Economic Operation of Battery Energy Storage System in Industrial Park Based on the Power Load Characteristics

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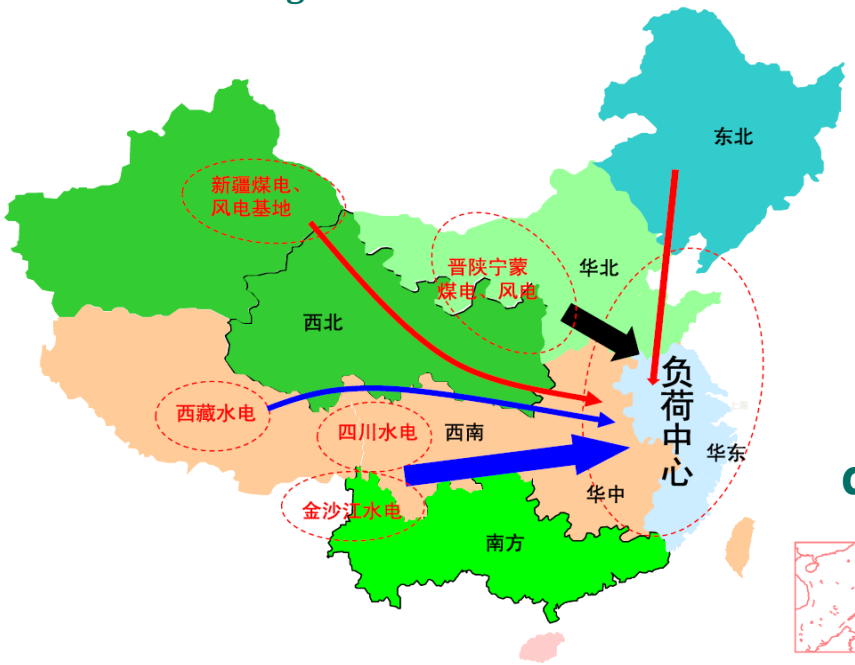
Content

Situation of power system in China

2015	Installed Capacity 1.5 billion KW	Generating Capacity 5618. 4 billion KWh
Thermal	0.99021 billion KW（65. 6%）	4210. 2 billion KWh（74. 9%）
Water	0.31937 billion KW（21. 2%）	996 billion KWh（17. 7%）
Nuclear	0.02608 billion KW（1. 7%）	168. 99 billion KWh（3. 01%）
Wind	0.12934 billion KW（8. 6%）	186. 3 billion KWh（3. 31%）
Solar	0.04318 billion KW（2. 9%）	40 billion KWh（0. 7%）

