国家电网
STATE GRID

中国电力科学研究院
CHINA ELECTRIC POWER RESEARCH INSTITUTE

Application of Plug & Play Devices in Comprehensive Energy Service

Lv Zhipeng
China Electric Power Research Institute
2018.5.23

Outline

1. The background of the integrated energy services

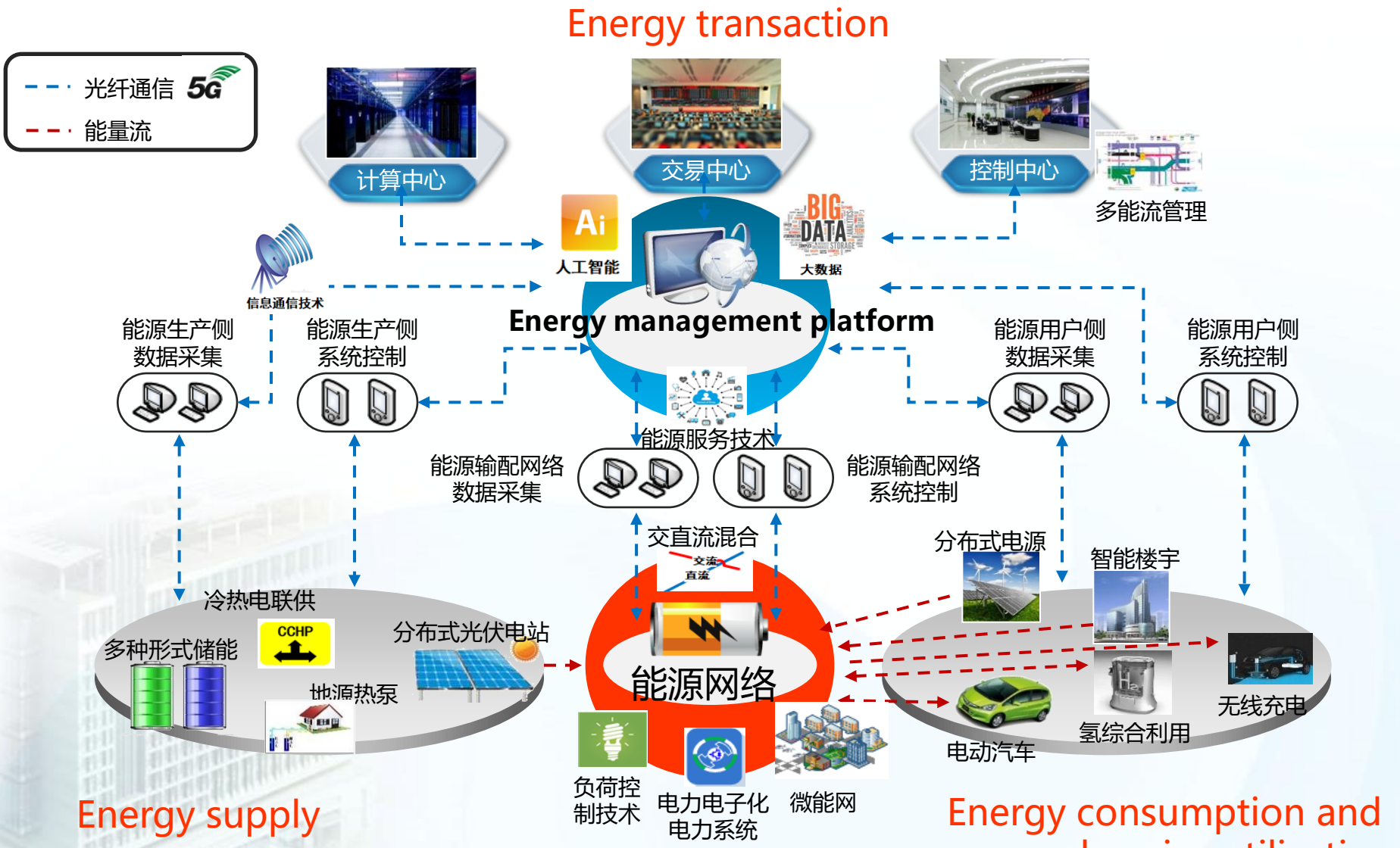
2. Problems in existing grid connected technology

