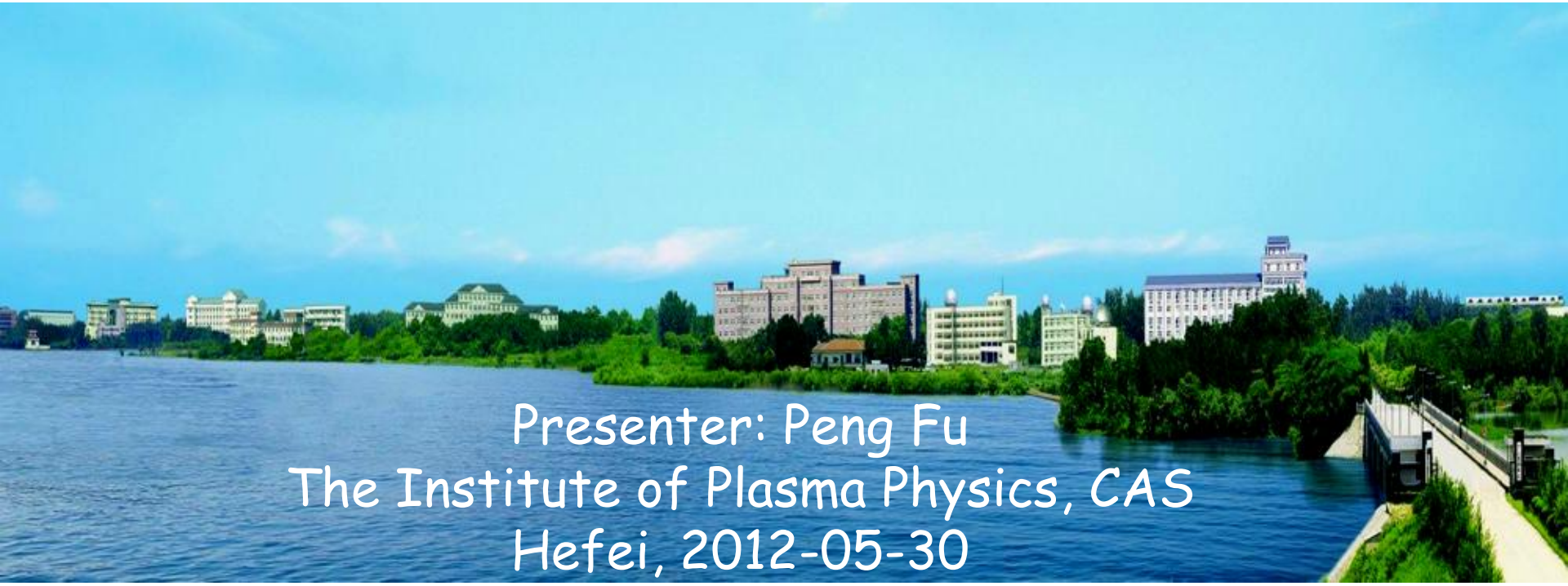
The Concept Design of PS and CW System for CFETR

For meeting May 30-Jun. 1, 2012 in Hefei



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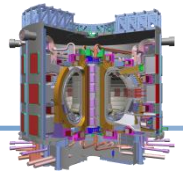
The Institute of Plasma Physics, CAS
Hefei, 2012-05-30



Background and input

ASIPP

CFETR machine parameters:

B_{to} : 5.3 / 4.5 T

I_p : 12 / 10/ 07 MA

R_o : 5.5 m

A : 1.6 m, K : 1.8

Blanket thickness 1.0m

Superconductive coil just ITER like and size

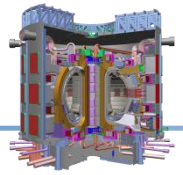
Operation parameters:

Pfusion=200MW

Duty cycle time ≥ 0.3 ~ 0.5

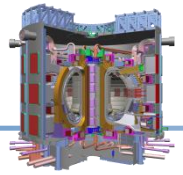
Heating system parameters

P_{total} =100MW (NBI 40MW)



Content

- **Concept design of PS system**
- **Concept design of CW system**
- **Next work to be done**
- **Summary**

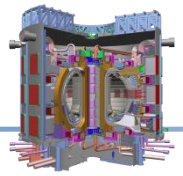


Concept design of PS system

ASIPP

Power supply consists of

- ★ **Power system and HV substation**
  transformer high voltage to lower level
- ★ **Pulsed power supply**
  magnet PS/ TF,CS, PF,VS, heating PS/microwave, NBI
- ★ **Steady state power supply**
  CW, Cryoplant ,HVAC,...
- ★ **Power plant**
  feed fusion power to grid

