The role of advanced technologies in power interconnection and emergency disaster response

Global Energy Interconnection
Development and Cooperation Organization

May, 2020

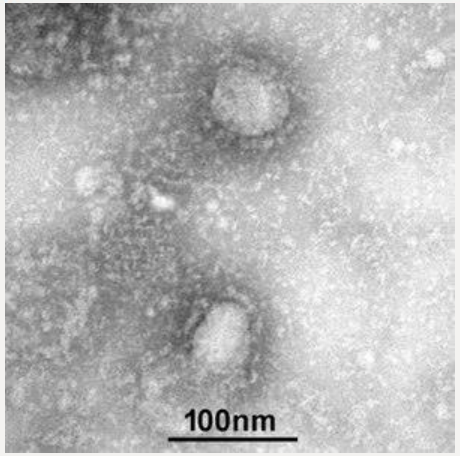
1. COVID-19 in China

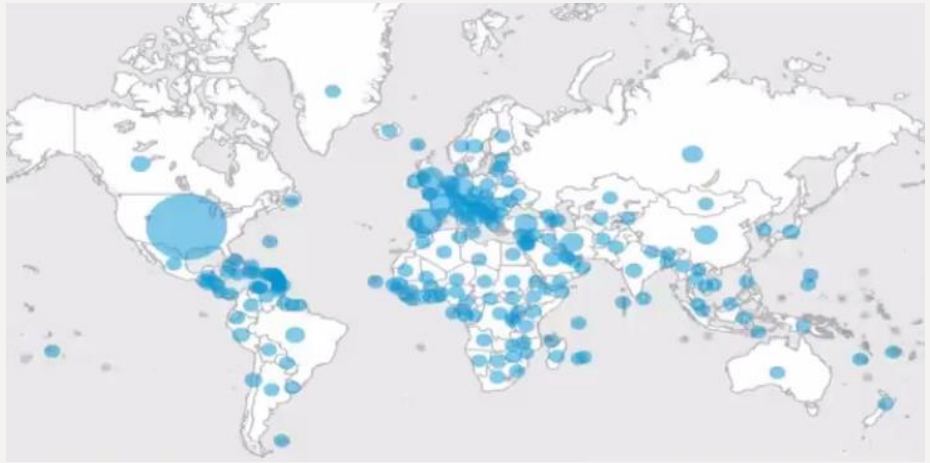
2. Measures against COVID-19

3. Advanced technologies on Transmission and Smart Grid

4. Epilogue

1.1 COVID-19 in China—progress





Wuhan reported 27 cases of pneumonia with unknown cause
2019.12.31

Every province in China reported COVID-19
2020.01.29

The first time new cases per day lower than 1000 in China
2020.02.19

WHO upgraded its coronavirus risk assessment to “very high”
2020.02.28

In China, COVID-19 is now under control, and work and production is being resumed in an ordered manner.

In Worldwide, COVID-19 is growing as a pandemic.

Now

Outbreak

Moderated

Controlled and work resumption

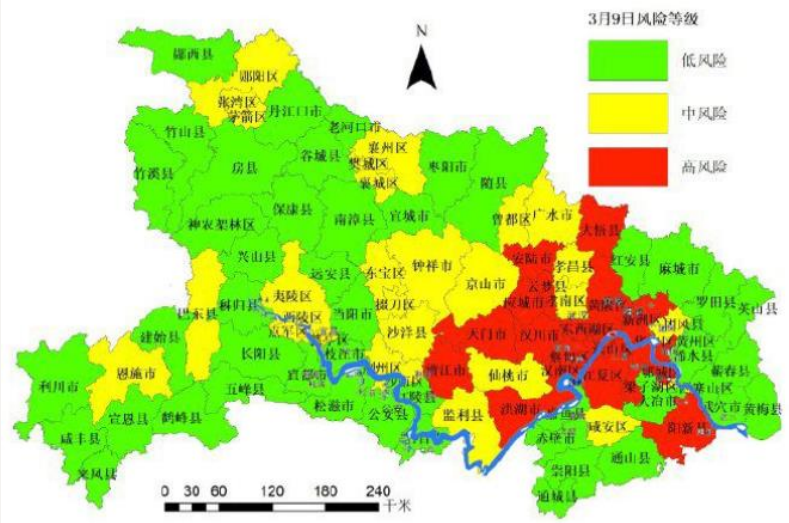
1.2 COVID-19 in China—actions

Open and transparent announcement

Separation and traffic control

Timely and professional treatment

1.3 COVID-19 in China—work resumption



Information infrastructure

5G　Blockchain　IDC

Integrated infrastructure

Intelligent transportation　Energy Internet

Innovation infrastructure

Major science and technology　Industrial technology

Region-specific and risk-based resumption of work

Ensure employment and help enterprises

New infrastructure development

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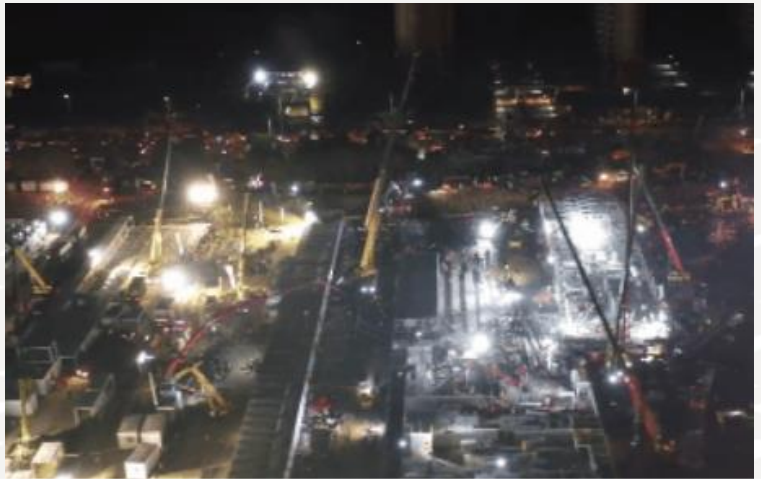
2.1.1 SGCC—against COVID-19

