On-site Co-generation Experience at Elettra

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on behalf of
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with the collaboration of

Collini S.p.A. – Trento – Italy

Landi S.p.A. – Bergamo - Italy

Energytech G.m.b.H./S.r.l – Bozen/Bolzano - Italy

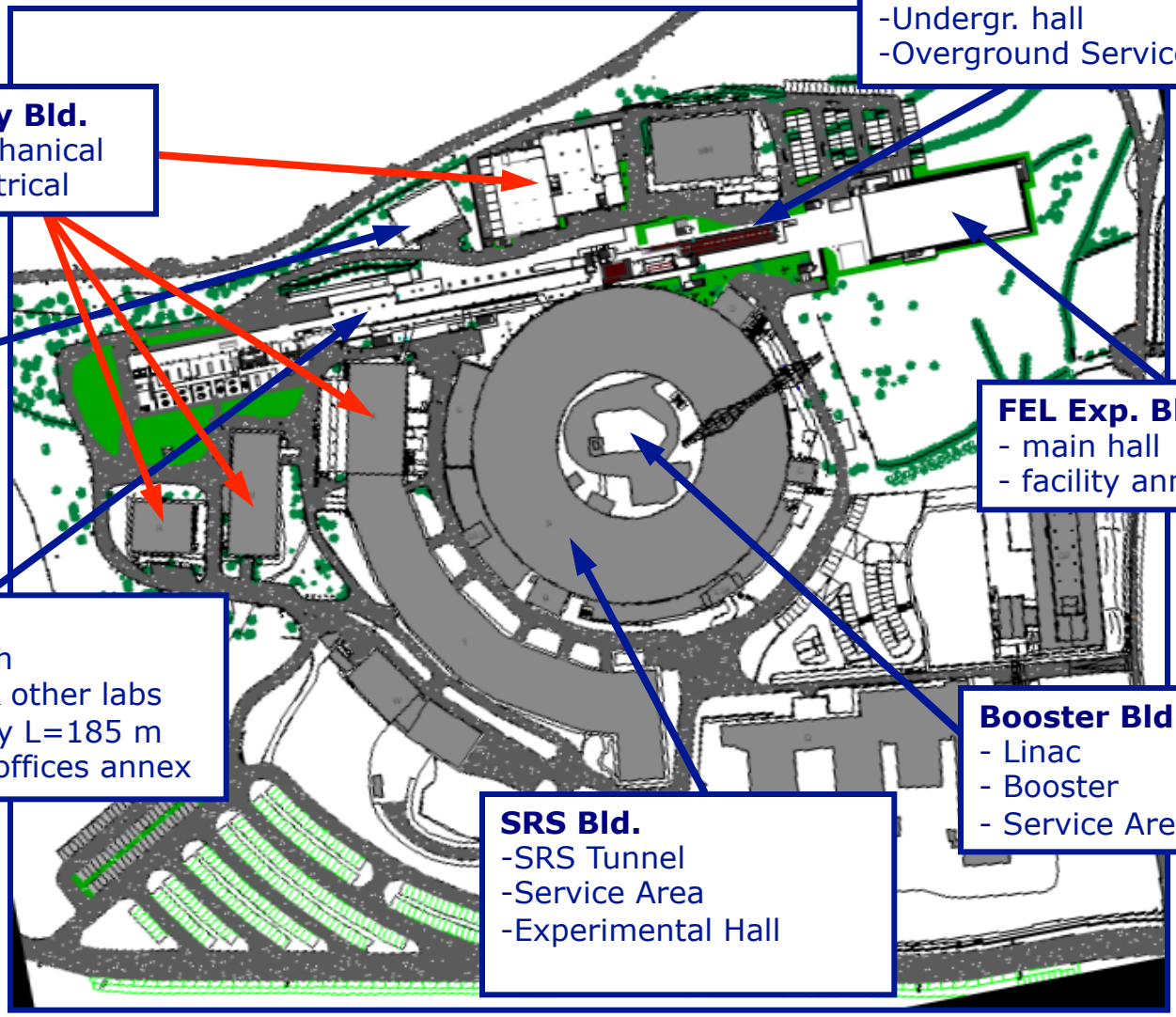
UPB AS CH – Liestal – Switzerland

Trigenerazione S.r.l. – Padova – Italy

Bettiol S.r.L. –Treviso - Italy

Elettra Laboratory

Elettra Laboratory Layout: SRS & FEL



FEL Undulator Bld.
-Undergr. hall
-Overground Service gallery

Utility Bld.
- mechanical
- electrical

Prefab. Bld.
- labs
- offices

FEL Exp. Bld.
- main hall
- facility annex

FEL Linac Bld.
- extended tunnel L=191m
- undergr. area for laser & other labs
- extended klystron gallery L=185 m
- control room, labs. and offices annex

