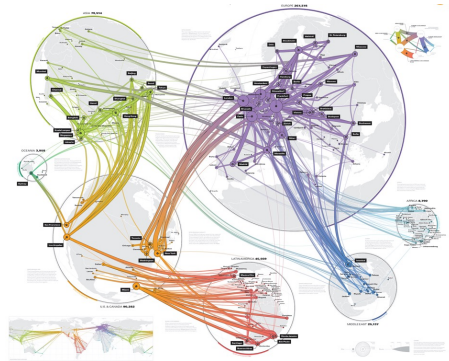
# Innovation in Energy

## New applications to improve efficiency and introduce new solutions in challenging problems

**Prof. Vassilios Vescoukis, Electrical and Computer Eng.**
Center of Geoinformation & Software Engineering Lab
National Technical University of Athens

# Multiple challenges, some critical



Efficiency calls for optimal balancing of conflicts:
technical , environmental, social, economical, political

The innovation alphabet

- **A**I and related technologies ➢ Optimization, forecasting, classification, …
- **B**lockchain applications ➢ Distributed intelligence + trust, tokenization
- **C**loud-based services ➢ Infrastructures, IoT
- **D**ata science ➢ Data semantics, timeseries management

Keys: integration, inter-disciplinarity and personalization

# AI and related technologies

## Optimization

- Energy management
- Trading risk management
- Bidding stategies
- Storage management
- Energy communities
- Flexibility & production mix
- Vehicle charging
- Environmental impacts, resilience, DR

## Forecasting

- RES production
- Load, Consumption, Prices
- Climate-related quantities

## Classification

- Consumer profiling
- Clustering
- Geospatial analysis

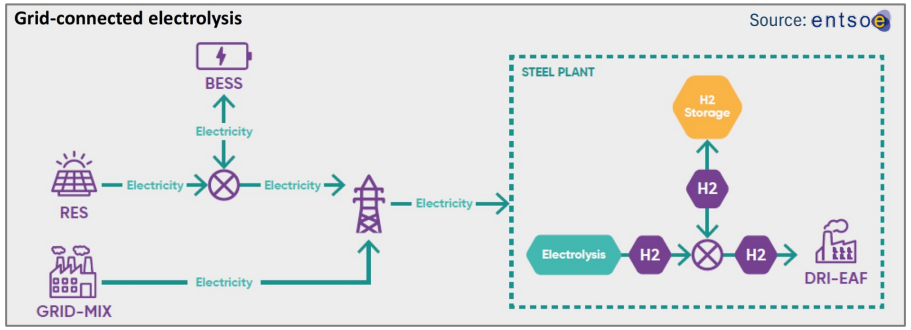
# Case: hybrid storage management

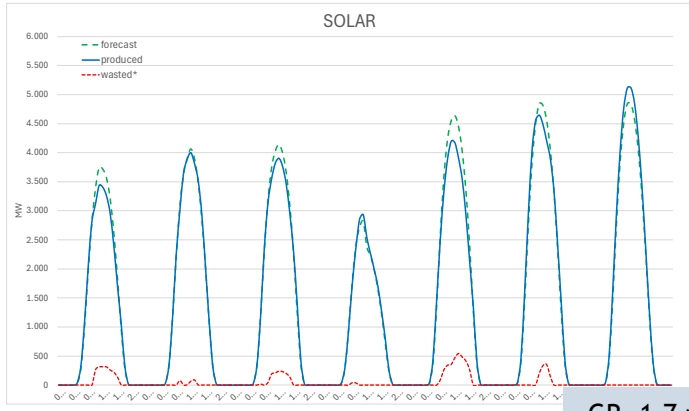
RES curtailments are here to stay

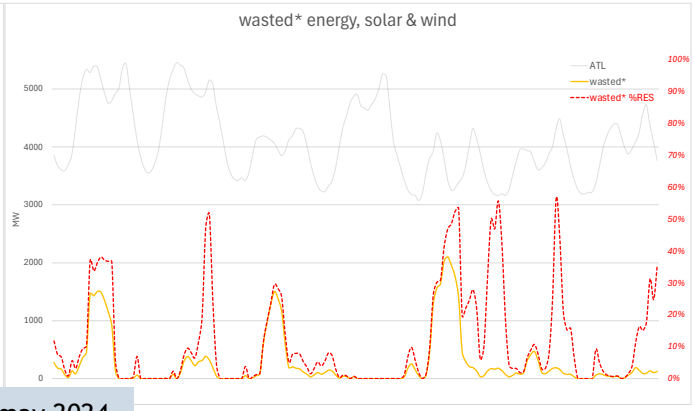
- Technical and market reasons
- BESS: Efficient & expensive
- H2: low round-trip efficiency (PH2P), price