Ensure power supply
—— 150,000 staffs and 1,000 emergency generator cars



Support construction of mobile hospitals
——power supply for Huoshenshan hospital within 5 days

2.1.2 SGCC—for resumption

Restart key projects
—— UHV construction

Focus on new infrastructure
—— e.g. EV charging station

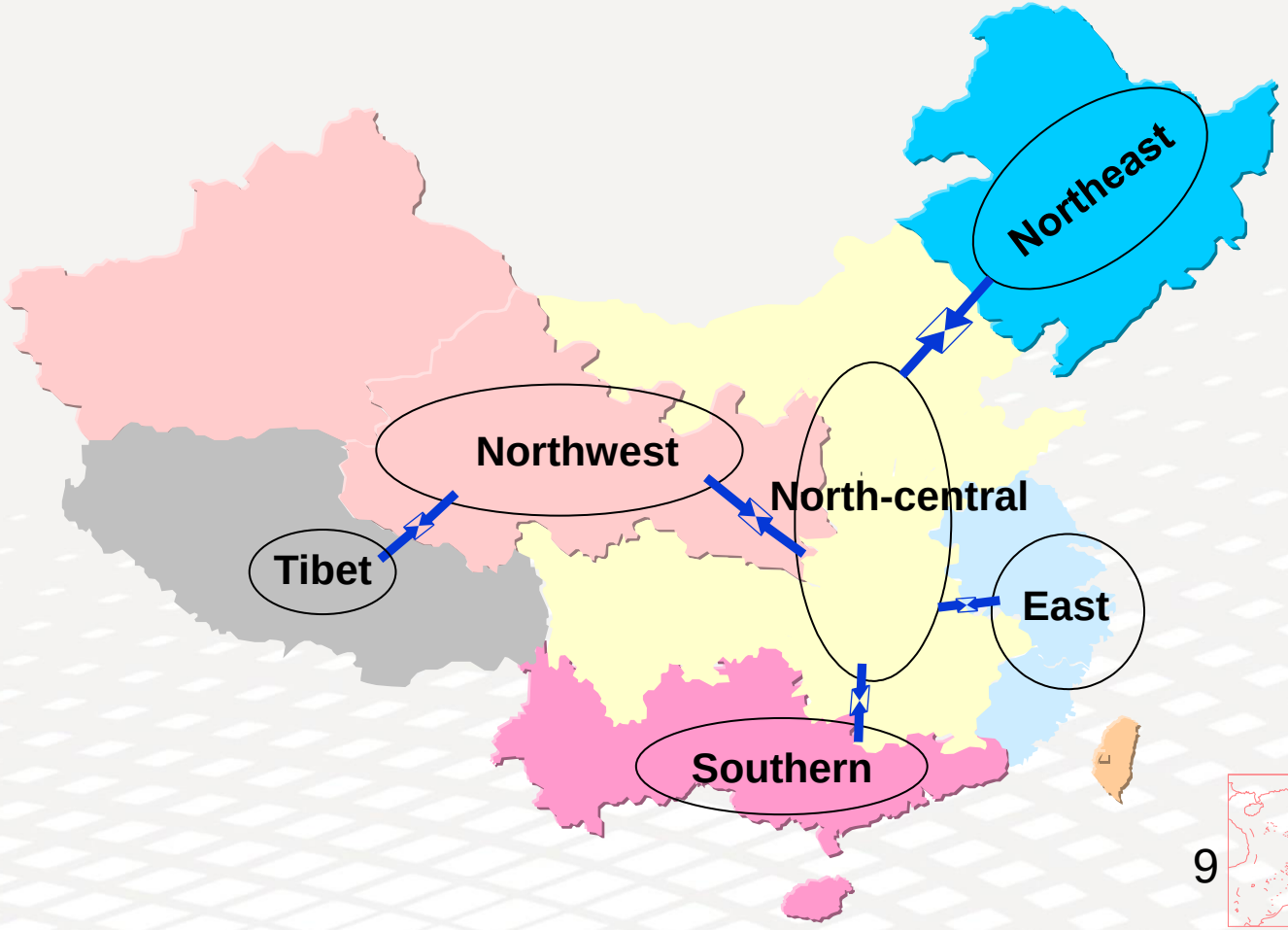
Reduce social electricity costs
—— 48.9 billion yuan

2.2.1 Key foundations for F&E response

— National-wide Interconnected power grid

① Interconnected large power grid constructs the base structure for rapid response.

China's power grid has experienced the development process of voltage levels from low to high, and the scale of interconnection from small to large. Up to now, six AC synchronous grids has been formed, including North-central, East, Northeast, Northwest, Southern China and Tibet. The Interconnected power grid can bring backup and mutual aid into full play in case of emergency.



