

China AMI Regulation and Standardization

Prof. Liu Jianming

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Lecturer Introduction — Liu JianMing



Prof. Liu Jianming

- **Academic Leader** of Chinese Electrical Communication . The Director of "Committee of Smart Grid Technology " of Chinese National "Thirteen-Five" Science and Technology Policy (2016-2020) . Expert of "Smart Grid Project " of "Chinese National High-tech R&D Program " . The inventor of the world 's first optical fiber composite low-voltage cable (OPLC) . Released the world 's first white paper on power big data .
- **Doctoral Supervisor , Professor** : Adjunct professor of North China Electric Power University, Wuhan University and Chongqing University of Posts and Telecommunications. Responsible for the formation of five national key laboratories.
- **International Council on Large Electric Systems(CIGRE) fellow** .CIGRE D2 China Committee Secretary-General, D2-5G working group leader.
- **Deputy Director** of Power Information Committee of CSEE (Chinese Society For Electrical Engineering) . Served as **deputy director** of Science and Technology Information Department of State Grid and **General Manager** of State Grid Information & Telecommunication Co., Ltd. National outstanding science and technology workers .

- I China Energy Sector Overview
- II AMI Technical Regulation
- III Communication technologies

1.1 Power Grid Companies of China



- 供电人口超过11亿
Supporting 1.1 billion population
- 2016年营业收入 20713亿元(RMB)
300B USD in 2016
- 世界财富500强第二位
Ranked No. 2 of Fortune 500 in 2016



- 供电人口超过2.3亿
Supporting 0.23 billion population
- 2016年营业收入 711亿元(RMB)
75B USD in 2016
- 世界财富500强第95位
Ranked No. 95 of Fortune 500 in 2016

SGCC : State Grid Corporation of China



- **Ranked No. 2 of Fortune 500 in 2017,** in comparison with No. 40 in 2005;
- **Largest public utility company globally;**

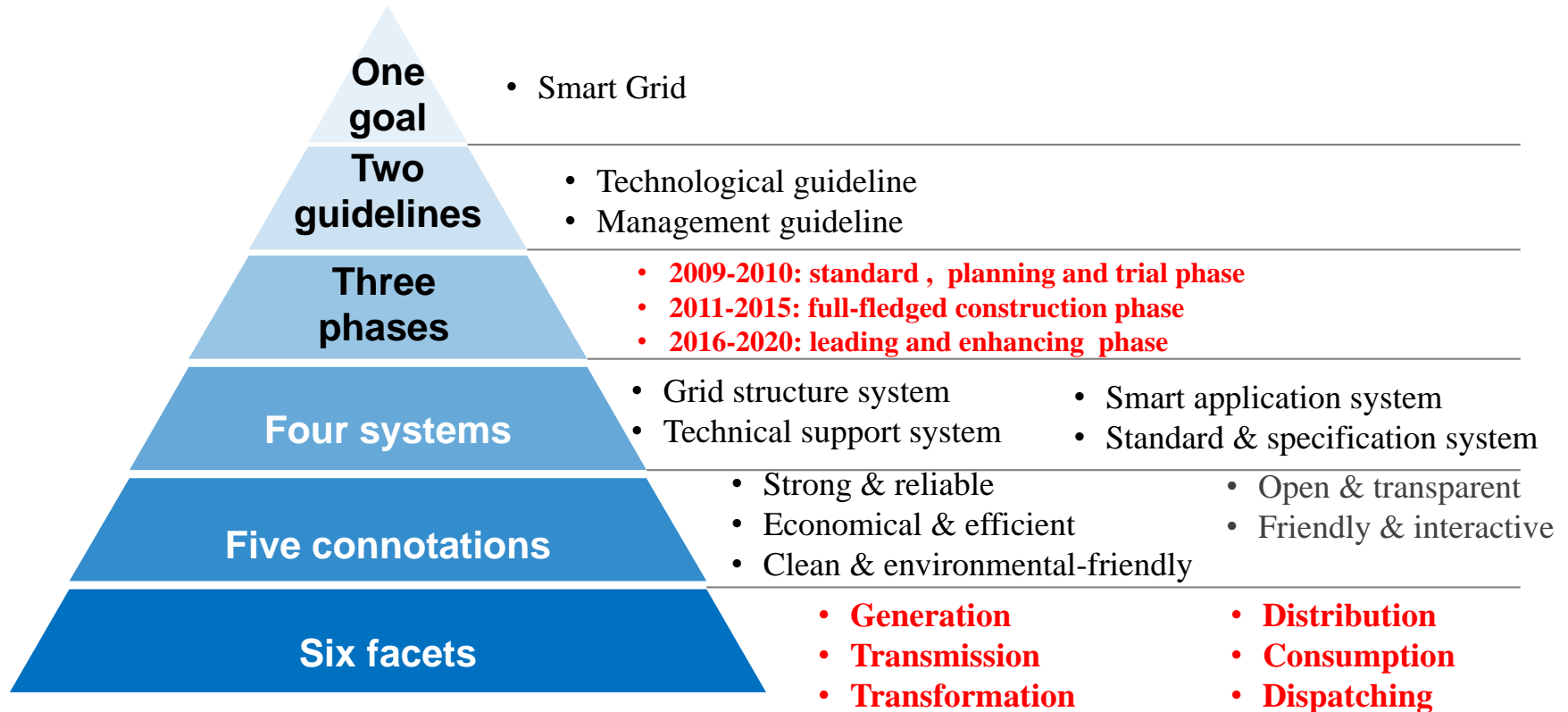
经营范围 Business Scope

- 经营区域覆盖27个省（自治区、直辖市），涵盖国土面积88%
27 Provinces, 88% of National Geographical Areas
- 供电人口超过11亿
Supporting 1.1 billion population
- 2016年营业收入 20946亿元（RMB）
300B USD in 2016

供电负荷 Electricity Load

- 2016年，经营区域最高用电负荷6.75亿千瓦，超过欧盟区域国家最高用电负荷总和。
- Maximum consumption load reaches 675 GW in 2016, **exceeding total load of European countries.**
- 2016年，完成售电量36051亿千瓦时
Electricity Sales 3605.1 B kWh

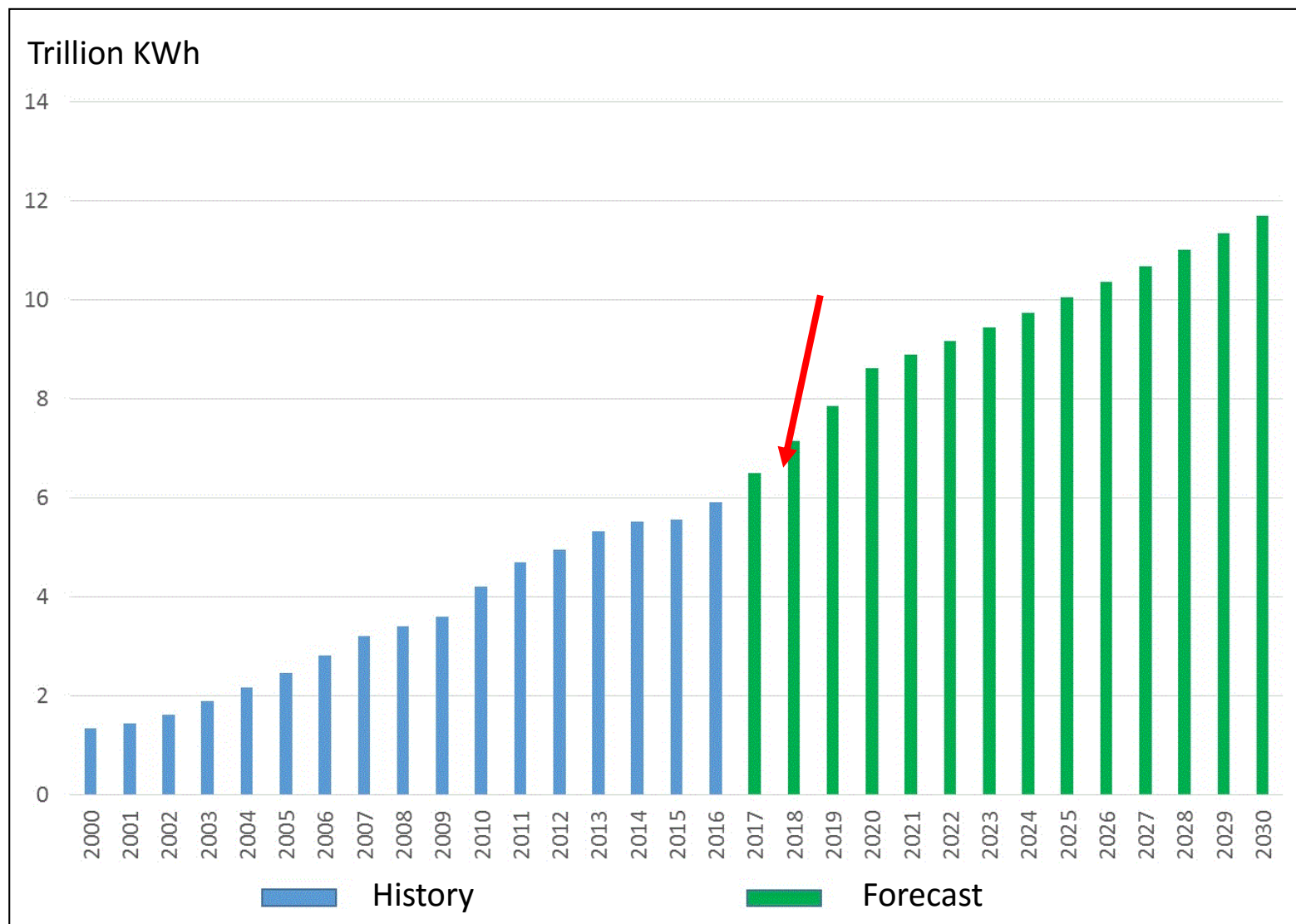
Smart Grid Develop Architecture



SGCC: Construction of Intelligent Power Grid and Quality of Power Supply

	2006-2010	2011-2015	2016-2020
Operating Income 年·营业收入	224 B USD/year Top 500 (8)	299 B USD/year Top 500 (2)	In 2016 300 B USD Top 500 (2)
labor productivity	60K USD/ Person·Year	95K USD/ Person·Year	120K USD/ Person·Year
AT&C LOSS	>8%	6.78%	6.3%
power outage time in city	8.234h/home/year	3.74h/home/year	1.78h/home/year
power outage time in rural	32.32h/home/year	12.74h/home/year	4.44h/home/year
total investment in 5 years 5年总投资	179 B USD	269 B USD	299 B USD
Investment in ICT 投资	11.1 B USD , 6.2%	42.7 B USD , 15.9%	53.7 B USD, 18%

