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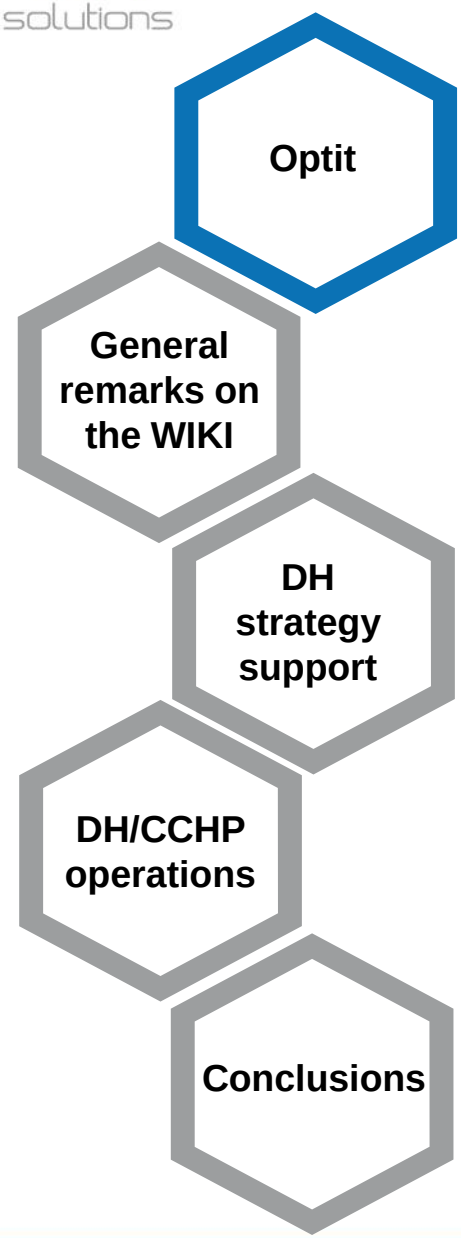
New problems in energy optimization: the industrial perspective

Current and future perspectives of DSS in support of thermal/district heating networks and plants

International Centre for Mathematical Sciences
Edinburgh
27th January 2016

AGENDA



Short Company Profile

Energy Commodities System
Electrical Energy System
DH & CCHP fundamentals

Optit's solution for District Heating development optimization

Optit's solution for Energy Production optimization

Future challenges & perspectives
Final remarks

OPTIT: WHO WE ARE

Optit srl is an academic spinoff of the Operations Research team of the University of Bologna, founded in 2007.

Optit develops innovative **Decision Support Systems** leveraging on forecasting, data analytics, simulation and optimization tools

OPERATIONS RESEARCH

- Operations research- based modelling (mathematical modelling, linear programming, heuristic algorithms, data mining)
- Members of the scientific community both at national and international level

IT SOLUTIONS DEVELOPMENT & DEPLOYMENT

- Industry-standard SW application development (J2EE, GXT/GWT, GIS tools, various DB, professional & open source optimization engines, …)
- IBM Business Partner
- FICO ISV

BUSINESS ANALYSIS & CONSULTING

- Management & business consulting
- Business focus, advanced project & change management
- Service focus

EURO 2012 25th European Conference on Operational Research 8-11 July 2012

EURO|INFORMS MMXIII 26TH EUROPEAN CONFERENCE ON OPERATIONAL RESEARCH ROME 1-4 JULY, 2013

informs

Veolia Innovation Accelerator

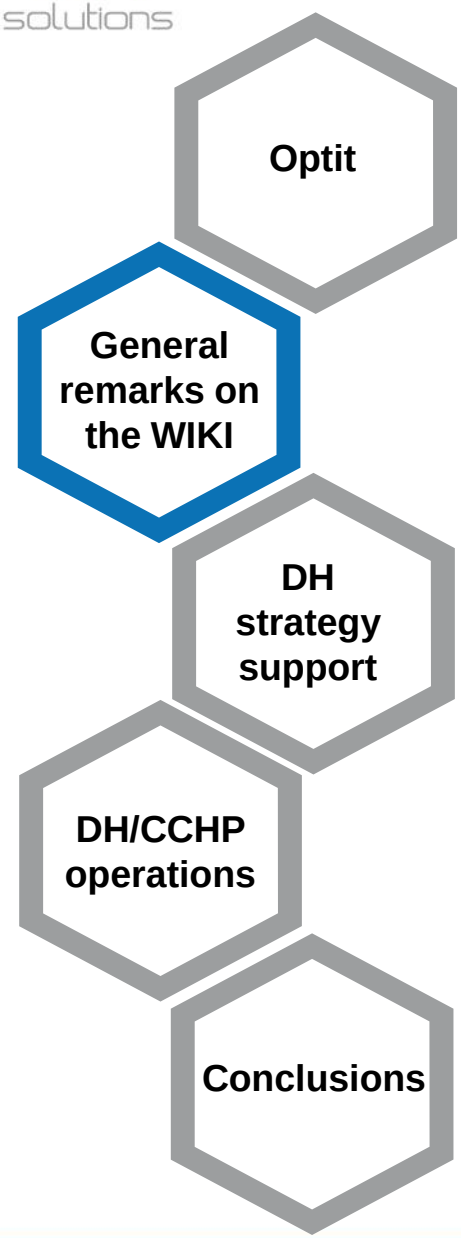
PREMIO INNOVAZIONE DIGITALE SMAU 2015

OPTIT: WHAT WE DO

Optit leverages on state-of-the-art **Operations Research** to develop solutions to support **strategic, tactical and operations planning** processes in various industries

- (Human) Resource planning and scheduling (Utilities, Retail)
- CHCP energy forecasting and production planning
- Development of District Heating networks
- Waste collection service planning (primary logistics)
- Waste flow management (secondary logistics)
- Distributive logistics
- Raiway traffic conflict solution
- Cash logistics
- Bin packing design

AGENDA



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ENERGY COMMODITIES SYSTEMS

The current focus seems to neglect entirely the opportunities and issues linked to **thermal energy (district heating/cooling) distribution**

Horizon/ Problems	Planning	Production	Network and storage management	Other Problems
Strategic	• Gas pipelines design • Thermal (District Heating) network design	• Oil wells placements • Gas wells placements		• Take or Pay (ToP) oil constracts • ToP gas constracts
Tactical	• Thermal (District Heating) commercial development			
Operational		• Total gas recovery maximization • District Heating Unit Committment	• Gas network flow optimization • Gas storage operation optimization • District Heating network flow optimization	• Gas balancing markets

