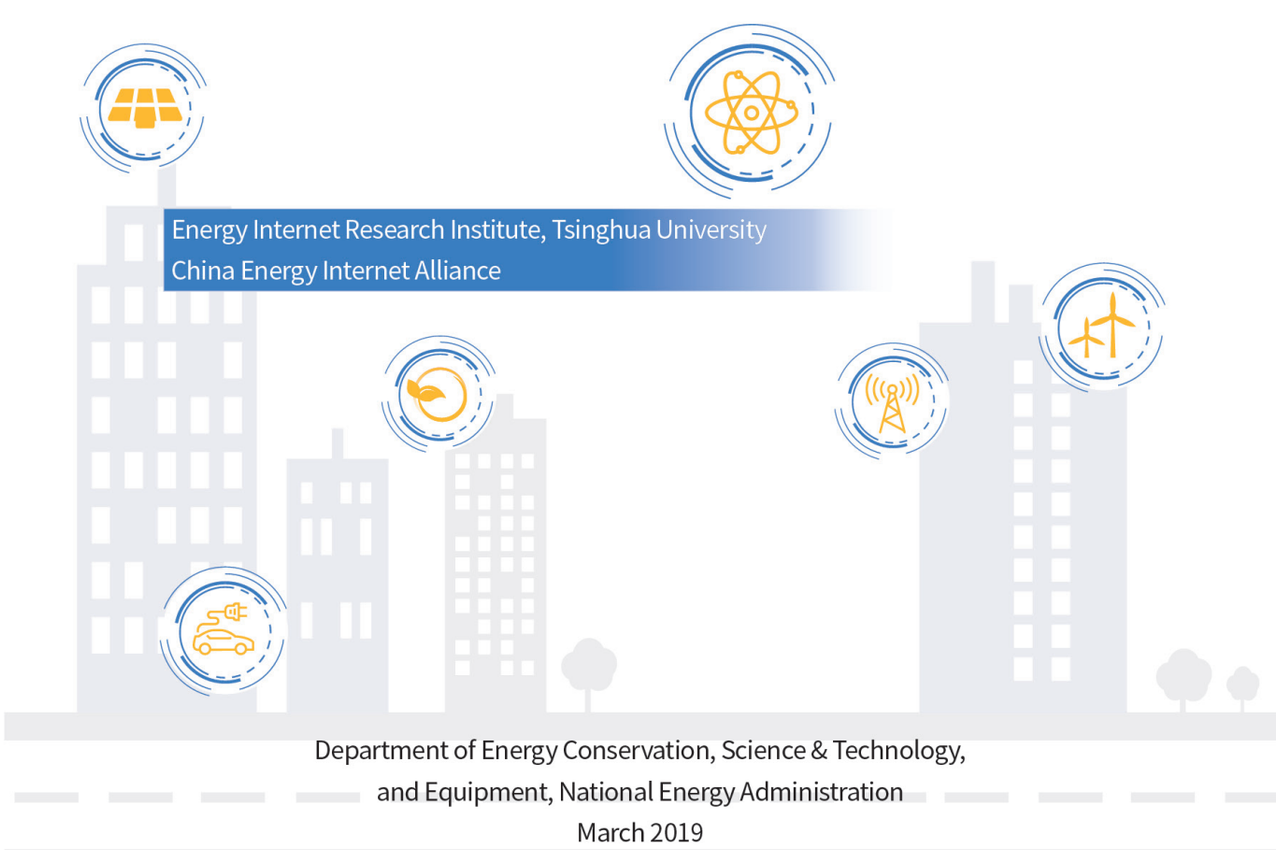
2018

The Development of National Energy Internet

White Paper



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Introduction

Energy is the cornerstone of existence and development of human being. It is a foundation industry of economy and an important strategic resource.

The Energy Internet is the pivot of current energy revolution. It realizes a deep fusion of Internet technologies with energy generation, transmission, storage, consumption and energy market, and greatly promotes the high-quality, sustainable development of China's energy industry.

In order to advance the strategic deployment of the State Council's "Internet +" action, follow and implement the requirements of the *Guiding Opinions on Pushing Forward the Development of "Internet +" Smart Energy* (FGNY [2016] No. 392) published by NDRC, NEA and MIIT, and consolidate the staged achievements of Energy Internet industries, the NEA entrusted the Energy Internet Research Institute, Tsinghua University with the task to organize the compiling of *National Energy Internet Development White Paper.*

This white paper reviews the background of Energy Internet, constructs the indicator system of Energy Internet, and depicts the current development situation of China's Energy Internet in terms of policy, industry, technology, innovation, construction, and public ecology. It also summarizes ten landmark events of China's Energy Internet, discusses the development of Energy Internet from a global perspective, and predicts the challenges and trends of Energy Internet. What the white paper focuses on is a general introduction of Energy Internet, while technology details will be presented in separate technological reports. The release of this white paper is to build consensus of all sectors of society on Energy Internet and ensure the rapid and sound development of Energy Internet industries by providing a fundamental and forward-looking reference in energy sustainable development for governments, enterprises, and research institutions to engage in and carry out energy revolutions.

Contents

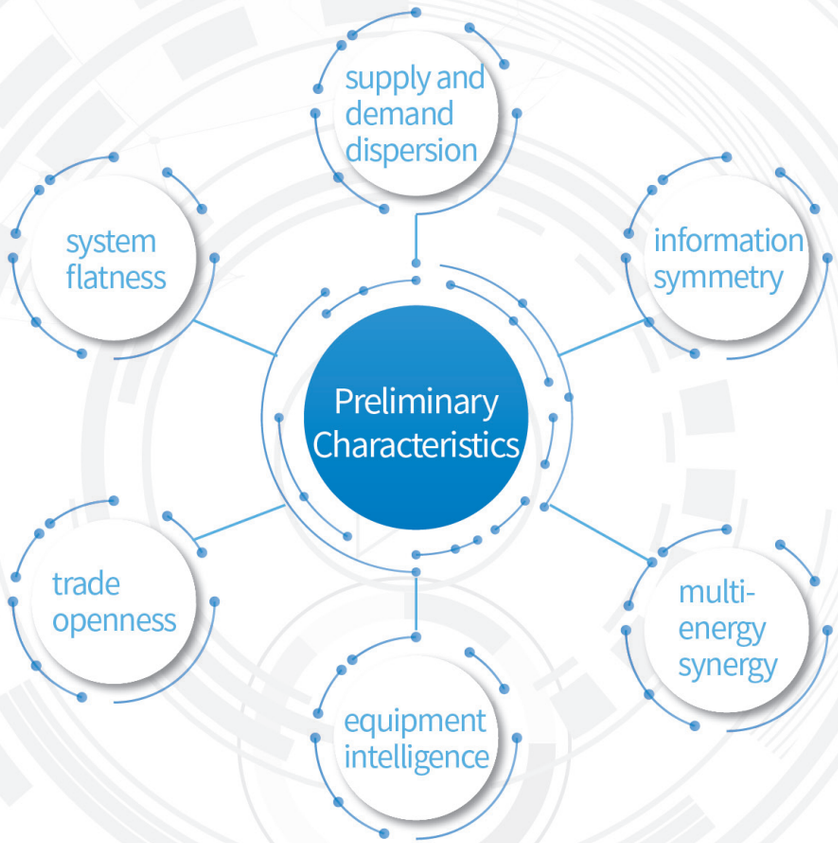
01
Background of Energy Internet

1.1 General and Extended Connotations

The general connotation of Energy Internet

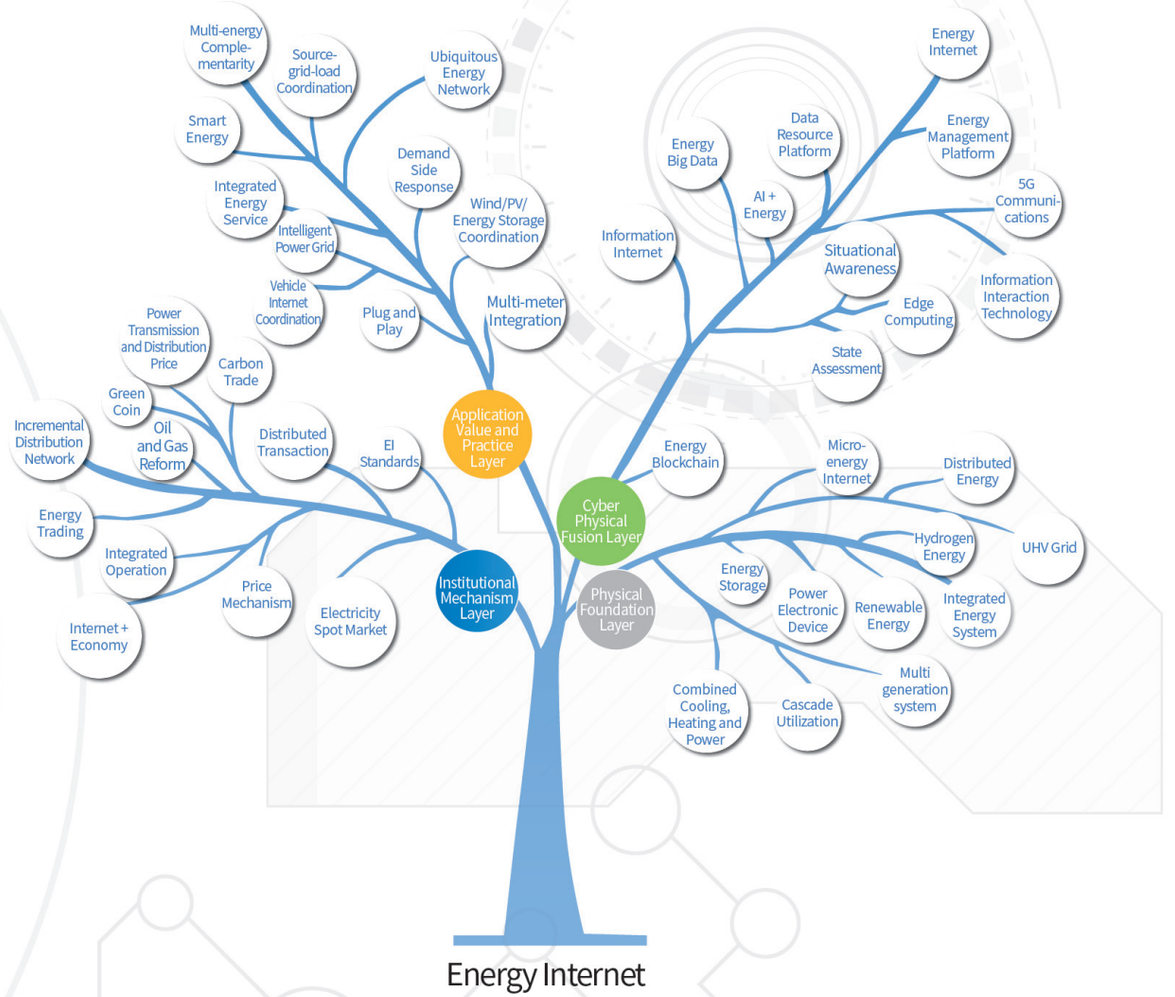
"Internet +" smart energy (Energy Internet) is a new development form of energy industries with deep fusion of Internet with energy generation, transmission, storage, consumption and energy market. It is primarily characterized by equipment intelligence, multi-energy synergy, information symmetry, supply and demand dispersion, system flatness, and trade openness.

Source: National Development and Reform Commission, National Energy Administration, Ministry of Industry and Information Technology, *Guiding Opinions on Pushing Forward the Development of "Internet +" Smart Energy*, February 2016



The extended connotation of Energy Internet

We can use the expressions of etymological word tree to interpret the object and application scope of Energy Internet.



1.2 Development History

The development of Energy Internet has gone through four phases: concept incubation from 1970 to 2003, preliminary study from 2004 to 2013, early action from 2014 to 2016 and application practice from 2017 to present. At present, the construction of Energy Internet is in full swing.

1970

Buckminster Fuller remarked that the global electrical energy grid is the highest priority objective.

2003

The Economist published the article "Building the Energy Internet" that explores intelligent power systems taking distributed energy generation and distributed energy storage as the core and supporting plug-and-play and surplus power access.

1970-2003 Concept Incubation

2008

The US launched the FREEDM project. Germany launched E-Energy project.

2011

The Europe launched FINSENY project. Japan launched the Digital Grid plan.

2012

Jeremy Rifkin wrote that the Energy Internet is a crucial element of the third industrial revolution in his book The Third Industrial Revolution.

2004-2013 Preliminary Study

2014

General Secretary Xi Jinping clearly stated the strategic thinking of energy revolution at the meeting of Central Leading Group for Financial and Economic Affairs.

2015

Premier Li Keqiang pointed out energy supply and security is key to the overall development of China's economy and society, and encouraged to advance the "Internet +" action plan.

2016

The 13th Five-Year Plan of China called for efforts to promote the deep integration of energy and information technology. The ministries of construction, energy and Internet jointly issued the Guiding Opinions on Pushing Forward the Development of "Internet +" Intelligent Energy.

2014-2016 Early Action

2017 Application Practice

2017

General Secretary Xi Jinping elaborated on ecological civilization construction and green development, and stressed the adherence to people-centered development and innovative, coordinated, green, open and shared development at the 19th National Congress.

2018

State Grid Corporation issued "State Grid Corporation Document No. 1, 2018", proposing to build a competitive world-class Energy Internet enterprise.

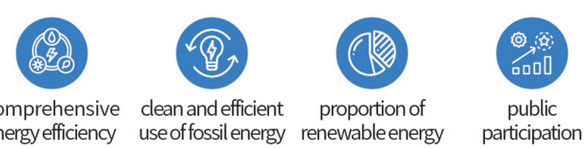
1.3 Development Targets

Phase 1: Double efforts in pilot demonstration of Energy Internet from 2016 to 2018.

- Launch a number of pilot demonstration projects of different types and scales.
- Make breakthroughs in a number of key technologies and core equipment.
- Formulate a number ofimportant technological specifications and standards.
- Develop a number of emerging industries such as energy finance and third-party integrated energy service.
- Cultivate a number of competitive emerging market players.
- Explore a number of sustainable and applicable development models.
- Accumulate a number of precious reform pilot experience.
- Finish the initial establishment of the market mechanism and market system of Energy Internet.
- Finish the initial establishment of the technology system and standard system of Energy Internet.

Phase 2: Double efforts in diversified, large-scale development of Energy Internet from 2019 to 2025.

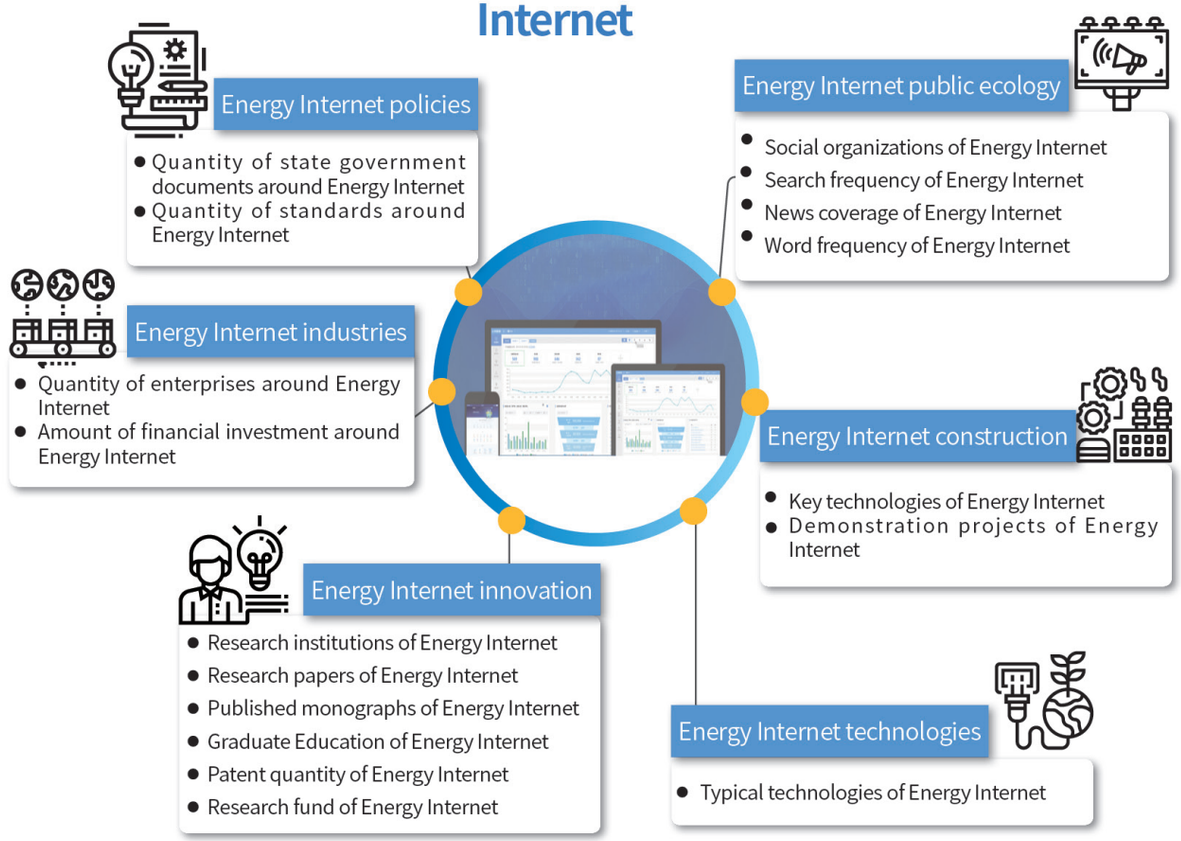
- Complete the initial establishment of the industry system of Energy Internet.
- Build a relatively complete market mechanism and market system of Energy Internet.
- Work out a relatively complete technology system and standard system and make the systems reach the international level.
- Create an open, shared ecosystem of Energy Internet.