Power generation in China in 2015

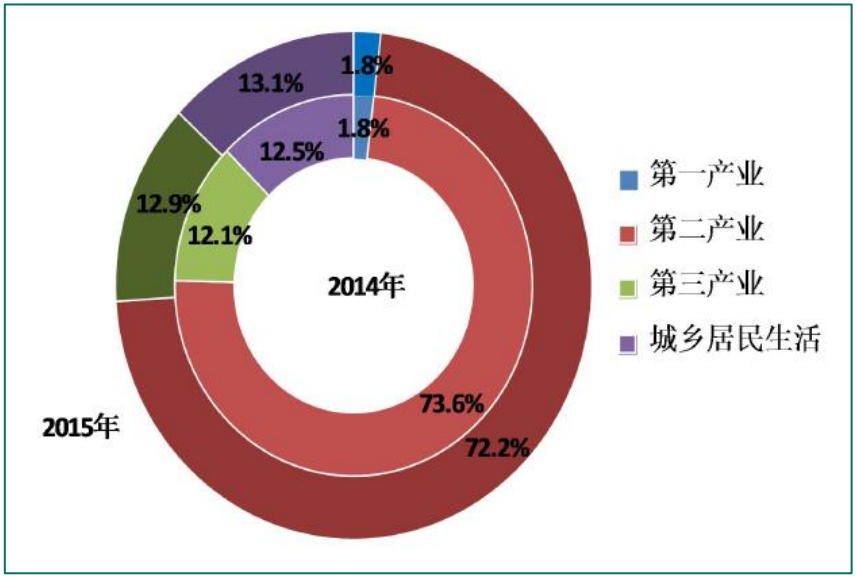
80%
supply



70%
demand

Primary energy and load are in reverse distribution

Situation of power system in China

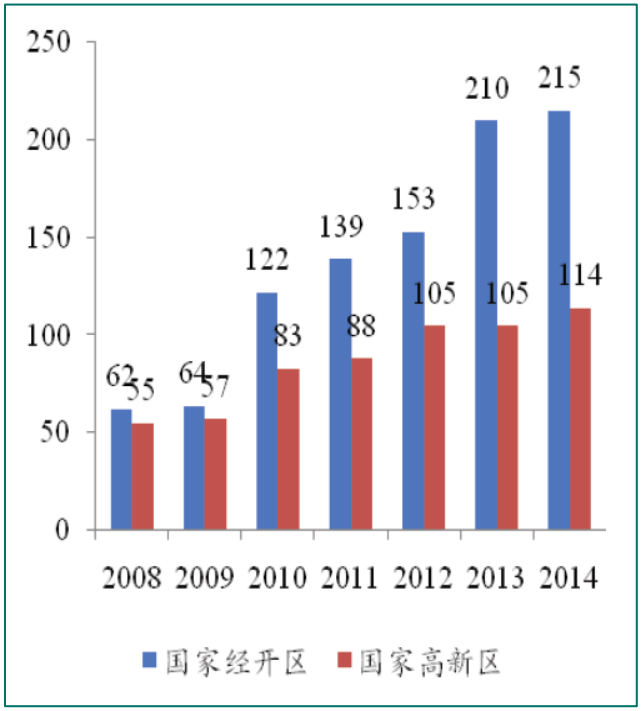


Power consumption structure in 2015 (compared with 2014)

In 2015,Total industrial electricity consumption is 3.93 trillions kWh. Growth rate has dropped, but the proportion is still great.