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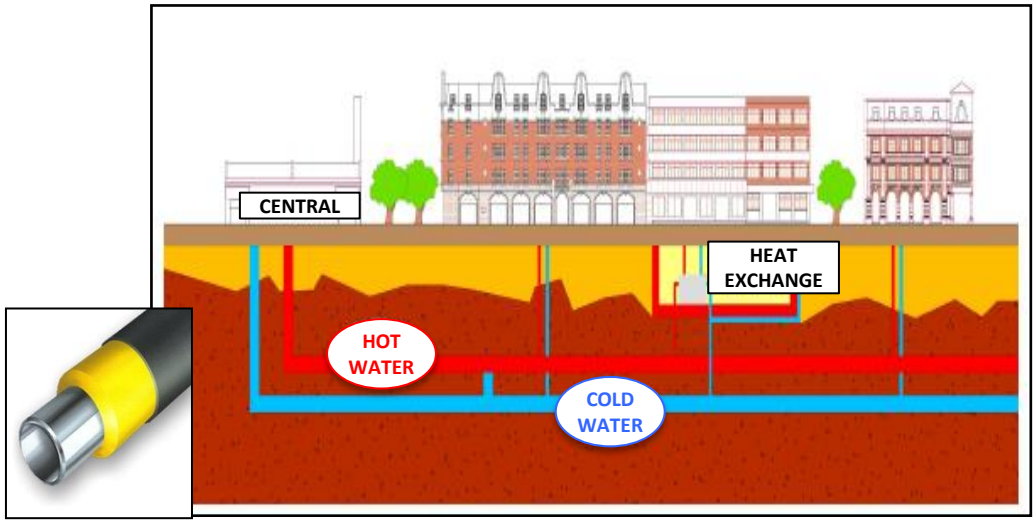
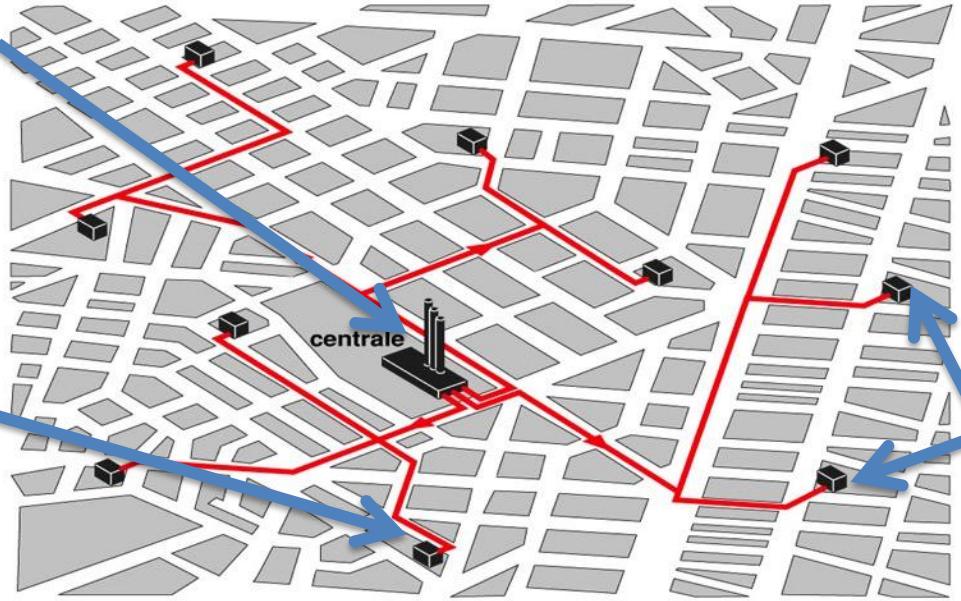
ELECTRICAL ENERGY SYSTEMS

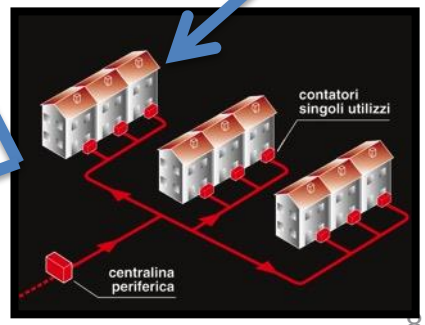
Horizon/ Problems:	Planning	Production Management	Network Management	Maintenance Management	Other Problems
Strategic	• Generation Expansion (dismission) Planning (GEP) • Network Expansion Planning (NEP)	• Long term Unit Commitment (UC)	• Transmission and distibution network reinforcements • Energy Storage System (EES) siting and sizing • Smart grids design	• Power plants long term maintenance • Transmission and Distribution network long term maintenance	• Long Term electricity bilateral contracts
Tactical	• DH Plants design	• Medium term UC • Medium term hydro reservoirs management		• Power plants medium term maintenance • Transmission and Distribution network medium term maintenance	• Portfolio optimization and derivatives intruments
Operational		• Monopolist:short term UC • Market: max profit short Term UC • Energy markets • Balancing markets and non programmable (renewable) power coordination • CHCP production to feed DH networks	• Optimal Power Flow • Security Constrained UC (SCUC) • N-k security problems • Optimal Transmission Switching (OTS) • Optimal Network Islanding • Smart grids operations		• Combined gas and power optimization (high level system focus)

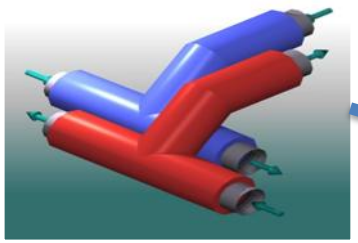
DISTRICT HEATING

- District heating systems provide the heat generated in a centralized location to a set of users (private and commercial)
- Heat distribution is made with hot water or steam flowing through a closed network of insulated pipes (two pipes: feed and return) and heat exchange stations at the users locations.