3.Intelligent grid connected technology

4. Summary

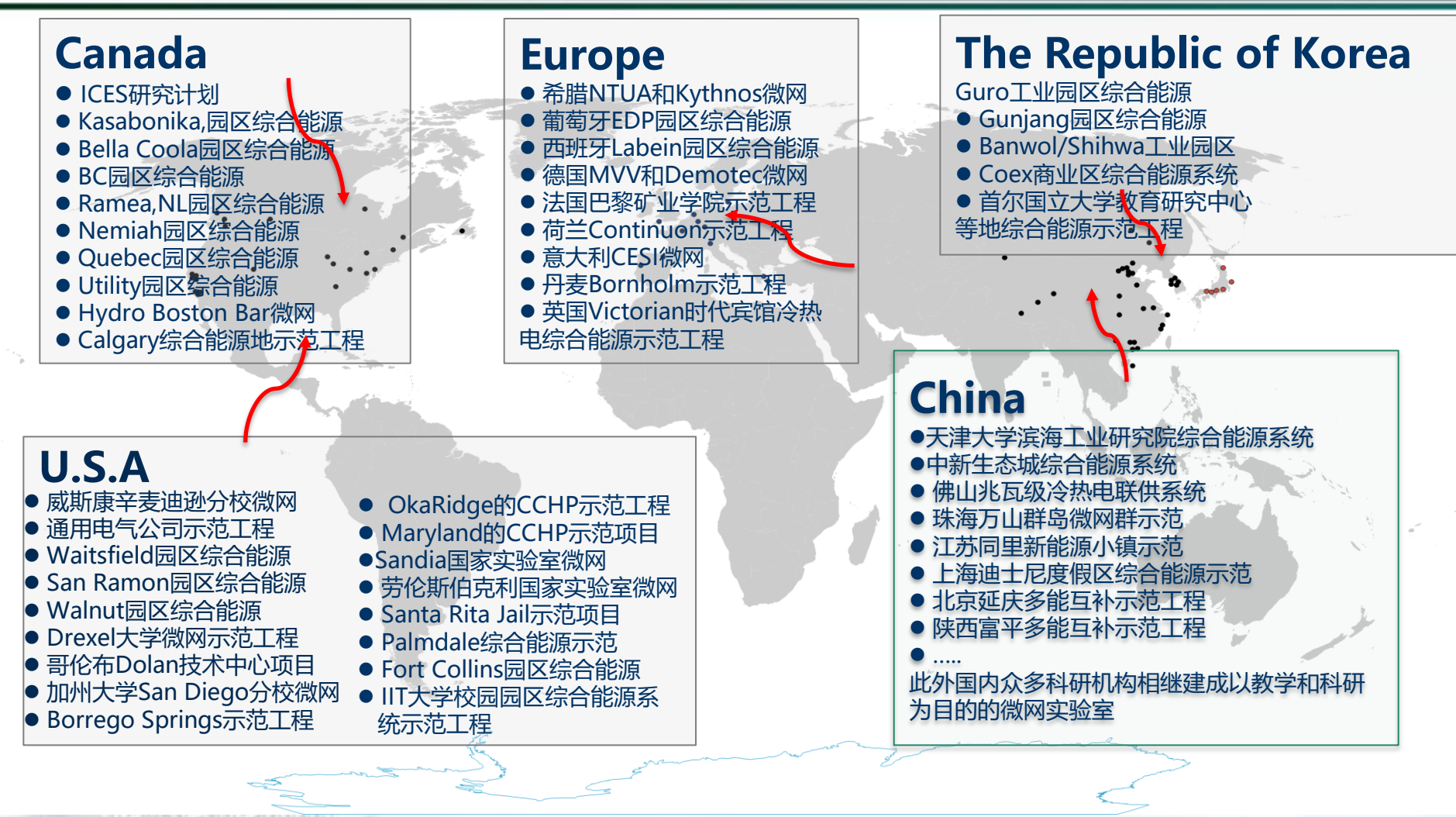
Integrated energy services

国家电网 STATE GRID
中国电力科学研究院 CHINA ELECTRIC POWER RESEARCH INSTITUTE



Integrated energy services

国家电网 STATE GRID
中国电力科学研究院 CHINA ELECTRIC POWER RESEARCH INSTITUTE



Canada

- ICES研究计划
- Kasabonika,园区综合能源
- Bella Coola园区综合能源
- BC园区综合能源
- Ramea,NL园区综合能源
- Nemiah园区综合能源
- Quebec园区综合能源
- Utility园区综合能源
- Hydro Boston Bar微网
- Calgary综合能源地示范工程

Europe

- 希腊NTUA和Kythnos微网
- 葡萄牙EDP园区综合能源
- 西班牙Labein园区综合能源
- 德国MVV和Demotec微网
- 法国巴黎矿业学院示范工程
- 荷兰Continuon示范工程
- 意大利CESI微网
- 丹麦Bornholm示范工程
- 英国Victorian时代宾馆冷热电综合能源示范工程

The Republic of Korea

Guro工业园区综合能源

- Gunjang园区综合能源
- Banwol/Shihwa工业园区
- Coex商业区综合能源系统
- 首尔国立大学教育研究中心

等地综合能源示范工程

U.S.A

- 威斯康辛麦迪逊分校微网
- 通用电气公司示范工程
- Waitsfield园区综合能源
- San Ramon园区综合能源
- Walnut园区综合能源
- Drexel大学微网示范工程
- 哥伦布Dolan技术中心项目
- 加州大学San Diego分校微网
- Borrego Springs示范工程
- OkaRidge的CCHP示范工程
- Maryland的CCHP示范项目
- Sandia国家实验室微网
- 劳伦斯伯克利国家实验室微网
- Santa Rita Jail示范项目
- Palmdale综合能源示范
- Fort Collins园区综合能源
- IIT大学校园园区综合能源系统示范工程

China

- 天津大学滨海工业研究院综合能源系统
- 中新生态城综合能源系统
- 佛山兆瓦级冷热电联供系统
- 珠海万山群岛微网群示范
- 江苏同里新能源小镇示范
- 上海迪士尼度假区综合能源示范
- 北京延庆多能互补示范工程
- 陕西富平多能互补示范工程
- .....

此外国内众多科研机构相继建成以教学和科研为目的的微网实验室

- **The Integrated energy services has attracted worldwide attention. More and more institutions participate in the research and construction of integrated energy power system.**

Integrated energy services

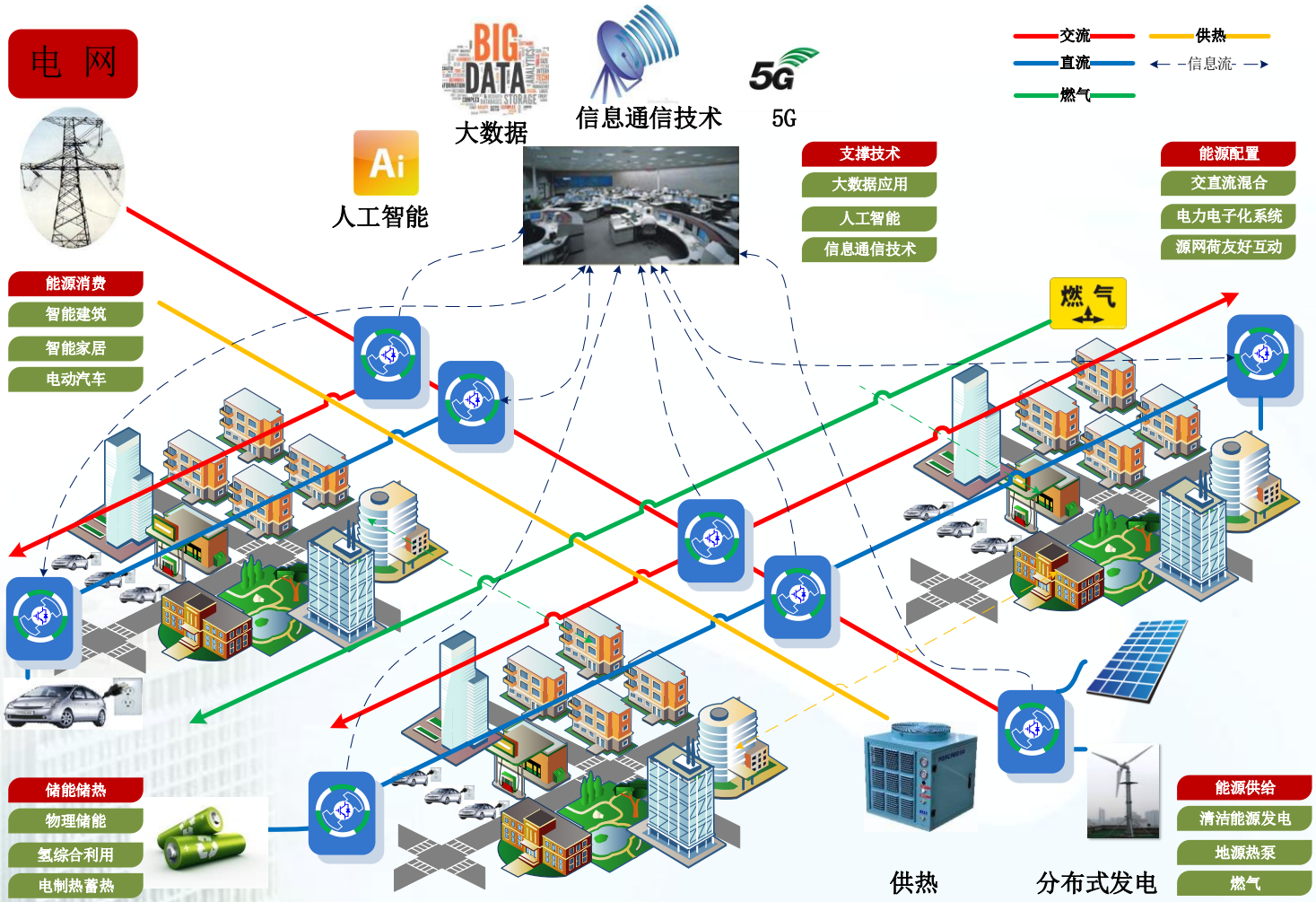
国家电网 STATE GRID
中国电力科学研究院 CHINA ELECTRIC POWER RESEARCH INSTITUTE

- State gird：2017.10, will mobilizing the resources of all parties, do the best and make the integrated energy service business bigger and stronger, promote the company to change from the power supplier to the comprehensive energy service provider.