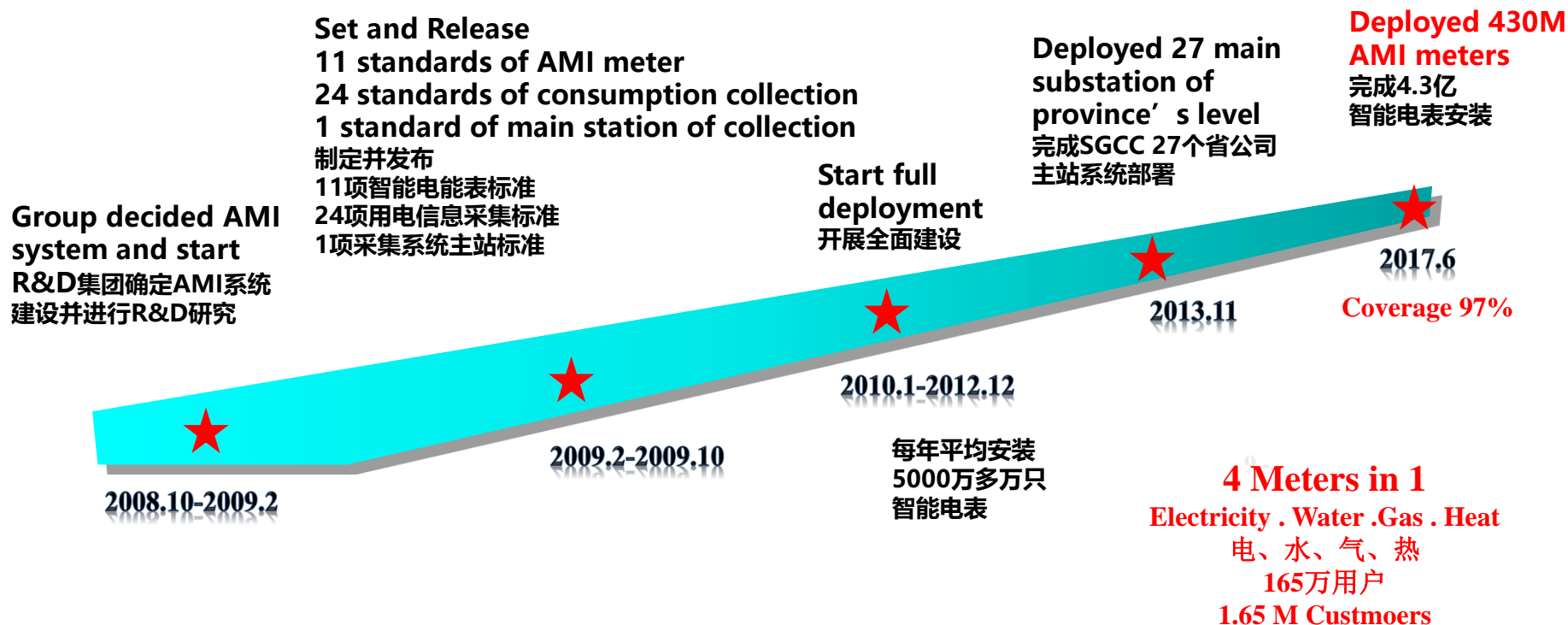
2000-2030 , The statistics and forecast of electricity consumption in China



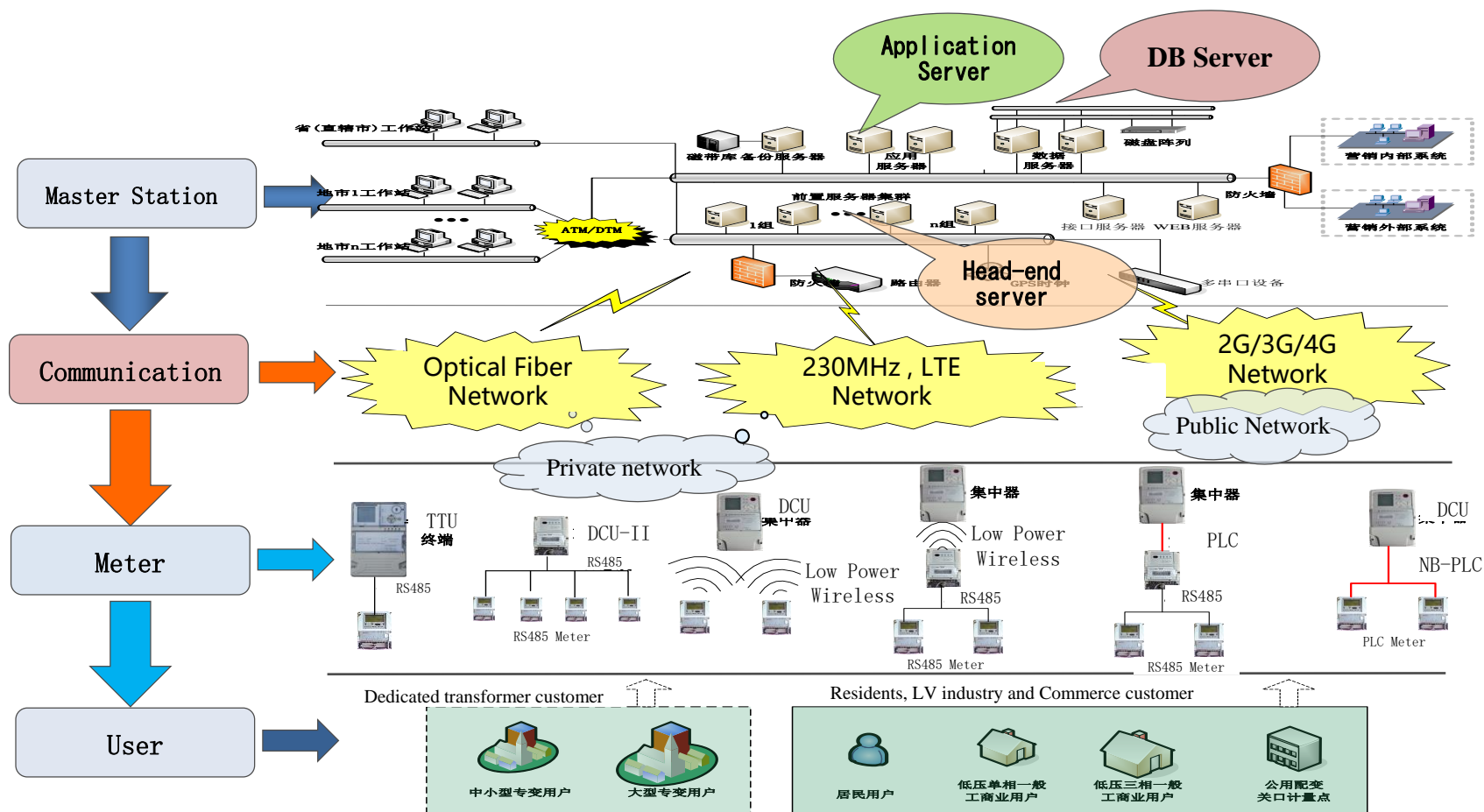
1.3 SGCC AMI System Construction Process and Experience

27 Main stations are deployed in centralized mode in province level with unified main station standard, telecom protocol, O&M

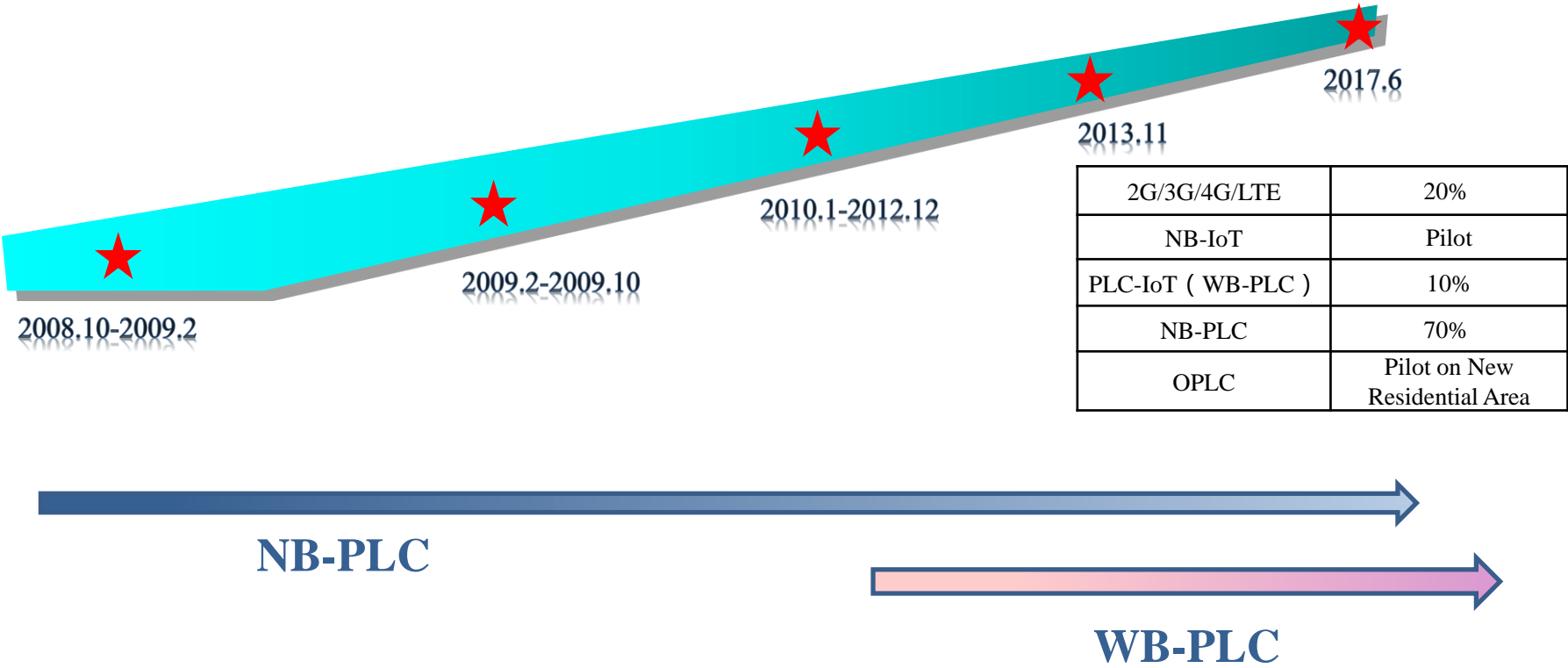
主站系统以省公司为单位统一建设，主站系统27套，采用集中式部署，对主站标准、通信协议、运维方式进行了统一。