Optimize revenue & minimize RES rejections by using hybrid (BESS, H2) storage

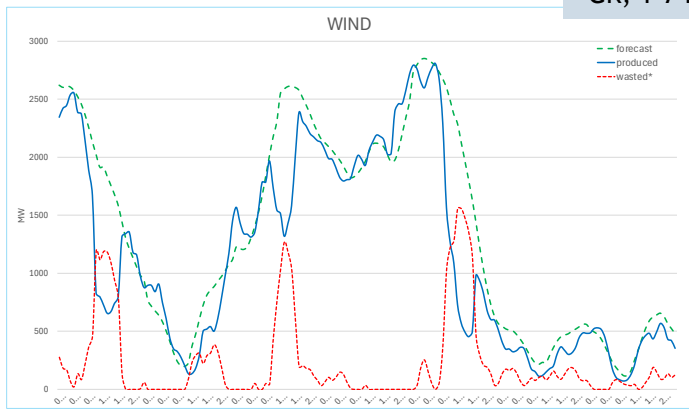
- RES & BESS CAPEX amortization
- Ground for new H2 business and strategy

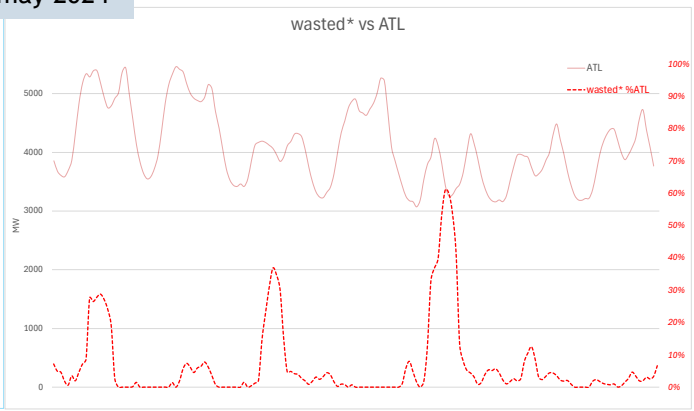



GR, 1-7 may 2024



# Case: hybrid storage management

Informed decisions need quantitative analyses with multiple parameters

- Long-term planning, new incentives for market & business development
- Policy and regulatory aspects, efficient planning and operation of RES
- Production scenarios, long-term licensing & deployment plans of new RES
- Price scenarios, CAPEX & OPEX

## ECHOS: Customizable optimizer service for hybrid storage

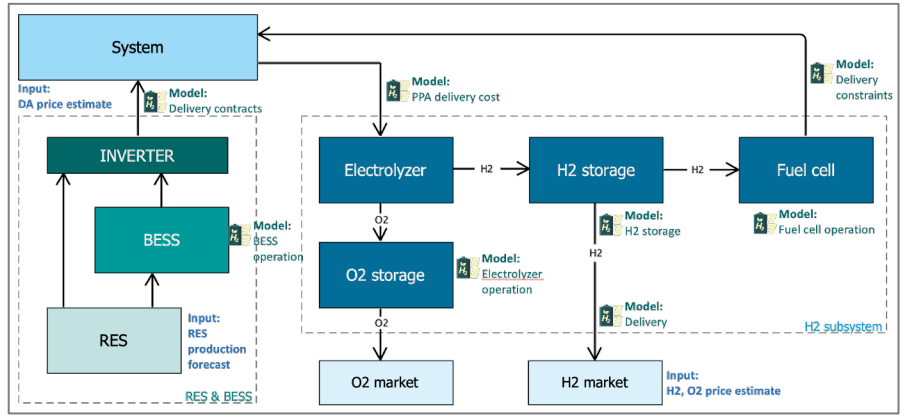
- Addressed to policy makers, regulators, investors, operators, energy communities
- Decision support in planning and operation