China process

At present, with the development of China's electric power system reform, the incremental business of distribution network and the gradual release of the retail electricity market, the multi market subject will gradually increase the investment and development of the microgrid and distribution network. In 2017, the State Power Grid Co., Ltd. issued the opinion of the national Power Grid Corp on comprehensive energy service in various provinces and companies, and formally entered the comprehensive energy service industry. According to the opinion, by 2020, we should ensure that the total energy service revenue of the company is about 50 billion yuan, and to achieve about 60 billion yuan, and the market share has been significantly improved.

Integrated energy services



- An integrated services system take electricity as the core and is highly coupled with gas system and thermodynamic system.

Integrated energy services

国家电网 STATE GRID
中国电力科学研究院 CHINA ELECTRIC POWER RESEARCH INSTITUTE

Integrated energy system

In the process of planning, construction and operation, the energy supply and marketing integration system, which is formed by the organic coordination and optimization of energy generation, transmission and distribution, transformation, storage and consumption, is the physical carrier of the energy Internet

- Multi energy coupling is one of the key features .
- Based on electricity is the basic consensus.
- The upper electric power grid and power conversion technology are important factors in determining the level of integrated energy services.
- Only the rapid control of electricity is realized first can solve the problem of highly coupled heat and gas.

Outline

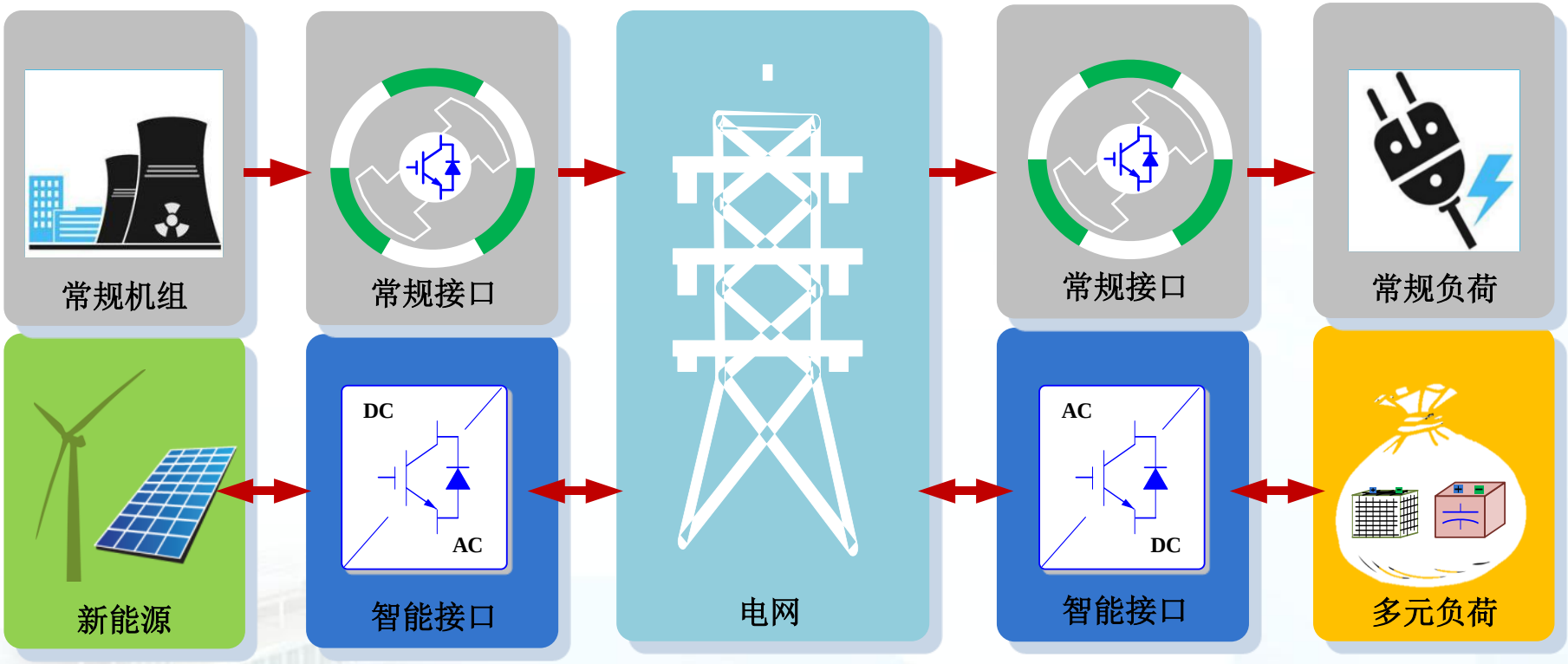
1. The background of the integrated energy services

2. Problems in existing grid connected technology

3.Intelligent grid connected technology

4. Summary

Integrated energy services



- Multi-layer communication and scheduling model causes real time reduction
- There is a bottleneck problem in power electronic conversion devices.
- The fragile power conversion device reduces the reliability and robustness of the integrated energy system.
- Compatibility problems with large inertia systems such as heat, water and gas.

Outline

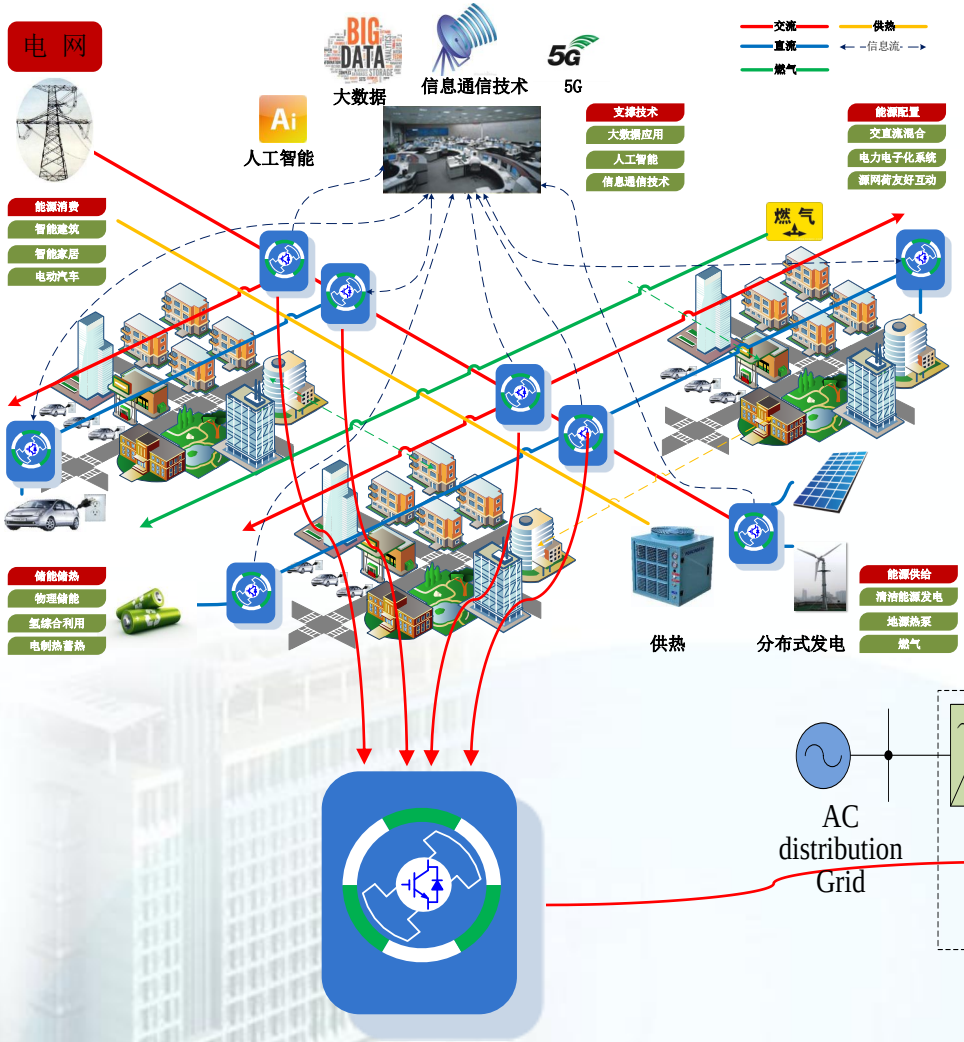
1. The background of the integrated energy services

