Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Power Supply System for DTT

DTT Industry Day

Villa Mondragone, Monte Porzio Catone (Rome), Italy – 14/12/2018

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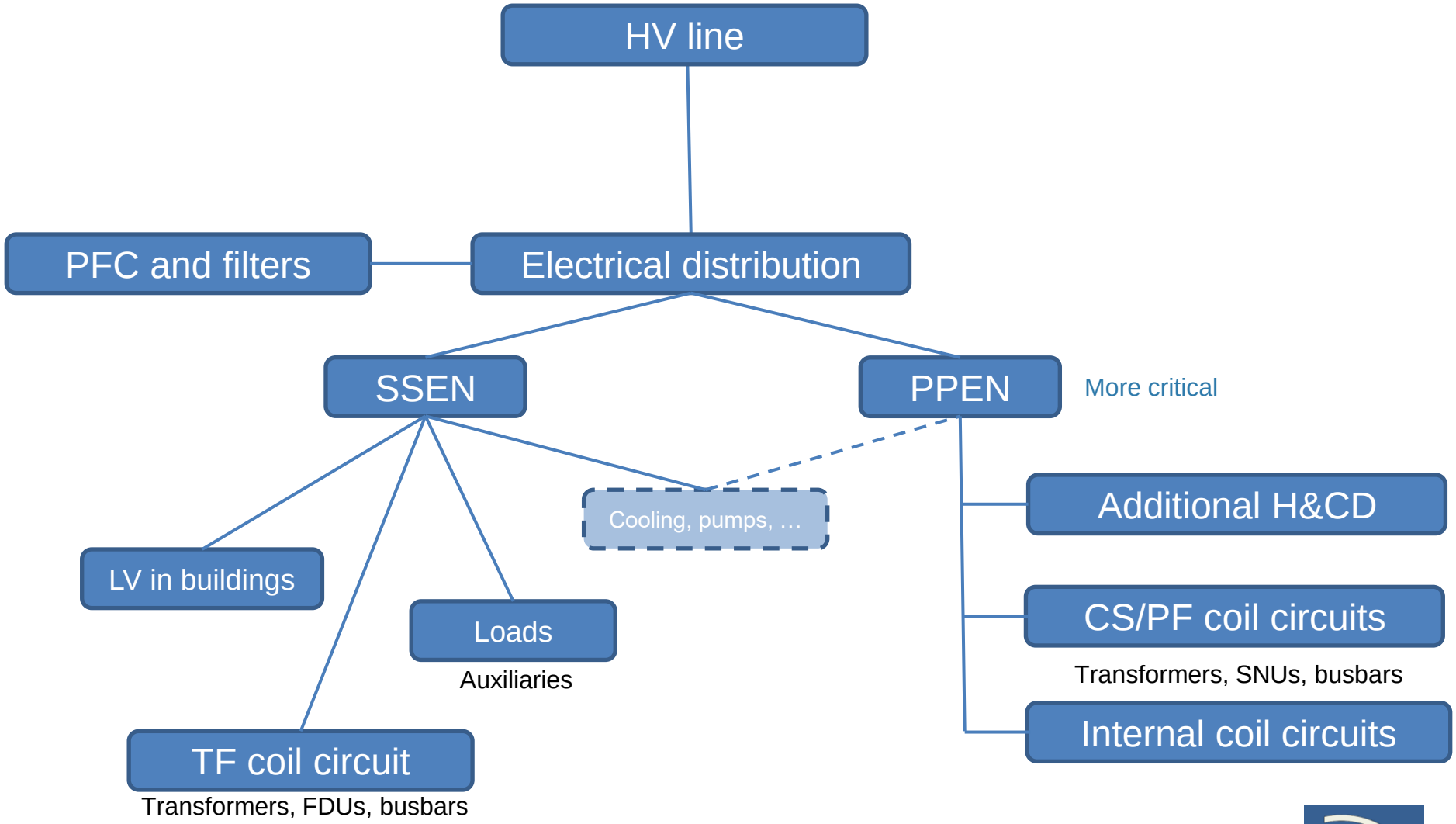
Topics of the presentation: PSS Procurements