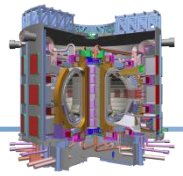


Concept design of PS system

ASIPP

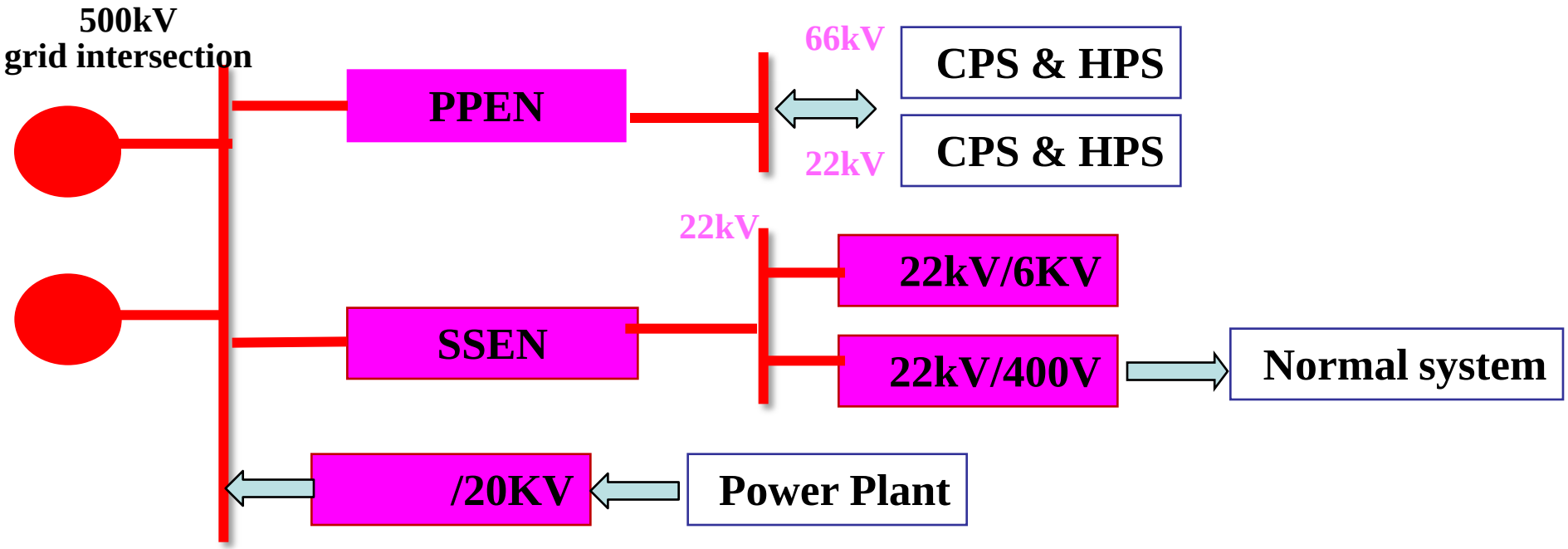
Configuration of AC power electrical network

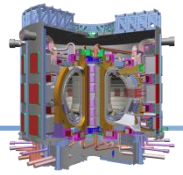
- General Substation
  - Pulsed Substation
    - Coil power supply
    - heating power supply
    - RPC & HF
  - Steady state Substation
    - Sub- substations
    - RPC
  - Power plant substation
    - Power plant



Concept design of PS system

Concept design of AC distribution





Concept design of PS system

Capacity estimation of Pulsed power supply

Electrical load for CFETR	Max. reactive power	Max. active power
Magnet power supply	800Mvar	230MW
Loss	20Mvar	20MW
Heating and current drive	150Mvar	300MW
Total	970Mvar	550MW