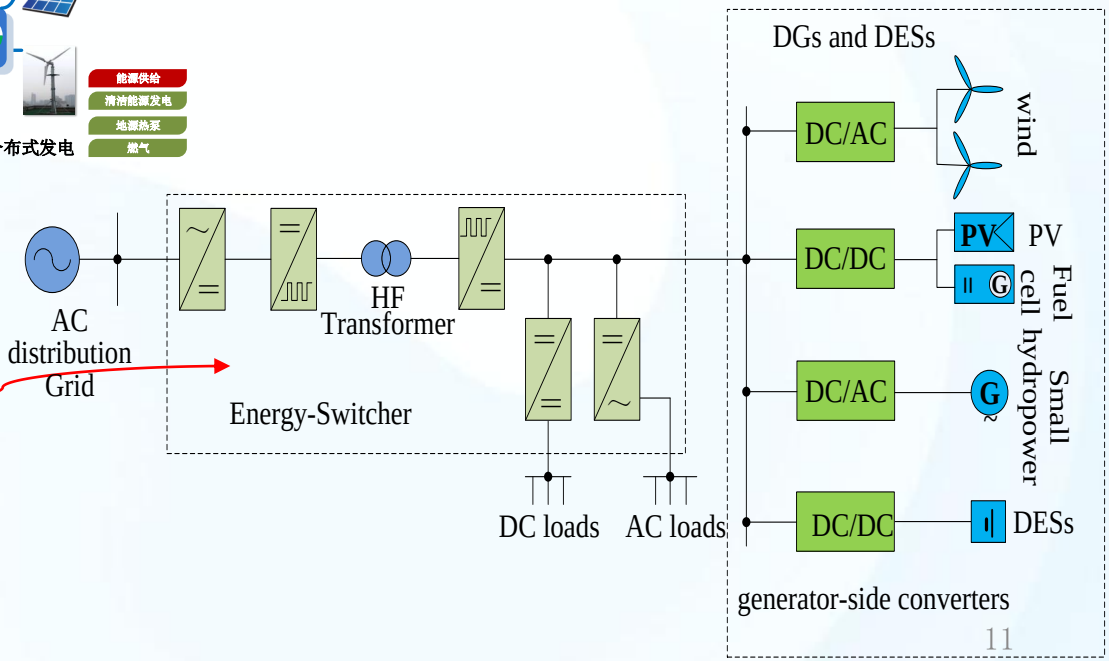
2. Problems in existing grid connected technology

3.Intelligent grid connected technology

4. Summary

Intelligent plug & play grid connected device



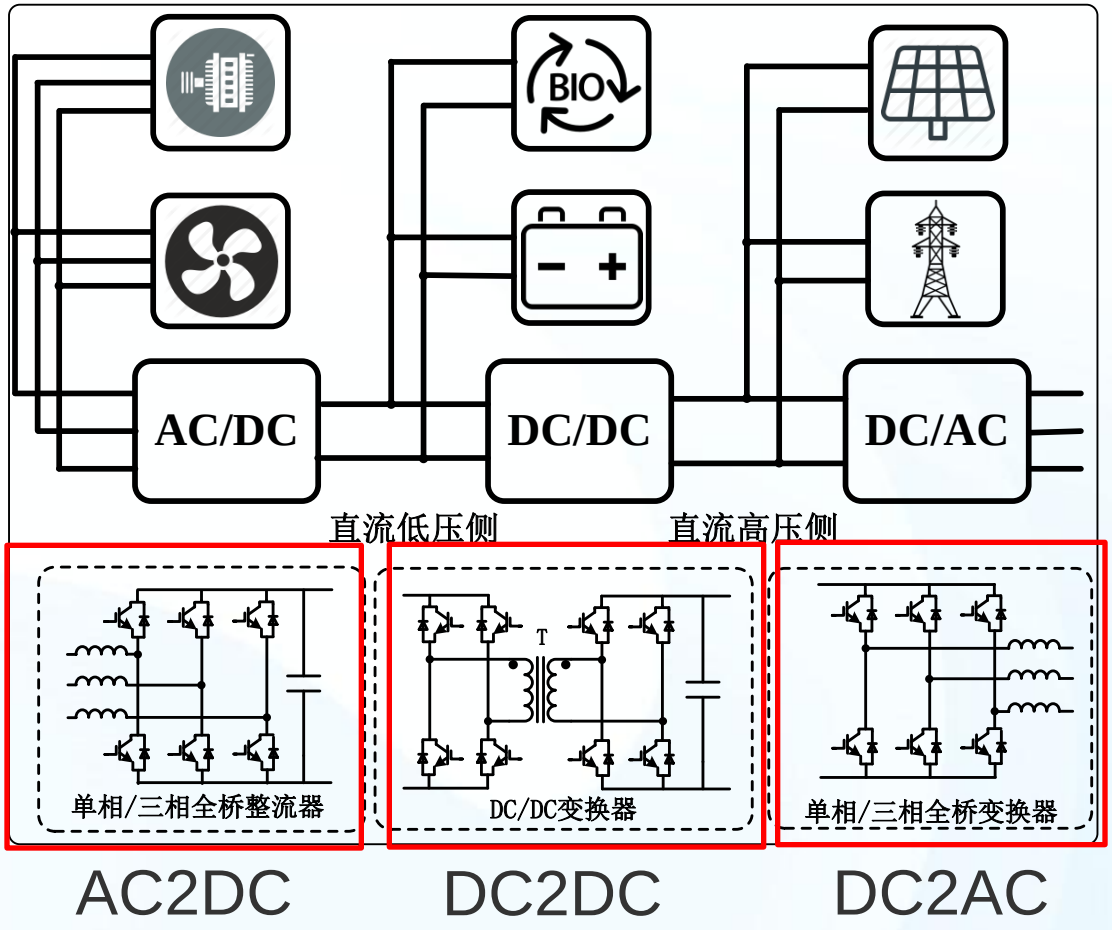


- **Intelligent plug and play equipment is the key link of building comprehensive energy service system.**

