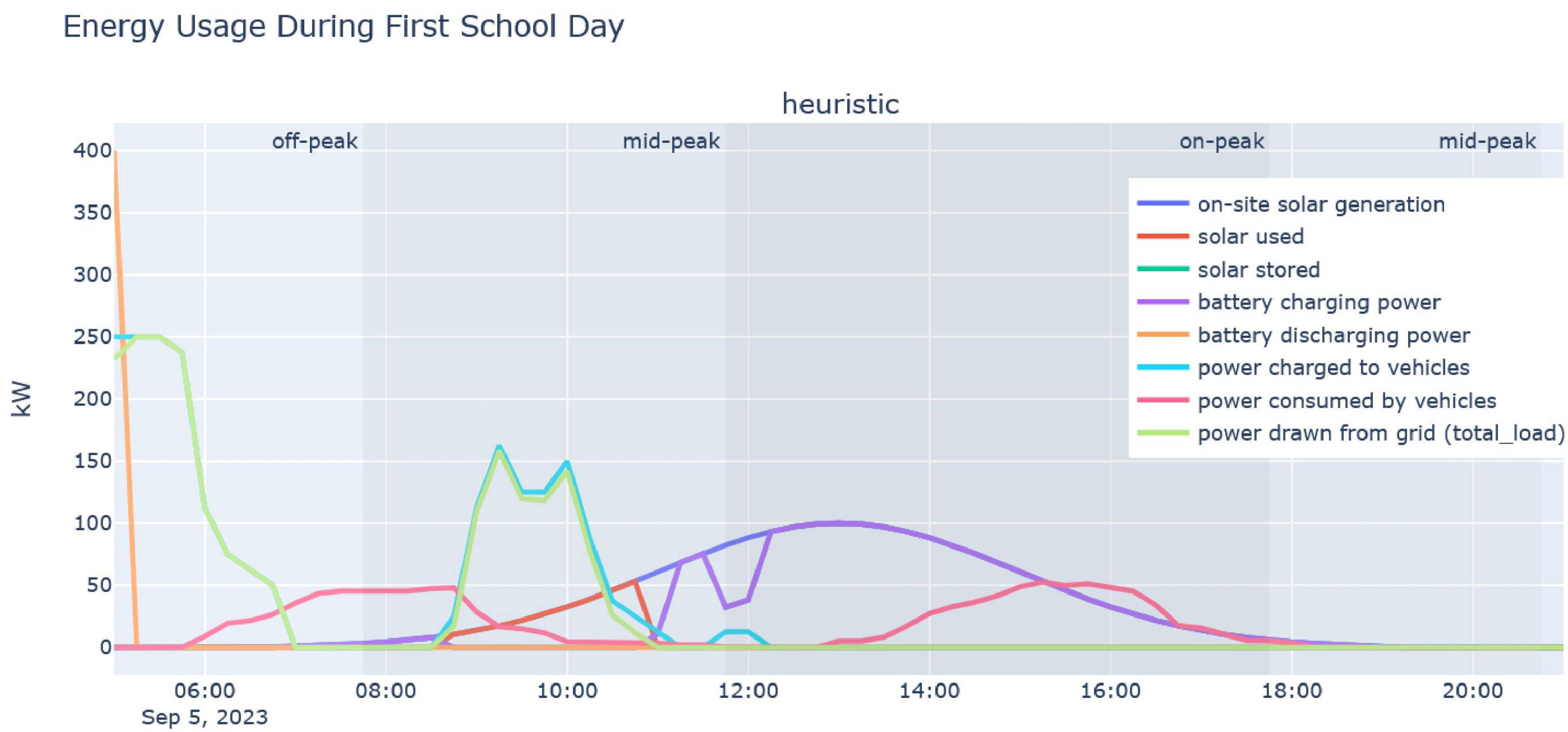
J. Buberger, A. Kersten, M. Kuder, R. Eckerle, T. Weyh, T. Thiringer (2022)

Relative reduction of total life-cycle emissions			
Gasoline (reference)	0 %	Hydrogen	60 %
Diesel	22 %	Gasoline & Electricity	54 / 73 %
Compressed Natural Gas	46 %	Diesel & Electricity	37 / 69 %
Compressed Biogas	81 %	Electricity	65 / 89 %