Booster Bld.
- Linac
- Booster
- Service Area

SRS Bld.
-SRS Tunnel
-Service Area
-Experimental Hall

AGENDA

Facility Energy Requirements: Electricity – Heating - Cooling

Business-as-usual: energy/cost balance with a traditional plant

More than co-generation: UPS & co-generation

The trigeneration plant: Layout & performances

Co-generation: energy/cost balance with co-generation

First operational experience: a different plant management

Critical issue: interfacing old pipe system

Benefits: costs & CO2 reduction

Laboratory Energy Requirements

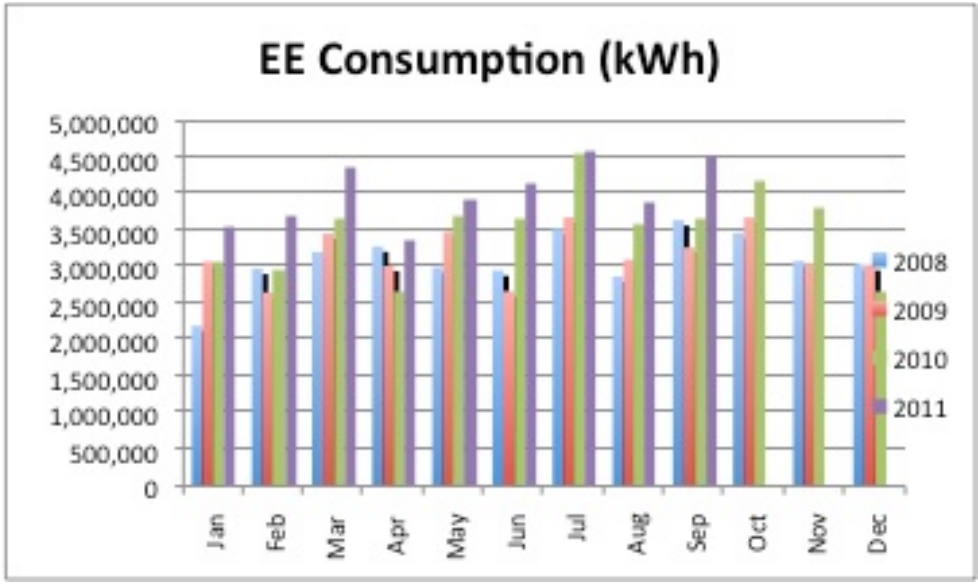
2011

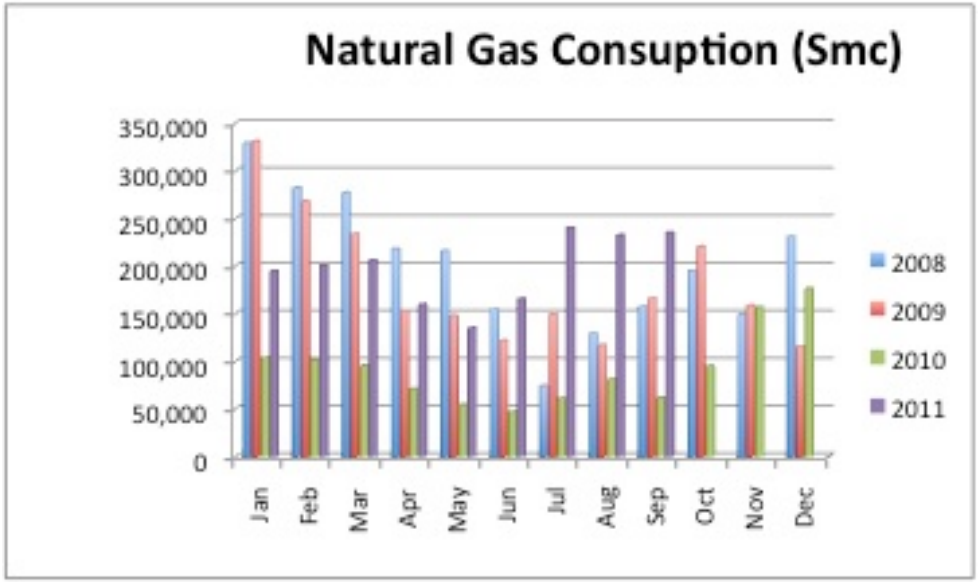
Electricity: 49 GWh

Cooling: 28.6 GWh_f

Heating: 6.4 GWh_t

Natural Gas: 800,000 Smc

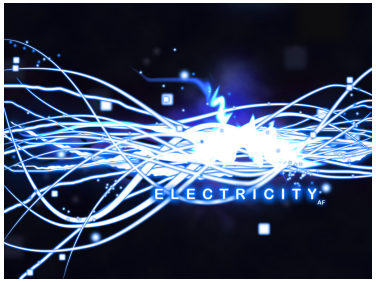




Business-as-usual: Costs & Environment Unsustainability

2011

Environmental Cost



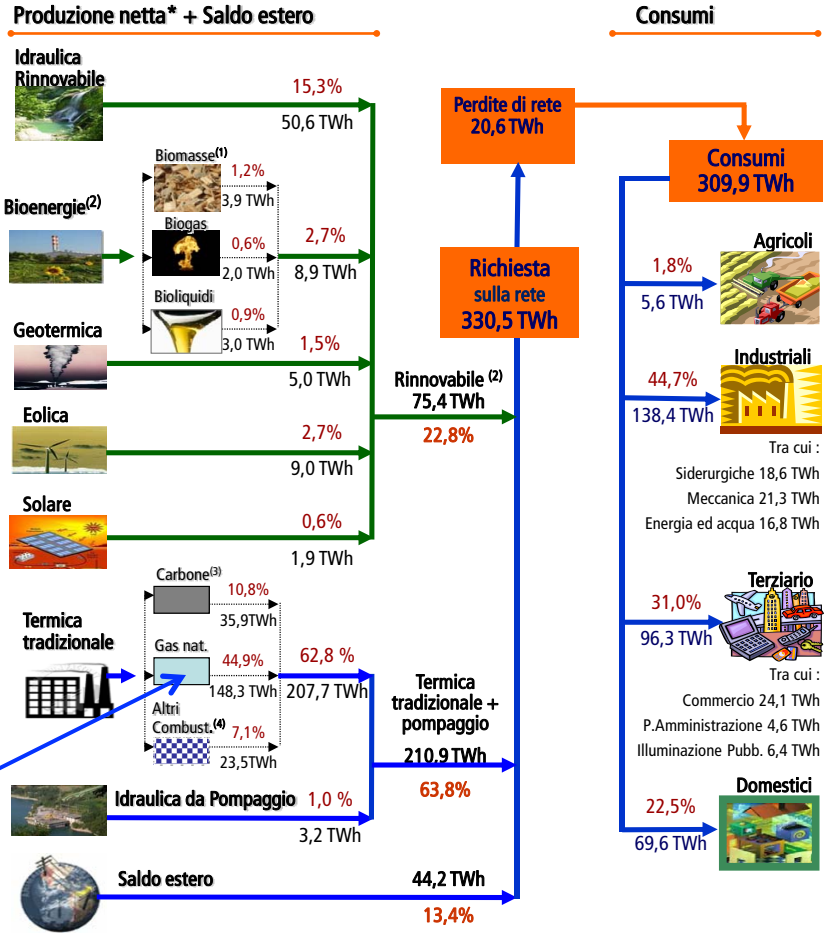
CO_2: 32,670 t

CO_2: 2,160 t

Energy Cost
EE: 6,700,000€
Gas: 320,000€
Total: 7,020,000€

Nel 2010 la richiesta di energia elettrica sulla rete in Italia è risultata pari a 330,5 TWh, circa il 3% in più rispetto all'anno precedente.

Italian EE Balance 2010



Natural Gas: 44.9%

*Produzione netta: è la produzione lorda al netto dei servizi ausiliari e dei consumi da pompaggio

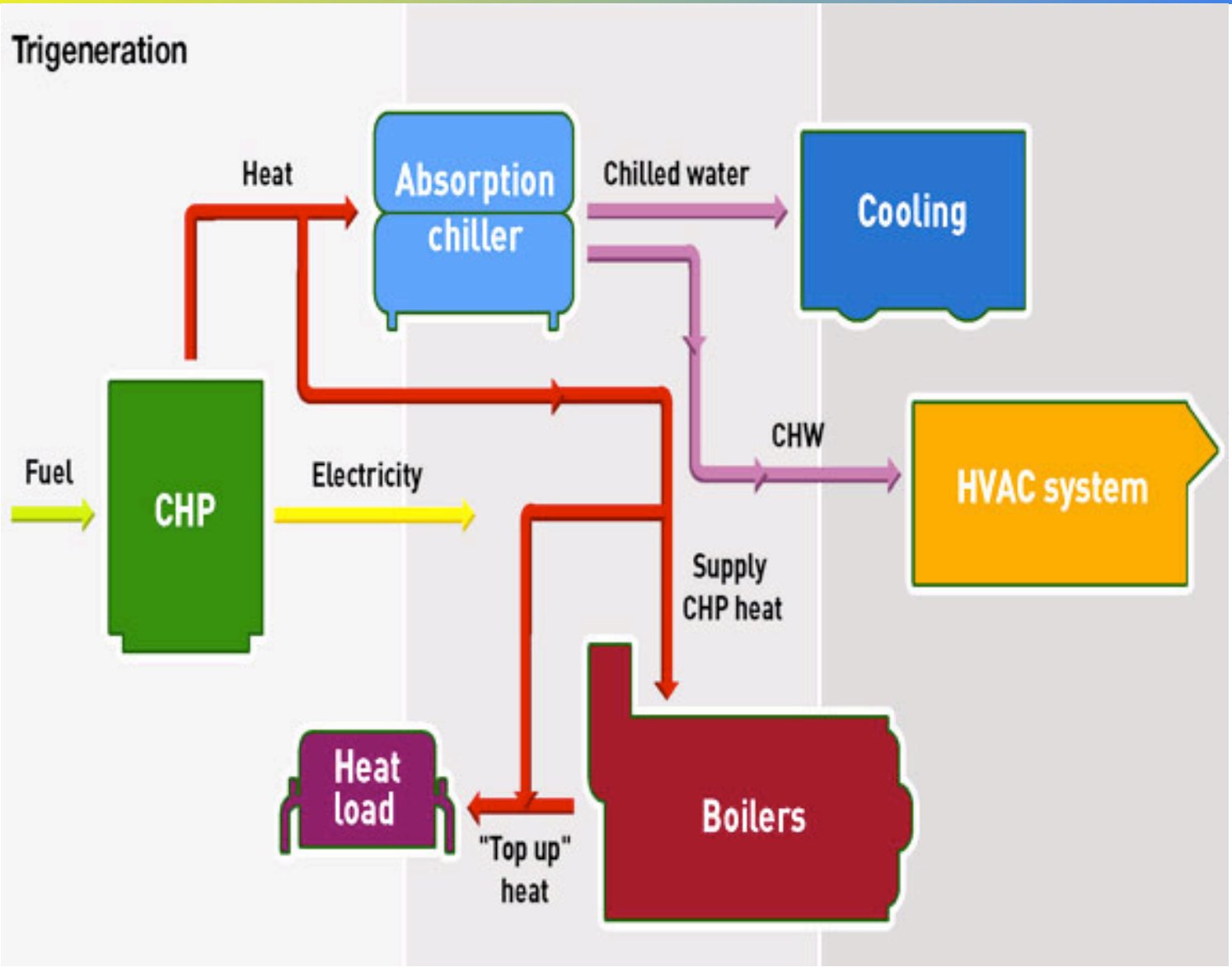
1) Include la parte biodegradabile dei rifiuti