Concept design of PS system

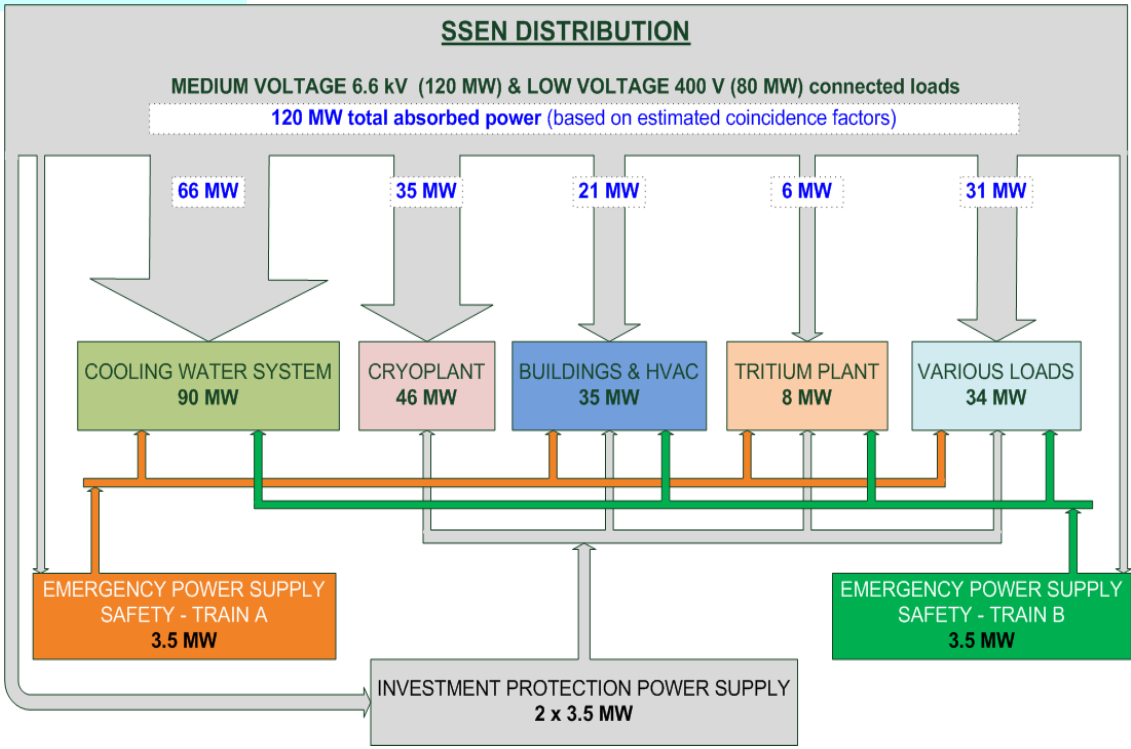
ASIPP

SSEN power Estimation

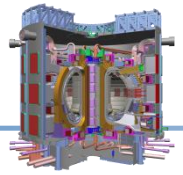
- ★ CWS 50MW
- ★ Cryoplant 30MW
- ★ Building & HVAC 10 MW
- ★ Tritium plant 5MW
- ★ Various load 10MW

Total : P=105MW

S=120MVA



ITER SSEN



Concept design of PS system

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Power supply type

Type of Loads:

- **SIC:** Safety Relevant loads (seismic requirements)
- **IP:** Investment Protection loads
- **OL:** Ordinary loads

Power classification:

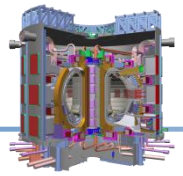
- **Class I** : Uninterruptible DC
- **Class II** : Uninterruptible AC
- **Class III** : Emergency AC power (temporarily interruptible)
- **Class IV** : AC grid power (indefinitely interruptible)

AC Voltage levels and tolerance range:

- 66kV ± 10%
- 22 kV ± 10%
- 10 kV ± 10%
- 6.6kV ± 10%
- 230V / 400V ± 8%

DC Voltage levels:

