Multi-energy systems design and operations in response of climate change policies

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Berlin 21st April 2023
Decision Support Systems & Services based on
Operations Research, Data Science, Advanced Analytics & Artificial Intelligence

45+ talents working to turn digital innovation into reality

Bologna: Headquarters
Cesena: SW Factory
• How is the sector being shaped by the current legislation for decarbonization?
• What is the role of OR (and Advanced Analytics) as enablers of the industry’s transition?
The role of Heating & Cooling in the general Energy System

- Heating and cooling represent 50% of TOTAL energy consumption in the EU!
- Around 2/3 of thermal energy was produced (in 2015) using fossil fuels (mostly gas)
- Things are changing fast following the fuel crisis, yet the issue remains: decarbonising this sector is the key to achieving the European Targets
Evolution of the DHC (and Smart Energy Systems) industry
In 2023, negotiations on the Green Deal “Fit for 55” package are expected to be finalised. Overall and pending final political deals, there are significant provisions for the DHC sector.

- **EU ETS**: The Emission Trading System (2) will be requested for all **fossil fuels used in buildings**, no distinction between commercial and private buildings (with cap to 45 euro/ton until 2030).
- **RED**: **Waste heat** accountable towards RES targets

- **EED**: **Gradual phase-in RES** and WH for efficient DHC
- **Sector integration**: accounting of green electricity towards H&C targets and DHC targets, **thermal storage** target
- **Some limitation on use of woody biomass**

- **EPBD**: **District approach to building** decarbonization
- **Phase-out of fossil fuel boilers** in new & refurbished buildings
- **Targets for Heat Pumps** and **Solar thermal**
Building resiliency since the ban on Russian Gas

In fact, an even stronger push has been introduced by the ban on Russian fossil fuels, due to the Ukrainian crisis

- Geo-political reasons are pushing the investment agenda even more towards increased diversification
- The district Heating community has a tremendous opportunity to serve the purpose of this transition

A 10-Point Plan to Reduce the European Union's Reliance on Russian Natural Gas

1. No new gas supply contracts with Russia
   - Impact: Taking advantage of upcoming long-term contracts, Russia will increase its contractual obligations by making early deliveries of Russian gas to 2022 to reduce the risk of a new supply uncertainty
2. Replace Russian supplies with gas from alternative sources
   - Impact: At least 30% of gas supply from non-Russian sources
3. Introduce minimum gas storage obligations to enhance market resilience
   - Impact: Enhance the resilience of the gas system, developing new gas pipeline routes and enhancing gas storage capacity
4. Accelerate the deployment of new wind and solar projects
   - Impact: An additional 15.7 GW of generation from renewables (wind and solar) would be deployed
5. Maximize generation from existing deployable low-emission sources: Bioenergy and waste
   - Impact: An additional 35.7 TWh of power generation from existing deployable low-emission sources, reducing gas use for electricity by 12 TWh
6. Speed up the replacement of gas boilers with heat pumps
   - Impact: Replace gas boilers in existing buildings with heat pumps, reducing demand for natural gas
7. Encourage a temporary thermostat adjustment by consumers
   - Impact: Encourage heated homes to adjust their thermostat to save gas, reducing gas demand by 10 TWh a year
8. Improve energy efficiency improvements in buildings and mobility
   - Impact: Reduce gas consumption for heat by close to an additional 2 TWh within a year
9. Strengthen the short-term flexibility of power system (flexibility)
   - Impact: Increase the flexibility of the European electricity system to reduce gas demand by 10 TWh a year
10. Support efforts to diversify and decarbonize sources of power system flexibility
    - Impact: Leverage existing gas pipelines to introduce new flexibility, reduce emissions, and increase security of supply.
• Resolving the **unit commitment** problem for a typical CHCP plant
• A rather well known problem, that uses (for the most part) MILP approaches
Optimizing production with increasing RES and sector integration

PLANT CONFIGURATION

SYSTEM INTEGRATION
- Field data
- Market data
- Price estimates
- Economics
- Weather forecasts

LONG TERM (YEAR)

SHORT TERM (NEXT DAYS)

FORECASTING

TRADING (SAME DAY)

STRATEGIC DECISIONS
- Investments
- Sensitivity (what-if)
- Budgeting

OPS DECISIONS
- Unit commitment
- Margin optimisation
- Automatisation

TRADING DECISIONS
- DA/SD adj. Trading
- Capacity markets
- XBID
Trading Optimization: Business Integration with conflicting objectives

