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上海市电力公司
SHANGHAI MUNICIPAL ELECTRIC POWER COMPANY

上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

Chongming Smart Grid Demonstration Project

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Chongming Island

China‘s third largest island. 76km * 18km.
Area: 1267km^2
Population: 800K

A county in Shanghai.

Main industries: agriculture, animal husbandry, tourism and shipbuilding.

Background and development plan

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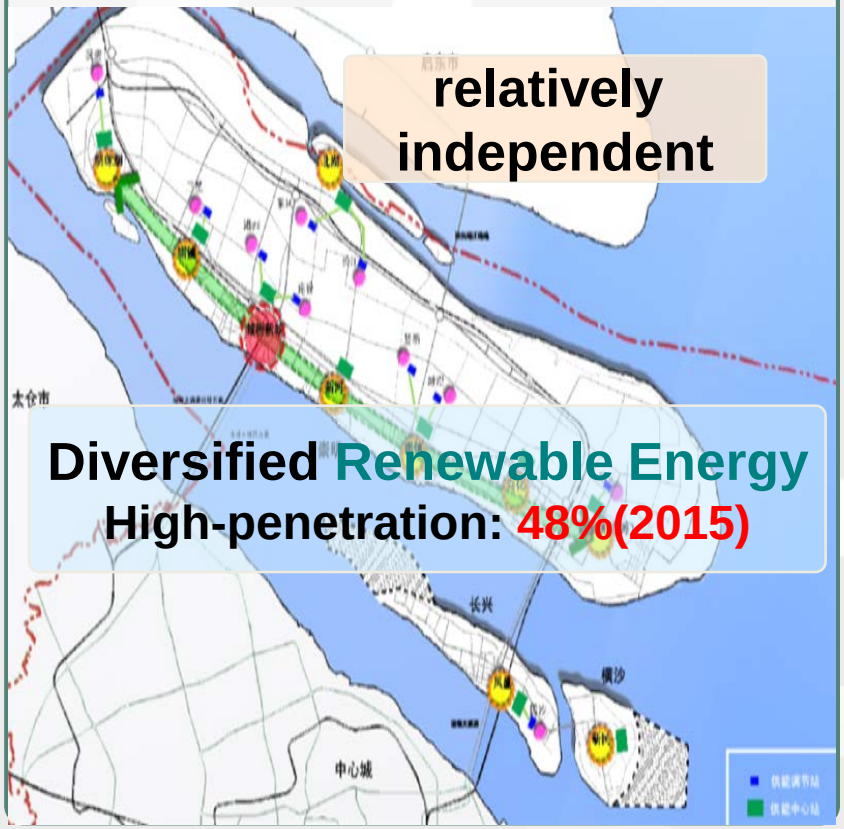
Chongming island

Ideal place for utilization of large scale renewable energy



Development Plan

Long-term

- Total RES installation: 3,200 ~ 4,200MW
- CCPP: 800MW
- Max Load: 2,000~2,500MW