Industrial and commercial users in China bear cross subsidies to residents and agriculture. Energy savings through the installation of energy storage systems are more attractive for them.

Situation of power system in China



State of the open area and high tech Development Zone (source: Chinese Ministry of Commerce)

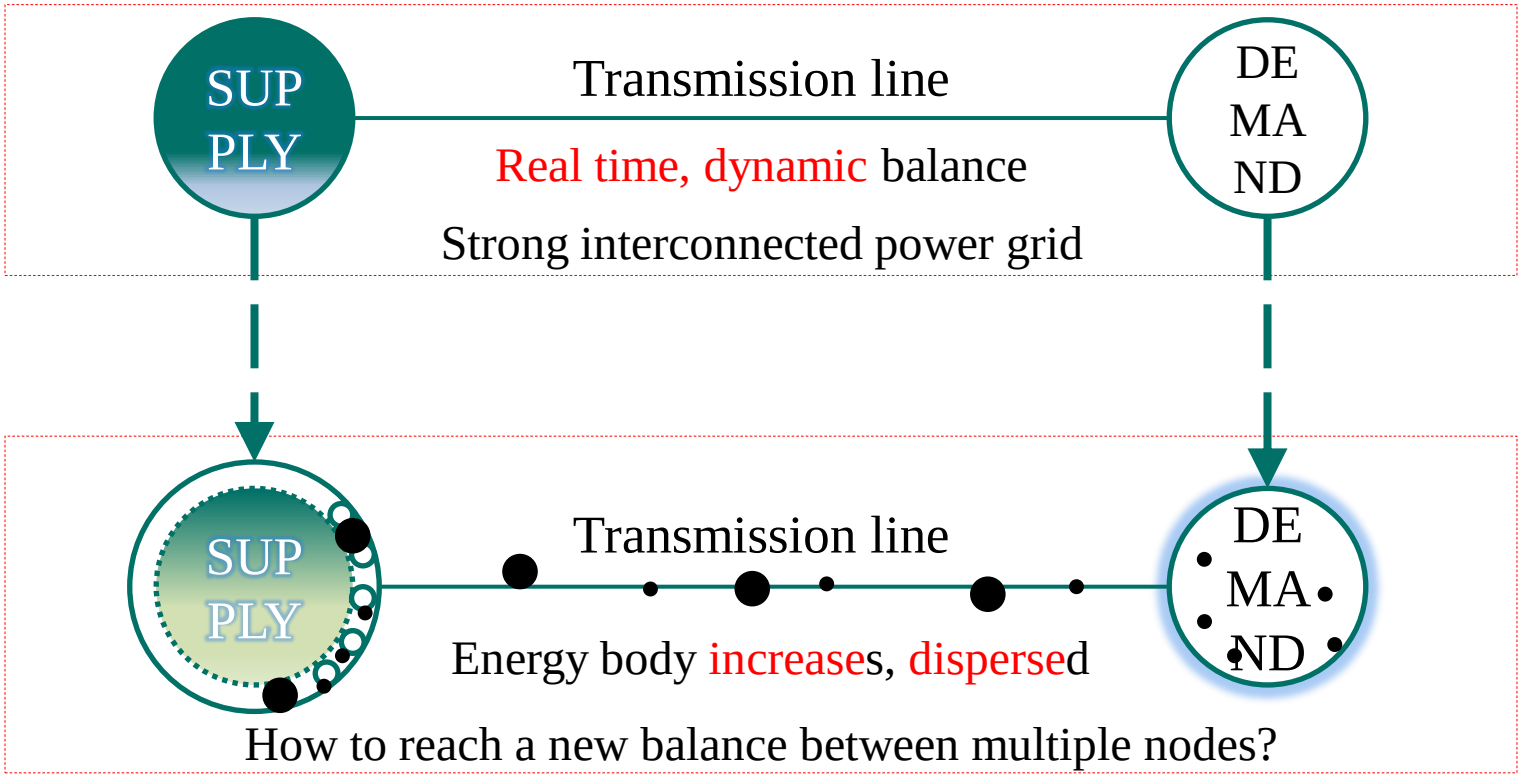
Until the end of 2014, China had 485 national industrial parks, the total industrial output value made up more than 1/3 of the total industrial output value.