2.2.2 Key foundations for F&E response

— Wide application of smart grid

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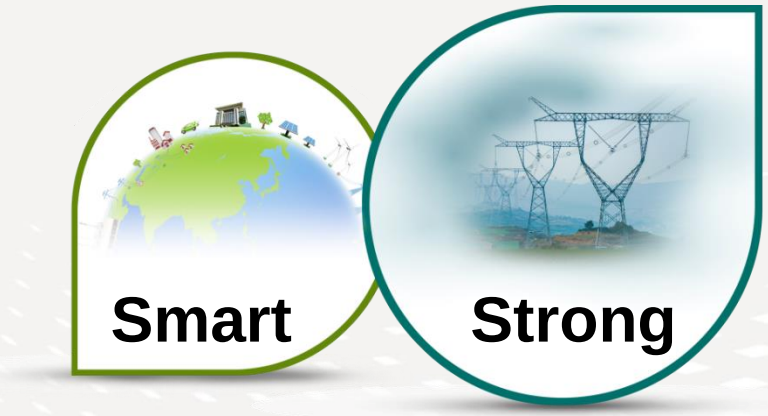
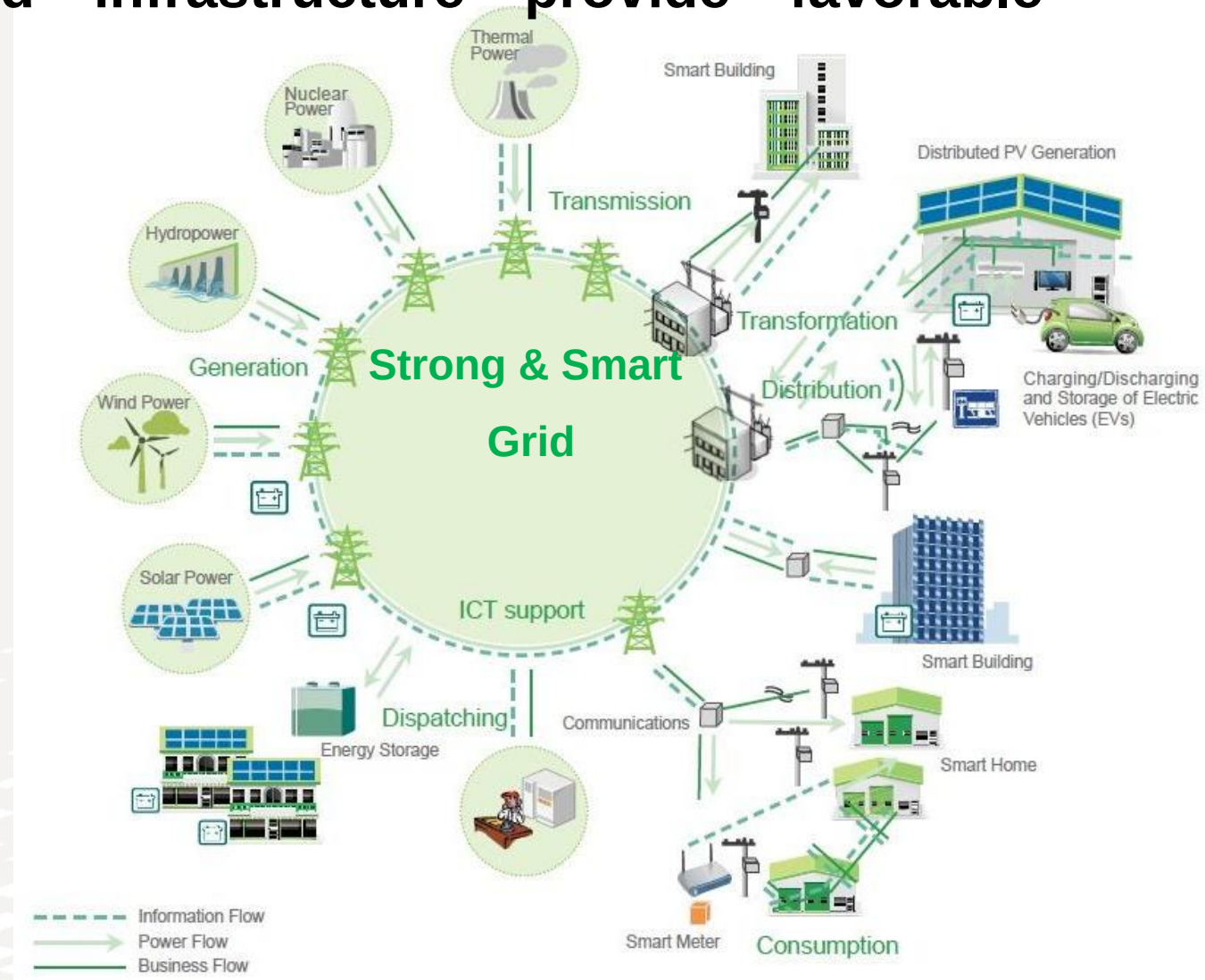
② Intelligent and efficient grid infrastructure provide favorable conditions for F&E response.

