LEAP: AI Assistant for Accelerating Distribution Planning and DER Analysis

Stephen Kerr, skerr@epri.com

LEAP = LLM-Enhanced Automation for distribution Planning

Operational Benefits

Boosts productivity, accuracy, consistency, workforce development.

Tier 1: API Code Assistant

Empowers engineers to script and debug automations.

Acts as a smart interactive manual.

Tier 2: Planning Study Assistant

Directly enable automated planning studies with utility system modeling software.

Notebook for Best Practices

Capture execution patterns and best practices for quick recall.

*Produced with Gemini

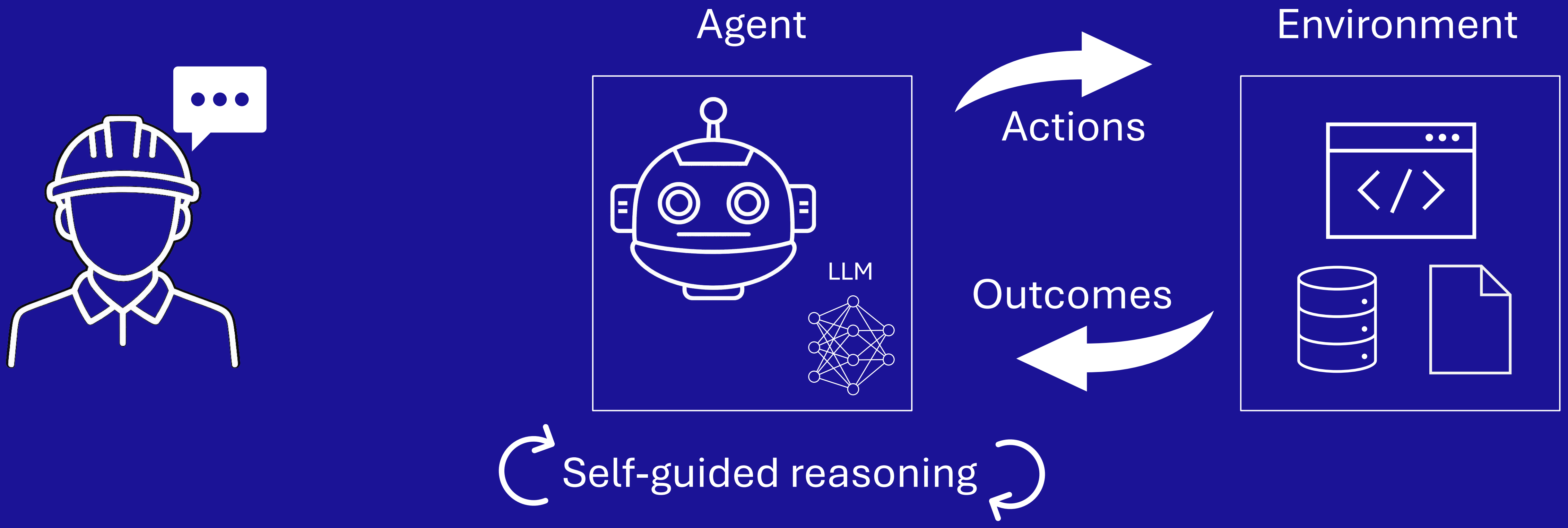
LEAP Workflow and Project Kickoff

*MS Copilot-influenced icons

Ask → Orchestrate → Execute → Respond

LEAP Workflow and Project Kickoff

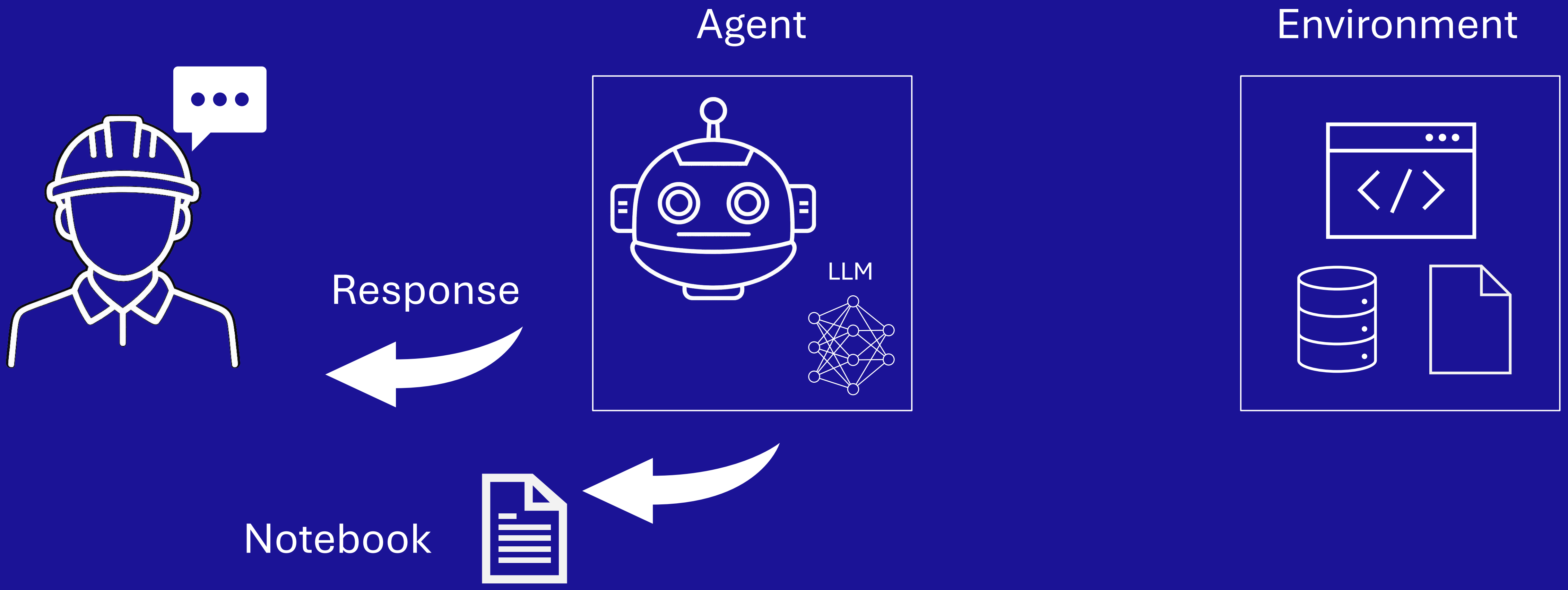
*MS Copilot-influenced icons



Ask → Orchestrate → Execute → Respond

LEAP Workflow and Project Kickoff

*MS Copilot-influenced icons



Project Kickoff – Today! Noon ET, [Meeting Info], [Project Flyer]
Stephen Kerr – skerr@epri.com

Renewable and Sustainable Energy Research Center (RSERC)

GridApp: AI-Driven Power Grid Planning for a Net-Zero Future

Dr Carlo Fanara

18 February 2026 - Online

GridApp - our Power Grid application

What

- Create a comprehensive energy modeling tool that enhances **Grid planning and decision-making** using Machine Learning and AI tools in UAE and elsewhere.
- Provide a robust, user-friendly platform for analyzing and optimizing **energy generation, storage & transmission**
- Allow quick decision making on **policies** by scenario-playing (What-if), including grid failure and weakness analyses
- Modular framework for network optimization: besides demand fulfilment with cost quantification management, enable **achievement of net-zero targets**.
- Agent-based simulation to evaluate system-wide **impacts** of decarbonization strategies in national and regional grids, proposing alternative paths at once.

How

Using the real grid topology in the field and underlying standard libraries (for python):

- Integration of **renewable** energy sources and grid support mechanisms (actual specific HW and components on lines and nodes).
- Enhance **energy mix planning** with various scenario analysis (use cases: Biomass, EV2G, industrial sites).
- **Grid Resilience** and weakness evaluations with contingency analysis (N-1, N-2), and cascading failure (using Graph Neural Networks).
- **Expanding** modelling **to EU countries** + Asia and use those datasets for training
- Yield several **decarbonization paths** at once using Reinforcement Learning (with timelines and costs),
- Allow **siting function** using infrastructure layers (transport, energy, water, industries on territory

Why

- Accurate, detailed energy mix and grid dynamics analysis
- Informed decision-making for capacity expansion and renewable integration
- Cost savings and emissions reduction through optimized planning
- User-friendly interface for enhanced usability and accessibility
- Improved resilience metrics through stress simulations
- Automated insights and interactive AI support for planners

Milestones

Conceptual Validation
Q4 2024

Functional Demonstration
Q2 2025

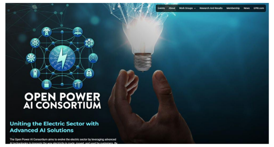
TRL6 Delivery
Q1 2026

Client Handover
Q4 2026

Interested parties / Target product

دائرة الطاقة
DEPARTMENT OF ENERGY

EWEC
Emirates Water & Electricity Co.



TAQA

مركز النقل المتكامل
INTEGRATED TRANSPORT CENTRE

IRENA
International Renewable Energy Agency

GridApp – evolving from self-contained to multi-agent :

At Present

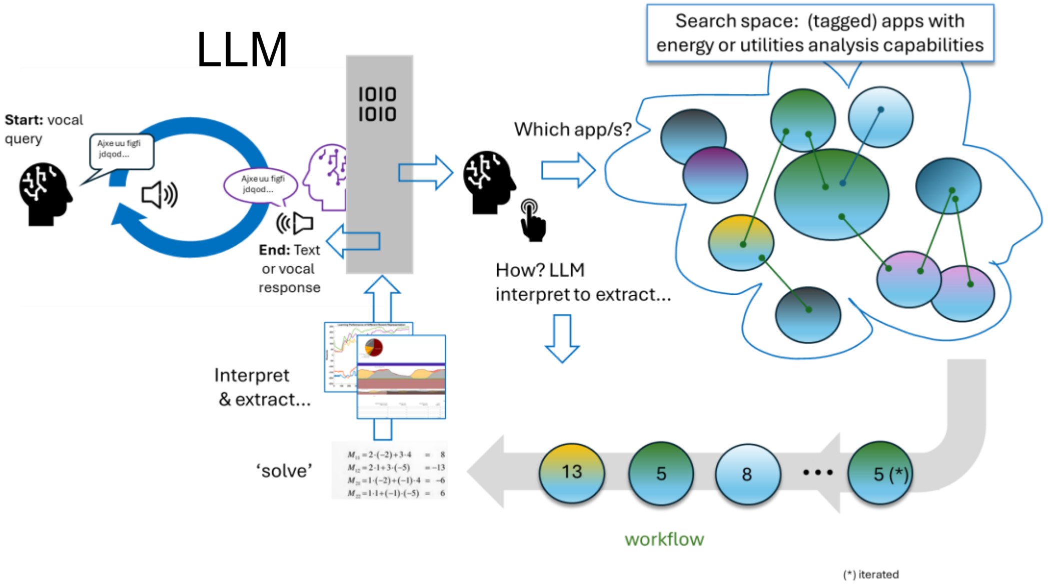
Self-contained, *functions:*

1. Power Grid Planner,
2. Energy Mix,
3. Grid Resilience,
4. Decarbonization,
5. Siting

Q2-Q3 2026

AI agents (automating Saas)

