

Energy Efficiency @ Elettra

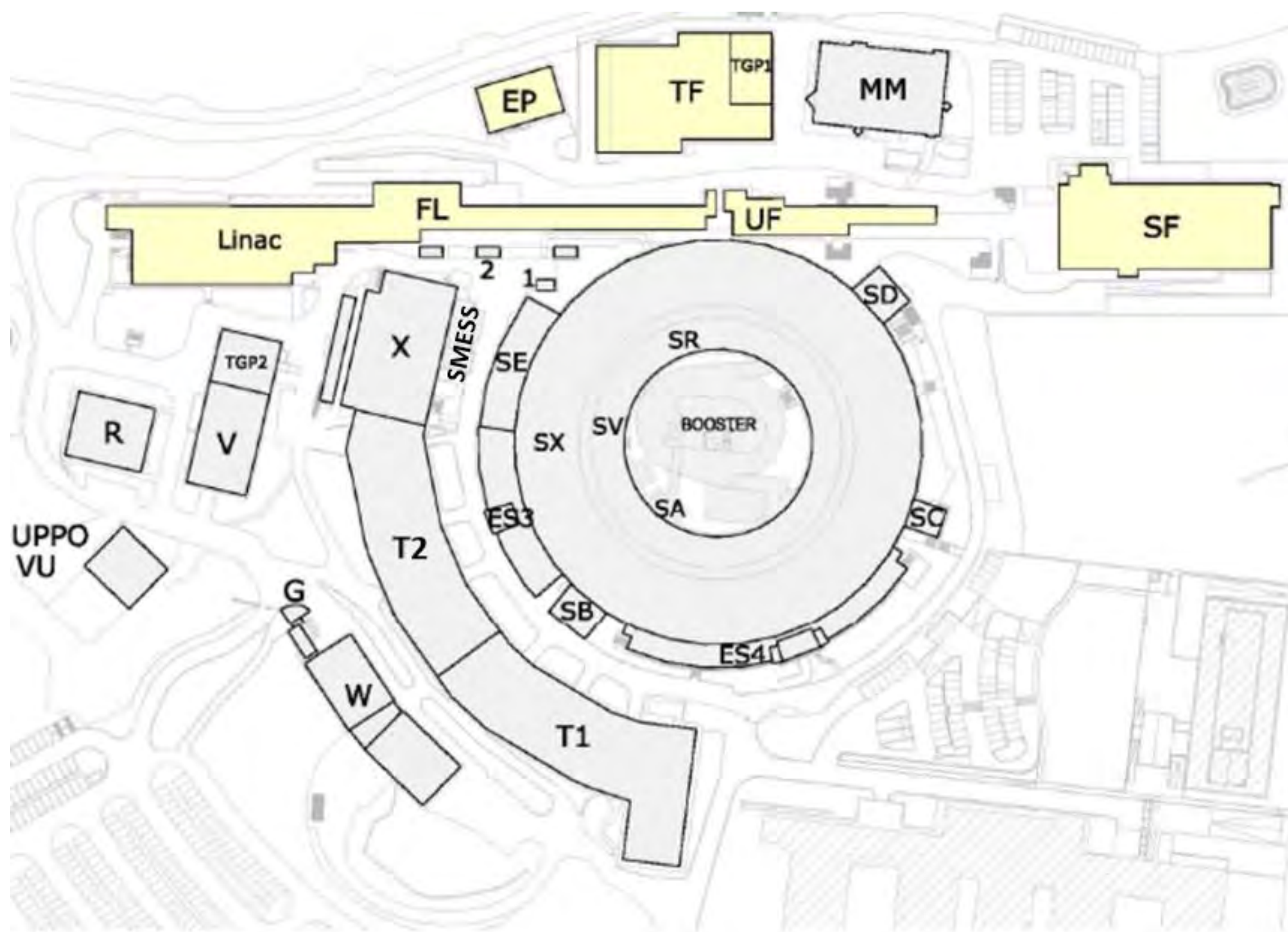
Layout & Monitoring



Elettra Sincrotrone Trieste

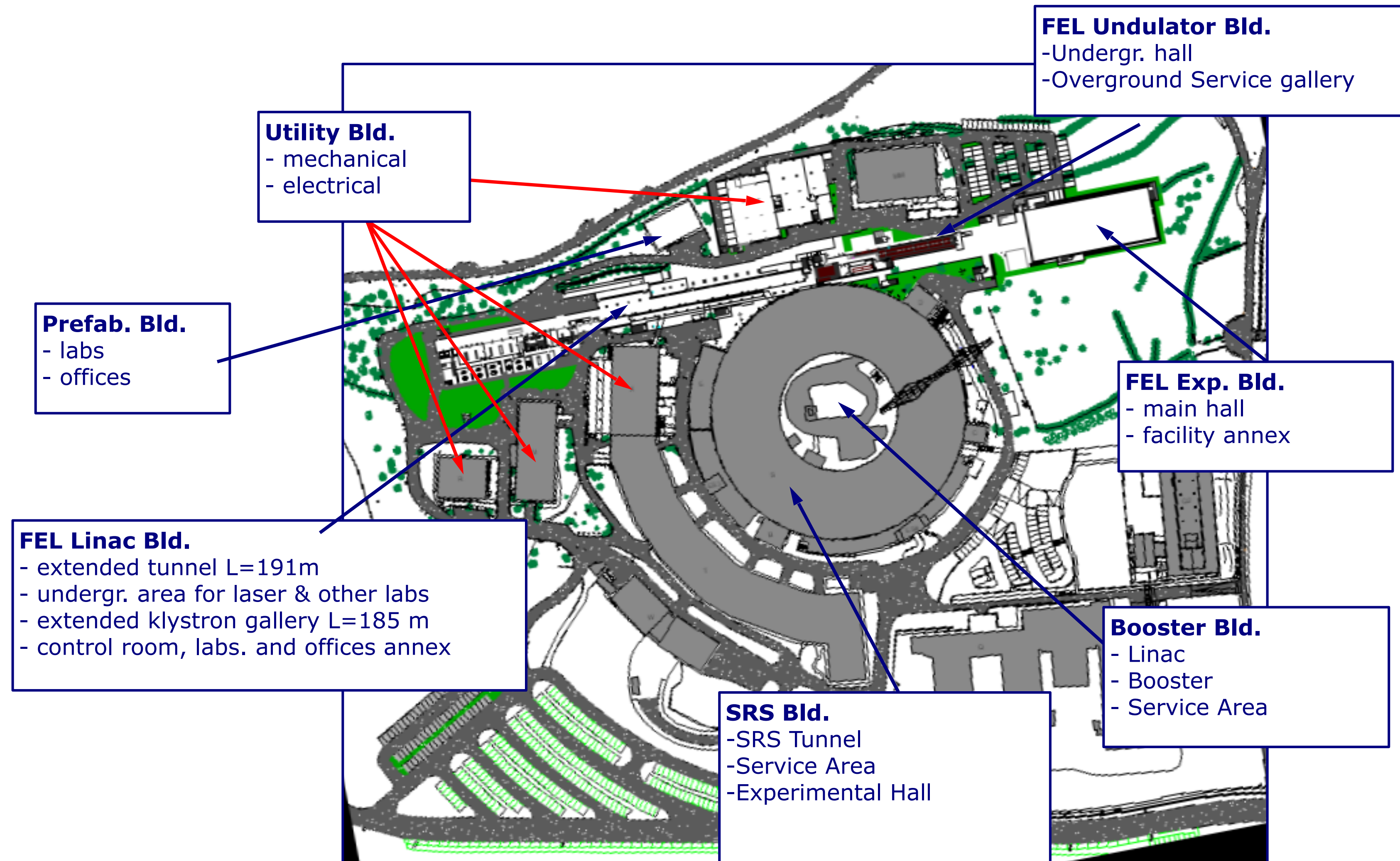
A. Galimberti - Energy Manager - 24/06/2021

Laboratory Layout



- Synchrotron Radiation Source (Elettra)
 - Bls. SX
- Free Electron Laser (FERMI)
 - Bls. FL, UF, SF
- Offices & Support Laboratories
- Infrastructures & Ancillary Systems