→ Green energy output base

2015

- Wind: 223MW
- Solar: 3.8MW
- Biomass: 9MW
- CCPP: 400MW

- Max Load: 345MW
- RES Penetration: 48%

Purpose of the demonstration project

Large-scale renewable energy utilization

- Efficient and eco-friendly use
- Schedulable, Dispatchable, Controllable

- Green Energy Output Base in Sea Island

Transmission

- Hierarchical Integration of DER using ADN

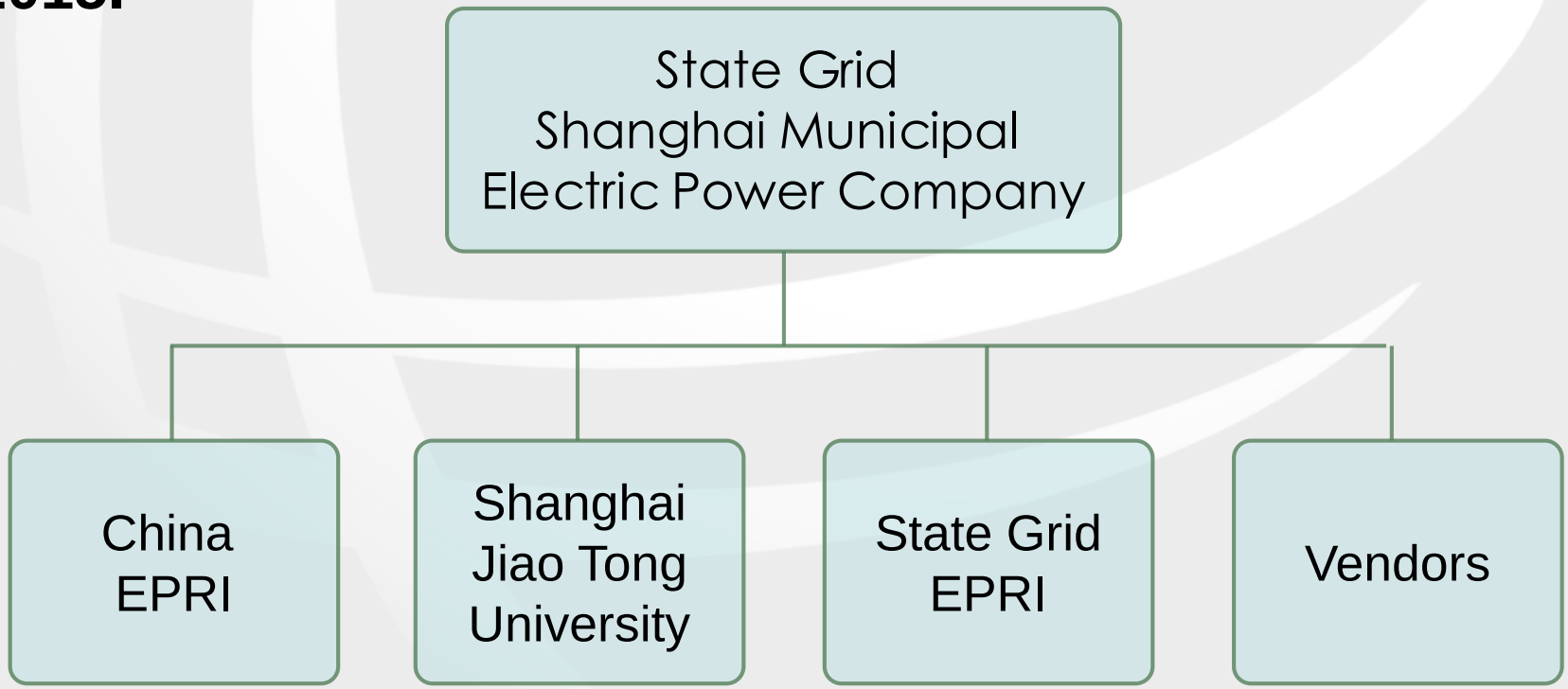
Distribution

- Local accommodation of RES, and responsive users

Consumption

Funding, organization of the demonstration project

- **This project is funded by National Science and Technology Support Program, and jointly completed by State Grid Corporation, Shanghai Jiao Tong University and several institutes and vendors.**
- **The implementation time of this project is from 2013 to 2015.**



Architecture of the demonstration project

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Geographical Map of the Demo by 2015

