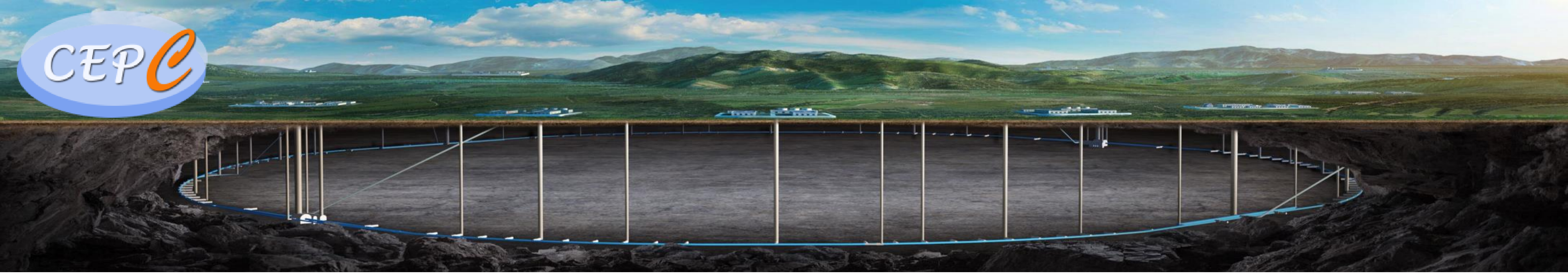

CEPC green collider energy saving EDR plan

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Content

- **跟踪分析各系统的工艺需求，以制定合理的通用设施方案**
  - Power consumption
  - Colling system
  - …
- **绿色及节能相关的工作计划和调研内容**
  - Green energy application
  - Energy recovery and reuse
  - Energy management
  - …
- **人员安排及经费需求**

EDR阶段的工艺需求收集、整理

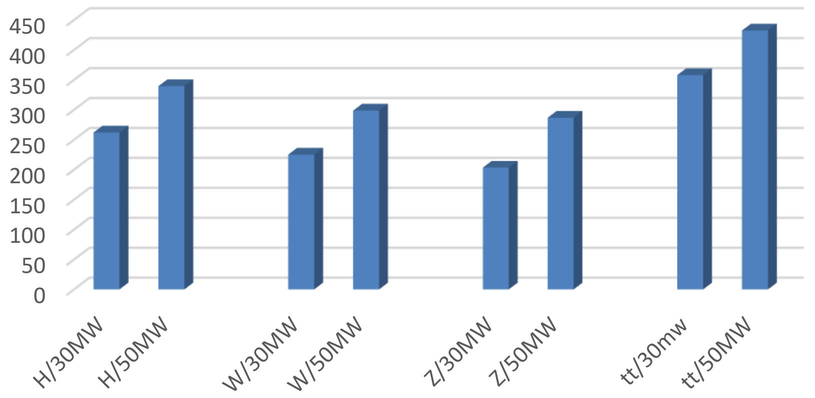
- 已开展EDR阶段工艺需求的收集
- 跟踪各系统的需求变化
- 阶段性调整和完善通用设施设计方案

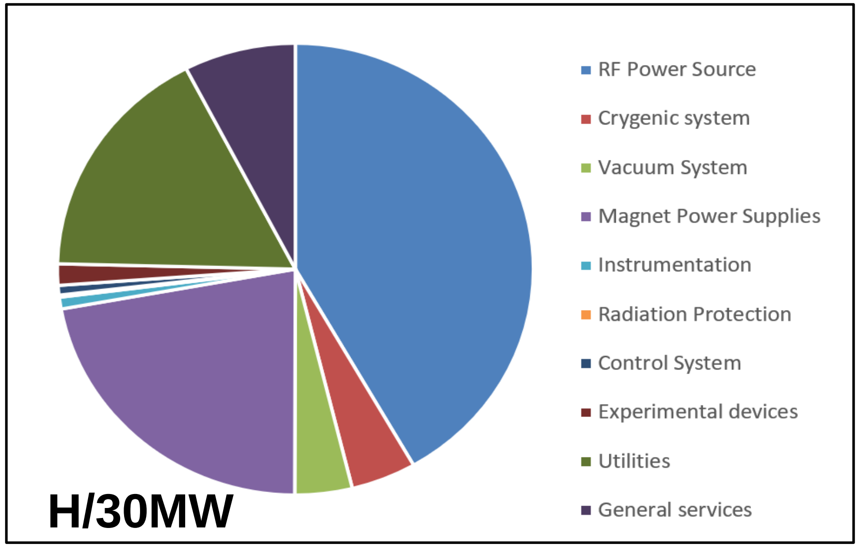
Power consumption - TDR

- **Power consumption of CEPC**
  - **Design electrical load： ~262MW (H/30MW)**

SN	System	TDR(Higgs30MW)						
		Collider	**Booster**	**Linac**	**BTL**	**IR**	**Surface buildin**	**Total**
1	RF Power Source	96.90	0.15	12.26				109.31
2	Crygenic system	9.72	1.71			0.16		11.59
3	Vacuum System	5.40	4.20	0.60				10.20
4	Magnet Power Supplies	42.16	8.46	2.15	4.89	0.30		57.96
5	Instrumentation	1.30	0.70	0.20				2.20
6	Radiation Protection	0.30		0.10				0.40
7	Control System	1.00	0.60	0.20				1.80
8	Experimental devices					4.00		4.00
9	Utilities	37.80	3.20	1.80	0.60	1.20		44.60
10	General services	7.20		0.30	0.20	0.20	12.00	19.90
	Total	201.78	19.02	17.61	5.69	5.86	12.00	**261.96**