2) Al netto dei rifiuti solidi urbani non biodegrabili, contabilizzati nella termica tradizionale

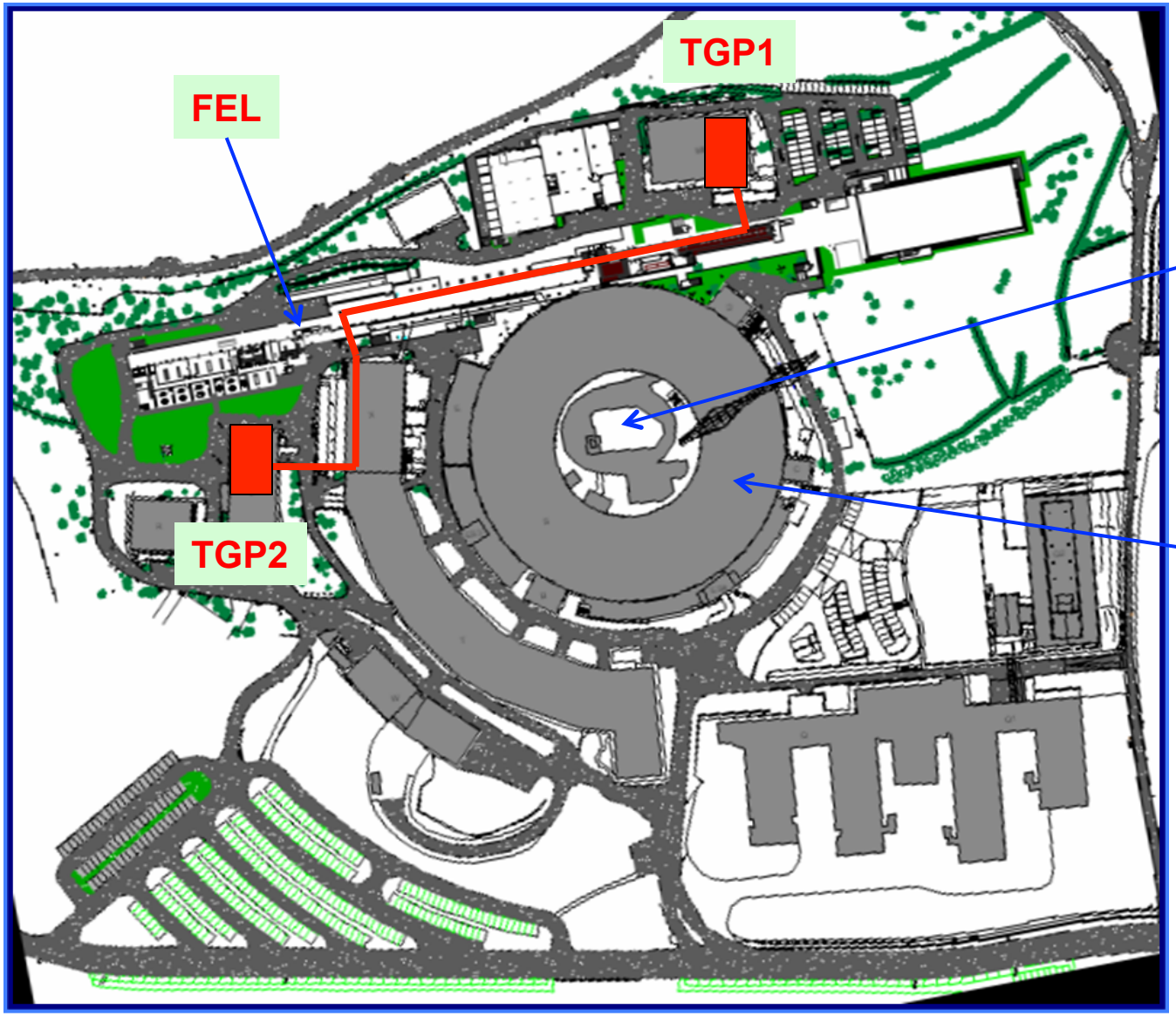
3) Carbone + Lignite

4) Al netto della produzione da biomasse, biogas e bioliquidi e dei consumi da pompaggio

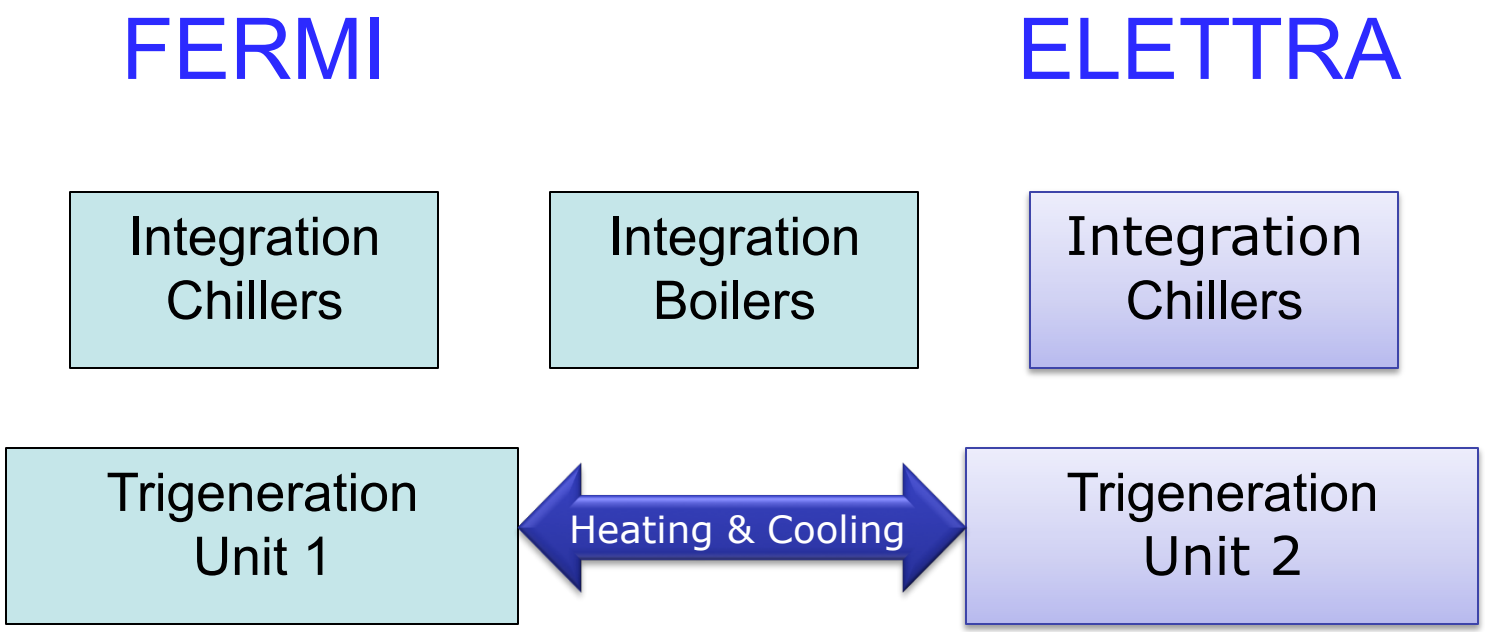
Trigeneration Concept



Elettra Plant Layout: A Distributed Plant



Mechanical Plant: The Energy Concept



Concepts

- TPG plant produces the thermal base-load
- Chillers & Boilers integrate the TPG and cover the thermal peaks
- Efficient control of the thermal fluxes according to the requests