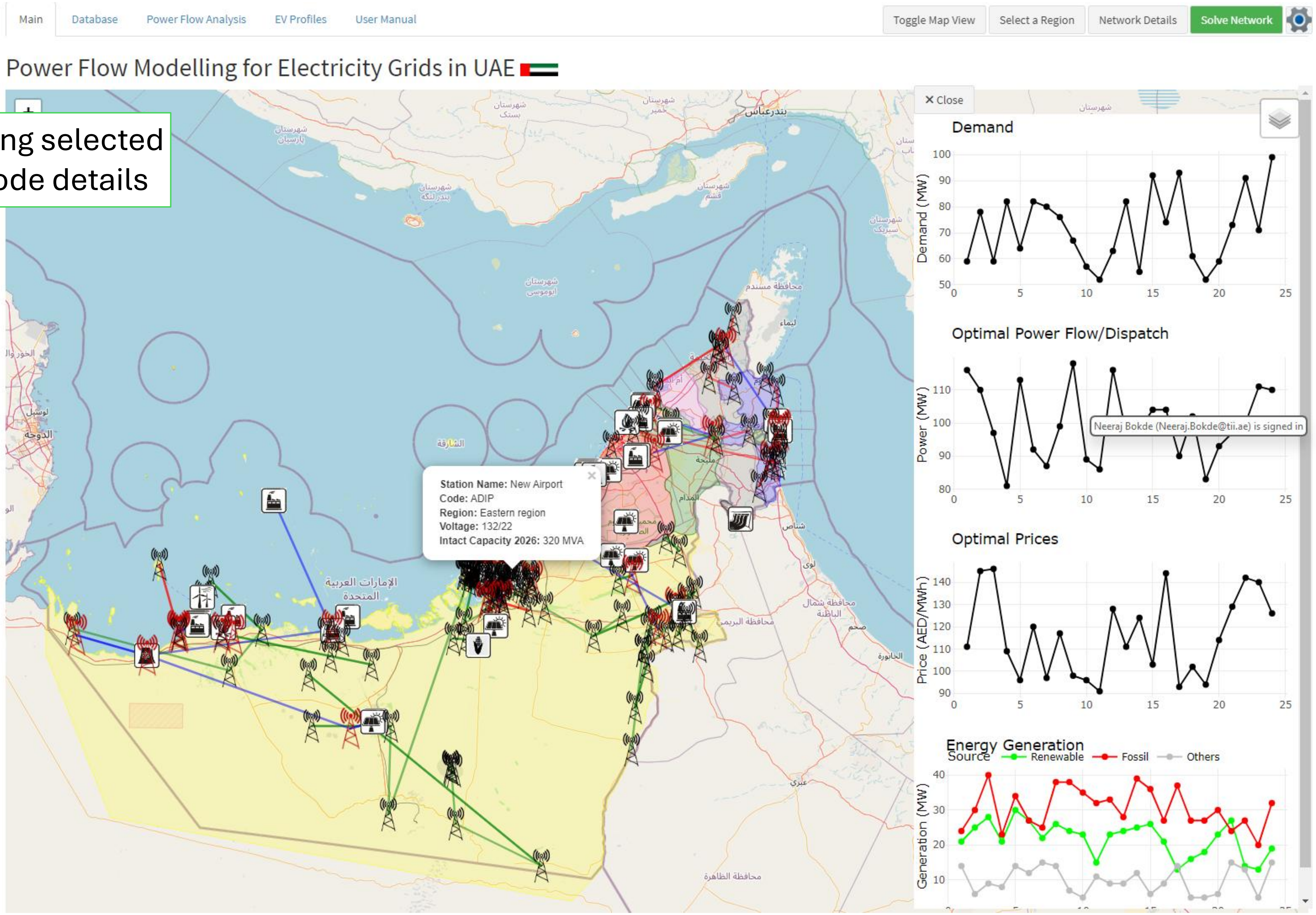
- Grid Planner,
- Energy Mixer,
- Resilience Studio,
- Decarb Studio,
- Siting Studio



1. Grid Planner

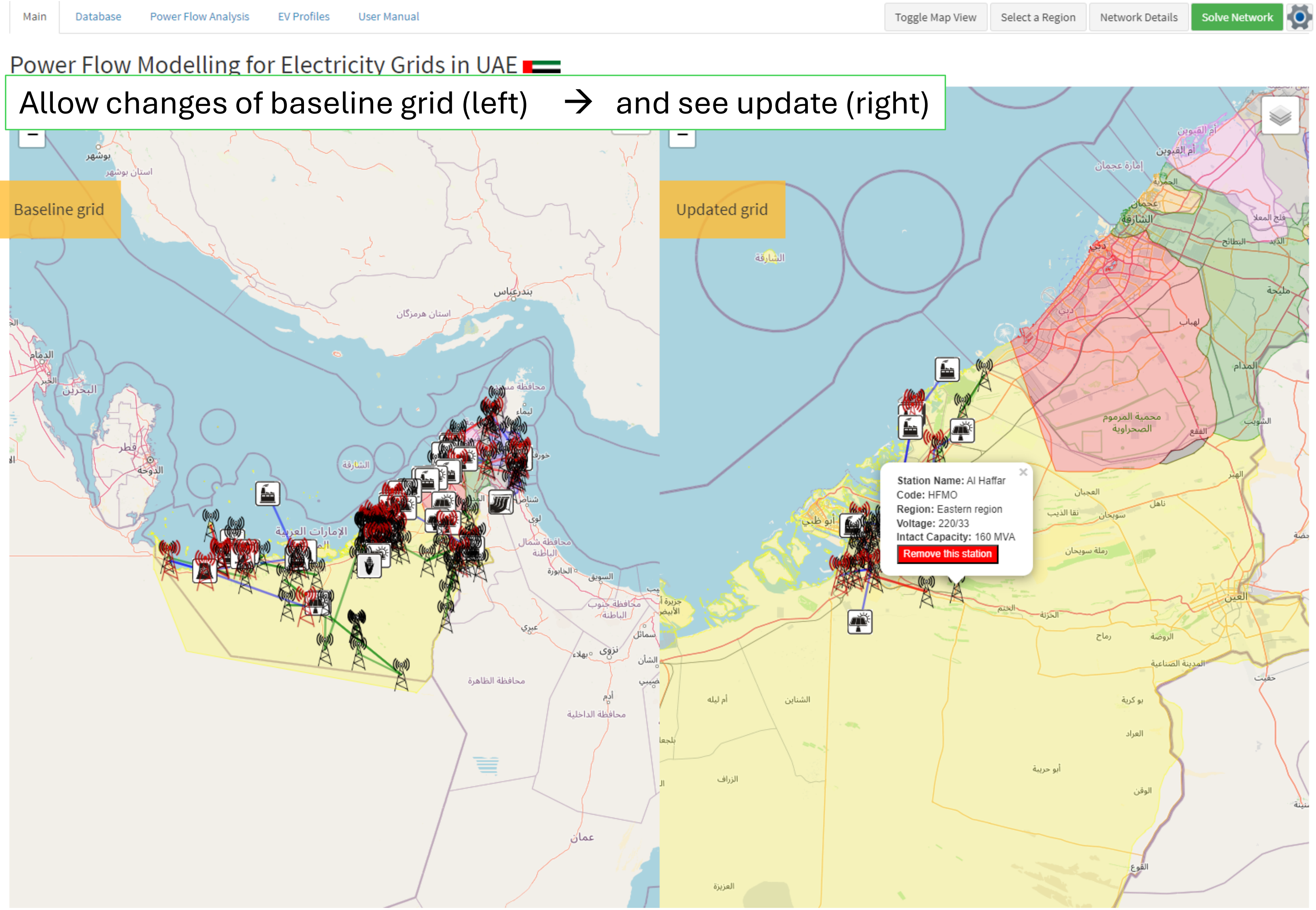
Showing selected grid node details

A playground to test:
upgrades
phasing out
new renewable
stresses on actual topology.



1. Grid Planner

A playground to test upgrades, phasing out, new renewable and stresses on actual grid topology.



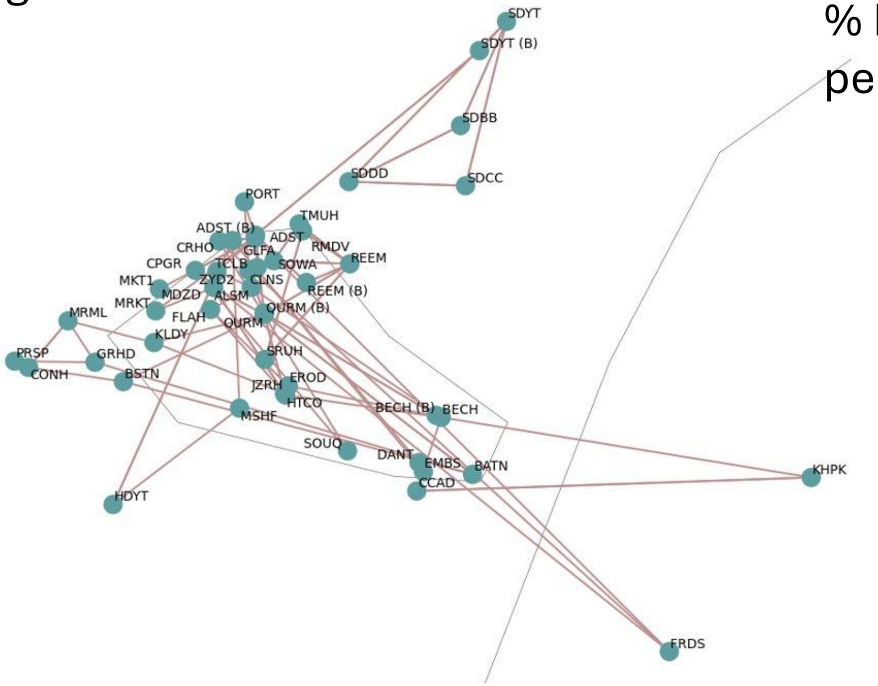
1. Grid Planner

A playground to test upgrades, phasing out, new renewable and stresses on actual grid topology.

Use case

Effect of introduction of EV

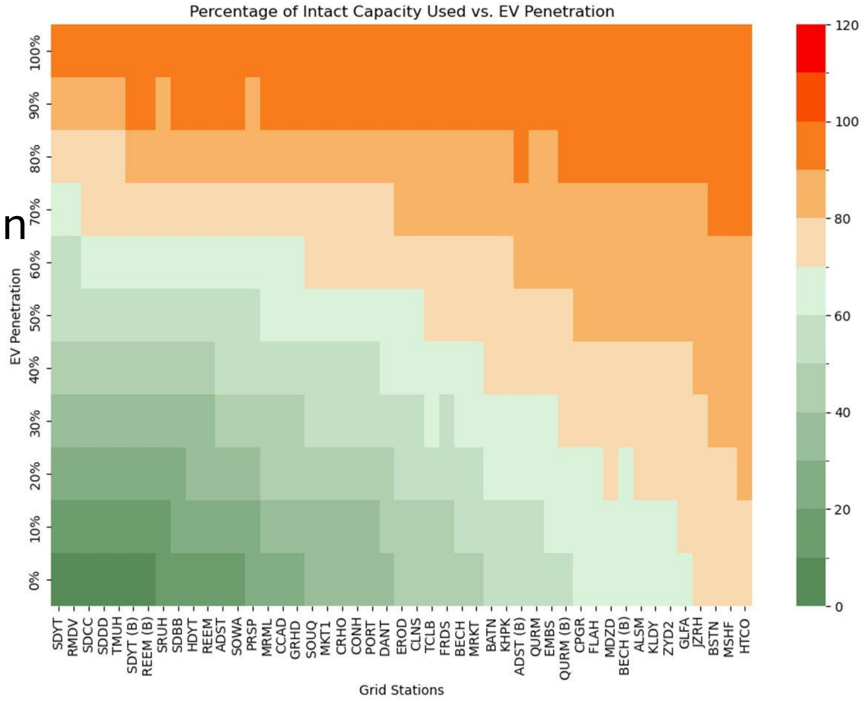
Grid Resilience (*)



Computing grid resilience, →
fraction of taken capacity per node.
Ex. 15, 000 EV in the grid: highlight fragility.