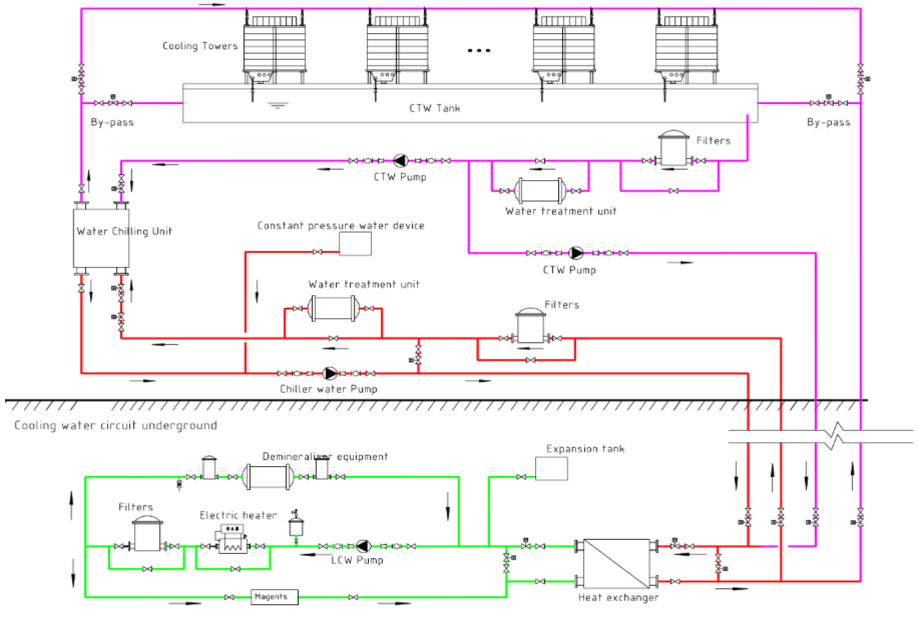
Power consumption (MW)



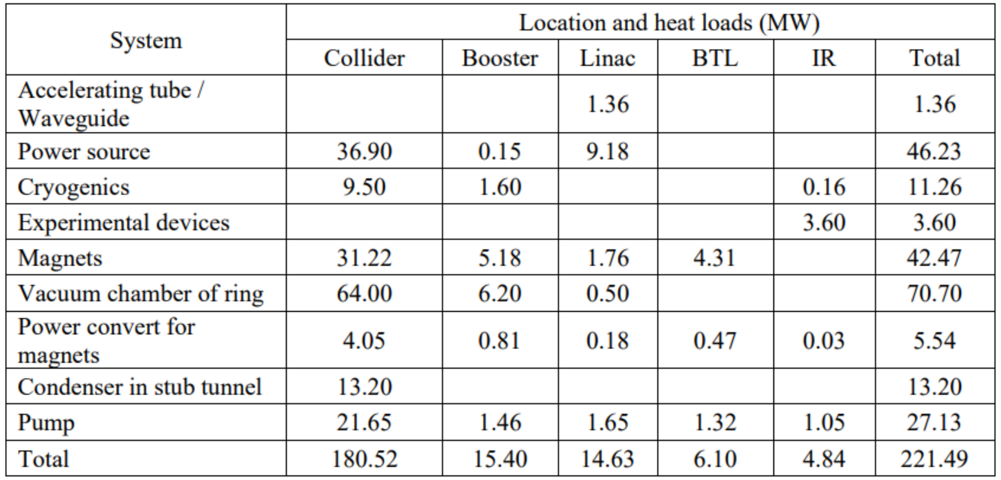


Cooling water system - TDR

- **Function**
  - Absorb heat, cooling process equipment.
  - Provide a constant temperature environment.
  - Adjusting resonant frequency by water temperature
- **Heat load** ： 221.5MW
- **LCW**
  - Flow rate ： 26751 m3/h.
  - Supply water temperature : ⩾ **30℃**.
  - Return water temperature : ⩾ **35℃**.
- **CTW**
  - Supply water temperature ＜ 29℃
  - By combination of chiller, heat pump and cooling tower— base on wet-bulb air temperature.
  - Machine shut down in summer



Process flow diagram of cooling water system

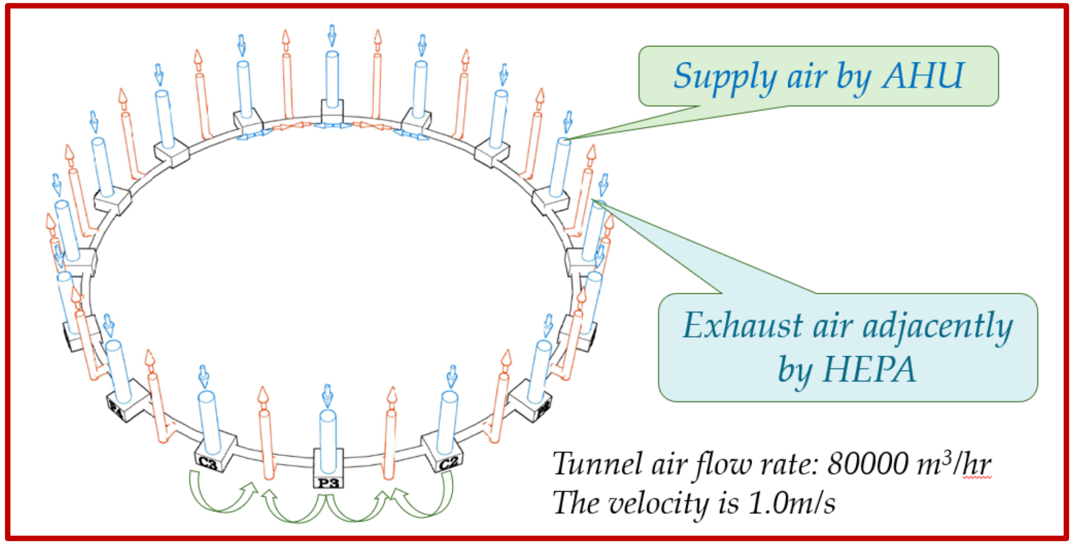


System	Location and heat loads (MW)					
	Collider	Booster	Linac	BTL	IR	Total
Accelerating tube / Waveguide			1.36			1.36
Power source	36.90	0.15	9.18			46.23
Cryogenics	9.50	1.60			0.16	11.26
Experimental devices					3.60	3.60
Magnets	31.22	5.18	1.76	4.31		42.47
Vacuum chamber of ring	64.00	6.20	0.50			70.70
Power convert for magnets	4.05	0.81	0.18	0.47	0.03	5.54
Condenser in stub tunnel	13.20					13.20
Pump	21.65	1.46	1.65	1.32	1.05	27.13
Total	180.52	15.40	14.63	6.10	4.84	221.49

HVAC - TDR

- **Estimated cooling loads of HVAC**

  Total: **40MW**
- **Coolant for air conditioning: chilled water**
- **Heat source for heating system in winter**
  - Heat pump -- heat recover from cooling system.
  - Backup boiler



Tunnel air flow rate: 80000 m³/hr
The velocity is 1.0m/s

- **Indoor Design Parameters**
  - Tunnel
    - Temperature: within 30-35℃ and shall be kept below 35℃.

