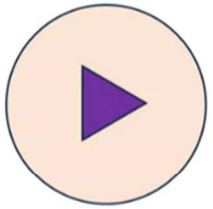
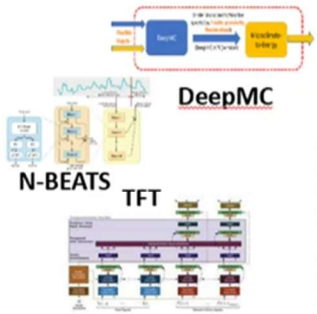
Flexible (Data and Forecast) Fusion Framework to Support Many Applications



Forecasting Framework Tech Video

Power & Utilities Forecasting Framework

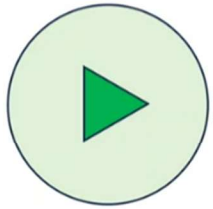
Granularity & Time Frame



Multiple DL Models

Diversity of Inputs

Spatial Dependence

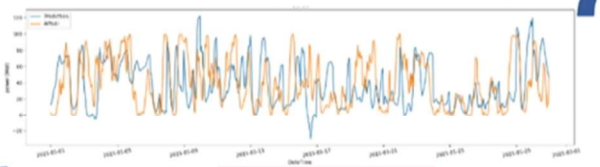


Time Series AI Tech Video

Hornsdale : Wind Forecasting Results
Value of Data/Forecast Fusion & Specialized Forecasting

Shivkumar Kalyanaraman (External)

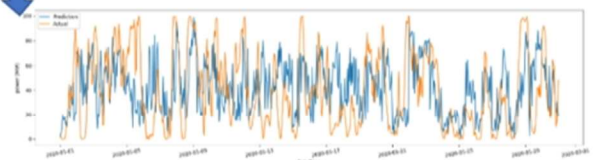
TFT w/o exogenous variables



nRMSE : 0.91

15% relative improvement

DeepMC w/o exogenous variables

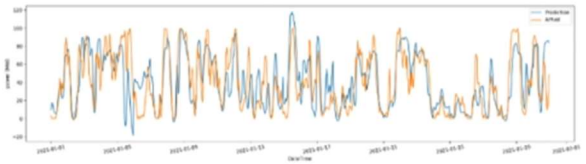


nRMSE : 0.77

37% relative improvement

40% relative improvement

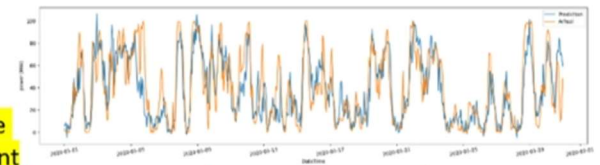
TFT Fusion with exogenous variables



nRMSE : 0.57

19% relative improvement

DeepMC Fusion with exogenous variables



nRMSE : 0.46

- ~20% relative improvement in performance vs TFT (Google)
- Fusion of onsite / offsite data and forecasts gives 35-40% relative improvement vs just on-site on-site data based forecasts

State-wide Demand Forecasting with BYOM Models, Deep Ensembles & New Features

Problem: *Predict the overall energy demand in a state for 1 to 24 hour Forecast horizon*

Dataset:

- Aggregate Demand data ~ 5 years+ (Hourly)
- Regional energy split data for ~25 months+ (Hourly)

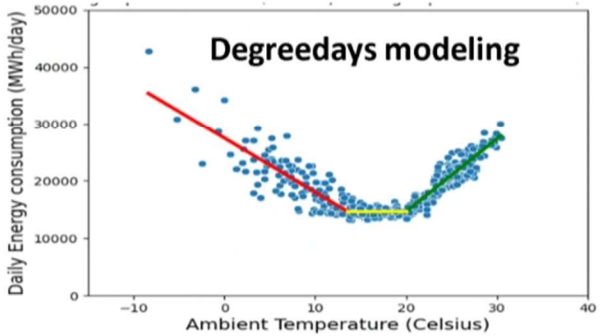
Additional data sources (inputs)