Can decide how many charging stations can be installed at a given node

% EV penetration



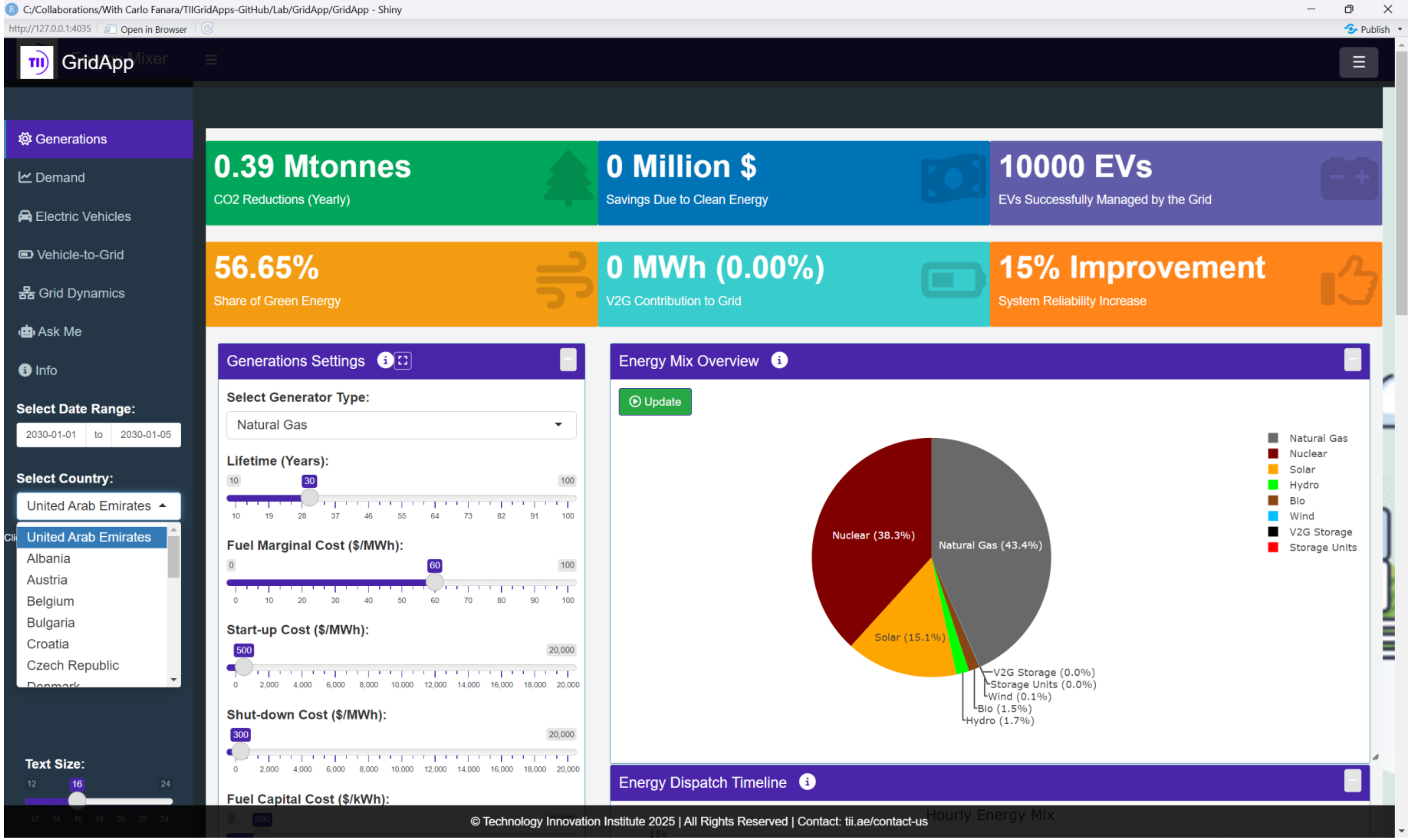
Grid stations (short names)

(*) hypothesis of ~15k vehicles

2. Energy Mixer

Study energy mix and Determine Solutions based on existing targets – capacity, demand fulfilment and Decarbonization.

For example, introducing EV's As **providers**



2. Energy Mixer

Allocating EV to each of the stations V2G

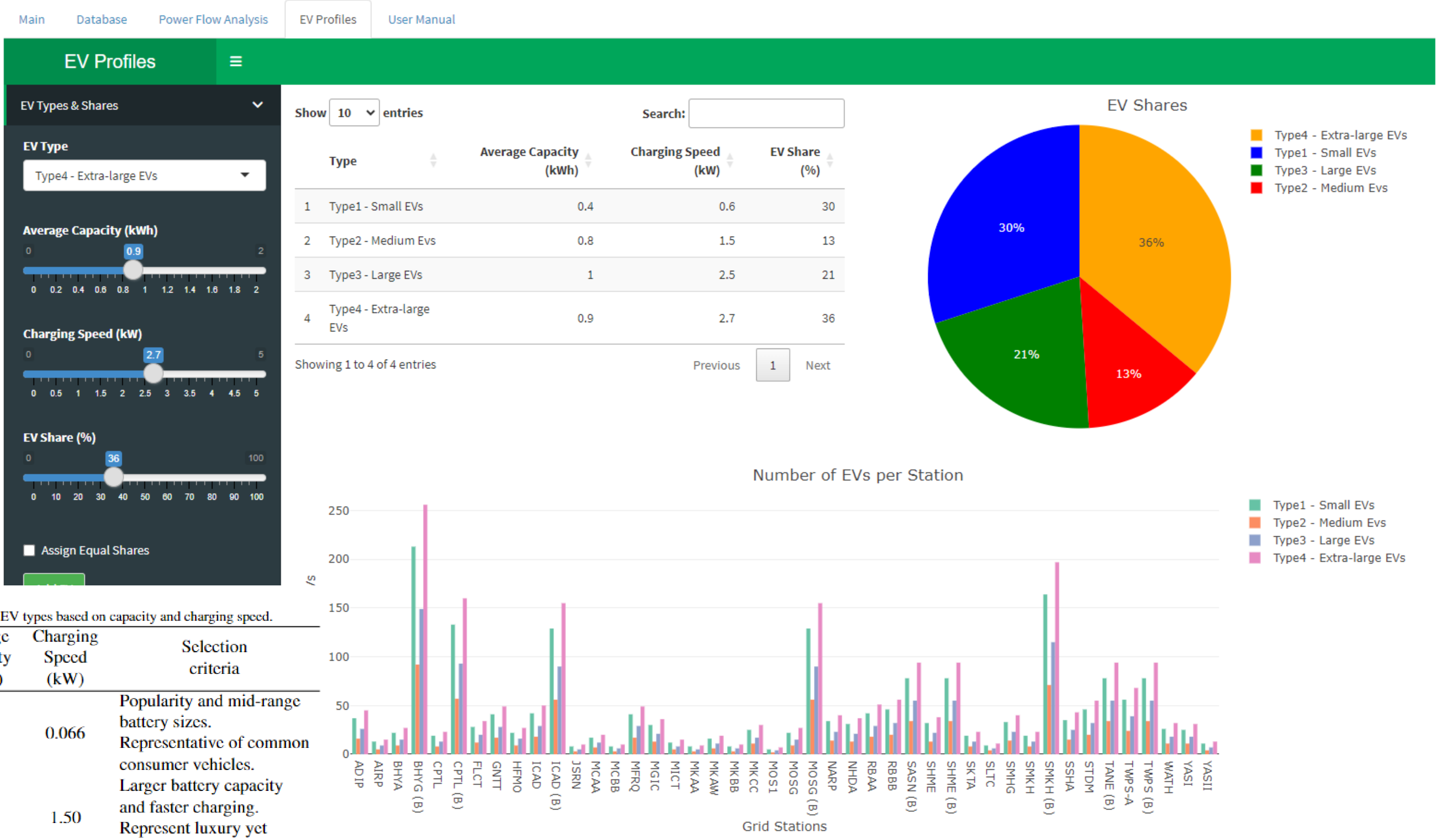


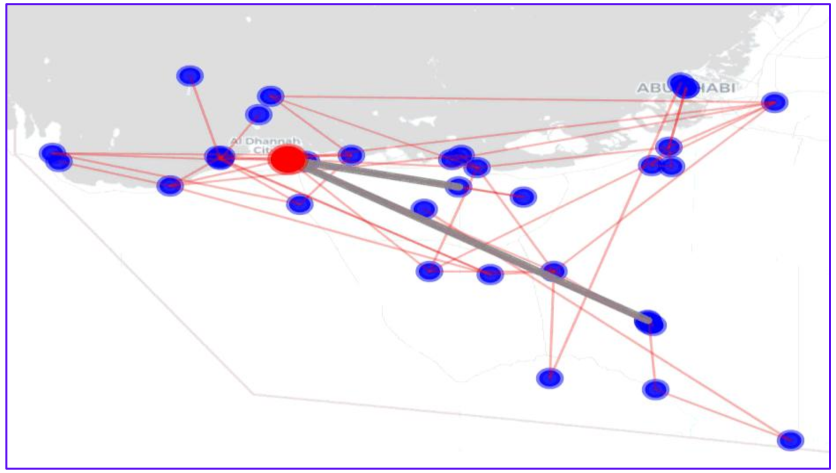
Table 1: Classification and characteristics of selected EV types based on capacity and charging speed.

EV Type	Representative EVs	Average Capacity (kWh)	Charging Speed (kW)	Selection criteria
Small EV	Nissan Leaf, BMW i3, Hyundai Kona Electric	0.40	0.066	Popularity and mid-range battery sizes. Representative of common consumer vehicles.
Medium EV	Tesla Model 3, Jaguar I-PACE, Audi e-tron	0.80	1.50	Larger battery capacity and faster charging. Represent luxury yet common EVs.
Large EV	Tesla Model S, Tesla Model X	1.00	2.50	Represent the upper echelon of consumer EVs with larger battery sizes and faster charging.
Extra-large EV	Porsche Taycan Turbo S	0.934	2.70	High-end specs and as a representation of premium electric sports cars with rapid charging.

3. Grid Resilience

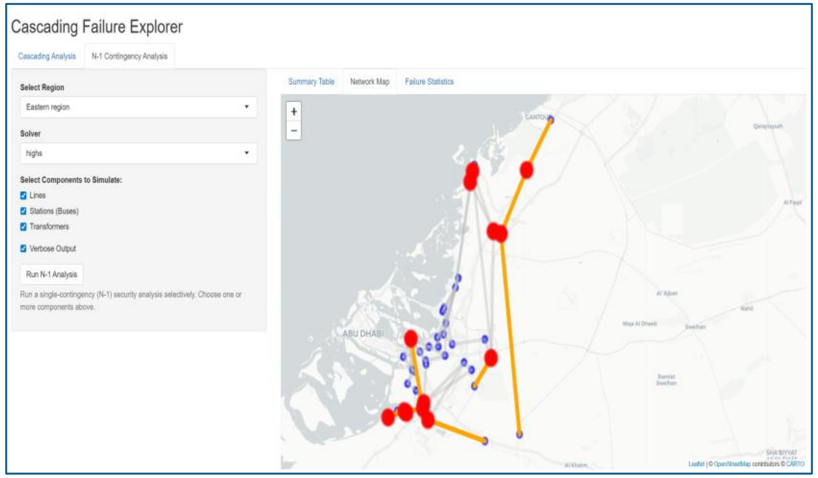
1. Cascading Failure Explorer

- Multi-stage failure propagation following an initial line or station outage
- Recursively compute **power flow** after each failure to capture **realistic cascade** behavior
- Supports both line-initiated and station-initiated disturbances
- Identifies **islanding**, unserved load, and **critical overload** paths
- Enables **stress-testing** of grid resilience under **extreme operating conditions**



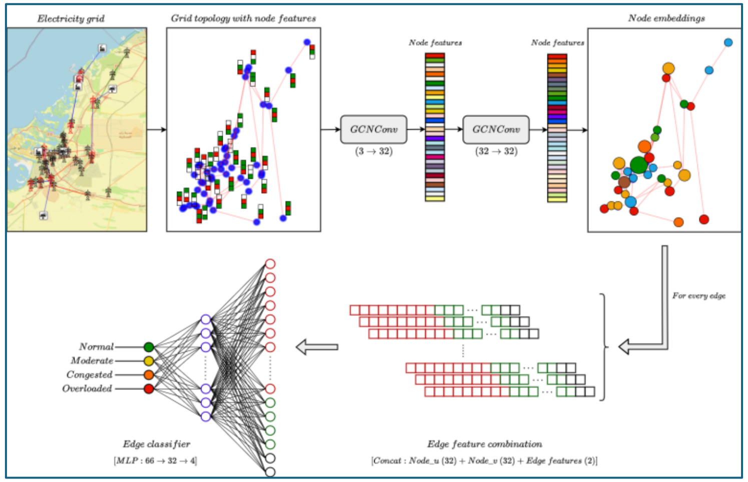
2. N-1 Contingency Analysis

- Perform **single outage** analysis for transmission lines and substations
- Evaluates **post-contingency** power flows and overload violations
- Identifies **vulnerable network** elements under normal and stressed loading conditions
- Provides a **baseline resilience benchmark** for higher-order contingency studies



3. AI-Enhanced N-2 Contingency Analysis (GNN Surrogate)

- Extends traditional contingency analysis **to N-2 events** using a **GNN-based** surrogate model
- Enables **rapid screening** of large N-2 contingency spaces that are computationally expensive
- **Prioritizes high-risk** contingency combinations for detailed physics-based analysis
- Acts as a **decision-support layer**, complementing (not replacing) full power-flow simulations