Heat required by a DH system is generally produced in centralized (large) plants, often using different thermal sources (industrial symbiosis)

TRADITIONAL BOILERS

CO-TRI-GENERATORS (CH&P)

HEAT STORAGES

INDUSTRIAL «WASTE HEAT»
(e.g. from chemical plants)

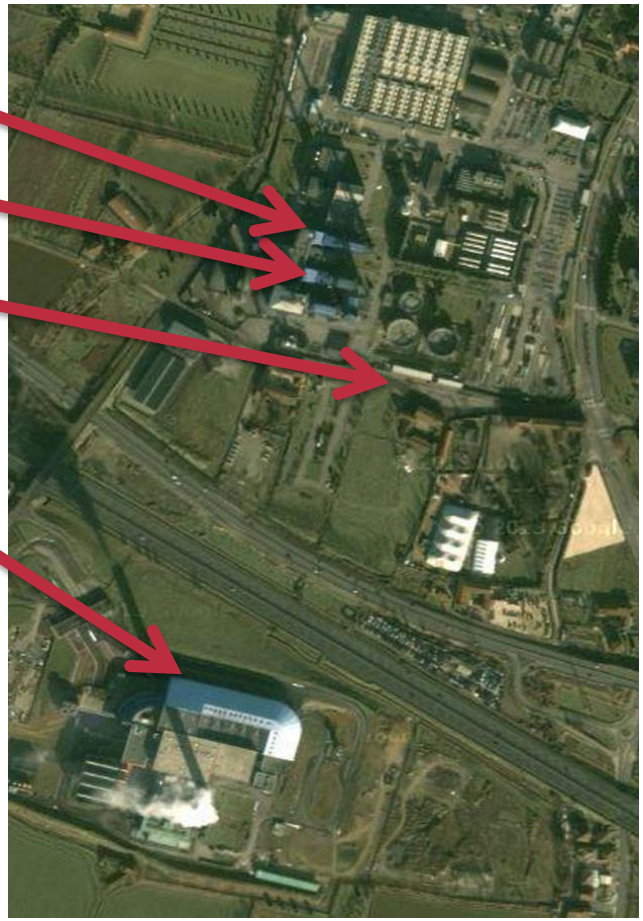
WASTE TO ENERGY

HEAT PUMPS

GEOTHERMAL SOURCES

SOLAR THERMAL

BIOMASSES



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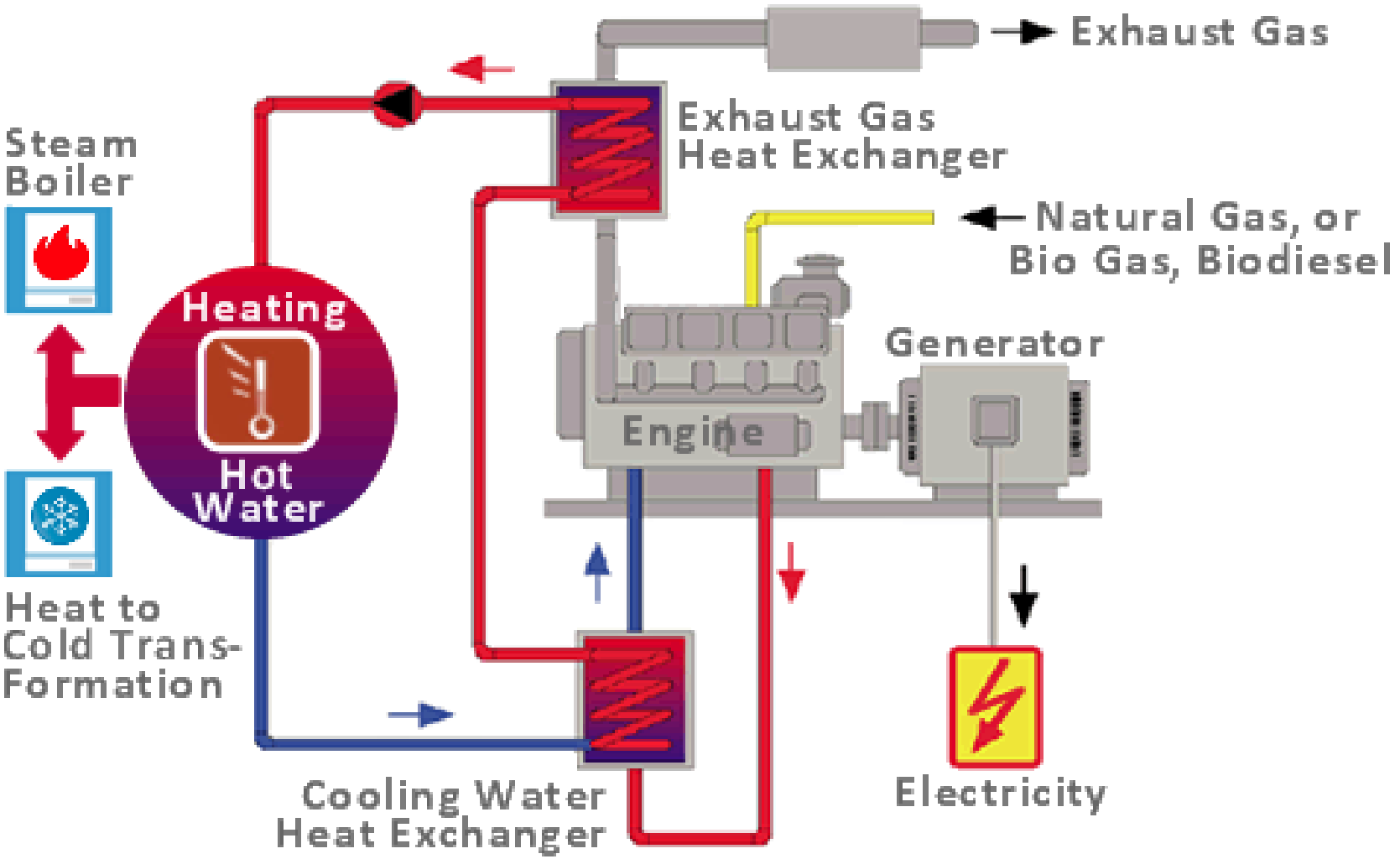
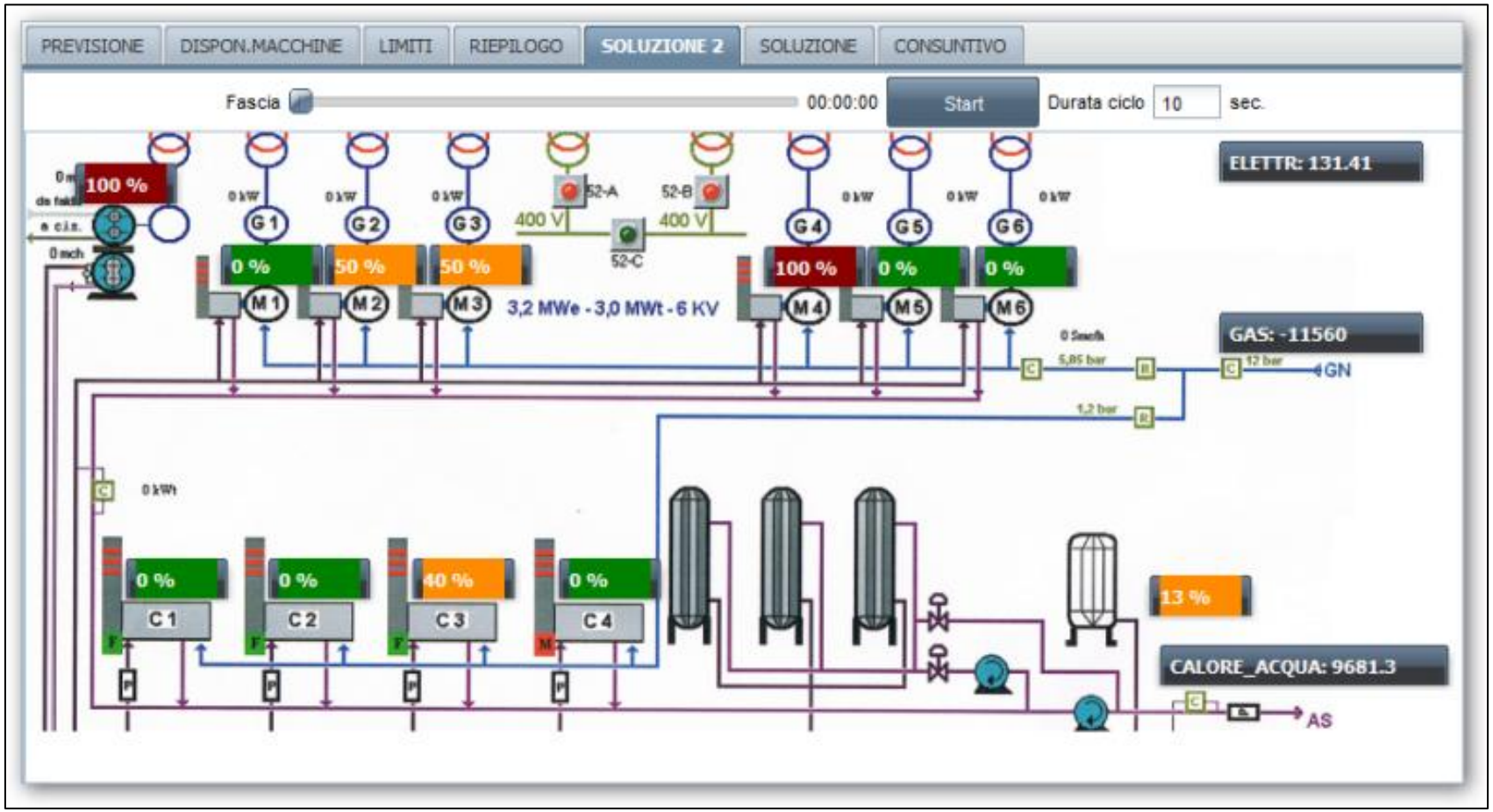
COMBINED HEAT & POWER GENERATION



