An Overview of City Smart Grid in China

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Contents

A Smart Grid will be characterized by a two-way flow of electricity and information to create an automated and widely distributed energy delivery network. It incorporates into the grid the benefits of distributed computing and communications to deliver real-time information and enable the near-instantaneous balance of supply and demand at the device level.

I. The needs and the requirements on city smart grids in China

I will introduce investigations on the needs and the requirements on city smart grids in China , which based on statistics of the current operation states of 10 kV power distribution grids of 40 large and middle size cities , and finished by CAE and Tianjin University.

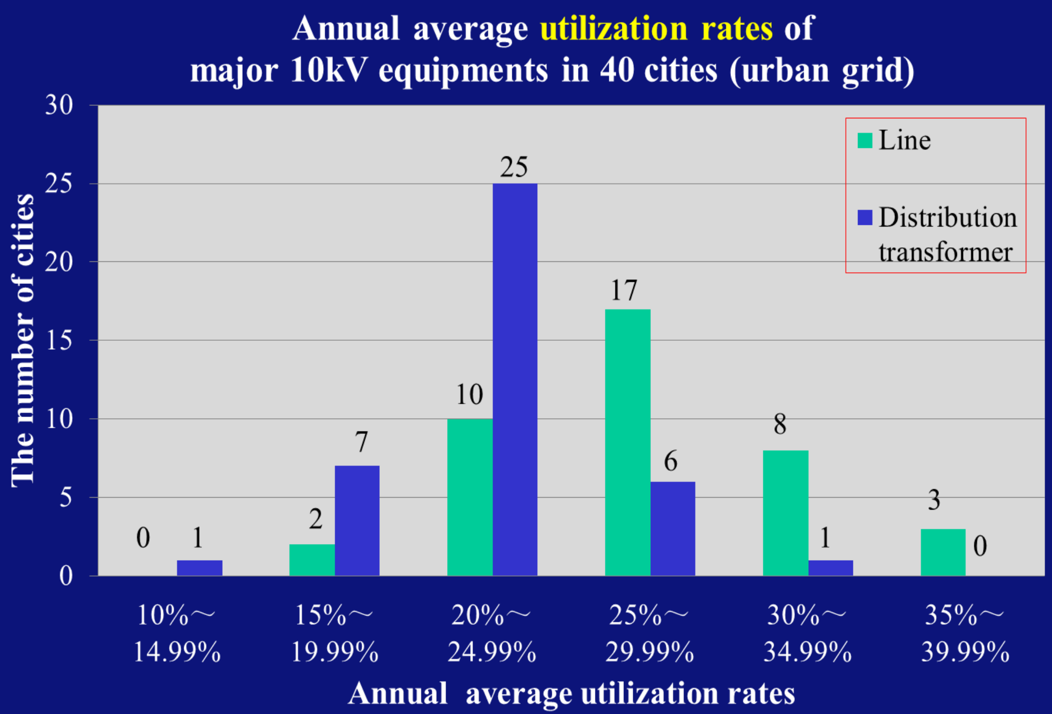
It includes the following 5 parts:

1. **Investigations on the practical distribution asset utilization**
2. **Investigations on the simultaneity factor**
3. **Investigations on the load compositions and characteristics**
4. **Investigations on reliabilities in urban areas**
5. **Investigations on distributed generations**

7 Results and 7 Facts are summarized from these investigations.

1. Investigations on the practical distribution asset utilization in 40 cities----2 facts can be summarized

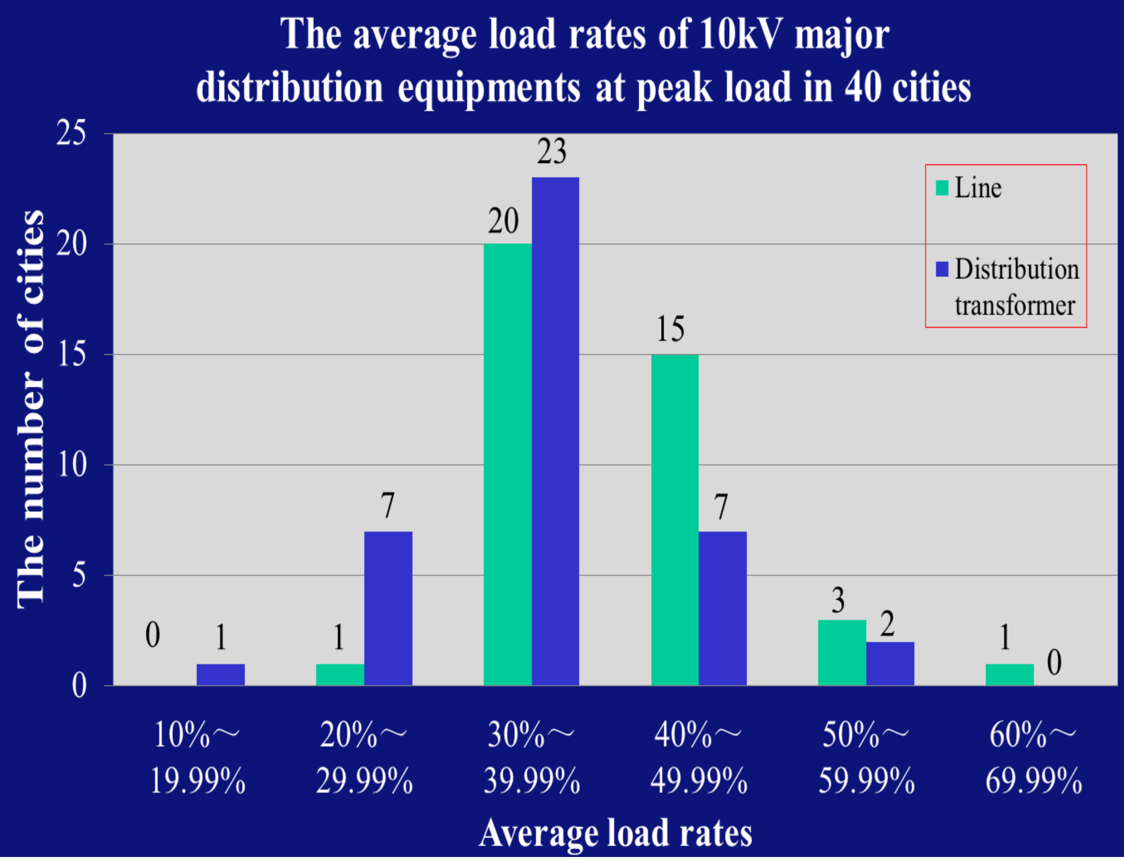
Result 1 :