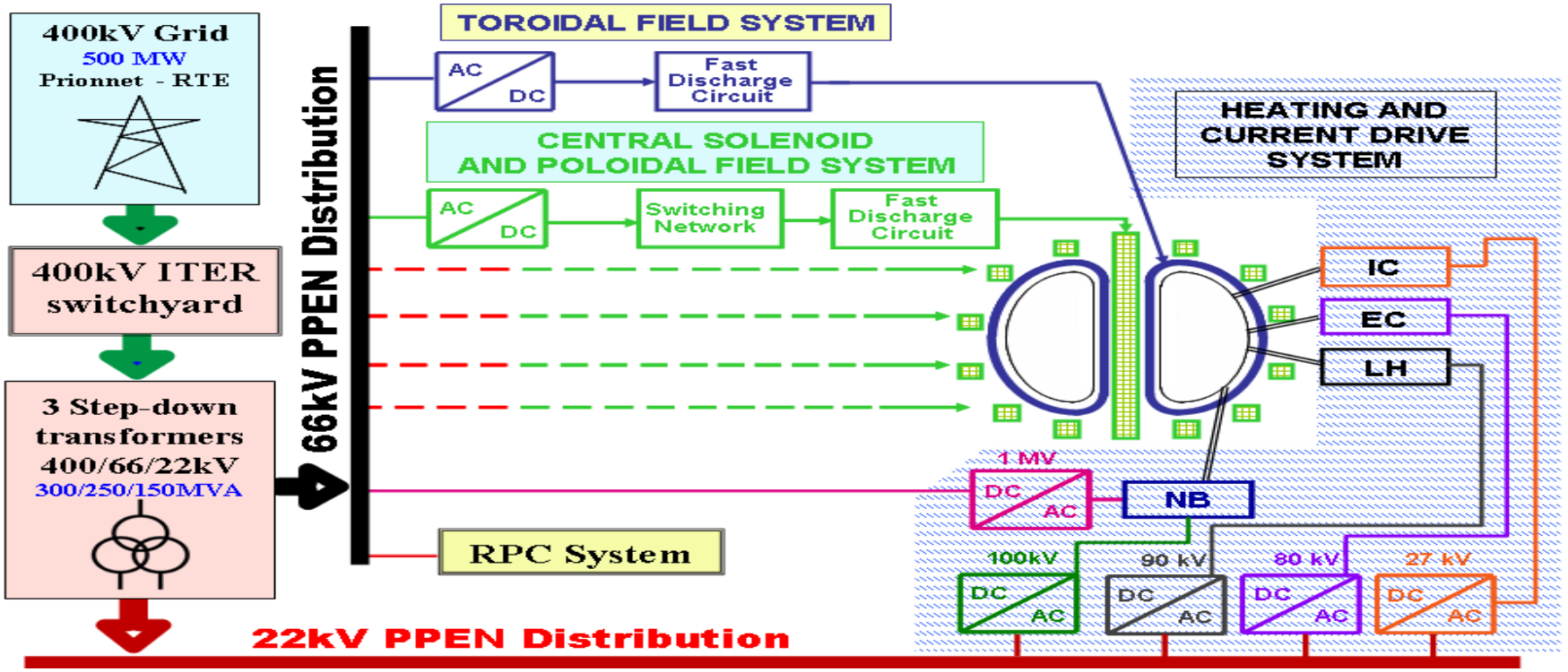
- 110V & 48V



Concept design of PS system

ASIPP

Pulsed power supply

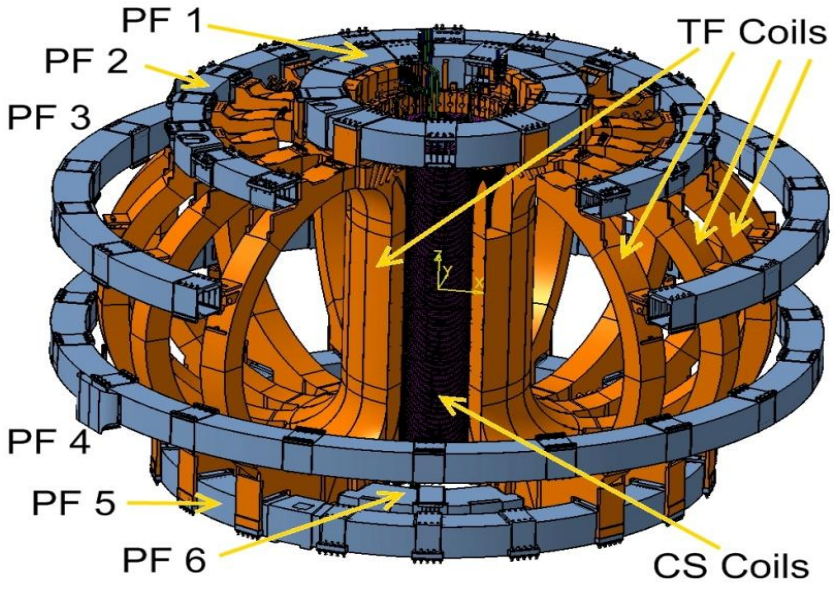


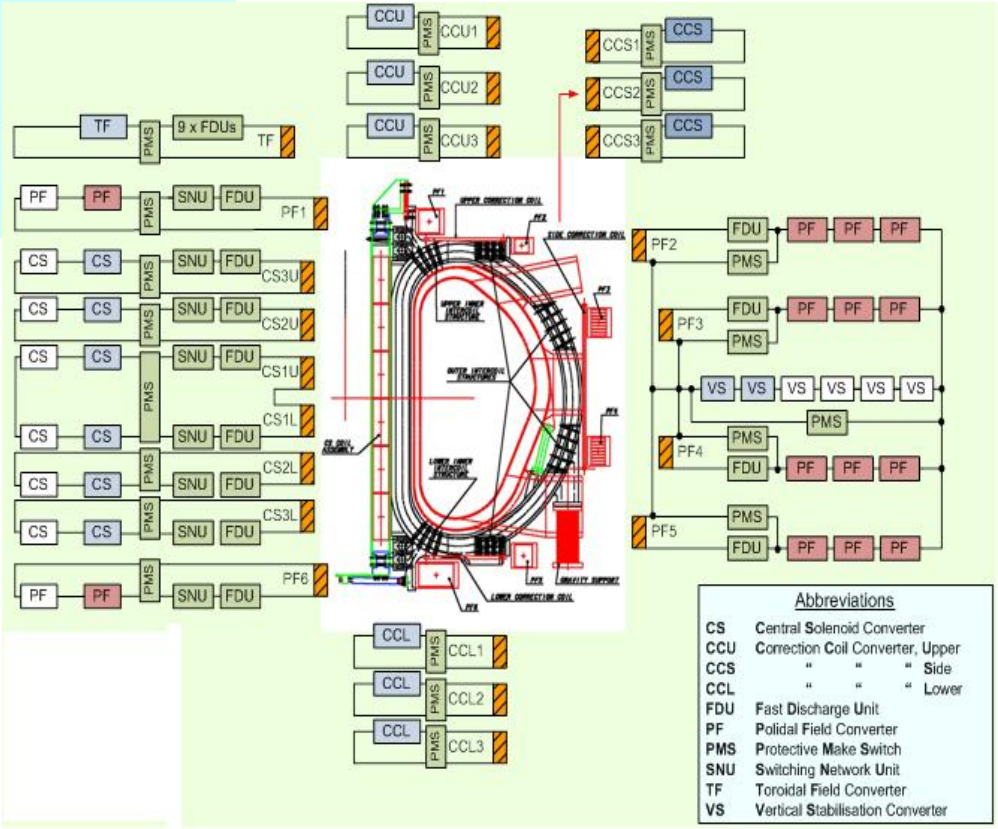
Concept design of PS system

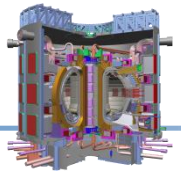
ASIPP

Magnet power supply

- ★ AC/DC converter: PF, CS, VS, TF, CC