TGP Technical Data

Main Components

- #3 x 2 Endothermic Gas Engines - MWM
- #1 x 2 Combined Absorber (Hot Water & Exhausts)
- #3 x 2 Engine Covers with heat recovering
- #3 x 2 Heat Pumps

Main Performances

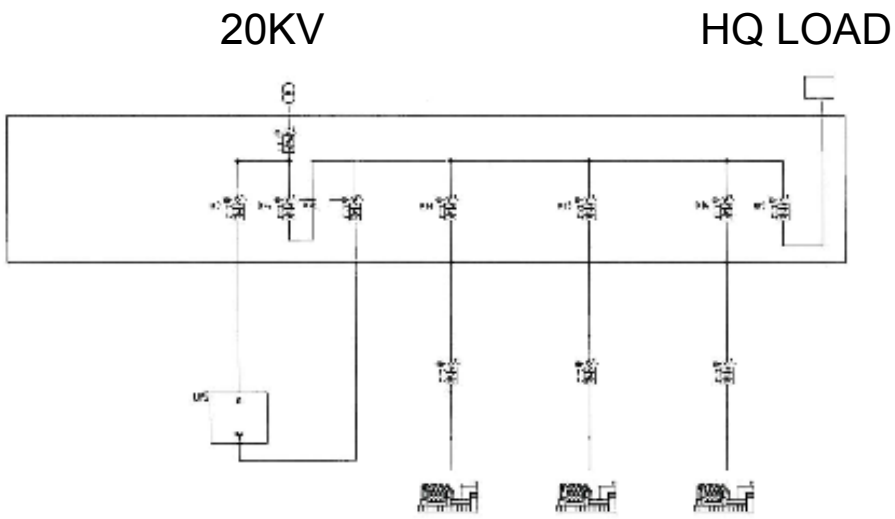
- Engine Electric Pw: 580 kW_e
- Total Electric Pw: 3,480 kW_e
- Engine Heating Pw: 760 kW_t
- Total Heating Pw: 4,560 kW_t
- Absorption Chiller Pw: 1,569 kW_f
- Total Cooling Pw: 3,138 kW_f

More than Trigeneration: UPS

UPS capability (for each unit)

- Each unit 800 kW_e
- 3 Engines (redundancy: 2 always running)
- Normal operation mode: 3 Engines at 75% Nominal Power
- Total EE production in operation: 1,200 kWe
- Free-wheel UPS system (PILLER) 1,100kVA
- Voltage tolerance: ±5%
- Frequency tolerance: ±1%
- Max time range: 15

UPS CONCEPT



Normal Mode Operations

- 3 Gen @ 75%
- Vs ST El. Grid: 1.1MW max
- HQ Load 0.8MW max

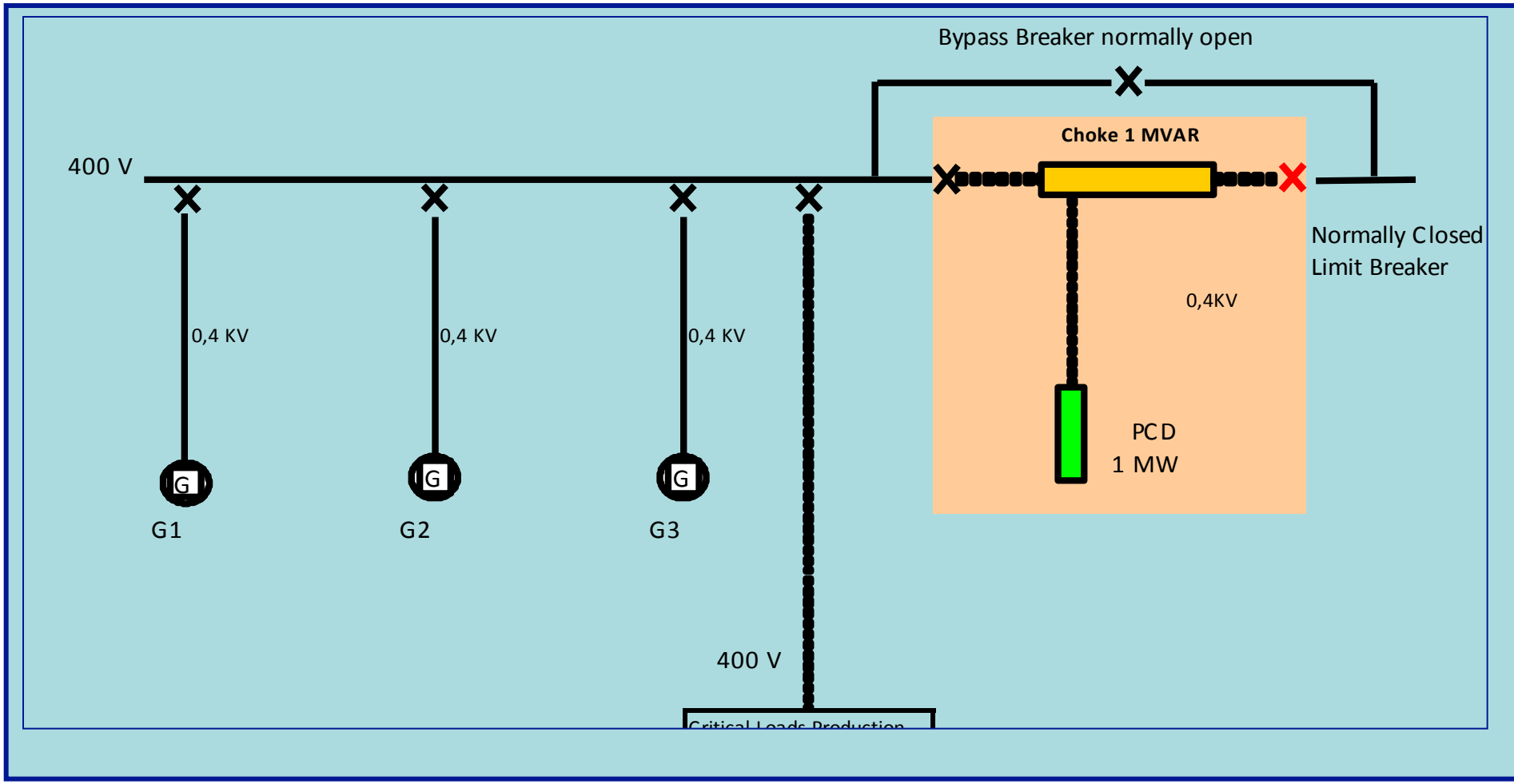
Island Mode Operations

- 3 Gen @ xx% according HQ Load
- Vs ST El. Grid: No Link
- HQ Load 0.8MW max

Technical Tolerances Requested

- Max Voltage Variation in static regime: ±1%
- Max Frequency Variation in static regime: ±1%
- Max Voltage Variation (under sudden load change above 50%): ±5%
- Max Frequency Variation (when 100% load under UPS): ±1%