Strong & Smart Grid

- the UHV backbone grid
- ICT-based，automated and interactive



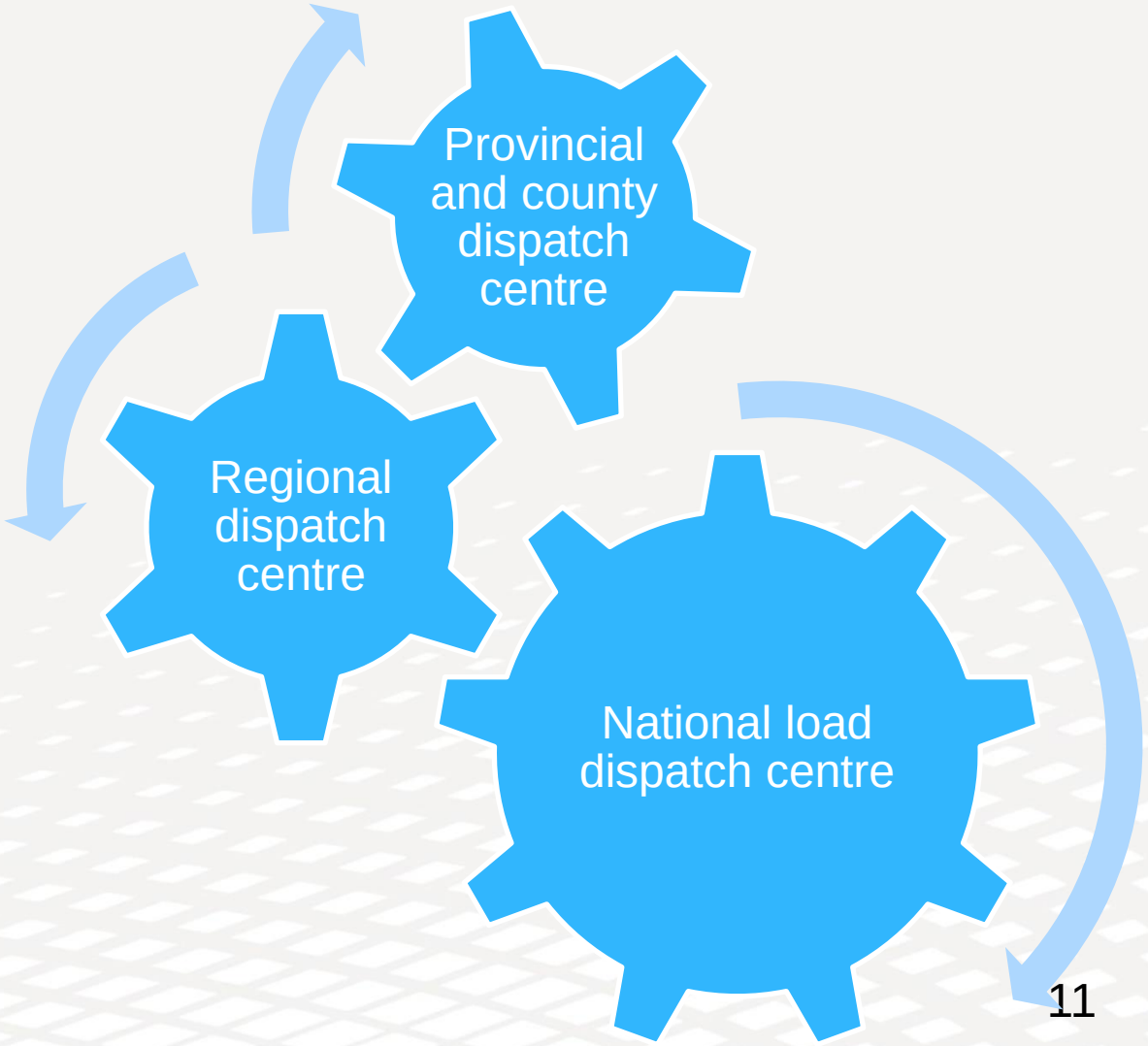


2.2.3 Key foundations for F&E response

— Unified and strong management

③ Unified dispatching and management make large power grid reach its full potential.

For a long time, China has implemented the integrated operation mechanism of power grid dispatch, which realized efficient dispatching and coordinated operation of power system and reduced the risk of serious power grid accidents. In normal times, the benefit of peak shave could be obtained. In case of accidental disasters, power grid of neighboring provinces and regions can be used for emergency support. The integrated operation mechanism of power grid dispatch is the key foundation for fast and efficient response in fighting against COVID-19.



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3.1.1 UHV Technical Advantages