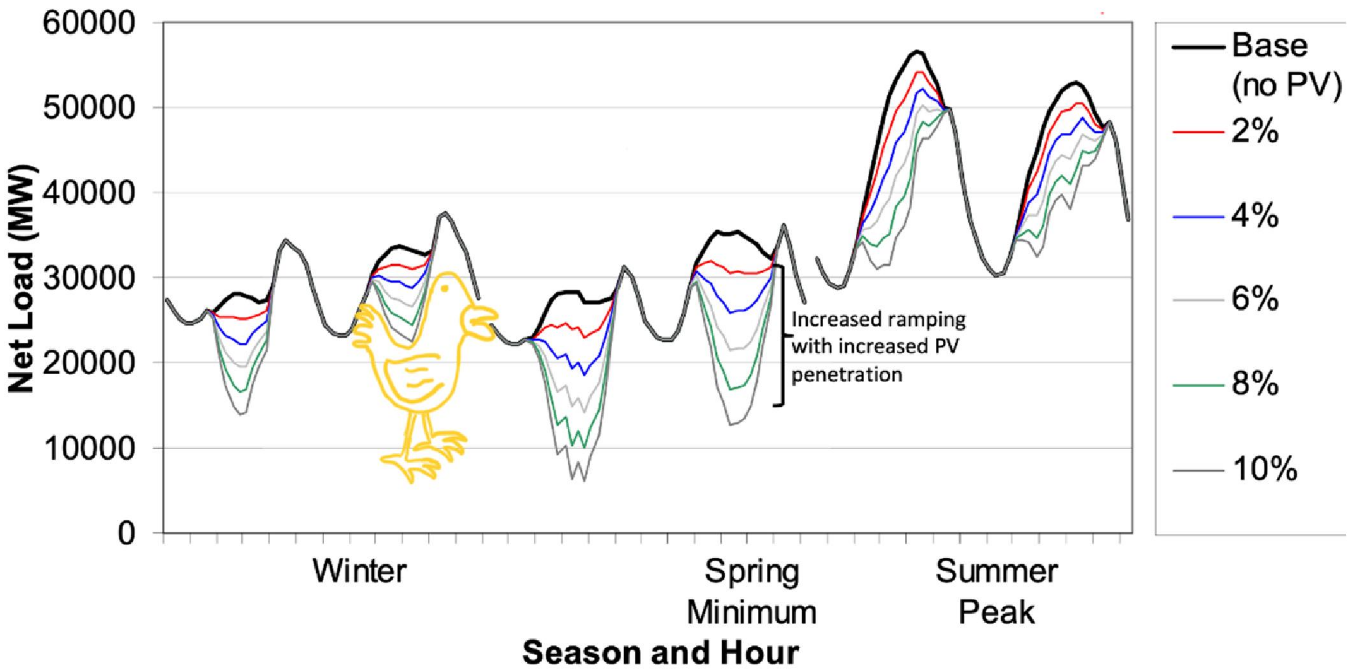
Conclusion:

Total life-cycle emissions can be reduced by up to 89 % through vehicle electrification. Renewable fuels and energy lead to lowest life-cycle emissions. Total life-cycle emissions increase relative to vehicle curb weight and peak motor power.