Power supply System (PSS) = everything electrical in the DTT project

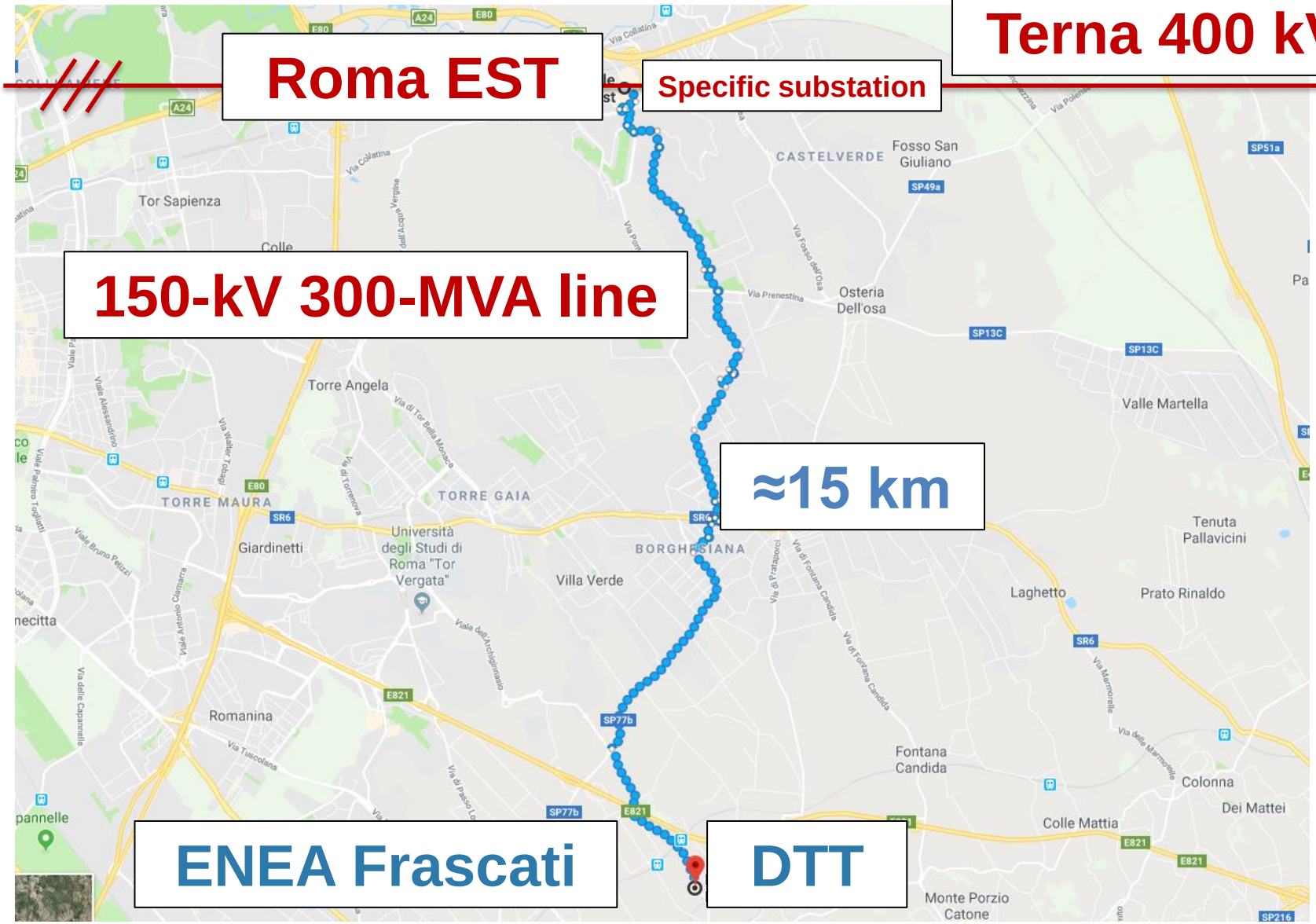
Excluding (partially):

1. The standard low voltage distribution inside the buildings
    - Included in the BUI/site procurements
2. The Additional Heating (ECRH, ICRH, NBI) PSs
    - Today presented by Gustavo Granucci
3. PSs for control of ELMs, RWMs
    - Not yet totally defined