GFS Global Forecast System

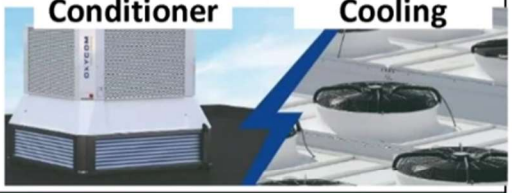
OpenWeather

WEATHER UNDERGROUND

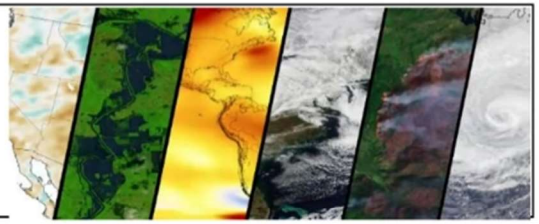
$$E_d^{total} = E^{base} + \gamma^{heat}(T^{heat} - T_d)^+ + \gamma^{cool}(T_d - T^{cool})^+ \forall d \in D$$



Using Humidity to predict evaporative cooling vs AC use

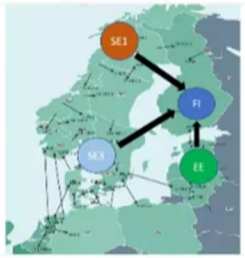


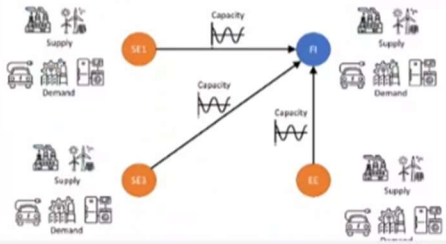
Calculating sensitivity to extreme weather events



- *Significant relative improvement using P&U Forecasting Framework "Deep Ensemble" vs best customer-provided baseline.*
- *Absolute MAPE below* ***< 1.5% in a US state.***
- ***Every few basis points of MAPE translates to risk-adjusted trading revenue upside***

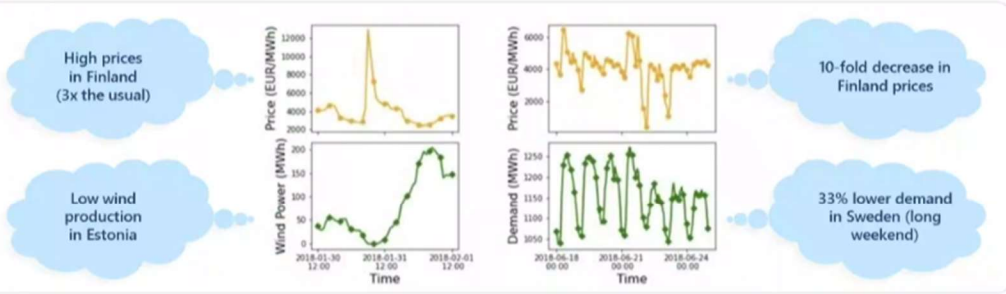
Price Forecasting (Nordpool exchange)