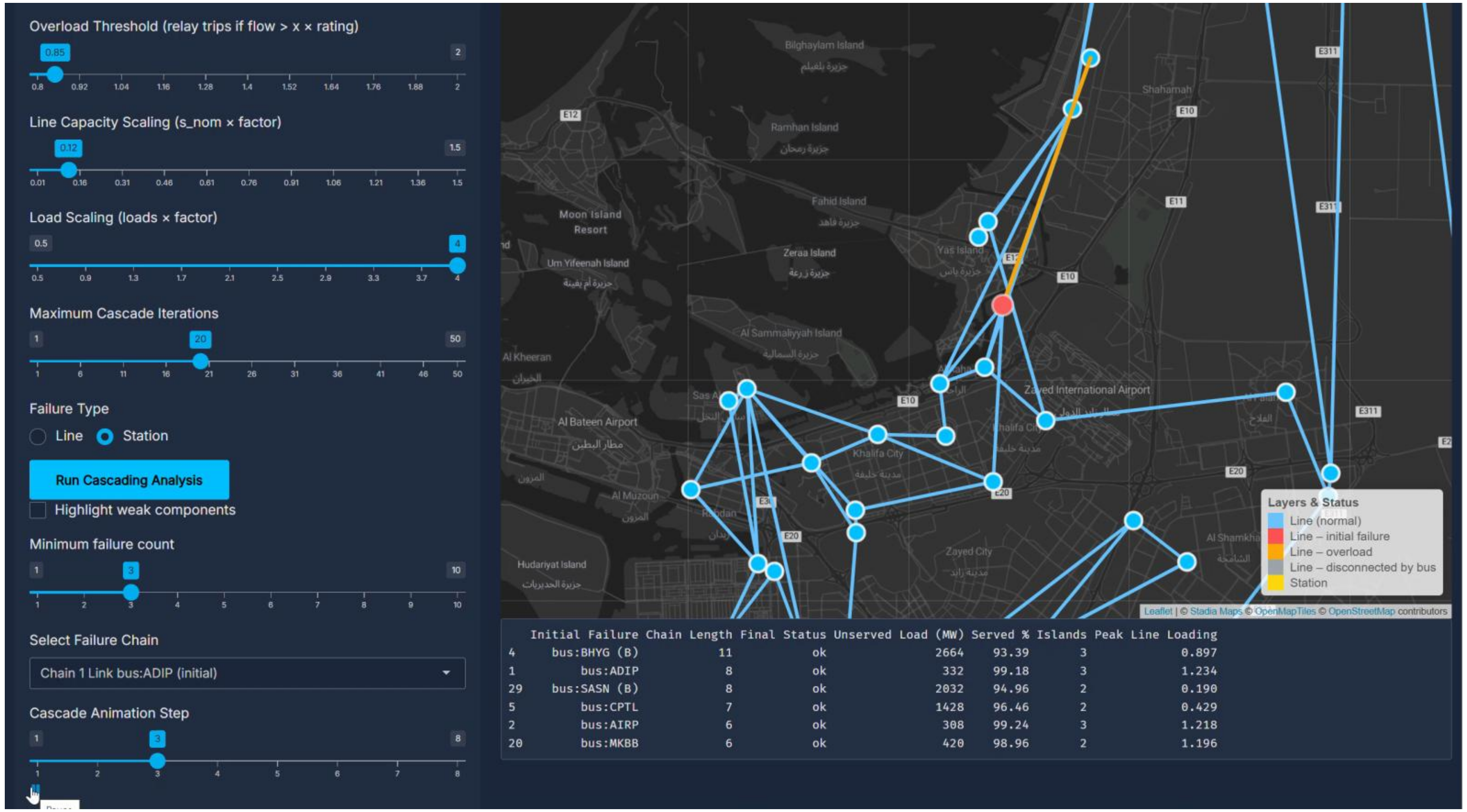
3. Power System Resilience Studio (New)

Cascading Failure Explorer

Simulating multi-stage grid collapse under extreme stress

- Models real-time failure propagation after line or station outage
- Recursively recomputes power flow to capture cascade dynamics
- Identifies vulnerable corridors and weak redundancy zones
- Quantifies unserved load, islanding, and overload amplification

Enables deep resilience stress-testing beyond N-1 compliance



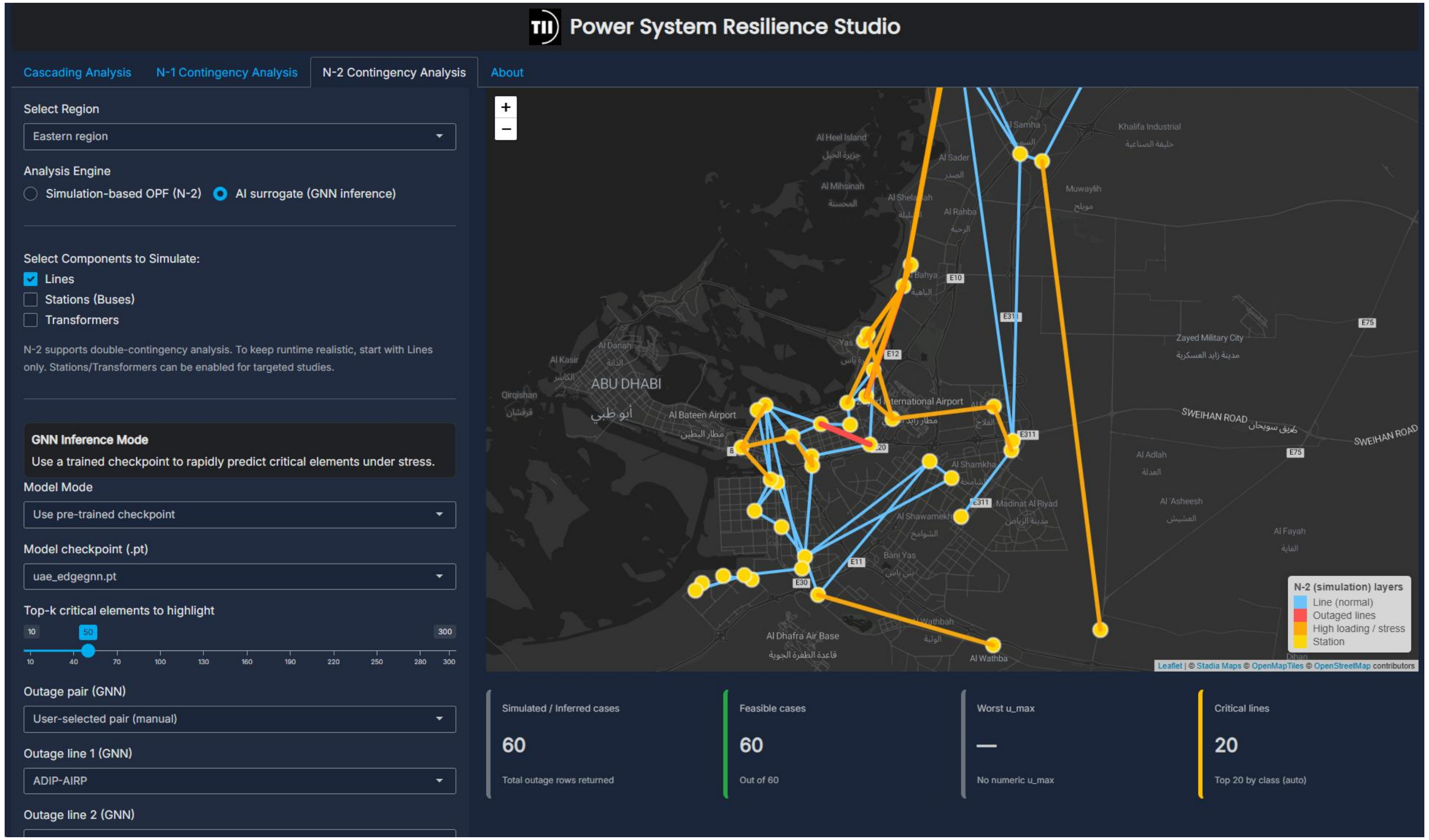
3. Power System Resilience Studio (New)

AI-Enhanced N-1/N-2 Contingency

Rapid screening of high-impact double contingencies

- Extends N-1 to N-2 and higher-order outage combinations
- AI surrogate (GNN) enables >1000× faster contingency screening
- Identifies critical line pairs with highest systemic risk
- Prioritizes scenarios for detailed physics-based validation

Scalable security assessment for complex transmission grids



4. Decarbonization Paths

UAE Decarb 2050: Grid-Realistic Long-Term Decarbonization Pathways

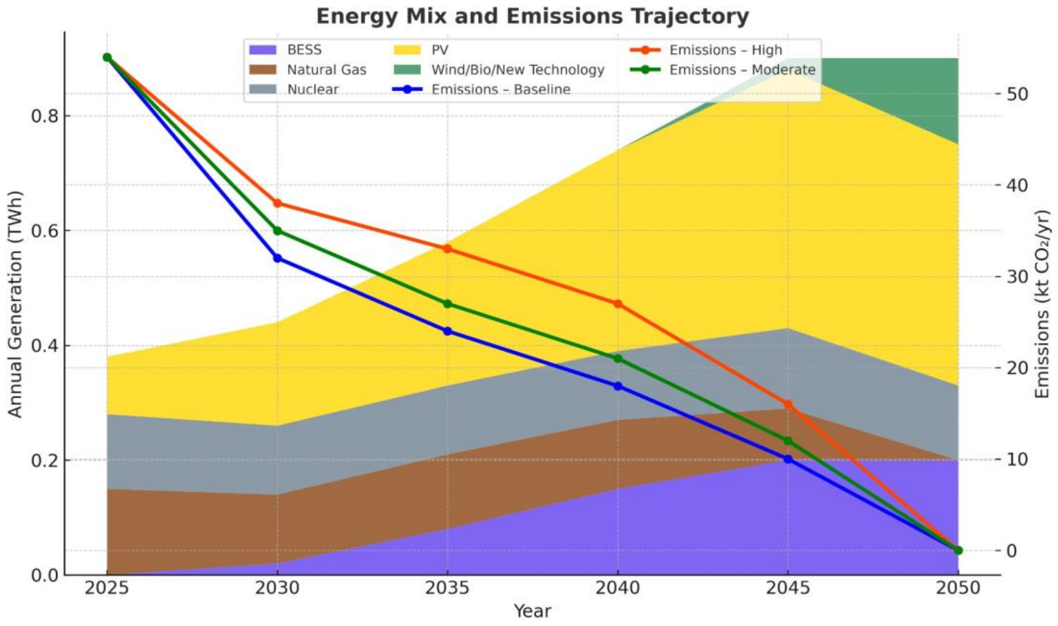
Objective: Develop an open, data-driven modeling framework to guide the UAE's electricity transition from 2025 to 2050. The model quantifies how renewables, storage, hydrogen, and flexible water and mobility demands can deliver a secure and cost-effective path to net-zero emissions.

Scope:

- Region: Abu Dhabi and interconnected UAE grid
- Horizon: 2025 → 2050 (5-year steps) – for now. More granular under way
- Focus: Power system decarbonization with **real grid structure** and operational stability
- Outcome: **Policy-grade projections of cost, emissions, and reliability** under multiple demand and technology pathways

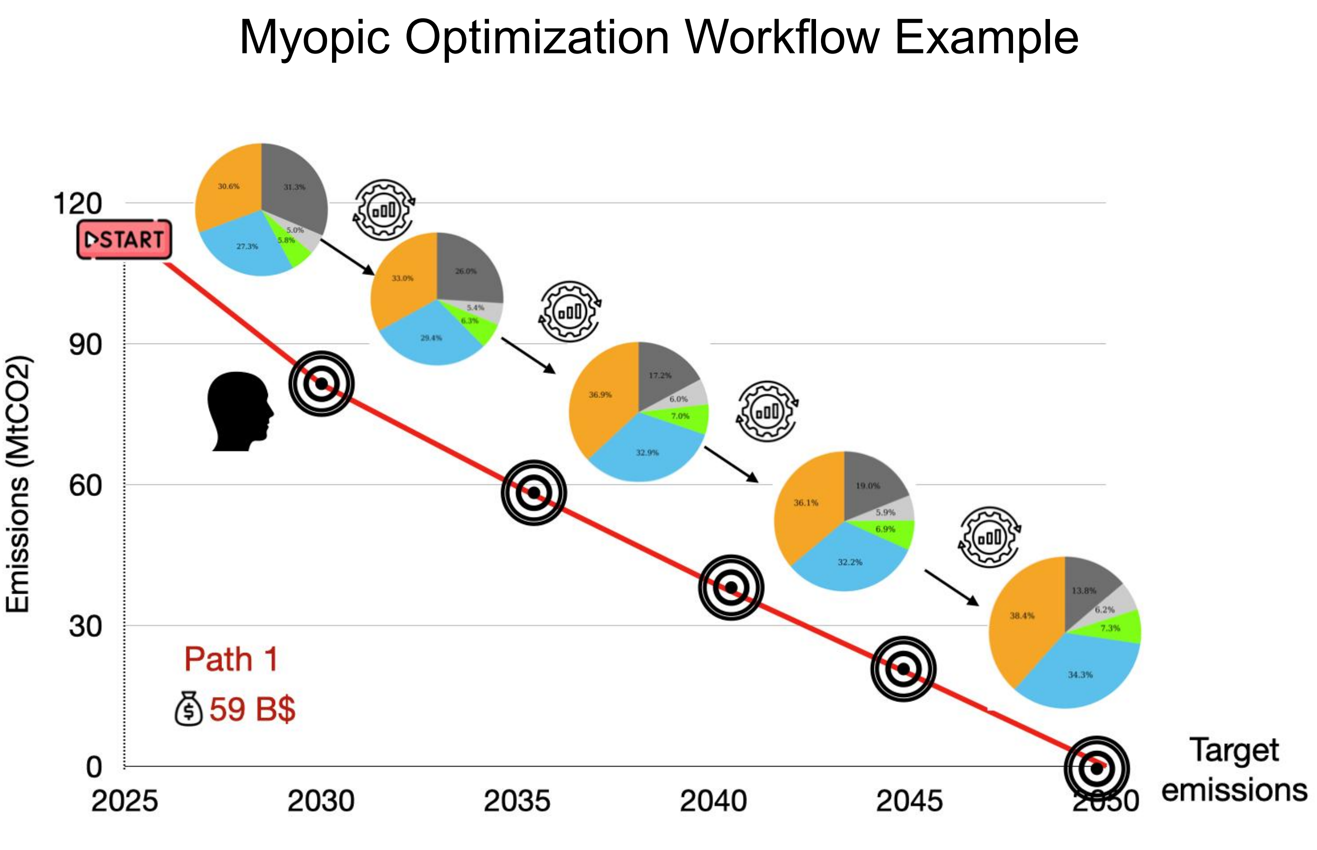
Status:

- Full network topology integrated (150+ substations, transformers)
- 2025-2050 automated scenario runs completed and validated
- Outputs: Demand, capacity mix, emissions, and cost trajectories with QA reports
- Trained **on EU countries + other** countries data
- Test: get outcomes in seconds



4. Decarbonization Paths

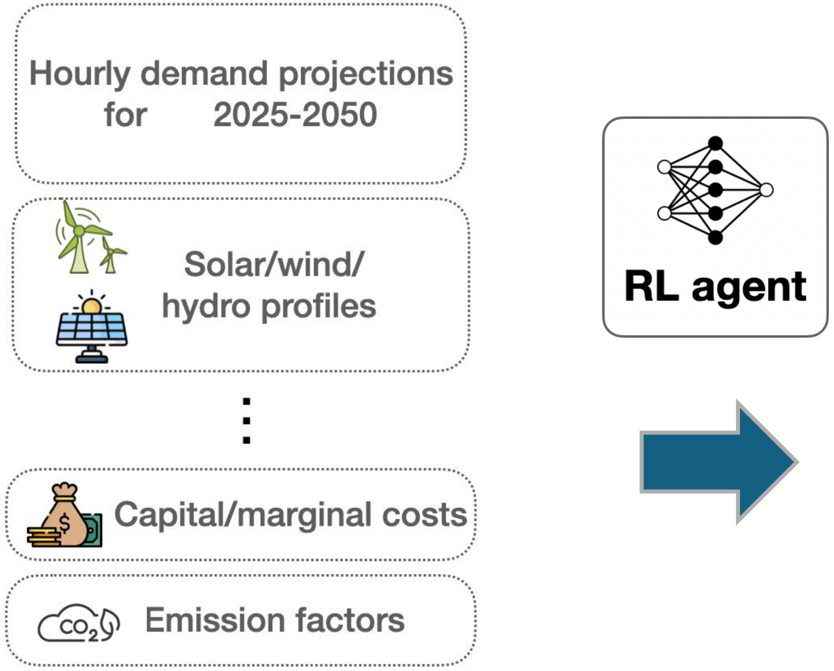
How it’s done now?



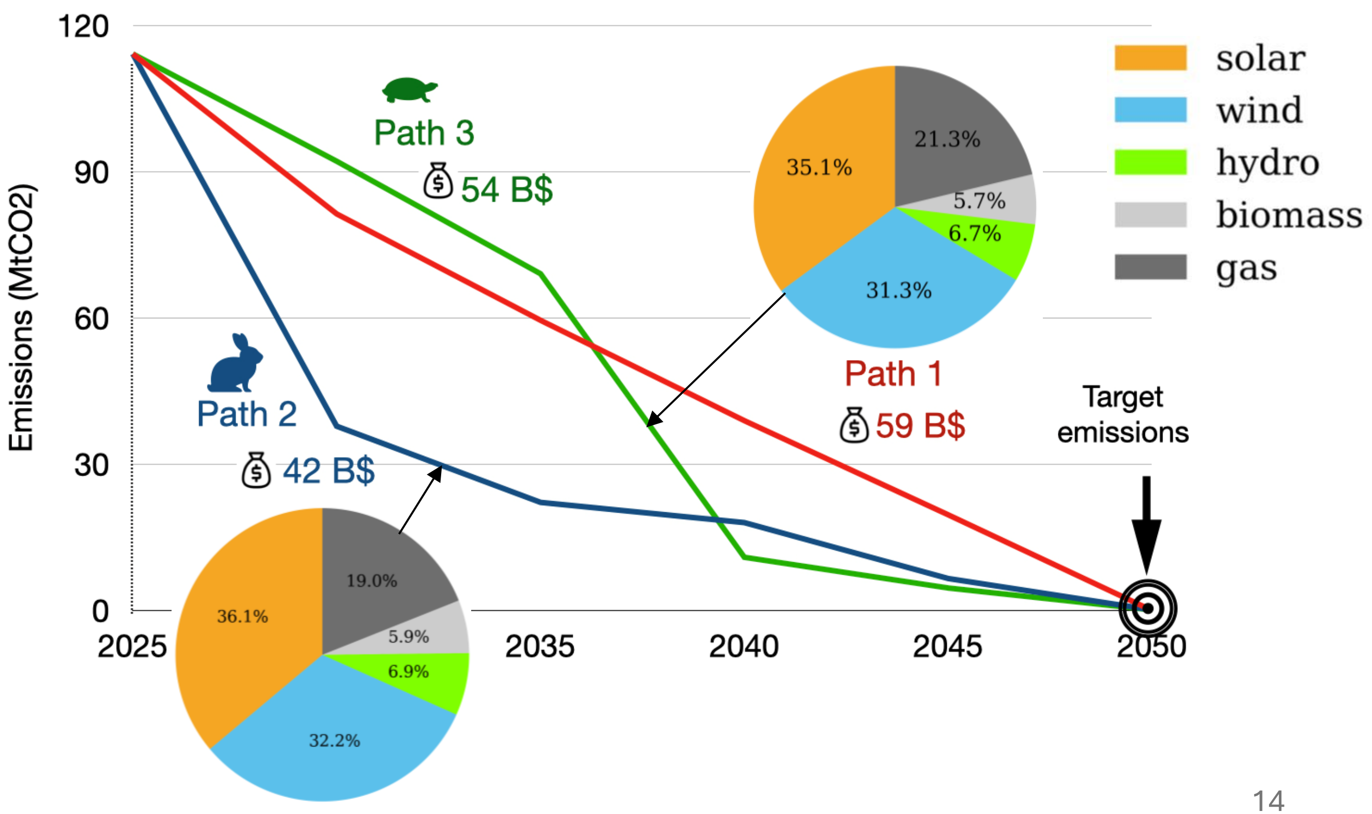
Conventional (Myopic Optimization)	Our Reinforcement Learning (RL) approach
Fixed optimization under CO_2 constraint	Learns policy via reward signals
Deterministic (Predefined)	Exploratory
Requires expert assumptions	Less domain dependent
Heavy combinatorial search	Scalable
Non-generalizable	Generalizable
Static per step	Adaptive
Limited (few hand-crafted predefined scenarios)	Diverse feasible pathways, including novel ones

4. Decarbonization Paths: using Reinforcement Learning

Objective: Generate diverse feasible decarbonization pathways for a given country by achieving set target emissions using Reinforcement Learning



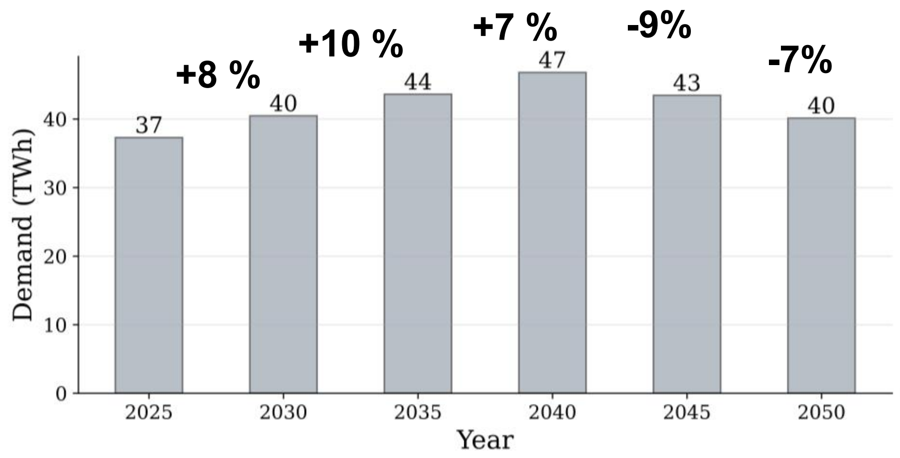
Example of Decarbonization pathways for one country



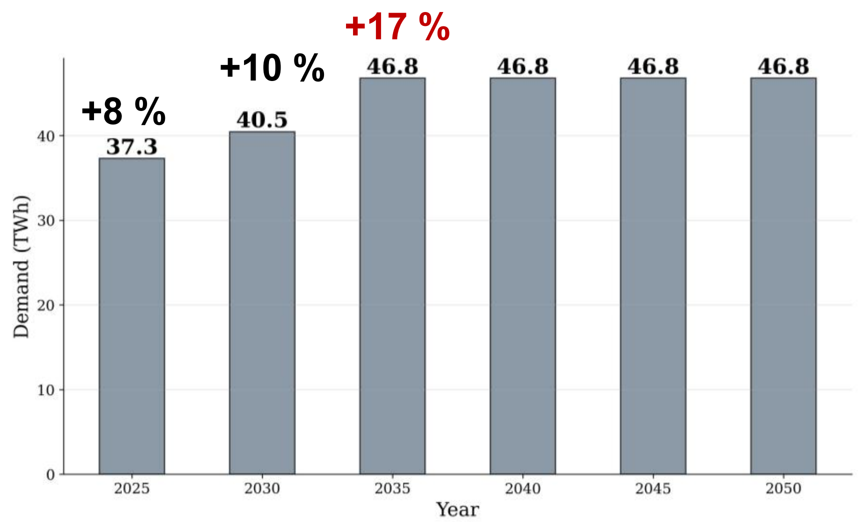
4. Decarbonization Paths: using Reinforcement Learning

What if scenario? Ex. sudden change

Original demand projections for Denmark (ENTSO-E)