- ★ SNU for plasma initiation : CS
- ★ FDU for quench: CS, PF, CC
- ★ Power supply: IC, ELM





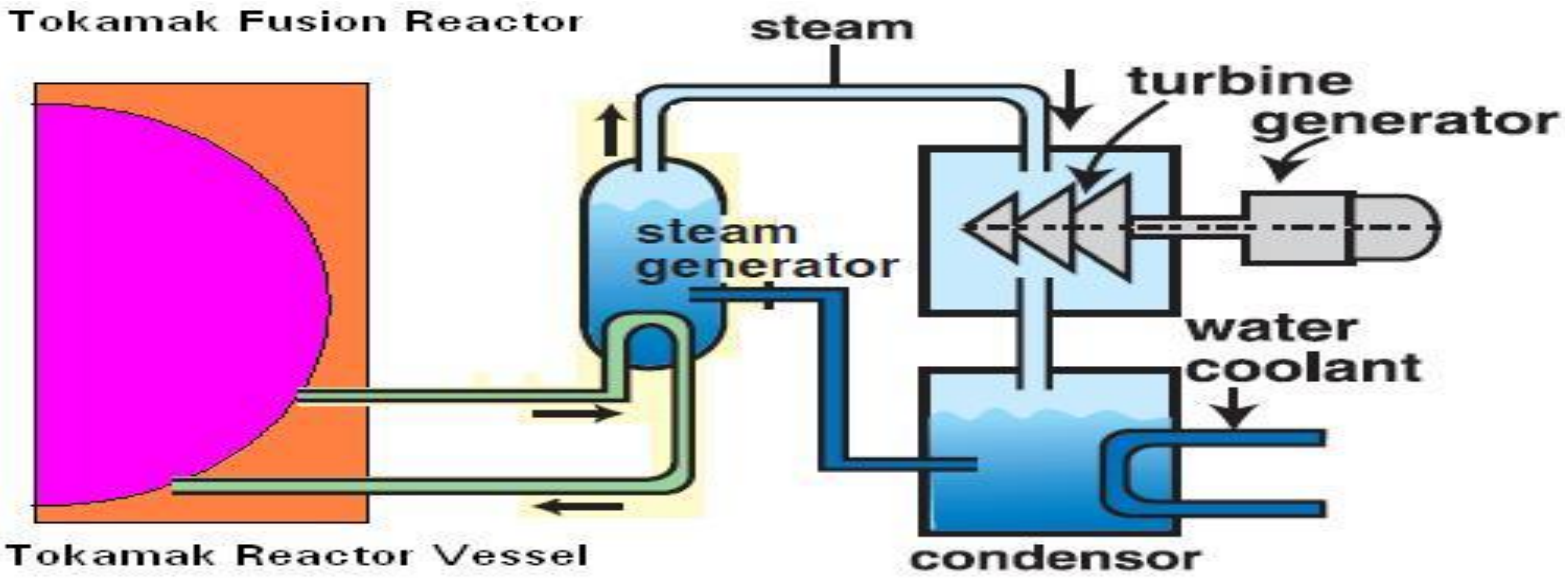


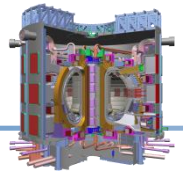
Concept design of PS system

ASIPP

Power plant system

- ★ Use water steam to drive generator
- ★ Conversion efficiency 30~45%
- ★ Generator capacity 60~100MW