1.4 Indicator System

Indicator system of Energy Internet can be analyzed in terms of policies, industries, technologies, innovation, construction, and ecology. The indicators are classified into different categories such as qualitative indicator, quantitative indicator, global indicator, and local indicator. Indicator systems are established by first referring to websites, science and technology literature and databases or handing out Internet questionnaires, and then conducting qualitative and quantitative analysis of multi-level indicators of Energy Internet. Specifically, the analysis involves indicator screening, indicator collection and status analysis. The specific indicators are as following::

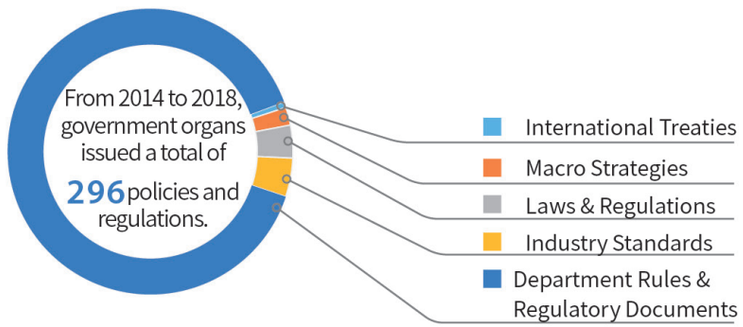
Indicator System of Energy Internet



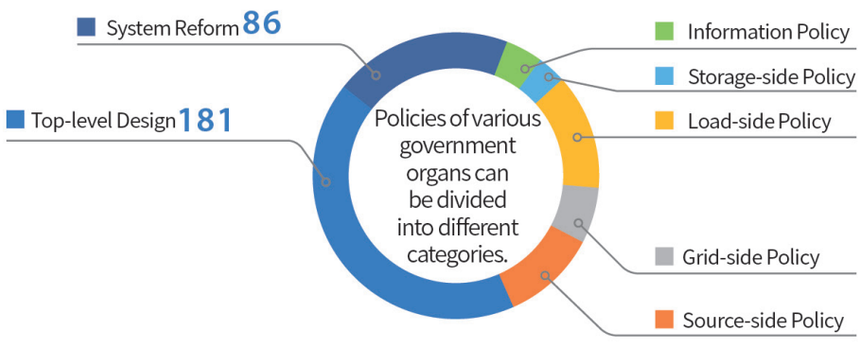
02
Policy of Energy Internet in China

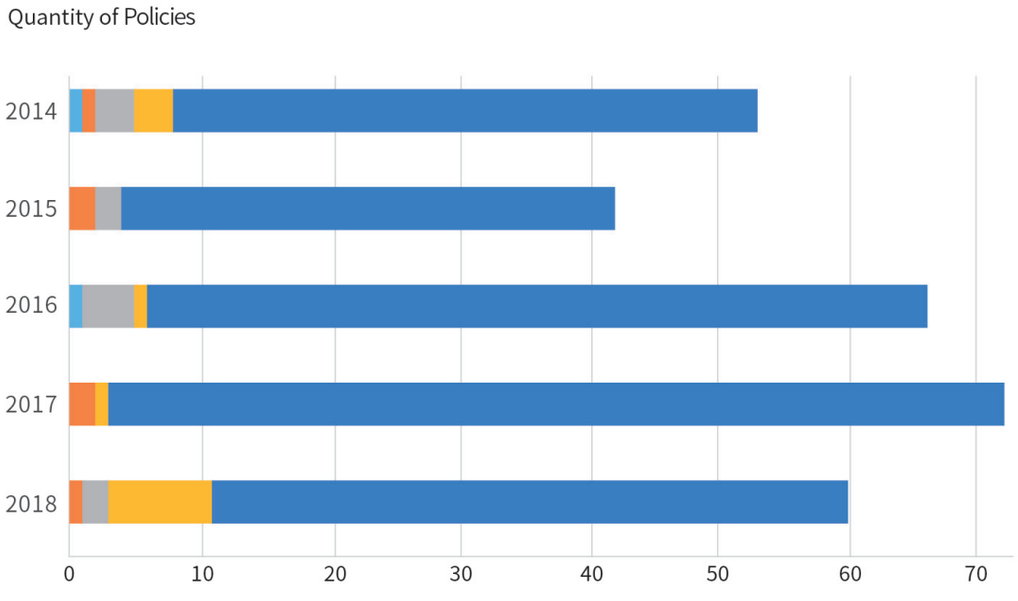
2.1
Policy Overview

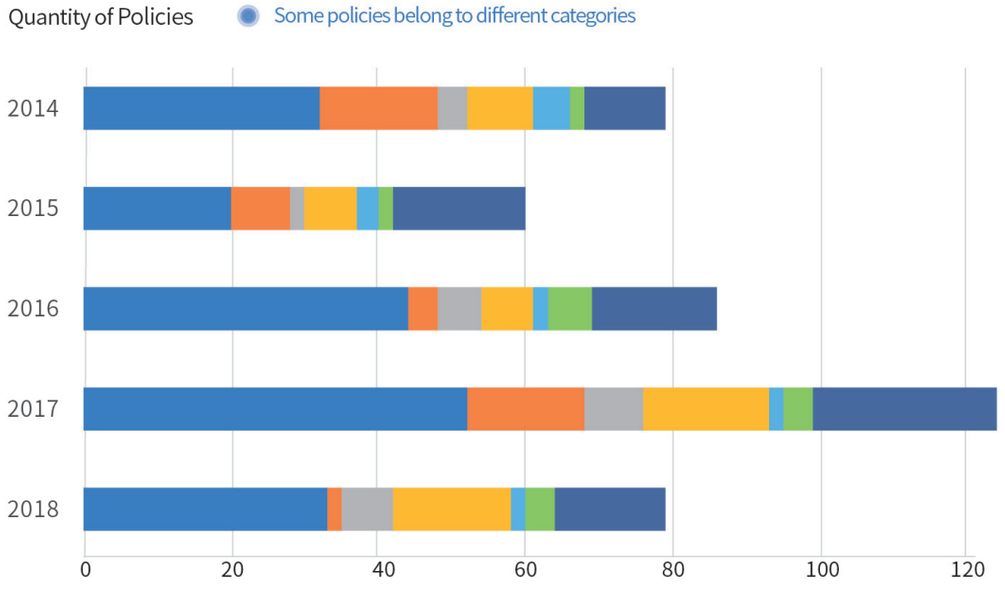
From 2014 to 2018, China has witnessed the initial establishment of a multi-level policy system of Energy Internet covering international treaties, macro strategies, laws and regulations, industry standards, departmental rules and regulatory documents. The statistics showed government organs issued a total of 296 policies and regulations. Most of them were released in 2016 and 2017.

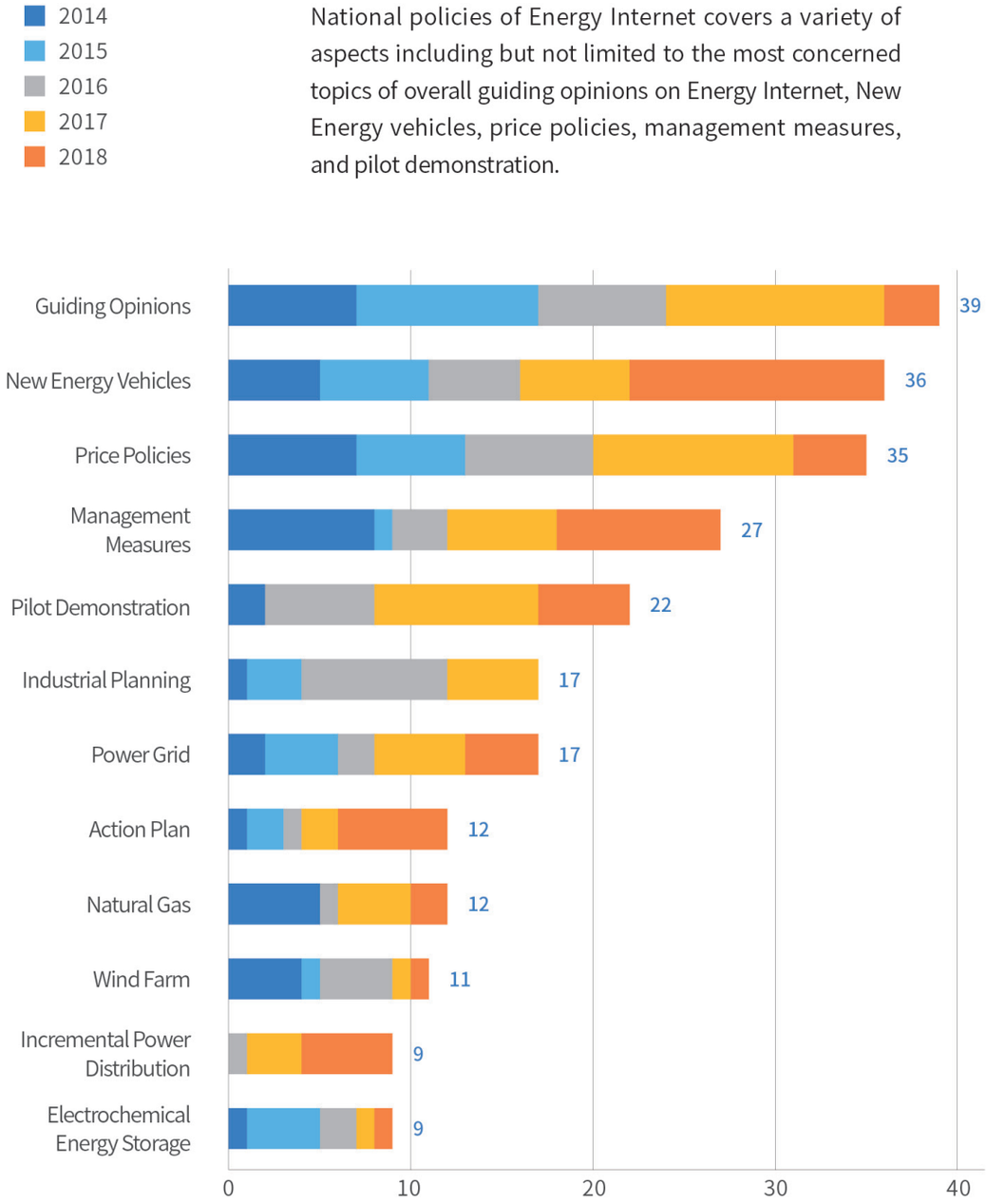


To be specific, policies of various government organs can be divided into different categories. The most attention is paid to top-level design and system reform, while policies on source, grid, load, storage, and information are also concerned.



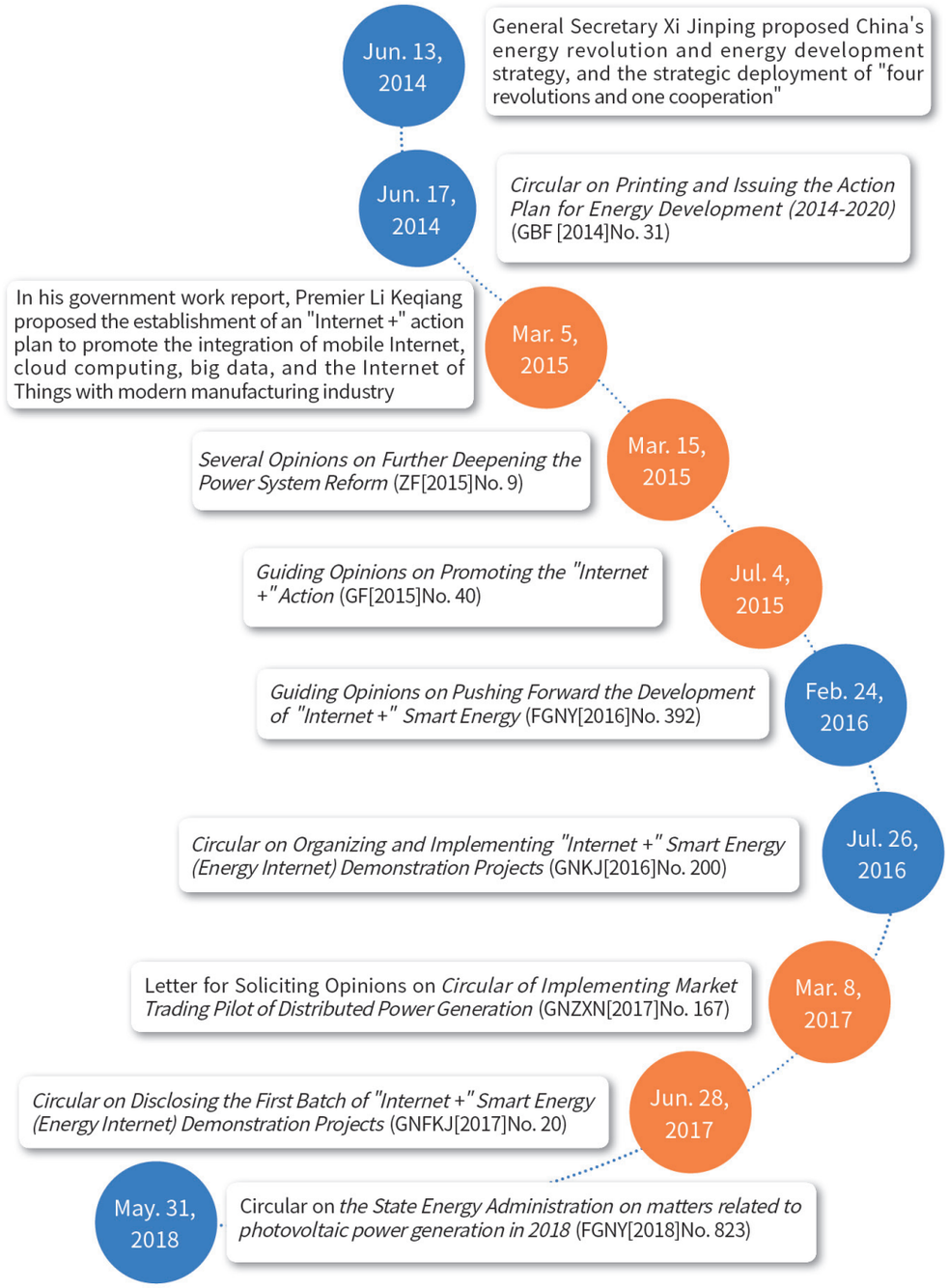






National policies of Energy Internet covers a variety of aspects including but not limited to the most concerned topics of overall guiding opinions on Energy Internet, New Energy vehicles, price policies, management measures, and pilot demonstration.

2.2 Representative Policies



2.3 Related Standards

Energy Internet standards relate to a wide array of contents such as basic standards of Energy Internet, and planning, design and acceptance evaluation of key equipment, management platform, information interconnection, regional Energy Internet, micro-energy Internet. Up to now, a total of 23 Energy Internet standards have been declared. Among them, 9 were submitted for approval as national standards and 14 as association standards. *T/CEC 101.1-2016 Energy Internet System Part I: General* has been announced.