GNN to capture spatiotemporal supply-demand dynamics between various regions

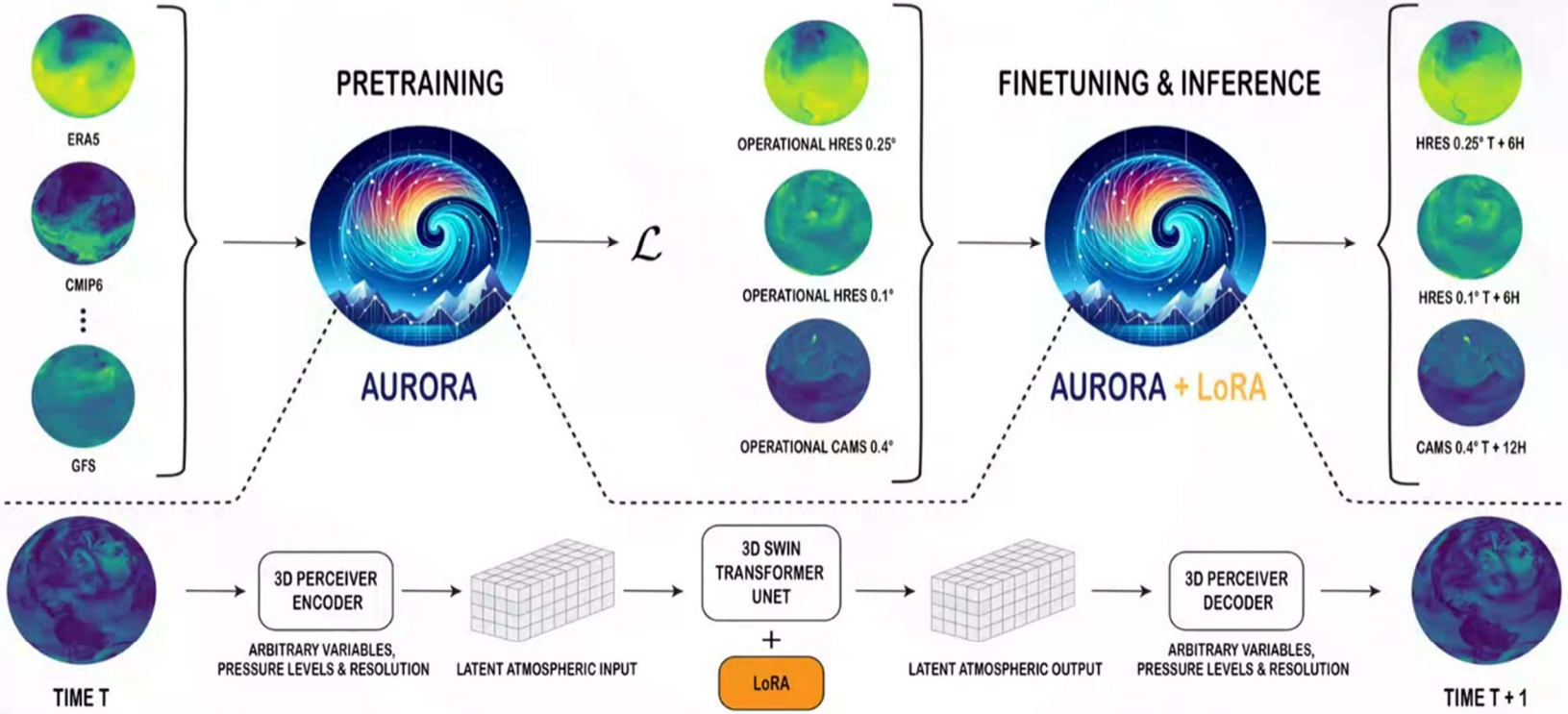
- **Market:** Day ahead market (DAM)
- **Granularity:** Hourly
- **Region:** 15 zones from five countries



30-50% relative improvement over state-of-the-art

Approach	MAPE	MAE	nRMSE
LSTNet	23.7	1077.3	35.3
N-BEATS	18.8	854.6	27.5
GNN-PRICE	15.9	722.7	25.2
GNNx-PRICE	15.0	682	24.94
GNN-PRICE+FLOW	12.9	586.3	24.2
GNNx-PRICE+FLOW	**12.8**	**582**	**24.1**

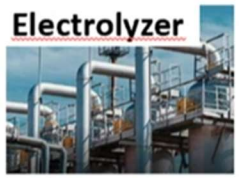
Aurora Foundation Model for Weather Forecasting

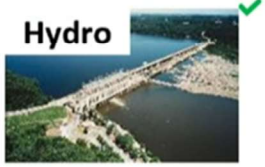


[Introducing Aurora: The first large-scale foundation model of the atmosphere - Microsoft Research]

Shivkumar Kalyanaraman (External)

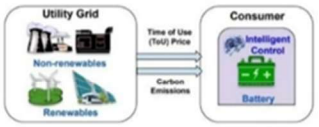
Autonomous Energy Management Decisions under Uncertainty