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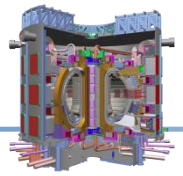


Concept design of CW system

ASIPP

CW system consists of

★ **Tokamak cooling water system (TCWS)**

(100~150 ºC, baking >200 ºC)

★ **Component Cooling Water System (CCWS)**

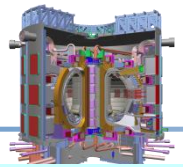
PHT pump, microwave system, power supply, tritium building (30~55ºC)

★ **Chilled Water System (CHWS)**

provide chilled water to PS, hot cell, air conditioning system …, (~6ºC)

★ **Heat Rejection System (HRS)**

water circulation system , cooling tower system



Concept design of CW system

ASIPP

TCWS system consists of

primary heat transfer system (PHTS) →
- First wall /blanket
- Diverter/limiter
- Vacuum vessel
- Neutral beam injector

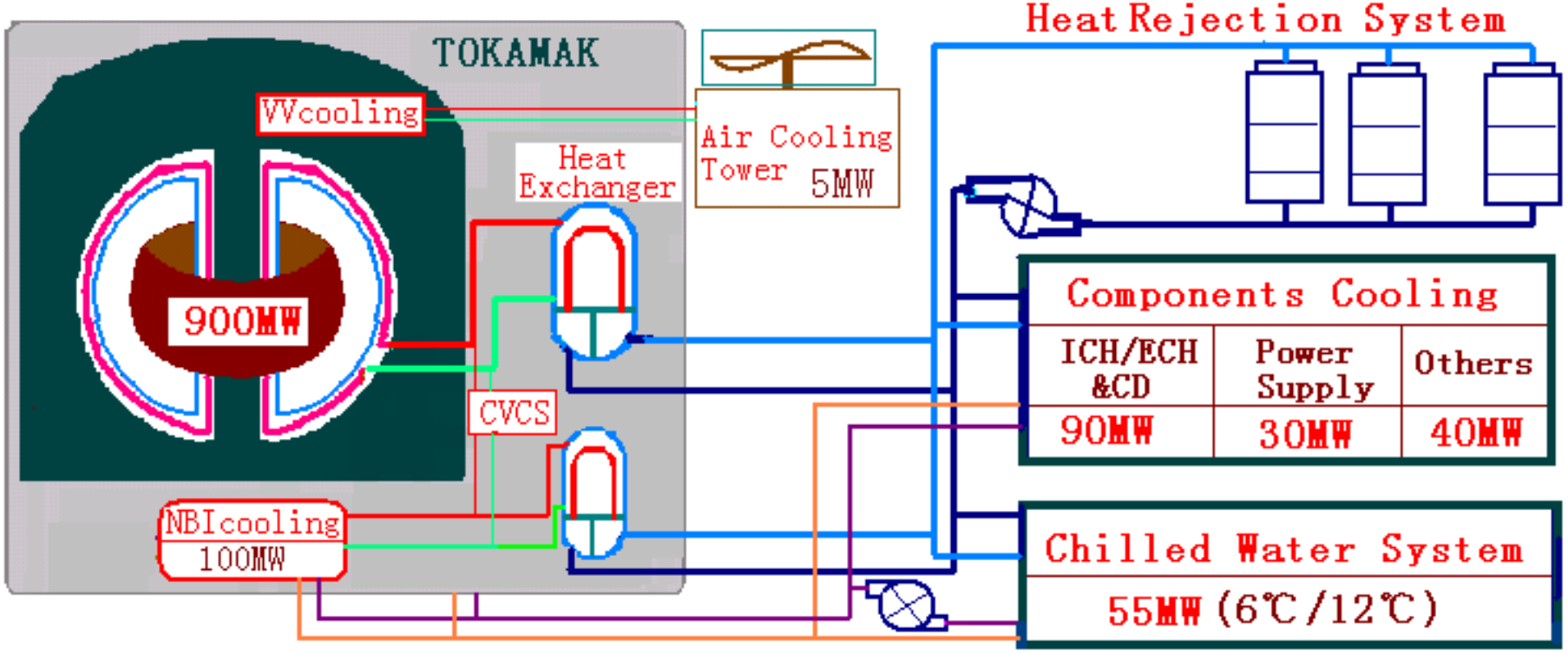
Chemical and volume control system(CVCS) → Filter, to demineralize and decontaminate coolant