UPS Scheme: The Island Mode



Rotating UPS System

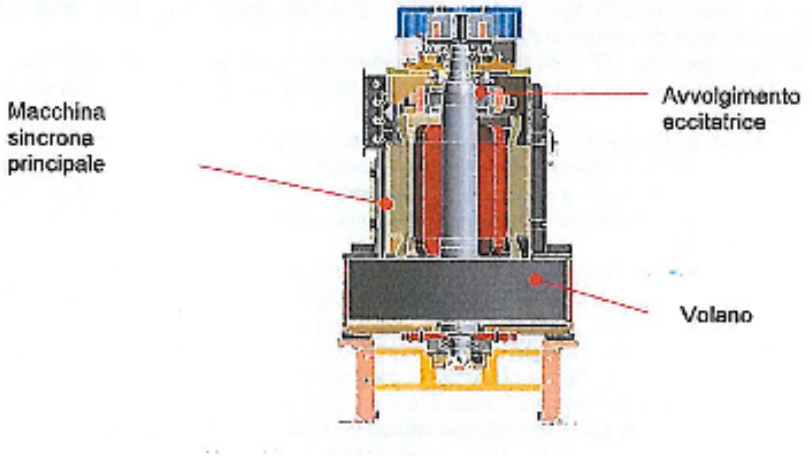
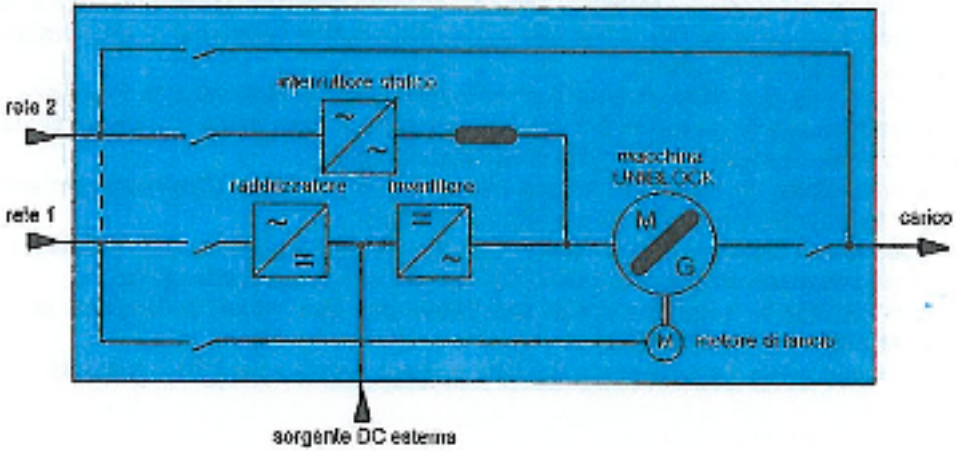
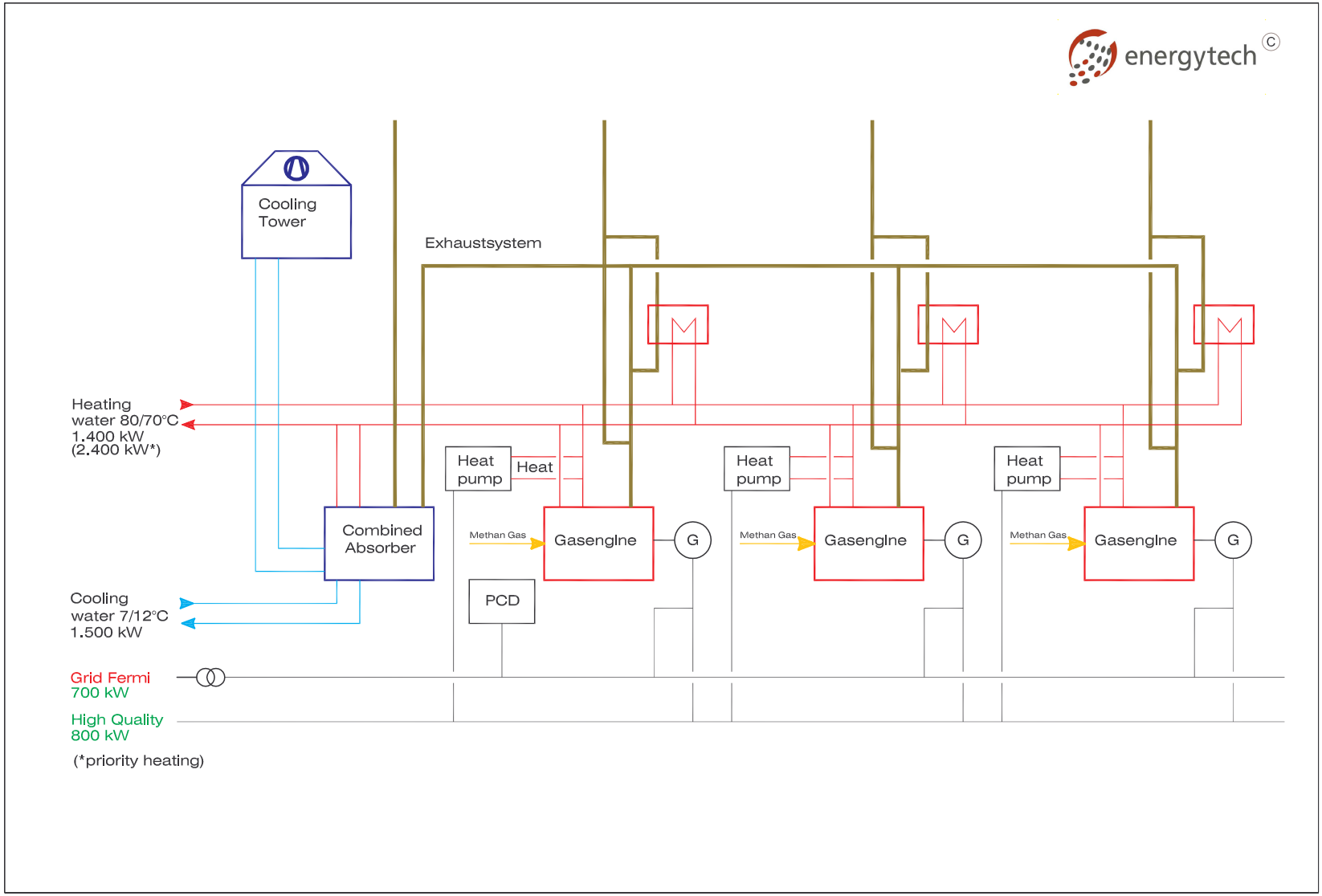


