



OPTIT
optimal solutions

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

4th EURO Practitioners' Forum Conference
Berlin 21st April 2023

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THE ASSOCIATION OF
EUROPEAN OPERATIONAL
RESEARCH SOCIETIES

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PRACTITIONERS' FORUM

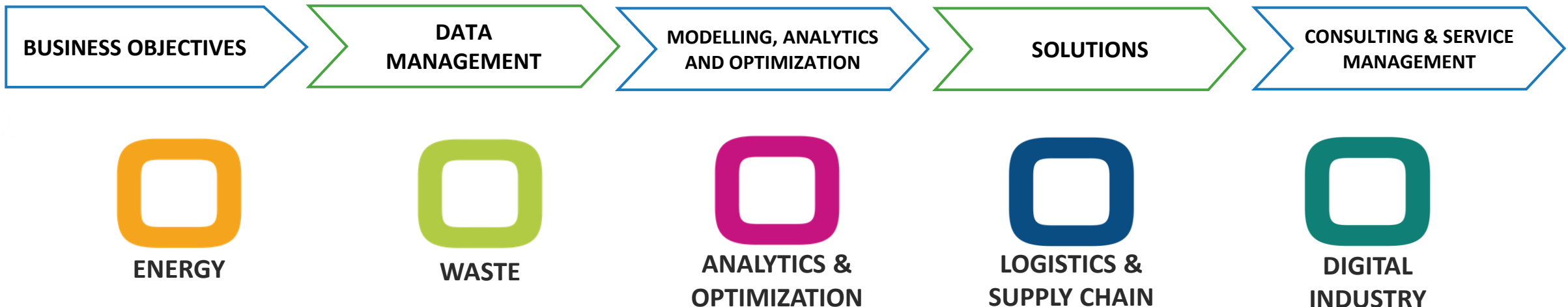
Decision Support Systems & Services based on Operations Research, Data Science, Advanced Analytics & Artificial Intelligence

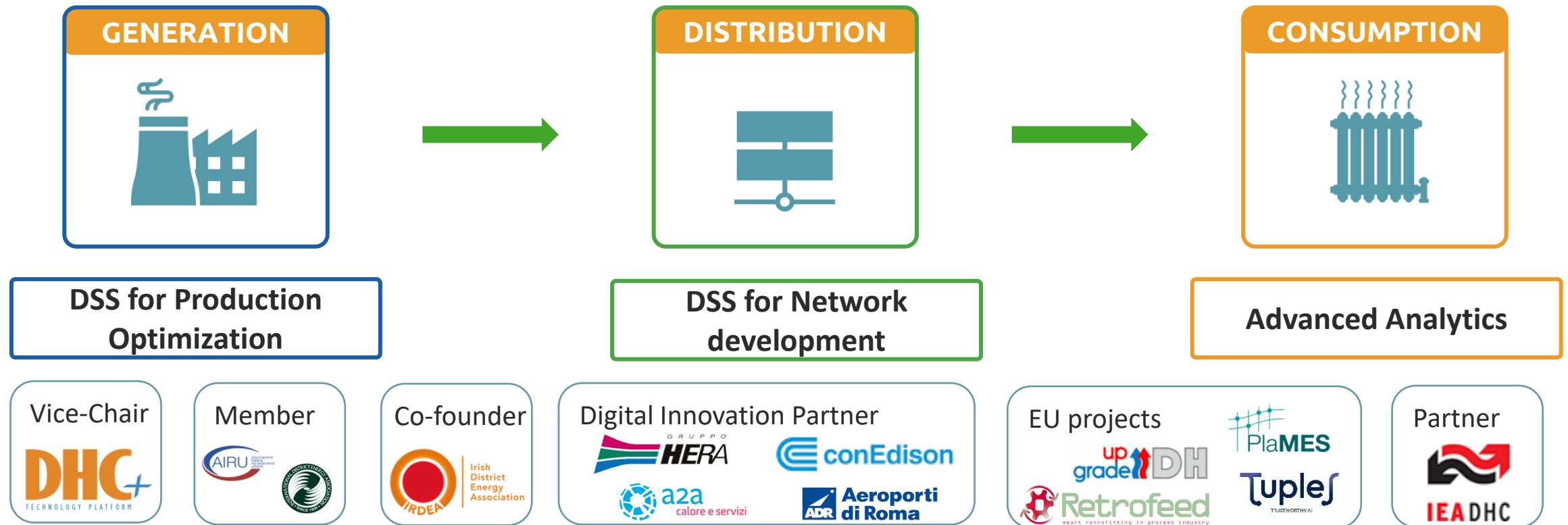


45+ talents working to turn
digital innovation into reality



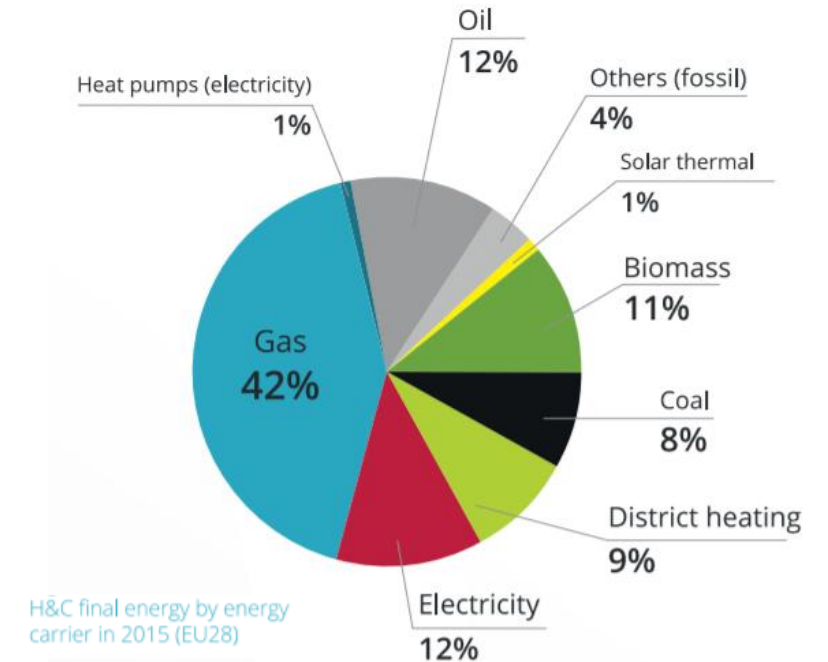
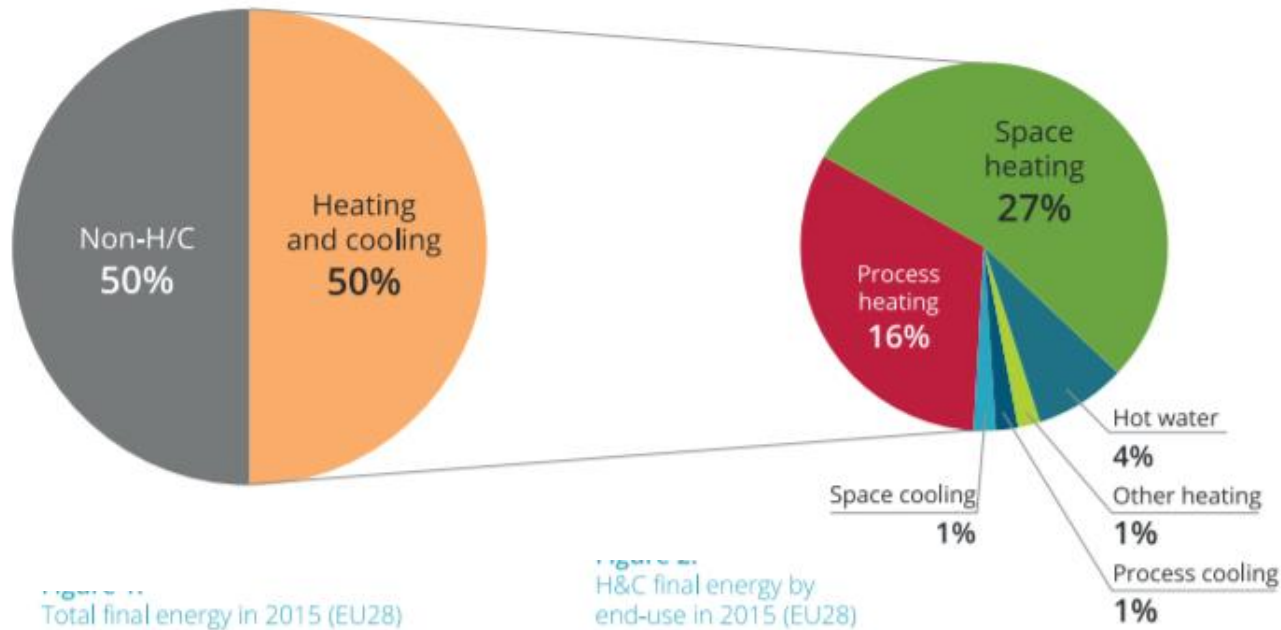
Bologna: Headquarters
Cesena: SW Factory