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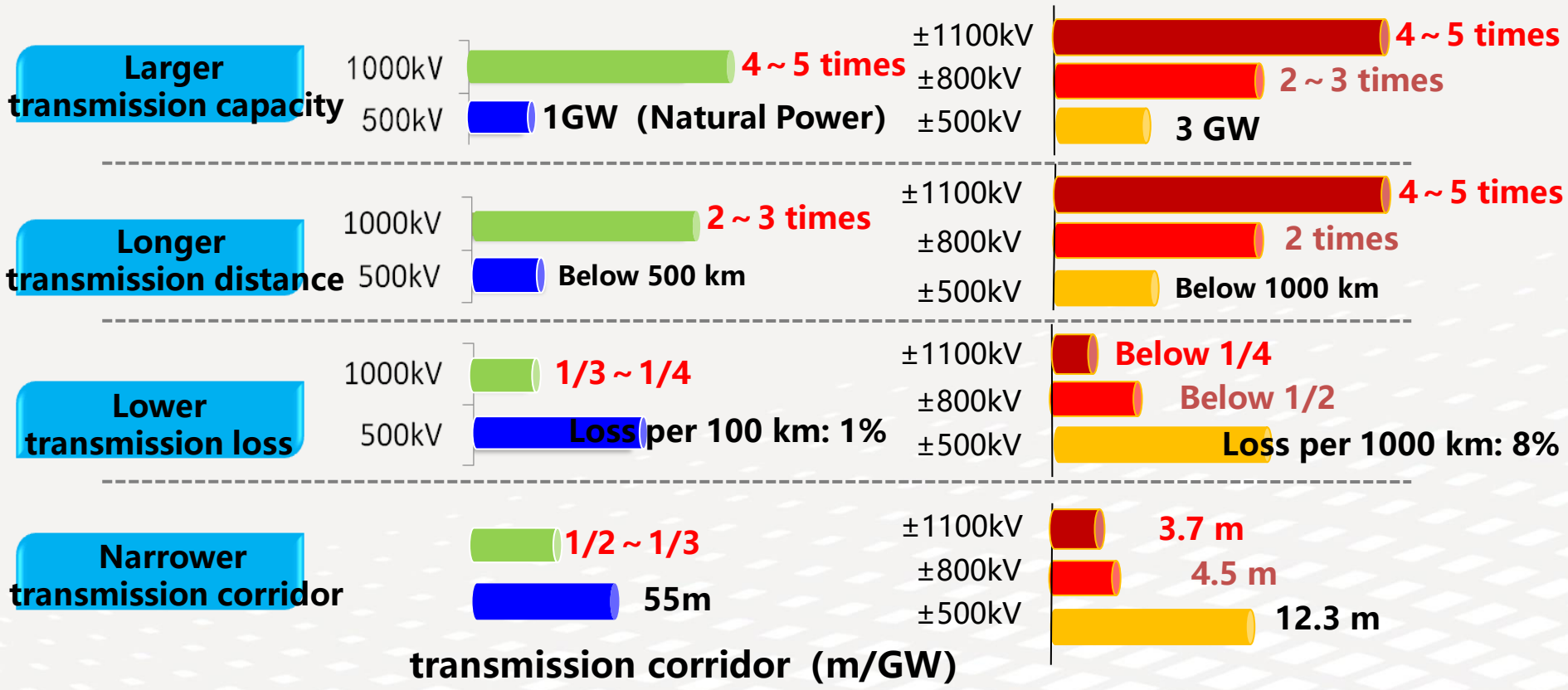
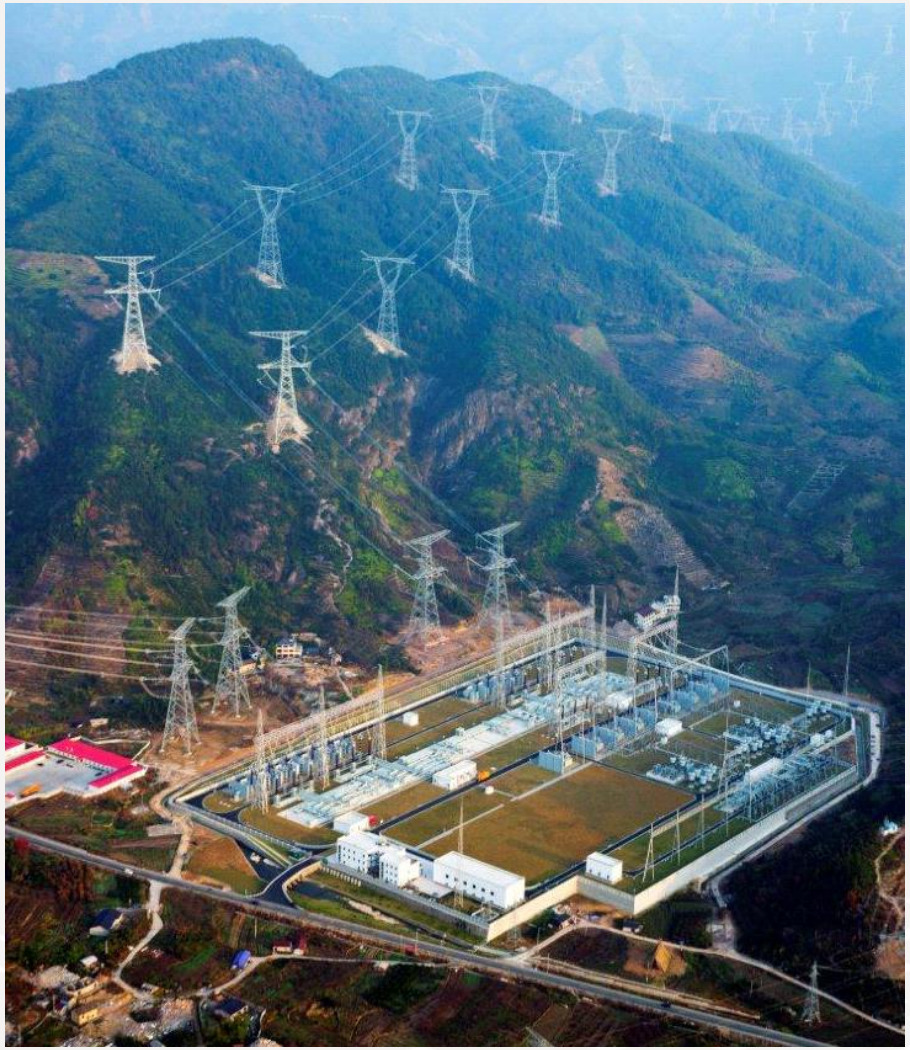
larger transmission capacity, longer transmission distance, lower transmission loss and narrower transmission corridor.