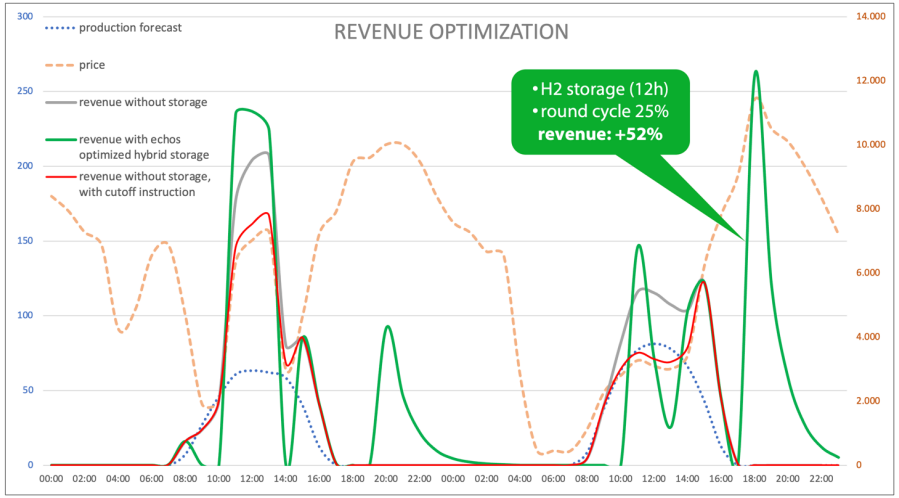
### Input

- Production & Price scenarios (electricity, H2, O2, gas)
- CAPEX & OPEX
- Dimensions and analysis time windows
- Constraints (market, technical, custom)

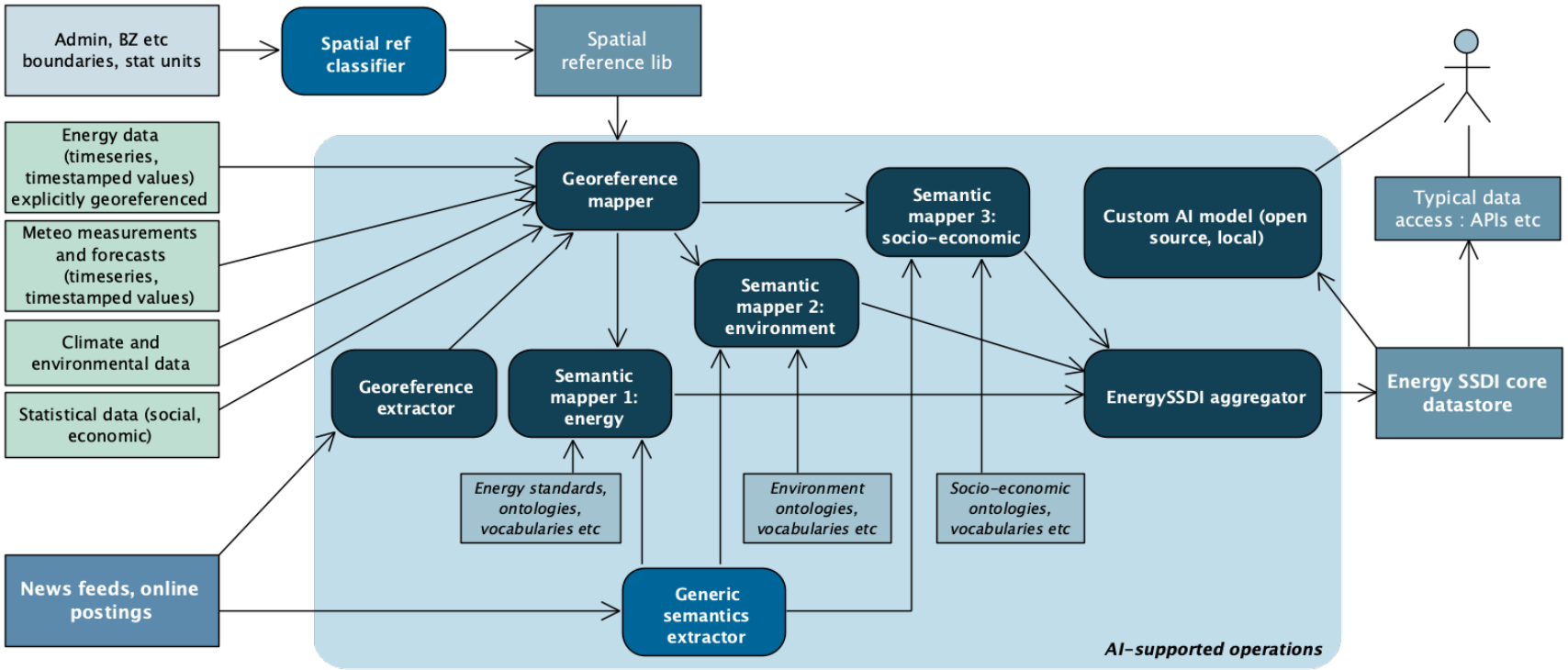
### Output

- Minimize curtailed RES
- Maximize H2 production
- Maximize revenue
- CAPEX amortization