S/N	Planned No.	Planned Subject	Organizing Unit
1	Part I	*Internet of Energy: General*	China Electric Power Research Institute
2	Part II	*Internet of Energy: Glossary*	Energy Internet Research Institute, Tsinghua University
3	Part III	*Energy Internet System-Architecture and Requirements*	
4	Part IV	*Energy Internet System-Cases*	
5	Part V	*Energy Router Functional Specifications and Technical Requirements*	China Electric Power Research Institute
6	Part IX	*Specifications for the Interaction Between Energy Internet and Distributed Generation*	
7	Part X	*Specifications for the Interaction Between Energy Internet and Electric Vehicles*	
8	Part XI	*Specifications for the Interaction Between Energy Internet and Storage Systems*	
9	Part XII	*Energy Internet System-Active Distribution Network Interconnection*	
10	T/CEC 20170201	*Energy Internet-Energy Router*	Jiangsu Modern Low-carbon Technology Institute
11	T/CEC 20170202	*Energy Internet-Specifications for Energy Management Platform Functions*	
12	T/CEC 20170203	*Technical Guidelines for Multi-energy Complementary Integrated Optimization*	
13	T/CEC 20170204	*Energy Internet-Energy Utilization and Conversion Efficiency Evaluation*	State Grid Economics & Technology Research Institute
14	T/CEC 20170205	*Energy Internet System Assessment*	Energy Internet Research Institute, Tsinghua University
15	T/CEC 20170206	*Interaction Between Energy Internet and Micro -energy Internet*	Integrated Electronic Systems Lab Co.,Ltd.
16	T/CEC 20170207	*Technique Guidelines for Regional Internet of Energy*	State Grid Economics & Technology Research Institute
17	T/CEC 20170208	*Internet of Energy Data Exchange*	
18	T/CEC 20170209	*The Guide for Planning and Design of Micro Internet of Energy*	
19	T/CEC 20170210	*Micro-energy Internet Engineering Design Specifications*	
20	T/CEC 20170211	*Micro-energy Internet Access Design Specifications*	
21	T/CEC 20170212	*Guidelines for Micro-energy Internet Planning and Design Assessment*	
22	T/CEC 20170213	*Guidelines for User-side Operation and Control of Integrated Energy System*	
23	T/CEC 20170214	*Guidelines for Operation and Control of Micro-energy-grid*	

03 Industry of Energy Internet in China

3.1 Enterprise Development

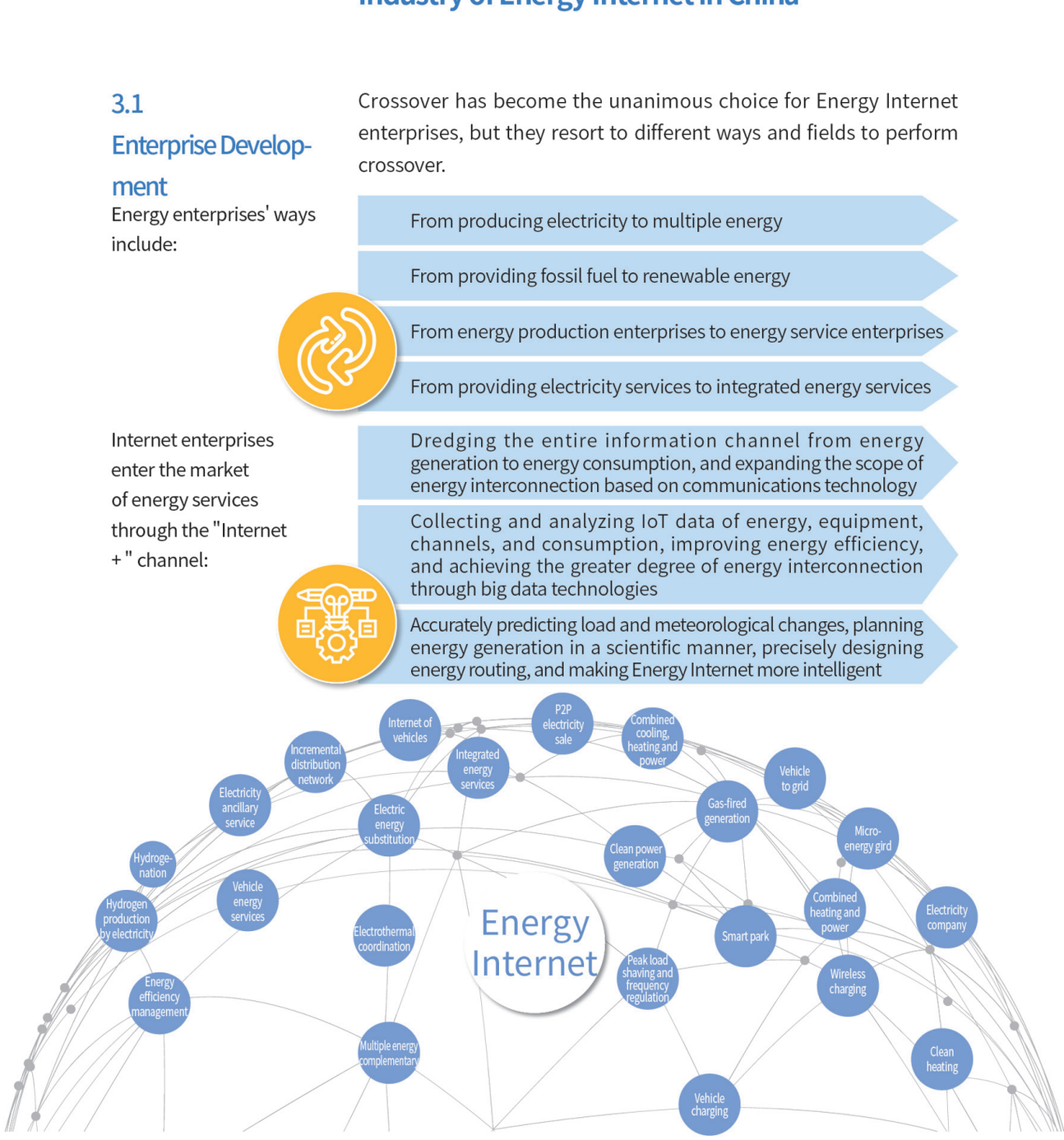
Crossover has become the unanimous choice for Energy Internet enterprises, but they resort to different ways and fields to perform crossover.

Energy enterprises' ways include:

- From producing electricity to multiple energy
- From providing fossil fuel to renewable energy
- From energy production enterprises to energy service enterprises
- From providing electricity services to integrated energy services

Internet enterprises enter the market of energy services through the "Internet +" channel:

- Dredging the entire information channel from energy generation to energy consumption, and expanding the scope of energy interconnection based on communications technology
- Collecting and analyzing IoT data of energy, equipment, channels, and consumption, improving energy efficiency, and achieving the greater degree of energy interconnection through big data technologies
- Accurately predicting load and meteorological changes, planning energy generation in a scientific manner, precisely designing energy routing, and making Energy Internet more intelligent



Cluster of Energy Internet Businesses

Current Development Situation of Energy Internet Industries

Traditional Electric Power

In addition to the increasing proportions of renewable energy power generation, the power generation industry develops hydrogen energy businesses, and penetrates into the power terminal market.

Power Transmission and Distribution

The power grid industry consolidates its strength in power transmission and distribution, seeks more development of integrated energy services and e-commerce, and expands its service scope to smart home and renewable energy.

Electric Vehicles

The market of electric vehicles has come into being. Focusing on the interaction between transportation and Energy Internet, the automobile industry creates the new business form of mobile energy.

Petroleum & Petrochemical

Petroleum and petrochemical enterprises set up professional electric power companies for electricity selling, explore hydrogen energy business, and join hands with Internet enterprises to offer big data energy service.

Renewable Energy

The renewable energy industry sees the transformation from manufacturing to energy generation and service, actively engages in the construction of Energy Internet demonstration projects, and launches new businesses such as incremental distribution network and integrated energy service.

Urban Gas

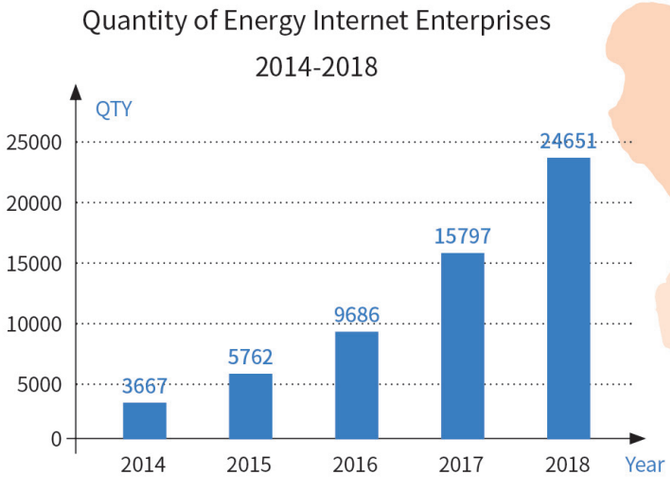
The gas industry explores new services of electricity/heat/gas/cold energy interconnection based on the urban gas pipeline network, and builds energy microgrid and park energy stations.

Information and Communications

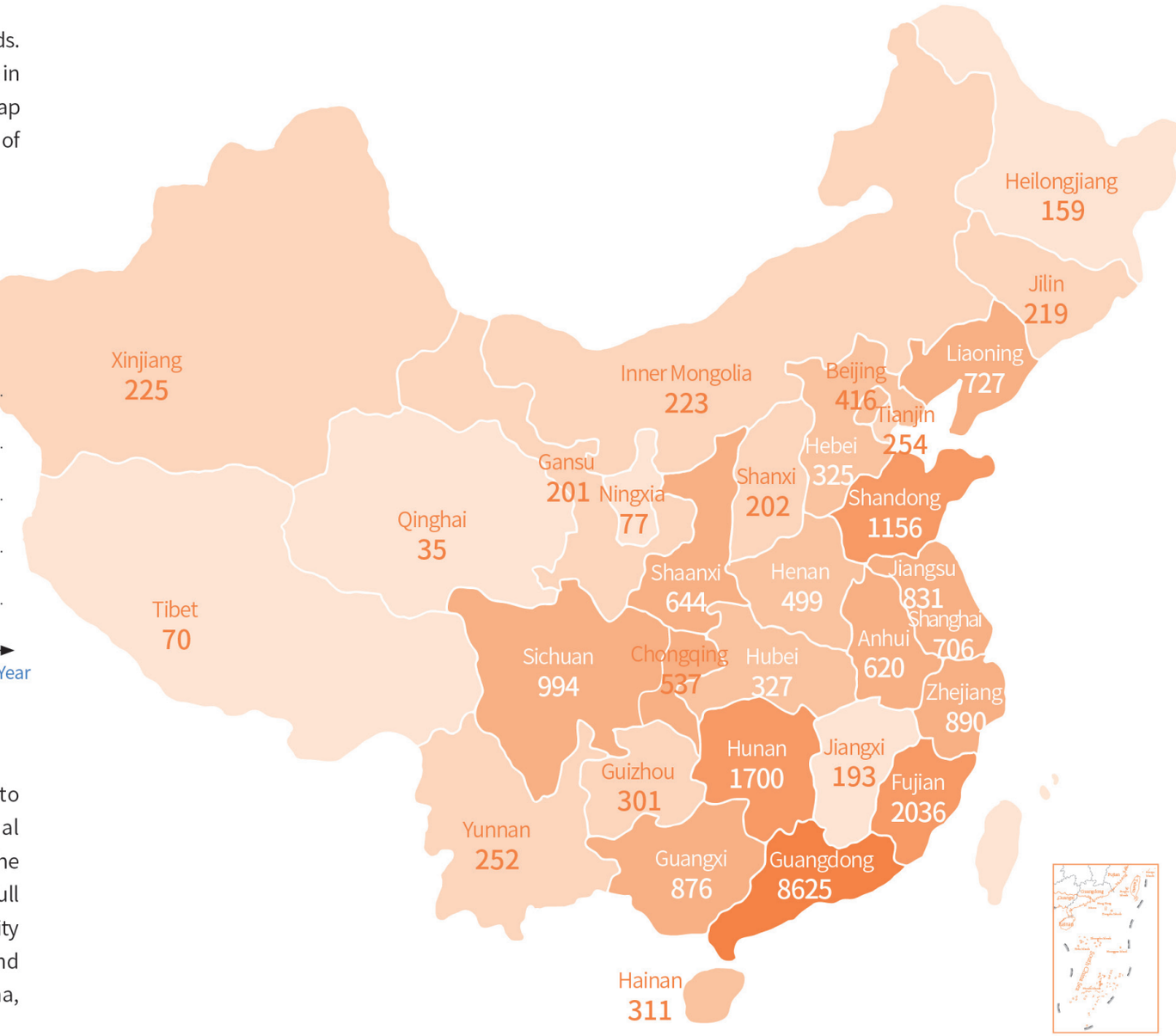
The Internet and information industry builds a bridge connecting energy and information to find solutions to integrated technologies.

3.2 Enterprise Quantity

The Energy Internet industry develops by leaps and bounds. As of December 2018, the number of registered enterprises in the Energy Internet industry has increased to 24,651. The gap between 3,667 at the end of 2014 and 24,651 at the end of 2018 is significantly large.



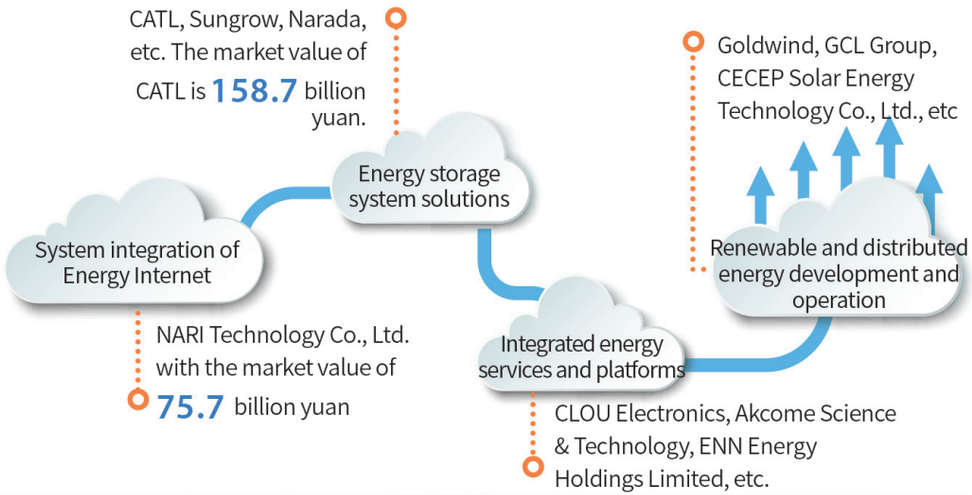
The distribution of Energy Internet enterprises tends to be a scenario that "the eastern region leads the national development, followed by burgeoning development in the central region, steady growth of the western region, and full readiness of the northeastern region." Regarding the quantity of registered energy Internet enterprises, Guangdong and Fujian, located in the coastal regions of Southeast China, Hunan, and Shandong ranked Top 4.



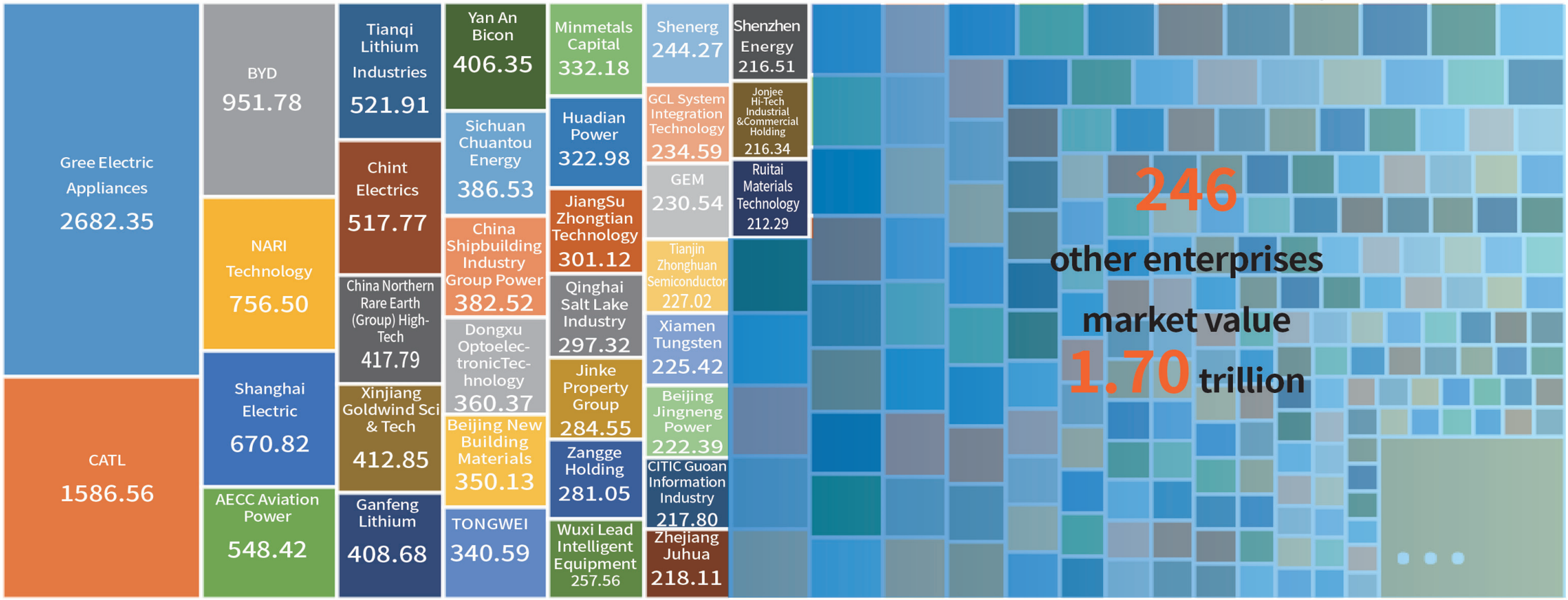
This map is referenced from the 10th printing of the 2nd edition of Hunan Map Publishing House in January 2015

3.3 Financial Development

The concept of Energy Internet injected vitality to the capital market, which also welcomes the increasing emergence of Energy Internet-related conceptions. According to the RESSET incomplete statistics of concept stocks in renewable energy, lithium batteries, and charging piles, there were a total of **287** Energy Internet-related stocks worth the market value of **3.37 trillion** yuan as of December 31, 2018.