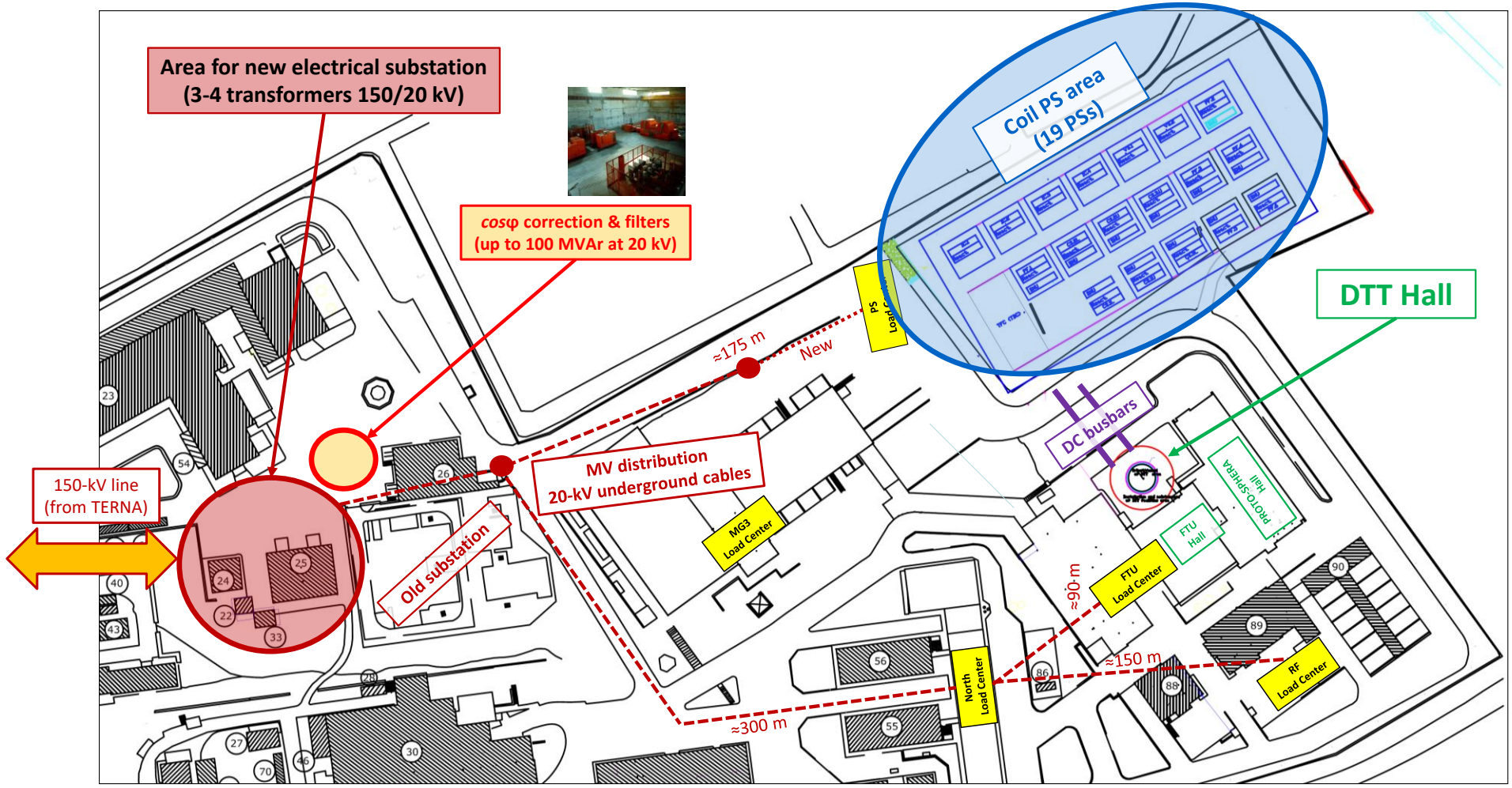
Description follows flow of power (stressing criticality)