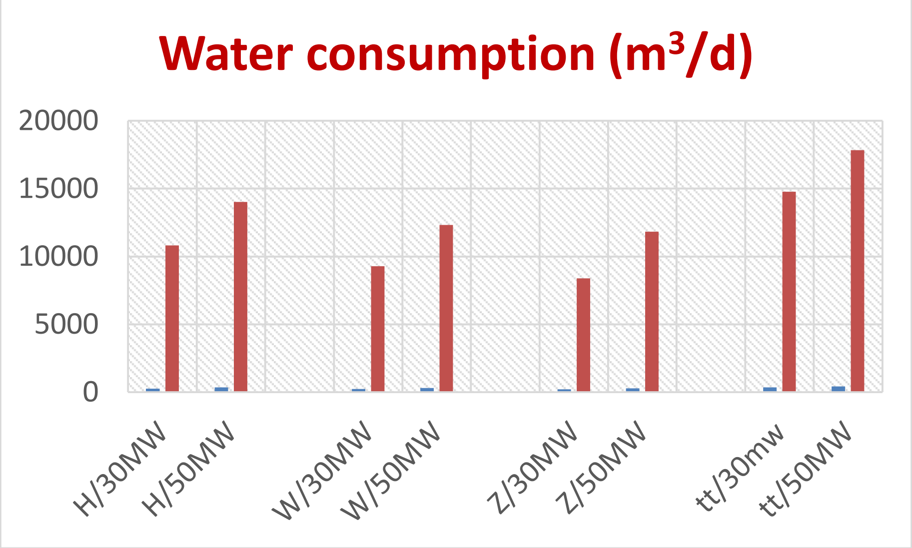
      -- Inlet: 18~20℃

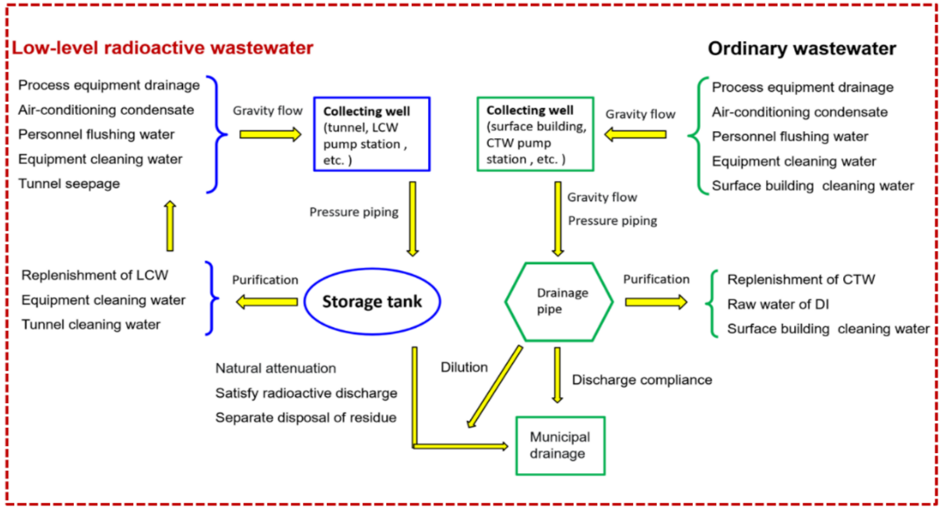
      -- Outlet: less than 35℃
    - Relative humidity: 50% ~ 60%, and shall be lower than 65%
  - Experimental halls
    - Temperature: about 26℃(summer), 20℃(winter)
    - Relative humidity: 50% ~ 60%, and shall be lower than 65%.
  - Control room (or electronics)
    - Temperature: about 20-25℃
    - Relative humidity: 45% ~ 60%
  - Other service building
    - Temperature: about 28℃(summer), 18℃(winter),
    - Relative humidity: lower than 65%

Water consumption - TDR

- **Water usage**
  - mainly used for cooling system refill, including cooling tower evaporation and drift, water makeup for LCW and CTW, etc.
  - 1% CTW flow rate and others. (If closed-circuit cooling towers or air coolers are used, the amount of water will be greatly reduced.)
- **Water source**
  - rivers, lakes, groundwater
  - reservoir
  - reclaimed-water
  - Wastewater recycling of CEPC

Need stable water source !




Low-level radioactive wastewater

Process equipment drainage
Air-conditioning condensate
Personnel flushing water
Equipment cleaning water
Tunnel seepage

Gravity flow

Collecting well (tunnel, LCW pump station , etc.)

Pressure piping

Storage tank

Purification

Replenishment of LCW
Equipment cleaning water
Tunnel cleaning water

Natural attenuation
Satisfy radioactive discharge
Separate disposal of residue

Dilution

Ordinary wastewater

Process equipment drainage
Air-conditioning condensate
Personnel flushing water
Equipment cleaning water
Surface building cleaning water

Gravity flow

Collecting well (surface building, CTW pump station , etc.)

Gravity flow
Pressure piping

Drainage pipe

Purification

Replenishment of CTW
Raw water of DI
Surface building cleaning water

Discharge compliance

Municipal drainage

Green collider energy saving EDR plan

To achieve green CEPC, we plan to conduct research from multiple perspectives in EDR.