AMI System Physical Architecture



SGCC AMI System Construction Process and Experience



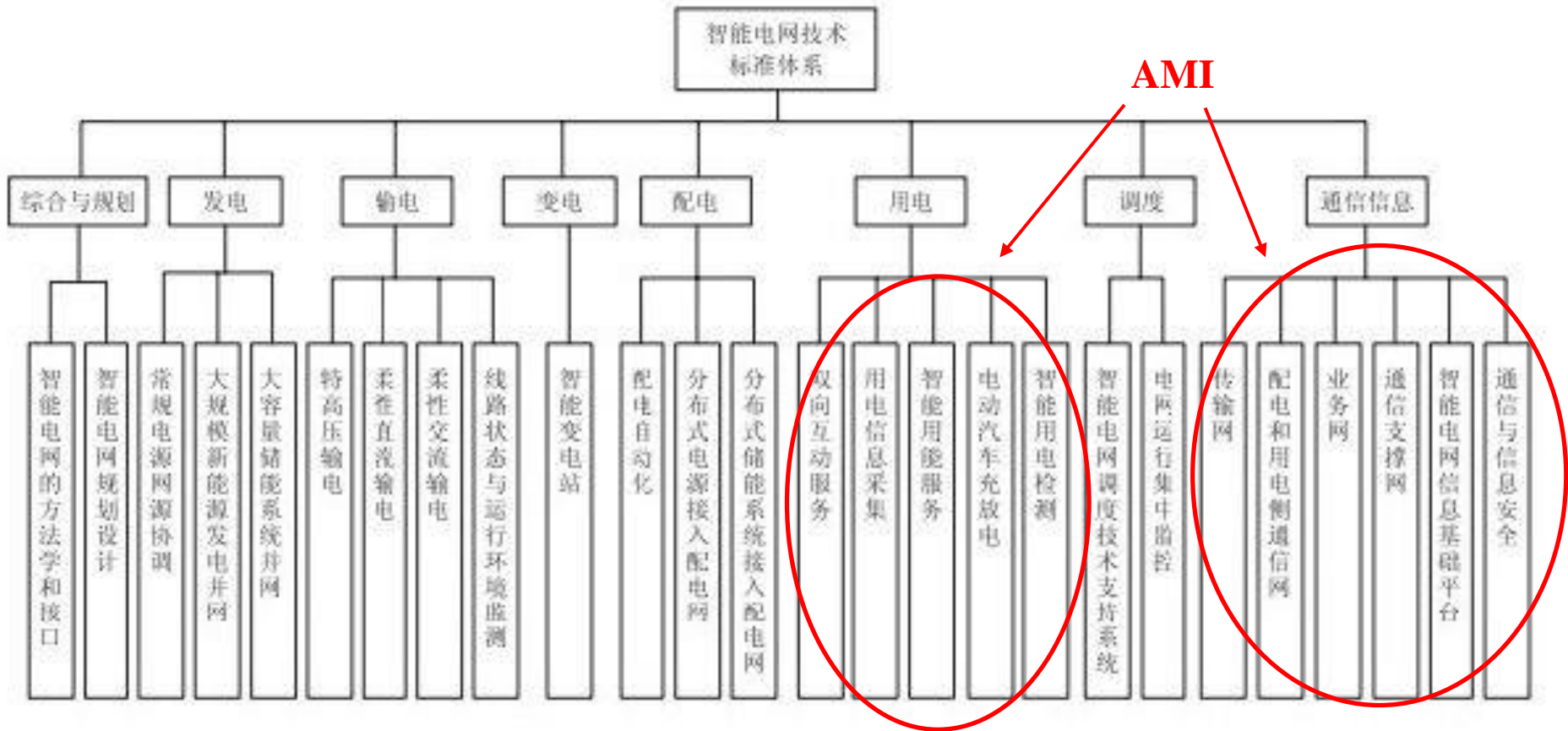
I China Energy Sector Overview

II AMI Technical Regulation

III Communication technologies

The research of key equipment and the technology standard family of Smart Grid

June, 2010, SGCC published “**The technology standard family plan of Smart Grid**”
Including 8 professional branches, 26 technology categories and 92 standard series.



IEC PC 118 Smart grid user interface

China Smart Grid standard system of public announcement, public offering.

September 2011, approved by the IEC Standards Authority, was formally established. State Grid Corporation of China undertakes the work of the IEC PC118 secretariat. Currently there are 15 P-member states (participating members) and 9 O-member states (observers).

IEC PC118 major participating countries: China, Germany, France, Britain, Japan, South Korea, Russia, the United States, Spain and so on.

中国智能电网标准标准体系对外公布，公开发行人。

2011年9月，经IEC标准管理局批准，正式成立。

由国家电网公司承担IEC PC118秘书处工作。

目前有P-成员国（参加成员）15个，O-成员国（观察成员）9个。

IEC PC118 主要参与国家：中国、德国、法国、英国、日本、韩国、俄罗斯、美国、西班牙等。

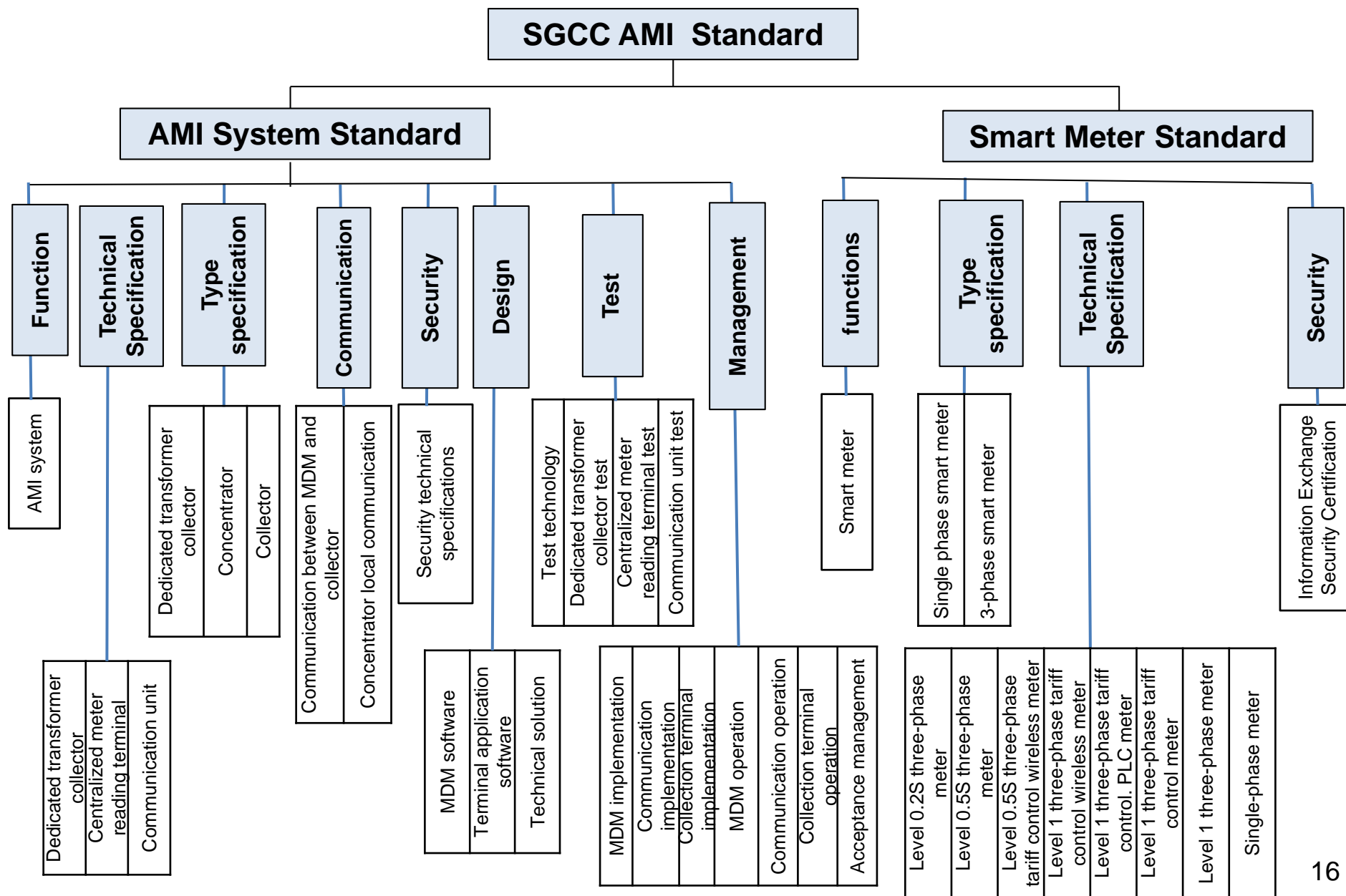
IEC PC 118 Smart grid user interface



2012.5.23-24 ,
IEC PC 118 2nd Working
Group Meeting, Held in Santa
Clara, California

IEC PC 118 latest progress :
2017.11.14-16 , IEC PC 118 sixth plenary session and the thirteenth Working
Group meeting held in Seoul, South Korea. Mr. Richard Schomberg,
Chairman of IEC PC 118, Secretary-General of IEC PC 118,
More than 20 experts from China, the United States, Britain, Australia, Japan
and South Korea attended the meeting.

2.1 AMI Standard System



2.2 AMI System technical standards

1. Functional specifications (1)	Electricity Information Collection System Functional Specification
2. Specifications (3)	Electricity Information Acquisition System Specialized collection terminal technical specifications
	Electricity information collection system centralized meter reading terminal technical specifications
	Technical Specification for Communication Unit of Power Information Collection System
3. Type specification (3)	Electricity Information Acquisition System Specialized Collection Terminal Type Specification
	Information collection system concentrator type specification
	Electricity Information Collection System Collector Type Specification
4. Letter of agreement (2)	Electricity Information Acquisition System Master Station and Acquisition Terminal Communication Protocol
	Electricity Information Collection System Concentrator Local Communication Module Interface Protocol
5. Safety regulations (1)	Power Information Collection System Security Protection Technical Specifications

2.2 AMI System technical standards

6. Design Guidelines (3)	Master Station Software Design Guideline
	Terminal application software design guidelines
	Technical Program Design Guidelines
7. Test specification (4)	Inspection technical specifications
	Special collection terminal testing technical specifications
	Centralized meter reading terminal inspection technical specifications
	Communication unit inspection technical specifications
8. Management practices (7)	Master station construction specifications
	Communication channel construction management practices
	Collection terminal building management practices
	Master operation and management practices
	Communication Channel Operation Management Specification
	Acquisition terminal operation and management practices
	System Acceptance Management Specification

2.3 Smart meter technical standards

9.Functional specifications (1)	Smart meter functional specifications
10.Type specification (2)	Single-phase intelligent energy meter style specification
	Three-phase intelligent energy meter style specification
11.Specifications (8)	0.2S Three-phase smart meter technical specifications
	0.5S three-phase smart meter technical specifications
	0.5S Three-phase charge smart meter (wireless) technical specifications
	Level 1 three-phase charge smart meter (wireless) technical specifications
	1 level three-phase charge smart meter (carrier) technical specifications
	Level 1 three-phase charge smart meter technical specifications
	1 level three-phase smart meter technical specifications
	Single phase smart meter technical specifications
12.Safety certificate (1)	Intelligent energy meter information exchange security certification technical specifications

2.4 AMI regulation — system functions

(1) Data collection

- As different types of information collection, program automatic tasks, and manage the execution of the tasks, and check the result.
- Data collected are: electrical energy data, pay mining data, working conditions data, power quality statistics, event record data.
- The ways of data collection are: automatic collection, data recall, event report etc.