- The annual average utilization rates of the 10kV feeders of 26 cities, which accounts for 72.5% of the 40 cities, is between 10% and 30%;
- The annual average utilization rates of 10kV distribution transformers in 39 cities, which accounts for 97.5% of the 40 cities, is between 10% and 30%.

***Fact 1**: The annual average utilization rates of the 10kV feeders and 10kV distribution transformers are much lower (even lower then that in the U.S.---Grid 2030)*

Result 2 ：



➢At city peak load time, the average load rates of 10kV feeders in 36 cities are below 50%, and in 22 cities are below 40%.

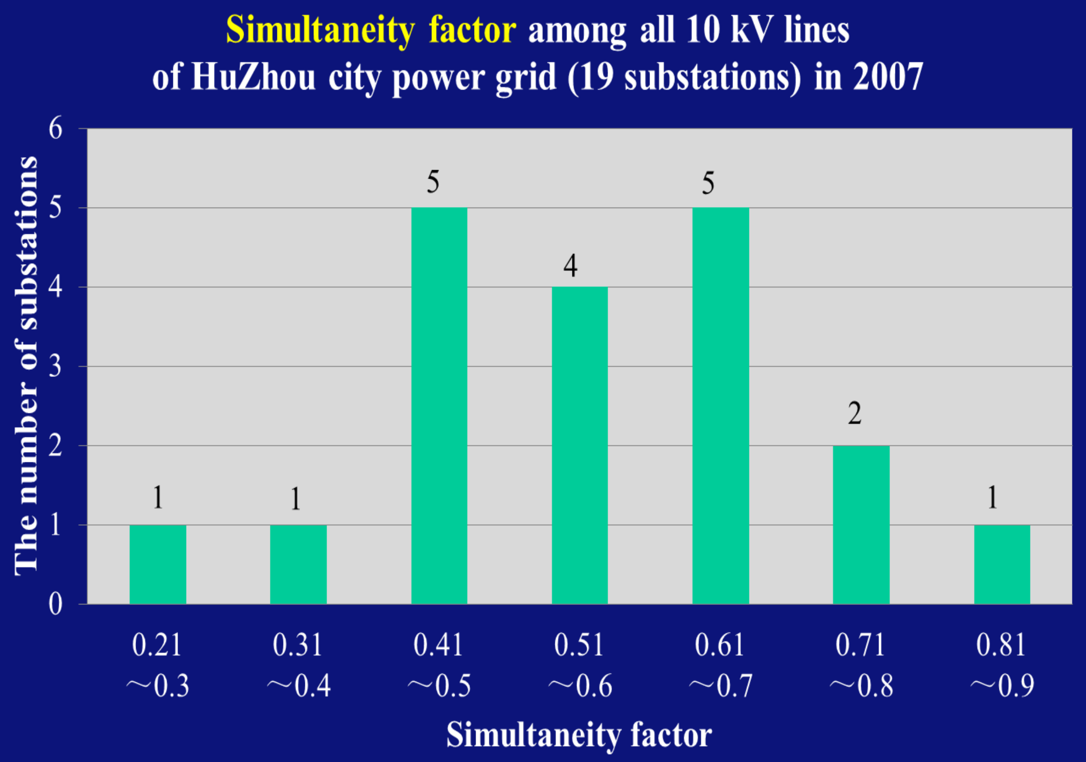
➢At city peak load time, the average load rates of 10kVdistribution transformers in 38 cities are below 50%, in 31 cities are below 40%.

Fact 2 : ***At city peak load time, the city average utilization rates of the 10kV feeders and 10kV distribution transformers are very low.***

2. Investigations on the simultaneity factor

Result 3:

The average simultaneity factor along all feeders connected to one substation is about 0.57.