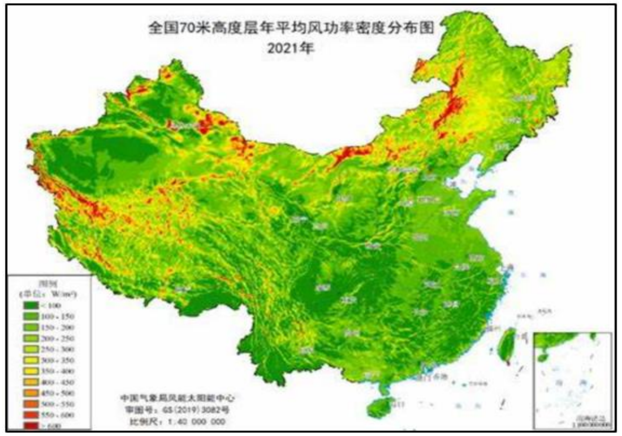
- Green energy application
- Energy recovery, reuse, and energy conservation
- Energy management

Green energy application

Based on the analysis of the power supply mode of the alternative sites for CEPC and the surrounding natural conditions, research and develop a green energy plan suitable for CEPC. This includes analyzing the applicability, economic feasibility, and viability of distributed energy in the project, integrating renewable energy sources such as wind power and solar photovoltaic power and maximizing the utilization of renewable energy.

- CEPC has a large distributed area, which presents certain advantages for the installation and application of photovoltaic power. HEPS has installed a 10MW photovoltaic, which has been completed and is currently undergoing grid commissioning. Its operation can provide experiential reference for CEPC's utilization of photovoltaic power generation..
- Wind power generation is a mature technology， It has been widely used in China, and is gradually more and more important.

HEPS photovoltaic power capacity of 10MW



Wind Energy Density Distribution Map of China

Energy Storage System

Combining traditional pumped storage hydropower plants with distributed energy storage systems, and exploring microgrid energy storage system technologies, aims to achieve the following objectives：

- **Enhancing the Stability of Distributed Energy**

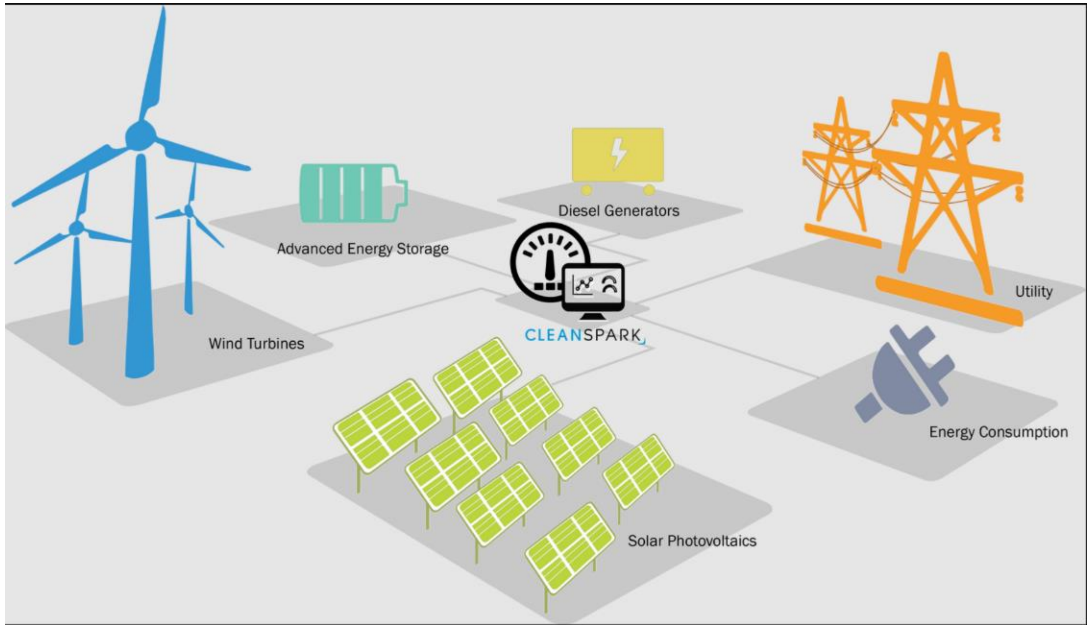
  Distributed energy sources such as solar and wind power are greatly influenced by external environmental factors, resulting in random and unstable power generation characteristics, making it unable to provide stable output for the load. Coordinated control of distributed energy sources with energy storage systems and the main grid can smooth the fluctuations of distributed energy, stabilize output, and improve the on-site utilization of distributed energy.

- **Improving the Power Quality**

  Energy storage systems can provide rapid power buffering, quickly absorb/supply electrical energy, provide active and reactive power support, and stabilize voltage fluctuations. Energy storage systems can also provide partial harmonic control functionality for microgrids.