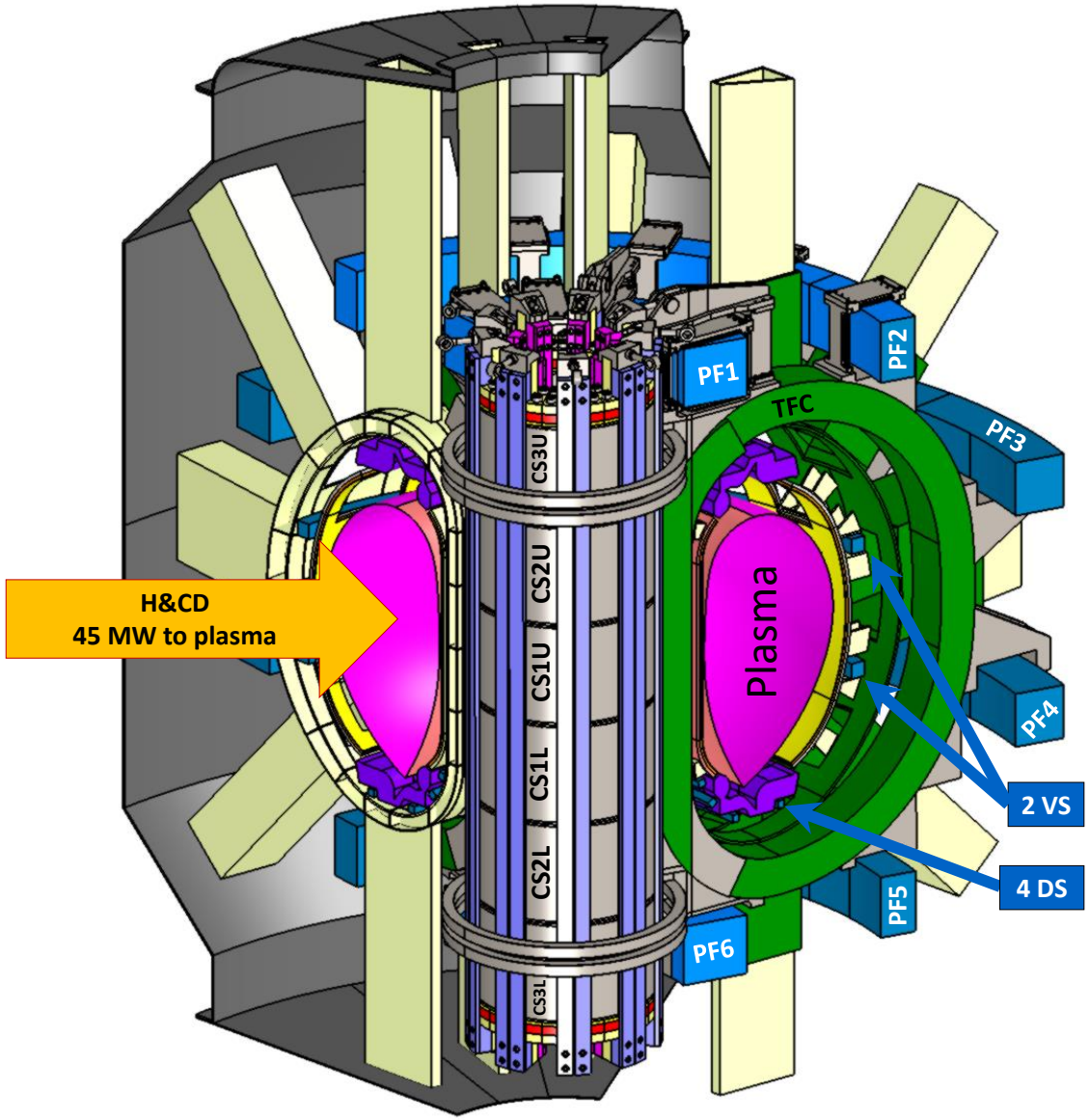
High voltage line (approximate) path



PS layout in the ENEA Center in Frascati



Summary of the 19 coil PSs



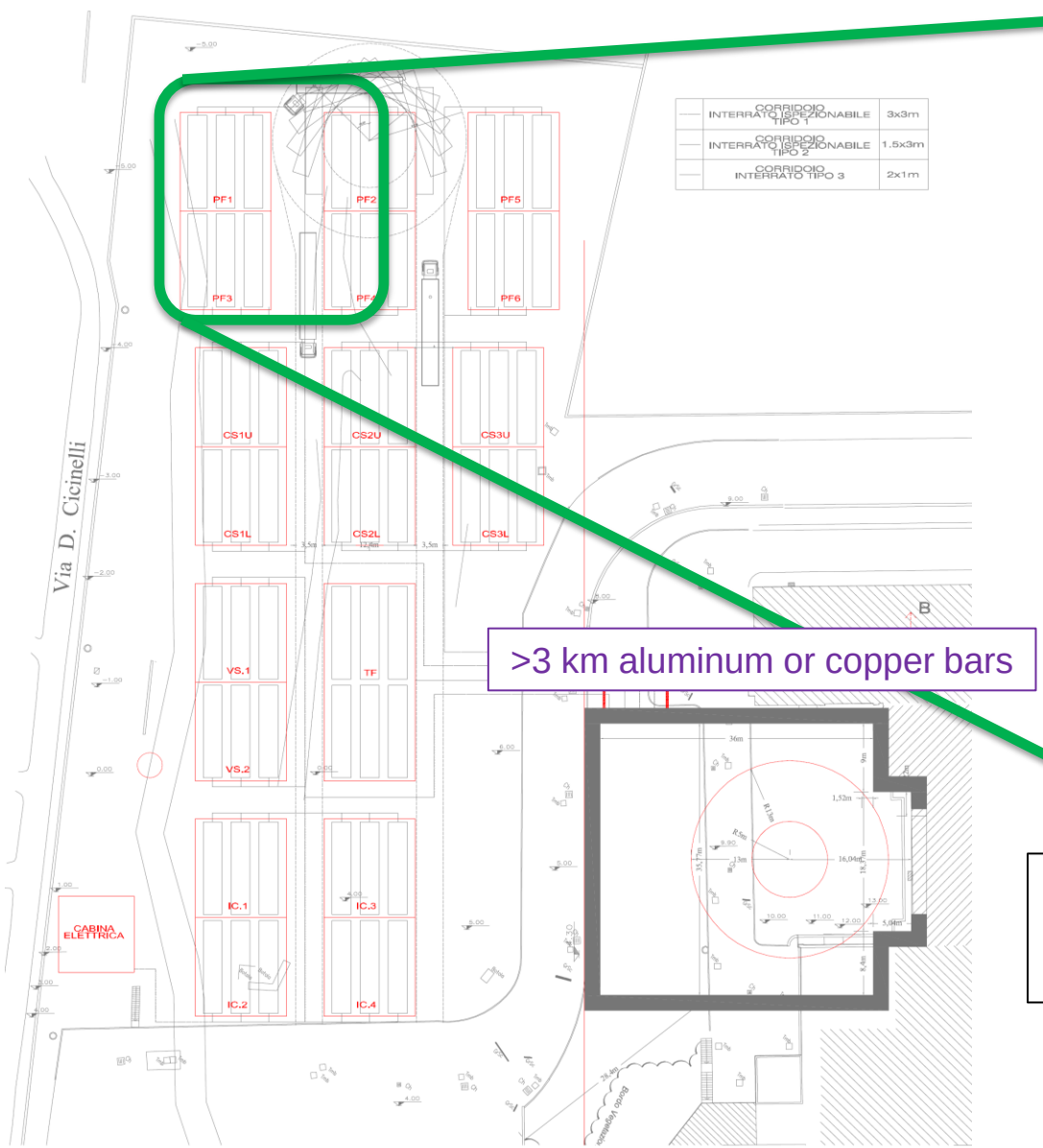
Operation: ≈100 s
Period: every 3600 s

Superconducting coils:
- 12 CS/PF ≈28 kA, ≈1 kV

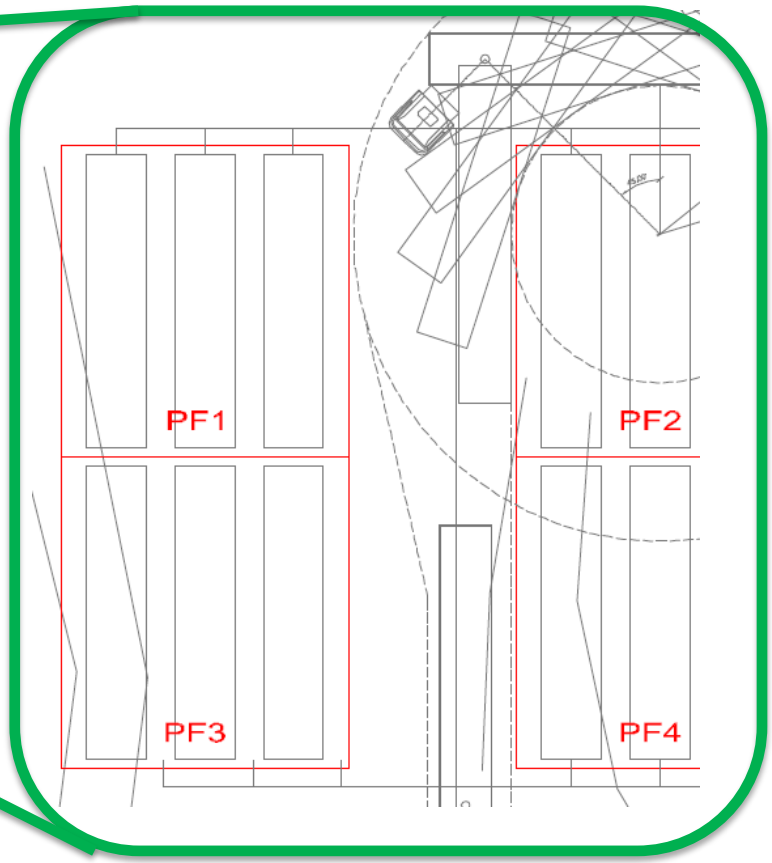
Copper coils:
- 2 VS ≈20 kA, ≈100 V