Drain/refill, drying → Tanks and pump to storage
Hot nitrogen gas to dry-out in-vessel

Concept design of CW system

ASIPP

ITER Parameters of CW



Concept design of CW system

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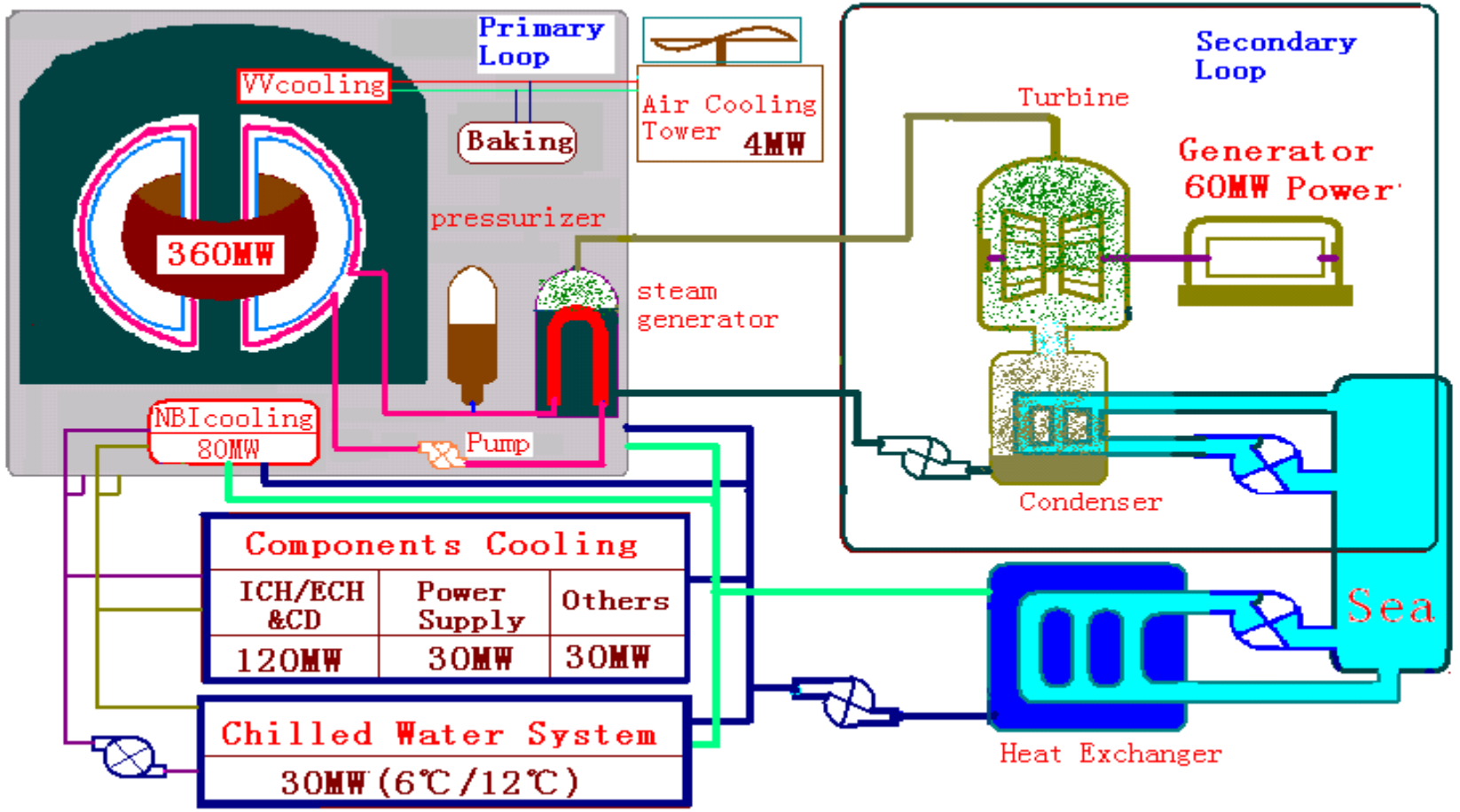
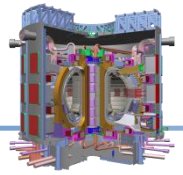
CFETR Parameters of CW



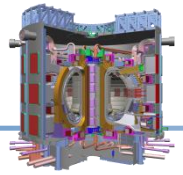


Concept design of CW system

ASIPP

CW parameter estimation of CFETR

Subsystem	Clients	Thermal Power (MW)
TCWS	Power Loop	360
	NBI	80
	VV	4
CCWS	ICH/ECH&CD	120
	Power Supply System	30
	Others	30
CHWS	HVAC &Components	30
Total		654MW