Electric Vehicles Integration in Energy System



Reinforcement Learning Control for Grid-Interactive Efficient Building



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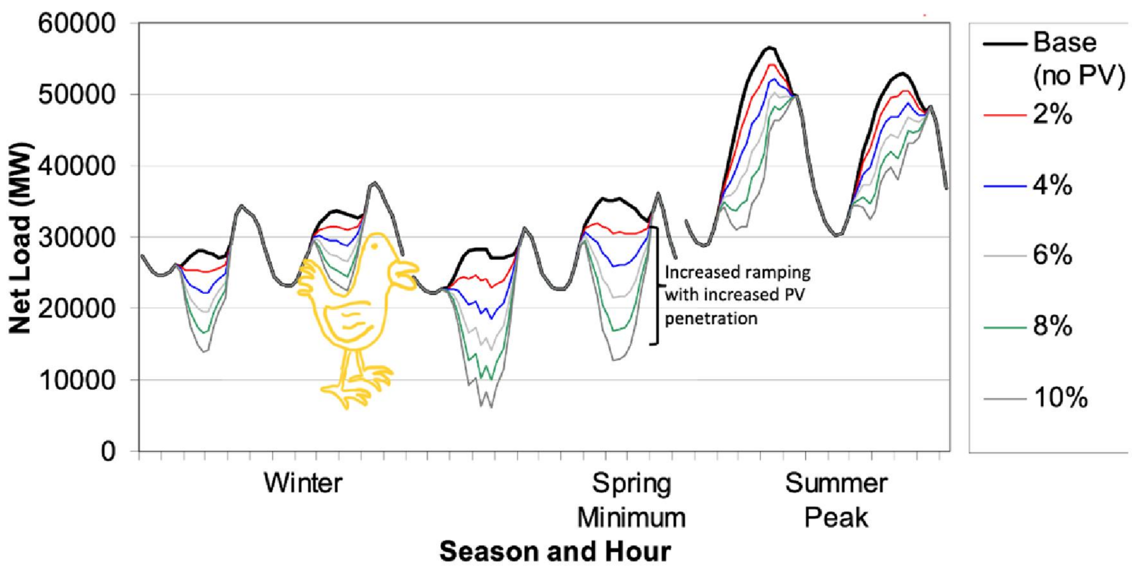