- 4 DC ≈60 kA, ≈100 V
- ELM, RWM

Continuative (days):
- 1 TF ≈27 kA, ≈100 V

Last layout of the are for the 19 coil PSs

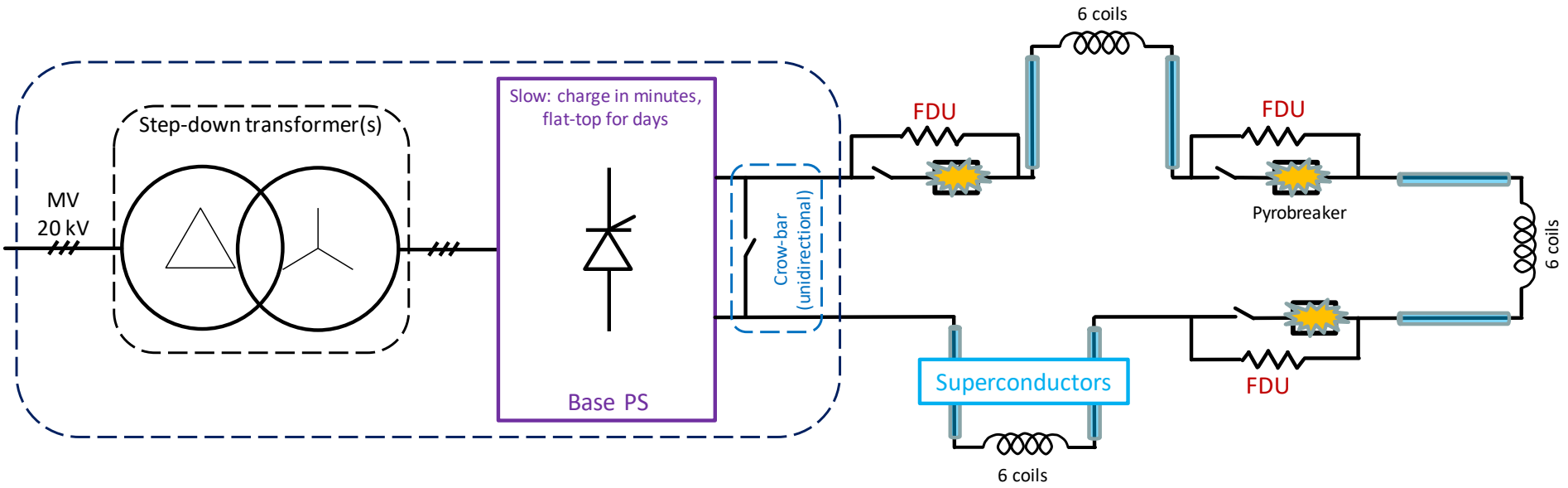


>3 km aluminum or copper bars



- Each PS has a dedicated area 12x13 m
- In each area 3-4 standard (40 feet) containers can be placed

Main characteristics of TF PSs



Current: 27 kA

Voltage: ≈100 V (slow ramps)