Fig. 5: Accumulatore inerziale PowerBridge

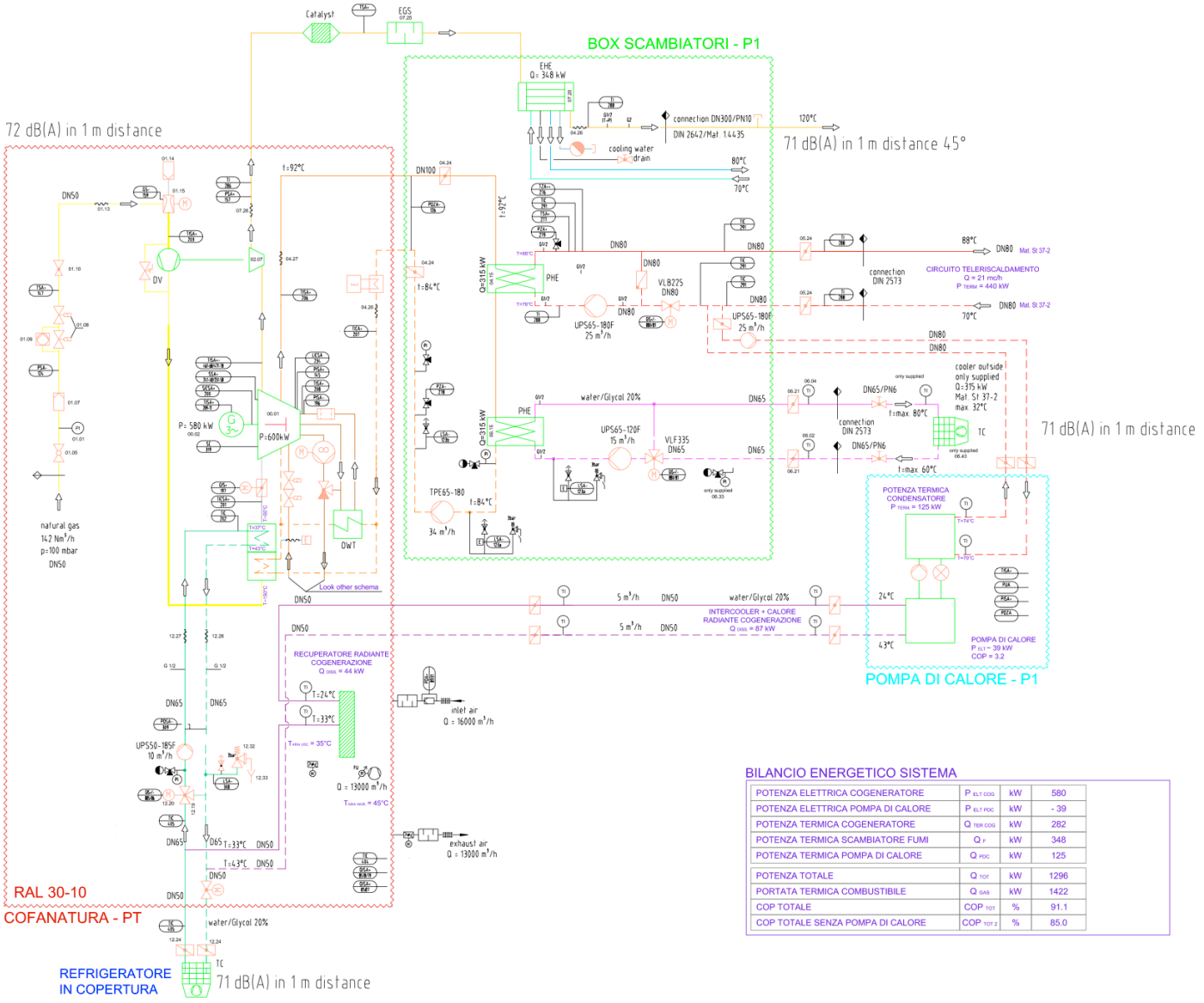


TGP LAYOUT



Block diagram Trigeneration plant

Mechanical Scheme: 1 Set

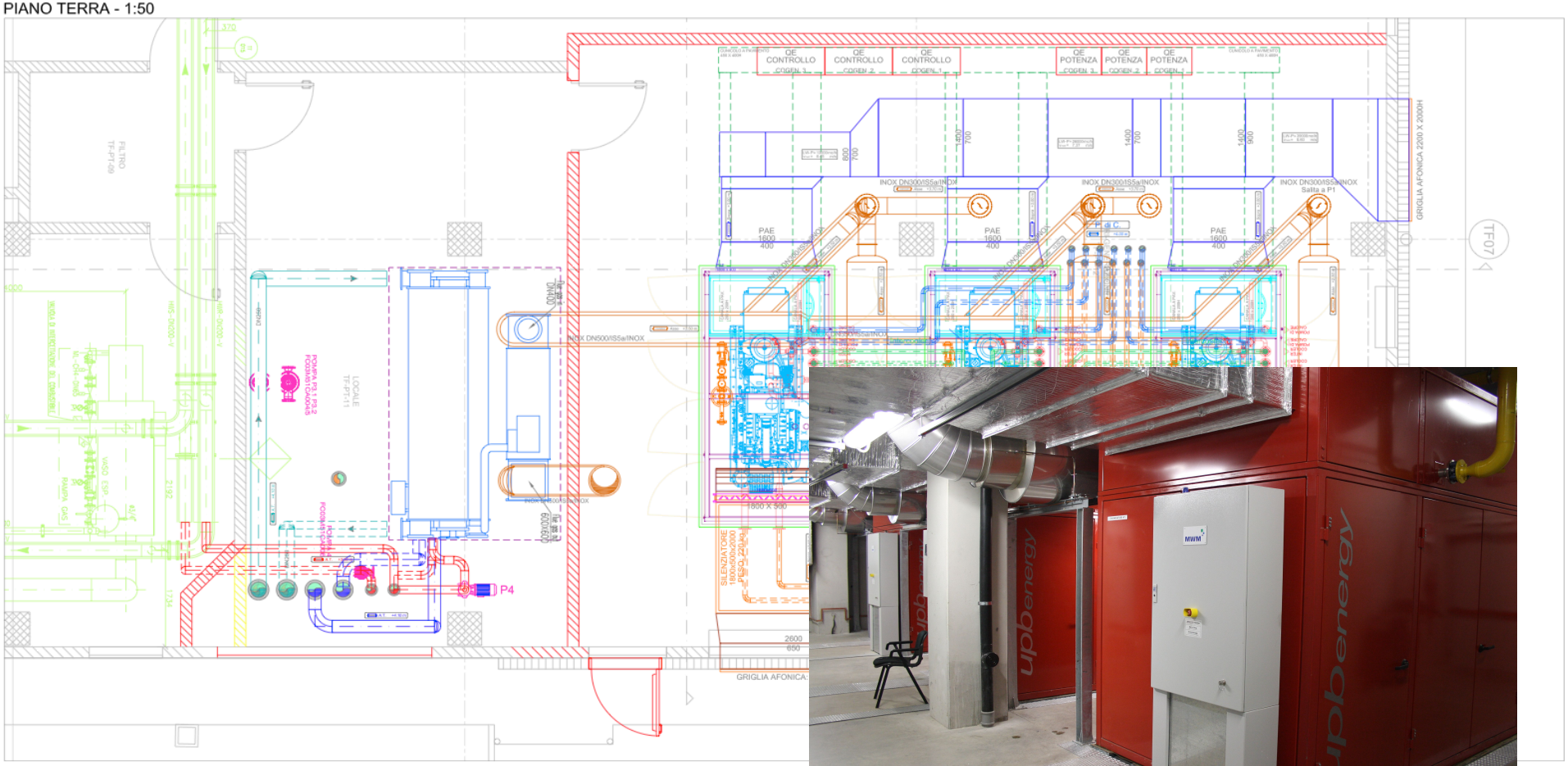


BILANCIO ENERGETICO SISTEMA

POTENZA ELETTRICA COGENERATORE	$P_{ELT\ COG}$	kW	580
POTENZA ELETTRICA POMPA DI CALORE	$P_{ELT\ POC}$	kW	- 39
POTENZA TERMICA COGENERATORE	$Q_{TER\ COG}$	kW	282
POTENZA TERMICA SCAMBIATORE FUMI	Q_{F}	kW	348
POTENZA TERMICA POMPA DI CALORE	Q_{POC}	kW	125
POTENZA TOTALE	Q_{TOT}	kW	1296
PORTATA TERMICA COMBUSTIBILE	Q_{GAS}	kW	1422
COP TOTALE	COP_{TOT}	%	91.1
COP TOTALE SENZA POMPA DI CALORE	$COP_{TOT\ 2}$	%	85.0