(1) 数据采集

- 根据不同业务对采集数据的要求，编制自动采集任务，并管理各种采集任务的执行，检查任务执行情况。
- 采集的主要数据项有电能量数据、交采数据、工况数据、电能质量统计数据、事件记录数据等。
- 采集方式有定时自动采集、随机召测、主动上报等方式。

2.4 AMI regulation — system functions

(2) Data management

- Check and analyze the integrity and correction of the data. Not correct the abnormal data, to guarantee the uniqueness and Authenticity of the original data.
- Calculate, statistics and analyze the original data by region, industry, line and time.

(2) 数据管理

- 对采集数据完整性、正确性进行检查和分析，对于异常数据不予自动修复，并限制其发布，保证原始数据的唯一性和真实性。
- 按区域、行业、线路、时间等对采集的原始数据进行计算、统计和分析。

2.4 AMI regulation — system functions

(3) Control

- Power control
- Electricity consumption control
- Tariff control
- Remote control
- Power protection control
- Removing control

(3) 控制

- 功率定值控制：时段控、厂休控、营业报停控、当前功率下浮控
- 电量定值控制：按月电量数据实施电量控制
- 费率定值控制：按电量费率、用电量、用电费实施费控
- 遥控：执行远方遥控
- 保电：实施保电措施
- 剔除：剔除操作

2.4 AMI regulation — system functions

(4) Applications

- Automatic meter reading management
- Tariff control
- Power consumption control: power limit and power ensuring
- Power consumption statistics:
- Abnormal power consumption analysis
- Power quality statistics and analysis
- Line loss analysis
- Value-add service

(4) 综合应用

自动抄表管理

费控管理：三个环节

有序用电管理：限电和保电

用电情况统计分析：负荷分析、电量分析、三相不平衡分析

异常用电分析：计量及用电异常监测、重点用户监测

电能质量数据统计：电压、功率因数、谐波数据统计

线损、变损分析：对线路线损和变压器损坏分析提供数据

增值服务：

多种渠道查询和发布信息、与售电系统联网实施网上售电、为实现双向互动提供技术手段

2.5 AMI regulation — system performance

(1) Reliability 可靠性

MTBF $\geq 2 \times 10^4$ h, system recoverable

(2) Availability 可用性

MDM: $\geq 99.9\%$, terminals: $\geq 99.5\%$

主站的年可用率应不小于99.9%, 终端的年可用率应不小于99.5%

(3) Response time 响应时间

Remote control: < 5 s 遥控操作响应时间

Important information inspection: < 15 min 重要信息巡检时间

Regular information recall and set: < 15 s 常规数据召测和设置响应时间

History information recall: < 30 s 历史数据召测响应时间

User event response: < 30 min 用户事件响应时间

Regular information (database) query: < 5 s 常规数据(数据库)查询响应

Fuzzy (database) query: < 15 s 模糊(数据库)查询响应时间

2.5 AMI regulation — system performance

(4) Data collection success ratio 采集成功率

User level 等级	One time collection success ratio 一次采集成功率	Periodic collection success ratio 周期采集成功率
C1	≥99%	100%
C2	≥97%	≥99.5%
C3	≥95%	≥99%
C4	≥90%	≥98%

2.6 AMI Deployment experience

Experience 经验

- ① Unified planning, step by step (all provincial companies to establish sub-annual construction program)
- ② Pilot first, focused important points
- ③ Inheritance and development combined
- ④ Practicality and forward-looking combination
- ⑤ The combination of advanced and reliable

- ① 统一规划、分步实施（各网省公司制定分年度建设方案）
- ② 试点先行、重点突出
- ③ 继承与发展相结合
- ④ 实用性与前瞻性相结合
- ⑤ 先进性与可靠性相结合

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3.1 AMI System communication

The communication channel adopts optical private network, 2G / 3G / 4G wireless public network, TD-LTE 230MHz wireless private network and power line carrier. Urban and town preferred fiber private network communications. The system considers the scale of construction, technology forward-looking, real-time, safety, reliability and other factors, to determine the specific mode of communication, or integration of communication.

通信信道采用光纤专网、2G/3G/4G无线公网、TD-LTE 230MHz无线专网和电力线载波等。市区和城镇优先选用光纤专网通信。系统综合考虑建设规模、技术前瞻性、实时性、安全性、可靠性等因素，确定具体通信方式，或者融合通信方式。

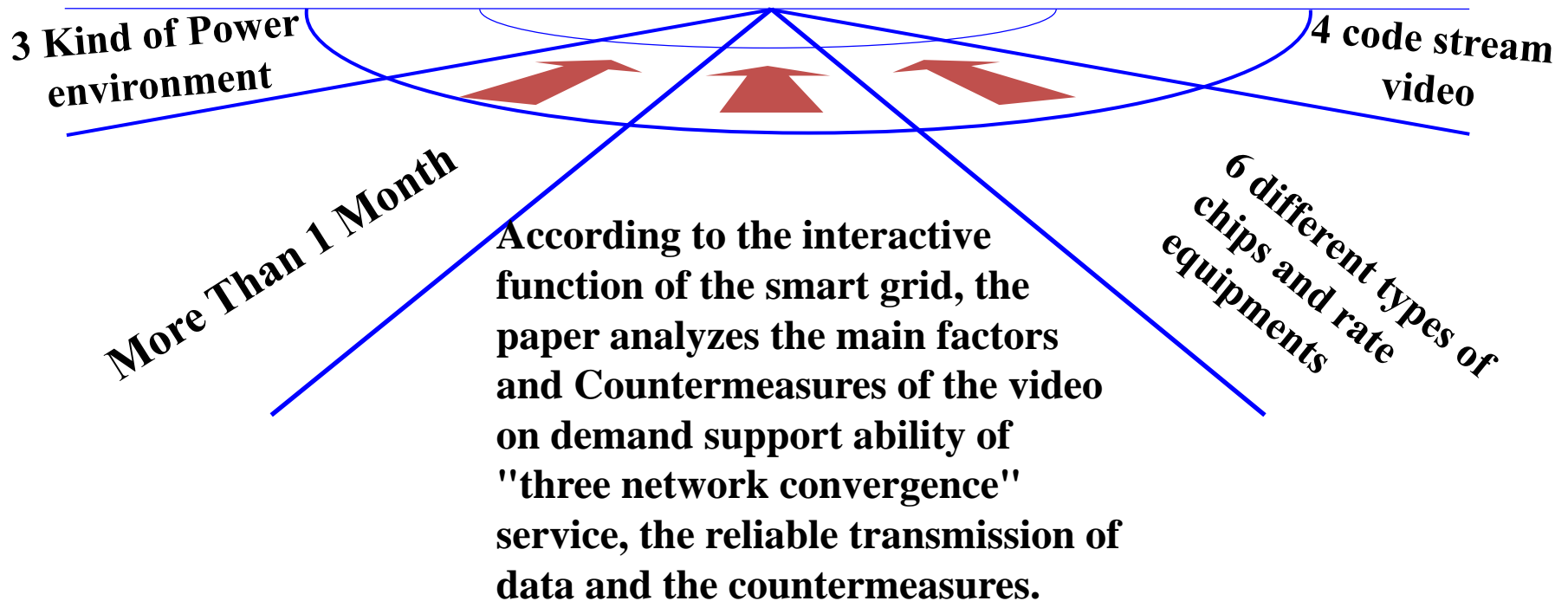
3.1 AMI System communication

Communication Technology	Optical fiber	LTE private	2G/3G/4G	NB-PLC	WB-PLC
Construction costs	One-time investment / high construction costs	Lower cost	Very high cost	No wiring required	No wiring required
Reliability	High reliability	High reliability	Poor reliability	High reliability	High reliability
Operation and maintenance costs	Low maintenance costs	Lower maintenance costs	Traffic accounting	Small amount of maintenance	Small amount of maintenance
Transmission rate	10-20Mbps	1-10Mbps	<1Mbps	< 2.4Kbps	> 512kbps
Access mechanism	Full duplex / bidirectional at the same time	Full duplex / bidirectional at the same time	Full duplex / bidirectional at the same time	Half duplex / polling	Full duplex / bidirectional at the same time
capacity	Unrestricted	Limited	Limited	Limited	Limited
Security	High security	High security	Poor security	High security	High security
Influencing factors	Not affected	Type / weather / electromagnetic interference	Terrain / weather / electromagnetic interference / not controllable	electromagnetic interference	electromagnetic interference

3.2 WB-PLC (PLC-IoT)

WB-PLC Performance Testing

Using power line broadband communication equipment network, multiple users to access the server at the same time, the transfer of documents to meet the needs of home users data transmission.