18 coil load: ≈5 H

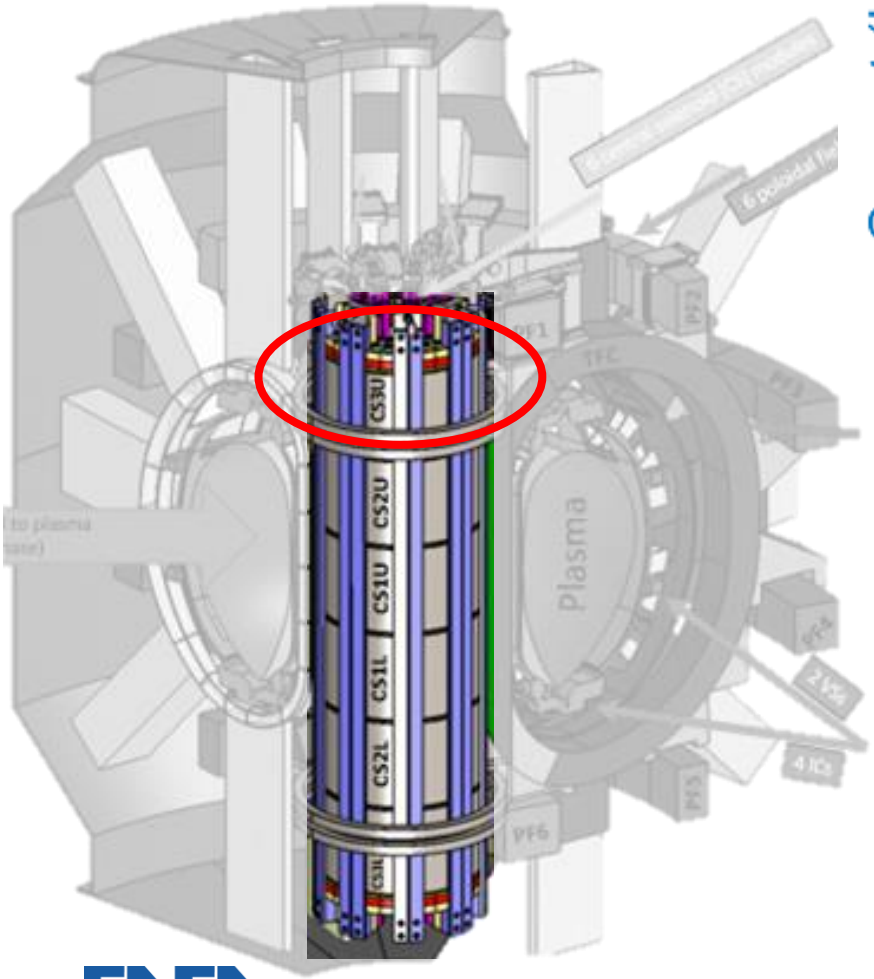
Raw water cooling will be provided (maybe free refill for demineralized)

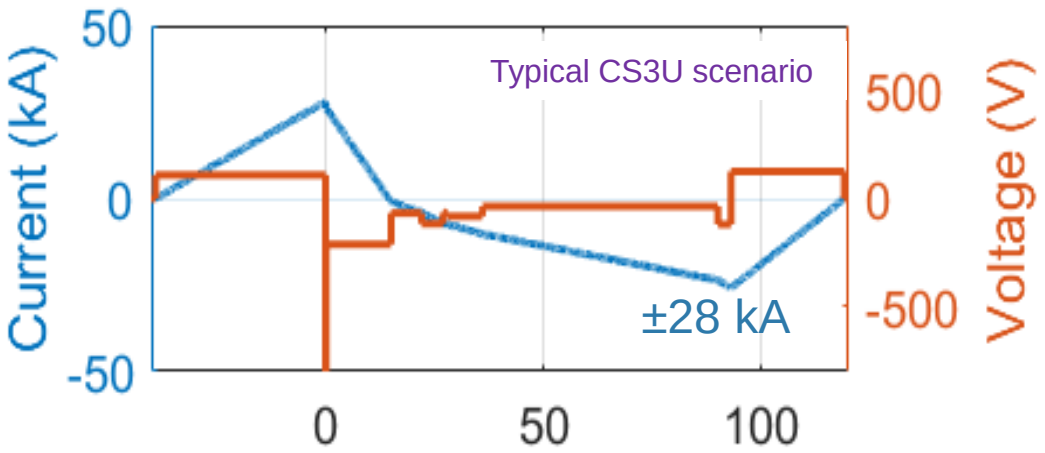
Crtical: high voltage, each >>7 kV
Mechanical switch (or hybrid)

A different Call for Tender will provide a system to discharge coil energy in case of fault (quench), divided in at least 3 Fast Discharge Units (FDUs)