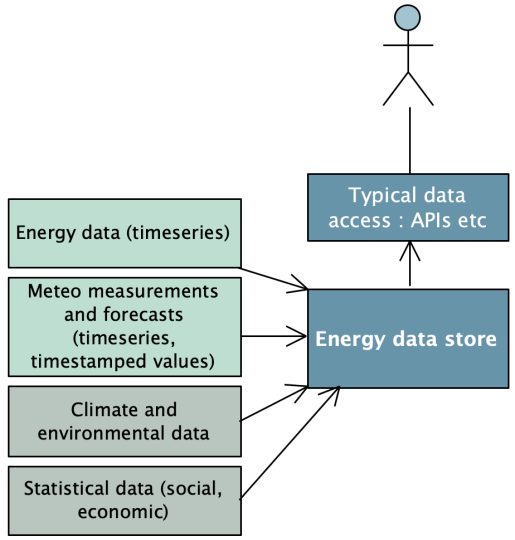


# Case: Energy Semantic Spatial Data Infrastructures




Modern energy data infrastructures




Legacy energy data infrastructures

# Blockchain

## Distributed intelligence & trust

- Democratization & transparency
- Secure business logic
- Rewarding models
- Micro-funding

## Self-governing systems

- Distributed autonomous organizations
- Fair-play by definition
- Energy communities

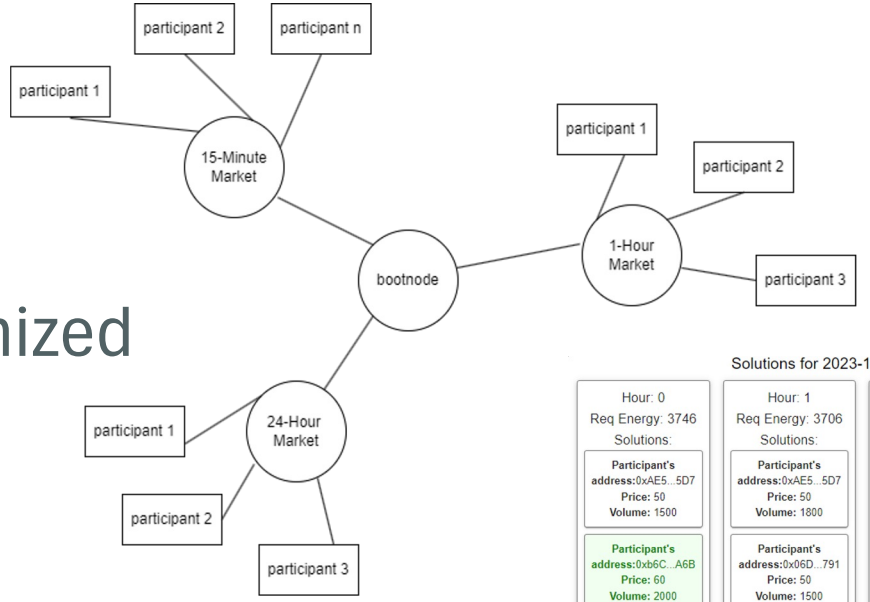
## Tokenization of energy assets

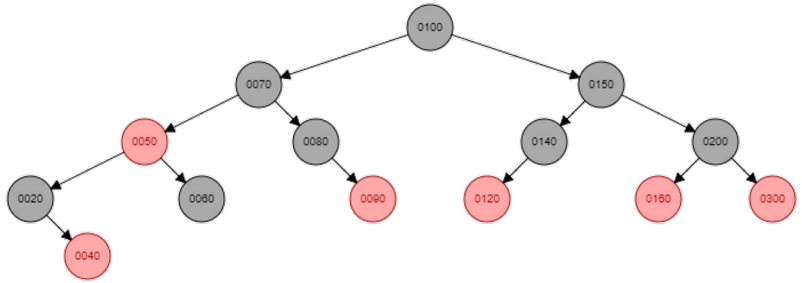
- Storage: BESS, H2
- RES and virtual power plants
- Consumption
- Transmission & distribution capacity for PPAs
- CO2 offsets, Oil/gas futures
- Hedging