Energy Internet Enterprises and Market Values on December 31, 2018 (Hundred Million Yuan)

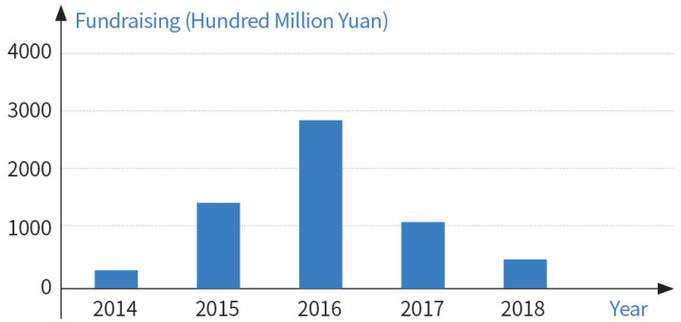


Some of the listed companies have multiple business sectors and are not entirely in the Energy Internet industry.

In 2016 the listed enterprises' fundraising soared to **280** billion yuan

From 2014 to 2018, the newly-raised fundraising of Energy Internet listed companies increased initially and then decreased. The fundraising was mainly from the new issuance of stocks. In 2016, Guiding Opinions on Pushing Forward the Development of "Internet +" Smart Energy was promulgated, enormously stimulating the Energy Internet market. As a result, the listed enterprises' fundraising soared to 280 billion yuan.

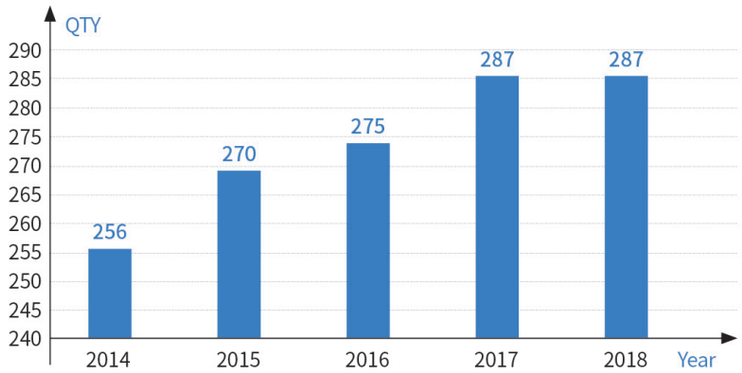
Fundraising of Energy Internet Listed Enterprises 2014-2018



leading to the rapid increase of listed enterprises to **287** in total

From 2014 to 2018, the number of Energy Internet listed enterprises gradually increased. In 2017, the National Energy Administration disclosed the first batch of 55 "Internet +" smart energy (Energy Internet) demonstration projects. The market was spurred to further invest in Energy Internet enterprises, leading to the rapid increase of listed enterprises to 287 in total.

Quantity Variation of Energy Internet Listed Enterprises 2014-2018

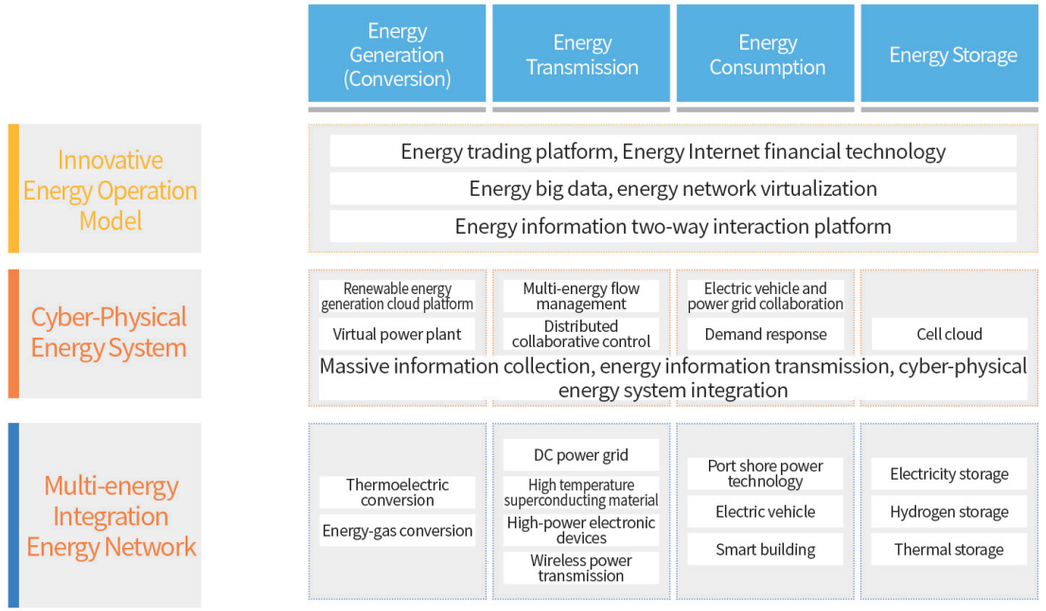


04
Technology of Energy Internet in China

4.1 Technological Framework

The maturity of Energy Internet technologies directly reflects the development of Energy Internet. We build the technological framework of Energy Internet. Vertically, the framework is made up of multi-energy integration energy network, cyber-physical energy system, and innovative energy operation model. The technologies regarding energy generation and conversion, transmission, consumption, and storage are the components of the framework on the horizontal level. The framework can provide a basis for specific technologies of Energy Internet.

As it is impossible to exhaust Energy Internet technologies of all kinds, only a few typical technologies are introduced later. They are energy storage technology and multi-energy integration technology at the level of multi-energy integrated energy network, big data technology at the level of cyber-physical energy system, and energy trading technology at the level of innovative energy operation model.



from Research on Energy Internet Development

4.2 Representative Technologies

Energy Storage Energy

The development of Energy Internet is inseparable from energy storage. With more emphasis to the R & D and application of energy storage technology, great progress has been made. Some energy storage technologies have been put into commercial operation, while others are basically in the stage of demonstration application. Detailed energy storage technologies is listed in the following table.

Main energy storage technology	Pumped storage	Compressed air energy storage		Flywheel energy storage	Hydrogen storage	Thermal storage		Cell energy storage	
		Traditional	Supercritical			Molten salt heat storage	Phase change heat storage	Lead acid cell	Lead carbon cell
Technological maturity	Commercial use	Commercial use	Demonstration	Commercial use	Demonstration	Commercial use	Commercial use	Commercial use	Commercial use
Levelized cost of electricity (¥/kWh)	0.1-0.2	0.1-0.3	0.1-0.3	——	——	——	——	0.5-0.7	0.5-0.7
Main energy storage technology		Lithium cell		Flow cell		Super capacitor	Nano cell		
	Lithium iron phosphate	Lithium titanate	NCM/NCA	Vanadium redox flow	Zinc bromine flow		Sodium sulfur cell	Sodium nickel cell	ARSBs
Technological maturity	Demonstration-commercial use	Demonstration	Demonstration-commercial use	Demonstration	Demonstration	Demonstration	Commercial use	Demonstration	Demonstration
Levelized cost of electricity (¥/kWh)	0.7-1.0	0.7-1.0	0.7-1.0	0.7-1.0	0.7-1.0	——	0.7-1.0	0.8-1.2	1.0-1.5

Data source: ESA-CIAPS Report on the Energy Storage Industry and Application in 2018

New energy storage technologies, due to low cost, long lifetime, high security, easiness to recycle and applicability to special scenarios, will be one of the R & D and application trends. Some energy storage technologies have potential for market application and are worth to conduct R & D and investment.

New energy storage technology	Seawater storage	New flow cell			Organic sodium ion cell	Aqueous rechargeable cell		Liquid metal cell
		Zinc bromine flow	All-iron flow	Iron cadmium flow		Aqueous rechargeable lithium/sodium	Aqueous rechargeable zinc-based cell	
Technological maturity	MWh device test	5kW demonstration	kW level system test	60kW pile	Ah level device	MW level demonstration	Ah device R & D	20kW system test
Applicable scenario	Coastal renewable energy grid connection and power grid peaking shaving	Hundred kilowatts and below terminal use	Large-scale peaking shaving	Large-scale peaking shaving	Distributed and microgrid, user side	User side	Distributed and microgrid, user side	Power grid peaking shaving, distributed and microgrid

Data source: ESA-CIAPS Report on the Energy Storage Industry and Application in 2018

Multi-energy Integration Technology

With the development of the concept of Energy Internet, there is an increasing number of multi-energy systems researches covering modeling, planning, operation, evaluation, and market.

Today, multi-energy integration technology has gradually shifted from theoretical research to practical application. The software solutions targeted at integrated multi-energy system planning, operation, decision making, and market simulation are available in the market, serving the construction and implementation of multi-energy systems.

Modeling

- Modeling of multi-energy system and components
- Modeling of steady state and transient state of multi-energy network

Planning

- Optimization planning for inter-regional multi-energy systems
- Optimization planning for the structure of regional multi-energy systems
- Coordination planning for multiple energy sources for renewable energy consumption

Operation

- Power flow calculation and steady state analysis of multi-energy systems
- Multi-energy coupled unit commitment and economic dispatching
- Optimization operation considering the spatio-temporal characteristics of renewable energy

Evaluation

- Operational efficiency evaluation of multi-energy systems
- Reliability evaluation of multi-energy systems

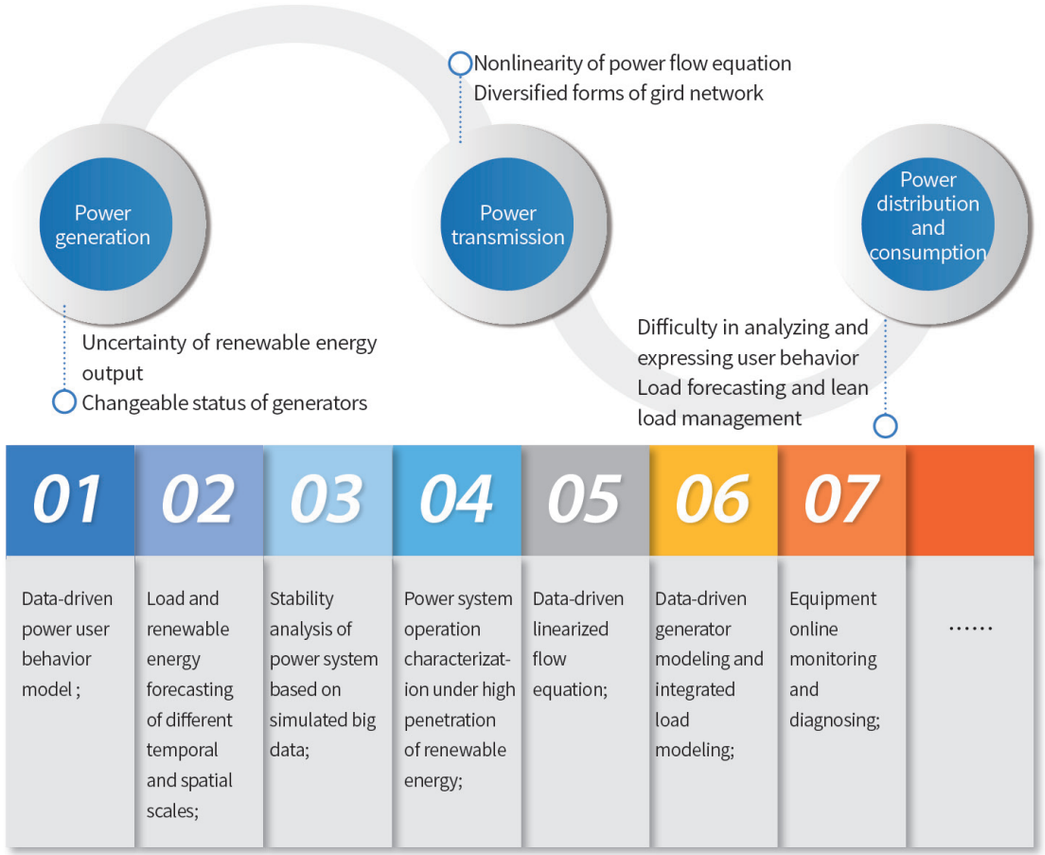
Market

- Equilibrium analysis of power-gas-heat multi-energy coupling market

Electricity Big Data Technology

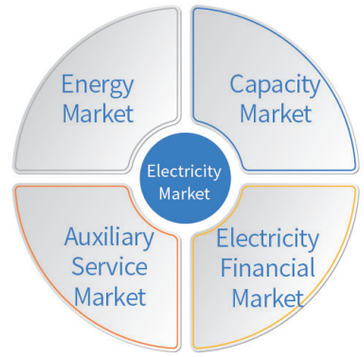
At the end of 2013, the Electric Power Information Committee under Chinese Society for Electrical Engineering released the "White Paper on the Development of China's Electricity Big Data". Since then, electricity big data has aroused more attention in both the academic and industrial circles. The application of big data technology covers "generation-transmission-distribution-conversion-consumption-storage", all links of the power system.

Collecting massive data is the first step for big data analysis. In the power system, the operation data are fetched on a real time basis from SCADA, PMU, AMI, customer service system, and various equipment sensors. Up to now, China has accelerated its construction of sensors and communication systems. Based on this, we have also carried out relevant researches on intelligent distribution and consumption, transparent grid, and power simulation.



Electricity Market and Trading Platform Technology

The new round of power system reform in China kicked off when the No. 9 document of the CPC Central Committee was issued in 2015. An important task in this round is to establish a electricity market system and optimize resource allocation through the market adjustment. A complete electricity market generally consists of energy market, capacity market, auxiliary service market, and electricity financial market. Each market is a component of the power market trading system.



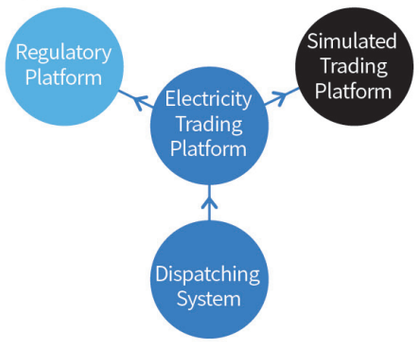
In 2018, the electricity amount traded with the support of the electricity market (including power generation rights trading) reached

2,065.4 billion kWh

The year-on-year increase of

26.5%

The structure of a trading platform is determined by market trading rules. Besides the trading platform, a regulatory platform and a simulated trading platform are also built.