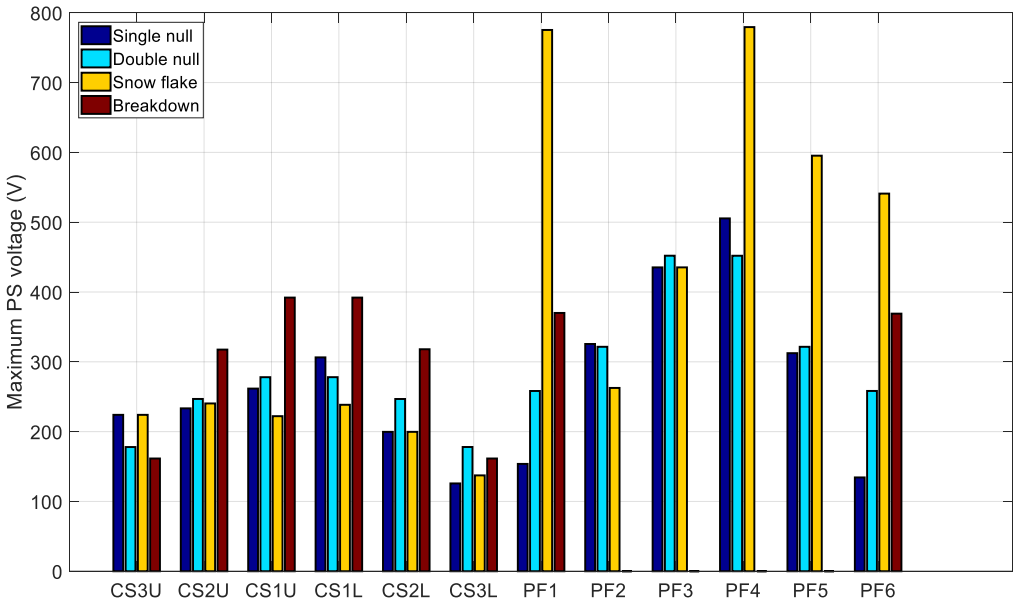
Typical CS/PF scenarios

CS/PF loads:
≈100 mH plus mutual inductances

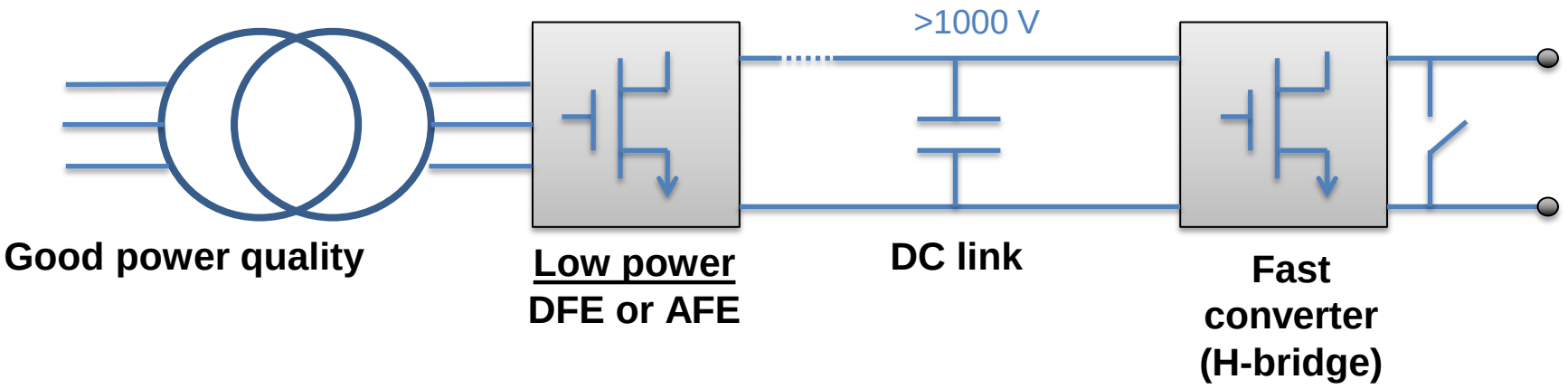




Maximum coil voltages reached during different scenarios



Other specifications of CS/PF PSs



Low power input: 20 kV, <100 kW (energy recovery)

DC link is up to you but remember Ragone plot

Cooling: raw water will be provided

Fast SNU → Static (IGCTs)

Each PS shall include:

1. A system (SNU) to increase the voltage at breakdown (t=0) up to ≈3 kV
2. A system (FDU) to discharge coil energy in case of fault (quench)
3. An internal protection system (crowbar)

Can be merged

PSs for copper coils

PS circuit	Main characteristics	Possible topology & technology
2 vertical stabilization (VS) coils	≈20 kA ≈100 V Fast control	DC link H-bridge IGBTs
4 divertor coils (DCs)	≈60 kA ≈100 V Maybe slow control	Thyristors
Coils for edge-localized (ELMs) and resistive wall modes (RWMs)	Fast	H-bridge Silicon Carbide?