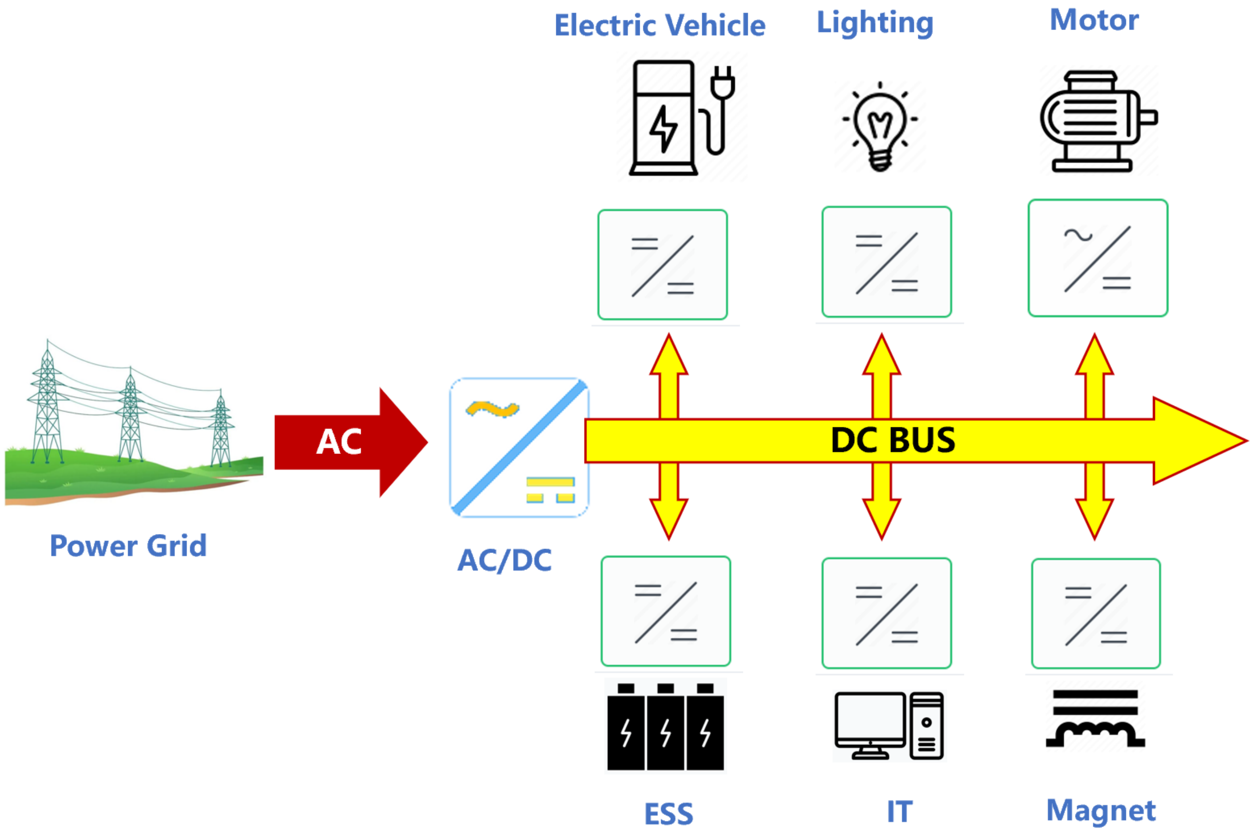
- **Peak Shaving**

  In a microgrid, energy storage systems can store excess electrical energy generated by distributed energy sources during low load periods and release the energy during peak load periods to regulate load demand. As an essential energy buffering element in microgrid systems, energy storage systems can meet peak load power consumption while reducing the required capacity of generators or transformers.



Direct Current Power Supply System

- In the current power supply architecture, power needs to be transformed back and forth between AC and DC, incurring additional costs and wasting energy at each step.
- In order to improve the power quality of the AC grid, the distribution system usually needs to be additionally equipped with active filters and reactive power compensation devices.
- DC grid architecture can eliminate intermediate links and save equipment costs, application costs and energy consumption.



Energy recovery, reuse, and energy conservation

In terms of heat recovery utilization, the goal is to simulate and calculate the cooling system, heat recovery system, and accelerator tunnel environment to achieve the following objectives.

- Based on the local climatic conditions of the project, plan and design appropriate energy supply, cooling, and energy recovery processes to maximize the project's energy efficiency while ensuring the stable operation of CEPC.

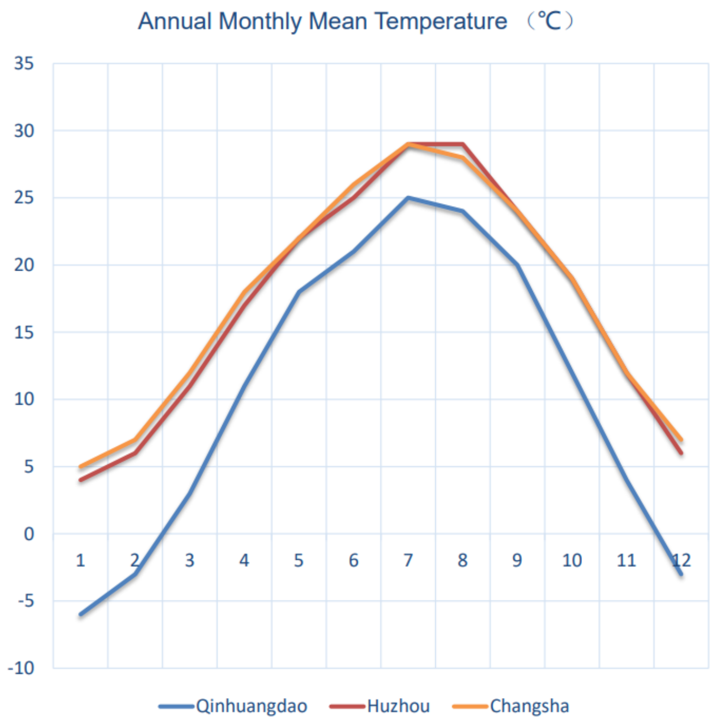
- Auxiliary facility should be built near to the heat load center.
- Minimize the operating pressure.
- priority→natural cooling sources, renewable energy
- maximizing waste heat recovery
- avoid using electric heater for dehumidification
- high system reliability, minimize impact on process operating

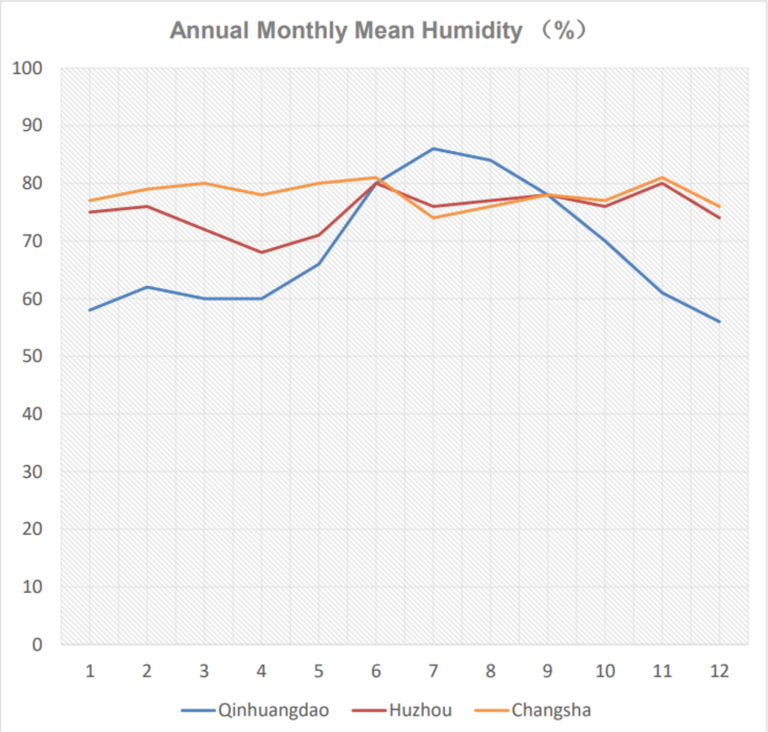
Measures

- ✓ cooling tower for free-cooling
- ✓ solar generator for streetlight, EV charger...
- ✓ solar water heaters for Li-Br absorption chiller
- ✓ heat pump for heating and cooling simultaneously
- ✓ using desiccant dehumidification in AHU

Energy recovery, reuse, and energy conservation

- For different operating conditions and load requirements of CEPC, conduct computational simulations of the cooling system, develop corresponding heat recovery heating strategies, calculate the overall economic indicators of the heat recovery system, and fully improve the efficiency of energy cascade utilization, thereby enhancing the overall operational efficiency.