WB-PLC Performance Testing

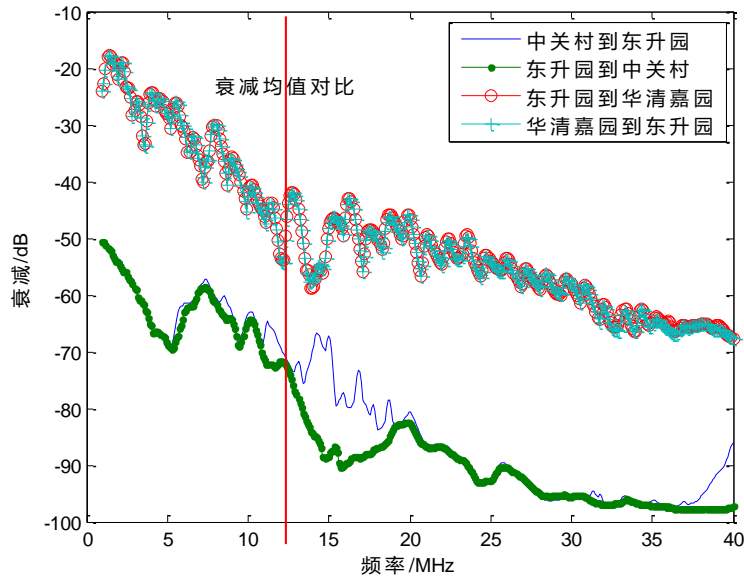
Accumulated a large number of first-hand data for the research of project based algorithm



WB-PLC Performance Testing

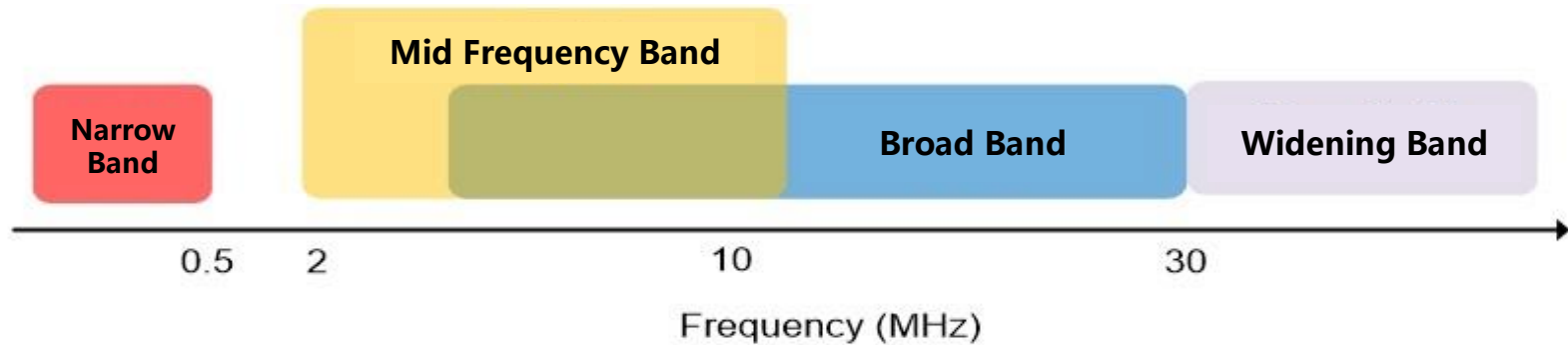
Complete site channel recording (Beijing, Shenyang, Wuhan, etc.)

Complete channel modelling

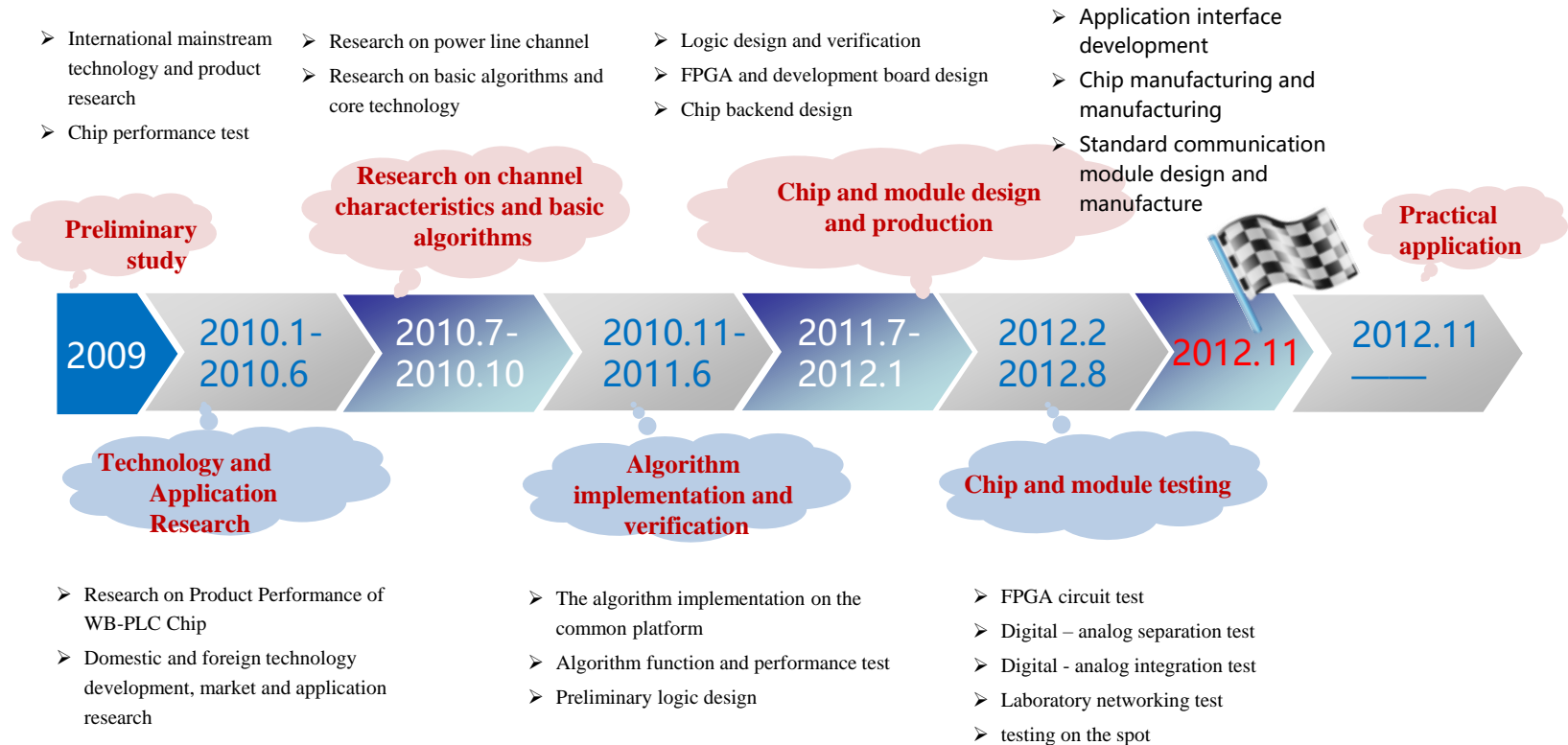


Chip physical layer design + bandwidth

Bandwidth range: **2MHz-12MHz**

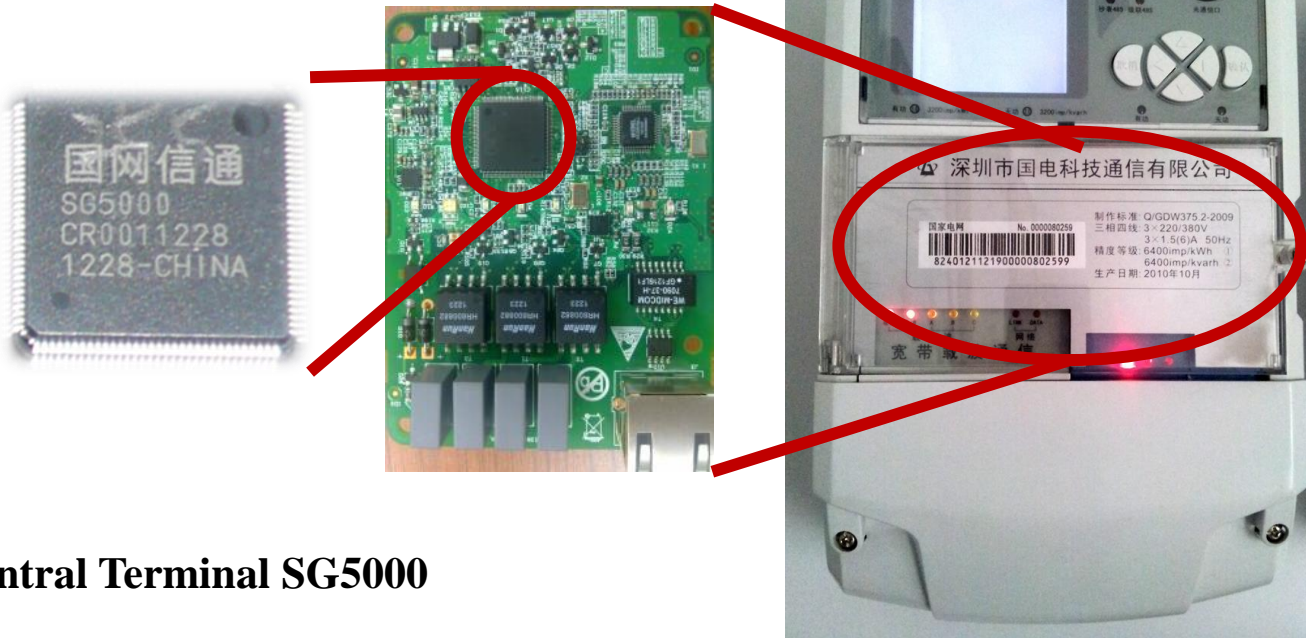


WB-PLC Milestone



WB-PLC module (central terminal)

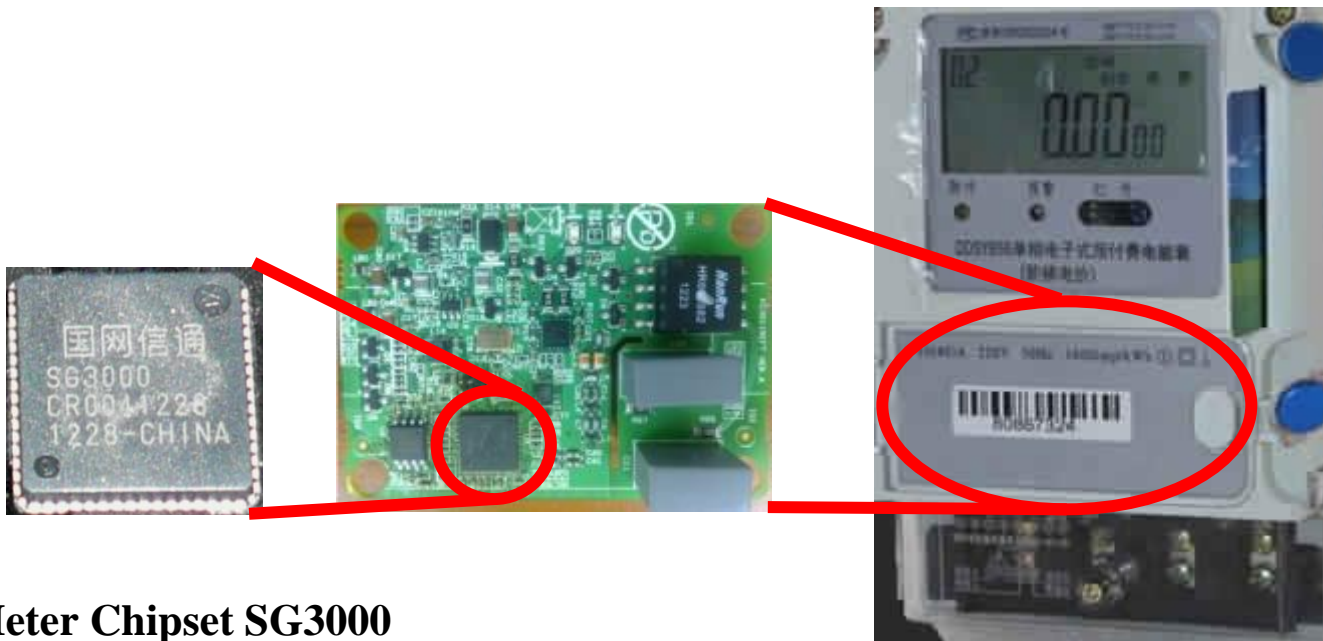
Central Terminal(DCU)Module



Central Terminal SG5000

WB-PLC module (meter terminal)