The outstanding problems of power supply:

- √ Local area distribution network overload
- √ Unreasonable structure, Poor reliability
- √ High loss, Low voltage at the end of the line
- √ Drop voltage transient, Power quality problems

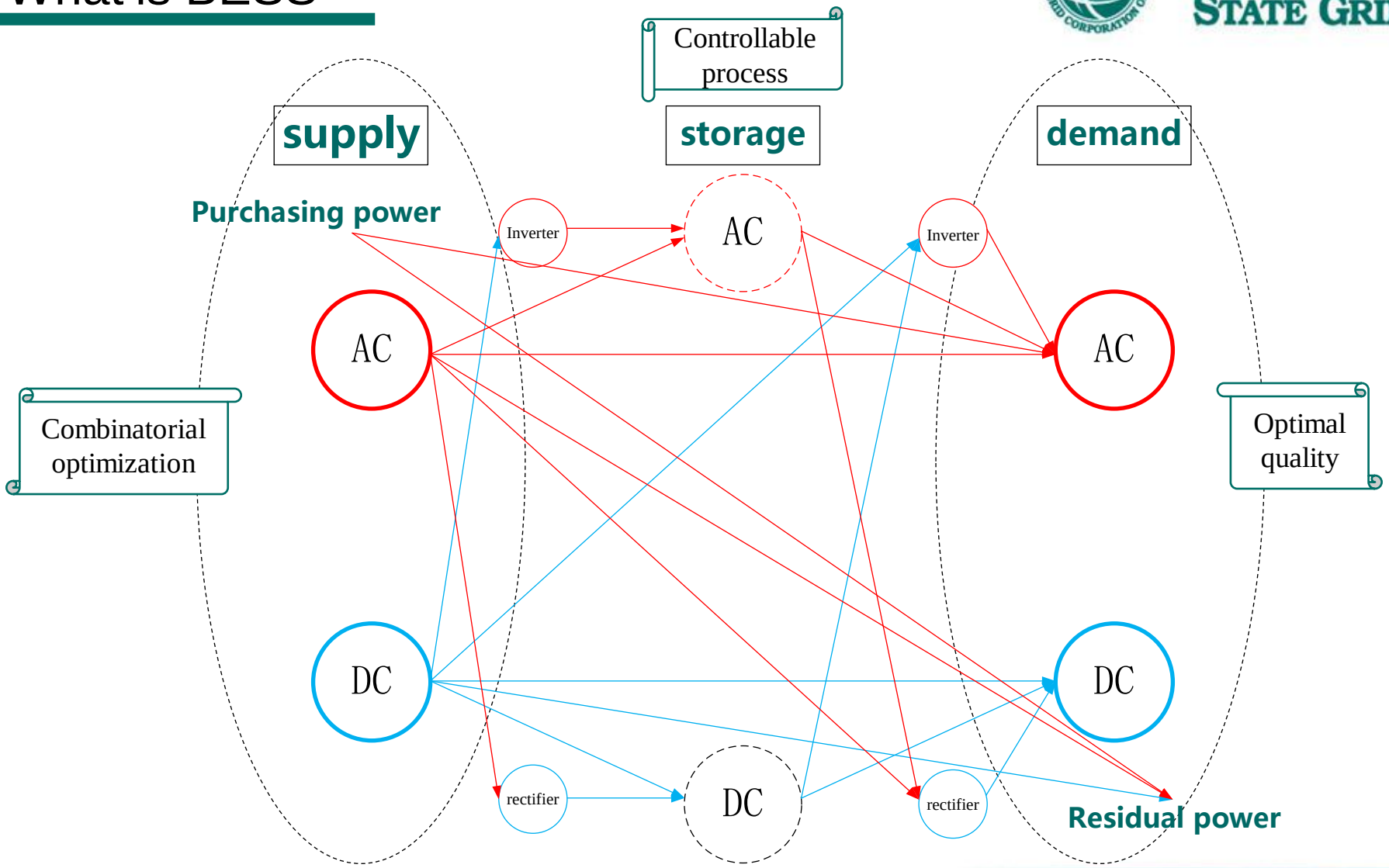
The access of distributed power supply has advantages and disadvantages to the power supply in industrial parks. But it will be an inevitable trend for the development of power system to establish a new type of power grid with distributed power supply.