Fact 3: *The probability of simultaneity occurring of maximum load along two or more feeders , which have mutual connections, is not very high, such that they have potential supporting capacities of power flow with each other at peak load.*

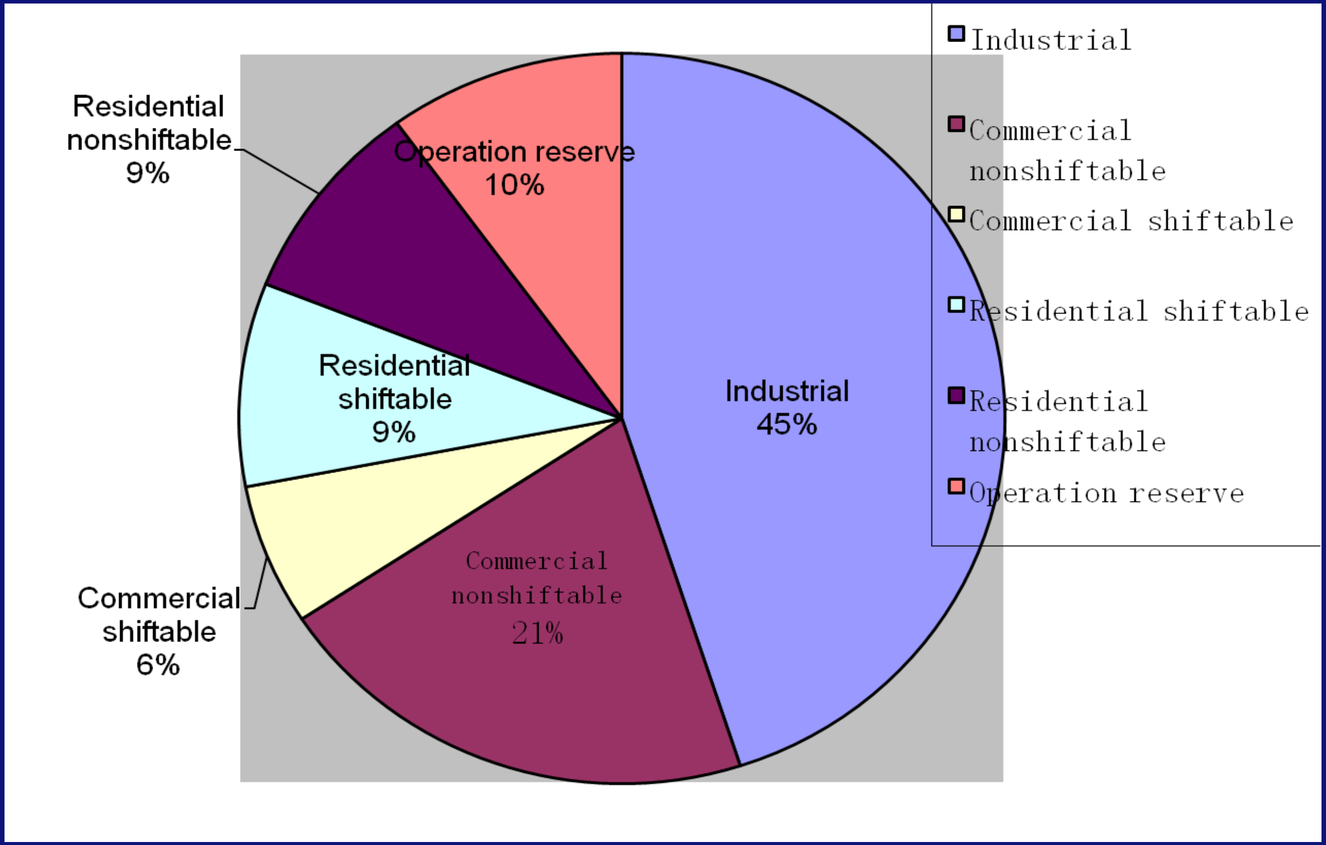
Facts 1-3 show that there exist the following potential needs and requirements for increasing the asset utilization rates:

- ***Expanding and upgrading infrastructure to have flexible distribution grid topologies and communications to assure cyber security and resilience, and***
- ***Implementing functions of self healing and operation optimization based on intelligent distributed control system architecture.***

3.Investigation on the load composition and characteristic

Result 4:

This figure, and Tab.1 and Tab.2 (in next page) are showing the investigation results on load composition & characteristic.



Proportion of peak load in winter in a big city in China

industry	Energy（%）				Load（Power）（%）			
	Shenzhen	Dongguan	Qingdao	Zhengzhou	Shenzhen	Dongguan	Qingdao	Zhengzhou
Primary industry	3.87	0.19	2.02	7.21	8.23	0.39	4.31	11.26
Second industry	61.24	78.18	67.39	36.35	47.91	65.28	49.80	25.80
Teriary industry	22.86	12.10	14.47	26.92	27.02	17.89	17.87	30.02
Resident	12.03	9.53	16.12	29.52	16.84	16.45	28.02	32.92
Socioety	100	100	100	100	100	100	100	100

Table 1.The load characteristics of some cities in the investigations

−the residential load might be reach to 16%-30% of the peak load

City	Daily load characteristics	
	Winter typical day	Summer typical day
	Day peak-valley difference rate	Day peak-valley difference rate
Shenyang	0.387	0.407
Hefei	0.361	0.430
Guangzhou	0.468	0.407
Shenzhen	0.394	0.443
Dongguan	0.475	0.409
Foshan	0.310	0.300
Shantou	0.516	0.390
Guiyang	0.461	0.367
Zhengzhou	0.429	0.494
Jinan		0.631
Qingdao		