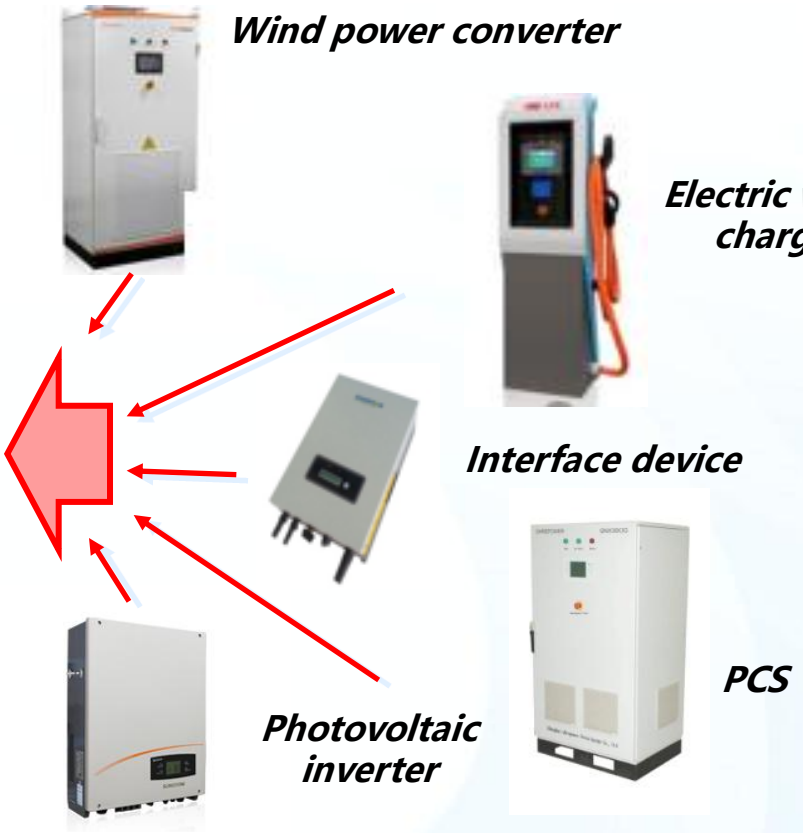
Intelligent plug & play grid connected device

国家电网 STATE GRID
中国电力科学研究院 CHINA ELECTRIC POWER RESEARCH INSTITUTE

- The maximum design of plug and play devices is the energy router.
- MMC cascaded topology for medium voltage AC2DC
- The medium voltage bidirectional DC2DC converter selects the module series parallel topology (ISOP), the high-voltage side is connected in series, the low-voltage side is connected in parallel, and the high frequency isolation is adopted.
- Three-phase four wire topology for low voltage DC/AC
- Each of the modules can also be used alone, like AC2DC, DC2DC, DC2AC



Intelligent plug & play grid connected device

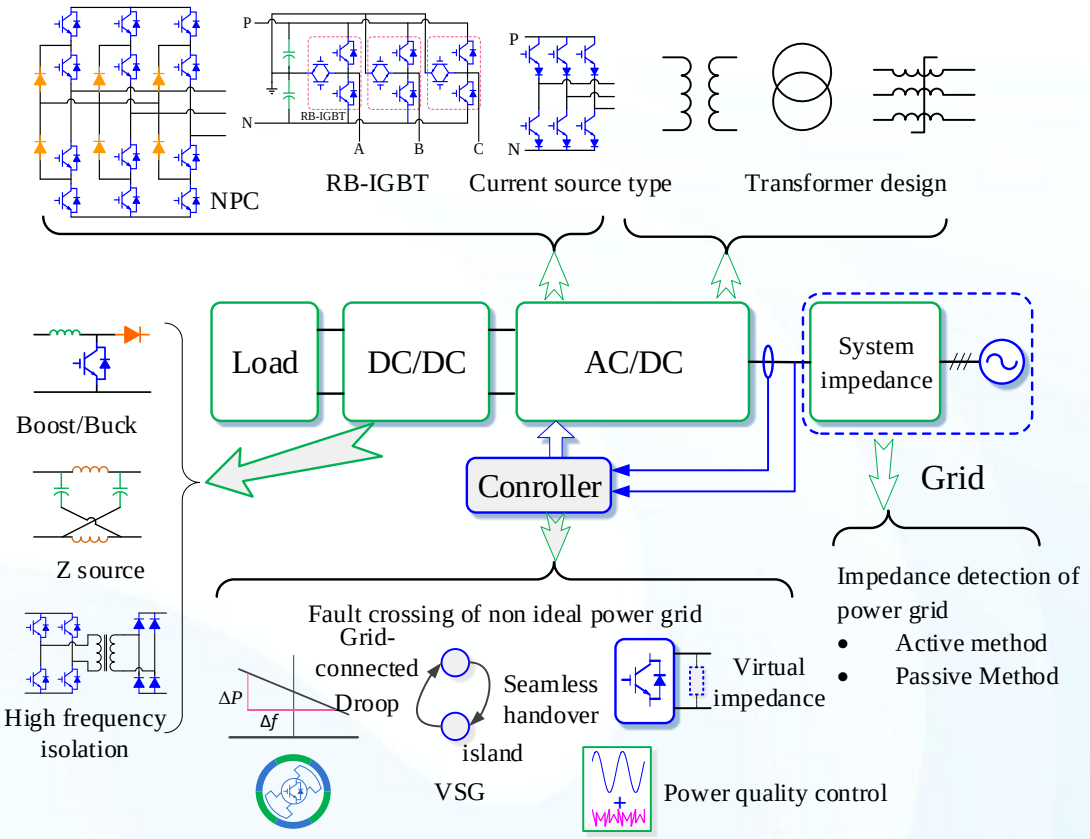


- One of series of Intelligent Plug & Play Grid Connected Devices
- Integrate and unify a variety of energy interfaces, like photovoltaic, energy storage and electric vehicle plug interface
- Greatly saving the operation and maintenance costs and the intensity of work

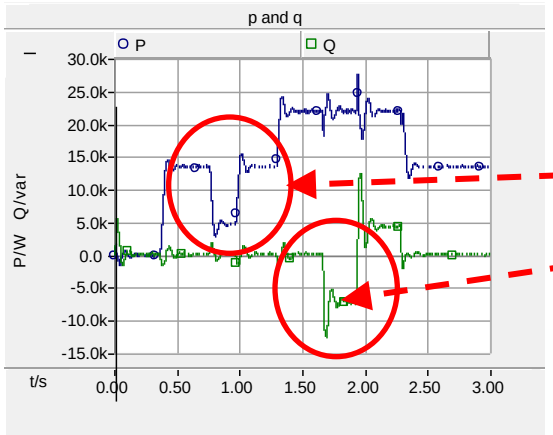
Intelligent plug & play grid connected device