What is BESS


SUP
PLY
Transmission line
DE
MA
ND
Real time, dynamic balance
Strong interconnected power grid
SUP
PLY
Transmission line
DE
MA
ND
Energy body increases, dispersed
How to reach a new balance between multiple nodes?

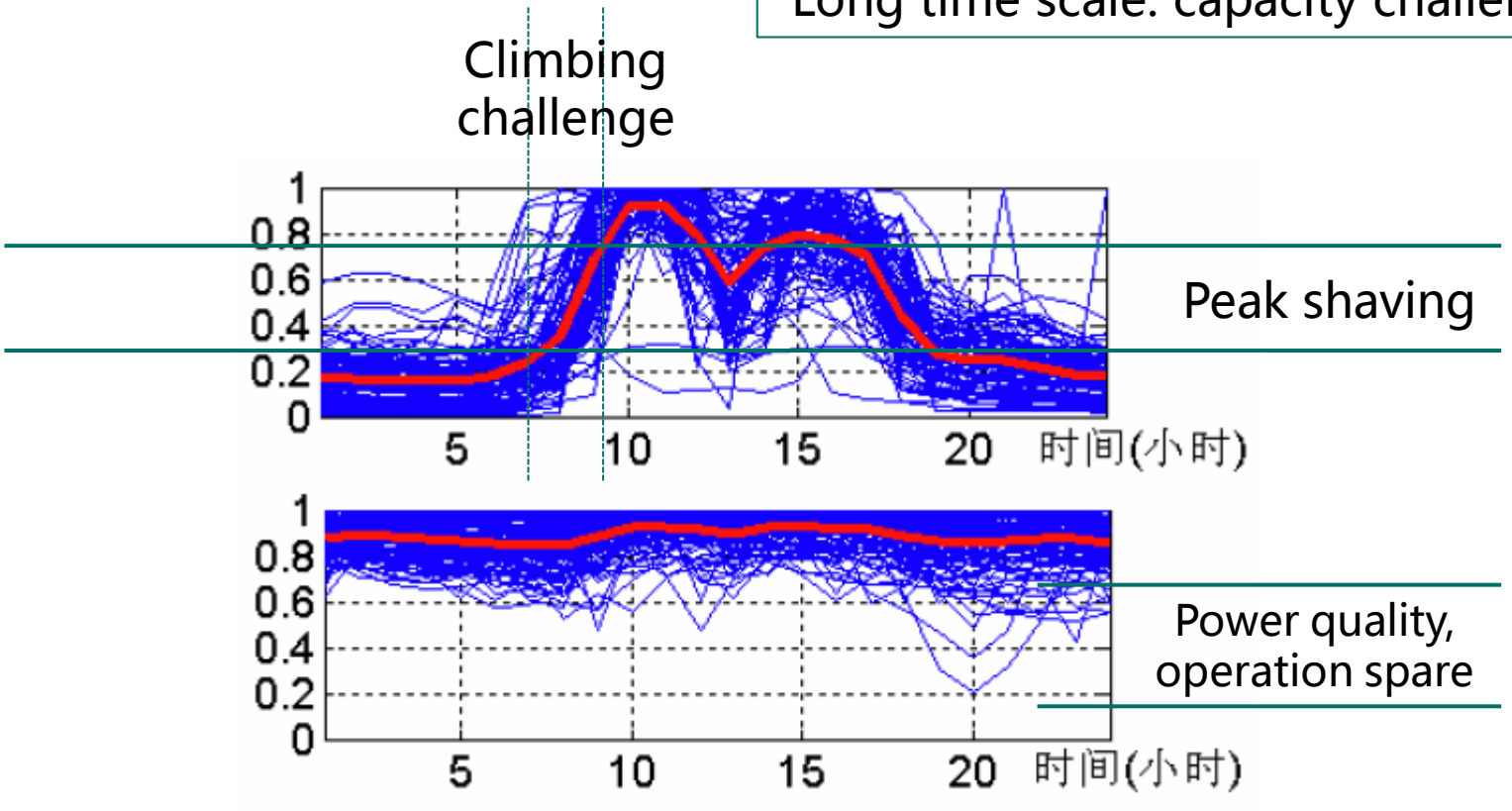

Lowest possible cost
Supply reliability
Fluctuating demand
Power System

What is BESS


Controllable process
supply
storage
demand
Purchasing power
Inverter
AC
Inverter
AC
AC
Combinatorial optimization
Optimal quality
DC
DC
rectifier
DC
rectifier
Residual power

Electric load of Industrial Park

Long time scale: capacity challenge



Source: Zhejiang University

Step 1: clear requirements, load type

Several typical scenarios of industrial park using battery energy storage systems (sustainable?) ：

Electricity saving, emergency power supply, power quality, virtual power plant, energy management, renewable energy smoothing

AC LOAD

Mechanical Type 1	Mechanical press
	Metal lathe drive
	Driller drive
	Planning machine drive
	Shaper drive
	Hammer drive
	Metal shear drive
	Hydraulic press
	Forging press
	Grinder/raw-mill drive
	Chipper drive
	Crusher drive
Mechanical Type 2	Pump drive
	Fan drive
	Blower drive
	Air compressor drive
	Conveyor drive
HVAC	Chiller motor drive
	Cooling water fan drive
	Condenser pump drive
	Air handler motor drive
Lighting	Fluorescent lamps