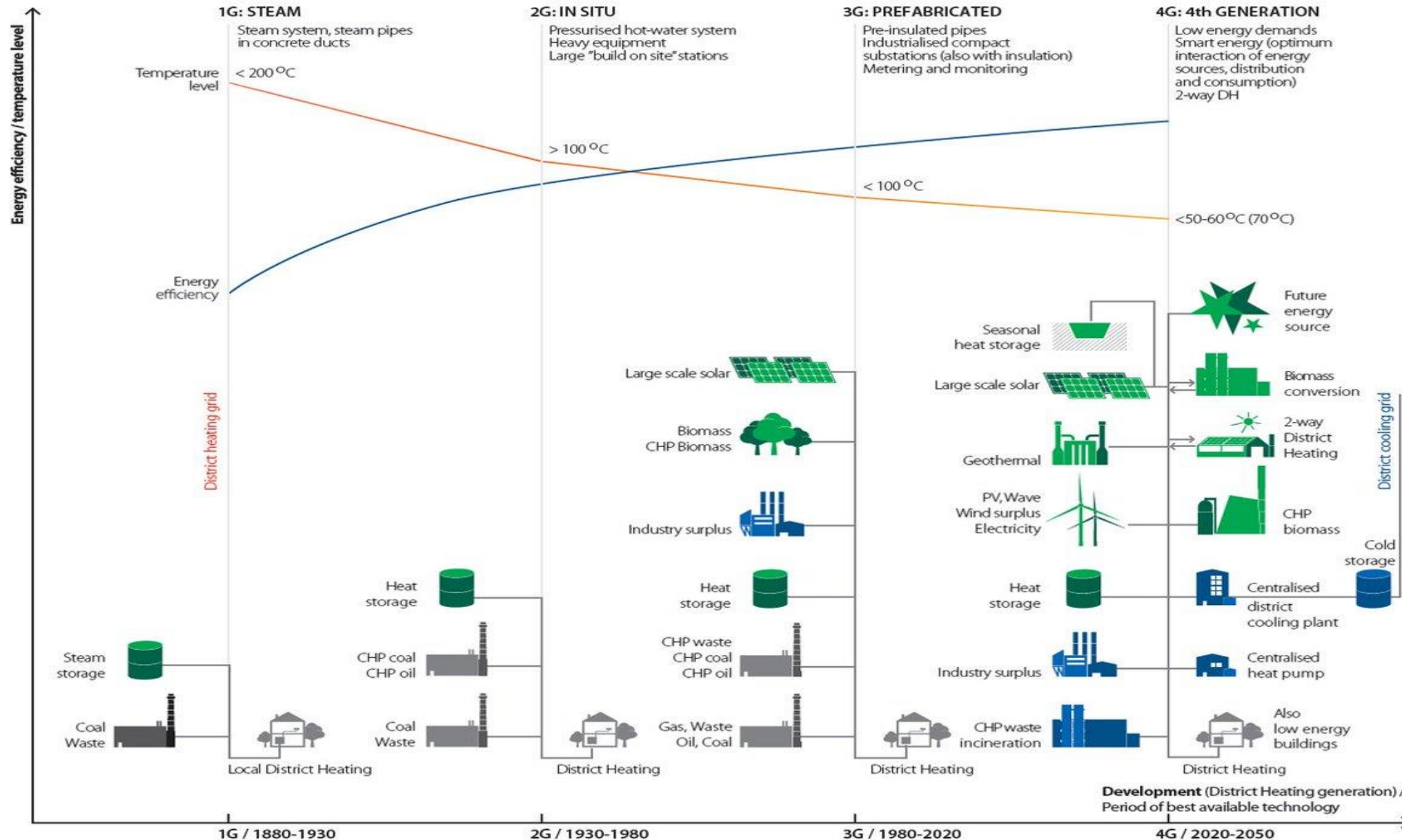
- How is the sector is being shaped by the current legislation for decarbonization?
- What is the role of OR (and Advanced Analytics) as enablers of the industry's transition?

Courtesy by Heat Roadmap Europe



- 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.



COMPLETED

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 45euro/ton until 2030).