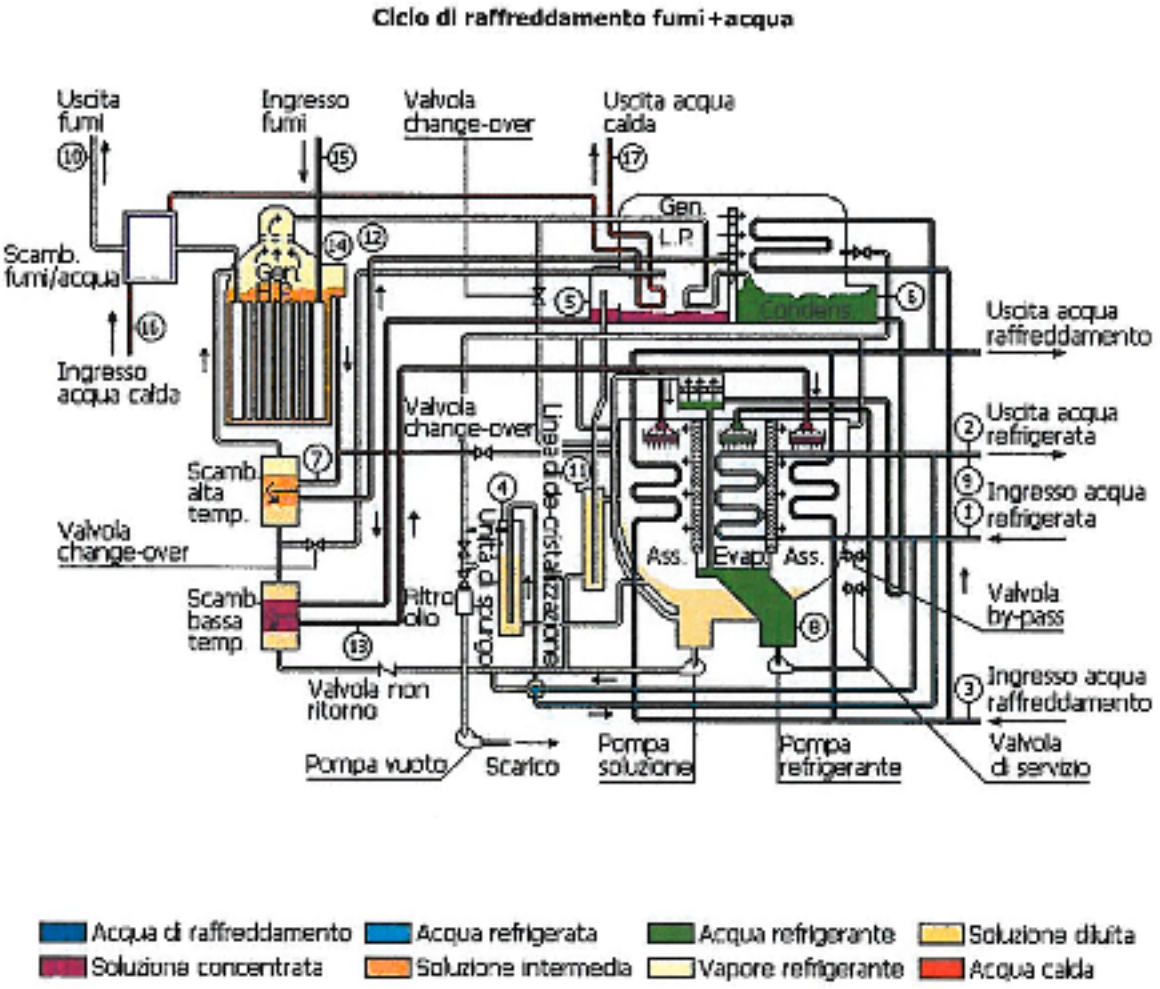
TGP Layout: Ground Floor

PIANO TERRA - 1:50



TGP Layout: First Floor

Combined Absorber



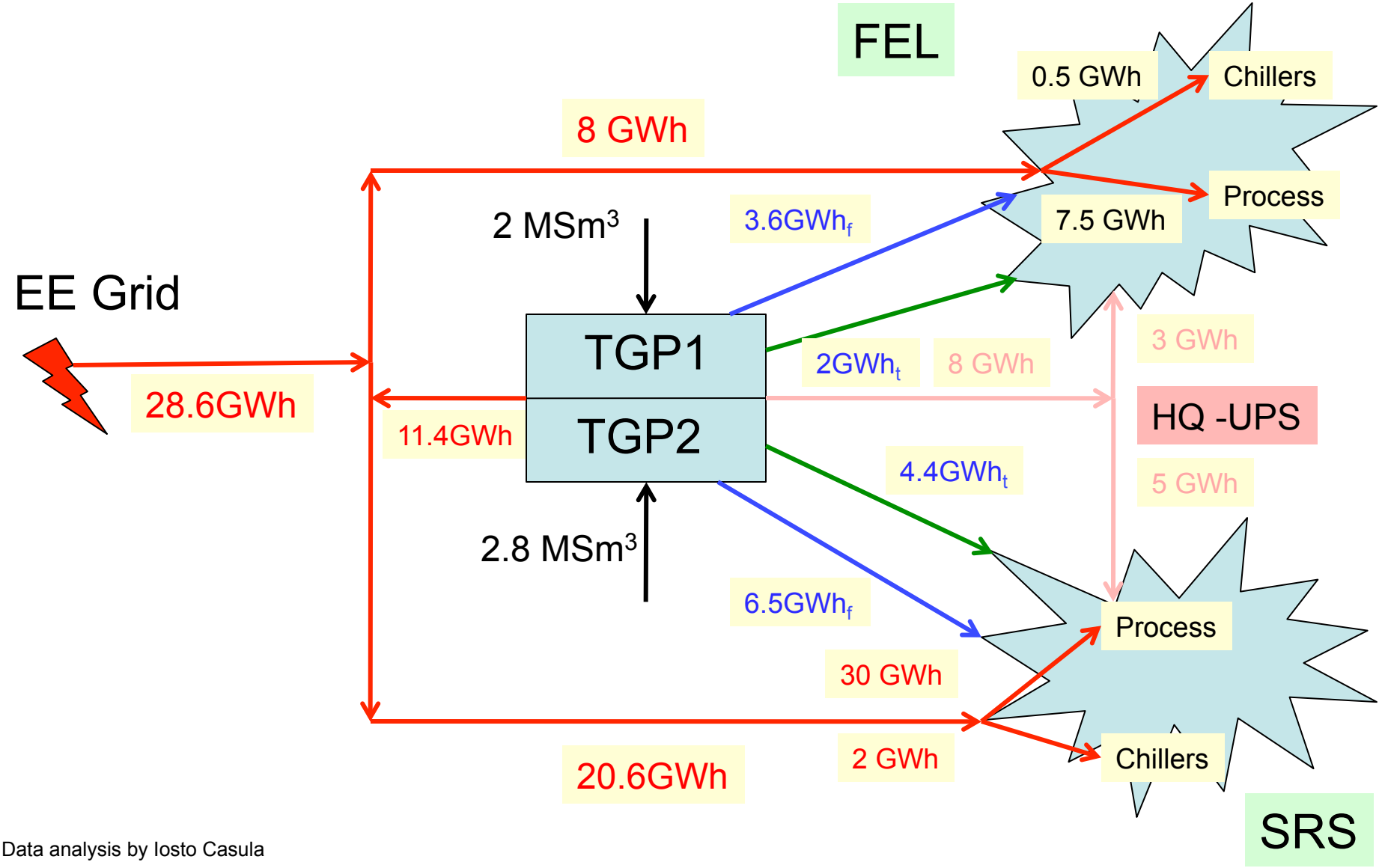
Combined Absorber Chiller

Table of Flue Gas With Hot Water Absorption Chiller Technical Parameters

Model		YRX470(90/79)-149(30/35)H2	
Refrigerating capacity		kw	1490
Chilled water	Inlet/outlet temperature	℃	12/7
	Flux	m^3/h	256
	Pressure loss	mH_2O	3.5
	Connection diameter (DN)	mm	200
Cooling water	Inlet/outlet temperature	℃	30/35
	Flux	m^3/h	517
	Pressure loss	mH_2O	7.5
	Connection diameter (DN)	mm	250
Flue gas	Inlet/outlet temperature	℃	470/170
	Flux	kg/h	3X2400
	Pressure loss	mmH_2O	165
	Inlet connection diameter (DN)	mm	450
	Outlet connection diameter	mm	650X650
Hot water	Inlet/outlet temperature	℃	88/80
	Flux	m^3/h	55.2
	Pressure loss	mmH_2O	3.5
	Connection diameter (DN)	mm	100
Electrical data	Power supply	3Φ-380V –50Hz	
	Total current	A	27.2
	Electric power	kW	8.65
Overall dimensions	Length	mm	4900
	Width		3400
	Height		3575
Shipping weight		t	19.9
Operating weight			28.7

Absorption Chiller

Elettra Laboratory Energy Balance



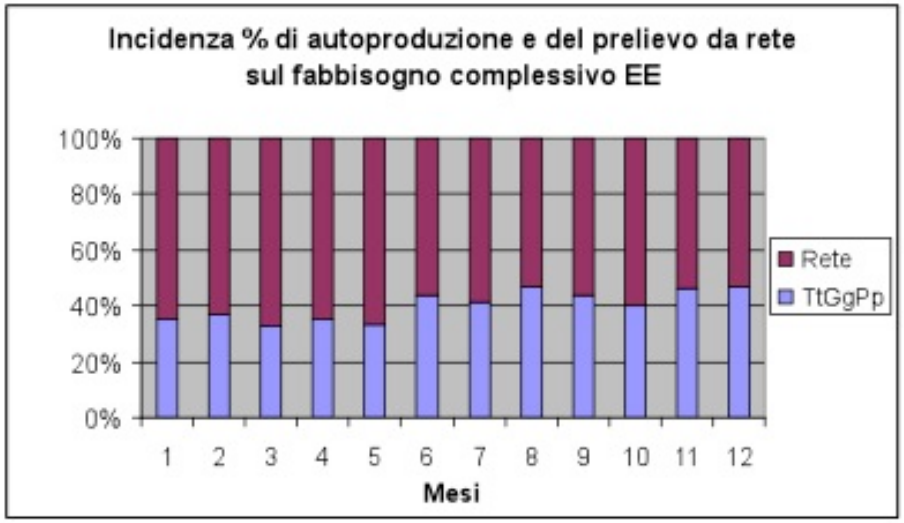
Data analysis by Iosto Casula

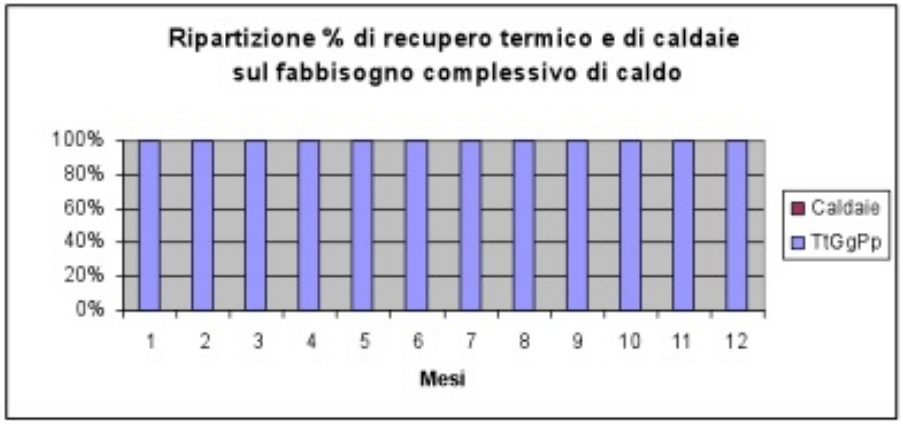
First operational experience

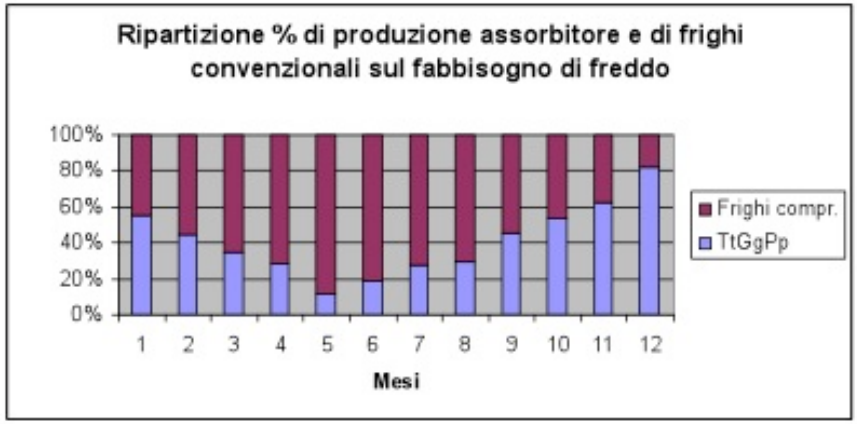
A different plant management:

- Maximize the use of the thermal energy