Friendly

Adjustable

Neutral

Interruptible

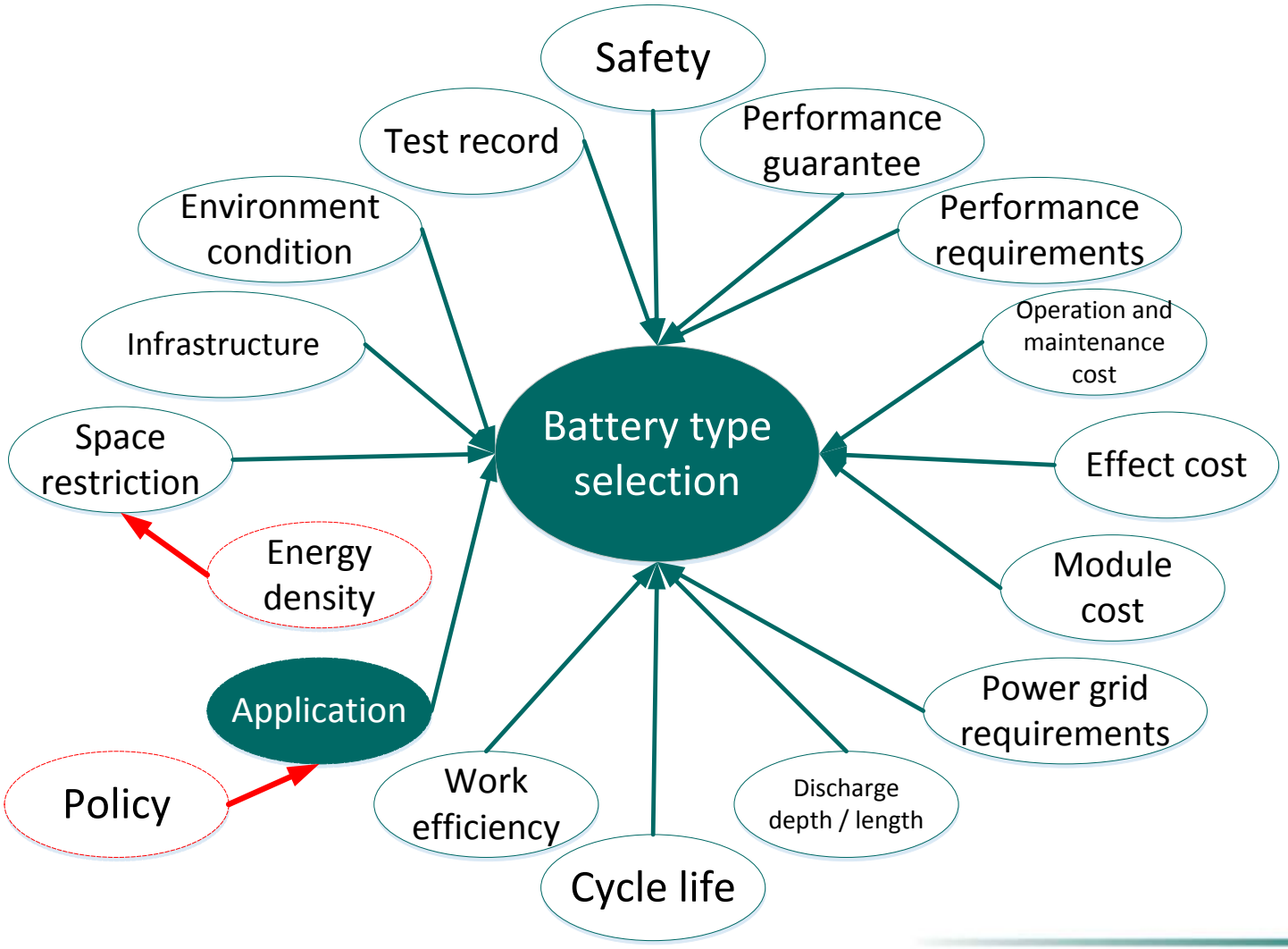
Unfriendly

Important and sensitive

DC LOAD

Mechanical Type 1	Mixer drive
	Crane
	Hoist
	Freight elevator
Mechanical Type 2	Kiln drive
	Variable-speed fan drive
	Variable-speed blower drive
Thermal	Smelter
	Arc furnace
	Electrolytic cell
	Induction furnace
Lighting	LED lamps

Step 2: battery selection



Step 3: capacity planning for BESS

Maximum annual income=Distribution station capacity↓+ Basic electricity ↓ + **Electricity purchase cost** ↓ + Transformer loss ↓ + **Outage loss** ↓ - Investment cost ↑- Operation cost ↑

Source: Shanghai Jiao Tong University

$$\max E_{year} = E_1 + E_2 + E_3 + E_4 + E_5 - C_1 - C_2$$

$$E_1 = \begin{cases} \gamma_d C_d P_{max} & P_{max} \leq P_c \\ \gamma_d C_d (2P_c - P_{max}) & P_{max} > P_c \end{cases}$$

$$P_c = P_{dmax} - P_a$$

$$C_1 = \gamma_p (C_f + 2k_p P_{max}) + \gamma_w k_w W_{max}$$

$$C_2 = C_m P_{max}$$

$$E_2 = \begin{cases} e_r P_{max} & P_{max} \leqslant P_c \\ e_r (2P_c - P_{max}) & P_{max} > P_c \end{cases}$$

$$E_3 = n \sum_{i=1}^{24} (P_i^+ - P_i^-) e_i$$

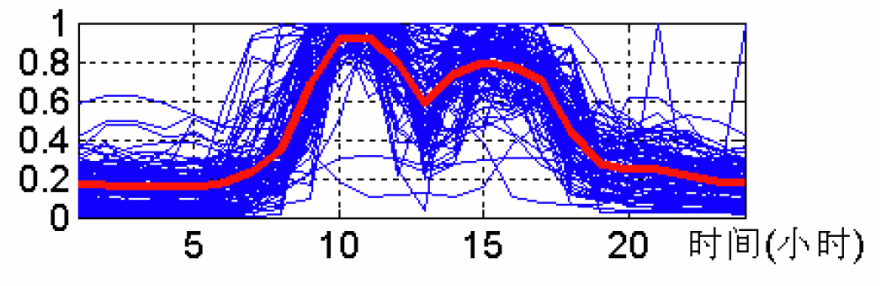
$$E_4 = n \sum_{i=1}^{24} \frac{[P_i^2 - (P_i - P_i^+ + P_i^-)^2] P_k e_i}{(S_N \cos \varphi)^2}$$