Laboratory Layout



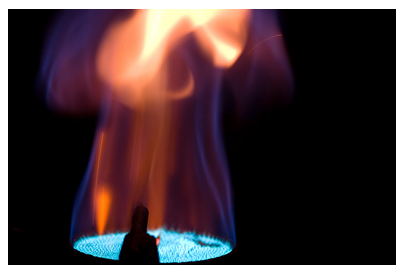
Laboratory Energy Requirement



Electricity: 49 GWh



Cooling: 28.6 GWh_f



Heating: 6.4 GWh_t

Natural Gas: 800,000 Smc

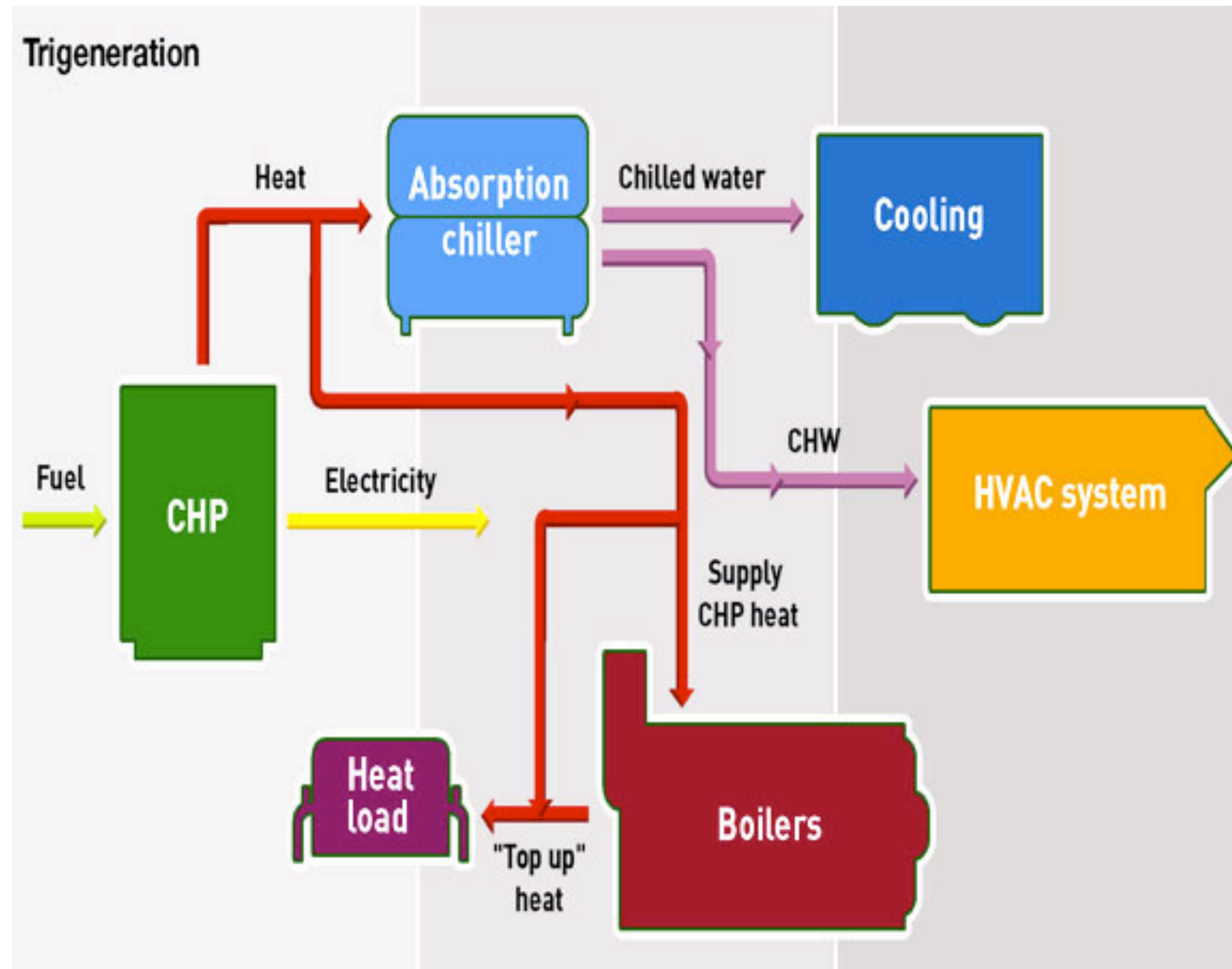


Environmental Cost

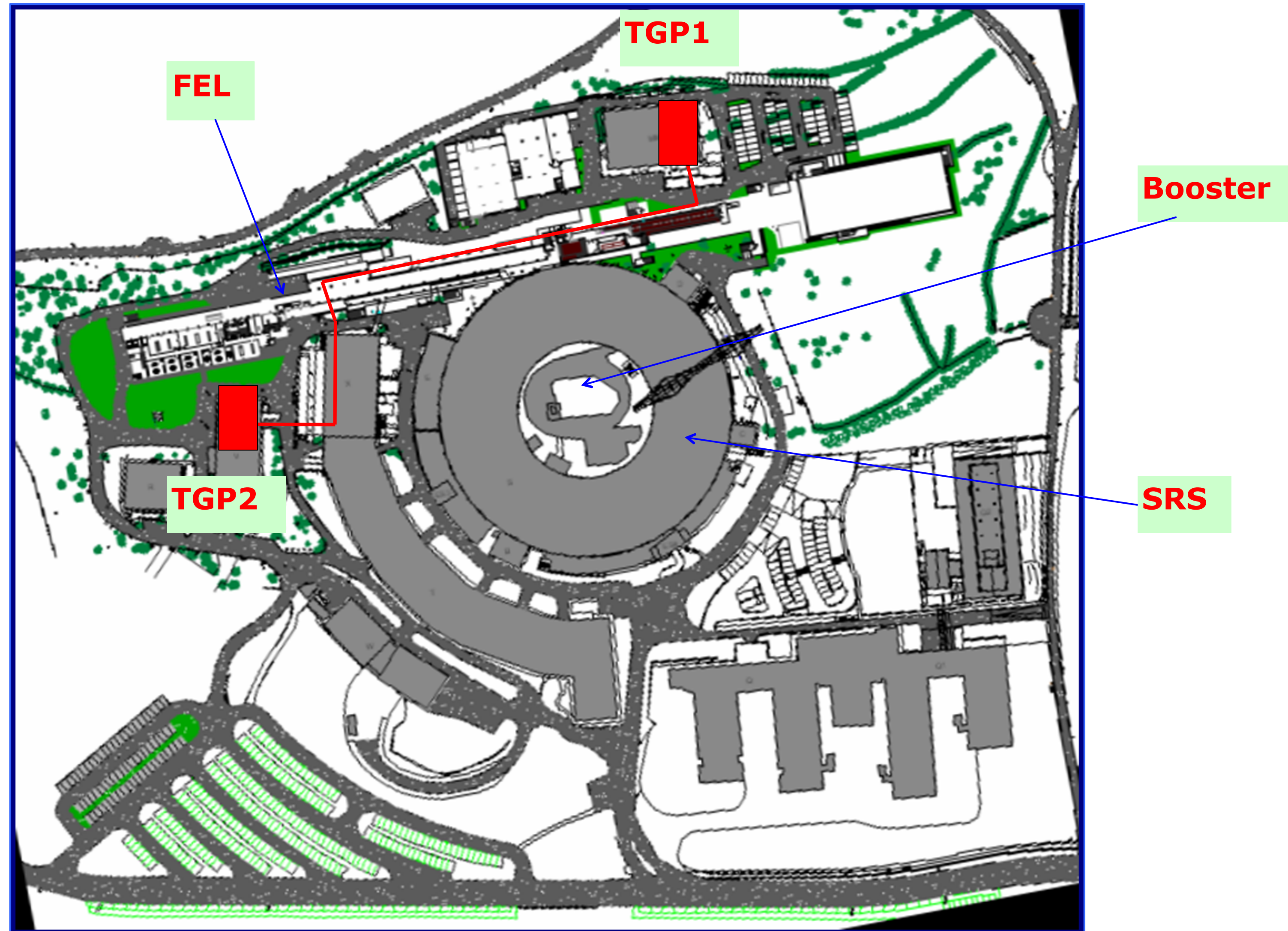
CO₂: 32,670 t

CO₂: 2,160 t

Trigeneration Concept



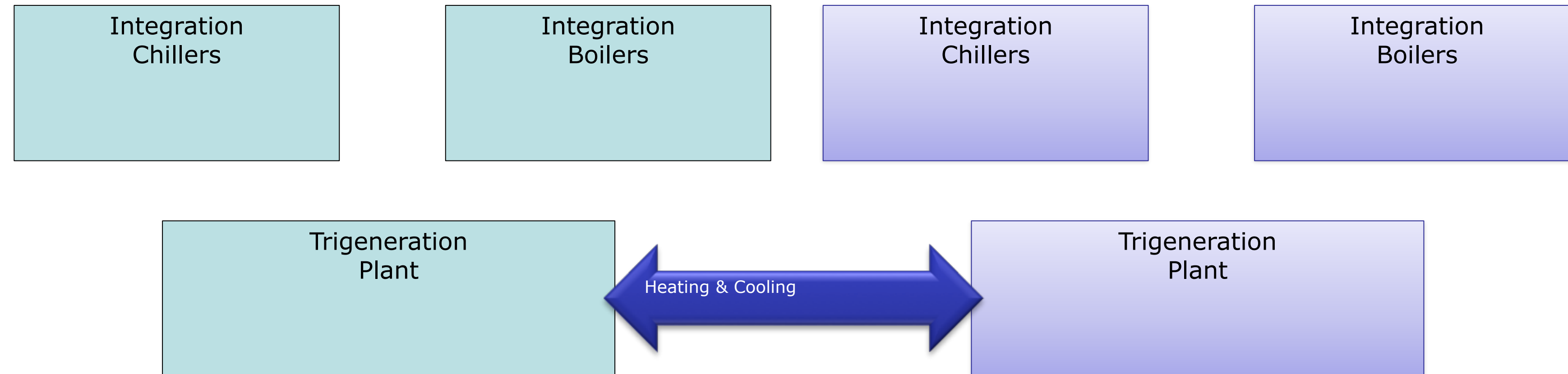