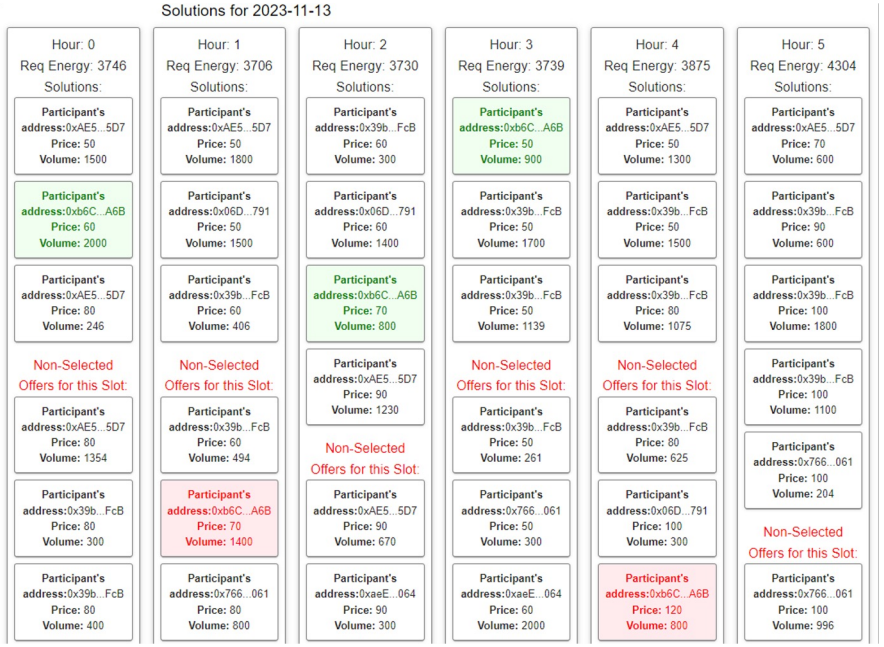
# Case: Blockchain-based electricity market resolution

## Concept

- Private-permissioned blockchain
- Continuously anonymized bids, accessible by participants
- Resolusion based on balanced reb-black trees
- Market resolution is verifiable by all participants



# Case: Blockchain-based RES aggregators as DAOs

## Concept

- RES aggregator as a distributed autonomous organization (DAO)
- Members agree on algorithm for settlements
- Data is shared transparently
- Settlements are automatic and verifiable by all
- No human intervention

# Cloud technologies

## New service providers

- Anyone with knowledge and capacity

## New business models

- SaaS: optimization, data, operations
- Custom personalized offerings
- Adaptive and flexible service billing