Last trilogue on 29.03

RED

- **Waste heat** accountable towards RES targets
- **Sector integration**: accounting of green electricity towards H&C targets and DHC targets, **thermal storage** target
- Some limitation on use of woody biomass



Last trilogue on 09.03

EED

- Gradual **phase-in RES** and WH for efficient DHC
- Mandatory local heating & cooling **planning** (45k citizens)
- Mandatory waste heat recovery for **data centers** above 1MW



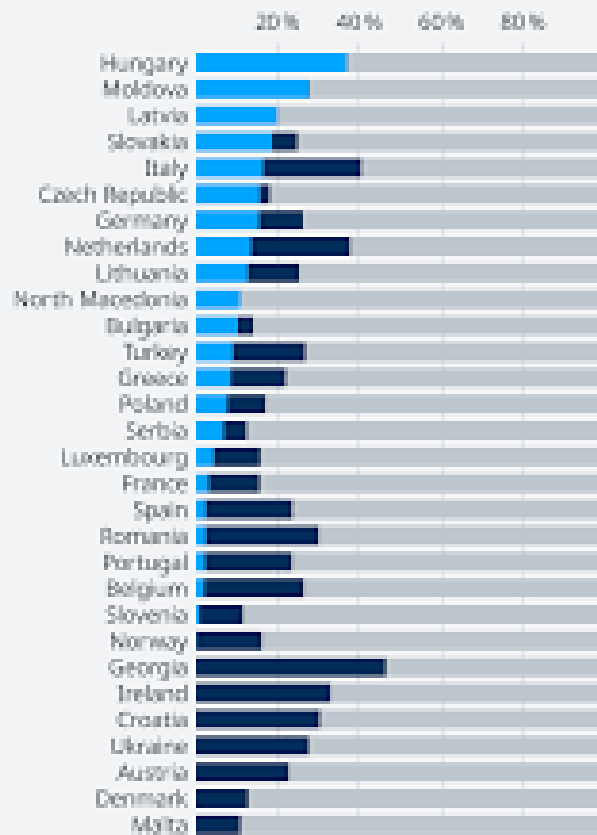
EPBD

- District approach to **building** decarbonization
- **Phase-out of fossil fuel boilers** in new & refurbished buildings
- Targets for Heat Pumps and Solar thermal

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

The European countries most dependent on natural gas from Russia

Share in energy mix of ■ natural gas from Russia, ■ gas from other sources, and ■ other energy types

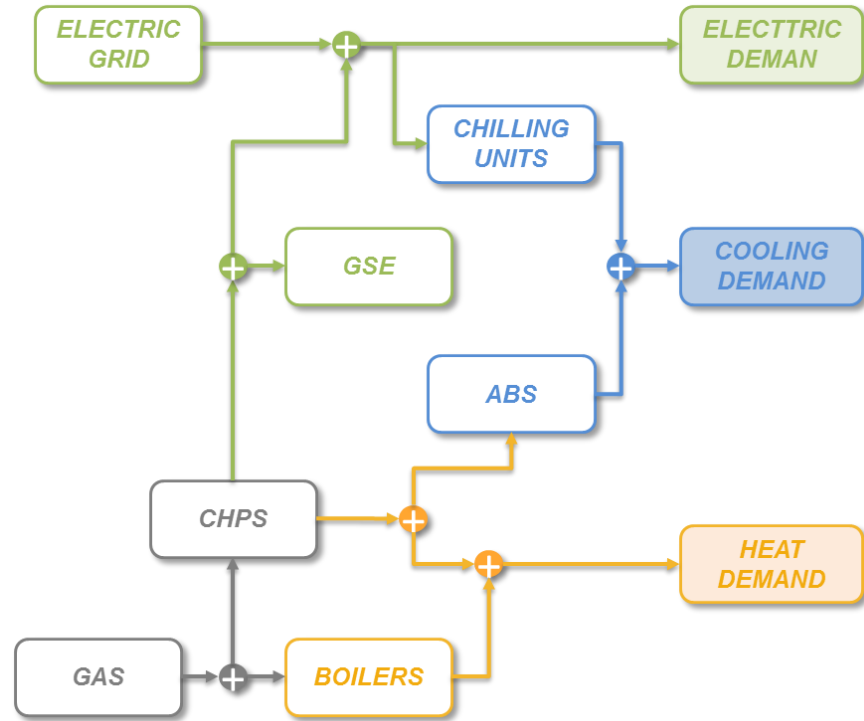


- Geo-political reasons are pushing the investment agenda even more towards increased diversification
- The district Heating community has a tremendous opportunity to serve the purpose of this transition

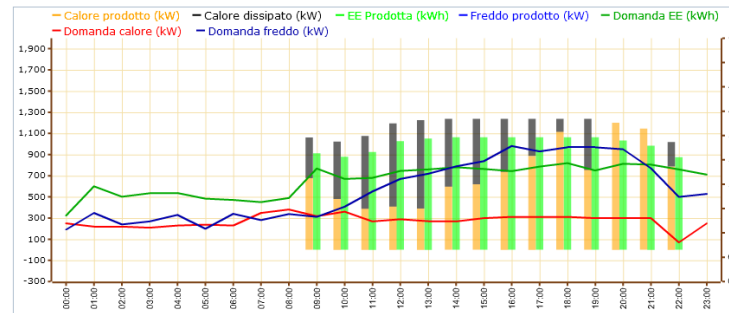
A 10-Point Plan to Reduce the European Union's Reliance on Russian Natural Gas

Measures implemented this year could **bring down gas imports from Russia by over one-third**, with additional temporary options to deepen these cuts to **well over half** while still lowering emissions.

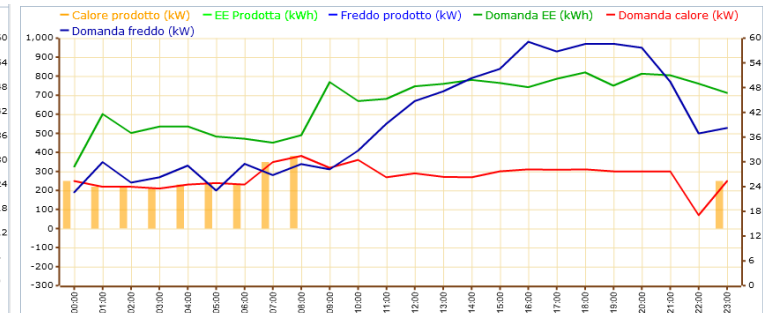
- | | |
|---|--|
| Action 1
No new gas supply contracts with Russia
Impact: Taking advantage of expiring long-term contracts with Russia will reduce the contractual minimum take-or-pay levels for Russian imports and enable greater diversity of supply. | Action 2
Replace Russian supplies with gas from alternative sources
Impact: Around 30 bcm in additional gas supply from non-Russian sources. |
| Action 3
Introduce minimum gas storage obligations to enhance market resilience
Impact: Enhances the resilience of the gas system, although higher injection requirements to refill storage in 2022 will add to gas demand and prop up gas prices. | Action 4
Accelerate the deployment of new wind and solar projects
Impact: An additional 35 TWh of generation from new renewable projects over the next year, over and above the already anticipated growth from these sources, bringing down gas use by 6 bcm. |
| Action 5
Maximise generation from existing dispatchable low-emissions sources: bioenergy and nuclear
Impact: An additional 70 TWh of power generation from existing dispatchable low emissions sources, reducing gas use for electricity by 13 bcm. | Action 6
Enact short-term measures to shelter vulnerable electricity consumers from high prices
Impact: Brings down energy bills for consumers even when natural gas prices remain high, making available up to EUR 200 billion to cushion impacts on vulnerable groups. |
| Action 7
Speed up the replacement of gas boilers with heat pumps
Impact: Reduces gas use for heating by an additional 2 bcm in one year. | Action 8
Accelerate energy efficiency improvements in buildings and industry
Impact: Reduces gas consumption for heat by close to an additional 2 bcm within a year, lowering energy bills, enhancing comfort and boosting industrial competitiveness. |
| Action 9
Encourage a temporary thermostat adjustment by consumers
Impact: Turning down the thermostat for buildings' heating by 1°C would reduce gas demand by some 10 bcm a year. | Action 10
Step up efforts to diversify and decarbonise sources of power system flexibility
Impact: A major near-term push on innovation can, over time, loosen the strong links between natural gas supply and Europe's electricity security. Real-time electricity price signals can unlock more flexible demand, in turn reducing expensive and gas-intensive peak supply needs. |