国家电网 STATE GRID
中国电力科学研究院 CHINA ELECTRIC POWER RESEARCH INSTITUTE

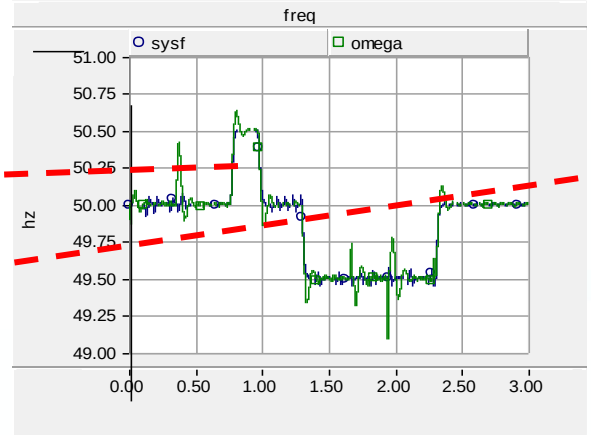
- Friendly & flexible grid connected device for clean energy, controllable loads and energy storage devices
- Adaptive software function includes adaptive grid impedance, adaptive grid voltage, active power tracking and power quality control;
- It is a comprehensive access solution for smart home and intelligent community.
- In particular, inertia control is designed, which greatly reduces the dependence on communication. This is especially important in the comprehensive energy system centered on electricity.
- Especially in some special cases, energy conversion and conversion can be done autonomously and autonomously.



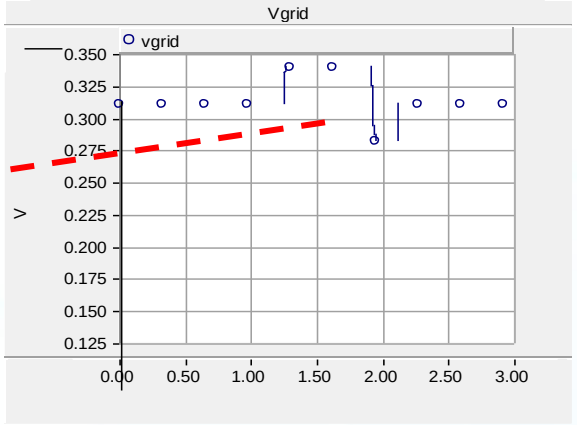
Function 1： Active tracking



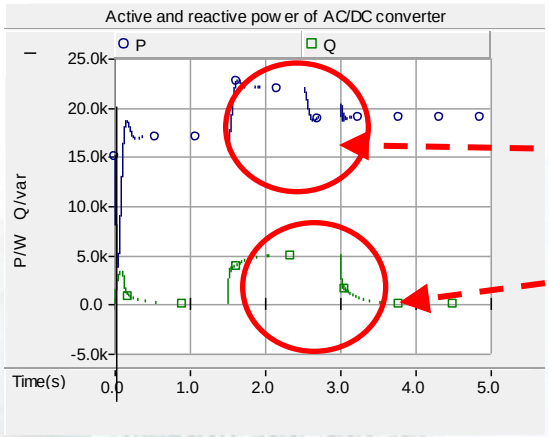
Active power and reactive power



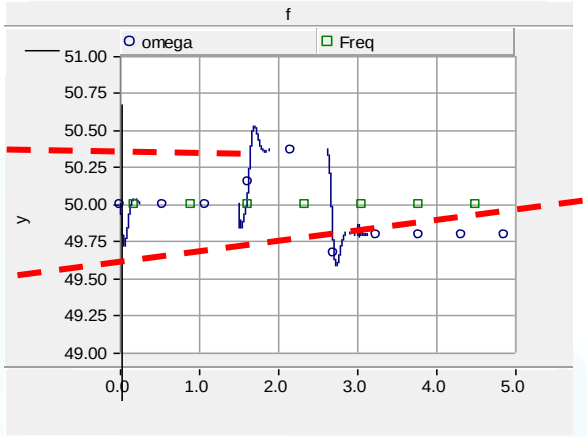
Power grid frequency



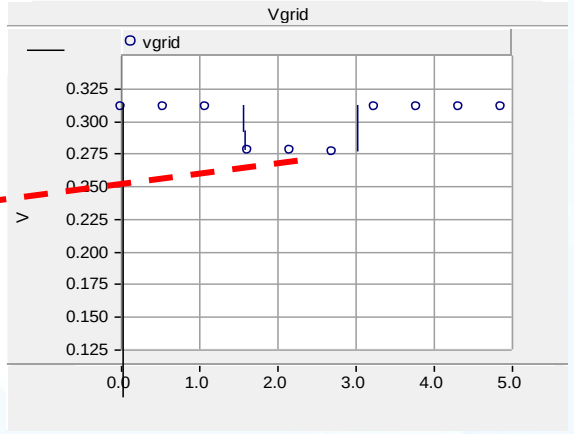
Power grid voltage



Active power and reactive power



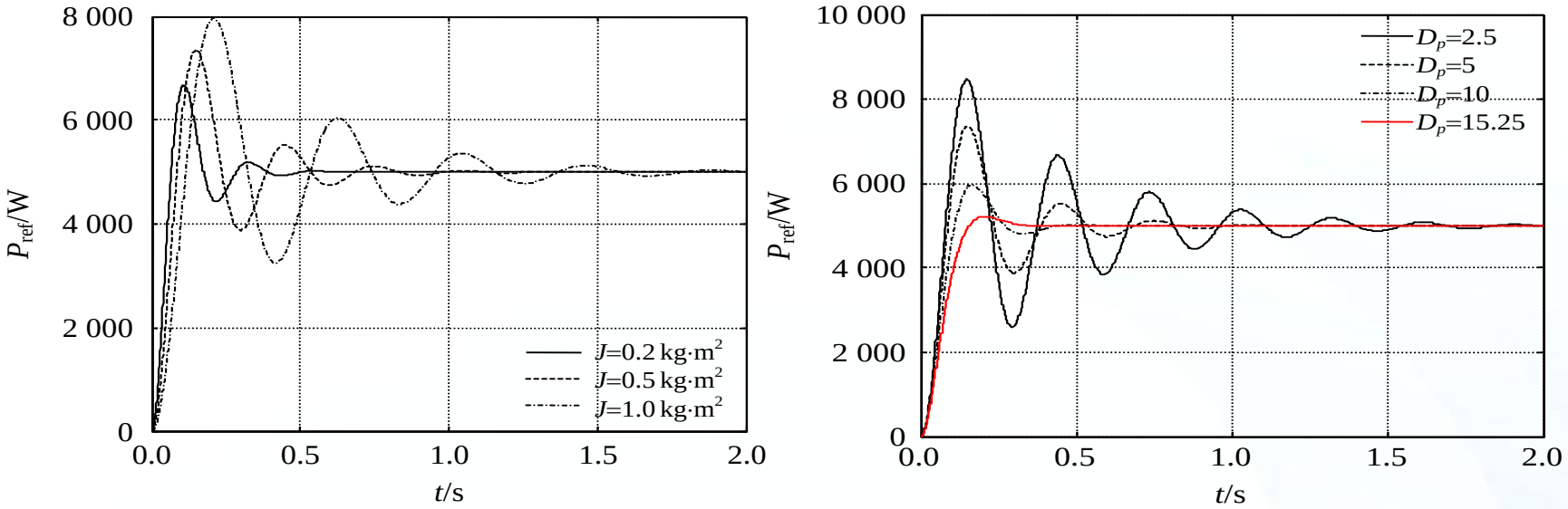
Power grid frequency



Power grid voltage

Source/load side: the power output/input can be adjusted according to the frequency and voltage of the power grid, so as to reduce the impact on the power grid.