# Data science

## Data semantics

- Alignment with standard data models
- Ontologies and classification

## Intelligent data management

- Data therapy
- Timeseries imputation
- Context-aware timeseries BI

## Correlation of semantic with quantitative data

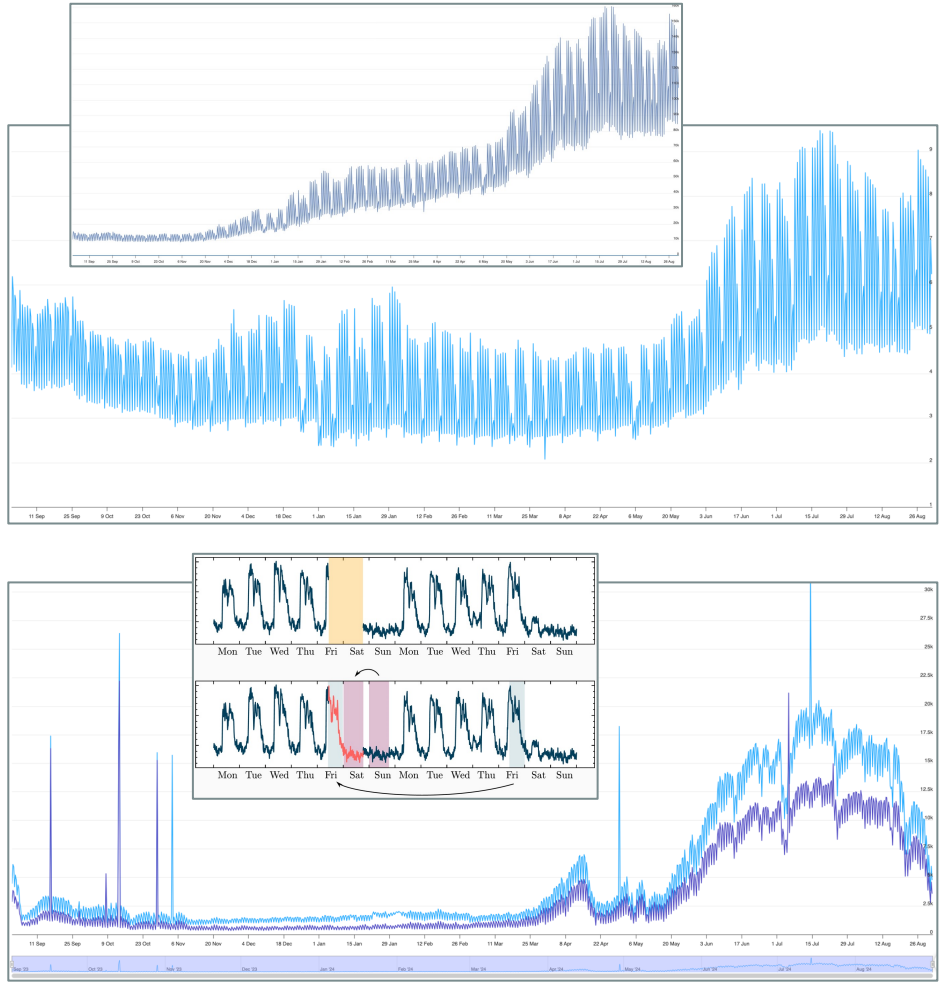
# Case: Semantics of energy timeseries

## Tools

- AI, including NNs, ML and LLMs
- Traditional signal processing methods

## Cases

- Consumer profiling & classification
- Timeseries Business Intelligence
- Regulatory decision support
- Context-aware sanitization
- Semantics-based timeseries imputation