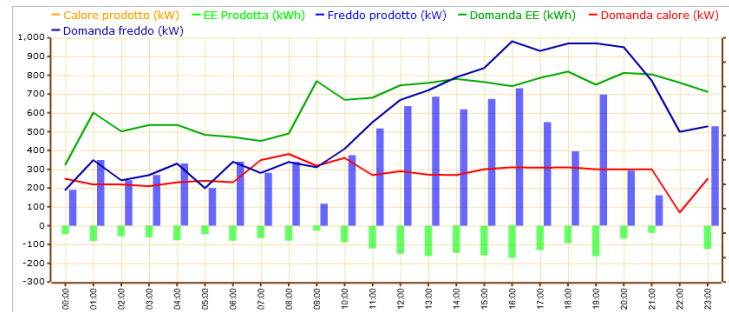
CHPs



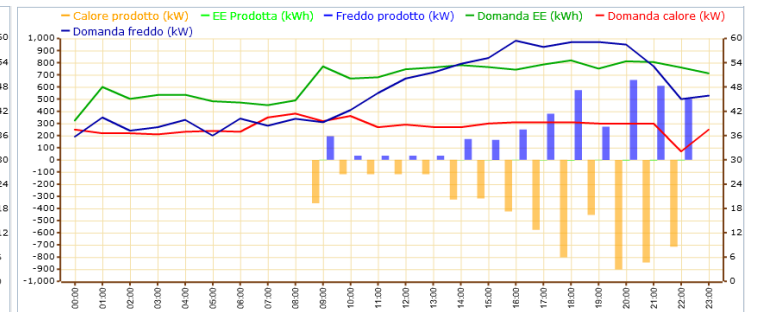
Boilers



Electrical Chillers

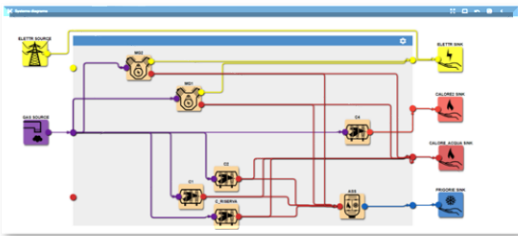


Absorption Chillers



- Resolving the **unit commitment** problem for a typical CHCP plant
- A rather well known problem, that uses (for the most part) MILP approaches

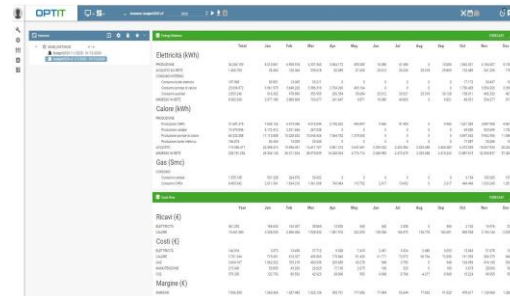
PLANT CONFIGURATION



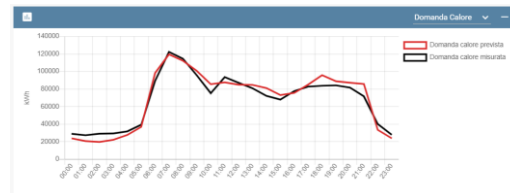
SYSTEM INTEGRATION

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

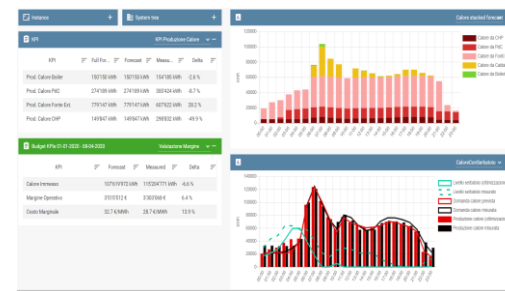
LONG TERM (YEAR)



FORECASTING



SHORT TERM (NEXT DAYS)