CHP PLANT FOR A LARGE URBAN DISTRICT HEATING NETWORK



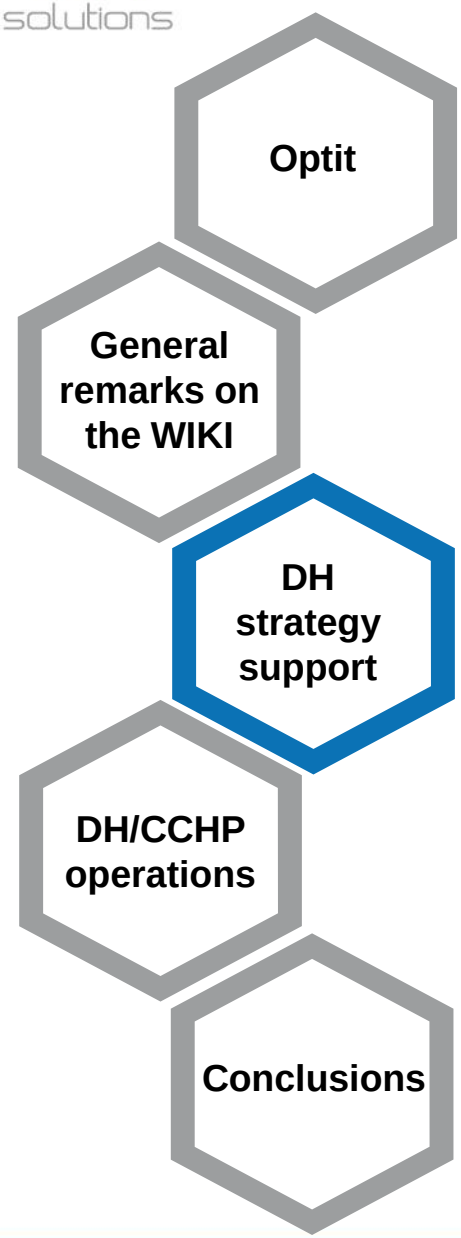
District Heating & Cooling and Combined Heat & Power production are fully recognized measures in the European Energy Efficient Strategy

Energy Efficiency Directive 2012/27/EU , Art. **14 "Promotion of efficiency in heating and cooling"**

- Encourages the identification of **cost effective potential** for delivering energy efficiency, principally with CHP, efficient district heating and cooling and the recovery of industrial waste heat or, when these are not cost-effective, through other efficient heating and cooling supply options, and the delivery of this potential.
- Requires Member States to adopt **authorization or permit criteria and procedures** for operators of electricity generation installations, industrial installations and district heating and cooling installations ensuring that they carry out an installation-level cost-benefit analysis on the use of high-efficiency CHP and/or the utilization of waste heat and/or connection to a district heating and cooling network when they plan to build or refurbish capacities above 20 MW thermal input or when they plan a new district heating and cooling network.

A strategy for the district heating sector is expected to be formulated by the European Commission by early 2016 (February?)

AGENDA



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BUSINESS ISSUES

Finding the extension plan for a district heating network that maximizes the NPV over a given time horizon. It is therefore necessary to decide: (i) the set of potential new customers that should be reached, (ii) which new backbone should be installed, and (iii) their diameter.satisfying both thermoidraulic and urban constraints.

SOLUTION

OptiTLR (District heating) is a decision support system, based on GIS technology, that supports strategic and commercial development scenarios of district heating networks.