3.1.2 UHV Transmission Technologies



- **UHV AC Technology & Equipment**
  - UHV GIS
  - UHV series capacitor
  - UHV controllable shunt reactor
  - UHV grid power flow controller
  - UHV control and protection equipment
- **UHV DC Technology & Equipment**
  - Complete equipment of DC power transmission
  - UHV DC circuit breaker
  - UHV DC flexible converter valve
  - UHV DC cable
  - Control and protection equipment for hybrid UHV DC power transmission
- **T&E for New Types of Power Transmission**
  - Superconducting power transmission
  - Gas insulated power transmission

3.1.3 Research Direction

— (1) UHV AC Technology & Equipment

- **UHV GIS**
  - UHV GIS equipment with a long life span
  - UHV AC instrument transformers in extremely cold, extremely hot and other special environments
  - UHV lightning arresters with high discharge current capacity, low residual voltage and high voltage ratio
- **UHV series capacitor**
  - UHV series compensator for special environments such as extremely cold, extremely hot, and high altitude
  - High-power density capacitors, large-capacity solid state switches, and other primary devices
  - Scheme of compact series compensation platform
- **UHV controllable shunt reactor**
  - UHV-CSR with quick response and high compensation capacity
  - Special UHV-CSR for extreme environments
- **UHV grid power flow controller**
  - Main circuit topology of reliable, flexible and economical power flow control
  - Prototype of mixed-type PFC
- **UHV control and protection equipment**
  - UHV AC control protection equipment for transnational and intercontinental power grid interconnection
  - New relay protection device based on state of the art technologies

1000kV fixed series capacitor

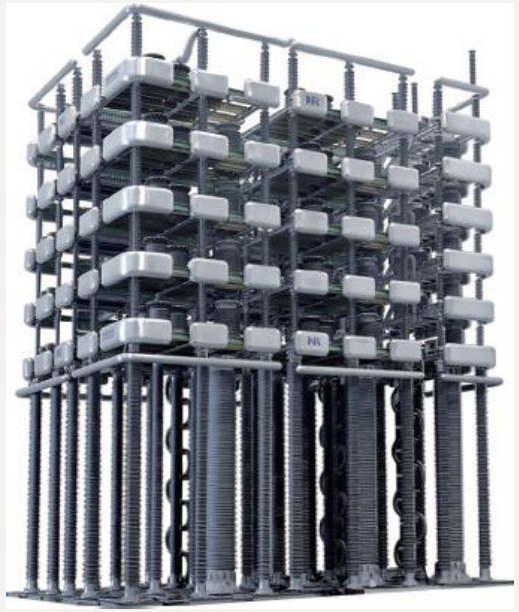
1000kV AC arrester

500kV controllable reactor

500kV UPFC

3.1.3 Research Direction
— (2) UHV DC Technology & Equipment

- **Complete equipment of DC power transmission**
  - Prototype of ±1500kV converter valve, converter transformer, and instrument transformer
  - ±1500kV gas insulated DC circuit breakers, and DC bushing
  - UHV equipment and DC bushings for extreme environments
- **DC circuit breaker**
  - Optimized design for the topology of UHV DC circuit breaks
  - High-Speed mechanical switch and DC circuit breaker integrated design technology
  - Prototype of ±800kV UHV DC circuit breaker for engineering applications
- **Converter valve for UHV flexible DC**
  - Optimized design of converter valve topology
  - ±800kV/10GVA UHV DC flexible converter valve
- **UHV DC cable**
  - ±800kV and above DC cable systems
- **Control and protection equipment for hybrid UHV DC power transmission**
  - DC power transmission control and protection technology, and rapid recovery technology
  - Converter station coordinating control technology, and ultra-high speed communication technology