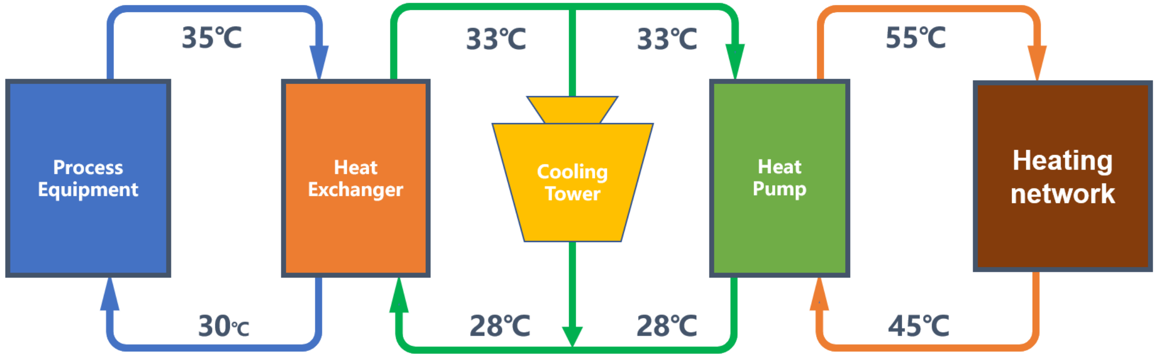
Energy recovery, reuse, and energy conservation

- **Winter**

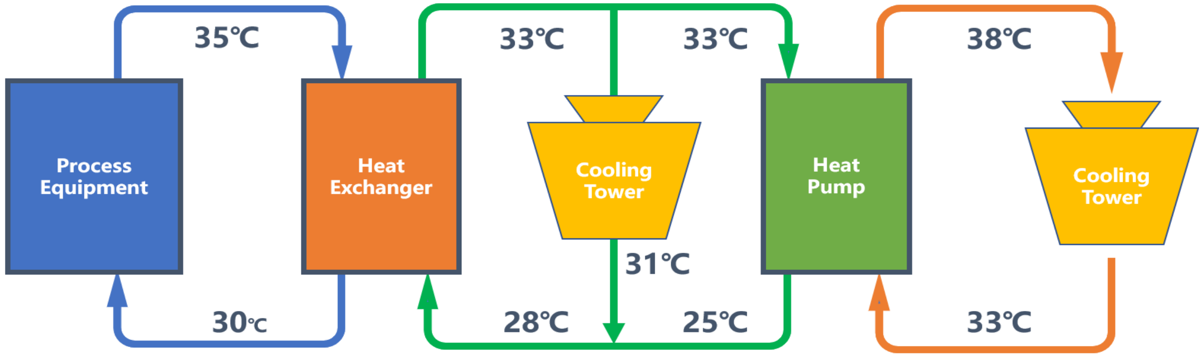
The heat pump system is connected to the cooling tower and extracts hot water flowing towards the cooling tower. When the heat pump system is in heating operation, the hot water flowing towards the cooling tower decreases. At this time, the operating frequency and number of the cooling tower are reduced to maintain the outlet temperature of the tower at 28℃.

- **Summer and transitional seasons**

When heating is not required, the main cooling is achieved through the cooling tower. In extremely hot conditions, the heat pump unit can be activated to assist with cooling.



Heat Exchange Process Diagram（Winter）



Heat Exchange Process Diagram（Summer and transitional seasons）

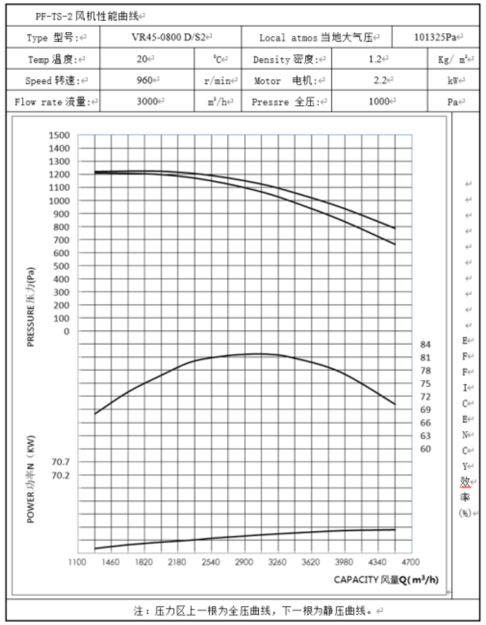
Energy recovery, reuse, and energy conservation

- Through simulating calculations of major equipment such as heat pumps, cooling towers, and water pumps, formulate technical selection indicators for different equipment, and strive to ensure that the actual operating results meet the theoretical research expectations.