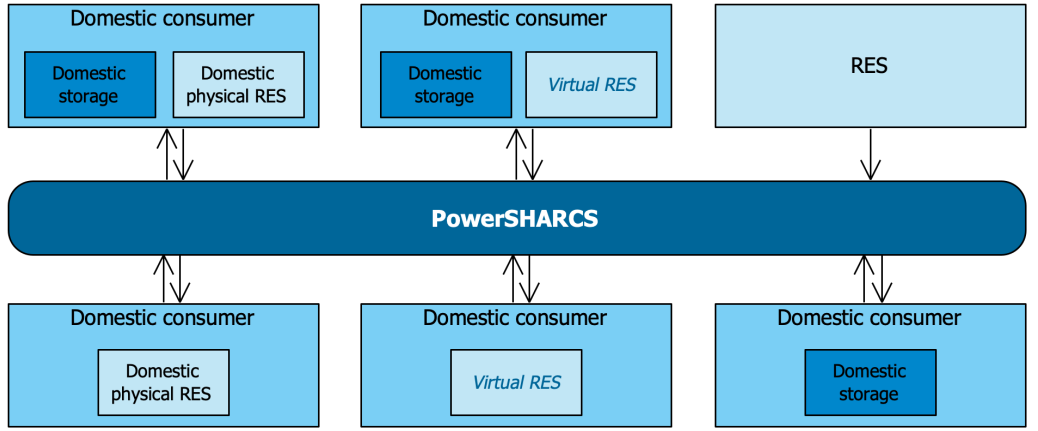


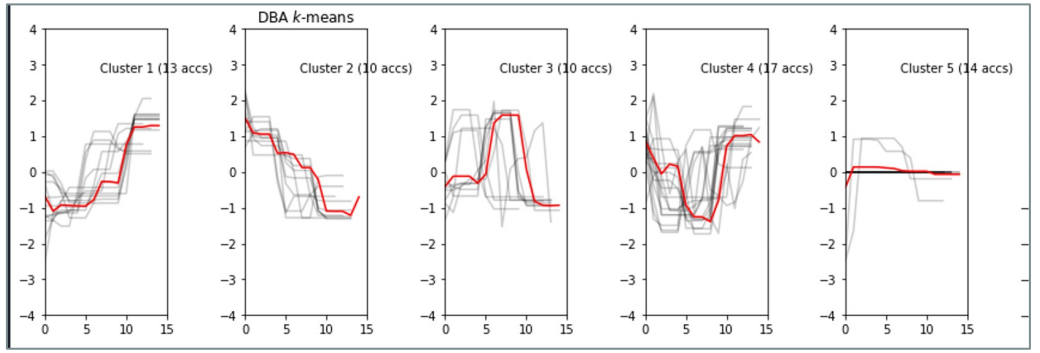

Credits: HEDNO regulatory affairs directorate,

# Case: intelligent energy communities

## Concept

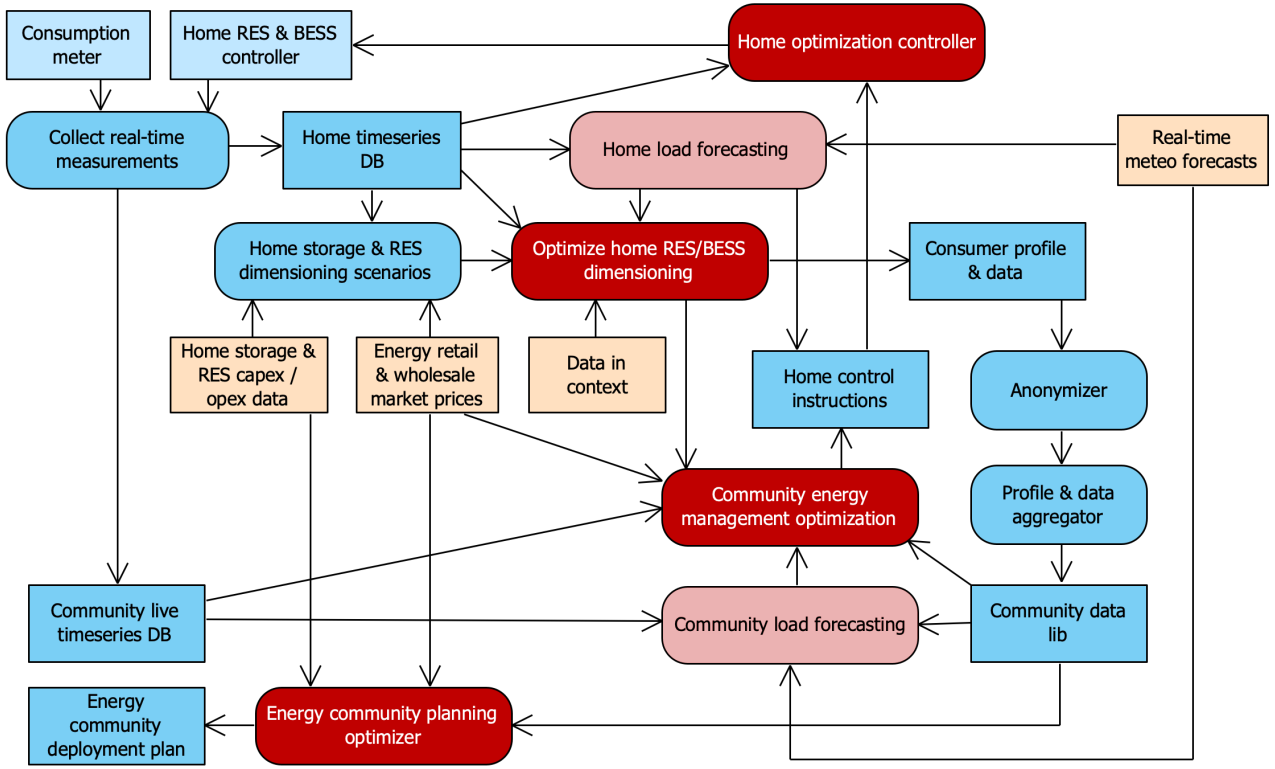
- Autonomous energy (DAO) communities by domestic participants
- Micro-forecasting and optimization
- Continuous profiling at consumer- and community-level
- Sharing of storage & physical home RES
- Virtual RES production from curtailments & PPAs
- Extensive data management