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

ENERGY PRODUCTION AND TRADING MANAGEMENT



CROSS-BU PLATFORM COVERING THE WHOLE SUPPLY CHAIN

MULTI-USER

MULTI-PLANT

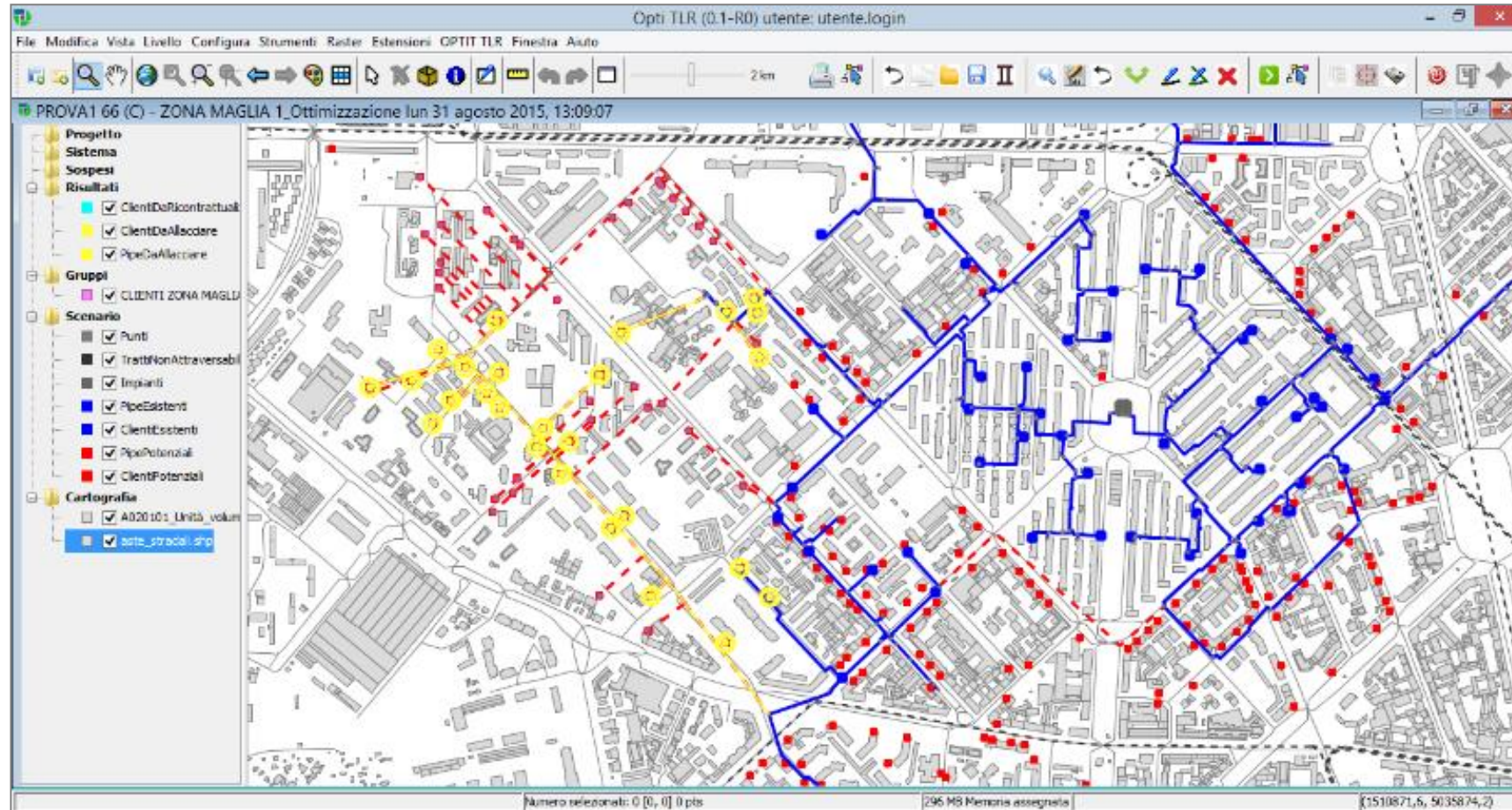
MULTI-MARKET


Existing &
potential **pipings**


Existing &
potential **users**


Existing &
potential **plants**


Import + Puntual
editing /drawing




Advanced
Scenario Mgmt

€
Tariffs &
Capex/Opex


Technical
constraints


Financial
parameters

INVESTMENT EVALUATION

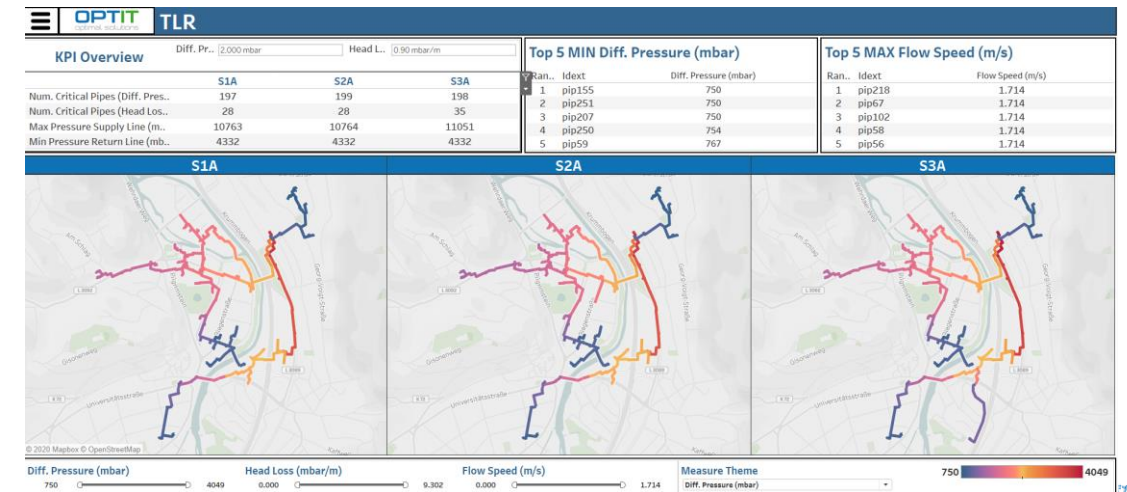
- **Investment Validation** for network expansion
- Evaluation of **new equipment** integration
- Evaluation of Policy or Contractual Framework **Impacts**