A Distributed Plant Layout



Mechanical Plant: The Energy Concept

FERMI

Elettra



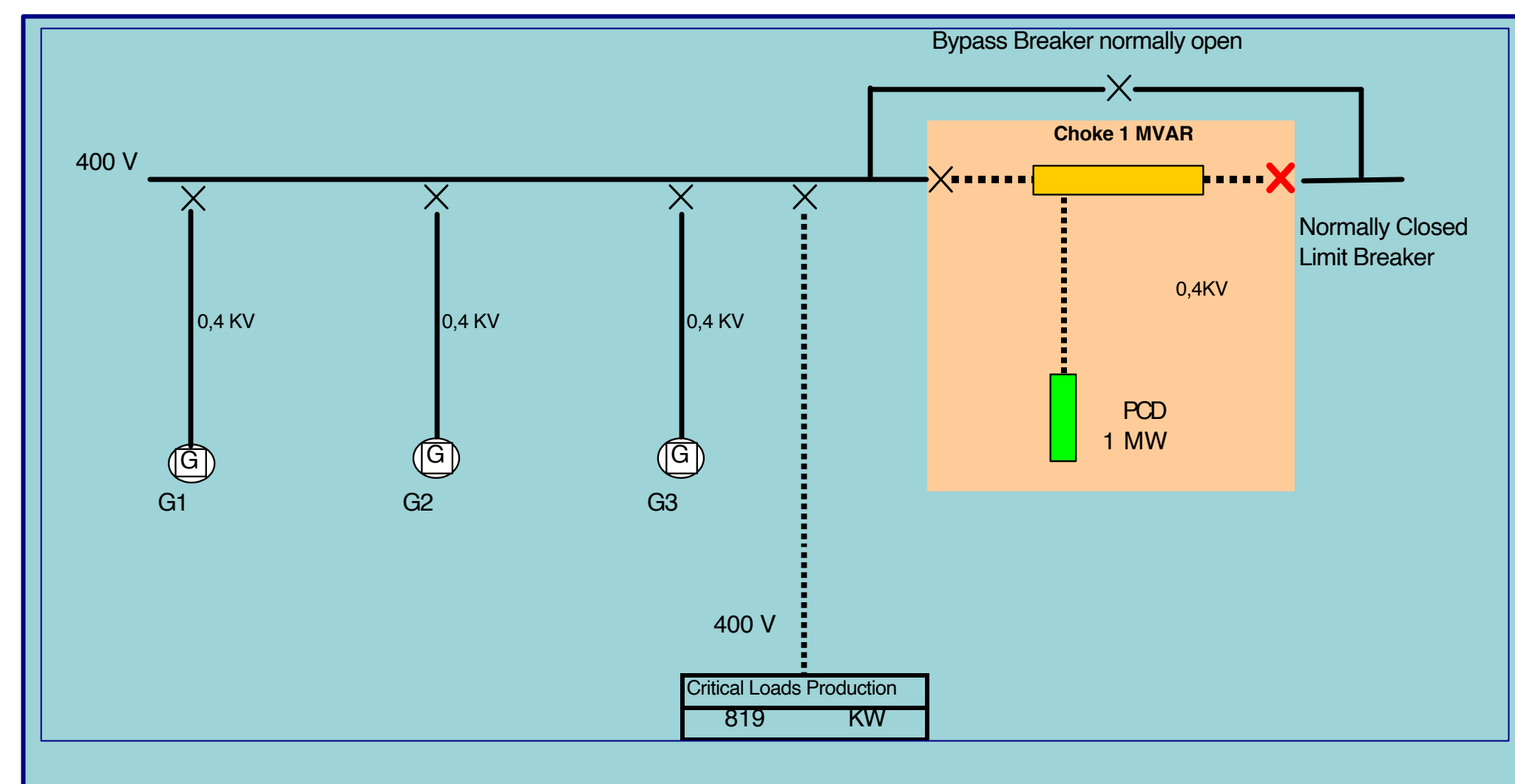
Concepts

- 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

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 kW_e
- Free-wheel UPS system (PILLER) 1,100kVA
- Voltage tolerance: $\pm 5\%$
- Frequency tolerance: $\pm 1\%$
- Max time range: 15