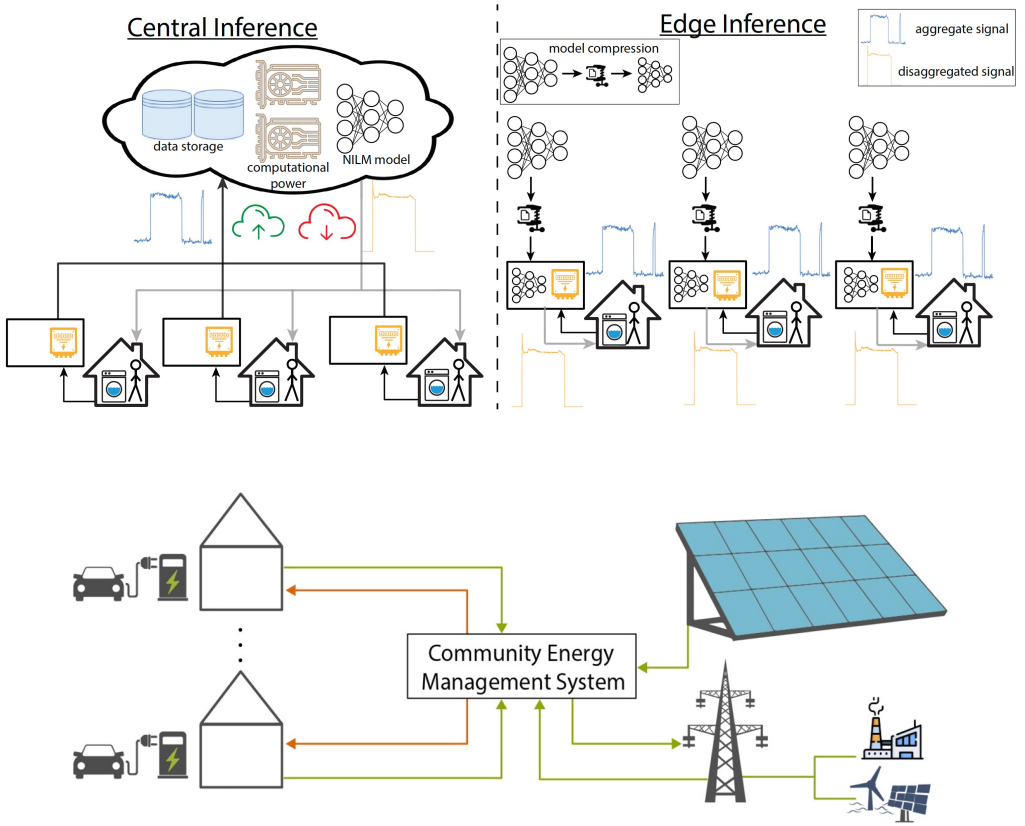



Credits: PowerSHARCS proposal (NTUA, QUBITEQ), Avocado AI

# Case: intelligent energy communities




Credits: PowerSHARCS proposal (NTUA, QUBITEQ), S.Sykiotis Ph.D. thesis

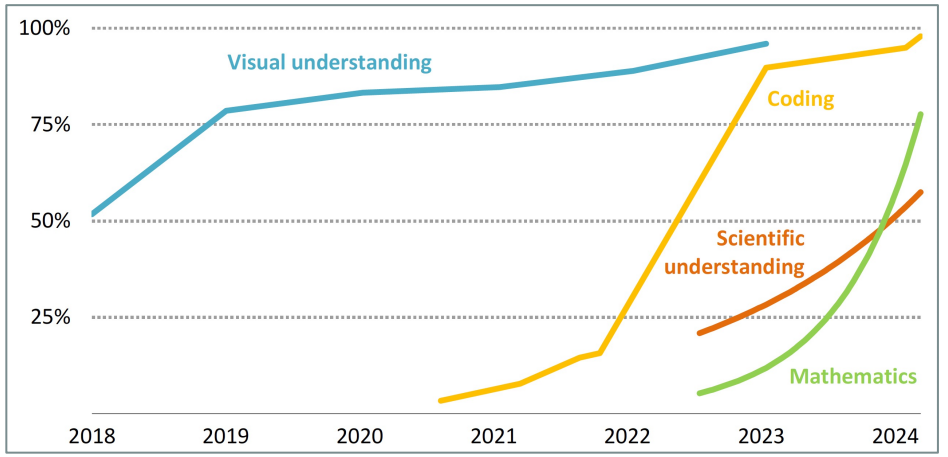
# Notable points

## AI is not a panacea

- AI revenue models still disputable
- How about QA & liability
- Marketing+politics foster great expectations

## Innovation: practice vs. theory

- Focused and knowledgeable decisions are worth the risk
- The AI hype is added to the innovation hype
- The dotcom fiasko should not be repeated




**Source: IEA 2025**

*The data centres used to train and operate AI models consume much of this energy. A typical AI data centre, according to the International Energy Agency (IEA), uses as much power as 100,000 households right now, but the largest centres currently being constructed will consume 20 times that amount.*

**Source: World Economic Forum**


The Washington Post

Climate Environment Weather Climate Solutions Climate Lab Green L

**Trump administration plans to end Energy Star program for home appliances**

Since 1992, the program has helped American families and businesses save more than $500 billion in energy costs, a federal report says.

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**Contact**

v.vescoukis@cs.ntua.gr
www.linkedin.com/in/vvescoukis/