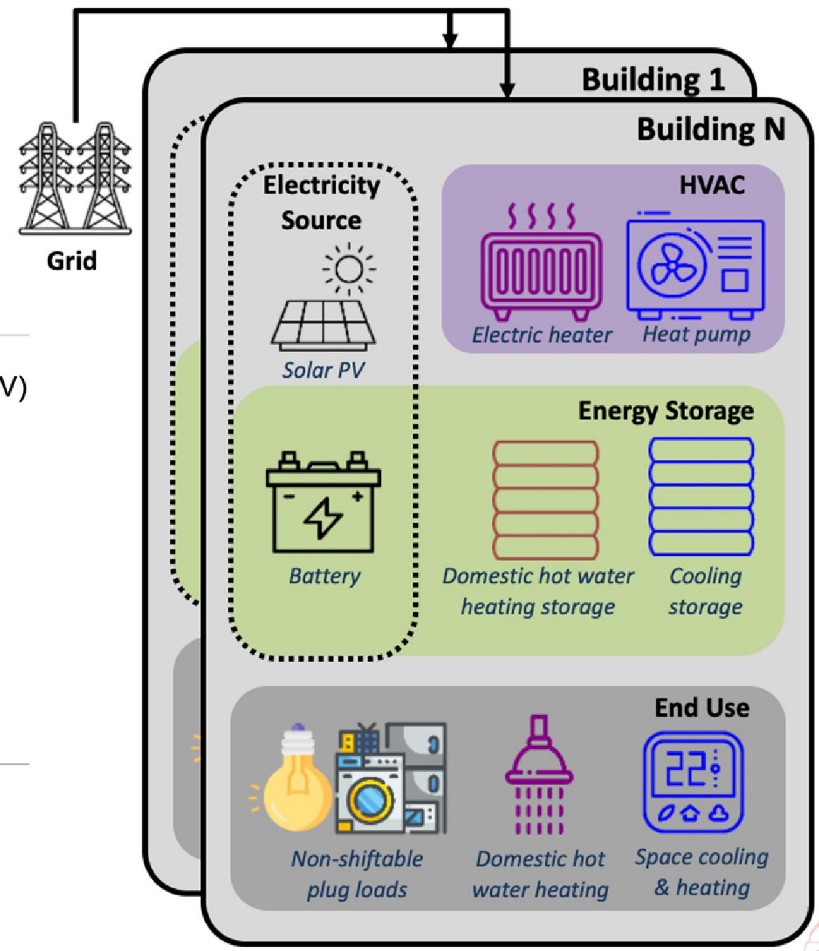

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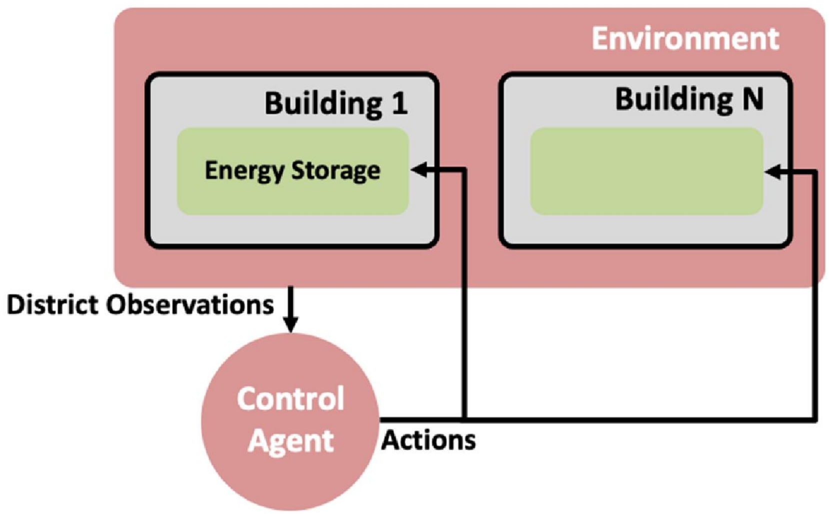
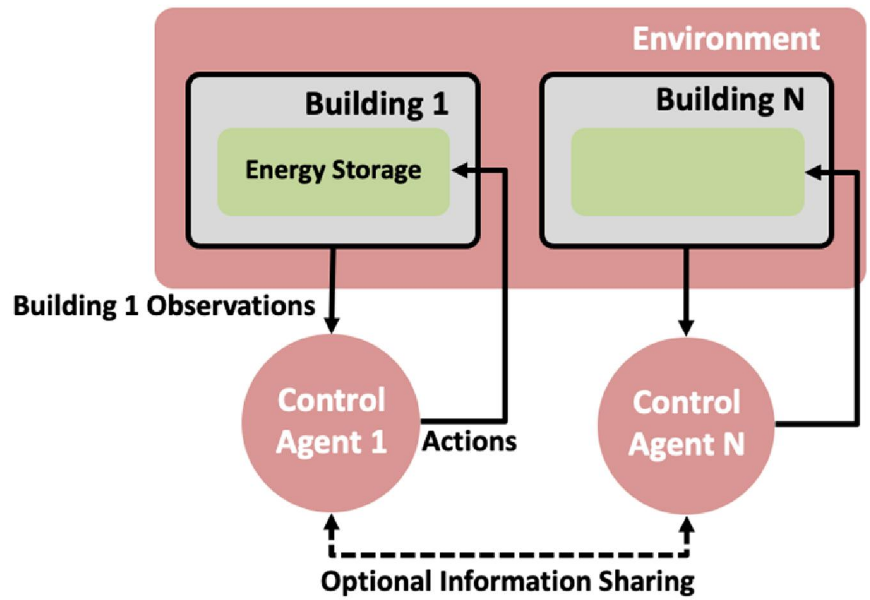
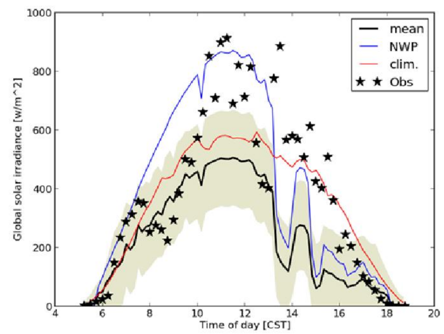
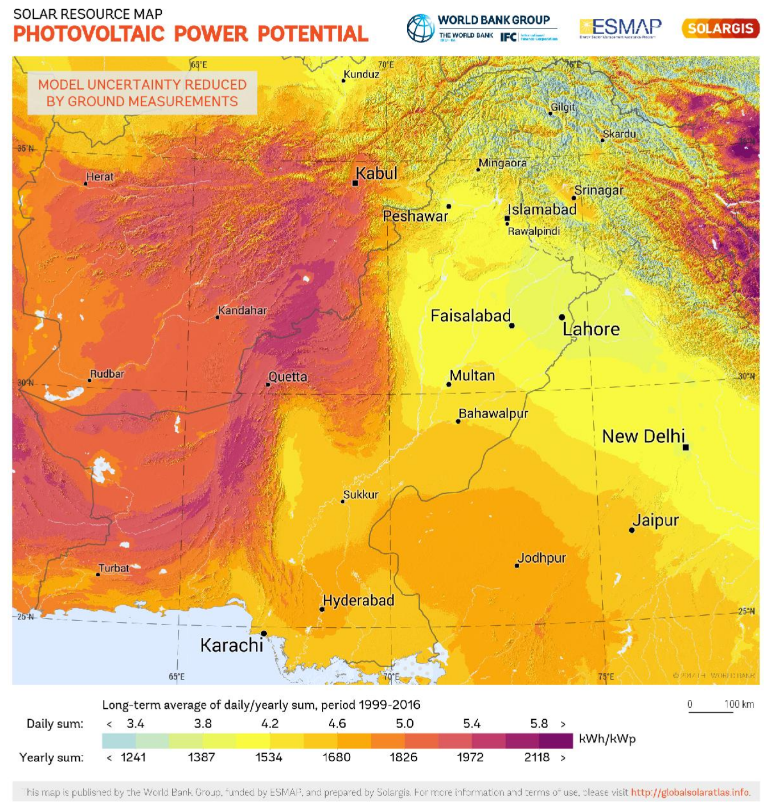