Rotating UPS System

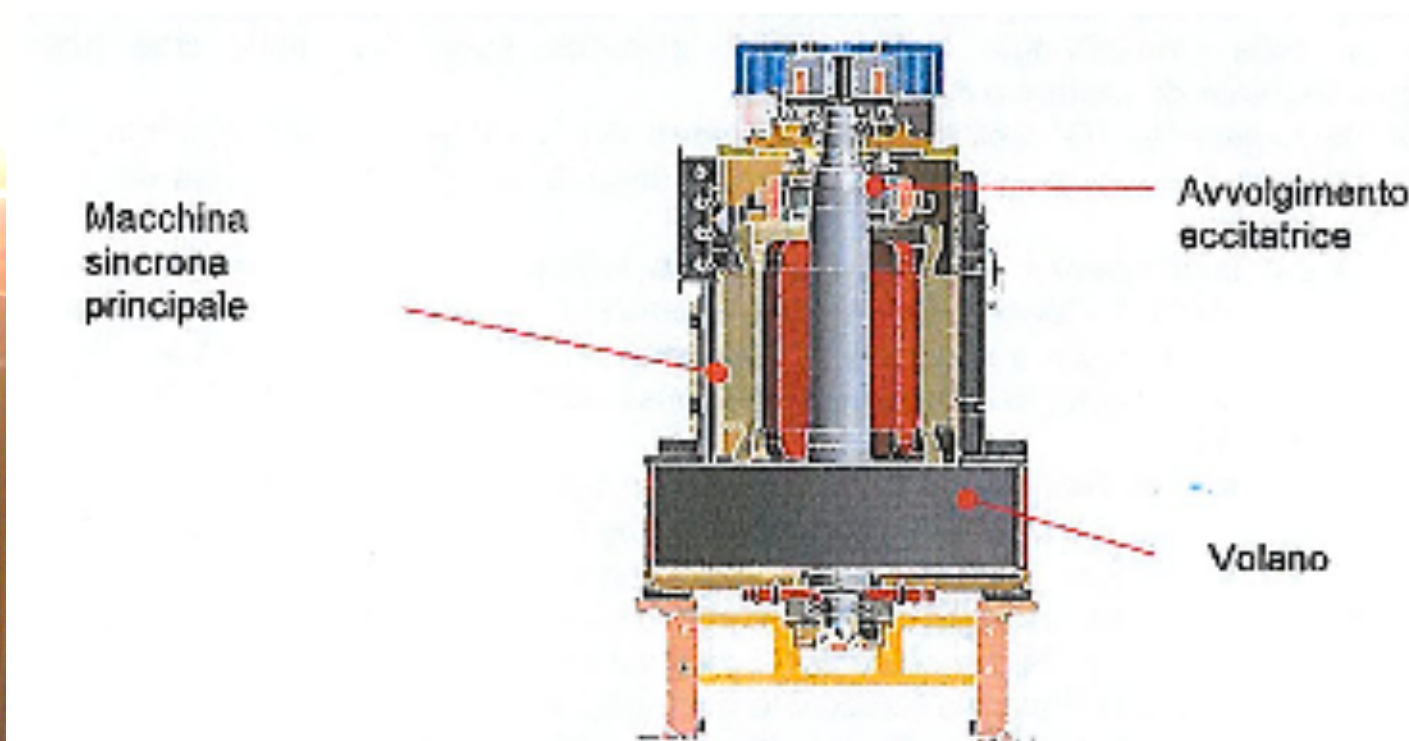
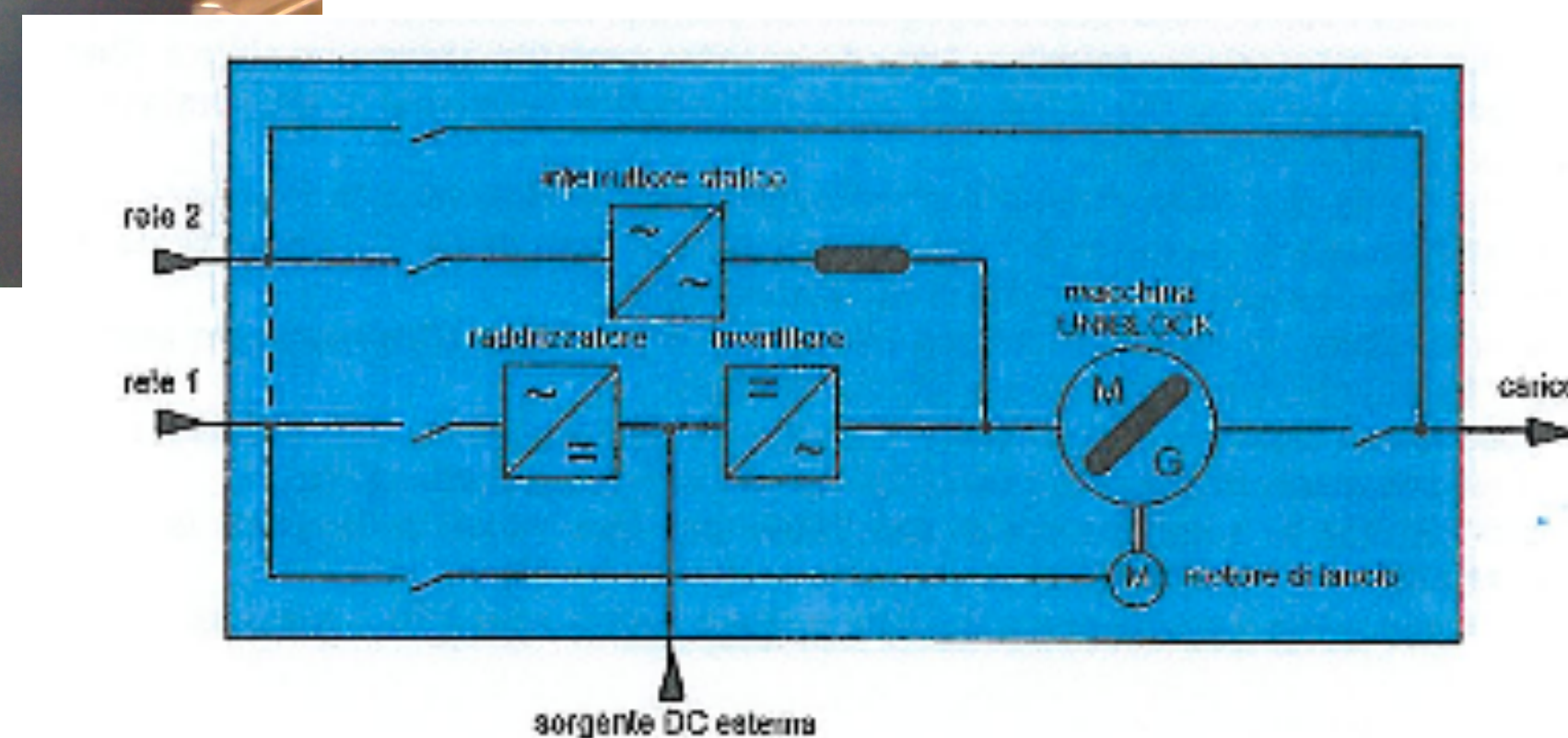
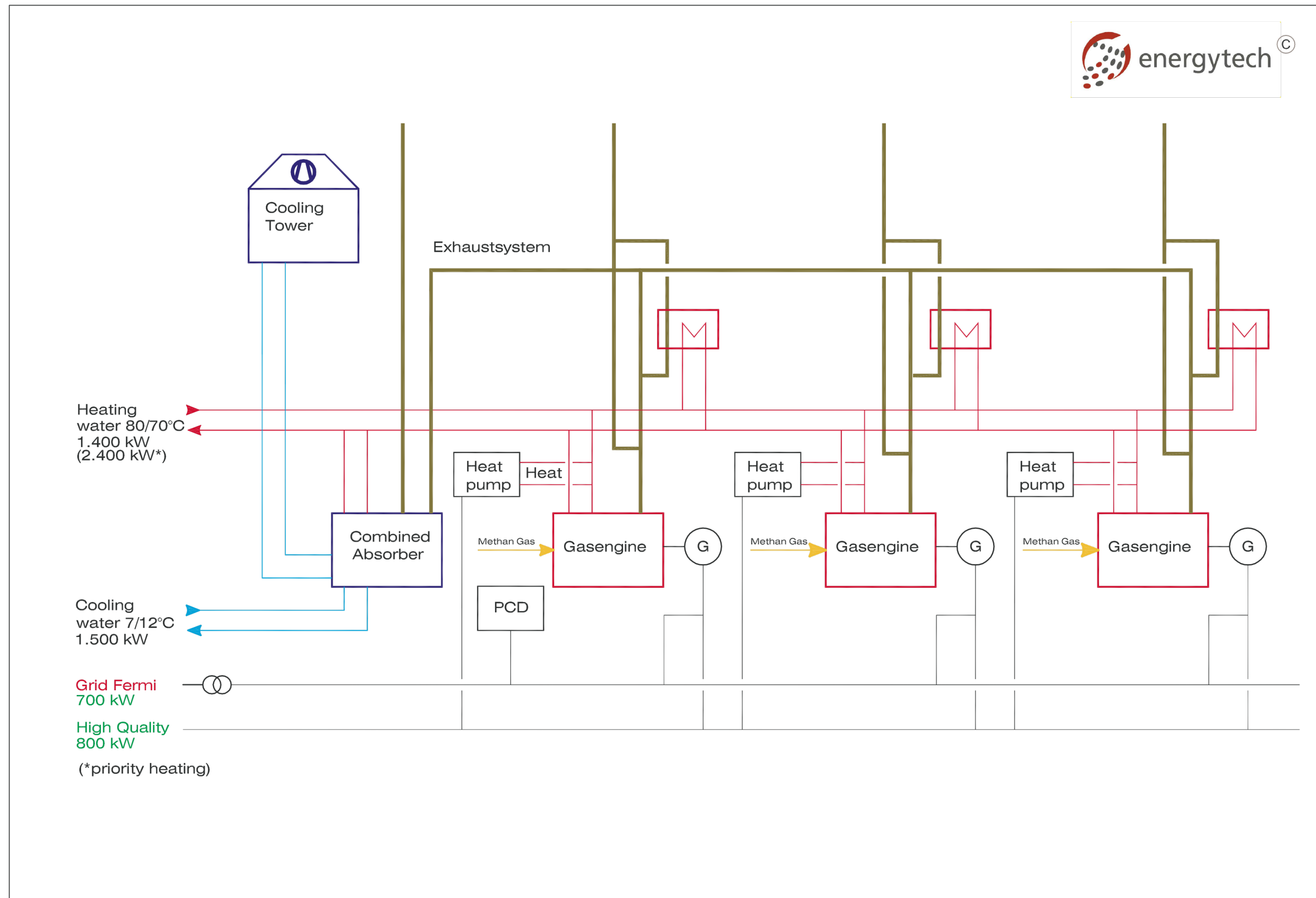