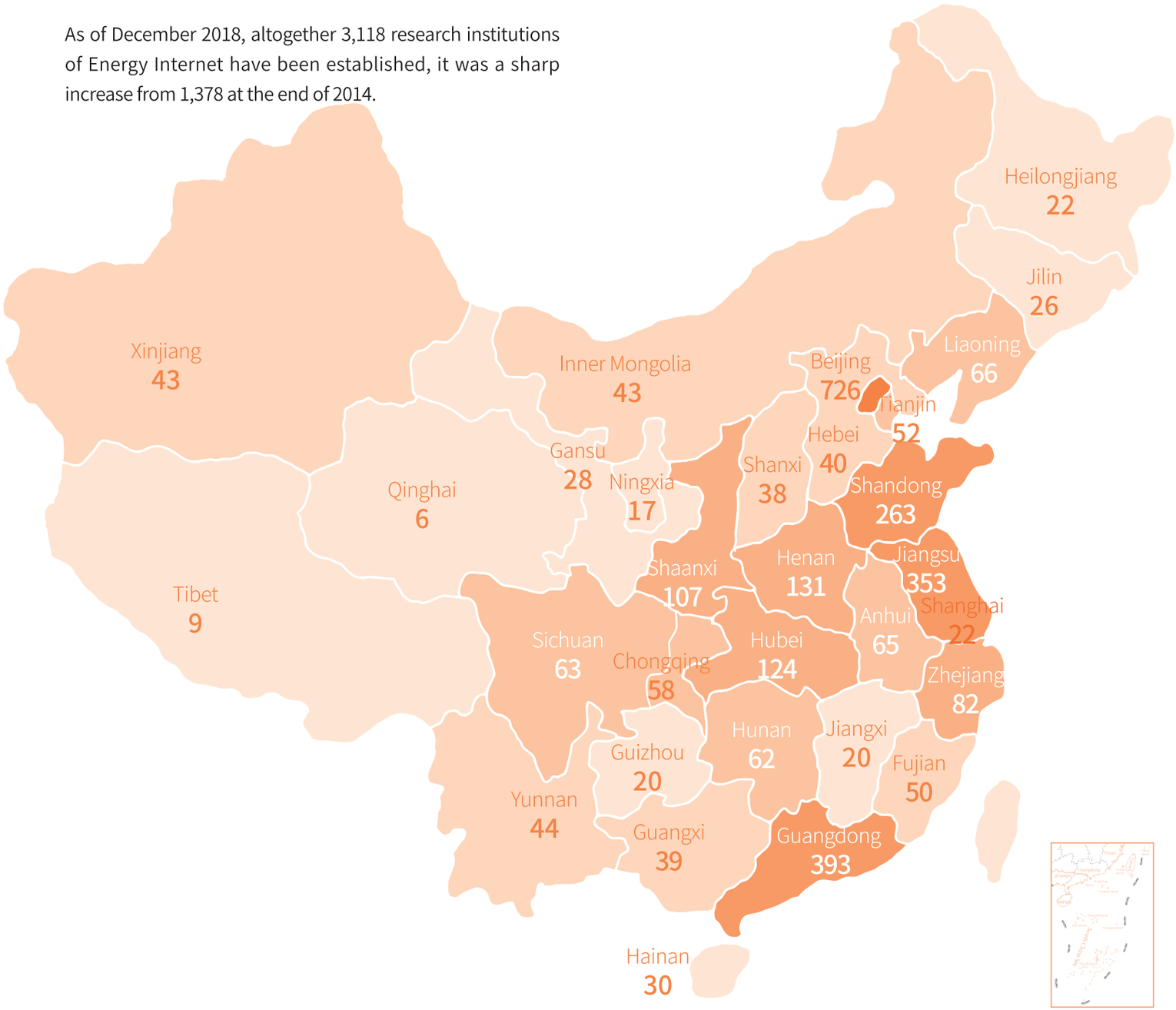


At present, the construction of electricity market and trading platform develops rapidly in China. Medium- to long-term power transactions have been promoted across the board and grown maturer day by day. Meanwhile, eight power spot trading pilots have been launched. In 2018, the electricity amount traded with the support of the electricity market (including power generation rights trading) reached 2,065.4 billion kWh, a year-on-year increase of 26.5%. This accounted for 30.2% of the electricity consumption of the whole society, and 37.1% of the electricity sales of power grid enterprises.

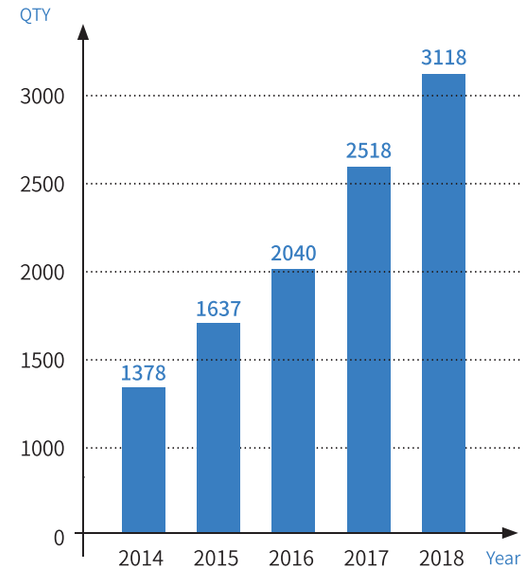
05
Innovation of Energy Internet in China

5.1 Research Institutions

As of December 2018, altogether 3,118 research institutions of Energy Internet have been established, it was a sharp increase from 1,378 at the end of 2014.



Quantity of Energy Internet Research Institutions
2014-2018



In the rankings of the quantity of Energy Internet research institutions, Beijing was at the top. Below it were Guangdong in the coastal area of southeast China and Jiangsu, holding the second and third places respectively. A number of research institutions were also set up in central China, such as Shandong, Henan, Hubei or Shaanxi. Each of them had more than 100 related institutions.

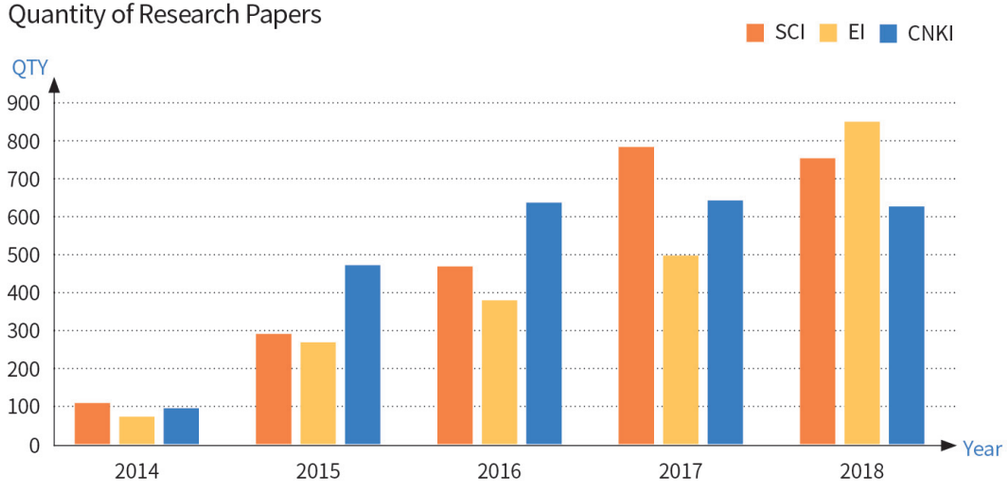
This map is referenced from the 10th printing of the 2nd edition of Hunan Map Publishing House in January 2015

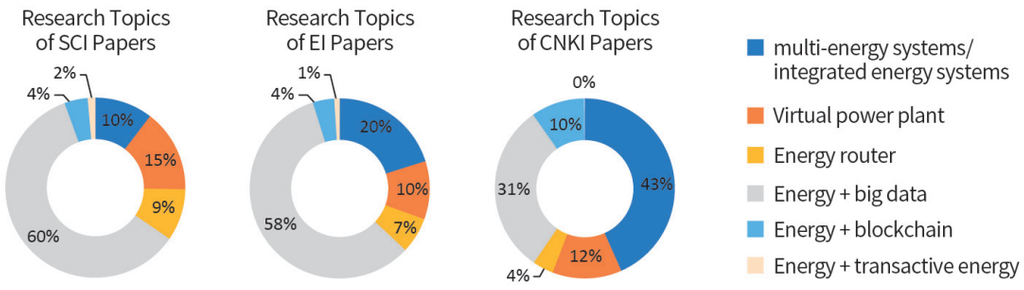
5.2 Paper Publication

The quantity of papers related to Energy Internet showed an ascending trend over the past five years. The significant increase in the quantity of papers in the databases like SCI index, EI index and CNKI suggests that more and more scholars at home and abroad have paid attention to Energy Internet and carried out related researches.

The researches on Energy Internet can be categorized by the following six topics: multi-energy systems/integrated energy systems, virtual power plant, energy router, "energy + big data", "energy + blockchain", "energy + transactive energy".

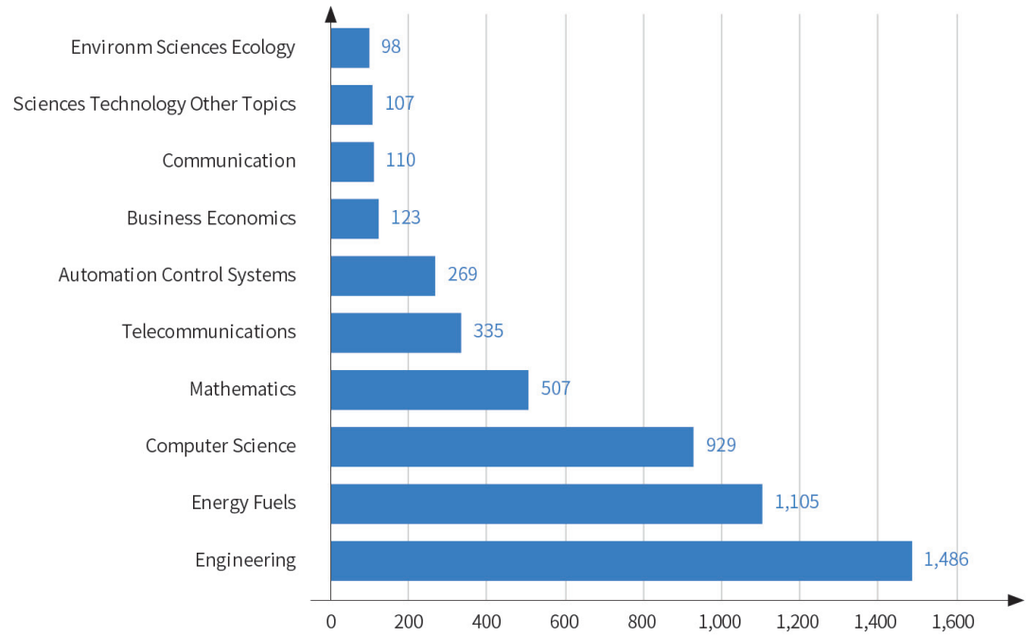
Quantity of Research Papers





The largest quantity of papers discuss the topic "energy + big data" in the SCI index and EI index, while multi-energy systems/integrated energy systems in CNKI. It indicates that international and domestic scholars focus more on "energy + big data" and multi-energy systems/integrated energy systems respectively.
In all the three databases, most of research papers are around the topics "energy + big data", multi-energy systems/integrated energy systems, or virtual power plant. It is a reflection of the research focuses at home and abroad in the past five years.

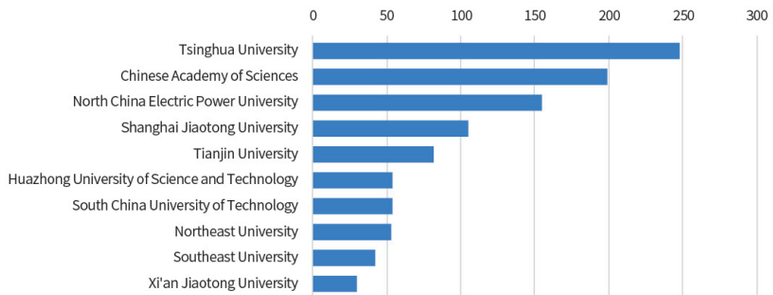
Discipline Distribution of SCI Research Papers



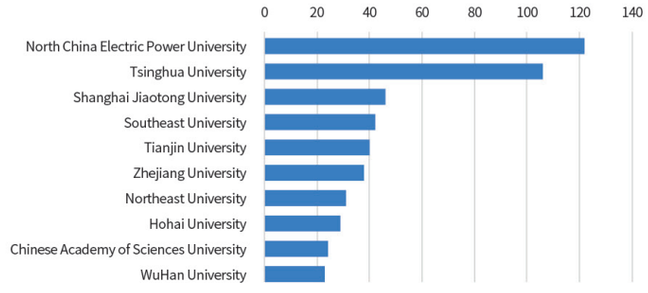
Research on Energy Internet involves many disciplines. SCI research papers are not mainly from one discipline, but are evenly distributed into various disciplines. This fact shows that interdisciplinary research of Energy Internet have aroused widespread attention of scholars with different discipline backgrounds.

According to the statistics of papers related to Energy Internet published by universities and research institutes in SCI, EI and CNKI databases, some universities and research institutes are active in the field of Energy Internet, while others are not. Tsinghua University, North China Electric Power University, Shanghai Jiaotong University and Tianjin University are active and rank Top ten in all the three databases.

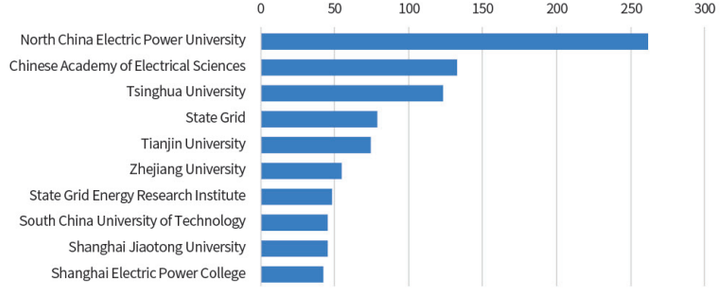
Quantity of SCI Papers



Quantity of EI Papers

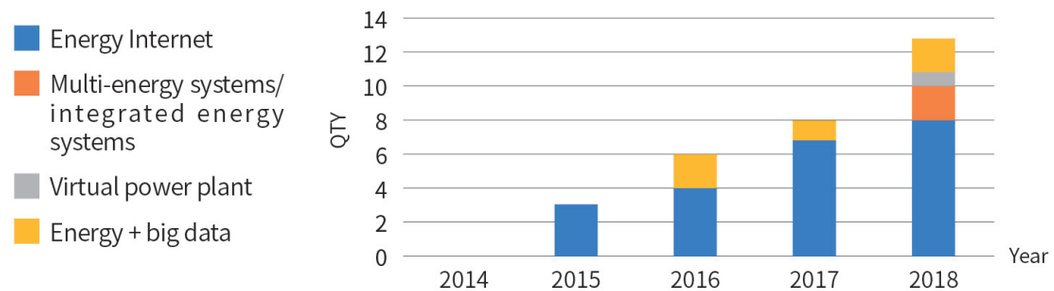


Quantity of CNKI Papers



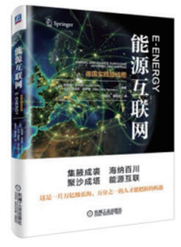
5.3 Monograph Publication

The quantity of monographs on Energy Internet has increased year by year. The following chart shows the quantity of monographs on Energy Internet from 2014 to 2018. The concepts including Energy Internet, integrated energy system, virtual power plant, and "energy + big data" are included in these monographs. It can be seen that the quantity of monographs has soared in the past five years, from 0 in 2014 to 13 in 2018.

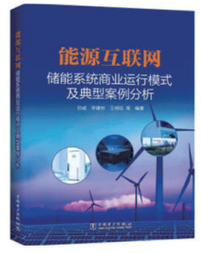


Monographs of Energy Internet in recent five years are listed in the following table:

Global Energy Internet
Liu Zhenya
China Electric Power Press



Energy Internet
Authors: Arnold Picot, Karl-Heinz Neumann;
Translators: Wen Ruijue, Dong Xiaoqing
China Machine Press



Energy Internet: Business Operation Mode and Typical Cases Analysis of Energy Storage System
Sun Wei, Li Jianlin, Wang Mingwang, etc.
China Electric Power Press

Energy 4.0: Industrial Energy Internet Reshapes China's Economic Structure
Gu Weidong
Publishing House of Electronics Industry

Energy Internet and Energy Conversion Technology
Sun Qiuye, Ma Dazhong
China Machine Press

Energy Internet Development Research
Energy Internet Research Subject Group
Tsinghua University Press

Energy Internet Technologies and Industries
Zhu Gongshan, Xu Yongjun, Cao Junwei, Chen Xinguo, Zhang Chi
Shanghai Scientific & Technical Publishers

Regional Energy Internet Exploration and Practice
Xiao Shijie, Chen Anwei, Shang Quanhong, Wang Kaijun
China Electric Power Press

Research on the Energy and Power Development of Anhui Against the Background of Global Energy Internet
Lin Boqiang, Chen Yu
Science Press

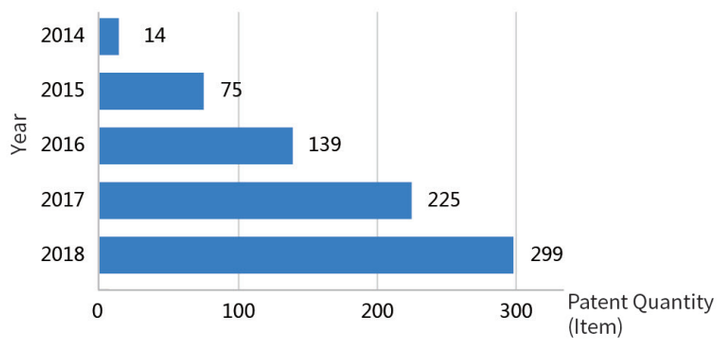
Energy Internet and Smart Energy	Feng Qingdong	China Machine Press
Energy Internet	Sun Qiuye	Science Press
Energy Internet System Part I General	The National Energy Administration	China Electric Power Press
Energy Internet and Energy System	Cao Junwei, Sun Jiaping	China Electric Power Press
Global Energy Internet	Wang Cunhua	China Water & Power Press
Urban Energy Internet Development and Practice	State Grid Tianjin Electric Power Company	China Electric Power Press
Energy Internet Advances China's Energy Transformation and Institutional Innovation	The Writing Group of Energy Internet Advances China's Energy Transformation and Institutional Innovation	China Development Press
Energy Industry Revolution: A Brief History of Global Energy Internet	Chen Fuqiang	Zhejiang University Press
Research on Regional Resources-Economy-Environmental Sustainable Development and Energy Internet -Case Analysis of Beijing-Tianjin-Hebei Development	Shen Xiaoliu	Science Press
All-round Team: Urban Energy Internet and Power Team Upgrading	State Grid Tianjin Electric Power Company	Enterprise Management Publishing House
Action Plan for Global Energy Internet Technology & Equipment Innovation (2018-2025)	Liu Zhenya	China Electric Power Press
Information-based Practice in the Smart Electricity Selling Market	Ma Tongtao, Han Yinghao	China Machine Press
Urban Energy Internet: Chengdu Practice	Chu Yanfang	China Electric Power Press

5.4 Patent Quantity

From 2014 to 2018, the quantity of patent applications in the Energy Internet field has increased year by year, without any slowdown. The quantity of patent applications raised from merely 14 in 2014 to 299 in 2018. The addition of patent indicators means more emphasis has been attached to intellectual property rights of Energy Internet in the past five years.