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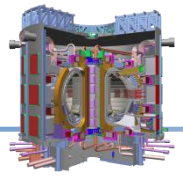
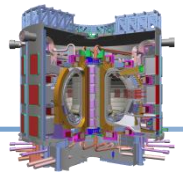


Next work to be done

Next work

- Design of PPEN, SSEN, Magnet power supply, CW
- Power grid requirement: short circuit capacity, Q, P, V
- Suitable CFETR Location from power supply side
- How big area is necessary for PS &CWS
- New technology in fusion power supply



Next work to be done

ASIPP

CFETR location

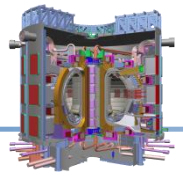
★ grid active power

★ grid short circuit capacity

★ Compatibility between pulsed power and grid

CN high voltage grid plan in 2015

R&D: power flow analysis, dynamic circuit analysis, oscillation



Next work to be done

ASIPP

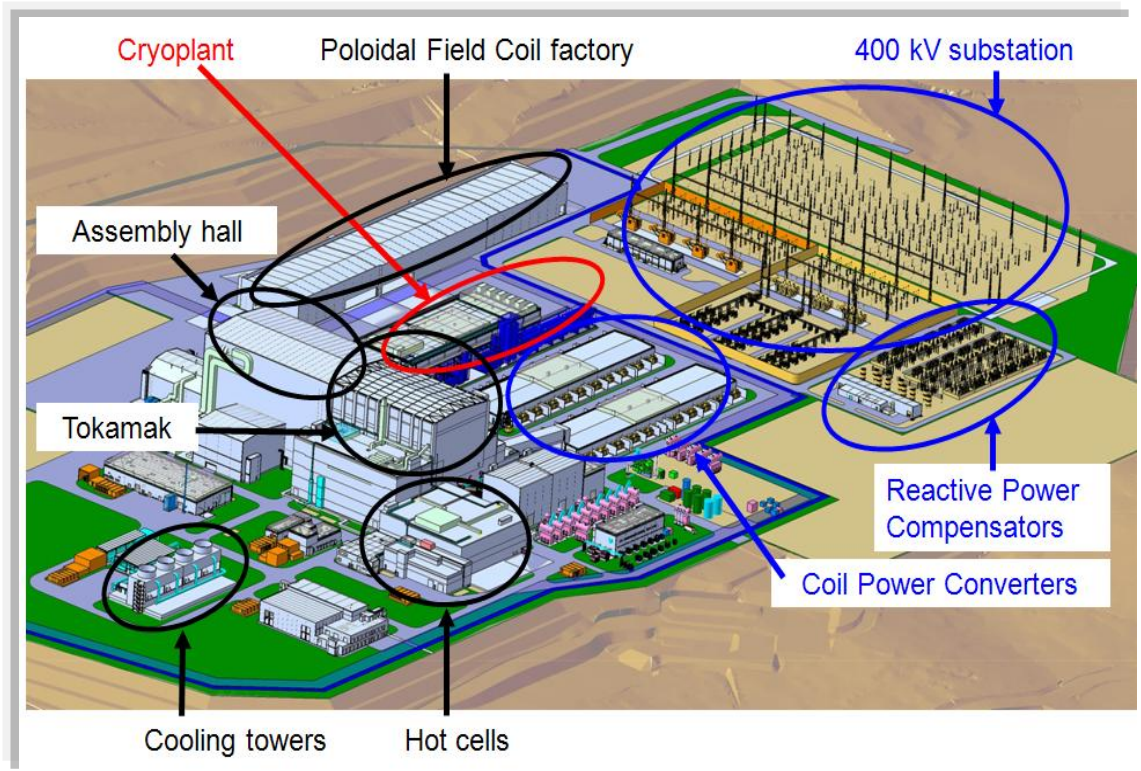
CFETR PS area

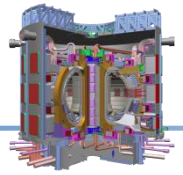
ITER area:

18 building/180 Hectares

PS &CWS → 90 Hectares

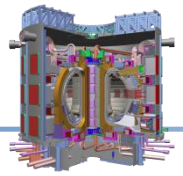
CFETR: 90 hectares ?





Conclusion

- Preliminary consideration for PS &CW system has been performed, P=~650MW, S=1GMVA.
  If copper coil, >1. 5GW
- Above work was based on in the a rough input, next work will be performed after the relevant requirement is fixed.



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