Terminal Communication Module(Collector, PLC Meter)



Meter Chipset SG3000

Evaluation, Simulation and Testing



Power line communication network test environment

Power Industry Standard

- Technical Requirements of Low Voltage WB-PLC Access System (Released DL / T 395)
- Technical Requirements of Smart Power WB-PLC (to be released)



IEEE 1901.1 Meeting in Mannheim , Germany , 2017



Germany



America



Spain



Poland



China



India

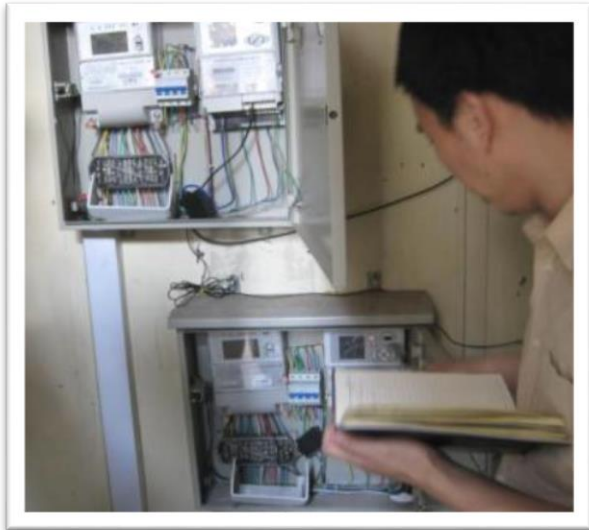
...

Multiple Meters To One

June 2011

Power Information Collection
(Shenyang)

Technical application assessment



July 2012

carry out the chip site (Shenyang, Wuhan, Beijing)
installation

- SGCC's Information a Telecommunication Group Co ,.Ltd in **March 2012 jointly hosted the 16th IEEE ISPLC** International Conference in Beijing,
- Three keynote speeches, papers, and extensive exchanges with international academia and industry

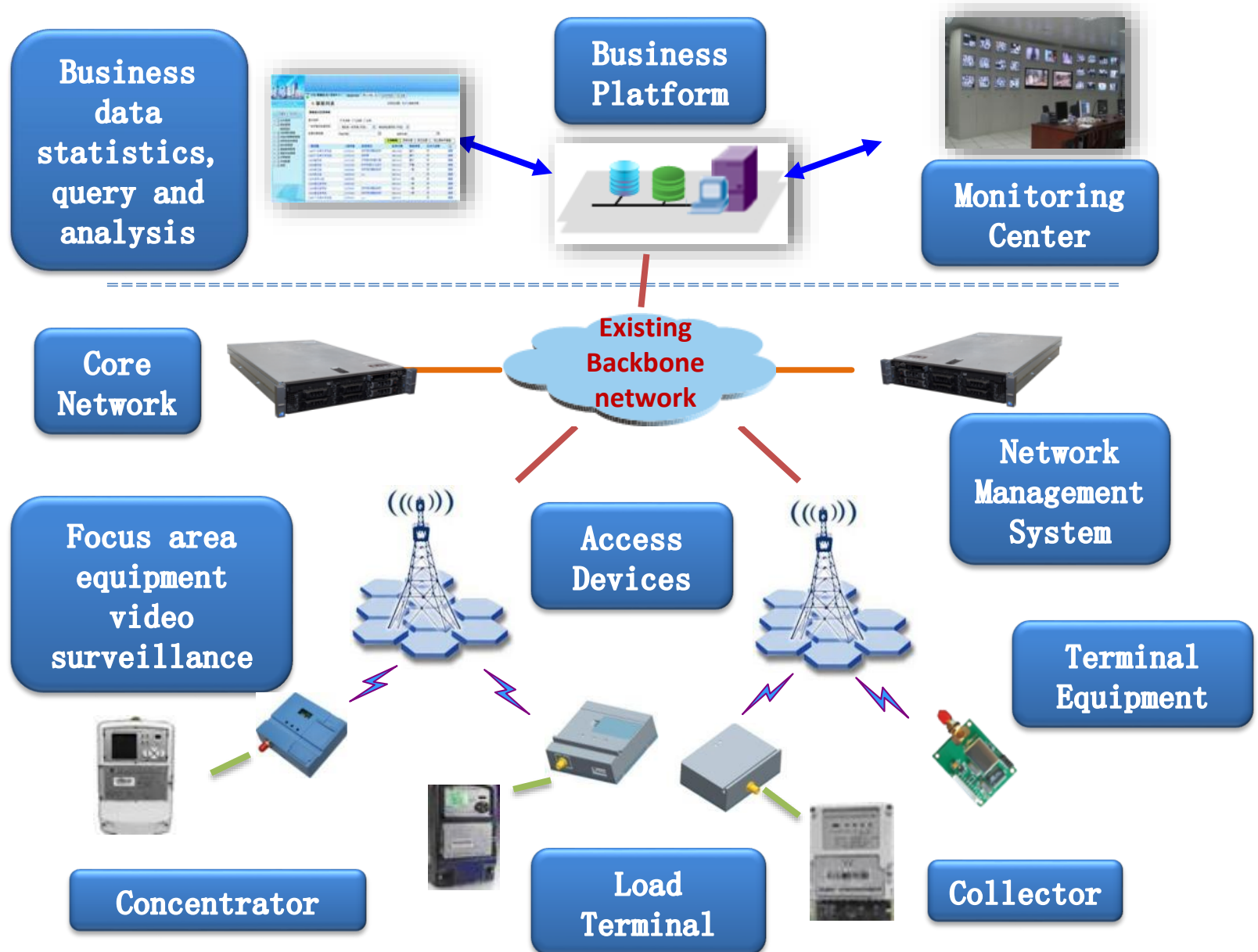


- ISPLC is the most influential international power line communication conference
- During the project period, Information a Telecommunication Group Co ,.Ltd for four consecutive years at the ISPLC conference preaching papers

3.3 Current Frequency Situation

LTE 230 System technical indicators	
Frequency	223.025 ~ 235.000MHz (Power system dedicated frequency)
Multiple access	OFDM Multiple access methods
Duplex	TDD Duplex
Modulation	QPSK、 16QAM and 64QAM
Base station system RF channel bandwidth	Discrete 8.5MHz
Single cell throughput	Peak rate: uplink 14.96Mbps , downlink 7Mbps
Single cell support for online users	2000/MHz
Terminal peak rate	Peak rate: uplink 1.76Mbps, downlink 0.7Mbps
Coverage radius	Dense urban 3-5km , suburban 10-15km , rural 30km
Receiving sensitivity	-120dBm

TD-230M system structure



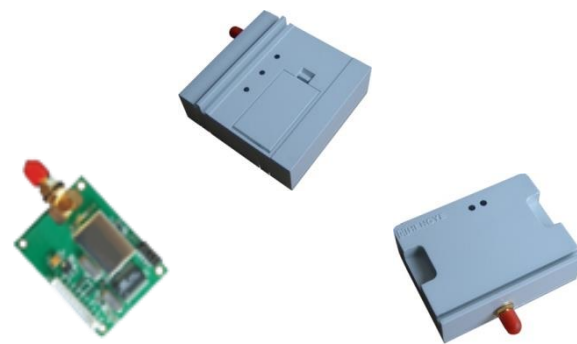
On-site operation: support a variety of power business

- ❑ Electricity collection
- ❑ Load control
- ❑ Equipment inspection
- ❑ Power distribution automation
- ❑ Emergency communication

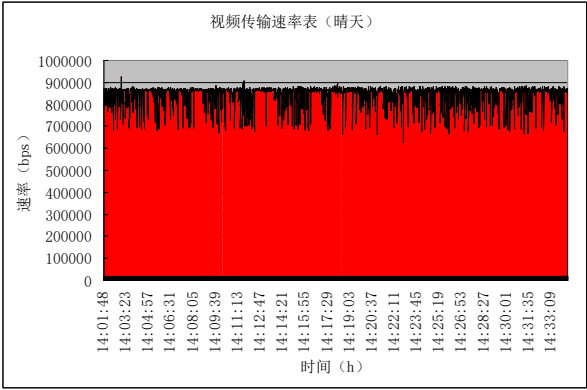
分体式基站



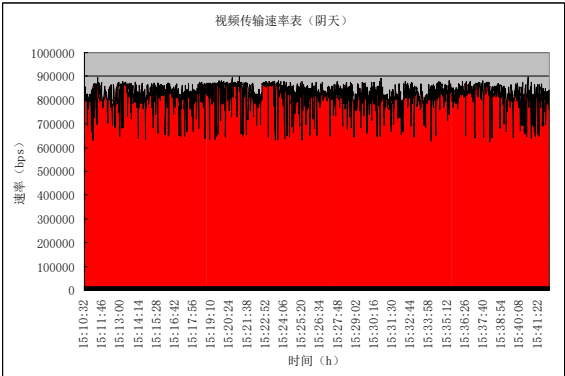
Directly inserted in the concentrator / special variable control / collector communication terminal module