Patent Quantity of Energy Internet Across the Nation 2014-2018

The quantity of patent applications raised from merely
14 in 2014 to
299 in 2018



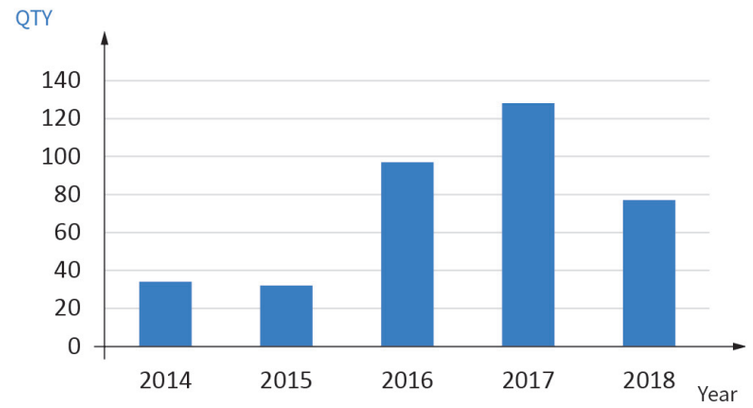
5.5 Graduate Education

The cultivation of professionals is crucial to the development of a discipline. In the past five years, the quantity of postgraduates graduated from the field of Energy Internet has been on an ascending trend across the nation, from only 34 in 2014 to 128 in 2017 (The data is based on the statistics of graduation theses in CNKI, and the data of 2018 is incomplete.) From the relatively obvious growth in 2016, we can infer that a great number of postgraduates chose to specialize in Energy Internet in 2013 and 2014. The three most popular concentrations of postgraduates coincide with the Top three popular research topics of the published papers, exactly the same as the rankings of quantity of CNKI papers.

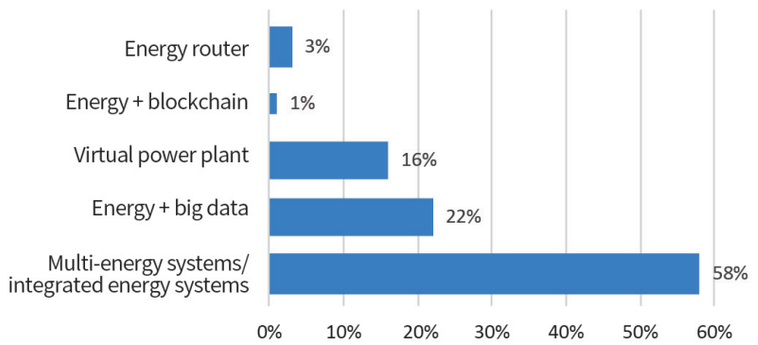
Quantity of Graduates

in 2014
34

in 2017
128



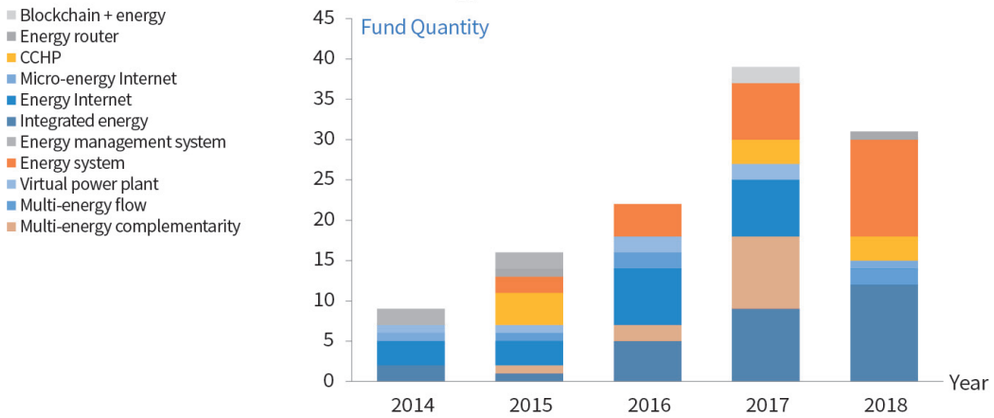
Graduation Thesis Topics of Graduates



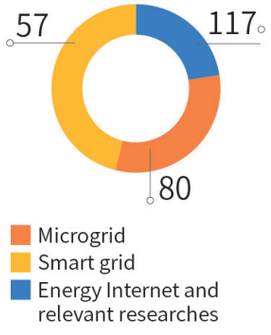
5.6 Research Fund

According to the research funds approved by the National Natural Science Foundation of China for the Energy Internet field, we can see that the fund especially for Energy Internet and relevant researches has risen year by year from 2014 to 2017, reaching the peak value of 39 in 2017 and then declining in 2018.

Fund for Energy Internet and Relevant Researches

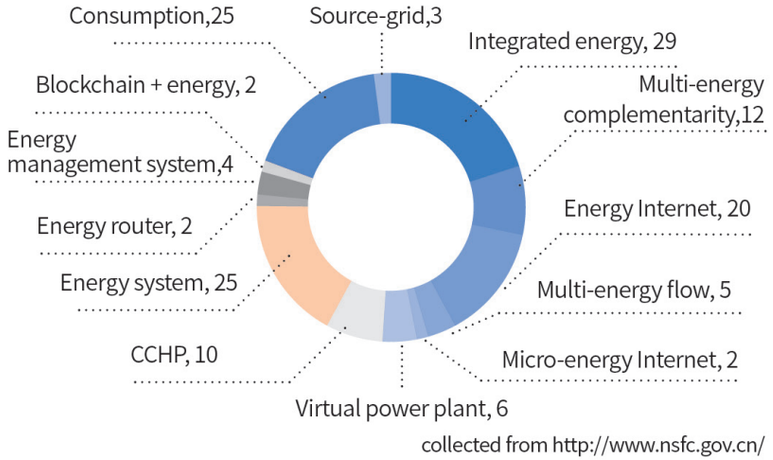


Distribution of the Funds for Energy Internet, Smart Grid, and Microgrid



The following pie chart describes the distribution of the funds for Energy Internet and relevant researches. It tells us that the most funds in the past five years are used for integrated energy, totaling 29. The quantity of funds for energy system and consumption are 25. Respectively, 20 and 10 funds are approved for Energy Internet and combined cooling, heating and power system (CCHP). A total of 117 funds are used for Energy Internet and relevant researches, exceeding the funds whose titles contain smart grid and microgrid.

Distribution of the Funds for Energy Internet and Relevant Researches



collected from http://www.nsfc.gov.cn/

06 Construction of Energy Internet in China

6.1 Infrastructure Construction

Overview of overall indicators

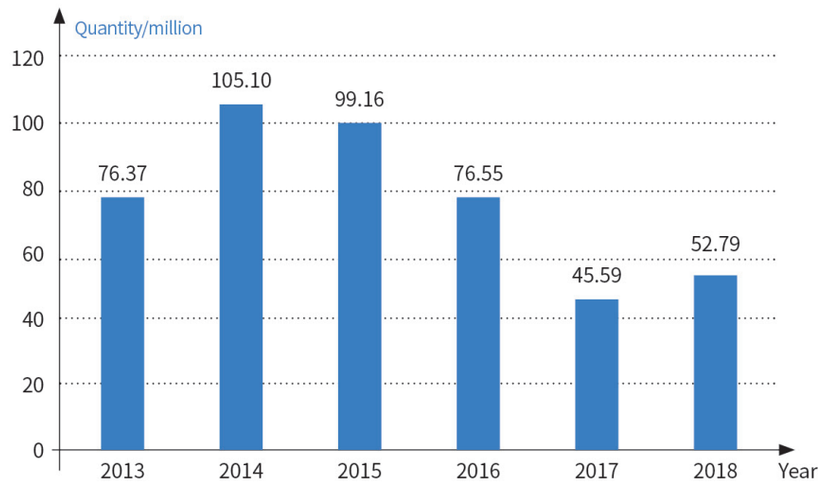
The current development and construction situation of the Energy Internet is widely reflected in the complementary level of multi-energy supply on the supply side, the interaction of the user side and the controllable degree of the system. By 2018, the key indicators for the development and construction of China's Energy Internet are shown in the following table:

Multi-energy complementary energy base 14	Thermal power storage installed capacity 1210MW	Distributed multi-energy joint installation 16.13million KW	Smart meter installation 598 million	Integrated energy meter installation 7.44 million
Battery storage installed capacity 2135MW	Demand side response capacity 28GW	Renewable energy vehicle ownership 2.61 million	Quantity of charging piles 289,7 00	Smart home device penetration rate 0.3%
Hydrogen generation 21 million tons	Quantity of hydrogen refueling stations 14	Integrated pipeline length 1180 km	Energy router installed capacity 14MW	Medium and low voltage DC distribution network 125.76MVA

Smart meter

- State Grid: In 2018, the coverage of Smart meters reached 98.83% in the State Grid, with cumulative meter collection of 523 million households and the new installation of 42.159 million meters.
- Southern Grid: By the end of 2018, Smart meters and the centralized low-voltage meter-reading system were applied to the entire network of Southern Grid, fulfilling the full-coverage goal in advance.

Quantity of Smart meters bidding of State Grid in 2013-2018



Multi-energy meter integration

In July 2015, the National Development and Reform Commission and the National Energy Administration issued the "Guiding Opinions on Promoting the Development of Smart Grid" to support the centralized purchase and reading of water, gas and electricity meters, and to build a dynamic data integration platform for cross-industry energy operation.

Shandong, Shanghai, Jiangsu, Jiangxi, Ningxia and other provinces and cities are pilots making the exploration into integrated energy metering.

At present, the integrated energy meters installed in China has amounted to 7.44 million.

Shandong has established a large scale multi-energy meter integration:

2016

In mid-2016, the multi-meter integration system in Shandong covered 138,000 customers.

2017

Two years later, the number grew to 620,000.

2018

At the end of 2018, a cumulative number of 1.1 million customers were connected to the multi-meter integration system of Shandong Electric Power Corporation.

The cumulative installed capacity of energy storage projects that had been put into operation in China was

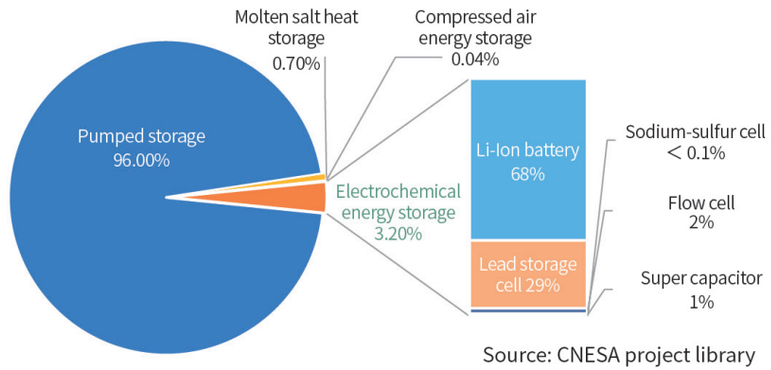
31.2GW

Year-on-year growth

8%

Energy storage technology

According to the statistics of CNESA project library, by the end of 2018, the cumulative installed capacity of energy storage projects that had been put into operation in China was 31.2GW, with an increase of 8% year-on-year. Among the installed capacity of all kinds, the pumped storage was the largest, reaching approximately 30.0GW with a year-on-year increase of 5%. It was followed by the electrochemical energy storage and molten salt heat storage with the installation capacity of 1.01GW and 0.22GW, up by 159% and 1000% respectively.



Source: CNESA project library

CHP/CCHP

The "13th Five-Year Plan" for electricity puts forward the specific requirement that the installed capacity of combined heating and power (CHP) shall reach 133 million kilowatts. According to the plan, Combined cooling, heat and power (CCHP) shall realize a total of 15 million kilowatts capacity in 2020. Below are some examples of practical construction projects in the nation:

In 2017, the State Power Investment Corporation Limited built a natural gas CCHP project with an investment of 5 billion yuan in Wuhan Development Zone, which plans to build 2 energy stations and 3 refrigeration stations.

Henan Province issued a document requesting the overall planning for setting gas-fired CHP projects in Luoyang, Zhoukou, Xinyang and other cities, with a view to building gas-fired CHP units with the capacity of 1.4 million kW and putting into operation in 2020.

By the end of 2017 in Datang Corporation Limited, 51.8% of clean and efficient power units and 49.8% of CHP units had produced the capacity of 600,000 kW or upwards. The installed capacity of gas units reached 361.08 million kW.

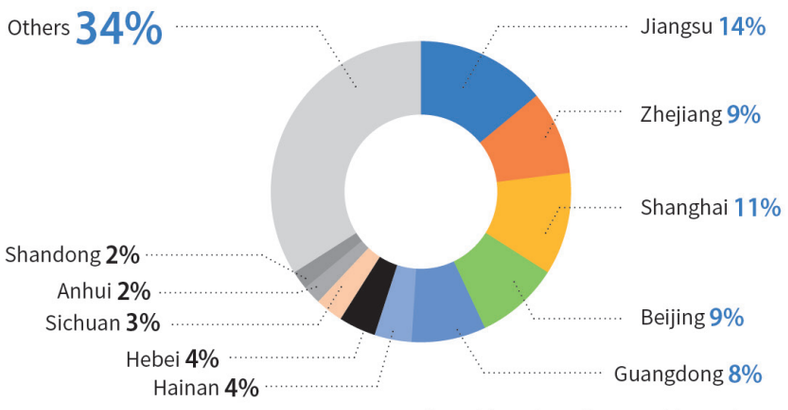
Smart home devices

The overall market size of China's Internet of Things industry had reached **1.2** trillion yuan

- According to the "White Paper on the Internet of Things 2018", the overall market size of China's Internet of Things industry had reached 1.2 trillion yuan by mid-2018. At the same time, the quantity of M2M connections in the public network amounted to 540 million. There are 120 enterprises whose output values are more than 1 billion yuan.
- Smart home manufacturing enterprises can be broadly divided into three categories by source:

Old-fashioned home business enterprises after transformation	Midea Haier GREE格力
Internet enterprises with expanded businesses	JD.COM 京东 Alibaba.com 阿里巴巴 Tencent 腾讯
Start-ups	BroadLink VIOMI 云米 KELADI

- Most of smart home integration service providers are located in the following Top 5 provinces and cities: Jiangsu, Zhejiang, Shanghai, Beijing, and Guangzhou. The distribution of smart home integration service providers nationwide is shown in the following figure.
- Those provinces and cities with a large penetrate rate of smart home service also lead the national development of demand response. The popularity of smart home service, in some degree, provides a basis for demand response.
- Smart home service mainly focuses on smart lighting, home security, smart home appliances and smart audio and video.



collected from http://www.cshia.org/

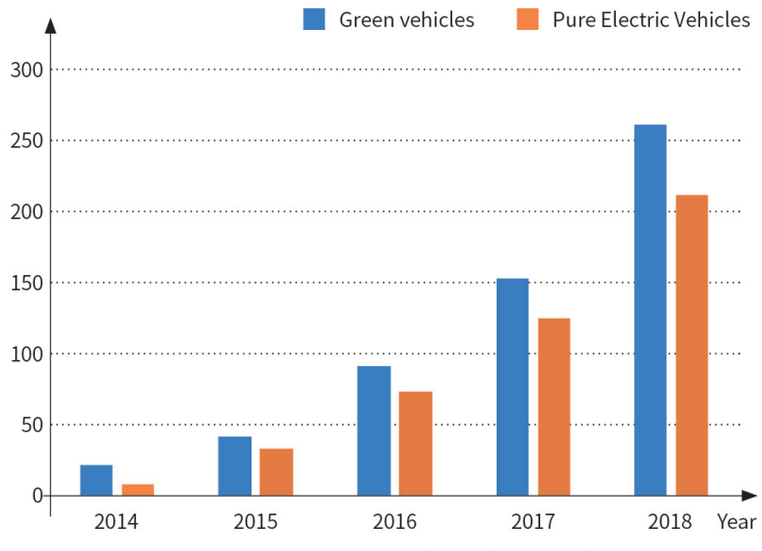
Green vehicles

- Chinese green vehicle industry has developed rapidly in the past few years. In the first half of 2018 (January to July), the sales of green vehicles were 445,000 in China.