Table 2. The load constitution of some cities in 2008

--the Dailly peak-valley difference rate of load might be reach to 0.36-0.5

Fact 4: ***The tertiary industry and residential loads have enough potentials as shiftable loads (grid friendly users) to help reducing the peak-valley load difference of power system.***

- ***Note that: Via prompting DR, Grid Friendly Appliances (GFAs) such as heating, AC, HW, refri. and so on will shaft their demand, such that the big differences between peak and valley of the daily load curves can be reduced.***

Fact 4 shows that there exist the following <u>potential needs & requirements</u> for active interactions between utilities and customers :

- ***Develop a mature, robust and well-integrated wholesale markets***
- ***Implementing AMI , with developing smart tools and technologies to utilize DR, DLC and EE.***

4. Investigations on reliabilities

----3 facts can be summarized

The investigations on reliabilities show that:

Result 5:

During the past years, the average annual outage time at end-users of urban in China were much longer than 1 hour , and even longer than several hours. While the average annual outage time of urban and rural users was less than 80min. in the US, 40-70min. in European countries and less than several minutes in Hongkong, Tokyo and Singapore.

Fact 5 : Although the distribution systems are with quite large capacity margins in China, the power interrupt time at end-users are much longer then that in developed countries and areas.

Result 6:

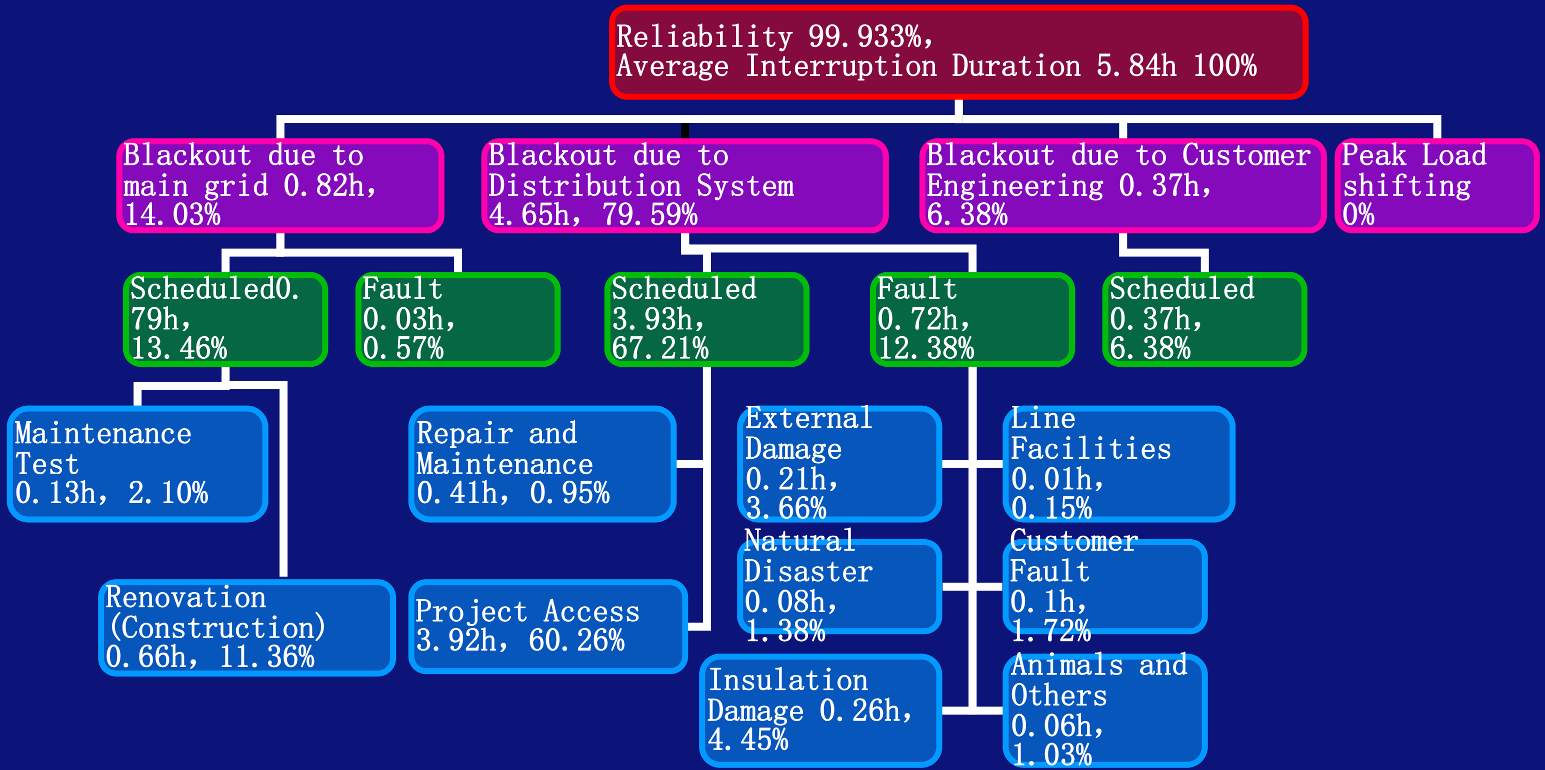
The 10kV and lower voltage distribution networks are impacting urban customer's reliability with more than 70-80% contribution in customer hour loss.