Transmission
Distribution
Consumer

Architecture of the demonstration project

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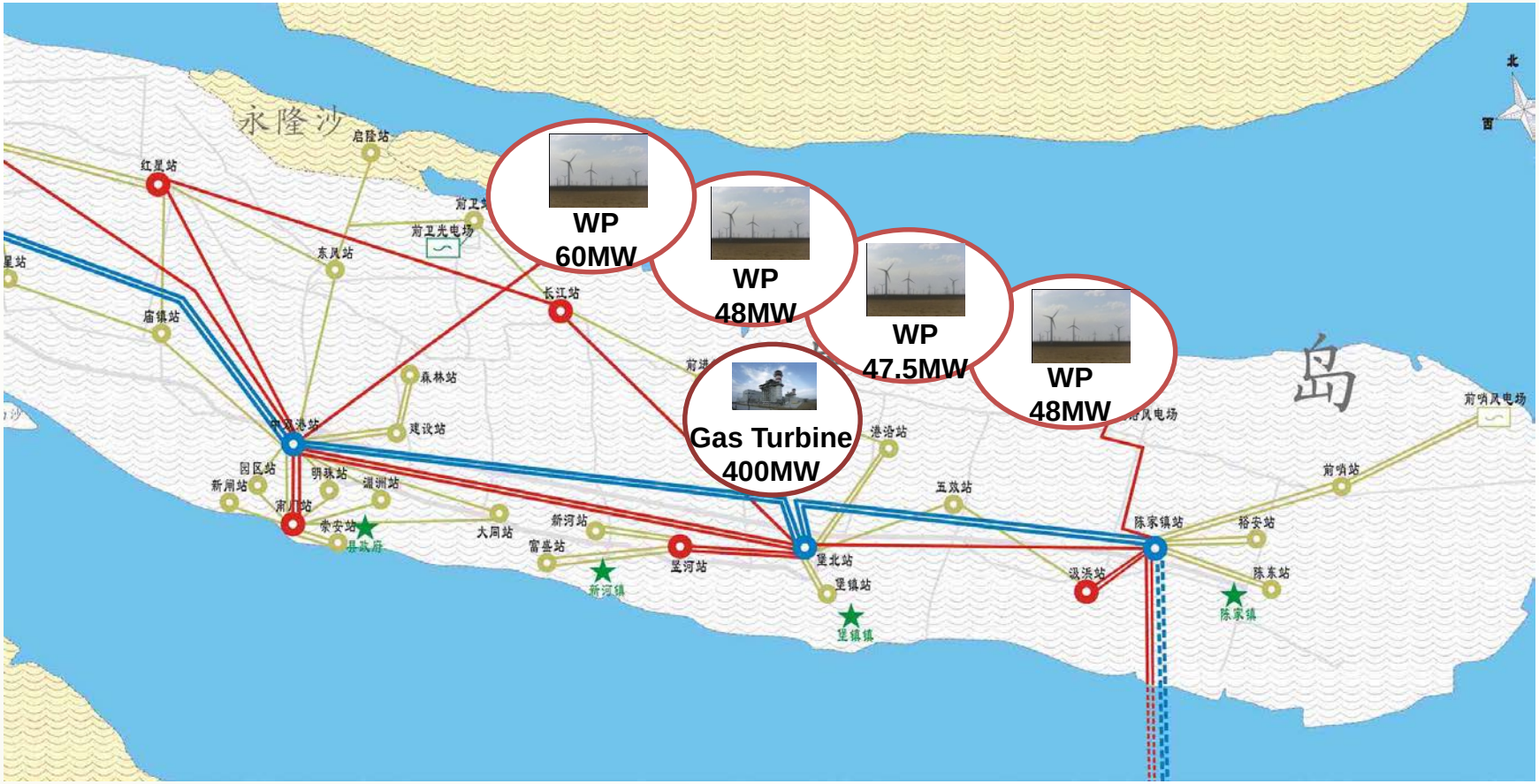
Transmission