- By 2018, the ownership of green vehicles had reached a total of **2.61** million, pure electric vehicles **2.11** million

- According to the latest data in NEVI 3.0, most of electric vehicles are found in the following Top five cities: Guangzhou, Shenzhen, Shanghai, Beijing and Hangzhou.

- Throughout the world, the well-known green vehicles brands include BYD, BAIC Group, Tesla, VW, Chevrolet, BMW, Nissan, etc.



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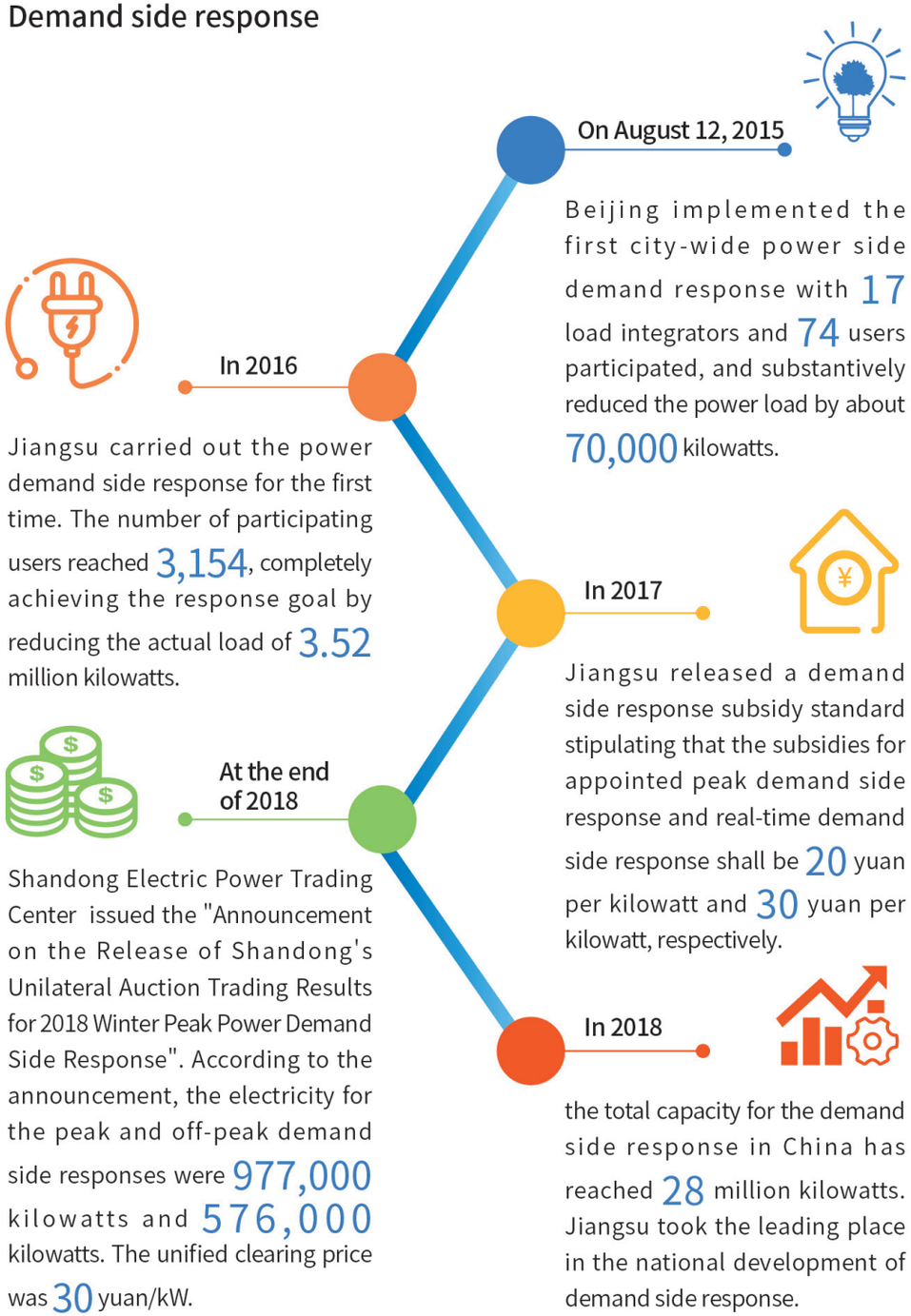
Demand side response



6.2 Demonstration Projects

From 2014 to 2018, in order to support and boost the development of China's Energy Internet industry, relevant government departments and agencies successively launched a host of pilot demonstration projects, including renewable energy microgrid demonstration projects, incremental distribution network demonstration projects, and multi-energy complementary integration and optimization demonstration projects, and "Internet +" smart energy demonstration projects.

Issuance Date	Project Type	QTY
7/13/2015	Renewable energy microgrid demonstration project	23
6/16/2016	Energy storage demonstration project	3
9/13/2016	Solar thermal power generation demonstration project	20
12/1/2016	First batch of incremental distribution network demonstration project	105
1/25/2017	Multi-energy complementary integration and optimization demonstration project	23
5/5/2017	Renewable energy microgrid demonstration project	28
6/28/2017	"Internet +" smart energy demonstration project	55
8/31/2017	Wind farm economical net pricing demonstration project	13
10/31/2017	2017 Intelligent manufacturing pilot demonstration project issued by the Ministry of Industry and Information Technology	9
11/21/2017	Second batch of incremental distribution network demonstration project	89
1/19/2018	"100 towns' clean heating demonstration project	136
6/25/2018	Third batch of incremental power distribution business reform pilot	28

On June 28, 2017, the Circular of the National Energy Administration on Disclosing the First Batch of "Internet +" Smart Energy was released. Since then, 55 Energy Internet demonstration projects covering 2 categories and 9 subcategories were officially launched.

First batch 55 Energy Internet demonstration projects

- Urban comprehensive pilot
- Park comprehensive demonstration
- Inter-regional transregional
- Electric Vehicles
- Flexible resources
- Green energy trading
- Industry integration
- Big data & service
- Intelligent infrastructure

1 Yanqing Science Park, Beijing
2 Suzhou Industrial Park
3 Xiamen Torch Development Zone
4 Haidian Northern New Area, Beijing
5 Chongming Island, Shanghai
6 Haining City, Zhejiang
7 Tianfu New Area, Sichuan
8 Hefei New & Hi-tech Industrial Development Zone
9 Urban comprehensive pilot, Guangzhou
10 Urban comprehensive pilot, Shanghai
11 Lingang District, Shanghai
12 Shanxi Science & Technology Innovation City

13 Beijing Economic Technology Development Area
14 Kunming Cheng Gong Information Industrial Park
15 Taixing Hongqiao Industrial Park, Jiangsu
16 Zhongning County, Ningxia
17 Economic Development Zone, Beijing Economic Technology Development Area
18 Tiangong Industrial Park, Jiangsu
19 Mengxi High-Tech Industrial Park, Inner Mongolia
20 Gaogou cable base, Wuwei Town, Wuhu
21 Jinggangshan Economic and Technological Development Zone
22 Green cloud computing center, Lvliang
23 Shanghai Disney Resort
24 Xinzhende Organic Agricultural Area, Anyang

25 Hengqin Industrial Development Zone, Zhuhai
26 Jingbian Industrial Demonstration Park, Yulin
27 Changxing New Energy Town, Huzhou
28 Zhuhai National Hi-tech Industrial Development Zone
29 Yongxing Island, Sansha

30 Public transport hubs demonstration, Chengde
31 Electric vehicles demonstration, Chengdu
32 New energy vehicles demonstration, Qinghai
33 Electric vehicles operation innovation, Changzhou
34 Time sharing renting of electric vehicles in three cities, Anhui
35 Low-carbon,intelligent public transport,Xixian New Area

36 Large-scale source-grid-load interaction, Jiangsu
37 Wind/PV/hydrogen storage microgrid, Baoji

38 Green energy trading platform, Xiamen
39 Green data center, Zhangjiakou
40 Power real-time trading platform, Gansu

41 Demonstration project of Zhangbei County
42 Huadian intelligent heating system, Dandong
43 Qinzhou aquaculture/PV/wind storage demonstration, Guangxi
44 Distributed energy trading, Hefei New and Hi-tech Industrial Development Zone

45 Big data energy service, State Grid
46 Natural gas e-commerce service platform, Changsha
47 PetroChina e-commerce platform
48 Energy management and auxiliary decision-making, Guangzhou
49 CLOU intelligent energy utilization, Shenzhen
50 Energy big data cloud platform, Guizhou

51 Energy big data application platform, Yunnan
52 Intelligent power utilization platform, Liaoning Electric Power Company

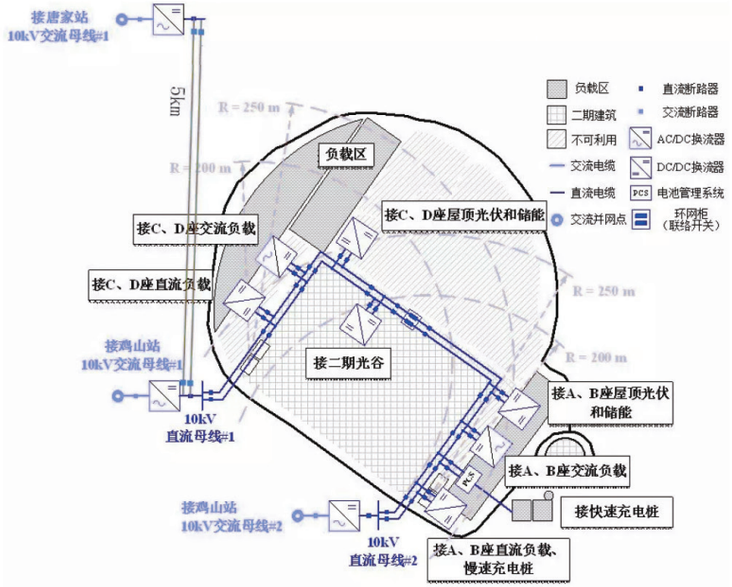
53 Energy and chemical industry base, China Pingmei Shenma Group
54 Green data center, Ningbo 21Vianet Information Technology Company
55 Lianyungang Economic & Technological Development Area, Lianyungang

6.3 Featured Projects

Here are some featured Energy Internet projects of certain reference significance for future projects.

The City-Park bilevel "Internet +" smart energy demonstration project supporting energy consumption revolution

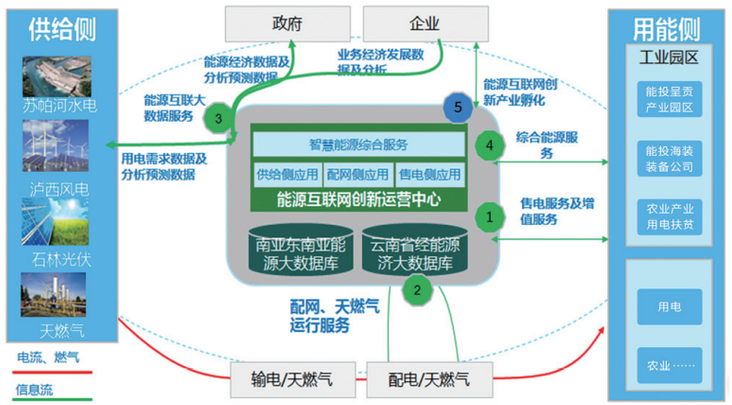
On December 25, 2018, the demonstration project was successfully put into operation. It is the world's largest multi-terminal flexible DC distribution network project with the largest capacity, the most voltage levels and many key independently innovative technologies. The integrated energy operation service platform is the key part of the demonstration project. In the energy consumption revolution, the project helps build a new model of "Internet +" smart energy, which has widespread demonstration significance.



Smart Energy Industry Integration Application Platform Based on Yunnan Energy Big Data

The project was completed and put into operation in June 2018. Based on the "Energy Cloud" platform independently developed by Yunnan Provincial Energy Investment Group, the project built an integrated application system of the smart energy industry that combined the intelligent energy operation monitoring platform, cross-industry big data integration analysis, and intelligent terminal application. Through the empirical analysis of big data, the project is the first to establish a comprehensive system of big data intelligent application. The system takes the energy industry as the core and supporting the integrated development of economic, industrial, agricultural and international capacity fields.

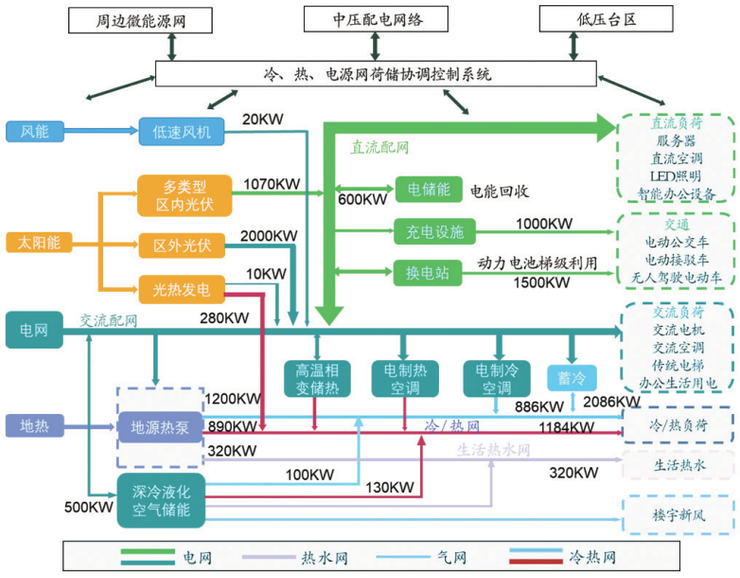
The project has innovated a new model of smart energy utilization, promoted the structural reform on the power supply side and the transformation and upgrading of the energy industry, and facilitated the rapid development of the energy big data industry in Yunnan.



Tongli Renewable Energy Town, Suzhou

On October 18, 2018, Tongli integrated energy service center was officially put into operation in Suzhou. It built a new regional Energy Internet with "power grid as the platform, multi-energy complementarity and intelligent configuration. A green, low-carbon park was set up in the Jiangnan area, integrating all links of energy generation, service, demonstration, R & D, and office use.

Tongli integrated energy service center launched 15 world's first energy innovation demonstration projects involving energy supply, configuration, consumption and services.



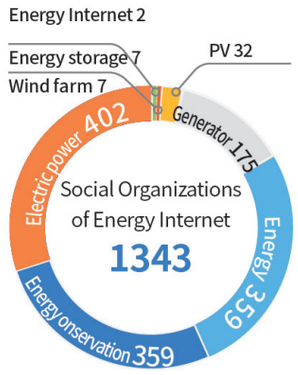
Transport and Energy Crossover Intelligent Innovation-Monitoring and Early Warning System for Natural Gas Supply Guarantee

The system used in the project was jointly developed by Zhongqi New Energy Investment Company and China Transport Telecommunications & Information Center under the Ministry of Transport. The project adopted big data mining and technologies to process the trajectory data of 13,000 LNG transport tanks across the country, and employed artificial intelligence algorithms for multi-dimensional data source fusion. More than 20,000 LNG gas terminals nationwide were identified, covering the data of industrial, urban fuel, refueling, power generation fields in the whole network.

07
Public Ecology of Energy Internet in China

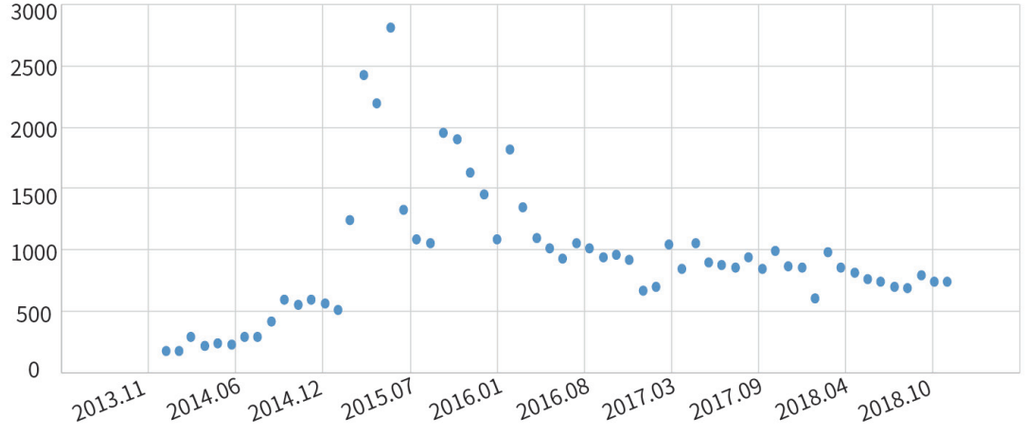
7.1 Social Organizations

China's open, sharing Energy Internet ecosystem has been gradually constructed. Driven by the industrial upgrading, a great number of social organizations related to Energy Internet have emerged and formed an organic ecosystem. A total of 1,343 social groups of Energy Internet with independent legal person were registered in China. The following distribution map is drawn according to industry or keywords.