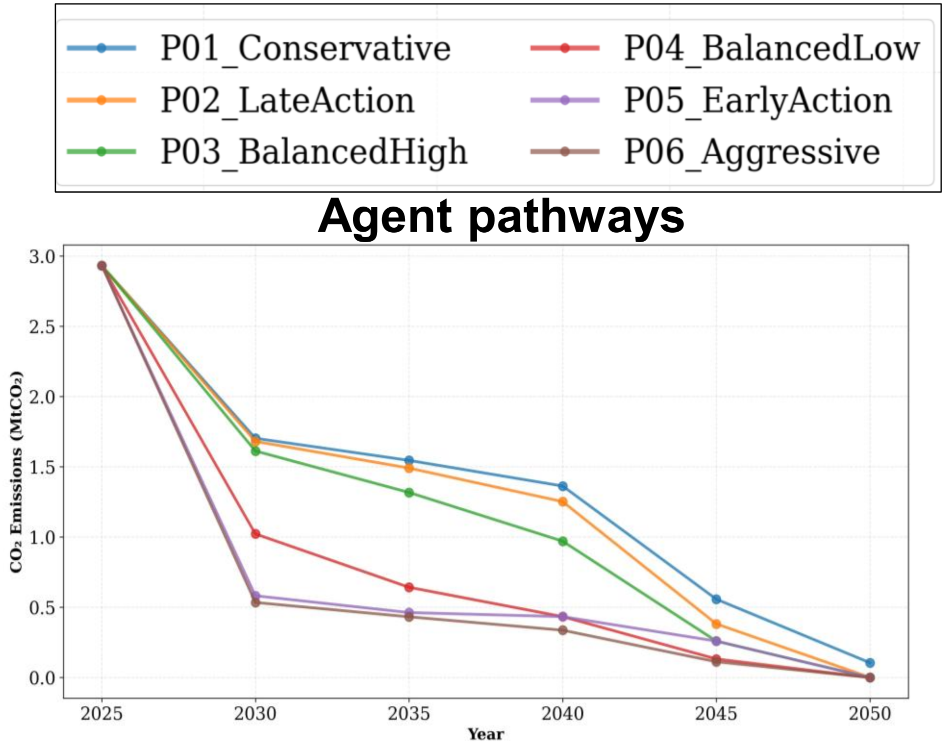


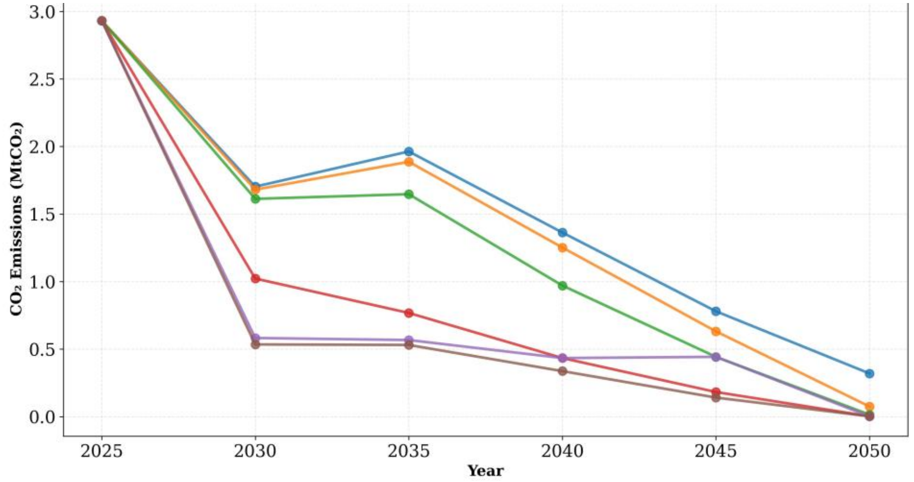
Increased demand for Denmark



Average inference time to generate new 6 paths with pretrained model ~90 sec

Agent pathways



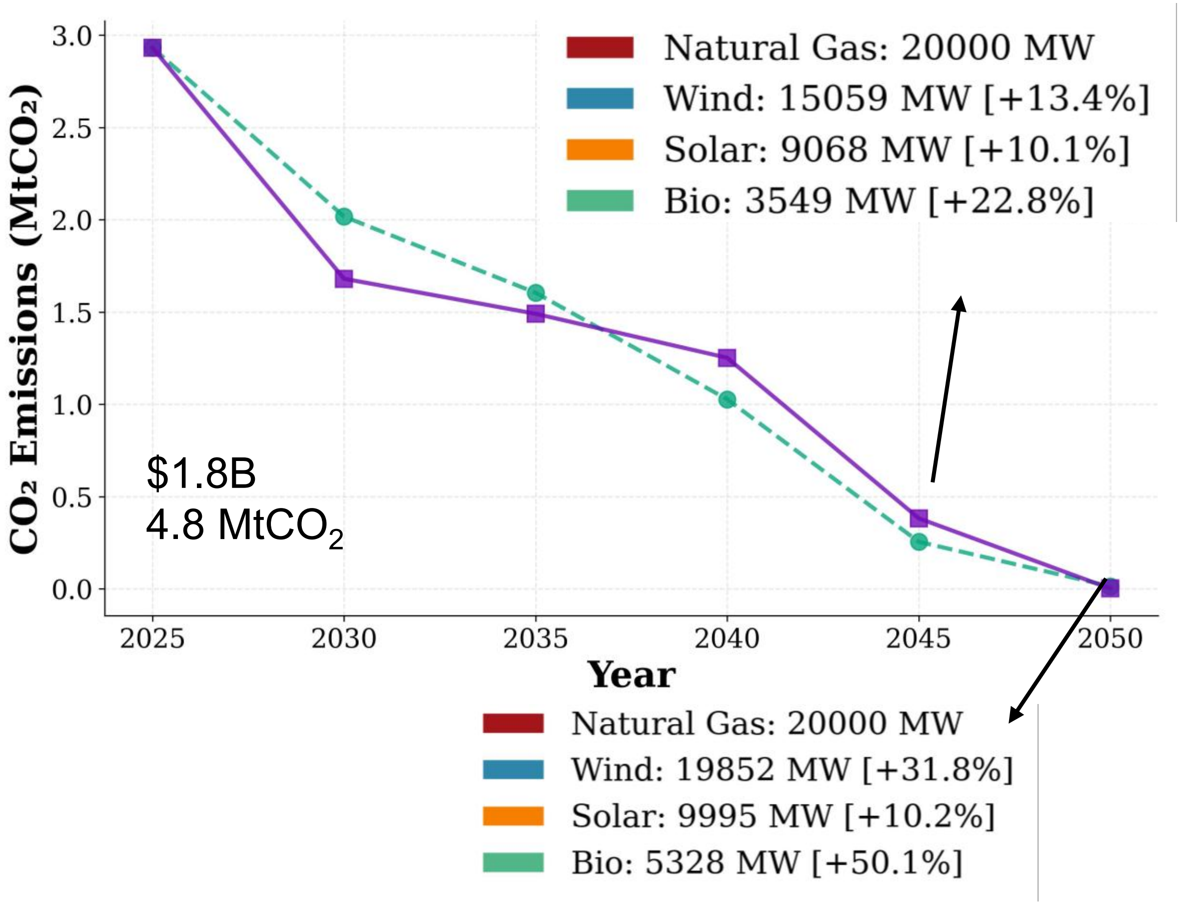


4. Decarbonization Paths using Reinforcement Learning

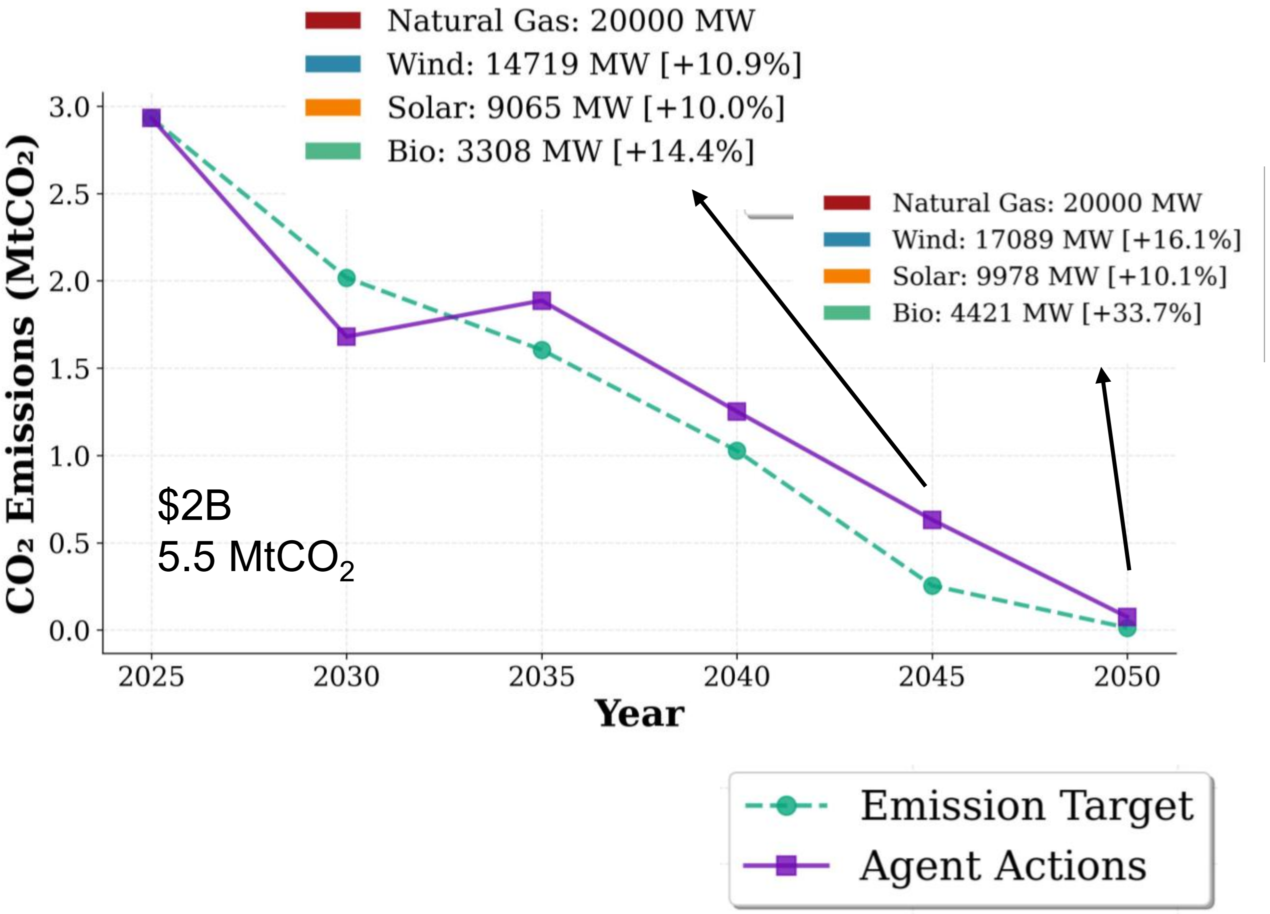
What if scenario: Late Action pathways

- We can compare generated pathways for different scenarios (e.g., sudden increase in demand due to data centers, etc)

Original demand projections (DK)



Increased demand projections (DK)

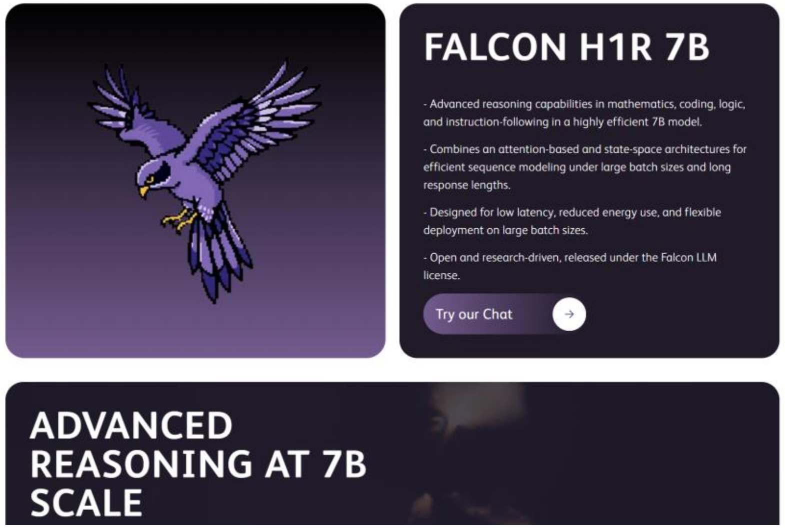


Further AI Integration? → Falcon© LLM and Chat-GPT (*)