±500kV/25kA HVDC breaker

±1100kV/650MVA converter transformer

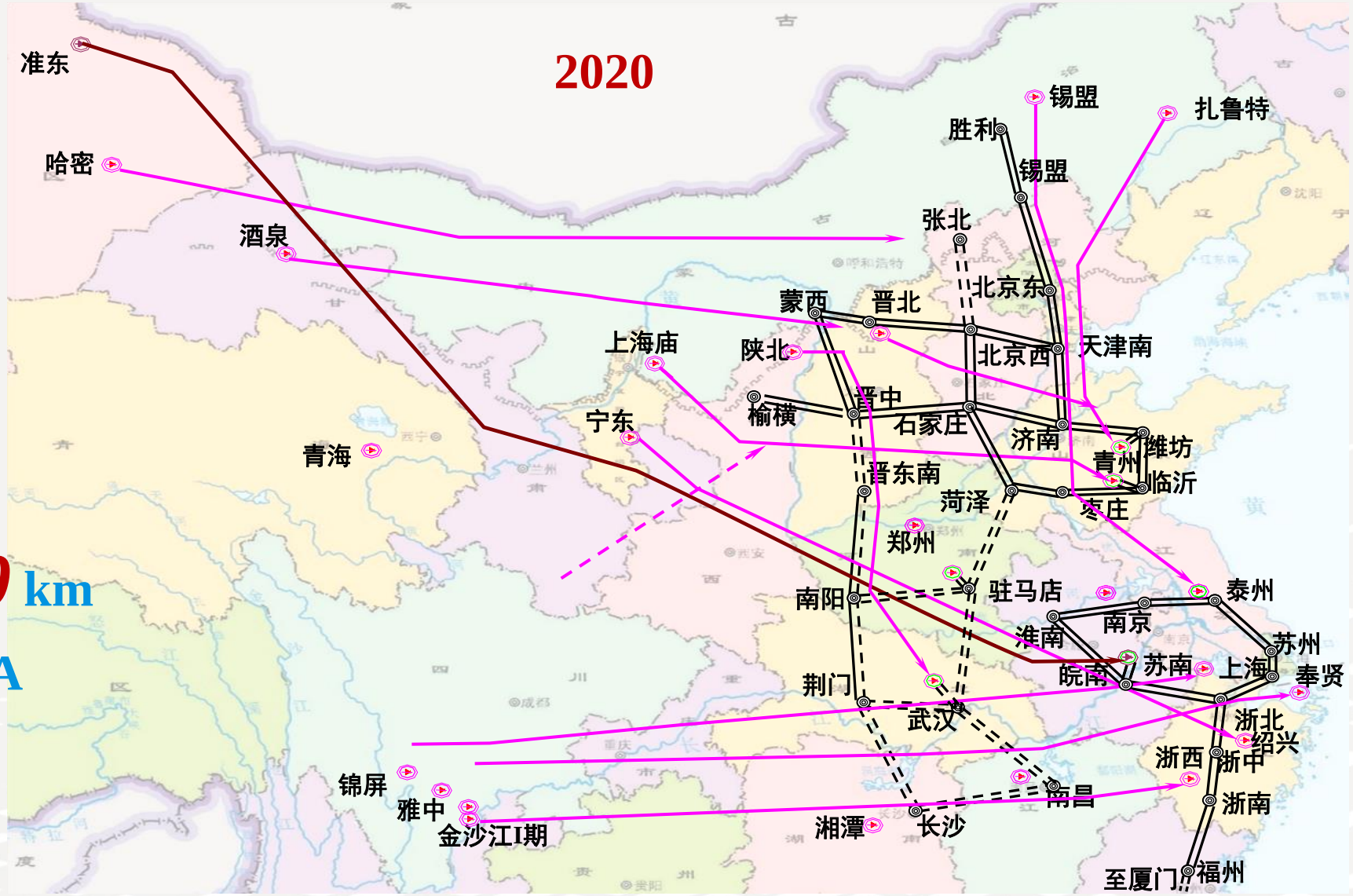
Cross-linked polyethylene DC submarine cable

Flexible DC converter valve tower

3.1.4 UHV Development in China

- ***14*** **in operation**
- ***5*** **under construction**
- ***5*** **planned**

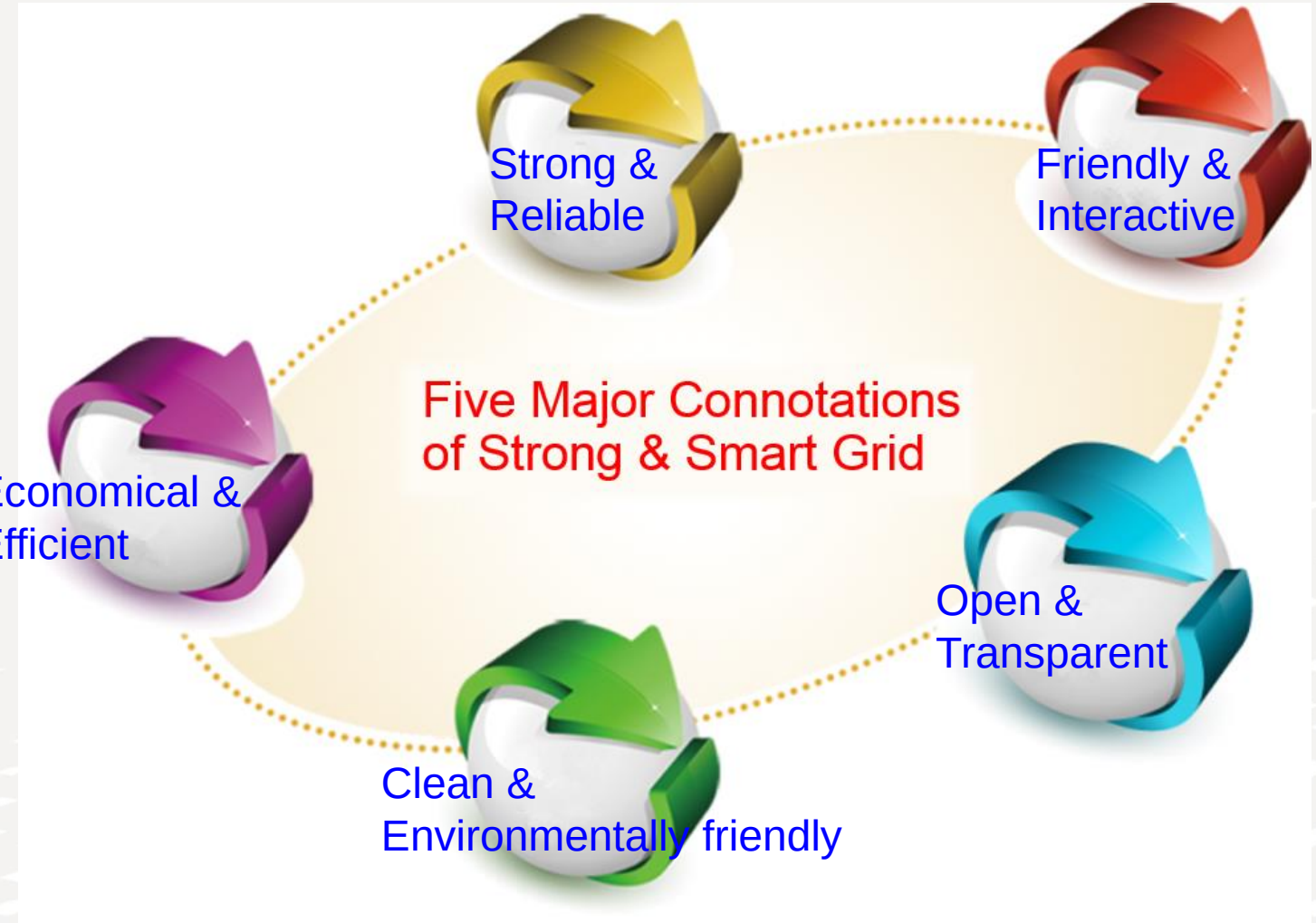
- **Total length >** ***20000*** **km**
- **Total power >** ***26*** **MVA**