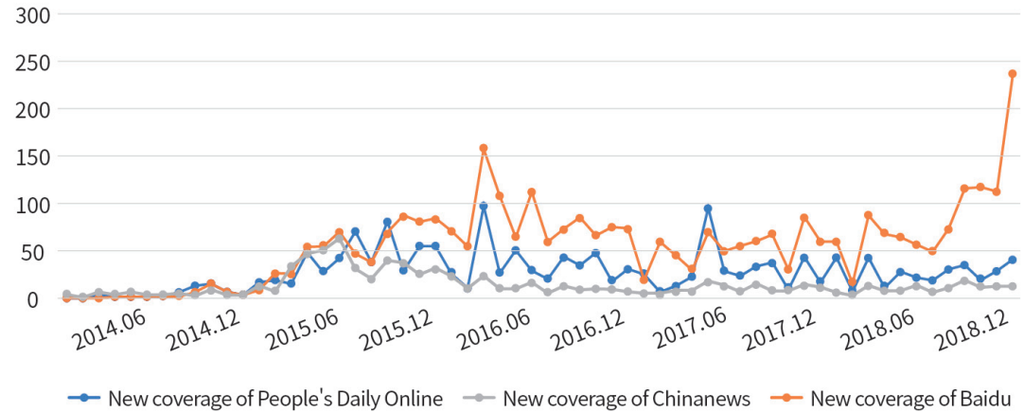
7.2 Public Awareness

The Baidu Index shows that the public attention to Energy Internet rose rapidly in 2015. In that year, people began paying attention to the Baidu index. After that, the public attention to Energy Internet remained a stable level.



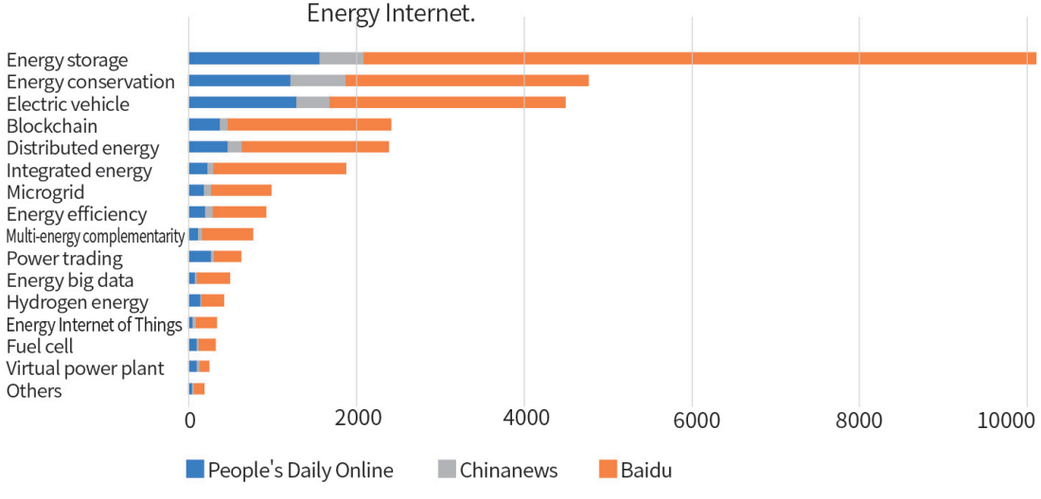
7.3 News Coverage

A massive explosion of Energy Internet broke out in 2015. An increasing quantity of Energy Internet news was reported by different online media. After that, the news coverage of Energy Internet remained a stable level. It is worth noting that in December 2018, the news coverage of Energy Internet on Baidu News surged, reaching about 250 pieces in a single month.



7.4 Word Frequency

The statistics of word frequency reflect that the attention to Energy Internet varies with topics. According to the statistics of word frequency from 2014 to 2018, energy storage, energy conservation and electric vehicle ranked top three among all words related to Energy Internet.



08
Top Ten Events of China Energy Internet

Top Ten Events of China Energy Internet

1 At the 6th meeting of Central Leading Group for Financial and Economic Affairs in 2014, General Secretary Xi Jinping clearly stated the "four revolutions and one cooperation" strategic thinking of energy revolution. Premier Li Keqiang proposed the establishment of an "Internet +" action plan. The CPC Central Committee issued the No.9 document entitled Several Opinions of on Further Deepening the Power System Reform in 2015.

2 In April 2015, the Energy Internet Research Institute, Tsinghua University was officially founded, becoming China's first professional research institution of Energy Internet. In October of the same year, the Energy Internet Research Center of North China Electric Power University was established.

3 In March and August 2016, the Global Energy Internet Conference and the China Energy Internet Summit were held one after another. The Global Energy Interconnection Development and Cooperation Organization and the National Energy Internet Industry and Technology Innovation Alliance were established.

4 In February and April 2016, the National Development and Reform Commission, the National Energy Administration, the Ministry of Industry and Information Technology and other ministries and departments endeavored to work out action plans for the development of China's Energy Internet technologies, by promulgating a succession of documents including Guiding Opinions on Pushing Forward the Development of "Internet +" Smart Energy and Energy Technology Revolution Innovation Action Plan (2016-2030).

5 By 2016, PetroChina and Sinopec successively signed cooperation agreements with Tencent and Alibaba to establish a long-term, comprehensive strategic partnership and explore a new model of traditional energy + Internet cooperation.

6 In May 2016, the Huawei Electric Power Partner Conference was held, which aimed at joining hands with energy companies to realize the great vision of the global Energy Internet.

7 In June 2017, the National Energy Administration announced the first batch of "Internet +" smart energy (Energy Internet) demonstration projects.

8 In November 2017, the first IEEE Conference on Energy Internet and Energy System Integration was held in Beijing.

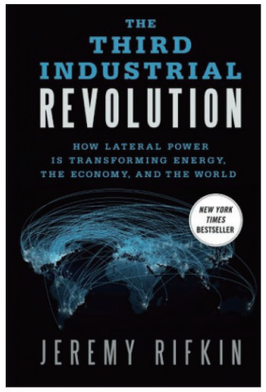
9 In January 2018, the State Grid Corporation of China issued the "State Grid Corporation 2018 No. 1 Document", proposing to build a world-class Energy Internet enterprise with sharp competitiveness.

10 In September, October and November 2018, the China Energy Research Society, IEEE Power&Energy Society, and Chinese Society for Electrical Engineering set up the Energy Internet professional committee separately.

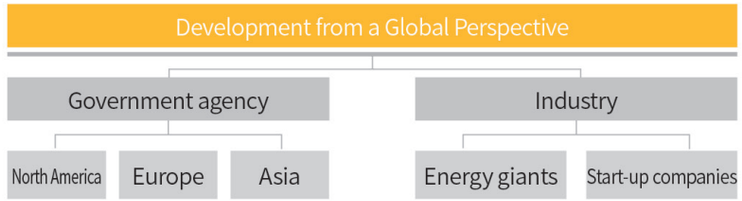
The above events were selected based on the results of online voting conducted by the Energy Internet Research Institute, Tsinghua University.

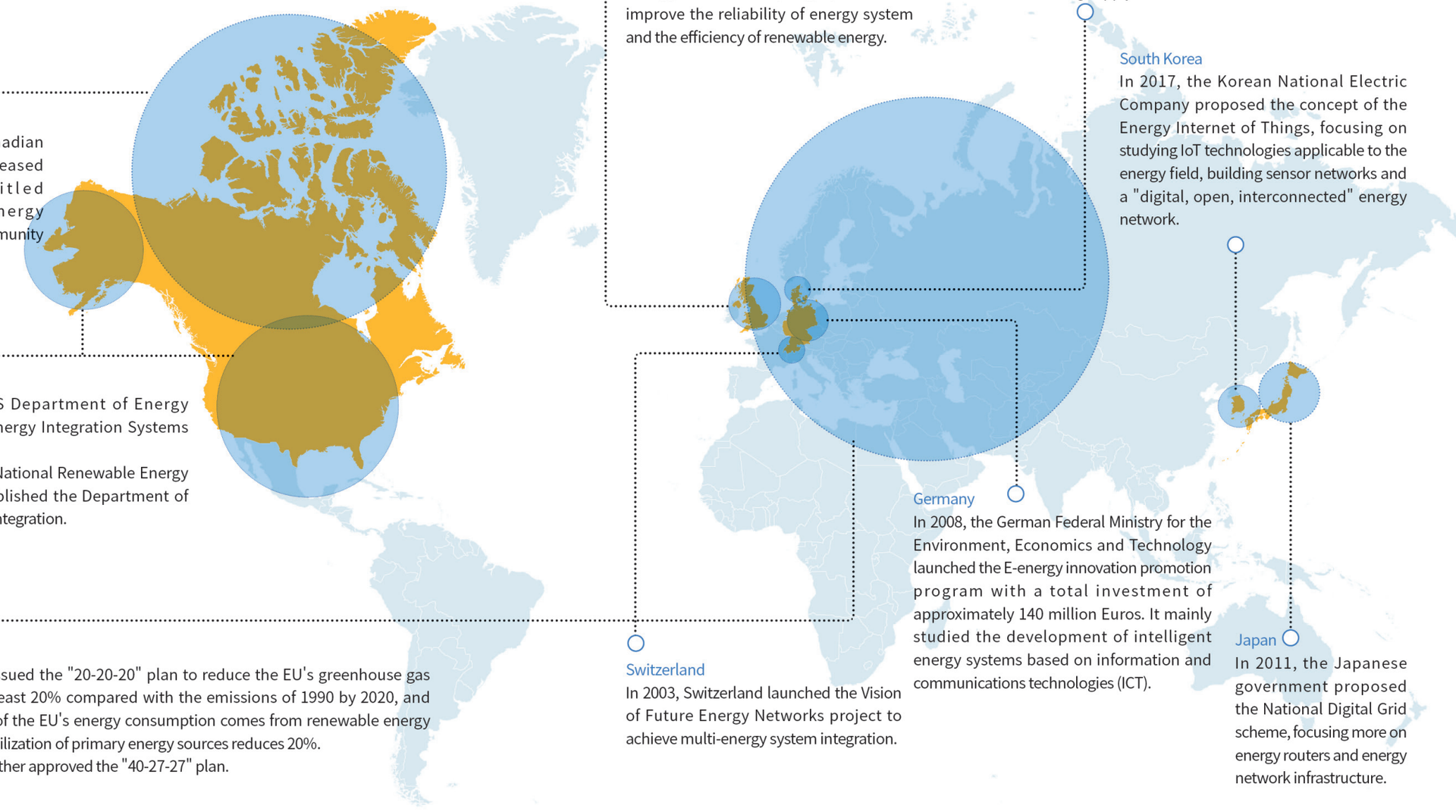
09
Energy Internet from Global Perspective

9.1 Definitions and Interpretations by Different Nations



From a global perspective, various countries around the world have begun to explore Energy Internet practices for more than a decade since 2000. They adopted different ways to interpret, construct, test, and demonstrate multi-energy integration systems. Their pactices and projects expect to find a new method of energy generation. These methods are formally named Energy Internet in Rifkin's book The Third Industrial Revolution.





Canada
In 2009, the Canadian government released a report entitled "Integrated Energy Systems for Community Development".

US
In 2001, the US Department of Energy proposed the Energy Integration Systems plan.
In 2008, the US National Renewable Energy Laboratory established the Department of Energy Systems Integration.

EU
In 2008, the EU issued the "20-20-20" plan to reduce the EU's greenhouse gas emissions by at least 20% compared with the emissions of 1990 by 2020, and ensure that 20% of the EU's energy consumption comes from renewable energy sources and the utilization of primary energy sources reduces 20%.
In 2014, the EU further approved the "40-27-27" plan.

UK
In 2011, the EPSRC in UK proposed HubNet project, focusing on the study of multi-energy network coupling operation to improve the reliability of energy system and the efficiency of renewable energy.

Switzerland
In 2003, Switzerland launched the Vision of Future Energy Networks project to achieve multi-energy system integration.

Denmark
In 2013, the Danish government set a medium-term goal and a long-term goal. They were to use renewable energy to satisfy all the electricity and heat demand by 2035, and to ensure the proportion of renewable energy reaching 100% by 2050. The government also encouraged to energetically develop distributed energy, and use biomass energy to realize combined heat and power, and centralized heating supply.

South Korea
In 2017, the Korean National Electric Company proposed the concept of the Energy Internet of Things, focusing on studying IoT technologies applicable to the energy field, building sensor networks and a "digital, open, interconnected" energy network.

Germany
In 2008, the German Federal Ministry for the Environment, Economics and Technology launched the E-energy innovation promotion program with a total investment of approximately 140 million Euros. It mainly studied the development of intelligent energy systems based on information and communications technologies (ICT).

Japan
In 2011, the Japanese government proposed the National Digital Grid scheme, focusing more on energy routers and energy network infrastructure.

9.2 Practices and Plans of Different Nations

The industrial circle carried out the following practices of Energy Internet.

Energy giants

SIEMENS Ingenuity for life

In 2015, Siemens proposed the Internet of Energy for Electric Mobility project to build a distributed, information-based future power system.

通用电气

In 2014, GE introduced the Digital Electricity Value Network project, which aimed to provide digital intelligent solutions for future power systems.

ABB Power and productivity for a better world™

In 2017, ABB launched the ABB energy industrial cloud platform, which aimed to advance the digital and intelligent development of the energy industry. A highlight of the platform was the intelligent management of urban low-voltage distribution networks, including the state intelligent estimation of circuit breakers, energy management pf distribution networks, and access management of renewable energy.

Start-up companies

Brookfield Utilities UK

Brookfield Utilities UK, a renewable energy services company, introduced a comprehensive energy infrastructure concept that was directly oriented to the user or incremental network energy market. It set up four subsidiaries-Gtc, Metropolitan, Power on and Exoteric to take charge of electricity, heat, gas, water supply network construction and integrated supply management.

Homer Energy

Homer Energy in the US specialized in micro-grid optimization control and user-side integrated energy consumption management. It launched several types of software for Energy Internet, including Homer Pro and Homer Grid.

Oracle Utilities

Oracle Utilities in the US conducted in-depth analysis and optimization management of various third-party data, and launched various services such as data analysis, energy conservation management, operation optimization, and network management.

C3

C3 Company in the US was dedicated to being an enabler of the traditional power energy industry through artificial intelligence. On the power generation side, it realized equipment intelligent management and information interconnection. On the grid side, it built the physical information system and optimized intelligent operation. On the user side, it undertook user portrait depiction and the management of intelligent demand response.

10
Expert Comments on Energy Internet

Cheng Shijie: The product after deep integration of energy system and Internet technology

An important role of Energy Internet is to promote complementary utilization of integrated energy.

Du Xiangwan: Building an Energy Internet with "Three Features" and "Two Combinations"

That is to build an electrical, low-carbon, and intelligent Energy Internet combining distributed and centralized systems, and meanwhile combining multi-energy complementarity on the horizontal level and "source-grid-load-storage-consumption" on the vertical level.

Guo Jianbo: Bringing a series of electric power-centered technological reforms and a long industrial chain with extensive comprehensive utilization

"Two replacements", replacing fossil fuel with clean energy and electrical power, are the main direction for sustainable development of the world's energy.

Han Yingduo: The burgeoning development of Energy Internet is inevitable.

The biggest difference between Energy Internet and the traditional energy network is multi-energy coordination, whose direct result is the improvement of efficiency.

Huang Qili: Global Energy Internet creates a new opportunity to lead clean energy technology innovation and industrial development.

The implementation of global Energy Internet is bound to greatly promote and advance the vigorous development of clean energy technologies, industries and modern power grids.

Liu Jizhen: Hybrid energy is the key technology for developing the global Energy Internet.

The original mode of the power system stuck to "primary energy storage and secondary energy control". This needs to upgrade to a new mode to achieve balance between stochastic energy supply and stochastic demand.

Lu Qiang: Compared with nuclear fusion, I am more looking forward to global Energy Internet.

It will lead us to a promising road for energy development and utilization. We would seek international collaboration and cooperation, and address the fundamental contradiction between the continuous growth of energy demand and the continuous improvement of the living environment.

Xue Yusheng: Using Internet technologies to promote the transformation from centralized fossil energy utilization to distributed renewable energy utilization

The coordination and interaction of various physical devices within Energy Internet requires the support of a powerful information network.

Yu Yixin: The future intelligent power grid is Energy Internet.

For the research and construction of Energy Internet, we shall combine theoretical researches and experimental researches.

Zhou Xiaoxin: Developing Energy Internet can draw reference to the development of the Internet.

As energy transmission is vastly different from information transmission, we cannot directly copy the concept of the Internet or the way the Internet is implemented.

Experts are listed by name in alphabetic order.