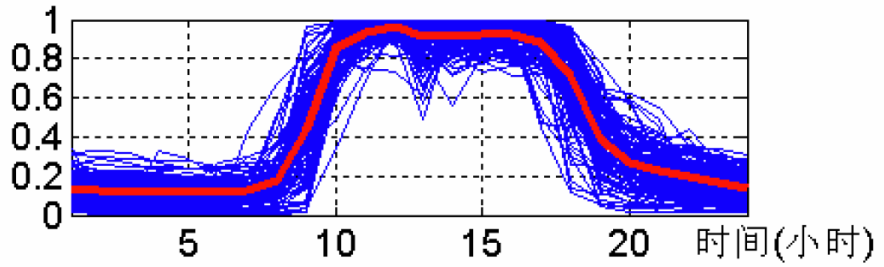
$$E_5 = R_{IEA} E_{ENS} \lambda_s (1 - P(W_i < E_{ENS})) + (\lambda_s - \lambda_s') E_\lambda$$

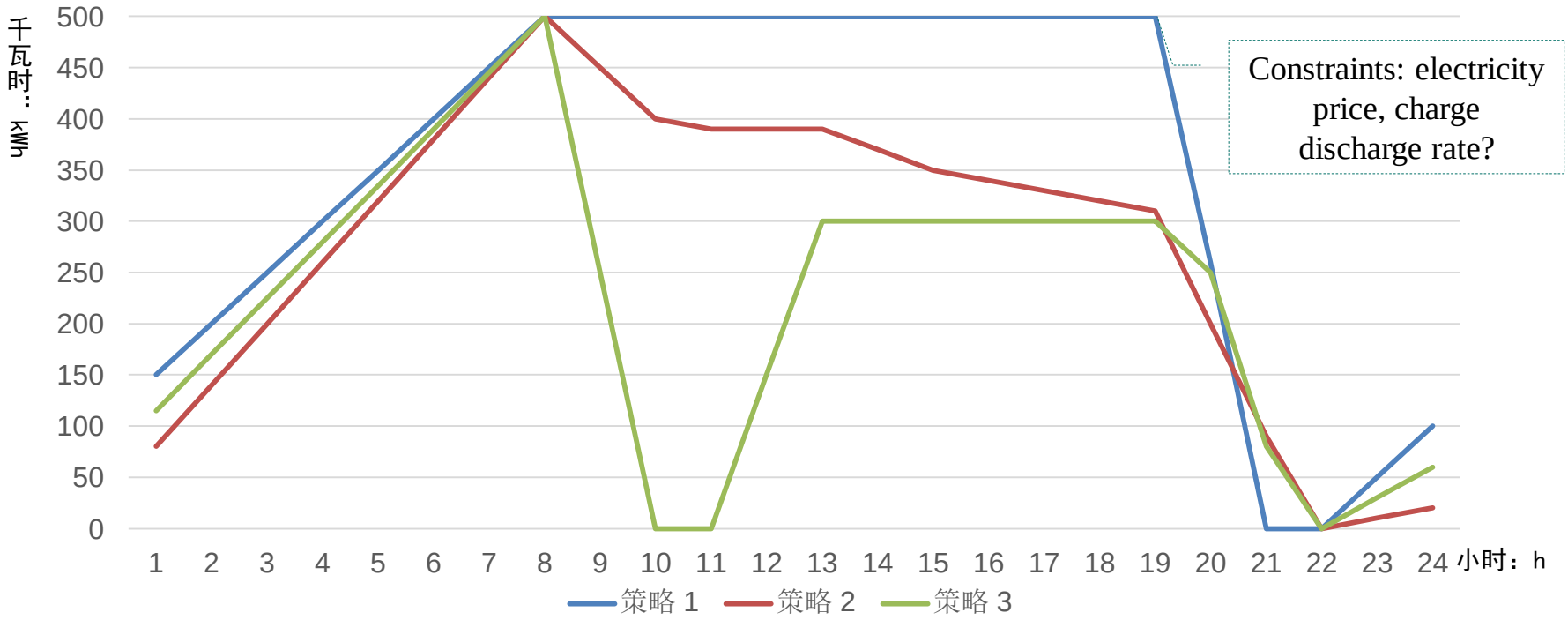
PSO+ Mult-SUMT

- ✓ Operation strategy is mainly based on electricity price incentives.
- ✓ According to the Peak / Valley segment to determine usually.
- ✓ Most of the situation is a charge of a release.
- ✓ Suitable for friendly or neutral load.