FEATURES

- High number of decision drivers in the optimization model (technical, financial, managerial)
- Fast generation of scenarios
- Easy what-if analyses on different evolution scenarios

APPLICATIONS

- Support for development/investment decisions (new networks or new backbone)
- Support for definition of commercial development plans (new connections) and their progressive refinement

LOGICAL FLOW

Input

• Geographic data • Technical data	• Geo-reference • Contracted power • Usage • Tariffs	• Potential networks • Prospects (expected usage and geo-reference)	• Tariffs (revenues) • Connection costs • Network & production cost
1. Existing DH network	2. Existing DH users	3. Potential DH users	4. Tariffs and costs

Main application modules

Main optimization parameters

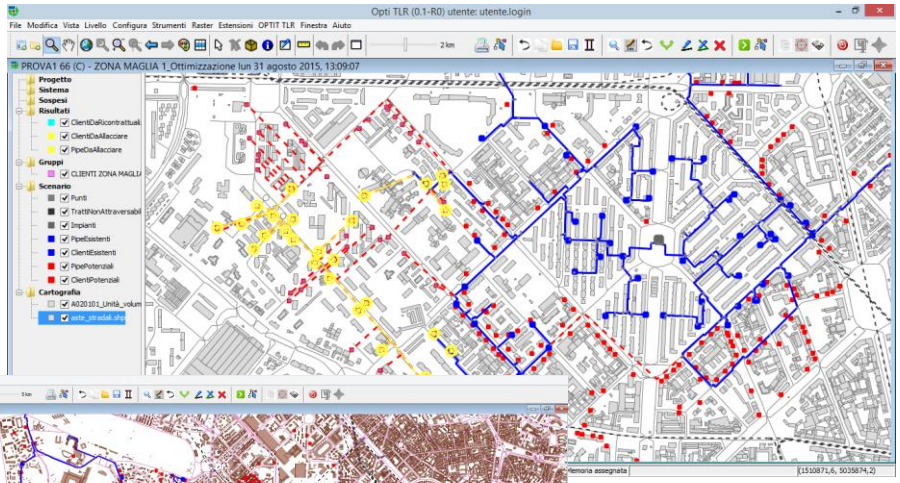
Technical parameters • Concurrency factors • Min/max pressures • Plant ops constraints • Pressure drops • Water speed • Leaks	Economic parameters • Budget constraints • Expected margins • Taxes &amortization • Discount rate • Actualization rules	Contractual parameters • Working equivalent hours •Tariff to be assigned to prospects

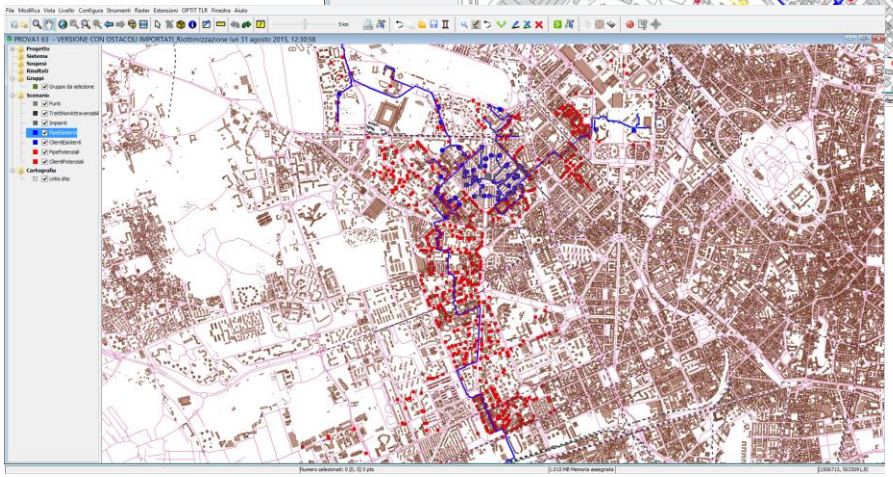
Output

- Best prospects to connect and power to offer
- New backbone networks to activate (and its optimal sizing)
- Possible change in existing contracts to recover additional capacity
- Economic (net present) value of each scenario respecting thermo-hydraulic constraints of the network

EXAMPLE OF OPTIMIZATION RESULTS

CARTOGRAPHIC VISUALISATION





KPI

Parametri input	
Parametro	
GRUPPO DI RIFERIMENTO	
Costo fisso contratto nuovo allaccio (€)	0
Costo fisso contratto ricontrattualizzazion…	100
Pressione min cliente (bar)	0,4
Fattore contemporaneità	0,6
Tasso di interesse VAN	0,065
Max clienti allacciabili	50
Max clienti ricontrattualizzabili	100
Profilo min ricontrattualizzabilità (h)	400
Profilo max ricontrattualizzabilità (h)	1.100
Pressione max impianto(bar)	100
Pressione ritorno cliente(bar)	1,5
Orizzonte temporale (anni)	10
Sconto allacciamento (%)	0
Tariffa assegnata ai clienti potenziali	Binomia Domestici
Fattore consumo equivalente (MWh/mc gas)	7,675
Soglia potenza per preventivo	1.450
Rapporto minimo ricontrattualizzazione	0
Rapporto massimo ricontrattualizzazione	10
Parametri output	
Parametro	Valore
Num tot clienti ricontrattualizzabili	179
Potenza tot ricontrattualizzabile(kW)	22.784,444
Num tot potenziali gruppo di riferimento	156
Potenza tot potenziali gruppo di riferiment…	19.989,23
Ricavo netto (€)	3.271.710,698
Num clienti da ricontrattualizzare	7
Potenza da ricontrattualizzare (kW)	1.222,63
Costo ricontrattualizzazione (€)	218.162,33
Num clienti da allacciare	50
Potenza da allacciare (kW)	12.109,75
Ricavo nuovi allacciamenti-VAN (€)	3.782.972,209
Costo nuovi allacciamenti(€)	1.465.496,07
Num clienti da allacciare	50
Potenza da allacciare (kW)	12.109,75
Ricavo nuovi allacciamenti-VAN (€)	3.782.972,209
Costo nuovi allacciamenti(€)	1.465.496,07
Contributo su costo nuovi allacciamenti(€)	1.172.396,89
Fattore VAN	7,656

	A	O	P	W	X	AA	AC
1	PDR	CONS_ANNUO	POT_CONTR	DATA	CONTATTANTE	STATO	POTENZA
2	*PDR*	*Consumo Annuo*	*Potenza contratto*	*Data contatto*	*Referente Commerciale*	*Stato del cliente*	*Potenza*
3	3118	51579	316,69			DA ALLACCIARE	16,69
4	3556	42950	263,7				263,7
5	3592	56207	345,11				345,11
6	3706	50700	311,29				311,29
7	3883	52722	323,7				