Function 2：Inertia design

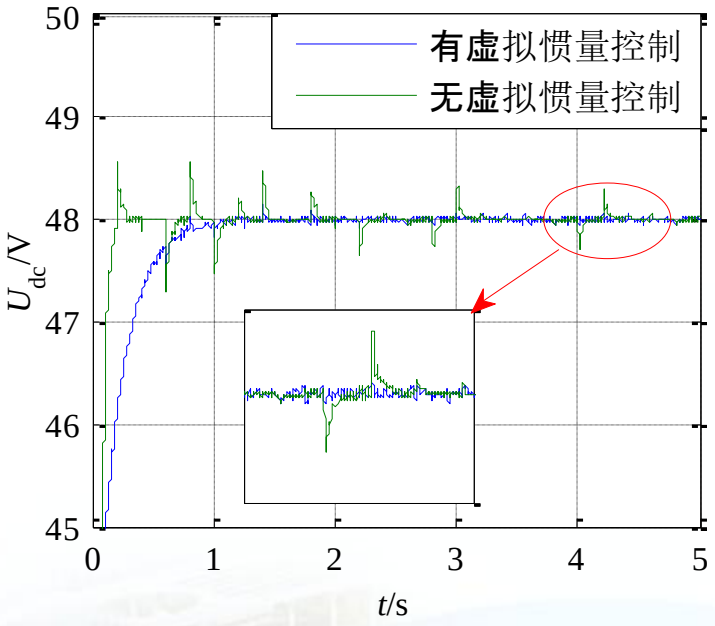


(a) D=8　　(b) J=0.5kg·m^2

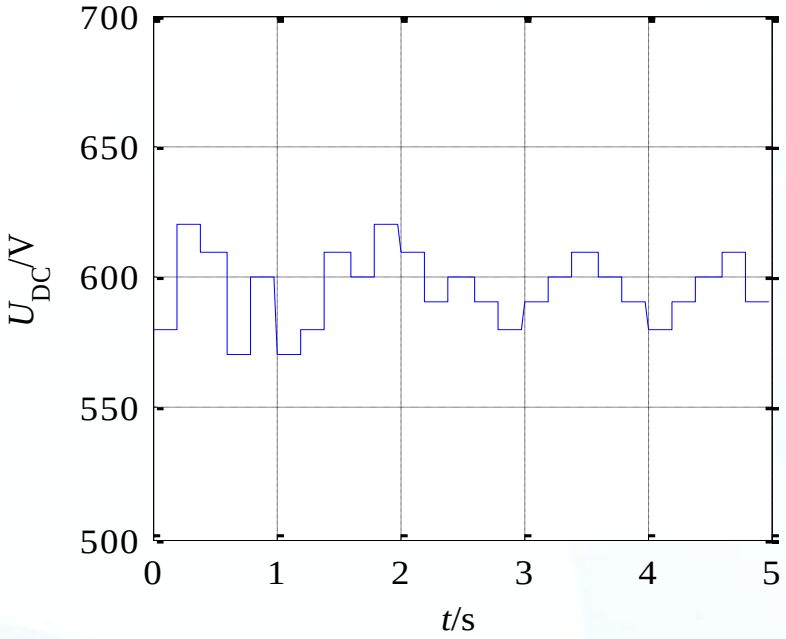
Using the inertia integral link to introduce the power swing process

- **The smart plug and play algorithm on the source side and the load side is concerned not only with the adjustment of internal characteristics, but also with the feedback of the operation characteristics of the power grid, so as to effectively integrate the sources, network and loads.**
- **The intelligent plug and play technology includes the inertia integral link, which can respond quickly when the state of the power grid changes.**
- **The conventional clean energy grid control does not pay attention to the feedback of the characteristics of the power grid.**

Function 3：Anti disturbance design



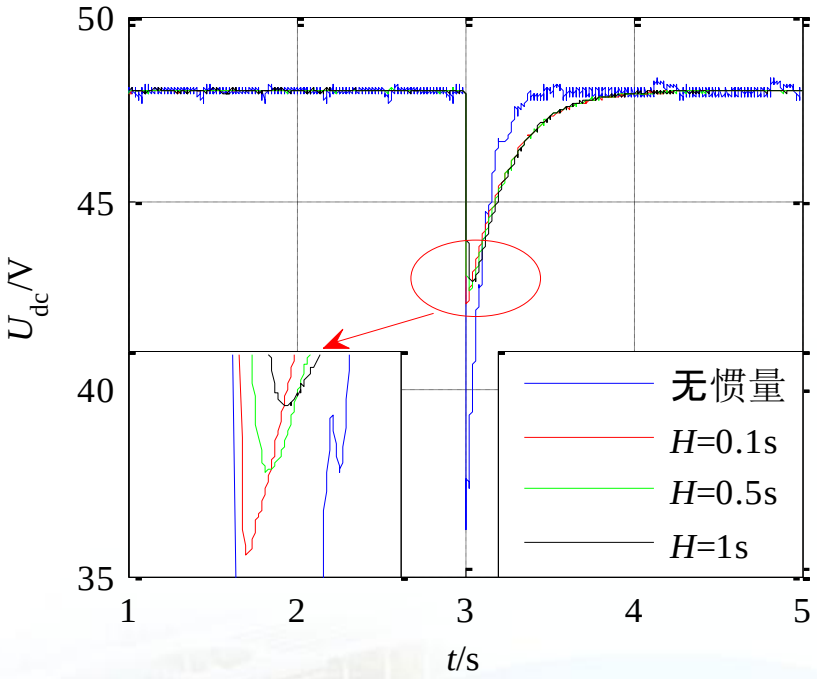
Load side voltage response of bus voltage fluctuation



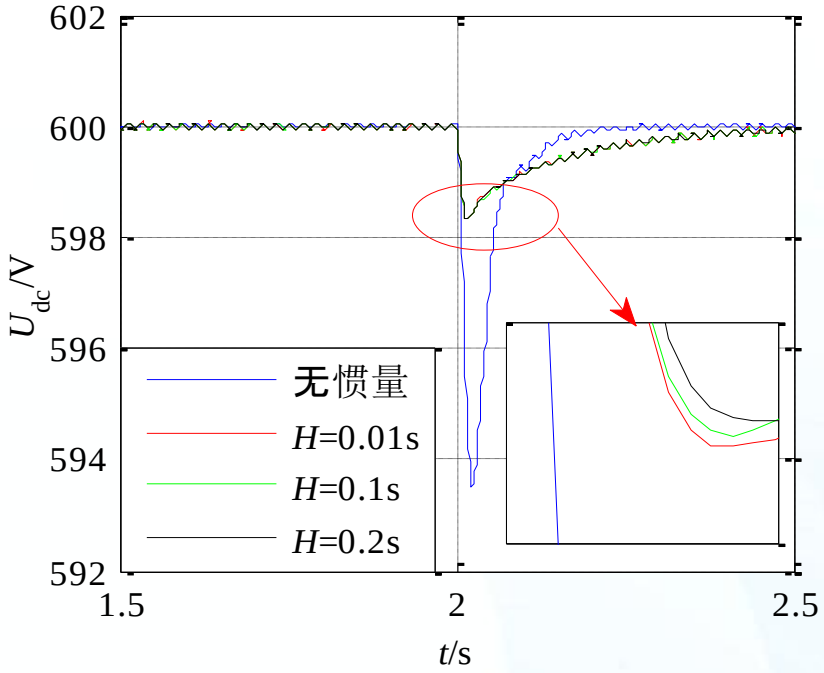
Random fluctuation of bus voltage

- **Filtering disturbance can improve the anti disturbance ability of the system and eliminate the pulsating spike, which will help improve the power quality.**

Function 4：Fault crossing and support



Load side



DC bus bar

- There is a lot of rapid energy transfer in integrated energy services.
- Sudden changes in load will lead to rapid changes in frequency, voltage or DC bus voltage.
- With the increase of the inertia time, the amplitude of the voltage drop decreases gradually, and the falling speed slows down.
- Timely inertia control can effectively support voltage stability on both sides.