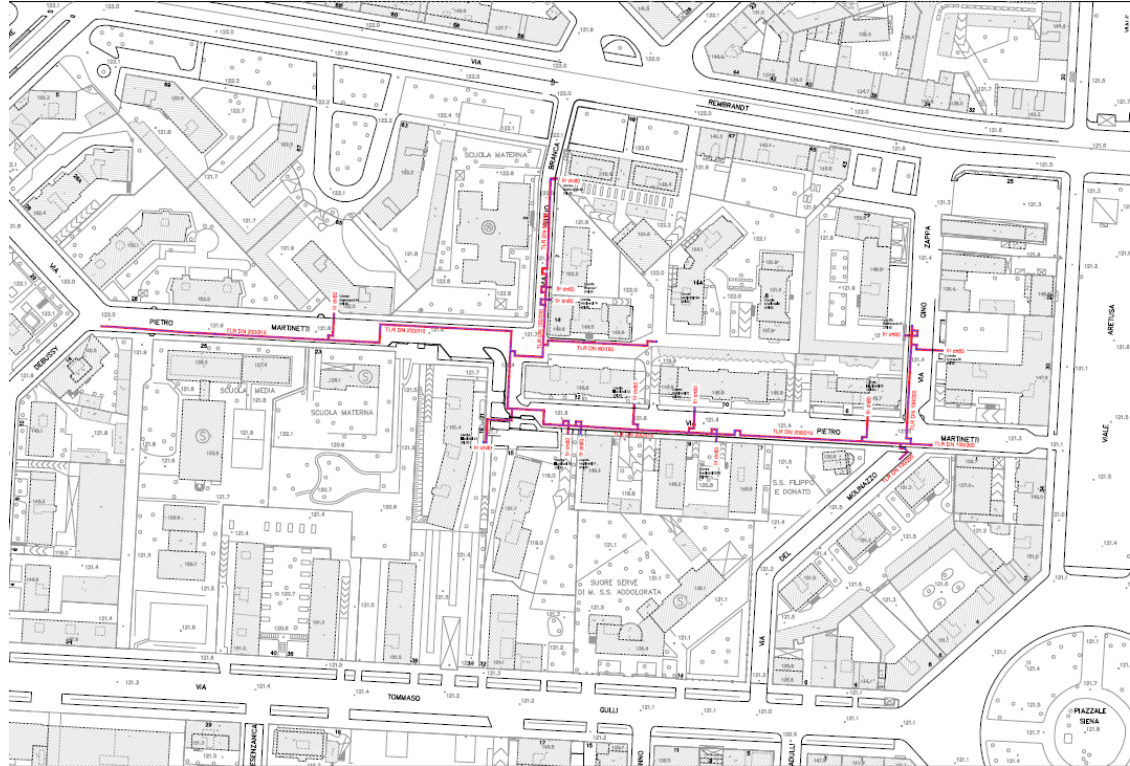
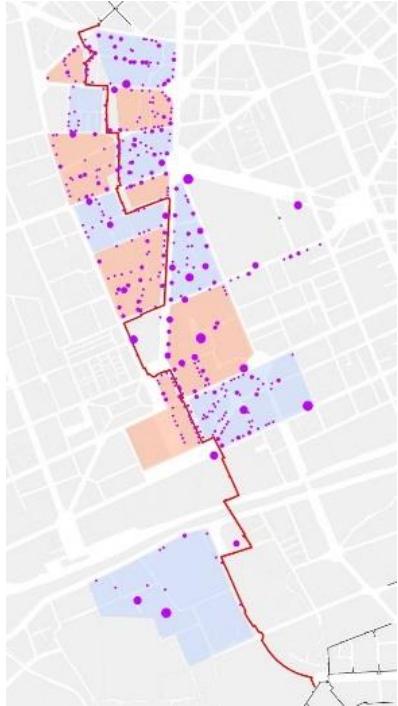
Parametri input											
Parametro	Valore										
GRUPPO DI RIFERIMENTO	Potenza (kW) >= 50.0 Distanza (m) <= ...										
Costo fisso contratto nuovo allaccio (€)	0										
Costo fisso contratto ricontrattualizzazio...	100										
Pressione min cliente (bar)	0,4										
Fattore contemporaneit�	0,6										
Tasso di interesse VAN	0,065										
Max denti allacciabili	50										
Max denti ricontrattualizzabili	100										
Profilo min ricontrattualizzabilit� (h)	400										
Profilo max ricontrattualizzabilit� (h)	1.100										
Pressione max impianto	...										
Pressione ritorno cliente	...										
Orizzonte temporale (an)	A	B	C	D	E	F	G	H	I	J	K
ANNO	RICAVO	COSTO	AMMORTAMENTO	IMPONIBILE	TASSE	FLUSSO_NETTO	COEFF	VALORE ATTUALIZZATO	VALORE_ATT_CUMULATO		
1	0	€ 221.612	€ 1.093.214	€ 23.296	€ 65.348	€ 20.519	€ 892.122	1,000	€ 892.122	€ 892.122	
2	1	€ 354.579	€ 357.999	€ 28.656	€ 113.175	€ 35.537	€ 38.957	0,926	€ 36.071	€ 928.193	
3	2	€ 443.223	€ 362.768	€ 32.229	€ 145.060	€ 45.549	€ 34.906	0,857	€ 29.926	€ 898.267	
4	3	€ 487.546	€ 340.945	€ 34.016	€ 161.002	€ 50.555	€ 96.046	0,794	€ 76.245	€ 822.022	
5	4	€ 531.868	€ 367.538	€ 35.802	€ 176.945	€ 55.561	€ 108.769	0,735	€ 79.949	€ 742.074	
6	5	€ 576.190	€ 394.131	€ 37.589	€ 192.887	€ 60.567	€ 121.492	0,681	€ 82.686	€ 659.388	

K	L	M
INDICE	VALORE	
VAN	€	399.739
TIR		12,1%
BPT		14

TECHNICAL ANALYSIS

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





- Optimal allocation of 100 MWth in densely populated area
- Quick transition from plan to construction



PROGETTO n. 15/0149	
DATA: 01/01/15	SCALA: 1:500
CANTIERE DI MILANO	
INDIZIO 3014	DATA: 01/01/15
REPERITO STRADA	PROTEZIONE NF
VISIBILITA' URBANA	PROTEZIONE NF
CONSEGNA DI ZONA	DA COLLOCARE
ATTRAVERSAMENTI	DA ABBANDONARE
ESISTENZE	DA ABBANDONARE
DA TOLLERARE	DA RINFORZARE
SEGNALETICA CRUCIALE	DA CAU PROTET. CA
SCAVO TOT. m	750
ASSAGGI	DA CAU PROTET. CA
MODIFICATO	DATA MODIFICA
DISIGNATO	Stefano Audi
VERSO	Giulia
REVISIONE	



DECISION DRIVERS INTEGRATION

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

Connection of a new user (10 MW_{th})

New planned DN350 backbone in Zemun

New pumping stations

New source connection (TENT A)

Connection Zemun - NB



**DISTRICT ENERGY
IN CITIES
INITIATIVE**



- New perspective users to be connected (88 MW_{th})
- New (greener) sources: Thermal Plant (600 MW_{th}) + WTE (56 MW_{th})
- Planned construction of new piping and refurbishing of existing piping

«Outer ring»

M3

“Outer ring” proved not to be necessary

Connection of new users (63 MW_{th})

New pumping station(s)

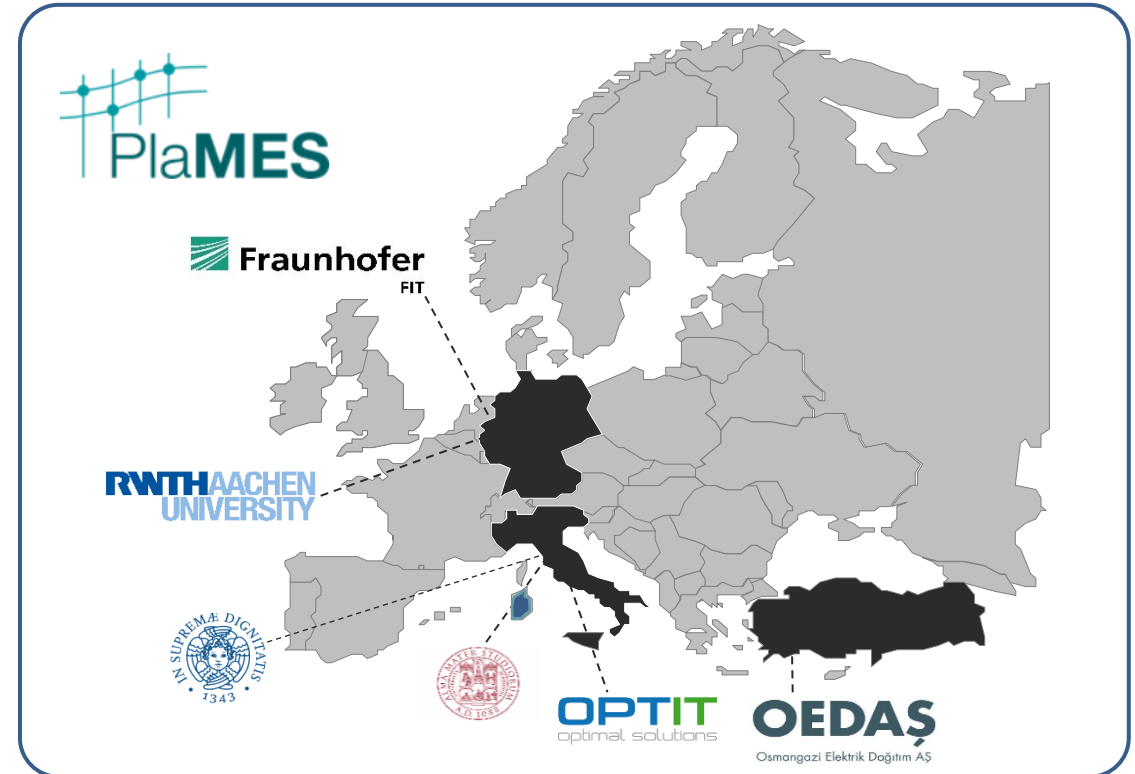
Existing Boiler stations to be shut down