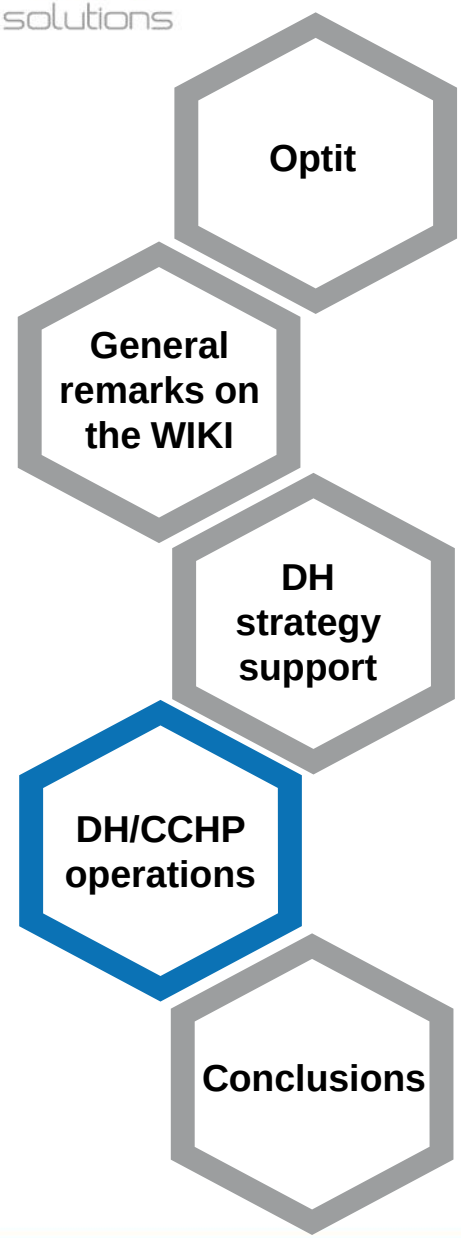
DA ALLACCIARE
RIFIUTA ALLACCIAMEN
NON ALLACCIABILE
ALLACCIATO

LIST OF PROSPECTS

	A	M	O	W	Y	Z		
1	PDR_/_POD	CONS_ANNUO	POT_CONTR	TP_TAR	DATA	CONTATTANTE	STATO	POTENZA
2	*PDR*	*Consumo Annuo*	*Potenza contratto*	*Tipo tariffa tlr ipotizzata*	*Data contatto*	*Referente Commerciale*	*Stato del cliente*	*Potenza ricontratt.*
3	1007	301500	427,13	C_B_TI2			DA RICONTRATTUALIZZARE	241,2
4	1050	412020	757,75	C_B_TG2				329,61
5	1064	130730	318,6	C_B_TI2				104,58
6	1158	57426	76,67	C_B_TI2			DA RICONTRATTUALIZZARE	45,94

DA RICONTRATTUALIZZARE
RIFIUTA RICONTRATTUALIZZAZI
RICONTRATTUALIZZATO

AGENDA



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OPTIEPM
(ENERGY PRODUCTION MANAGEMENT)

BUSINESS ISSUE

Optimize operating margins of energy production plants with multiple energy sources (CHP, CCHP, heat pumps, boilers, absorption chillers, electric refrigerators, renewables,…) satisfying all relevant technical, normative and economic constraints.

SOLUTION

OptiEPM (Energy Production Management) is a web-based, multi-user, multi-plant solution that supports optimal planning and management of energy production plants.

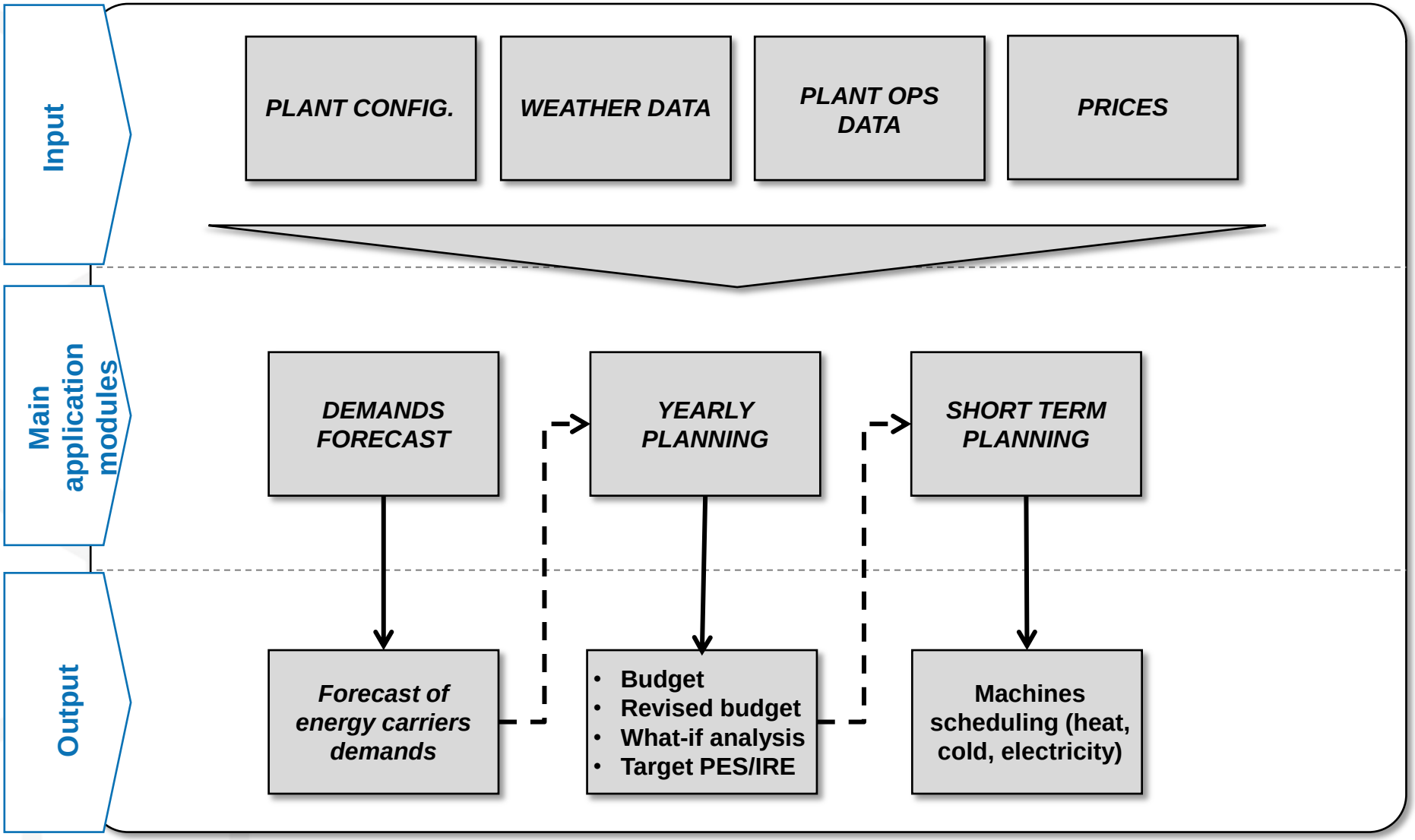
FEATURES

- Forecasting of carriers' demand
- Configuration of complex plants with numerous technical, financial and regulatory constraints
- Generation of energy production plans (15 minutes granularity) that optimize the profit of the plant