Fact 6: The city distribution network failures are the main factor of the causes of outage

Remark: ***In distribution grids, during outages, searching fault line, locating failure place, isolating fault, and supply recovery lack of the support of automatic means. Such that in most cities, switching non-failure segment into power supply takes a long time.***

Result 7 :

According to statistics of power supply of 364 cities in 2007, pre-arranged outage accounts for 78% of total outage time(see the Fig. below)



***Fact 7**: In many cities, **pre-arranged outage** has great effects on power supply reliability.*

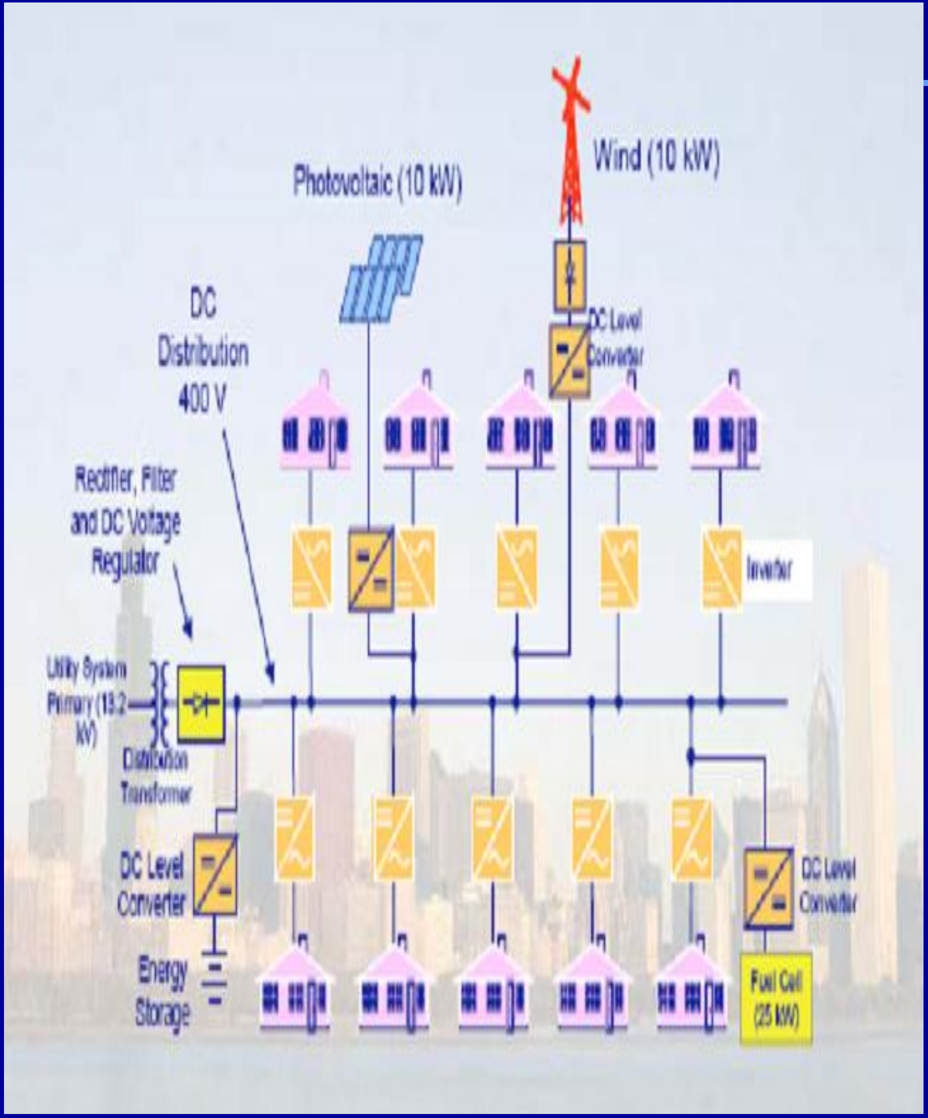
Facts 5-7 shows that there exist the following additional potential needs and requirements for improving reliability:

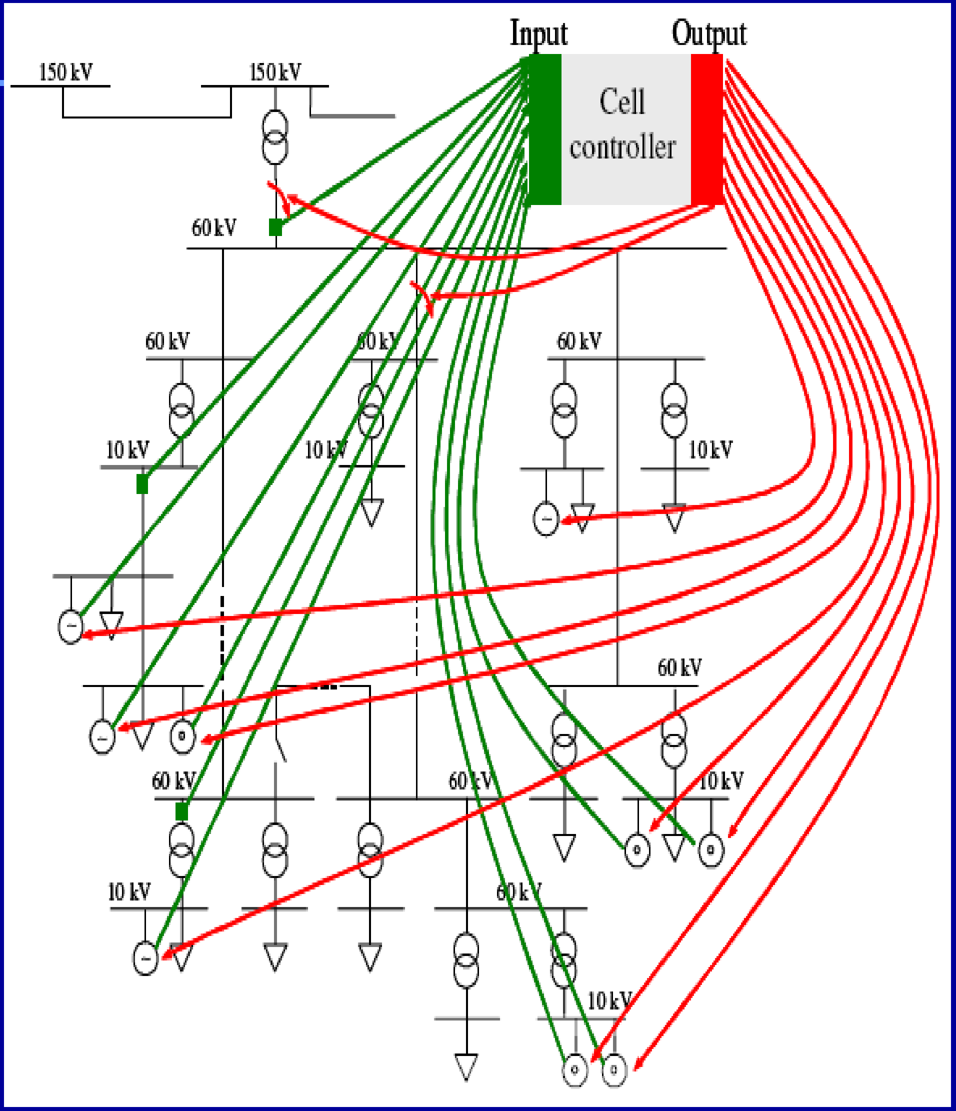
- ***to have flexible grid topology and communication***
- ***to have DFSM coordinated advanced distribution automation (ADA)***
- ***to have reliable distributed generation(DG).***

5. Investigations on integrating DG

The investigations on integrating DG show that:

- ***The costs of solar and wind power DG are starting to be acceptable for residential in China---, the theoretical payback period of the capital cost reduced to around 7-10 years.(1w capacity of PV costs less then 1 US$)***
- ***Exist "Plug and play" practices in some urban areas. Since right now the total amount of solar and wind power DG is very small, no impacts on frequency . However, utilities may need to improve distribution grid and VVC.***
- ***Even Smart Micro-Grids is a perfect version of CSG, but for most of the renewable distributed generation the scheme of active distribution grids is preferable, since prices of the energy storage devices are too high up to now.***





Micro-Grids

Active power distribution grids

The additional potential needs and requirements on R&D for integrating DG are as follows:

- ***Developing standards and protocols for equipment performance ，communication interoperability， distributed generator, interconnection distribution grid expansion，as well as collecting and managing distribution operations data.***
- ***Developing models， algorithms and tools to optimize smart grid capabilities for system planning and operations in the presence of high uncertainty (higher penetration of variable output)***

To increase the asset utilization rates, the electricity efficiencies and the reliability of city power grids, as well as to integrate increasing amount of distributed variable output renewable resources， city smart grids are needed in China with satisfying the abovementioned requirements:

1. ***Expand and upgrade infrastructure to have a flexible distribution grid topologies and communications to assure cyber security and resilience, to implement functions of self healing and optimization, and to integrated higher penetration of renewable generations.***
2. ***Implement AMI , with developing smart tools and technologies to utilize DR, DLC and EE.***
3. ***Implement functions of self healing and operation optimization with intelligent distributed control system architecture and voltage management.***
4. ***Build a mature, robust and integrated power market， as well as related policies, regulations, research and experiments on power market.***
5. ***Develop standards and protocols for equipment performance ， communications interoperability， distributed generator interconnection as well as distribution grid expansion， collecting and managing distribution operations data.***
6. ***Develop models， algorithms and tools to optimize smart grid capabilities for system planning and operations in the presence of high uncertainty (higher penetration of variable output)***

II. Considerations and implementations on city smart grid in China

While many interests and efforts on

- **Advanced transmission operations(ATO)**

have been taking ,other smart grid components as

- **Advanced Metering Infrastructure (AMI),**
- **Advanced Distribution Operations (ADO) and**
- **Advanced Asset Management (AAM) are**

emphasized as well in China .