Fig. 5: Accumulatore inerziale PowerBridge



TGP Layout 1

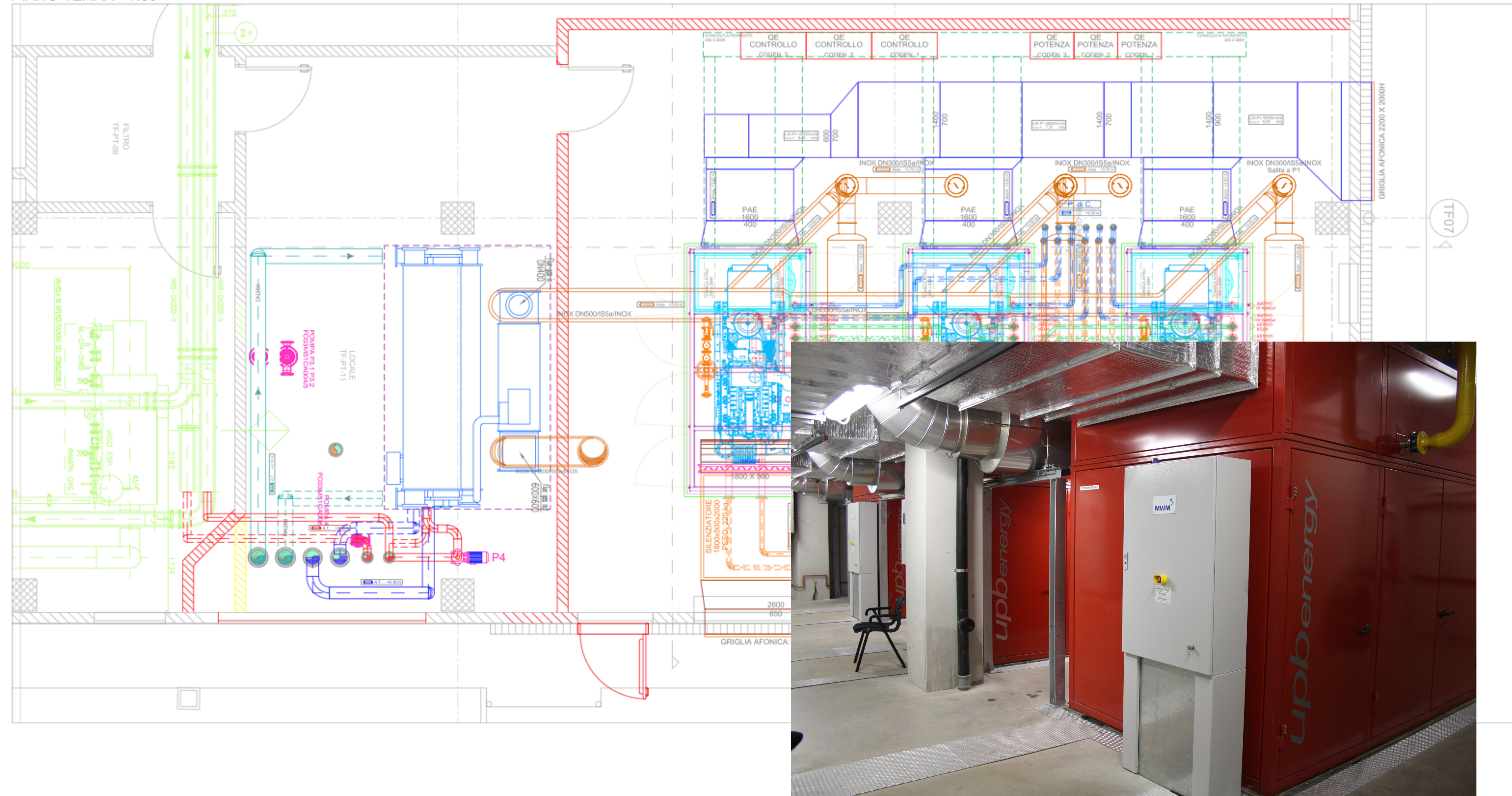


- Main Components
 - #3 Endothermic Gas Engines
 - #1 Combined Absorber (Hot Water & Exhausts)
 - #3 Engine Covers with heat recovering
 - #3 Heat Pumps
- Main Performances
 - Engine El. Pw: 600 kW
 - Total El. Pw: 1800 kW
 - Engine Ther. Pw: 1459 kW
 - Total Ther. Pw: 4377 kW
 - Total Refr. Pw: 1569 kW

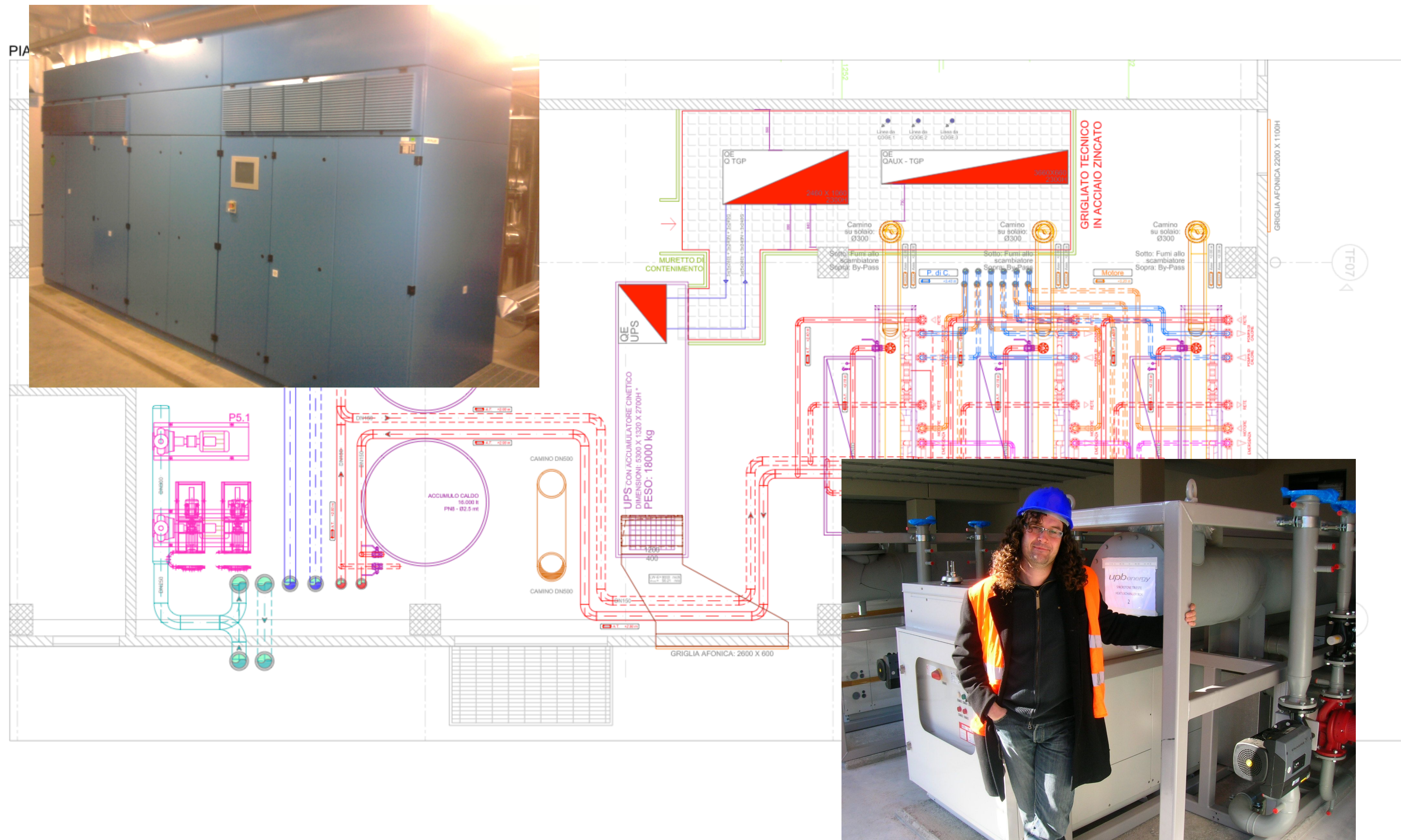
Block diagram Trigeneration plant

TGP Layout 2

PIANO TERRA - 1:50



TGP Layout 3



Energy Summary

| | | | |
|-----------------------|------------|------------|------------|
| Gas (Smc) | 2018 | 2019 | 2020 |
| Cogeneration | 5,074,161 | 5,195,774 | 5.434.769 |
| Boilers | 1,504 | 1,804 | 1.154 |
| | | | |
| Electric Energy (kWh) | 2018 | 2019 | 2020 |
| From Network | 31,118,563 | 29,914,272 | 29.768.208 |