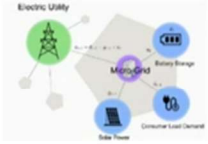


Digital Twin Abstractions

Decision Management (DM) Framework

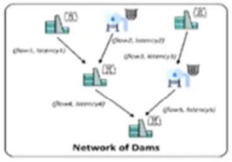


Battery Arbitrage ✔

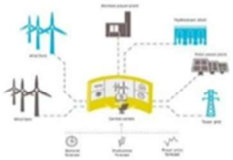


Microgrid ✔

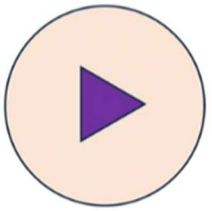
Multi market value stack ✔



Network of Dams



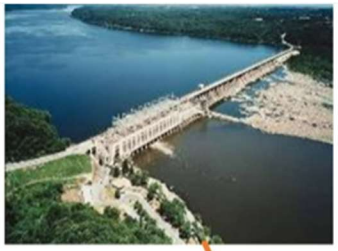
Virtual Power Plant

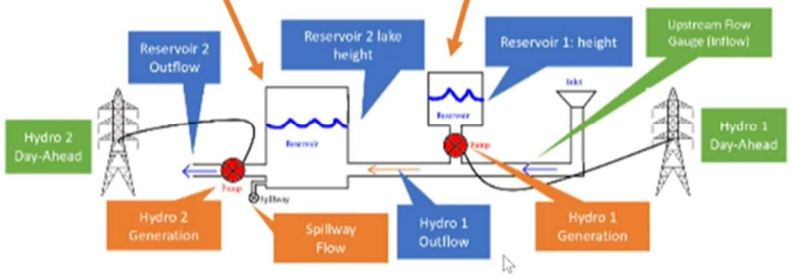


DM Framework Tech Video

Industry Patterns

Hydro Joint Optimization: Compliance, Monetization, Efficiency

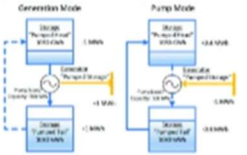




Parameters:
1. Reservoir elevation ranges
2. Generation capacity
3. Flow to generation for both dams
4. Volume change per feet reduction

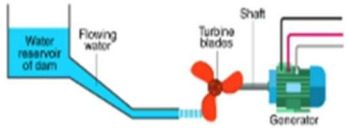
Input Variables | Decision Variables | Derived Variables

Elevation: 470 ft to 520 ft

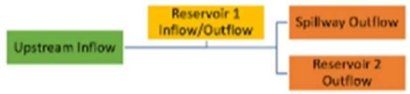


Roundtrip efficiency: 87.5%

Reservoir Shape:
Cylinder vs Frustrum of Cone

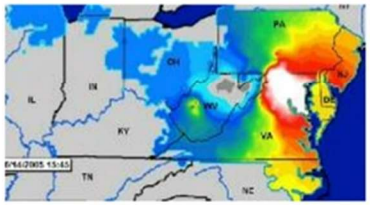


Generation Limits (MW):
Reservoir 2 (0, 530), Reservoir 1 (-800, 800)
Continuous value and not discrete

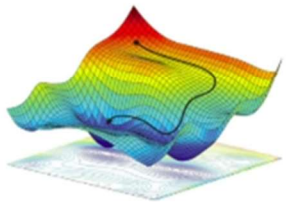


Conservation of Flow:
1. Evaporation, Surface runoff, etc. not considered
2. Latency not considered

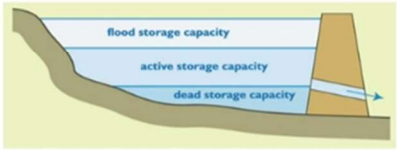
Customer saw **~25% increase in revenue potential** & double digit impact on other metrics with joint optimization. Accelerating production deployment



LMP prices:
Actual vs Forecasted



Objectives:
Realization vs hybrid



Elevation changes:
Weather, human activity, etc.