- 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

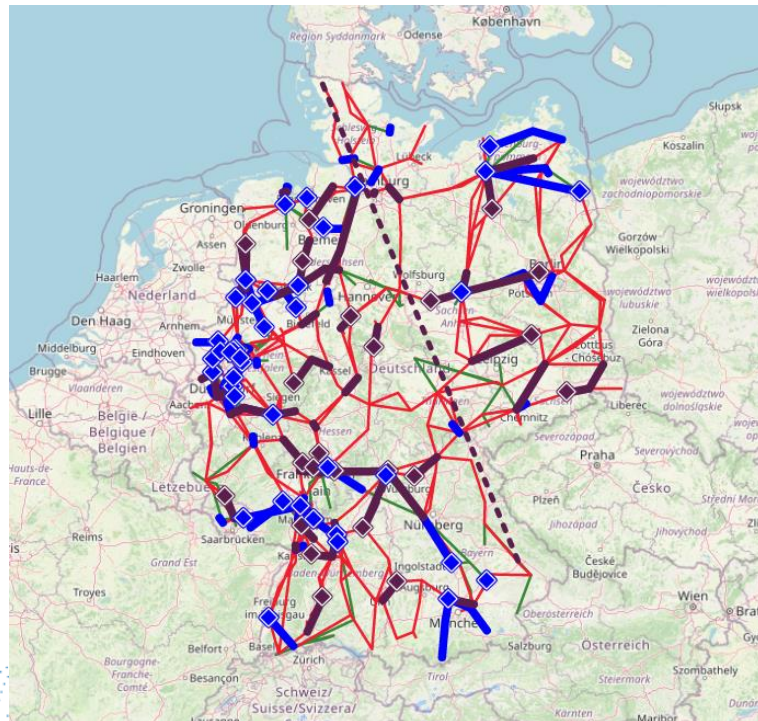
PlaMES

Instances comparison

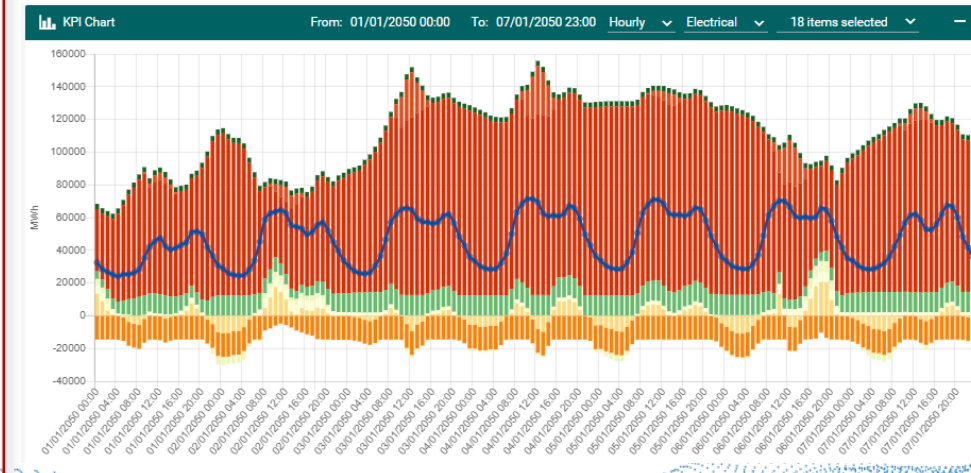
Target version: ehghways_2050_v3 | Network Category: Electrical

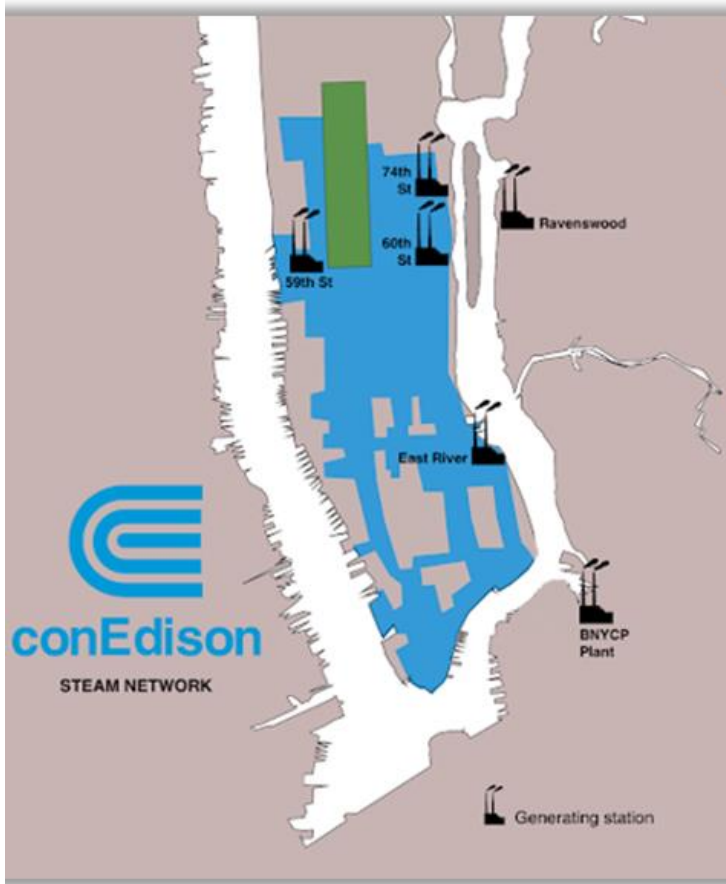
KPI	ehghways_2050_v3	Germany_2019_v3	Δ	baseline_large	Δ
Loads					
Electricity BaseLoad [TWh]	414.14	578.24	39.63% ▲	376.64	-9.05% ▼
Fuel Consumption [TWh]	305.78	709.73	132.10% ▲	212.10	-30.64% ▼
Generations [TWh]					
Total	412.50	605.44	46.77% ▲	375.00	-9.05% ▼
Total Non-Renewable	85.25	289.78	239.92% ▲	40.92	-52.68% ▼
Gas Engine expansion	3.33	81.33	2408.81% ▲	13.84	297.43% ▲
Combined Cycle Gas Turbine	46.13	148.63	222.21% ▲	9.72	-78.95% ▼
Simple Cycle Gas Turbine	0.76	1.21	57.66% ▲	0.03	-99.47% ▼
Steam Turbine Power Plant	0.78	16.78	2041.92% ▲	0.27	-65.63% ▼
Internal combustion engine	0.01	8.46	65649.04% ▲	0.01	-11.45% ▼
Combined Cycle Gas Turbine CCS	0.11	33.98	1.00% ▼	0.11	-0.16% ▼
District Heating SCOT (back pressure)	34.22	309.77	41.94% ▼	17.95	-47.55% ▼
Total Renewable	325.40	315.66	-3.09% ▼	334.08	2.67% ▲
Onshore wind turbines	295.52	147.68	-50.03% ▼	390.66	1.76% ▲
Photovoltaic	64.54	30.77	-21.33% ▼	134.30	108.10% ▲
Offshore wind turbines	92.89	30.80	-66.84% ▼	44.66	-51.83% ▼
Run-of-river	30.00	29.97	-0.10% ▼	28.00	-6.67% ▼
Biomass	50.54	50.54	-0.00% ▼	47.61	-5.70% ▼
Total Other	-206.24	5.89	102.85% ▲	-221.16	-7.23% ▼
CO2 Emissions [MtonCO2]	88.90	161.55	81.72% ▲	82.73	-6.94% ▼
Capex [B€]	244.43	233.66	3.77% ▼	266.66	9.09% ▲
Opex [B€]					