Primary Energy Consumption

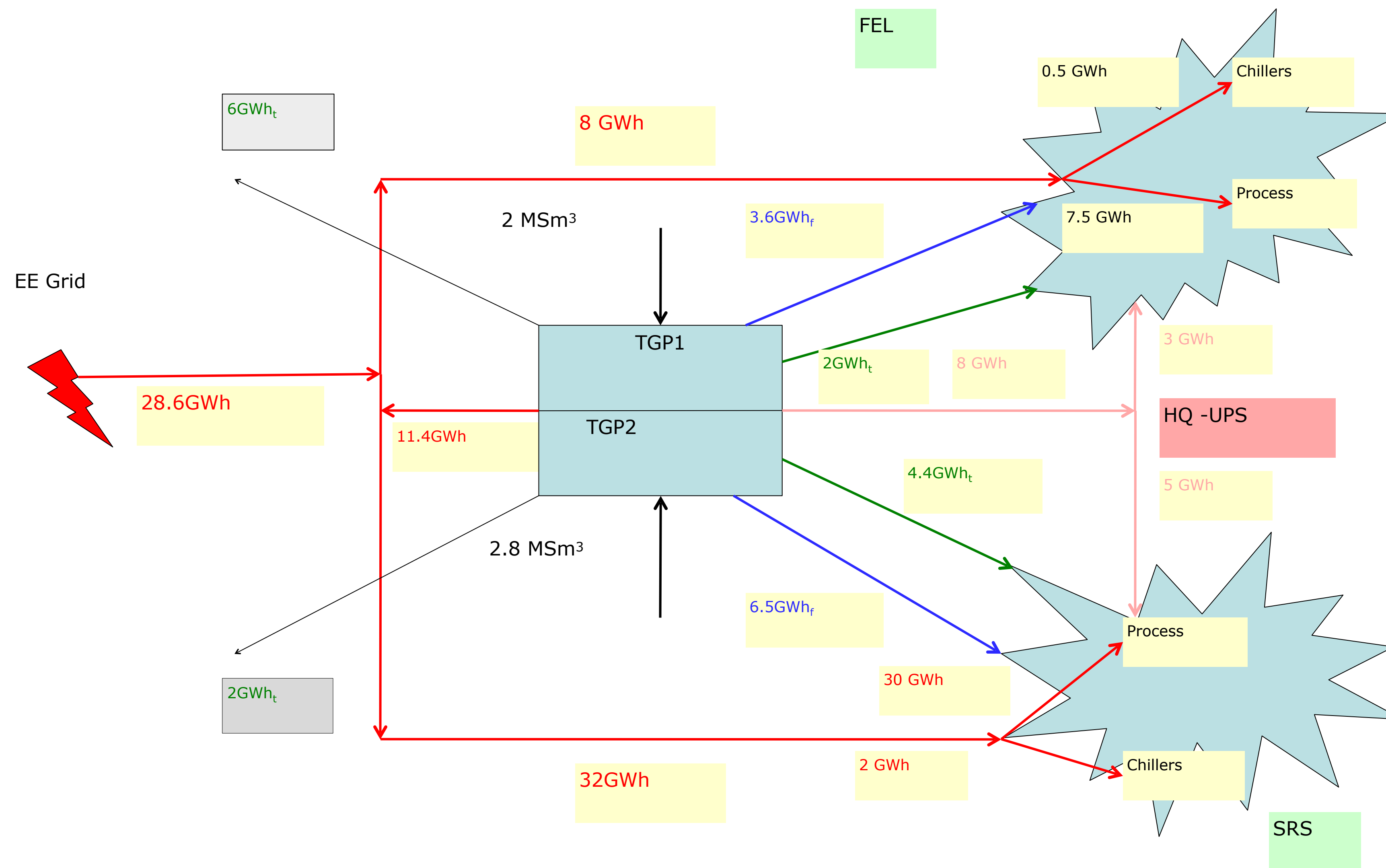
| | | | |
|-----------------------|--------|--------|--------|
| | 2018 | 2019 | 2020 |
| Electric Energy (MWh) | 49,125 | 48,464 | 49,296 |
| Thermal Energy(MWh) | 5,284 | 5.684 | 6.448 |
| Cooling Energy (MWh) | 12,762 | 13.064 | 13.335 |

Energy Consumption

| | | | |
|-----------------------|------------|------------|------------|
| Energia Elettrica | 2018 | 2019 | 2020 |
| EE from Network (kWh) | 31,118,563 | 29,914,272 | 29,768,208 |
| EE Produced (kWh) | 18,006,437 | 18,549,728 | 19,527,792 |

Electric Energy Detail

Energy Balance



Energy Efficiency: Actions

- 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



Sustainability



Electricity: 49 GWh



Cooling: 28.6 GWh_f



Heating: 6.4 GWh_t

Gas: 4,800,000 Smc

CO₂: 12,984 t

Electricity: 28.6 GWh

CO₂: 19,067 t



CO₂: -13,600 t



CO₂: +10,820 t

Total CO₂: -2,780 t (-8%)

Elettra - Power & Energy Monitoring

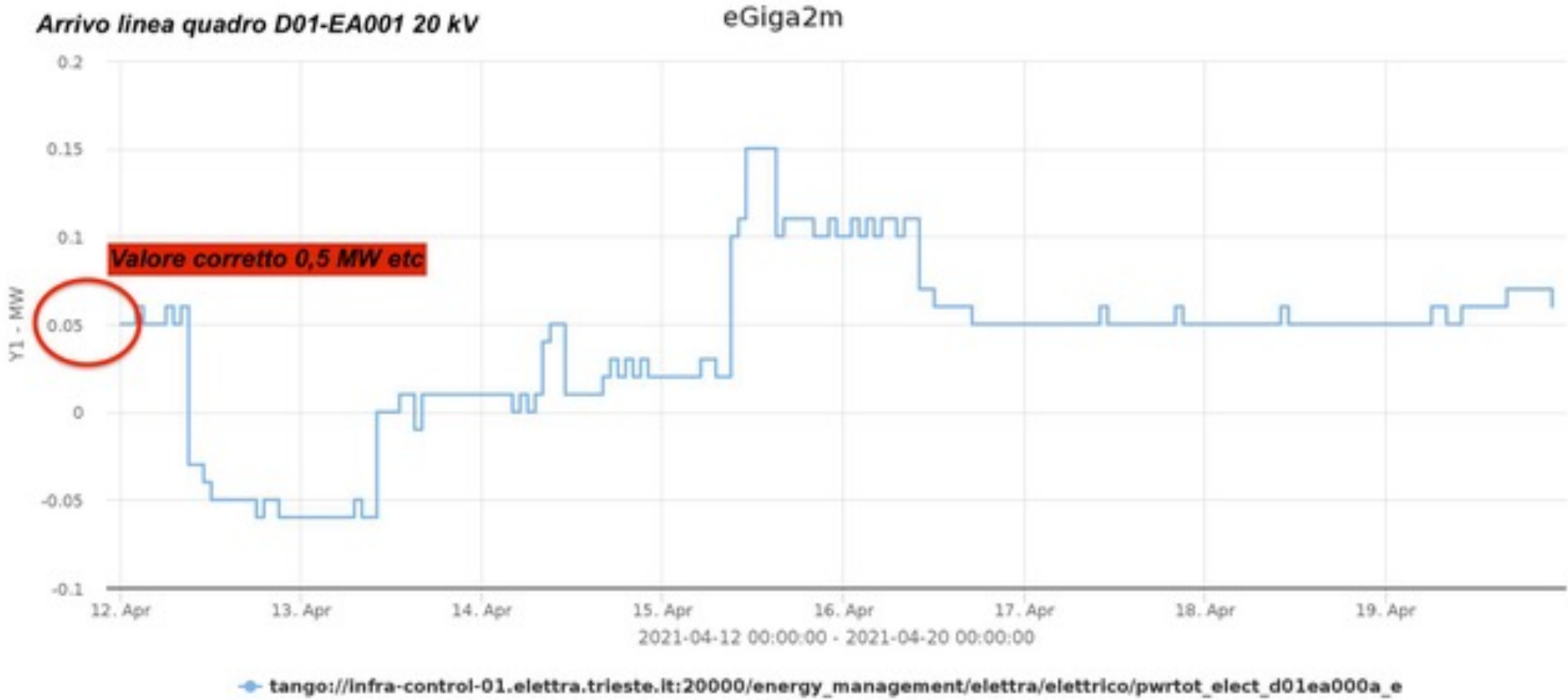
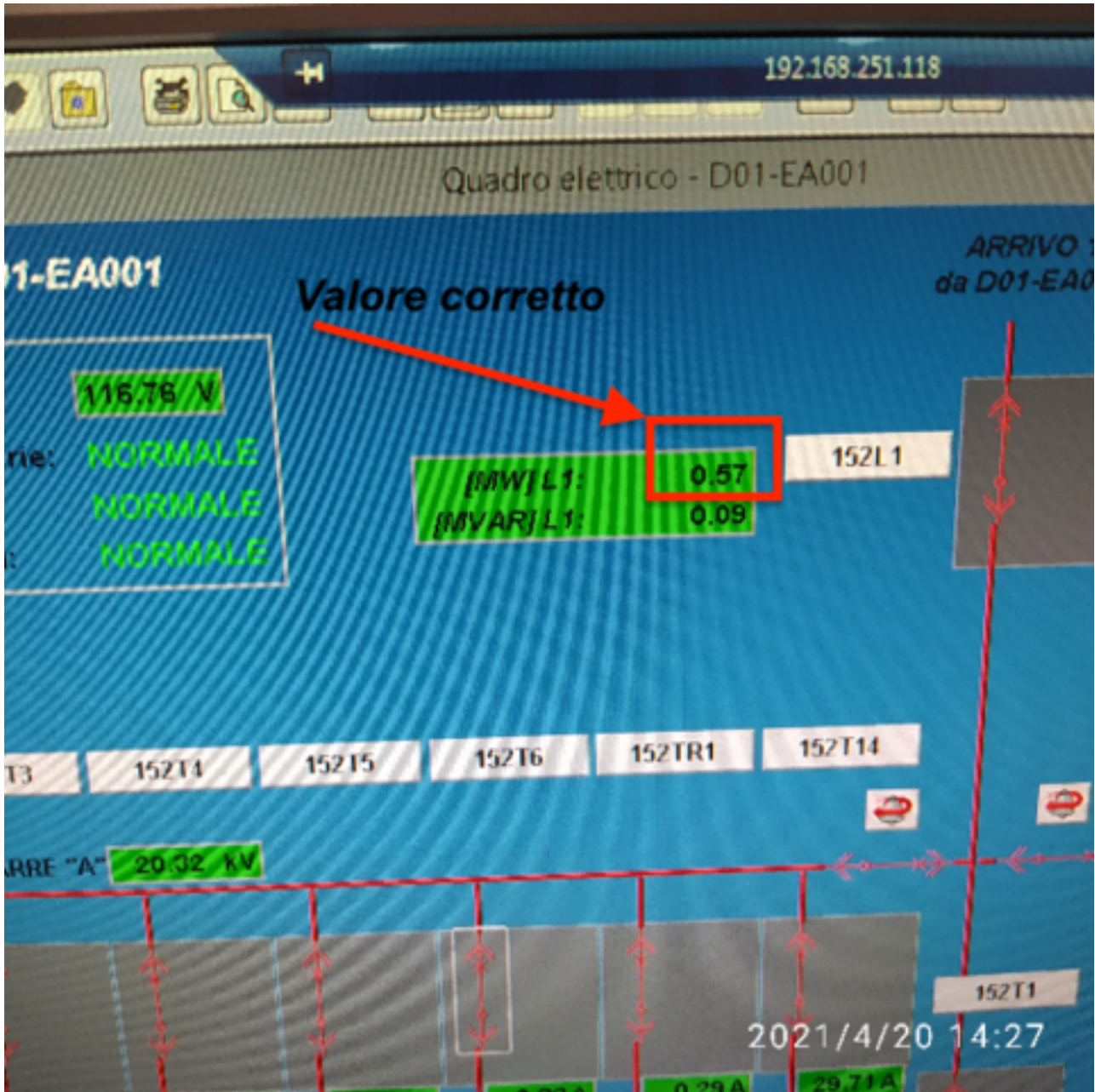
Table 1