MACHINE LEARNING FOR PREDICTING WEATHER - SOLAR IRRADIANCE

Develop highly accurate AI-based forecasting tool that provide forecasts of the solar energy specific to the region and geographical coordinates in Pakistan





Impact: Disruptive impact on enabling PV enabled power generation in Pakistan

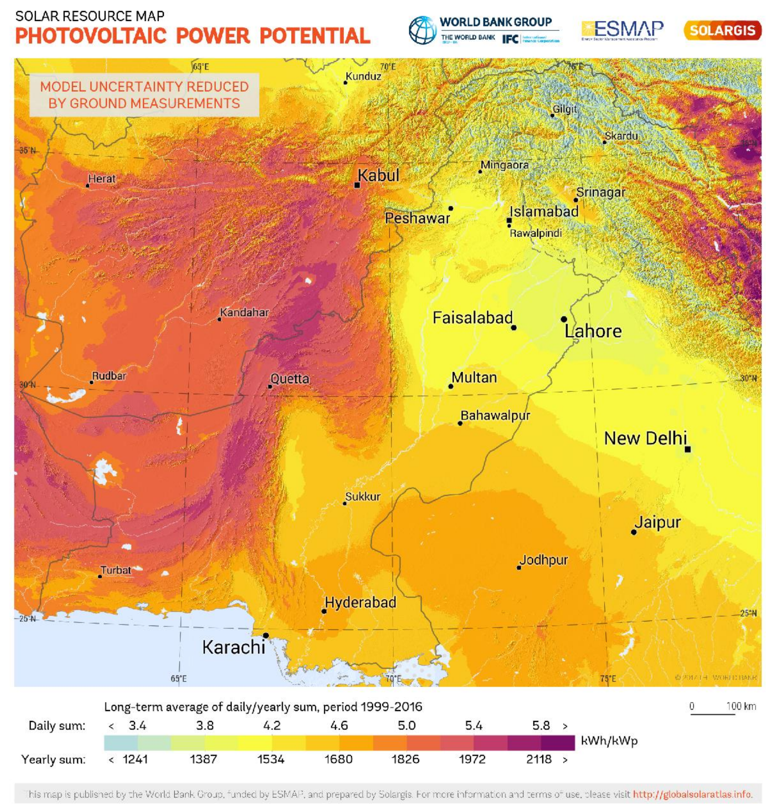
Budget: **9 Million PKR**

MACHINE LEARNING FOR PREDICTING WEATHER - SOLAR IRRADIANCE

Potential Market

- Highly accurate solar forecast as a service for industries and house holds
- Distribution system operators in supporting their operations
- Planning tool to deploy resources

Final Price (Product and Services):
The forecast as a service will be charged as pay-per-use and the desired resolution of the forecast



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Thank you!

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