Protections (crowbars) may be very critical (even twice nominal current)

Rough estimation of possible final configuration

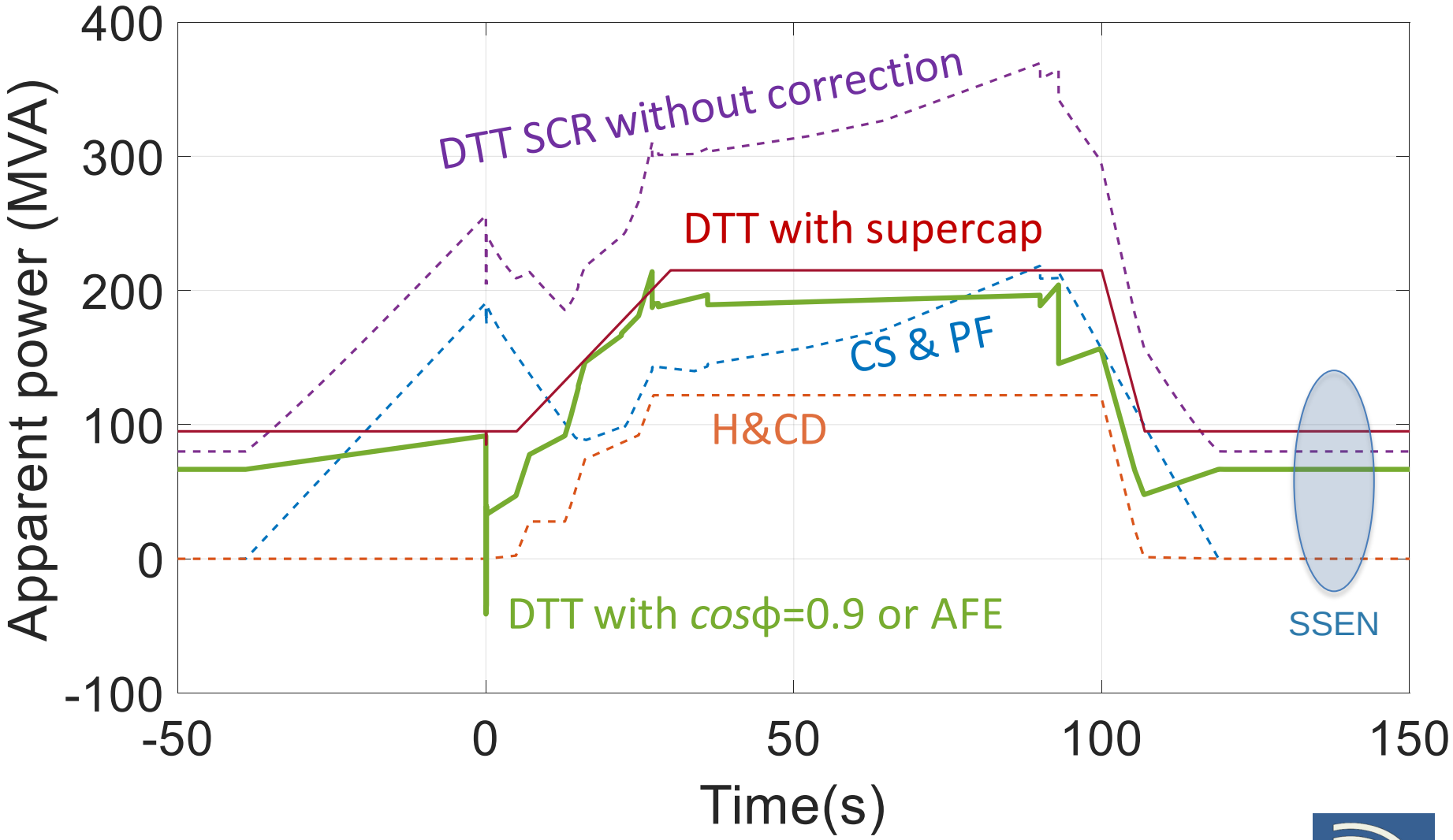
- Total Energy Storage for 12 PSs: 600 MW, 3600 MJ, 960 kWh
- Moreover, ENEA has SMESs and flywheels
- Comparison:
  - Korea: 25 MW supercap in several facilities
  - Endesa STORE, Canary Islands, Spain supercap: 4 MW, 20 MJ
  - Terna, Sicilia + Sardegna supercap: 1+1 MW, 1+1 MJ
  - Terna has some battery systems in order of 10 MW
  - DTT could be an “electrostatic lake” (Italy has 4 hydro-storage lakes at 1 GW)

If you like to know more:

2016: Frascati
2017: Valsamoggia
2018: Salerno

27-28 June 2019: Bologna
www.supercap.org

Expected total DTT power from grid



Summary of PSS Calls for Tenders

		2019				2020				2021				2022				2023				2024				2025			
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	High-voltage line																												
2	Electrical substation																												
3	Power factor corrrection and filters																												
4	Electrical distribution (SSEN & PPEN)																												
5	Toroidal Field Coil PS																												
6	Toroidal Field Coil fast discharge units																												
7	CS/PF PSs and SNUs (some BPSs)																												
8	Internal Coil PSs																												
9	DC busbars (CS, PF, TF, IC)																												
10	Others (dummy loads, auxiliary, transducers, …)																												

Color code:

- Preliminary analysis
- Prepare and launch the Call for Tender
- Call for Tender
- Design
- Manufactoring and factory tests
- Installation (and procedures for the HV line)
- Test
- Commisioning

Remember, not including:

- H&CD PSs
- ELM, RWM PSs
- LV in buildings

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