| | En Daily Mean [MWh] | | | | Operations [day] | | | | Pw Mean [MW] | | | | Energy [GWh] | | | | | | |
|-------------|---------------------|------|------|------|------------------|-------|------|--------|--------------|------|------|------|--------------|-------|------|------|-------|------|------------|
| | 2.4 | 2.0 | MP | SD | 2.4 | 2.0 | MP | SD | 2.4 | 2.0 | MP | SD | 2.4 | 2.0 | MP | SD | Total | UPS | GrandTotal |
| 20_01 | 95.9 | 81.2 | 84.8 | 18.1 | 6.0 | 11.0 | 6.0 | 8.00 | 4.00 | 3.38 | 3.53 | 0.75 | 0.58 | 0.89 | 0.51 | 0.14 | 2.12 | 0.52 | 2.64 |
| 20_02 | 97.8 | 81.9 | 87.0 | | 6.0 | 19.0 | 4.0 | 0.00 | 4.07 | 3.41 | 3.63 | 0.00 | 0.59 | 1.56 | 0.35 | 0.00 | 2.49 | 0.50 | 3.00 |
| 20_03 | 95.0 | 82.0 | 85.4 | | 3.0 | 24.0 | 4.0 | 0.00 | 3.96 | 3.42 | 3.56 | 0.00 | 0.28 | 1.97 | 0.34 | 0.00 | 2.59 | 0.52 | 3.12 |
| 20_04 | 94.8 | | 81.2 | 37.0 | 3.0 | | 2.0 | 25.00 | 3.95 | 0.00 | 3.38 | 1.54 | 0.28 | 0.00 | 0.16 | 0.93 | 1.37 | 0.52 | 1.89 |
| 20_05 | 96.3 | 87.7 | 92.0 | | 6.0 | 20.0 | 5.0 | 0.00 | 4.01 | 3.65 | 3.83 | 0.00 | 0.58 | 1.75 | 0.46 | 0.00 | 2.79 | 0.52 | 3.31 |
| 20_06 | 97.1 | 87.7 | 87.1 | 44.7 | 6.0 | 2.0 | 1.0 | 21.00 | 4.05 | 3.66 | 3.63 | 1.86 | 0.58 | 0.18 | 0.09 | 0.94 | 1.78 | 0.50 | 2.29 |
| 20_07 | 73.4 | 87.1 | 61.6 | 18.6 | 5.0 | 15.0 | 6.0 | 5.00 | 3.06 | 3.63 | 2.57 | 0.77 | 0.37 | 1.31 | 0.37 | 0.09 | 2.14 | 0.52 | 2.66 |
| 20_08 | 100.0 | 81.7 | 85.6 | 43.5 | 4.0 | 6.0 | 5.0 | 16.00 | 4.17 | 3.41 | 3.57 | 1.81 | 0.40 | 0.49 | 0.43 | 0.70 | 2.02 | 0.52 | 2.54 |
| 20_09 | 98.9 | 84.0 | 84.2 | | 3.0 | 21.0 | 6.0 | 0.00 | 4.12 | 3.50 | 3.51 | 0.00 | 0.30 | 1.76 | 0.51 | 0.00 | 2.57 | 0.50 | 3.07 |
| 20_10 | 89.6 | 88.9 | 82.3 | 49.4 | 7.0 | 3.0 | 1.0 | 20.00 | 3.73 | 3.71 | 3.43 | 2.06 | 0.63 | 0.27 | 0.08 | 0.99 | 1.97 | 0.52 | 2.49 |
| 20_11 | 96.0 | 81.0 | 85.0 | 39.9 | 6.0 | 14.0 | 6.0 | 4.00 | 4.00 | 3.37 | 3.54 | 1.66 | 0.58 | 1.13 | 0.51 | 0.16 | 2.38 | 0.50 | 2.88 |
| 20_12 | 97.9 | 81.5 | 80.0 | 37.1 | 5.0 | 14.0 | 3.0 | 9.00 | 4.08 | 3.40 | 3.33 | 1.55 | 0.49 | 1.14 | 0.24 | 0.33 | 2.21 | 0.52 | 2.73 |
| Totale 2020 | 94.1 | 83.6 | 82.5 | 39.6 | 60.0 | 149.0 | 49.0 | 108.00 | 3.92 | 3.48 | 3.44 | 1.65 | 5.65 | 12.45 | 4.04 | 4.28 | 26.42 | 6.18 | 32.60 |