Detailed (year, with hourly granularity) optimized **energy production mix** for each scenario



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

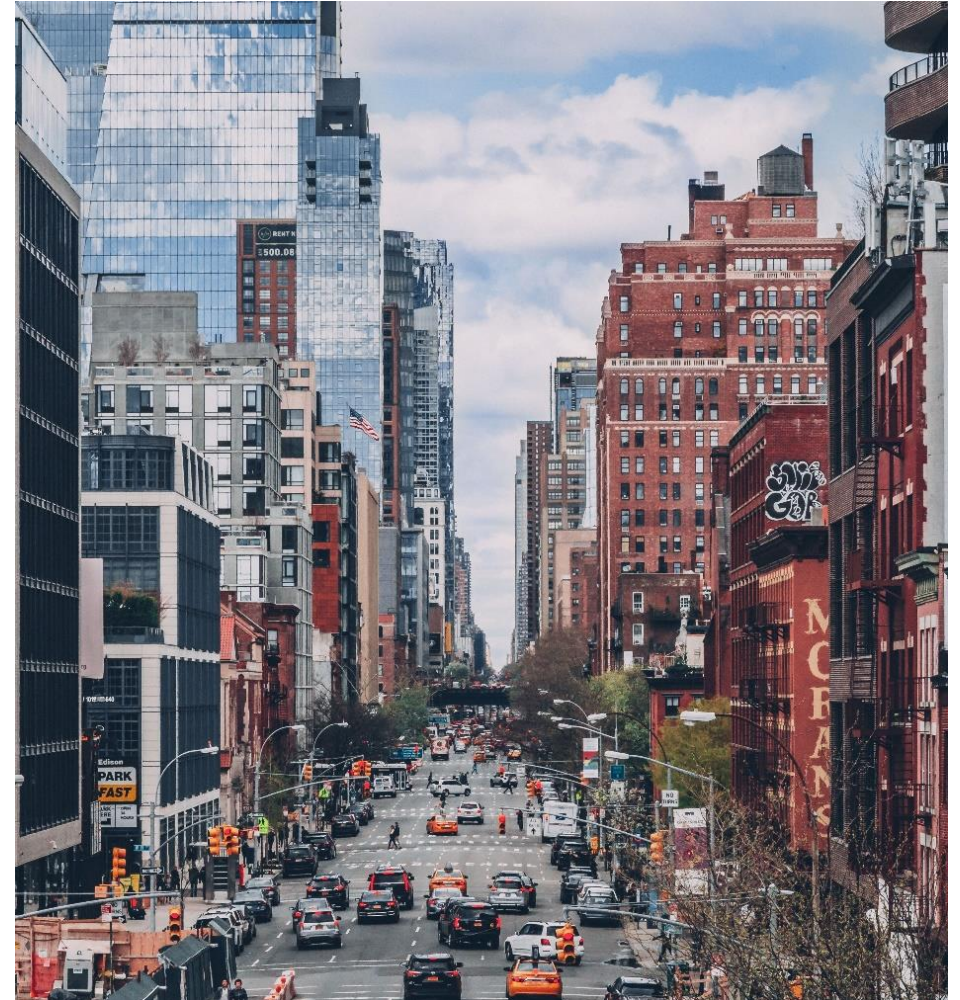




- New York State **Climate Leadership and Community Protection Act** is amongst the most ambitious climate laws in the USA and requires NYC to **reduce economy-wide greenhouse gas** emissions 40% by 2030 and no less than 85% by 2050 (wrt 1990 levels)
- **Local Law 97** requires most medium to large size **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





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

AIRBUS



KU LEUVEN



Université
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ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

SCISPORTS

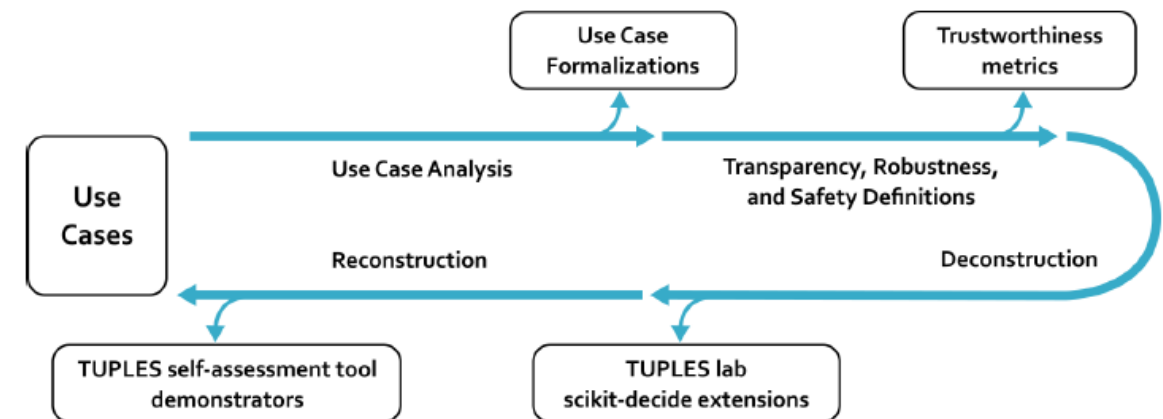


Figure 1: use-case driven development process

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