3.2.1 Strong & Smart Grid — Connotation

Strong & Smart Grid

- based on the UHV backbone grid and coordinating the development of subordinate grids at all levels
- optimize energy resources allocation, improve clean energy integration, and hence facilitate meeting power demand growth



3.2.2 Smart Grid — Technologies

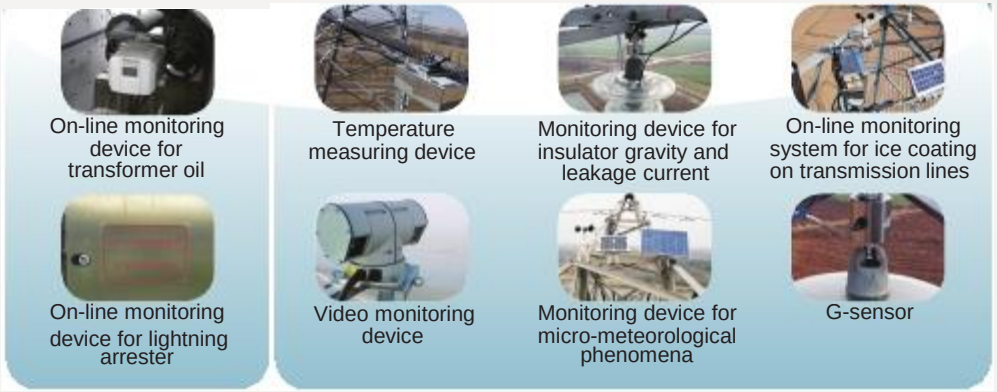
- **T&E for AC power Transmission and Transformation**
  - Flexible AC power transmission equipment
  - Smart HV equipment
  - Smart substation
  - Substation protection, measuring and control
  - Intelligent O&M
- **T&E for DC Grid**
  - DC grid fault current limiter
  - HV DC-DC converter
  - Super-speed fault locating and protection device
  - DC grid power flow controller
  - Intelligent DC network control
  - Wide-bandgap power electronic device

- **T&E for Power Distribution & Utilization**
  - Active distribution network
  - Intelligent power utilization
  - Charging and discharging of electric vehicle
  - Onshore power supply
- **T&E for Information Communication**
  - Communication infrastructure
  - Intelligent big data analysis
  - Distributed cloud data center
  - Mobile interconnection
  - AI cognition
  - Information security and credibility
  - Grid cyber-physical systems
  - Energy interconnection of smart city

3.2.3 Smart Grid—Key Equipment

Merging Unit

Smart dispatching system



Condition Monitoring Devices

Smart Meter

EV Battery Charging and Swapping Facility

UAV For Transmission Line Inspection

Inspection Robot

3.2.4 Research Direction
— T&E for Information Communication

- **Communication infrastructure**
  - Space-earth coordinated intercontinental backbone of communication network
  - Coordinated utilization of multiple technologies for communication network access
- **Intelligent big data analysis platform**
  - Storage and parallel computing of multi-source isomerous data
  - Multi-level coordinated analysis of wide-area distributed data
  - Forecast and early warning of GEI based on multi-source data
- **Distributed cloud data center**
  - Software/hardware framework and realization of high-performance cloud computing platform
  - Automatic O&M of data center
  - Centralized O&M system of distributed cloud data centers
- **AI cognition**
  - Deep learning engine for power cables
  - Multi-modal information processing platforms and terminals
- **Information security and credibility**
  - R&D on security and credibility mechanism and hardware/software
  - Quantum cryptographic communication technologies and devices

Early warning platform for risk monitoring of power grid and information security

Management and control platform of operation inspection of power grid

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Epilogue

Power interconnection improves the power system resource allocation and ability to respond to emergencies. The Global Energy Interconnection is a systemic solution for global energy green transformation, climate change, environment and health issues.

Addressing climate change is an eternal challenge for human beings, the trend of energy transformation will not be affected by this epidemic. Now COVID-19 has become a disaster for mankind. No matter fighting against pandemic or climate change, all the countries need to work together to build a clean, low-carbon and sustainable society.