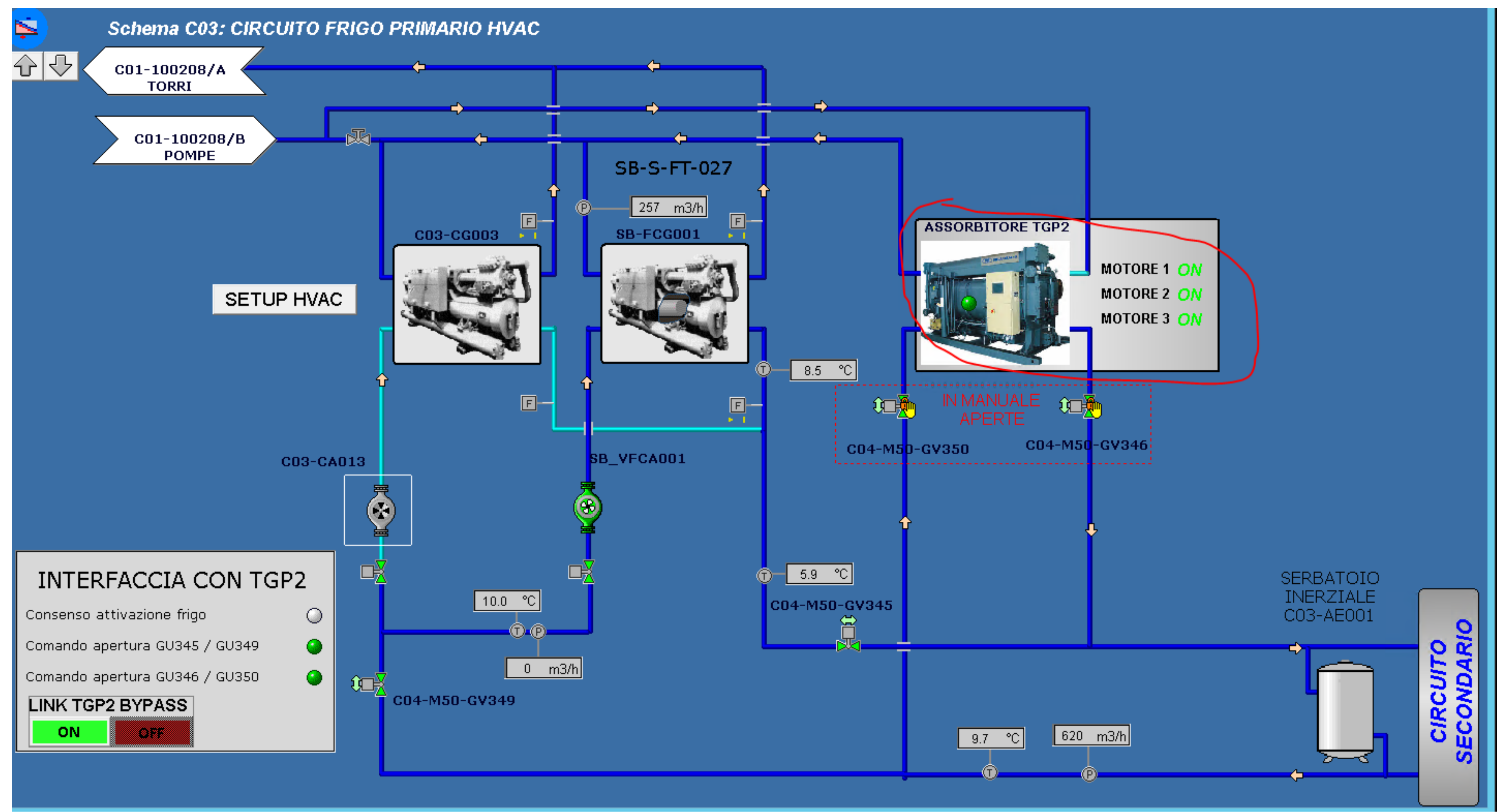
Elettra - Energy Consumption by System

| Table 1 | | | | | | | | | | | | | | | | |
|-------------|---------|-----------|-----------|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| | E01 | D01-EG001 | D01-EG002 | D01-EG003 | D01-EG004 | D01-EG005 | D01-EG006 | D01-EG007 | D01-EG008 | D01-EG009 | D01-EG010 | D01-EG011 | D01-EG012 | D01-EG014 | D01-EG015 | |
| | Arrivo | | Riserva | Correttori | Dipoli | Quad/Sest | RF | Cooling | Cooling | Cooling | Luce/FM | Riserva | Riserva | TGP2 | Booster | Totale |
| | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] | [MWh] |
| 20_01 | 1929.5 | 44.0 | 9.7 | 100.2 | 374.5 | 184.7 | 353.1 | 261.0 | 145.1 | 463.2 | 125.7 | 0.0 | 0.0 | 150.0 | 40.5 | 2101.6 |
| 20_02 | 2283.6 | 41.2 | 7.6 | 119.5 | 438.5 | 228.6 | 454.8 | 313.8 | 207.0 | 497.7 | 119.1 | 0.0 | 0 | 150.0 | 43.5 | 2471.3 |
| 20_03 | 2361.2 | 44.0 | 7.7 | 122.6 | 436.5 | 232.9 | 473.7 | 336.1 | 223.0 | 538.2 | 115.2 | 0 | 0 | 150.0 | 44.7 | 2574.8 |
| 20_04 | 1191.4 | 42.6 | 6.5 | 29.0 | 100.5 | 58.2 | 104.2 | 268.5 | 147.5 | 471.5 | 100.7 | 0 | 0 | 150.0 | 23.0 | 1352.2 |
| 20_05 | 2779.5 | 44.0 | 5.9 | 155.5 | 469.0 | 324.3 | 469.3 | 387.2 | 224.3 | 530.4 | 116.4 | 0 | 0 | 150.0 | 44.5 | 2770.8 |
| 20_06 | 1802.7 | 42.6 | 4.3 | 81.6 | 172.0 | 172.0 | 248.1 | 334.3 | 161.5 | 402.1 | 115.0 | 0 | 0 | 150.0 | 31.1 | 1764.5 |
| 20_07 | 1906.5 | 44.0 | 4.7 | 81.8 | 403.0 | 163.6 | 257.4 | 371.9 | 163.7 | 462.8 | 123.1 | 0 | 0 | 250.0 | 39.0 | 2115.2 |
| 20_08 | 1586.8 | 44.0 | 4.9 | 62.0 | 251.0 | 120.2 | 225.1 | 380.2 | 185.5 | 558.4 | 127.9 | 0 | 0 | 397.0 | 36.1 | 1995.3 |
| 20_09 | 1889.2 | 42.6 | 4.6 | 118.8 | 435.0 | 227.6 | 437.0 | 388.9 | 173.6 | 548.0 | 124.6 | 0 | 0 | 744.0 | 46.0 | 2546.7 |
| 20_10 | 1244.8 | 44.0 | 7.3 | 72.3 | 206.0 | 147.2 | 287.9 | 314.3 | 162.2 | 539.1 | 125.8 | 0 | 0 | 751.0 | 33.8 | 1939.9 |
| 20_11 | 1615.5 | 42.6 | 7.6 | 108.1 | 412.0 | 209.4 | 393.6 | 306.8 | 157.1 | 556.4 | 124.3 | 0 | 0 | 807.0 | 41.2 | 2358.9 |
| 20_12 | 1464.5 | 44.0 | 8.3 | 89.9 | 336.5 | 171.2 | 349.0 | 293.9 | 156.7 | 574.1 | 127.7 | 0 | 0 | 796.0 | 34.1 | 2185.3 |
| Totale 2020 | 22055.2 | 519.6 | 79.2 | 1141.2 | 4034.5 | 2239.7 | 4053.0 | 3957.0 | 2107.2 | 6142.0 | 1445.4 | 0 | 0 | 4645.0 | 457.5 | 26176.5 |
| | | | | | PS | | RF | | Cooling | | | | | | | |
| | | | | | 7,415 | | 4,053 | | 12,206 | | | | | | | |
| | | | | | 28.33% | | 15.48% | | 46.63% | | | | | | | |

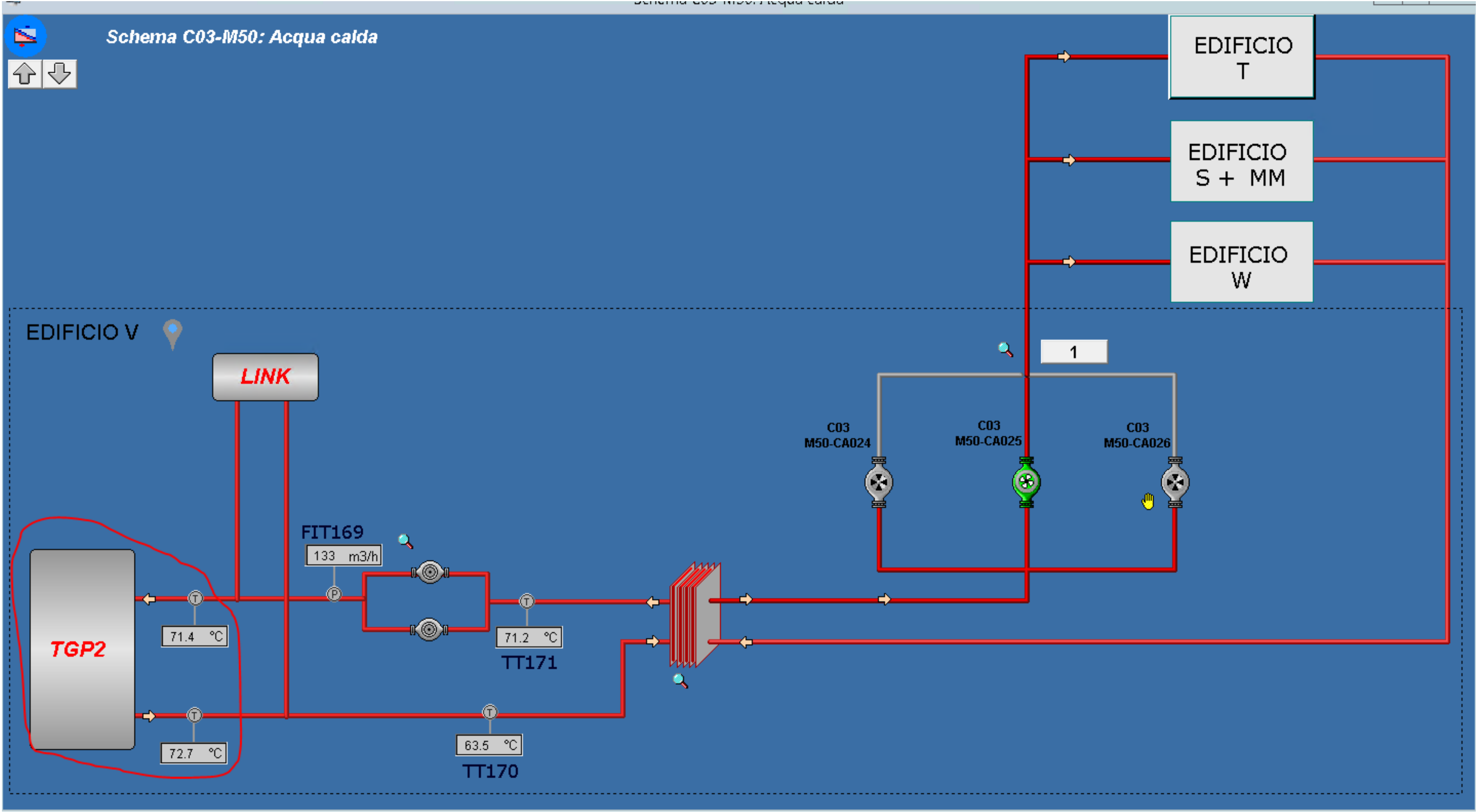
Electrical Energy Monitoring



Cooling System Monitoring



Heating System Monitoring



Thank you for your attention