Step 4: discuss the operation strategy





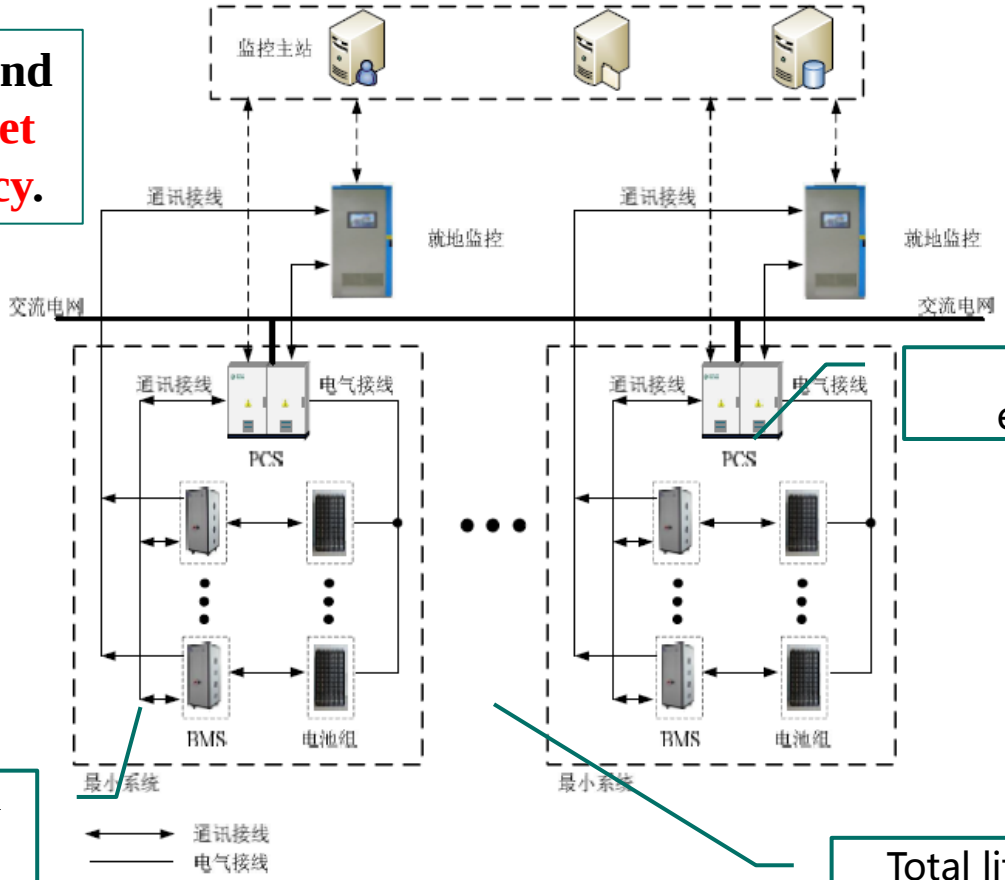


Constraints: electricity price, charge discharge rate?

Peak hour ：19：00-21：00；
Rush hour ：8：00-11：00、13：00-19：00、21：00-22：00；
Trough hour ：11：00-13：00、22：00-8：00

Step 5: BESS connected to the power grid

To ensure safety and reliability , Full set system redundancy.



Typical structure of BESS

PCS conversion efficiency ≥97%

Unit equipment charge and discharge conversion speed<100ms

Total life equivalent power cost <0.5YUAN/kWh

Conclusion

1、The trend of BESS applied in power system is beyond doubt, but the power system is expected to further break through the relevant ontology technology, especially the long life, high security and reliability of the BESS.

2、High confidence interval of the strong power grid is not one day of work, the high confidence interval of the “Renewable energy + Energy storage" combination can not be one day of work.

3、In order to gain the profit of the business model is not sustainable, the maximum value of the energy storage can be used to improve the reliability of power supply.

4、The electrochemical cell system is the product of the depth fusion of physics and chemistry, but its dynamic model is difficult to build.

5、The full consideration of the load is not friendly causes the need to configure the hybrid energy storage system.

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