**Energy Production and Trading Management**

- Cooperation among different divisions of the enterprise
  - System Operators
    - Optimized management with minimal stress on operating units
    - Safe and resilient process
  - DHN
- Trading Operators
  - Maximize margin with dynamic bidding strategies and manage a portfolio of 10 plants
  - Strict market daily sessions
  - Market

**Cross-BU Platform covering the Whole Supply Chain**

- Multi-User
- Multi-Plant
- Multi-Market

Operate on Infraday and Continuous Trading markets, while ensuring operational feasibility of the final plan at the same time.
Optimal development of DHC network (maximization of NPV)
**INVESTMENT EVALUATION**

- **Investment Validation** for network expansion
- Evaluation of **new equipment** integration
- Evaluation of Policy or Contractual Framework **Impacts**

**TECHNICAL ANALYSIS**

- **Thermal-Hydraulic** Simulation (flow and pressure profiles)
- Network Design Analysis and Optimization
- Risk and Maintenance Assessment
DECISION DRIVERS INTEGRATION

The Tool supported the transition from the commercial to the engineering departments, speeding up the project execution.

- Optimal allocation of 100 MWth in densely populated area
- Quick transition from plan to construction
New perspective users to be connected (88 MWth)
- New (greener) sources: Thermal Plant (600 MWth) + WTE (56 MWth)
- Planned construction of new piping and refurbishing of existing piping

- Temperature-based regulation in Zemun - NB
- Flow-based regulation in Konjarnik-NB-Dunav system
Objectives

- Develop a decision support tool to design the optimal (cost-effective) decarbonized energy systems of the future, balancing investments between supply & transmission/distribution networks.
- Electricity, heat, gas, EV-load and hydrogen integration exploiting synergies & flexibility.
- Dedicated models to manage:
  - Large scale / National / Transmission system (HV) - use case: Germany.
  - Local case / Regional / Distribution system (MV) Use case: Bilecik region, Turkey.

Partners

Advisory board

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 863922.
Generation of long-term and Large-scale scenarios of future multi-energy (electricity, heat, gas, EV-load and H₂) systems designed to meet decarbonization targets with minimum costs.

Balanced development requirements based on future demand between transmission / distribution and optimized RES supply and coupling infrastructure, leveraging on the flexibility of a multi-energy approach.

Detailed (year, with hourly granularity) optimized energy production mix for each scenario.
Decarbonisation is becoming key alo on the other side of the ocean

• New York State **Climate Leadership and Community Protection Act** is amongst the most ambitious climate laws in the USA and requires NYC to reduce economy-wide greenhouse gas emissions 40% by 2030 and no less than 85% by 2050 (wrt 1990 levels)

• **Local Law 97** requires most medium to large size **buildings** (that produce the majority of the emissions) meet new energy efficiency and GHG emissions limits by 2024, with stricter limits coming into effect in 2030 and beyond

• **Local Law 154** dictates the **phase out of fossil fuels** for all new constructions starting in 2024

The local utility, that manages the steam system for the city of NY (USA), has the imperative to become the key decarbonization enabler for the whole city (vs. costs of electrification)
• Review of regulatory and strategic objectives
• Analysis of current processes and systems
• Evaluate the impacts of new technologies, like the integration of Renewable energy sources (Wind + Solar) and lower temperature (hot water) networks
• Enable fuel source diversification, sector coupling and integration, crucial to manage the upcoming system
• Qualification of the digital and analytics tools to manage and integrate the whole value chain, from production to carbon accounting for the individual customer
• Definition of the development roadmap and its progressive implementation
Looking ahead: resorting to (Trustworthy) AI to explore novel approaches.

**TUPLES**

TRUSTWORTHY PLANNING AND SCHEDULING WITH LEARNING AND EXPLANATIONS

TUPLES is a 3 year project aiming to obtain scalable, yet transparent, robust and safe algorithmic solutions for planning and scheduling, combining symbolic P&S methods with data-driven methods.

We will demonstrate and evaluate our methods in a laboratory environment, on a range of use cases, including an energy management case posed by Optit.

We expect to explore novel hybrid modelling techniques to describe and resolve large, complex problems.

Figure 1: use-case driven development process