Spillway operation:
With and without

Multi-Market Trading Pattern: Portfolio Optimization in Markets

Solar Resource :

- Solar Profile – From Client
- Solar Capacity – **150MW***

Wind Resource :

- Wind Profile – From CLient
- Wind Capacity – **150MW**

Pumped Storage(PSP) :

Configuration :

- Storage Capacity - **600MWh**
- Charging Efficiency : 78%
- Discharging Efficiency : 100%
- Max Rate: **100 MW** (6hours backup)

Producer

Sources
-Increase or Decrease Production

Storage
-Pump In/Pump out

Market

Regulated Contracts

Markets

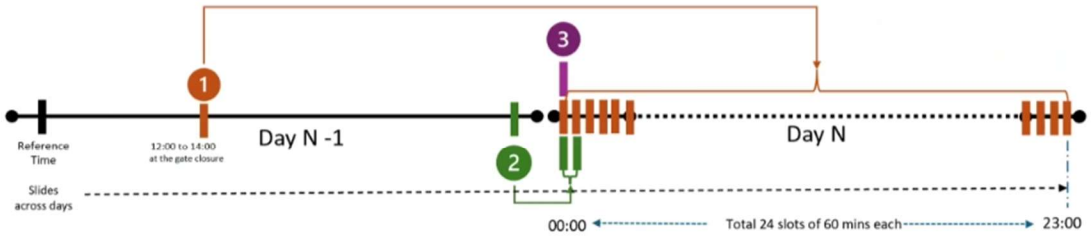
- Day-Ahead Bids
- Real-time Bids

Varying Market Price

Varying Forecasts

Markets:

1. **Day Ahead market (DAM)**
   - DAM bid time: 12 pm - 2 pm at (D-1) day
   - DAM commit time: 12 am to 12 am for (D) day
   - DAM bid frequency: once per day
2. **Real Time Market (RTM)**
   - RTM bid time: Throughout the day at time t
   - RTM commit time: t+1hr – t+1:30 hr
   - RTM bid frequency: Every 30 mins



Colour Coding	Optimization Name	No. of times to call optimization
1	Day-ahead bid optimization	1
2	Intraday/Real-time bid optimization	24
3	Actual Delivery Adjustment optimization	24

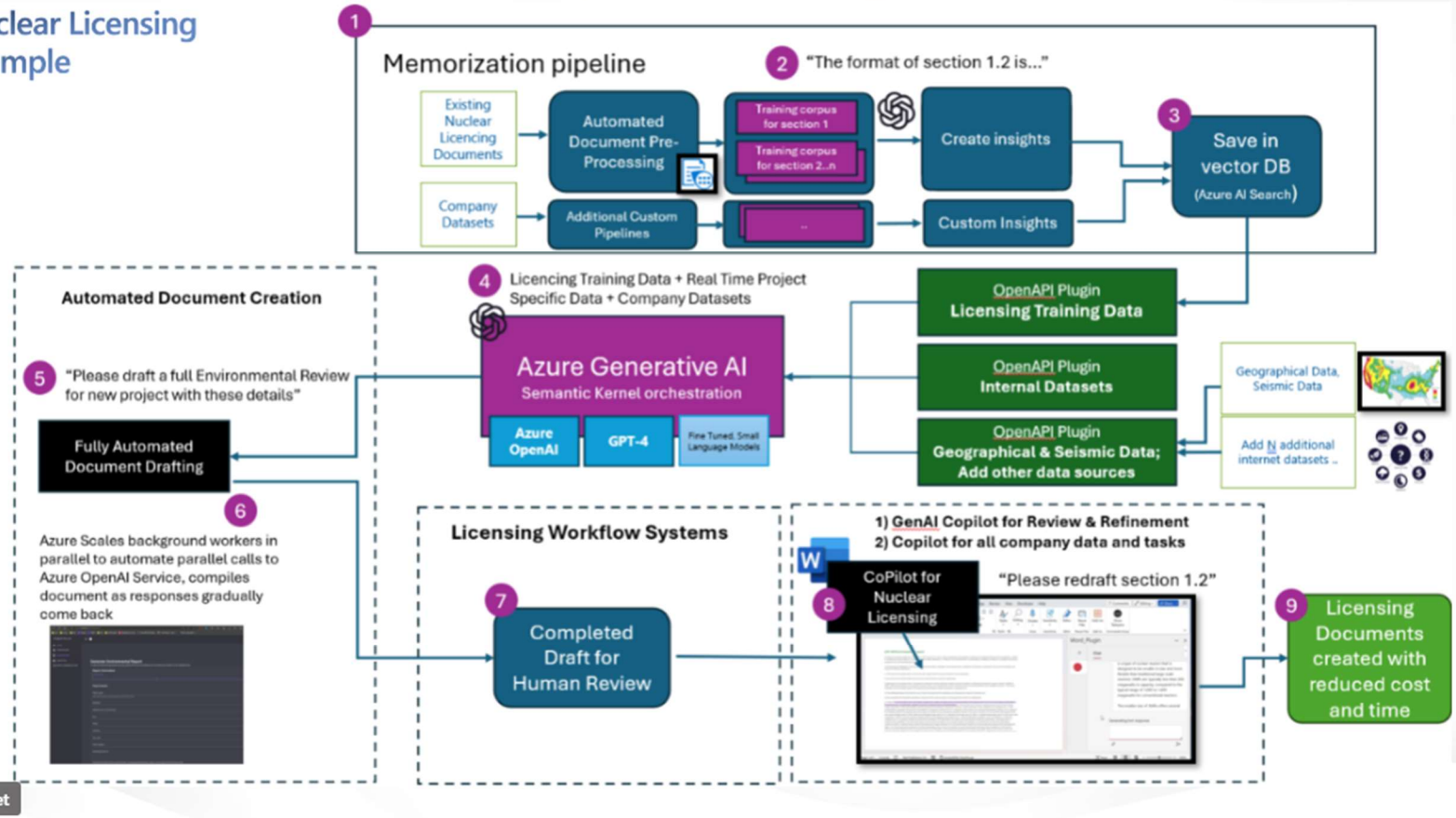
Shivkumar Kalyanaraman (External)