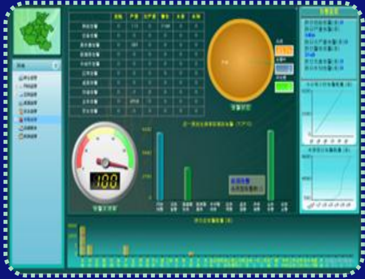
The following table is showing the investments of pilot projects related to city smart grid(CSG) since 2009 given by SGCC(state grid company , China—It supplies 80% of the electrical power in China)

1. Pilot Projects of SGCC related to CSG Since 2009

Field	Project	Investment (bil. yuan)
Distribution	1.Distribution Automation 2.Integration of Distributed PV 3.Micro-grid Operation & Control	2.04
Consumption	1.AMI 2.EV Charging and Swapping Facility 3.PFTTH 4.Call Center and Interactive Service Platform 5.Smart Community/Building/Industrial Park 6.Demand Response	4.18
Dispatching	1.Advanced EMS	0.58
ICT	1.Information Platform and Cyber Security 2. Cloud Computing 3.Internet of Things	0.46
Smart Demo	1.Shanghai Expo; Tianjin Eco-city; Beijing Future City; Yangzhou; Youth City, Jiangxi	1.30

In 2012, the State Grid Company have promoted 16 mature pilot projects as follows, for steadily constructing smart grid in China.



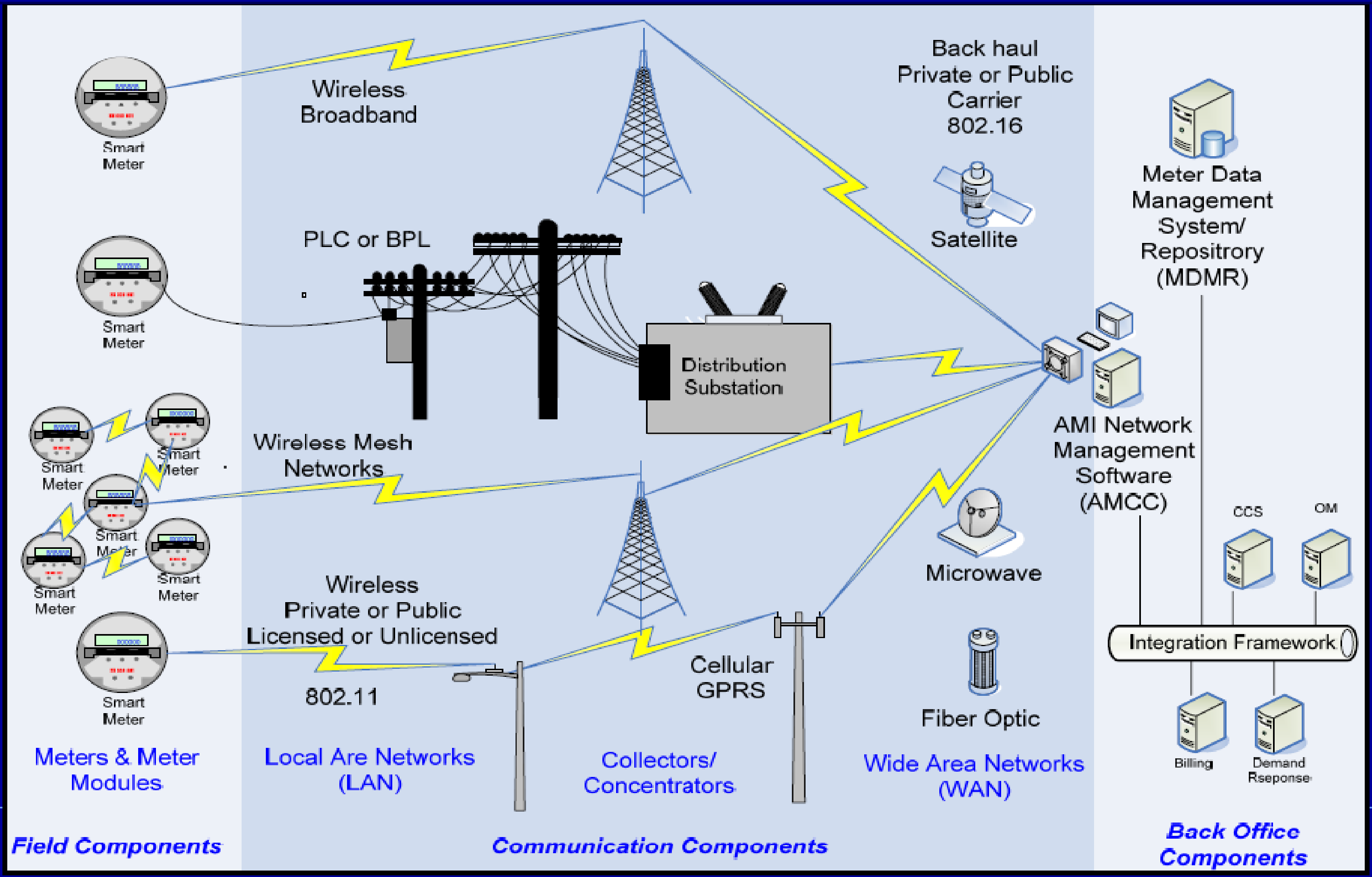

Construction of 17 integrated smart grid demonstration projects	**Construction of 196 new chargers and 1945 AC charging stations for EVs**	**Construction of 1329 new smart substations, and transformation of 132**	**Construction of 260,000 electricity FTTH**	**Construction of DAS in 26 provincial companies**
Construction of 8 provincial smart grid scheduling support system	***Now there exist o.12billions meters***	**In the 13 provincial companies to carry helicopters, UAV intelligent data logging**	**Construction of 17 provincial-level 95598 service websites**	**Building 281 nodes of backbone communication network**