APPLICATIONS

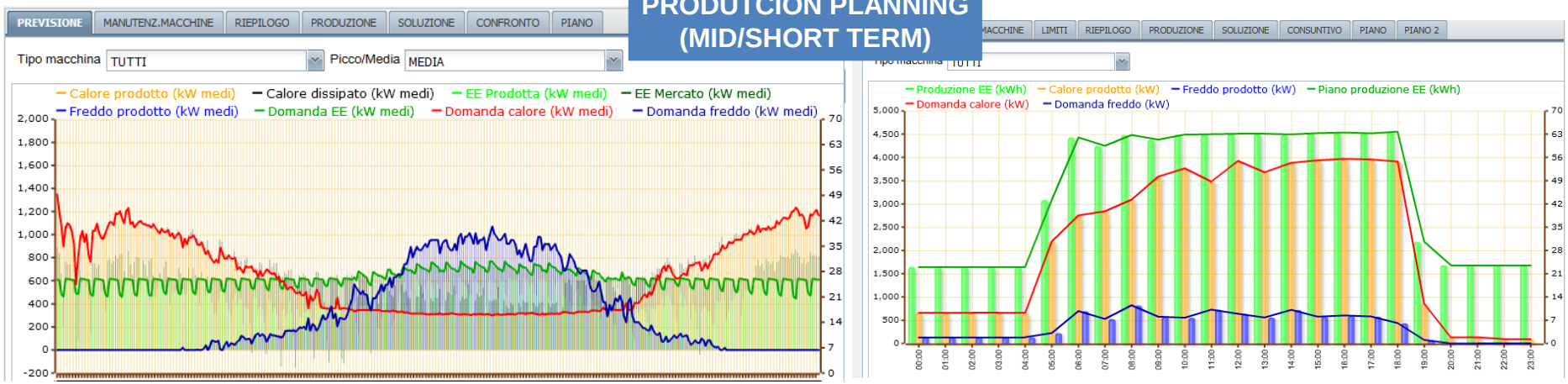
- Evaluation of different scenarios for what-if analyses
- Definition of plant's budget, down to daily production plans
- Ops management & monitoring

LOGICAL FLOW

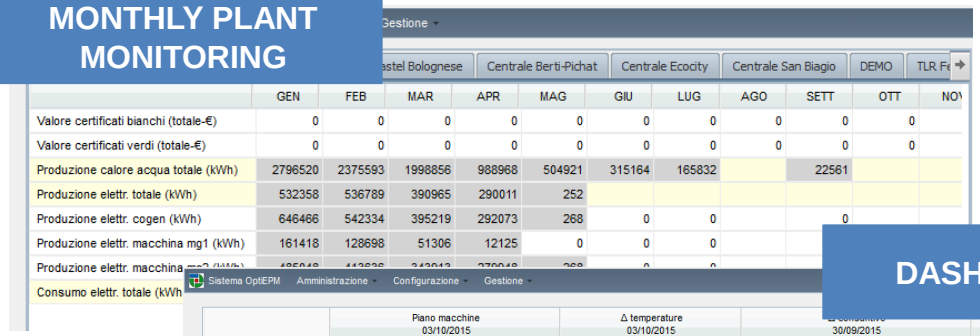


EXAMPLES OF OUTPUTS/USER INTERFACES

PRODUTCION PLANNING (MID/SHORT TERM)

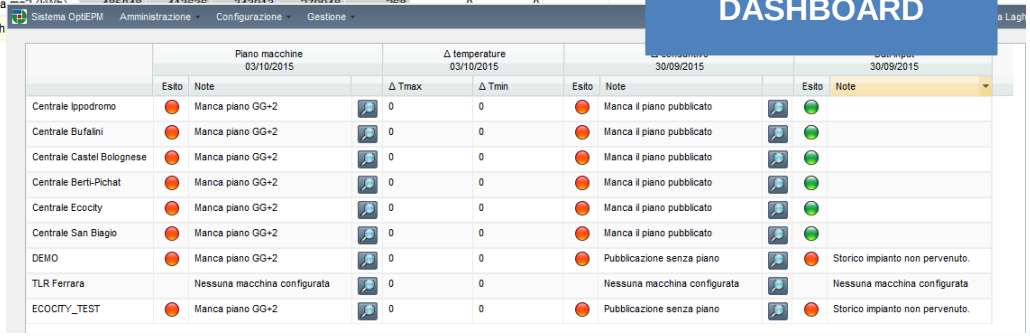


MONTHLY PLANT MONITORING



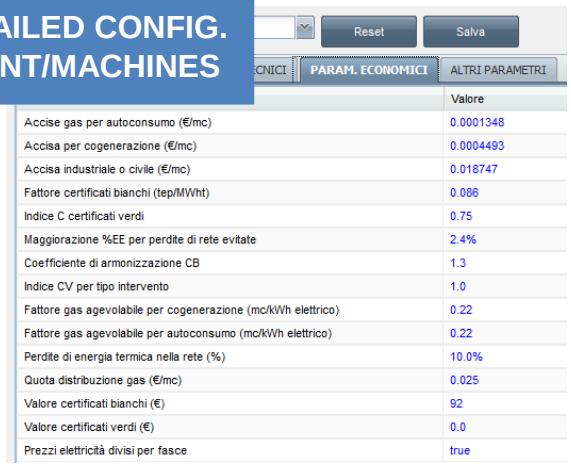
	GEN	FEB	MAR	APR	MAG	GIU	LUG	AGO	SETT	OTT
Valore certificati bianchi (totale-€)	0	0	0	0	0	0	0	0	0	0
Valore certificati verdi (totale-€)	0	0	0	0	0	0	0	0	0	0
Produzione calore acqua totale (kWh)	2796520	2375593	1998856	988968	504921	315164	165832		22561	
Produzione elettr. totale (kWh)	532358	536789	390965	290011	252					
Produzione elettr. cogen (kWh)	646466	542334	395219	292073	268	0	0		0	
Produzione elettr. macchina mg1 (kWh)	161418	128698	51306	12125	0	0	0			
Consumo elettr. totale (kWh										