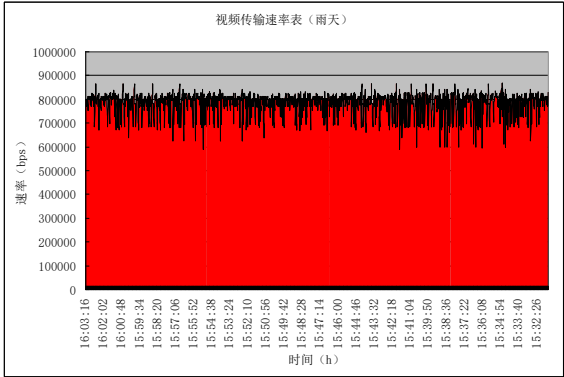
On-site operation: the impact of different weather changes



a) Sunny transit rate



b) Cloudy transmission rate



c) Rainy day transmission rate

Wireless Broadband Communication Laboratory



Power business
applications
True system testing

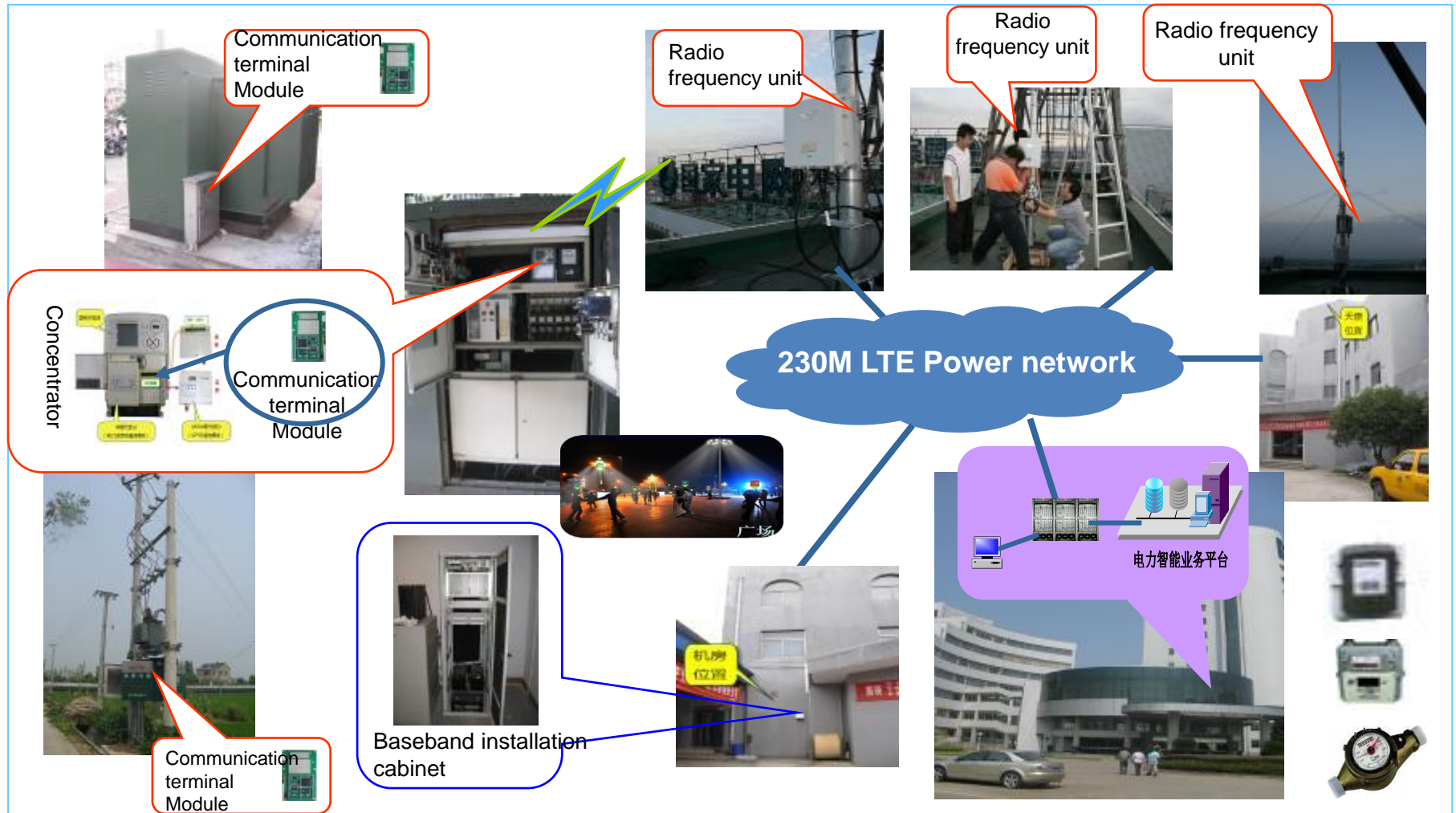
International cooperation



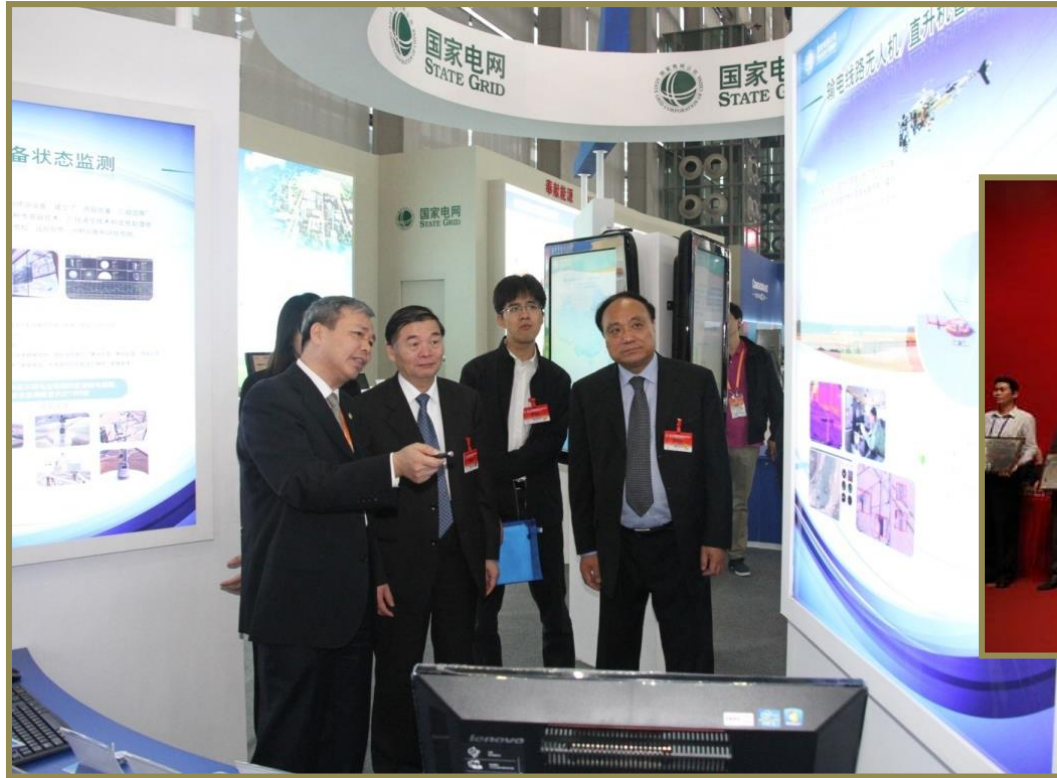
China International Information and Communication Exhibition



CASE : ZheJiang HaiYan



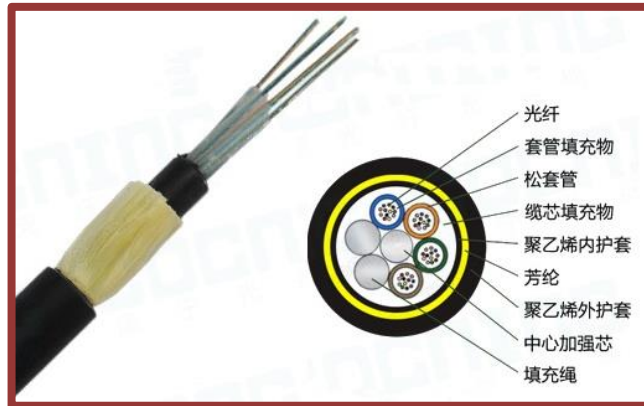
SG High level Communication Event



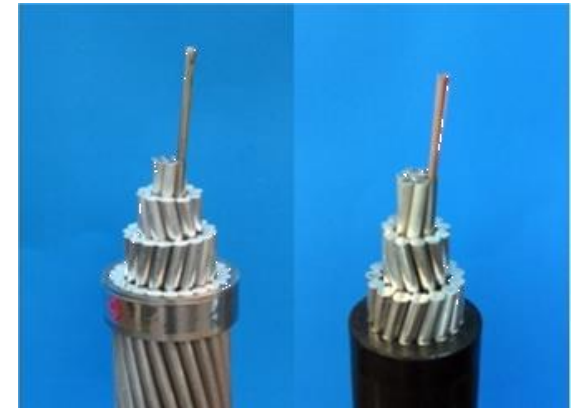
3.4 Fiber Composite Cable



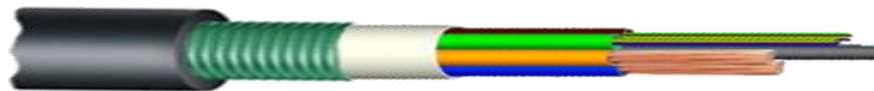
OPGW:
Optical fiber composite
overhead Ground Wire



ADSS:
All Dielectric Self-
Supporting Optical Fiber
Cable



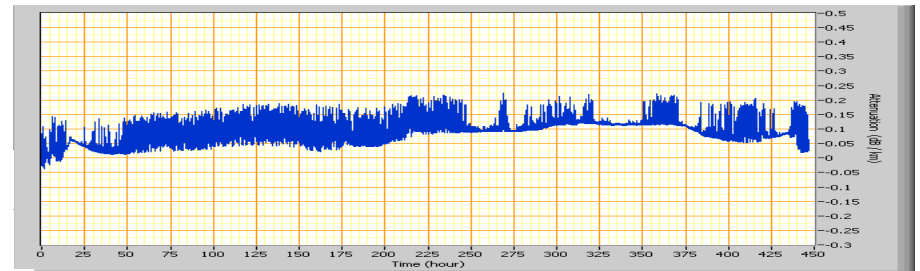
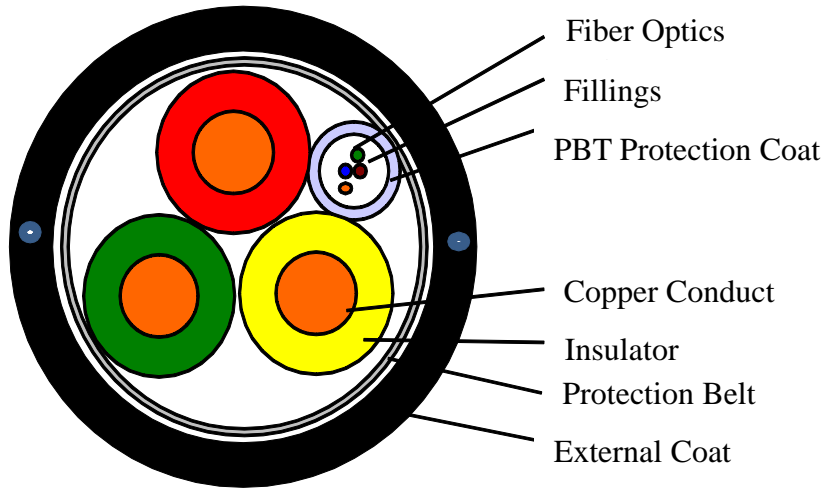
OPPC:
Optical phase conductor



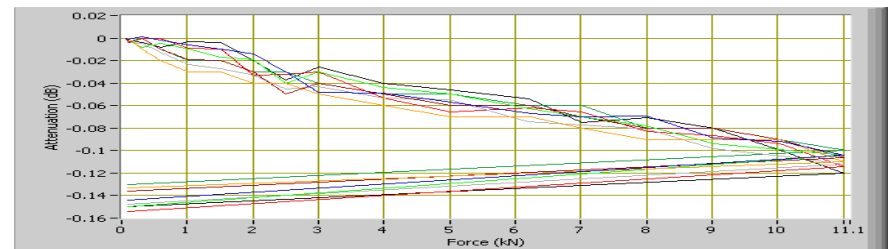
OPLC:
Optical fiber composite low voltage Cable

OPLC

OPLC Performance Test



An additional attenuation curve of fiber with continuous current heating.