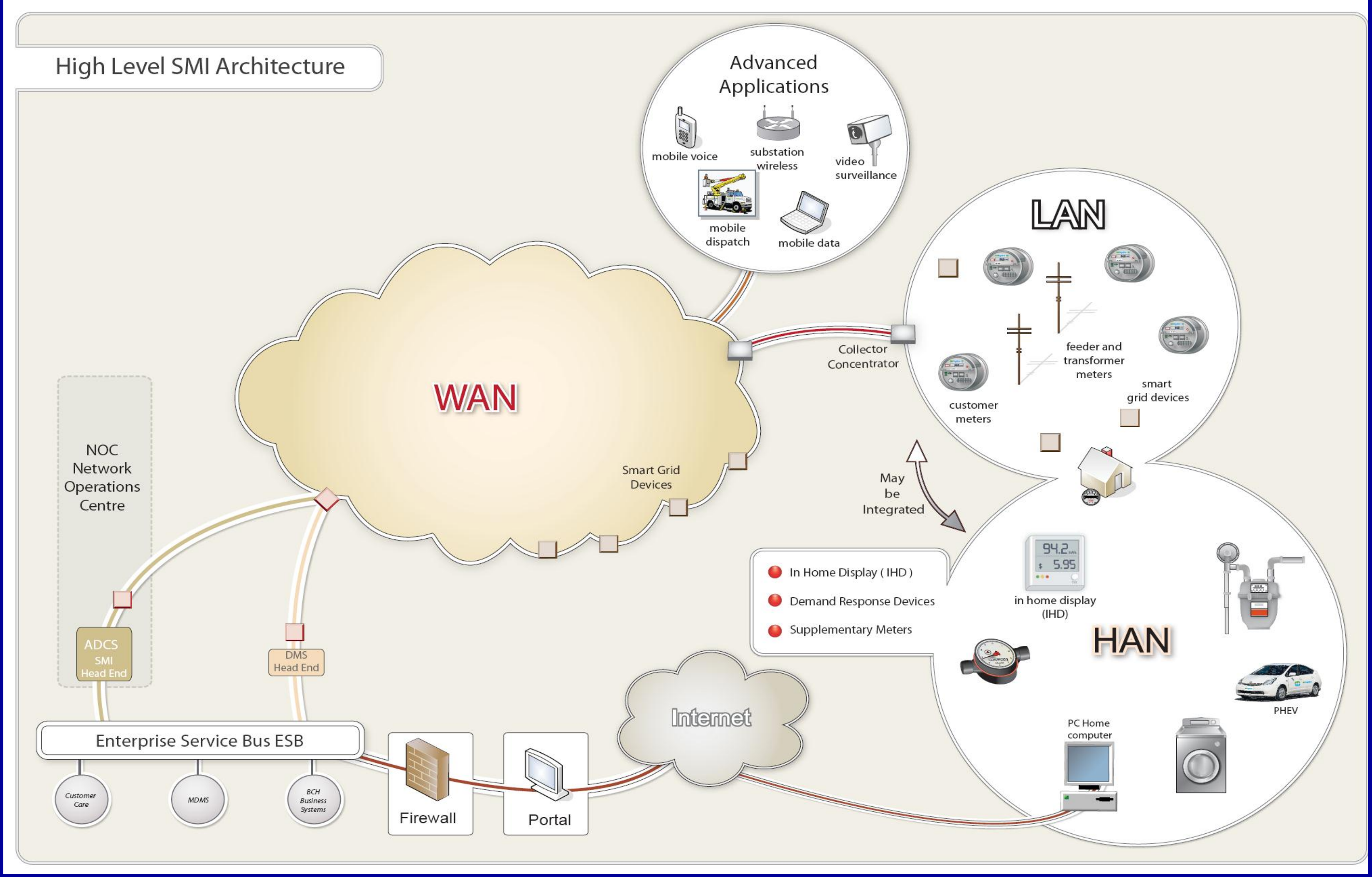
- ***It is also planned to install "smart meters" for all residential. Utilities have gained benefits of preventing electricity stolen. The studies on AMI data based analyses and applications are promoted .***

2. Investment planning of the State Grid Comp.

- **During 2011-2015， the total investment from the State Grid Company, China is to be 286.11billions Yuan（RMB）, for smartness of generation， transmission, substation, distribution, utilization and Smart scheduling control technology.**
- **30% of the total investment will be given to power comsumption , and mainly used for constructing infrastructures of**
  - **electrical measurement data acquisition system (mainly for master stations, channels of communication without fibers to homes, and acquisition devices).Up to 2014, 100% area will be covered.**
  - **charging points of a. c. electricity vehicles.**

• It will deliver last mile common communication infrastructure supporting





Both the CSG and its Communication system will act as mobility of intelligent city.

Conclusions

- ***City smart grid has been proposed in China to address those challenges that the existing electric grid is facing with, such as increasing distributed renewable energy generation access , low asset utilization and low energy efficiency, and growing demand and reliance on digital applications, etc.***
- ***Both the CSG and its Communication system will act as mobility of intelligent city.***
- ***Government and Utilities have paid more attention to implement CSG in China， however the emergent issues are to develop advanced markets and to realize flexible "plug and play".***

Q&A

Thanks!