- ➢ optimizing equipment operation within the high-efficiency zone.
- ➢ when in partial load, specify the parameter range for the safe operation

Parameters：

— chiller
— heat pump
— water pump
— cooling tower
— fans
— heat exchanger

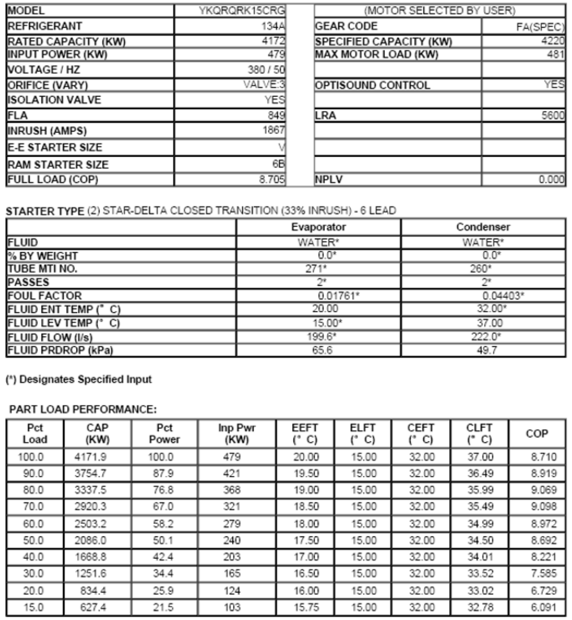


PF-TS-2 风机性能曲线

Type 型号:	VR45-0800 D/S2		Local atmos 当地大气压	101325Pa	
Temp 温度:	20	℃	Density 密度:	1.2	Kg/ m³
Speed 转速:	960	r/min	Motor 电机:	2.2	kW
Flow rate 流量:	3000	m³/h	Pressre 全压:	1000	Pa

注：压力区上一根为全压曲线，下一根为静压曲线。

performance curves of fans



MODEL	YKQRQRK15CRG		(MOTOR SELECTED BY USER)	
REFRIGERANT	134A		GEAR CODE	FA(SPEC)
RATED CAPACITY (KW)	4172		SPECIFIED CAPACITY (KW)	4220
INPUT POWER (KW)	479		MAX MOTOR LOAD (KW)	481
VOLTAGE / HZ	380 / 50			
ORIFICE (VARY)	VALVE:3		OPTISOUND CONTROL	YES
ISOLATION VALVE	YES			
FLA	849		LRA	5600
INRUSH (AMPS)	1867			
E-E STARTER SIZE	V			
RAM STARTER SIZE	6B			
FULL LOAD (COP)	8.705		NPLV	0.000

STARTER TYPE (2) STAR-DELTA CLOSED TRANSITION (33% INRUSH) - 6 LEAD

	Evaporator	Condenser
FLUID	WATER*	WATER*
% BY WEIGHT	0.0*	0.0*
TUBE MTI NO.	271*	260*
PASSES	2*	2*
FOUL FACTOR	0.01761*	0.04403*
FLUID ENT TEMP (° C)	20.00	32.00*
FLUID LEV TEMP (° C)	15.00*	37.00
FLUID FLOW (l/s)	199.6*	222.0*
FLUID PRDROP (kPa)	65.6	49.7

(*) Designates Specified Input

PART LOAD PERFORMANCE:

Pct Load	CAP (KW)	Pct Power	Inp Pwr (KW)	EEFT (° C)	ELFT (° C)	CEFT (° C)	CLFT (° C)	COP
100.0	4171.9	100.0	479	20.00	15.00	32.00	37.00	8.710
90.0	3754.7	87.9	421	19.50	15.00	32.00	36.49	8.919
80.0	3337.5	76.8	368	19.00	15.00	32.00	35.99	9.069
70.0	2920.3	67.0	321	18.50	15.00	32.00	35.49	9.098
60.0	2503.2	58.2	279	18.00	15.00	32.00	34.99	8.972
50.0	2086.0	50.1	240	17.50	15.00	32.00	34.50	8.692
40.0	1668.8	42.4	203	17.00	15.00	32.00	34.01	8.221
30.0	1251.6	34.4	165	16.50	15.00	32.00	33.52	7.585
20.0	834.4	25.9	124	16.00	15.00	32.00	33.02	6.729
15.0	627.4	21.5	103	15.75	15.00	32.00	32.78	6.091

part load performance of chillers

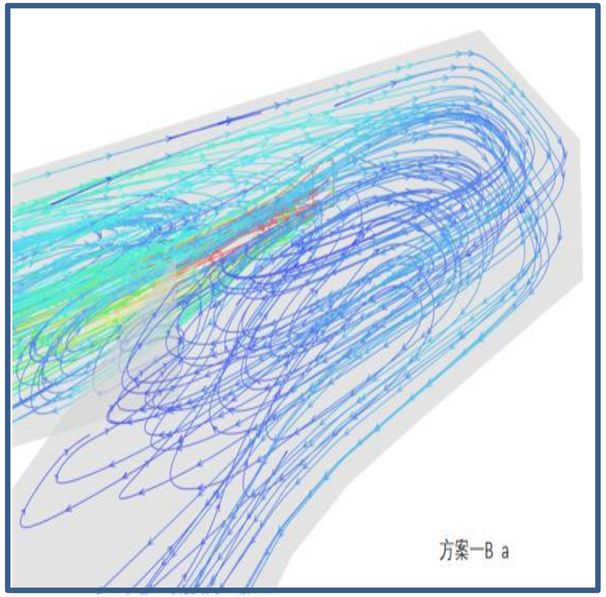
Energy recovery, reuse, and energy conservation

- Simulate the airflow organization under multiple working conditions in the CEPC tunnel and propose a ventilation and air conditioning system configuration scheme that considers both technical and economic aspects.

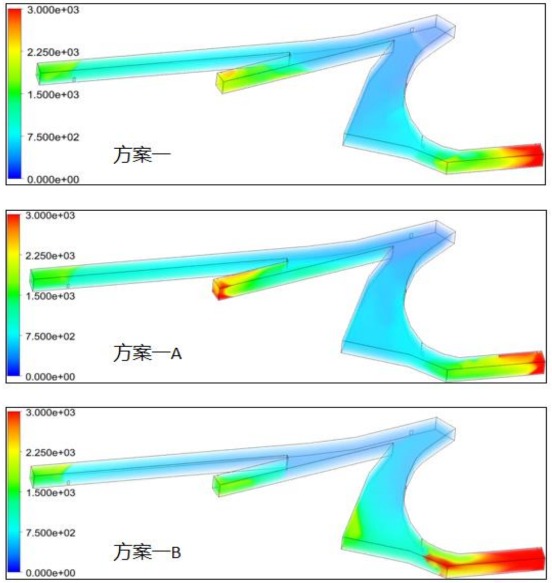
- using CFD to simulate multiple scenarios in tunnel
- identifying feasible air diffusion schemes
- conducting technical and economic analysis for air-conditioning system