Generative AI for Industry Permitting

Reducing cost and time for industry permitting scenarios

Generative AI for Industry Permitting Solution Accelerator

Nuclear Licensing Example



Henning Kilset

Drafting Entire Documents

Drafting documents with multiple calls to the GenAI model(s), using previous licensing data, project specific data, and company datasets—plugged into existing licensing workflow ready for human review and refinement.

Automated Document Creation

1. "Please draft a full Environmental Review for new project with these details"

Automated Document Drafting

2. Azure Scales background workers in parallel to automate parallel calls to Azure OpenAI Service, compiles document as responses gradually come back

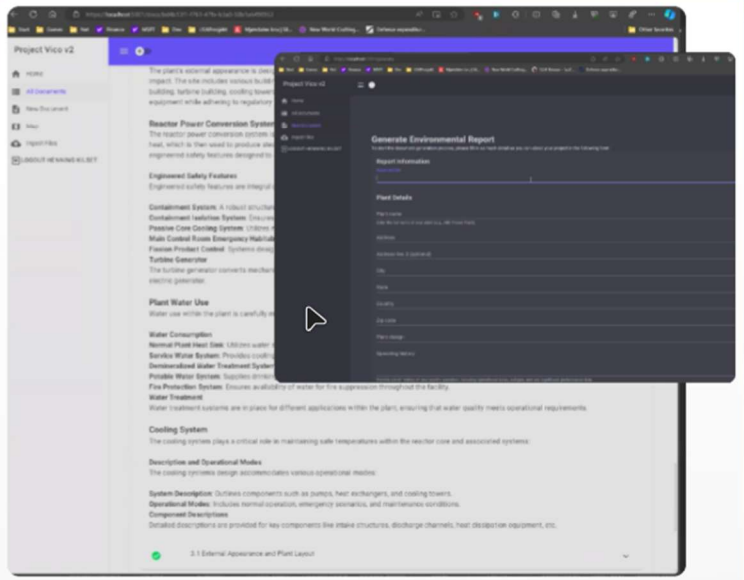
Azure Generative AI
Semantic Kernel orchestration

Azure OpenAI | GPT-4o | Fine Tuned, Small Language Models

Licencing Data + Real Time Project Specific Data + Company Datasets

3. **Existing Permitting Workflow**

Workflows and Human Refinement



Henning Kilset