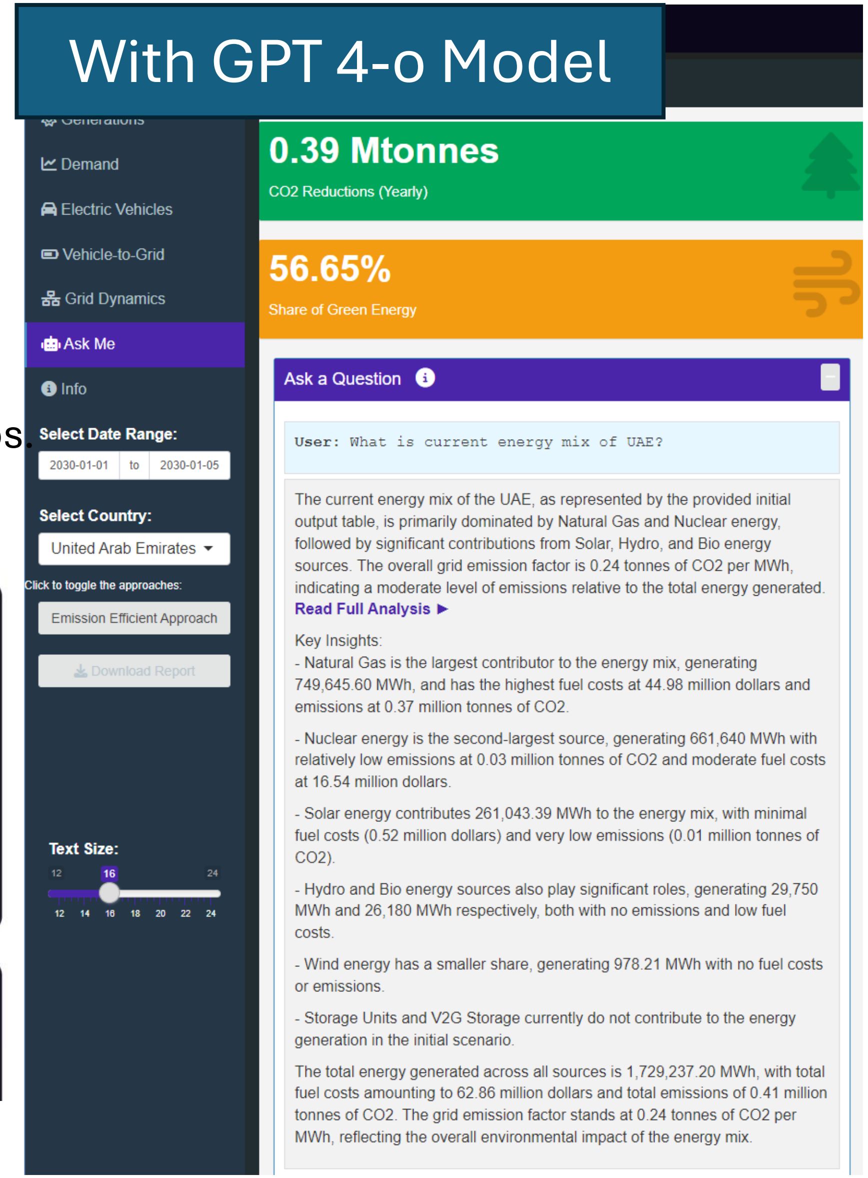
Usage

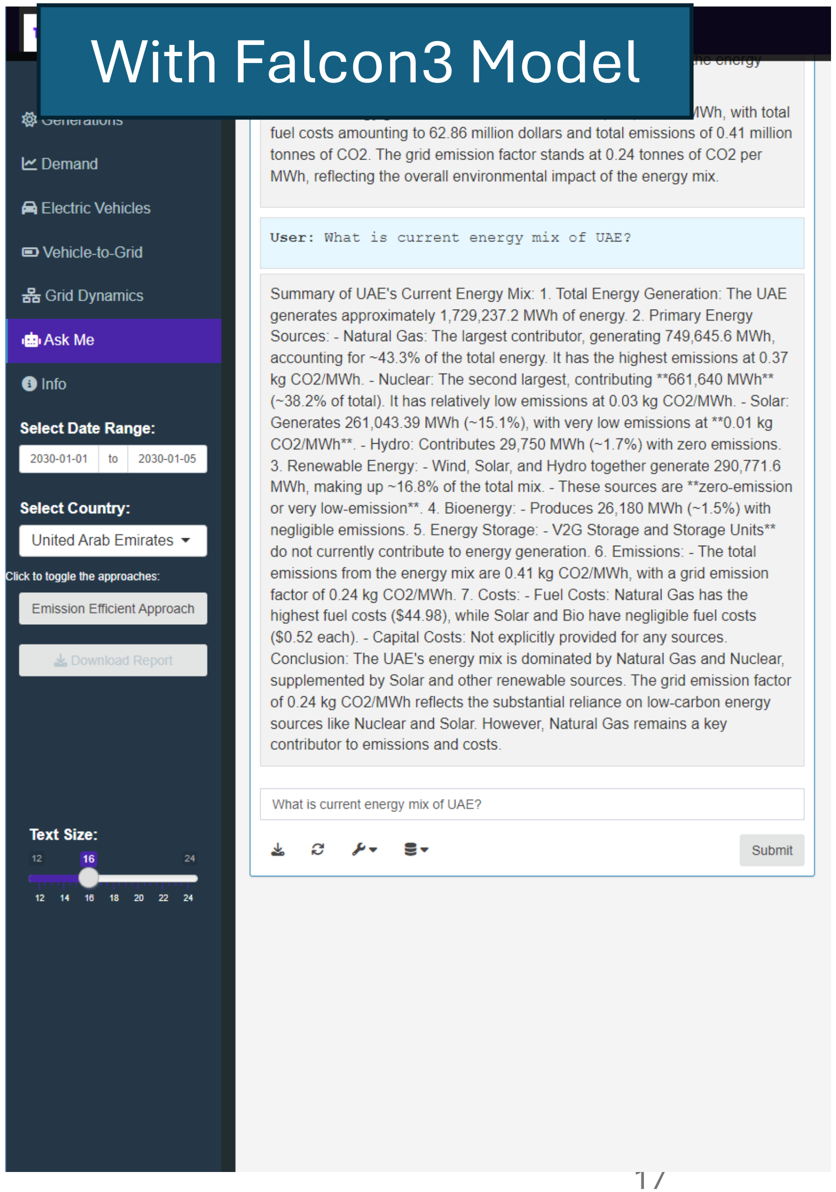
- User asks question
- LLM interprets and *triggers* right function
- GridApp execs and yields briefs, reports (screen, pdf's … Audio)
- User can still operate *normal* GUI interactively and play own scenarios

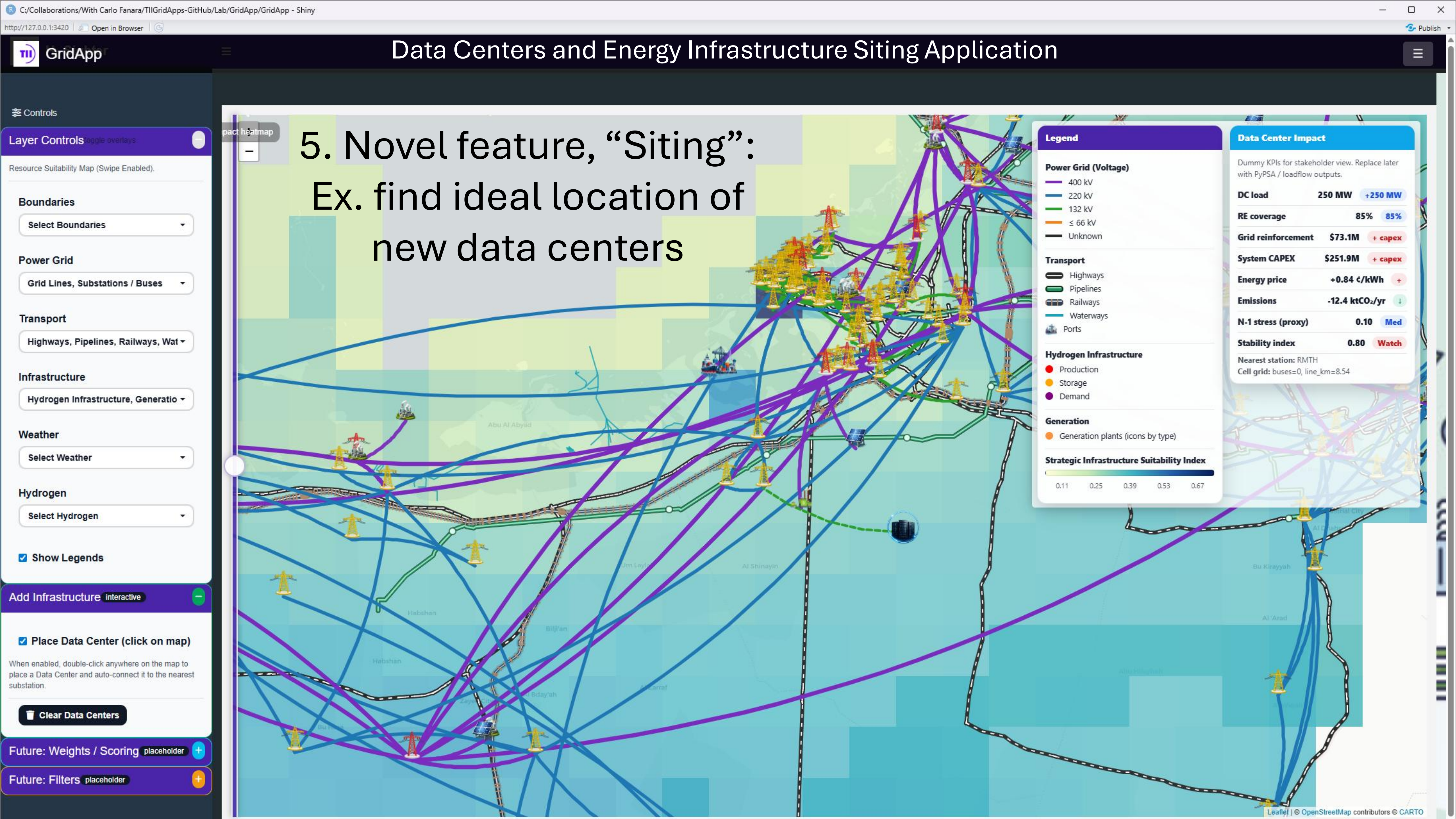
FALCON is TII's LLM



(*) trained on domain specific data





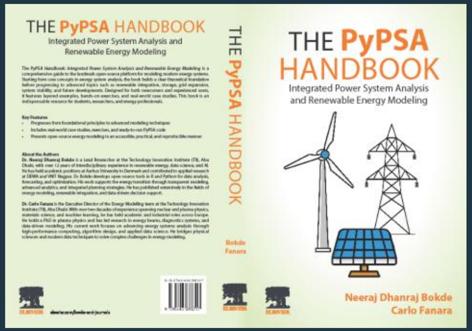

C:/Collaborations/With Carlo Fanara/TIIGridApps-GitHub/Lab/GridApp/GridApp - Shiny
http://127.0.0.1:3420
Open in Browser
Publish
GridApp
Data Centers and Energy Infrastructure Siting Application
5. Novel feature, "Siting":
Ex. find ideal location of
new data centers
Controls
Layer Controls
Resource Suitability Map (Swipe Enabled).
Boundaries
Select Boundaries
Power Grid
Grid Lines, Substations / Buses
Transport
Highways, Pipelines, Railways, Wat
Infrastructure
Hydrogen Infrastructure, Generatio
Weather
Select Weather
Hydrogen
Select Hydrogen
Show Legends
Add Infrastructure
interactive
Place Data Center (click on map)
When enabled, double-click anywhere on the map to place a Data Center and auto-connect it to the nearest substation.
Clear Data Centers
Future: Weights / Scoring
placeholder
Future: Filters
placeholder
Legend
Power Grid (Voltage)
400 kV
220 kV
132 kV
≤ 66 kV
Unknown
Transport
Highways
Pipelines
Railways
Waterways
Ports
Hydrogen Infrastructure
Production
Storage
Demand
Generation
Generation plants (icons by type)
Strategic Infrastructure Suitability Index
0.11
0.25
0.39
0.53
0.67
Data Center Impact
Dummy KPIs for stakeholder view. Replace later with PyPSA / loadflow outputs.
DC load 250 MW +250 MW
RE coverage 85% 85%
Grid reinforcement $73.1M + capex
System CAPEX $251.9M + capex
Energy price +0.84 ¢/kWh +
Emissions -12.4 ktCO₂/yr ↓
N-1 stress (proxy) 0.10 Med
Stability index 0.80 Watch
Nearest station: RMTH
Cell grid: buses=0, line_km=8.54
Abu Al Abyad
Al Shinayin
Habshan
Bu Kirayyah
Al 'Arad
Leaflet | © OpenStreetMap contributors © CARTO

Way forward

Action	Why?
Engage with **utilities providers** to propose solutions like siting procedures, integration of resources like water, industries and general infrastructure	Internal analyses – TII & V1 - have shown market lacks solutions in ***Siting*** (ex.: data centers, desalination plants, factories) and lack of ***integration*** with other layers (water, transport, agriculture…)
Engage with **energy policymakers** to propose solutions with availability of scenario playing – all available at once	As an example, our Decarb studio takes input from the grid (including resilience) and yields a **cost timeline dynamically**, along with the parallel evolution of candidate energy mixes.
Engage with **companies** and let them cherry-pick solutions from our set of tools – perhaps developing together.	Omni-comprehensive solutions might be too heavy or show limited interest. **Problem specific tools** with an AI **automated Saas** seem more attractive.
Most importantly: we need to be **accompanied** to transform our prototypes into full fledge software products. How? Transfer, license, and/or co-develop, with EPRI or companies in its landscape.	…Because as R&D provider, we stop ahead of market transfer, hence competitors closer to product will always **look better-** even if our content might be comparable or better…

THANK YOU!