Parameters：

—velocity
— temperature
— relative humidity
— mean age of air
— oxygen concentration



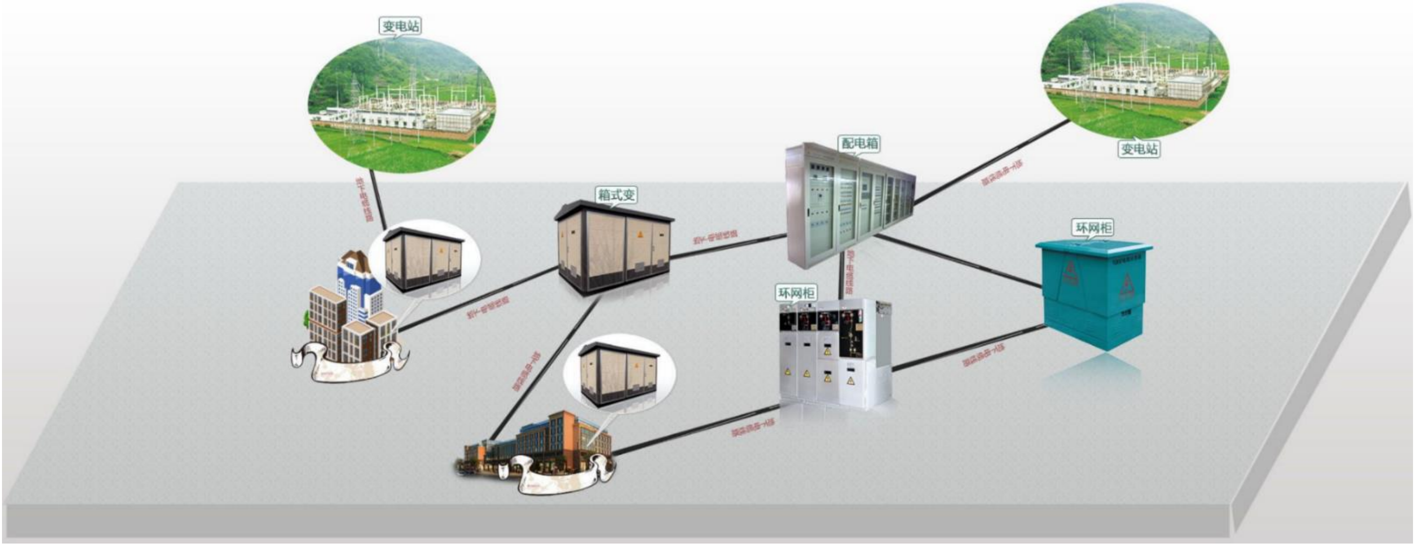
Analysis of dead zones
in the CSNS-II tunnel airflow

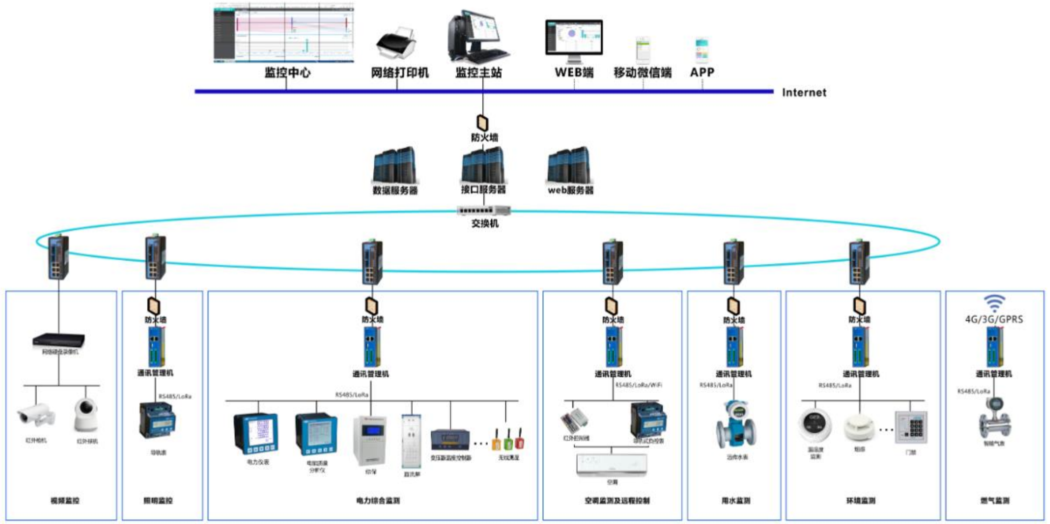


CSNS-II tunnel air age comparison

Energy management

Research and plan an energy monitoring scheme suitable for CEPC. The goal is to collect and process energy consumption data during the project implementation phase, to achieve energy planning, monitoring, statistics, and consumption analysis. Special emphasis will be placed on the management of key energy-consuming equipment and energy metering devices, with the aim of improving energy efficiency and conservation.





人员安排及经费

名称	工作内容和目标	经费	人员
CEPC绿色能源利用的调研及方案规划	在传统供电模式的基础上，调研和制定本项目绿色能源的规划方案，包括分析分布式能源在本项目中的适用性、经济性和可行性，将风能、太阳能光伏电站等可再生能源纳入项目，提高可再生能源的利用率。	200万元	3人；合作单位
CEPC能量再利用与节能方案规划与仿真模拟计算	（1）根据项目所在地气候条件，制定相应热回收供热策略、核算热回收系统总体经济性指标，充分提高能量梯级利用的效率；（2）针对CEPC不同运行工况和负荷条件，进行冷却循环系统的计算仿真，制定控制逻辑，提高总体运行效率；（3）通过对热泵机组、冷却塔及水泵等主要设备的仿真计算，制定不同设备的技术选型指标，力求实际运行结果符合理论研究预期。4）对CEPC隧道内多工况气流组织模拟，提出兼顾技术和经济性的通风空调系统配置方案。	600万元	4人，合作单位
CEPC的能源监测方案调研和规划	调研和规划适用于CEPC的能源监测方案。目标是在项目实施阶段。通过收集和处理能源消耗数据，实现能源规划、监测、统计和消纳分析，着重对重点能耗设备和能源计量设备进行管理，以期提高能源效率和节约能源。	200万元	3人；合作单位