DASHBOARD



	Piano macchine 03/10/2015			Δ temperature 03/10/2015			30/09/2015			30/09/2015	
	Esito	Note		Δ Tmax	Δ Tmin	Esito	Note		Esito	Note
Centrale Ippodromo		Manca piano GG+2		0	0		Manca il piano pubblicato			
Centrale Bufalini		Manca piano GG+2		0	0		Manca il piano pubblicato			
Centrale Castel Bolognese		Manca piano GG+2		0	0		Manca il piano pubblicato			
Centrale Berti-Pichat		Manca piano GG+2		0	0		Manca il piano pubblicato			
Centrale Ecocity		Manca piano GG+2		0	0		Manca il piano pubblicato			
Centrale San Biagio		Manca piano GG+2		0	0		Manca il piano pubblicato			
DEMO		Manca piano GG+2		0	0		Pubblicazione senza piano			Storico impianto non pervenuto.
TLR Ferrara		Nessuna macchina configurata		0	0		Nessuna macchina configurata			Nessuna macchina configurata
ECOCITY_TEST		Manca piano GG+2		0	0		Pubblicazione senza piano			Storico impianto non pervenuto.

DETAILED CONFIG. PLANT/MACHINES



	Valore
Accise gas per autoconsumo (€/mc)	0.0001348
Accisa per cogenerazione (€/mc)	0.0004493
Accisa industriale o civile (€/mc)	0.018747
Fattore certificati bianchi (tep/MWht)	0.086
Indice C certificati verdi	0.75
Maggiorazione %EE per perdite di rete evitate	2.4%
Coefficiente di armonizzazione CB	1.3
Indice CV per tipo intervento	1.0
Fattore gas agevolabile per cogenerazione (mc/kWh elettrico)	0.22
Fattore gas agevolabile per autoconsumo (mc/kWh elettrico)	0.22
Perdite di energia termica nella rete (%)	10.0%
Quota distribuzione gas (€/mc)	0.025
Valore certificati bianchi (€)	92
Valore certificati verdi (€)	0.0
Prezzi elettricità divisi per fasce	true

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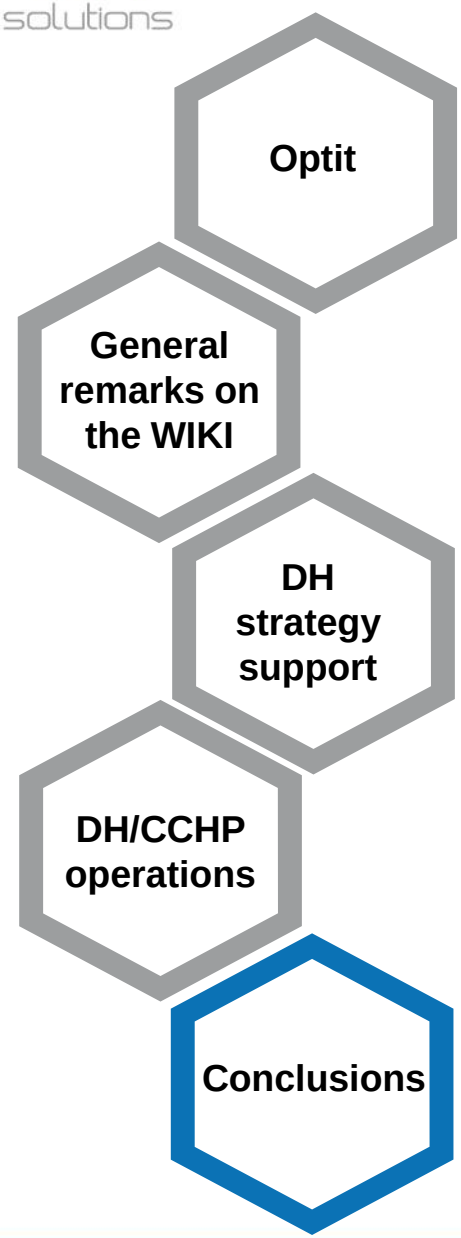

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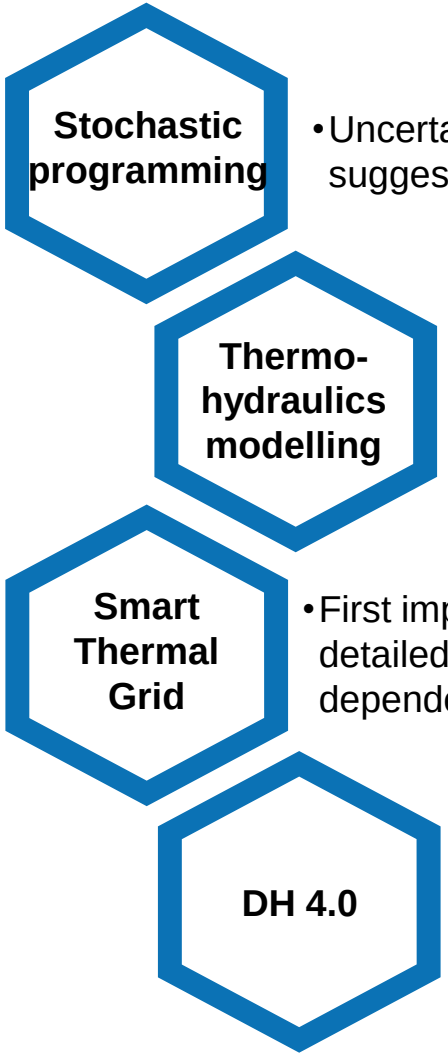
FUTURE CHALLENGES



- Uncertainty of electricity prices, operating temperatures, heat demand ect … suggests shifting from deterministic to stochastic programming
- Thermal energy grid is a complex thermo-hydraulics issue, with many non-linear entities, which makes it very challenging to model and optimize.
- First implementations of Smart Thermal Grids open new perspectives towards detailed user profiling and (Demand Side) management and advanced time-dependent dispatching models
- Current paradigm is shifting towards low temperature, multiple source head provision and distribution

CONCLUSIONS

Energy Topics Review

- The current WIKI does not take into account thermal (heating and cooling) energy. It may be appropriate consider this domain as integral part of the Energy Commodities scenario.
- CHCP optimal planning is an interesting topic that presents significant challenges

Future Challenges

- Various interesting and complex challenges ahead (see previous slides)

Thermal Energy & DH Expertize

- Optit is available to integrate existing partnerships to extend project scope to include DH and CHCP optimization with “business proof” DSS capabilities

Strategy & Operations support

- Our solutions are in use amongst the leading Italian DH & CHCP players, with interesting ROIs. We are obviously available to explore further potential collaborations.

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