Outline

1. The background of the integrated energy services

2. Problems in existing grid connected technology

3.Intelligent grid connected technology

4. Summary

Intelligent plug & play grid connected device

国家电网 STATE GRID
中国电力科学研究院 CHINA ELECTRIC POWER RESEARCH INSTITUTE

1. Inertia control, rapid response, fast decoupling control for a variety of energy sources

2. Power droop, absorptive power can be automatically changed according to the state of power grid.

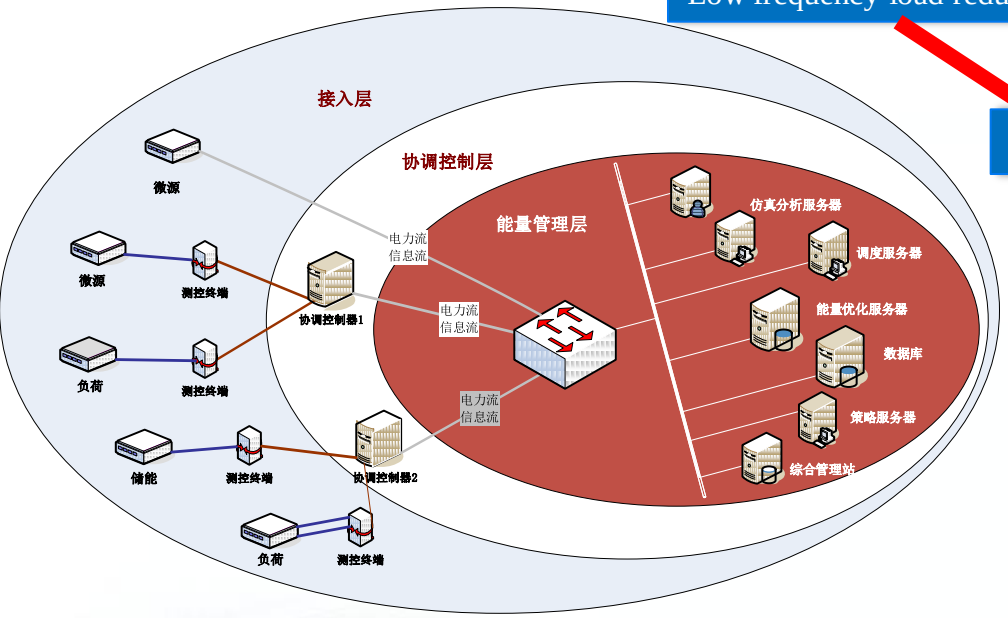
3.Improving anti disturbance ability & power quality, eliminating pulsating spike.

4. Smooth and stable control, a flexible comprehensive energy service system

- Smart plug and play technology seamlessly integrates power, load and network with control algorithm to achieve real coordinated operation .
- Avoiding electromagnetic transient time can increase the stability of power electronic devices based on switching mode.
- The time for the next change of the multi energy coupling system has been won.

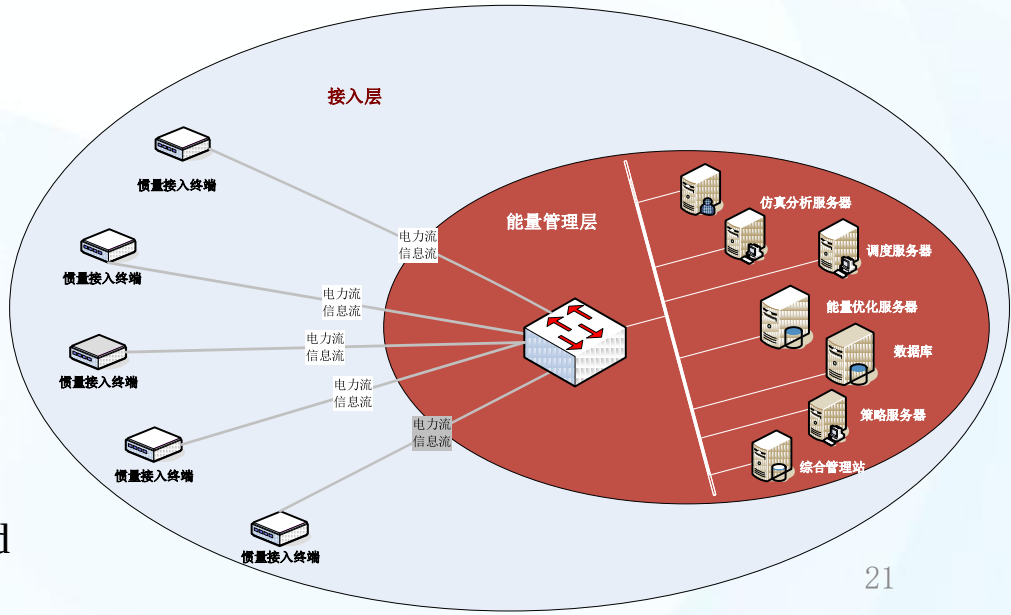
Summary

Low frequency load reduction	interactive system	Intelligent plug and play
20s+	650ms	100ms



The response time can be shortened to 100ms, which provides a prerequisite for decoupling control and measurement of different inertia systems for electricity, heat, water and gas.

- Traditional microgrid or energy Internet requires three levels of architecture.
- The underlying equipment needs to be operated through communication scheduling.
- Cannot satisfy the essential meaning of the plug and play
- The application of smart plug and play key technologies can fully explore the spontaneous and quick response capability of power and load.



Summary

Meaning

Integrated energy services include two meanings: integrated energy supply and comprehensive energy services.

Integrated energy services (integrated energy services) is a new type of energy service mode to meet the pluralistic energy production and consumption of terminal customers.

It is a diversified energy supply and diversified value-added service mode from a single electricity selling mode to electricity, gas, cold, heat and so on.

In the multi energy coupling control, the control of electricity is particularly important. Only with fast energy conversion and transfer control can we build a truly mature integrated energy service system.

Especially, the high speed energy conversion device, which takes the power electronic converter as the carrier, is an important link to promote the comprehensive energy service.

The intelligent plug and play key technology and equipment can realize the self dynamic and coordinated operation of the multiple elements of the source network, which is helpful to the construction of the backbone. Strong and flexible upper power grid is conducive to the construction of integrated energy service system.

Thanks!