[Technology Innovation Institute UAE | Advanced Tech Research Center]



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Dr Carlo Fanara, Carlo.Fanara @tii.ae

Source: https://www.sciencedirect.com/book/monograph/9780443266317/the-pypsa-handbook

Distill Uncertainty into Decisions

Q1 2026 Demo

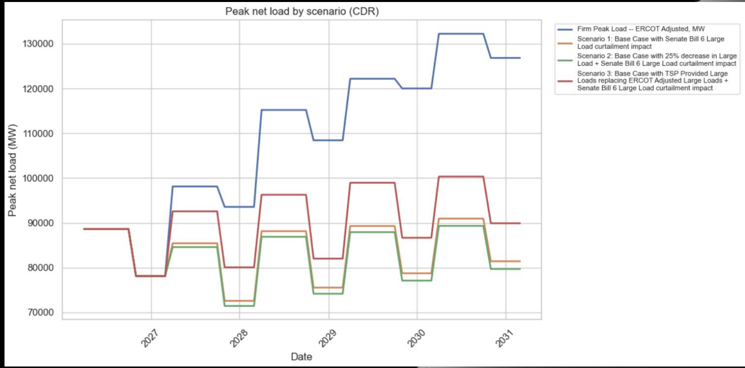
Distill Energy

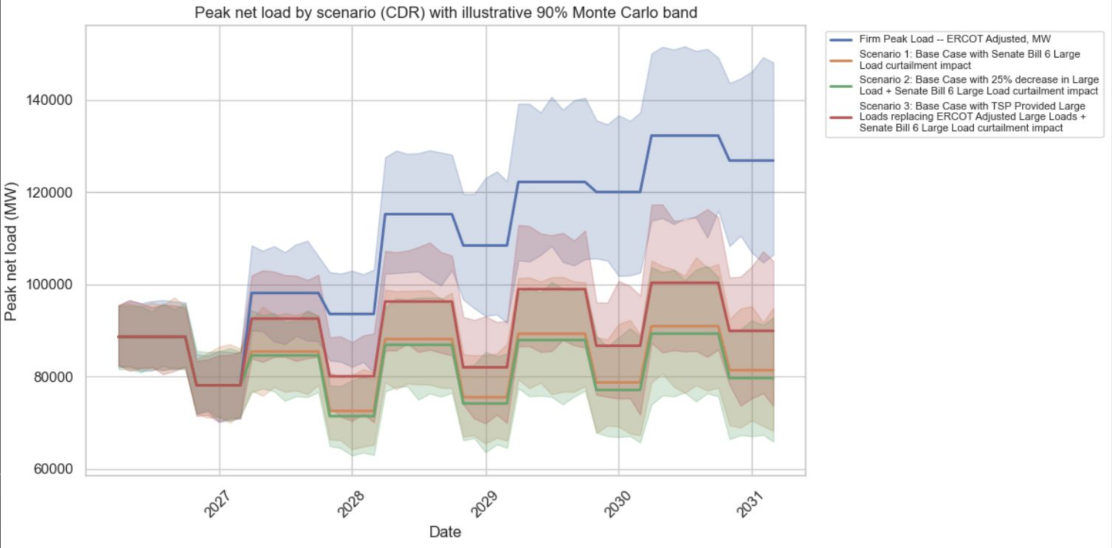
What we do

Distill is a forecasting and grid simulation platform

What we do

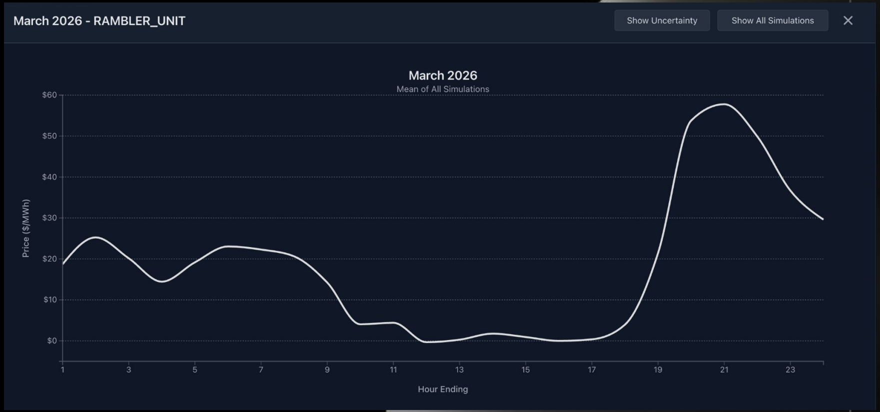
Distill is a forecasting and grid simulation platform

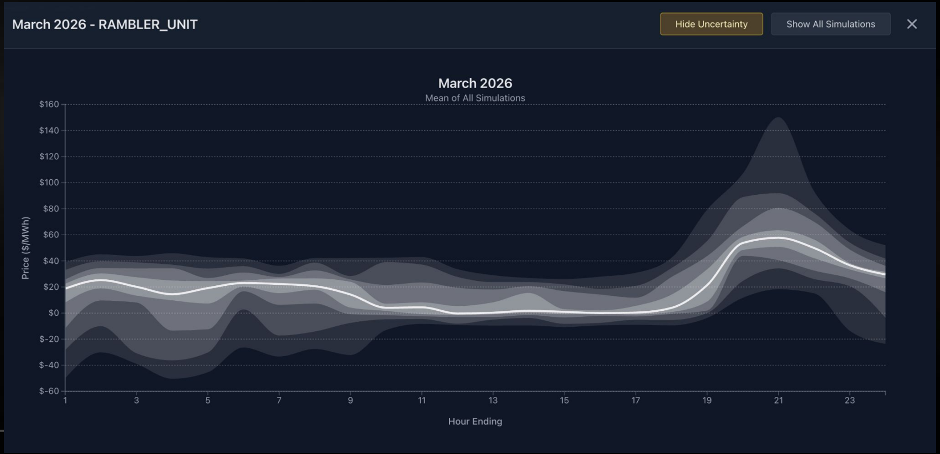




What we do

Distill is a forecasting and grid simulation platform





What we do

Annual Debt Service: $10.32M/yr

Breakeven Analysis

Price:	$35.23/MWh
Capacity Factor:	0.1%

P50 Case (Expected)

Price:	$319.02/MWh
CF:	33.0%
DSCR:	290.31x

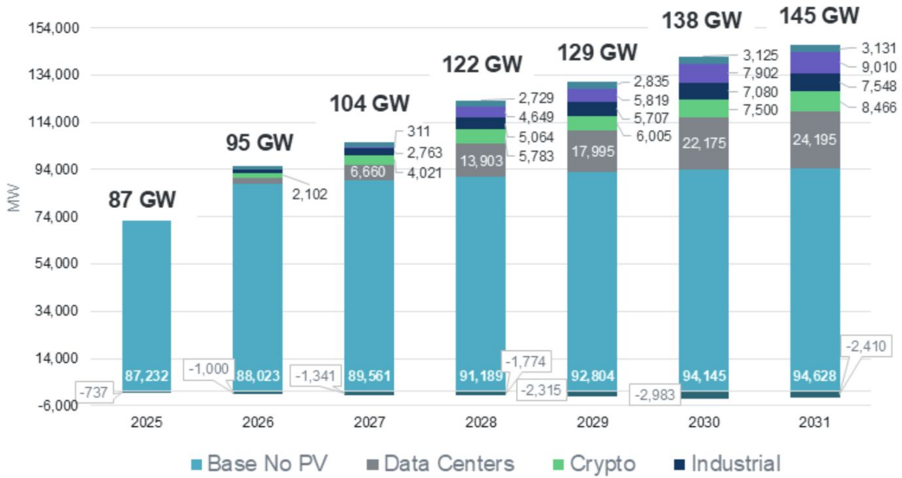
P10 Case (Conservative)

Price:	$93.19/MWh
CF:	28.1%
DSCR:	51.24x

Distill is a forecasting and grid simulation platform

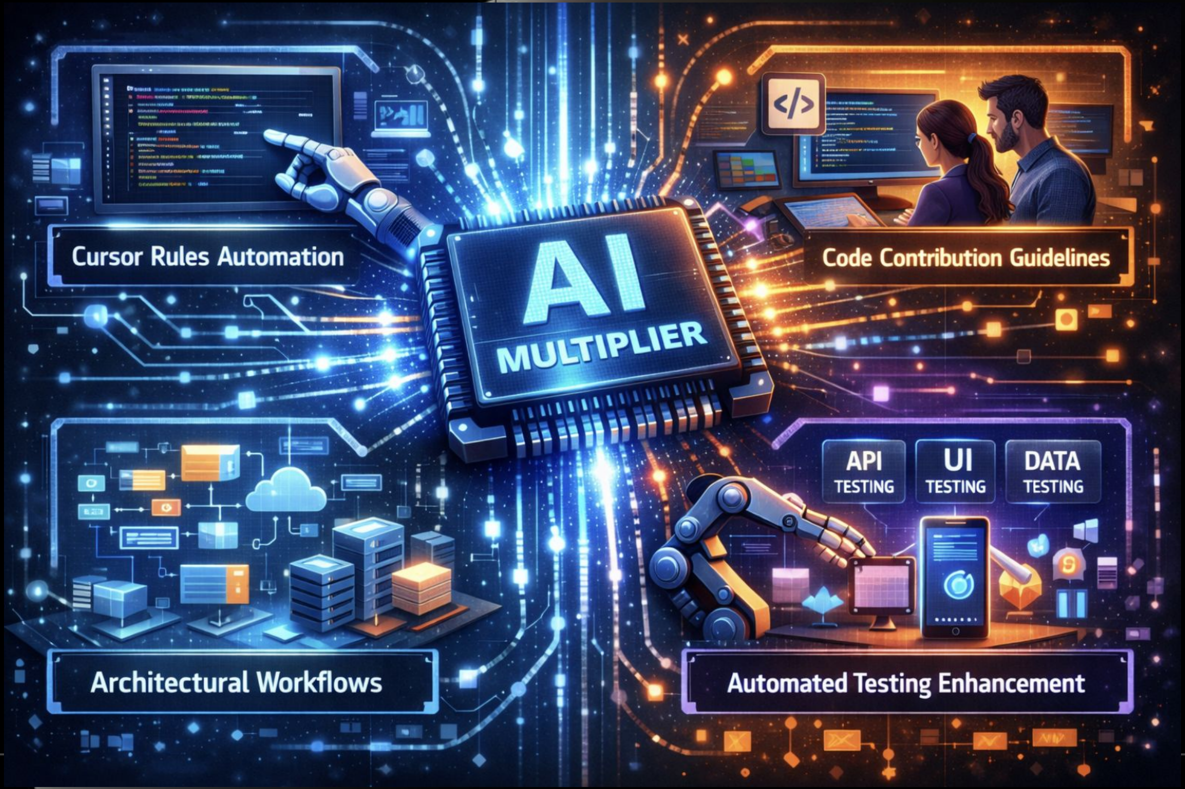
AI Enhanced

ERCOT Adjusted Large Load Breakdown



	2025	2026	2027	2028	2029	2030	2031
Data Centers	0	2,433	6,660	13903.35	17,995	22,175	24,195
Crypto	0	2,102	4,021	5782.964	6,005	7,500	8,466
Industrial	0	1,387	2,763	5064.178	5,707	7,080	7,548
Hydrogen	0	5	311	4649.1	5,819	7,902	9,010
Oil and Gas	0	1,699	2,320	2728.529	2,835	3,125	3,131
PV	-737	-1,000	-1,341	-1773.73	-2,315	-2,983	-2,410

AI Enhanced


Cursor Rules Automation
AI
MULTIPLIER
Code Contribution Guidelines
API
TESTING
UI
TESTING
DATA
TESTING
Architectural Workflows
Automated Testing Enhancement

AI Enhanced

Ask Distill AI

YOU

what are varying load patterns in the ercot cdr?

DISTILL AI

ERCOT CDR Load Patterns

The ERCOT Capacity, Demand and Reserves (CDR) report contains several key load patterns that are crucial for system planning and reliability assessments. Here's what you should know about these

Ask about this node...

Last updated: 2/18/2026, 6:51:18 AM
Scenarios: 5 market conditions
Resolution: Monthly with daily patterns

Complete Market Context

Fundamental Inputs

Curated fundamental drivers that include supply, demand,macro, commodities, technology and policy

Long Range Clarity

Integrated Powerflow

Distill's inputs seamlessly integrate into the powerflow. Powerflow runs are available for months and years into the future

Physics Driven Outcomes

Cloud Native OPF

Our solver runs thousands of scenarios at nodal resolution producing full distributions of LMPs, revenue and grid reliability context

Lightning Fast Simulation

Optimized for Usability

Run a year of hourly simulations in minutes, run five years in an hour. Our tools are optimized for both speed and ease of use