Additional attenuation curve of mechanical fiber stress

Interconnection of home energy management system

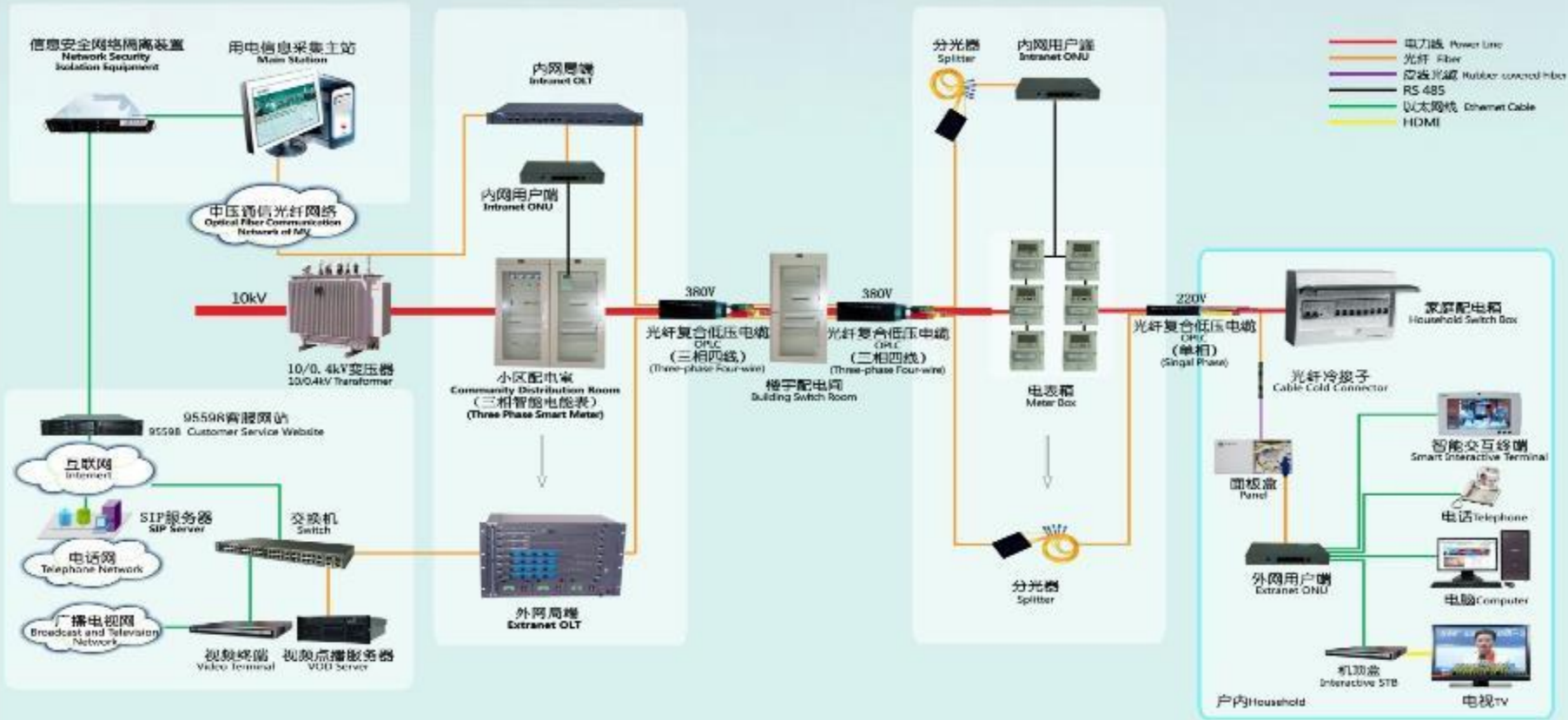


Interconnection of home energy management system



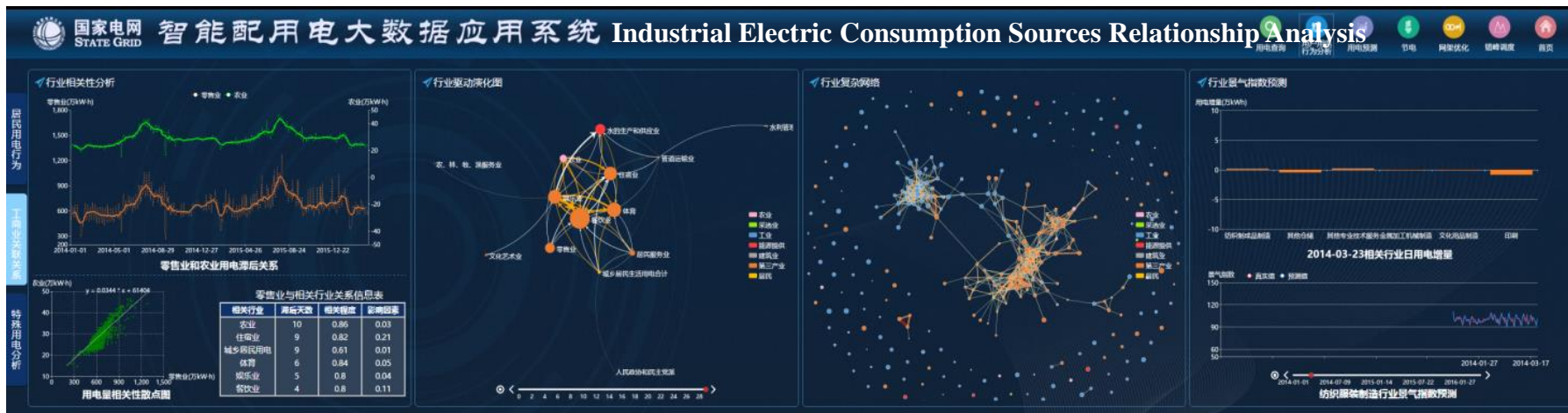
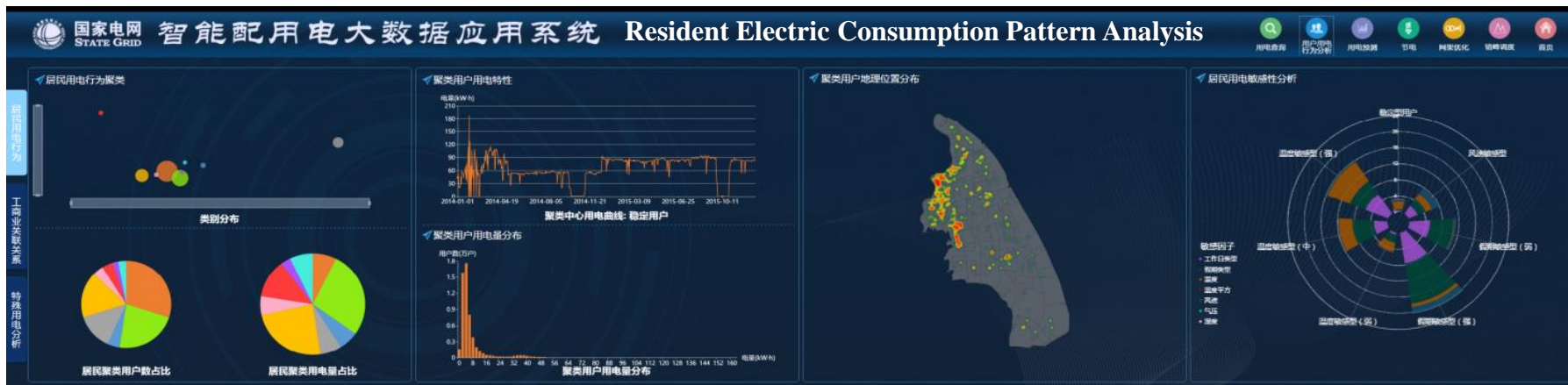
国家电网公司
STATE GRID
国网信息通信有限公司
State Grid Information & Telecommunication Co., Ltd.

智能电网电力光纤到户组网图 Smart Grid PFTTH Network Diagram



Live Demonstration on Mobile Phone

Example: SGCC, Shanghai, Big Data for smart distribution & consumption



Gracias!

谢谢！

Thank you !



Example: Residential Tariff of Hangzhou

Peak period: 6:00 – 22:00, tariff: 0.568CNY/KWh

Valley period: 22:00 – 6:00, tariff: 0.288CNY/KWh

defined by “[Zhejiang Province Electricity Tariff](#)”

The residential electricity cost reduced by 20% when use electricity more efficient.

Example: Residential Tariff of Shanghai

Peak period: 6:00 – 22:00, tariff: 0.617CNY/KWh

Valley period: 22:00 – 6:00, tariff: 0.307CNY/KWh

Example: Industry Electricity Tariff of Guangzhou

The peak, valley, regular period is defined according to regions' real situation. There is no uniform standard.

The industry tariff of Guangzhou is:

- Peak period: 9:00 – 23:00, tariff: 1.8CNY/KWh
- Regular period: 7:00 – 9:00, 23:00 – 24:00, tariff: 1.2CNY/KWh
- Valley period: 0:00 – 7:00, tariff: 0.7CNY/KWh

Overview of National UHV Transmission