- Priority1:Use energy from the Trigeneration System
- Priority2: Use heating first
- Priority3: Use energy locally first
- Priority4: Use the low enthalpy energy from the heat pumps
- Rule1: Use Boilers only if necessary (winter peak load)
- Rule2: Use Chillers only if necessary (summer peak load)
- Dynamic modulation of thermal energy (between heating and cooling) with respect the field loads and the environmental conditions (season, day/night, …)
- Monitor and verify the plant parameters daily

TGP vs. Energy Requirements







Critical Issues

- Interfacing with the old distribution systems
  - TGP based on a variable flux distribution system
  - Old plant is based on a constant flux distribution
- Double cooling system:
  - HVAC (5/7°C)
  - Process (12/15°C)
- Old pipes not well thermal insulated
- Cooling towers (absorption chiller needs more water)
- Old pumps (high EE consumption)

Trigeneration: Costs & Environment Sustainability

2011

Electricity: 49 GWh

Cooling: 28.6 GWh_f

Heating: 6.4 GWh_t

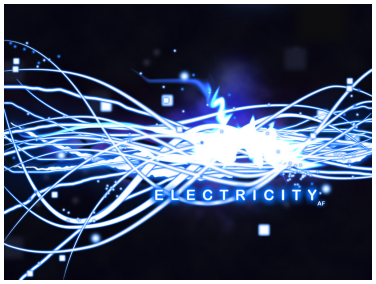
Energy Cost
EE: 3,880,000€
Gas: 1,920,000€
Total: 5,800,000€

Gas: 4,800,000 Smc CO_2: 12,984 t

Electricity: 28.6 GWh CO_2: 19,067 t

Costs & Emissions Saving

2011



CO_2: -13,600 t

CO_2: +10,820 t

Energy Cost
EE: -2,820,000€
Gas: +1,610,000€
Total: -1,220,000€
(-17%)

Total CO_2: -2,780 t (-8%)

Thank you for your attention