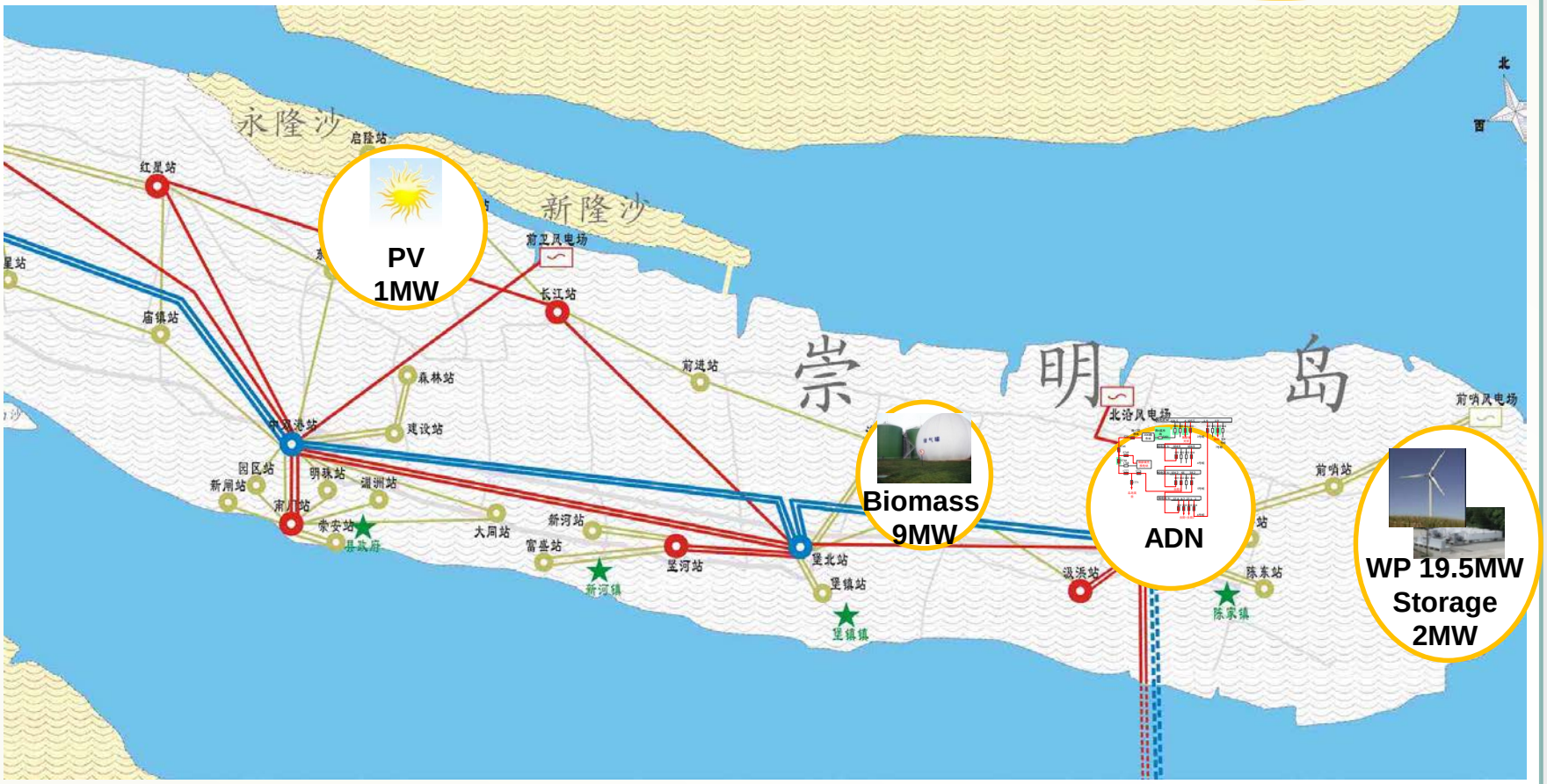
Geographical Map of the Demo by 2015



Architecture of the demonstration project

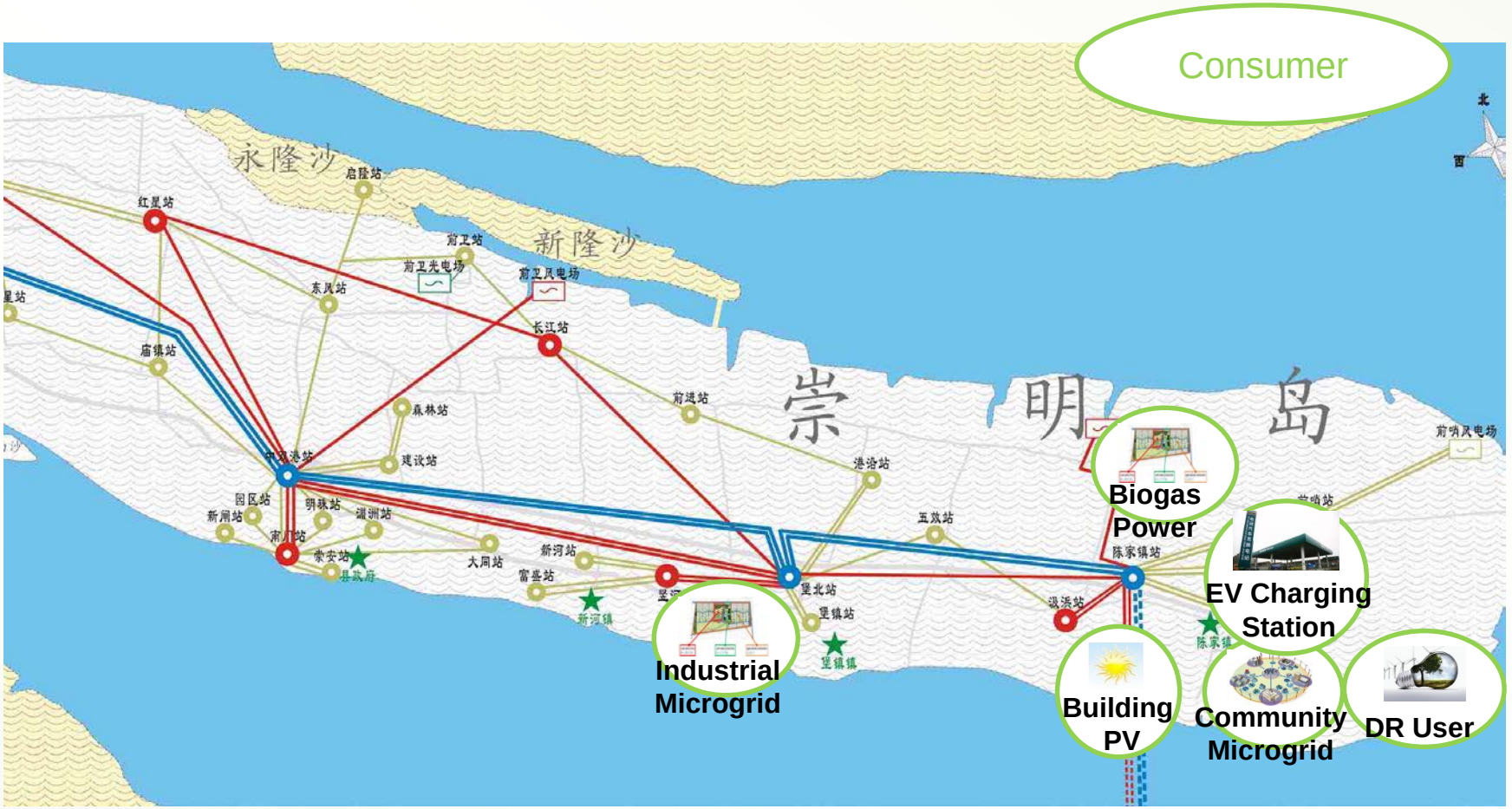
Geographical Map of the Demo by 2015

Distribution



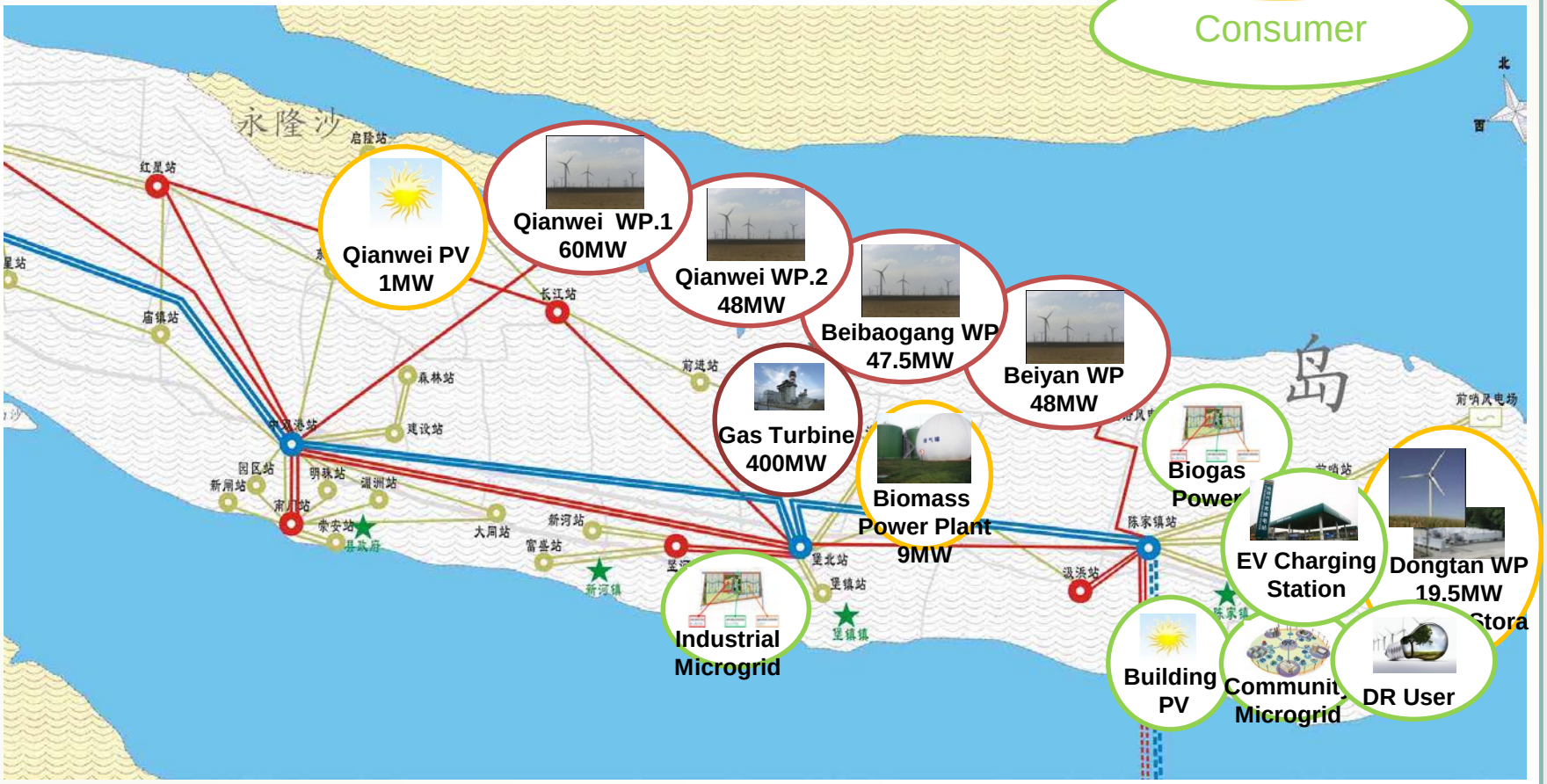
Architecture of the demonstration project

Geographical Map of the Demo by 2015



Architecture of the demonstration project

Geographical Map of the Demo by 2015



Architecture of the demonstration project

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Green Energy Output Base

Layer I，110 -220kV

- Large scale offshore, onshore wind plants, gas power plants
- Wind power bundled with gas turbines
- Schedulable and controllable equivalent power plant

Active Distribution Network

Layer II，10-35kV

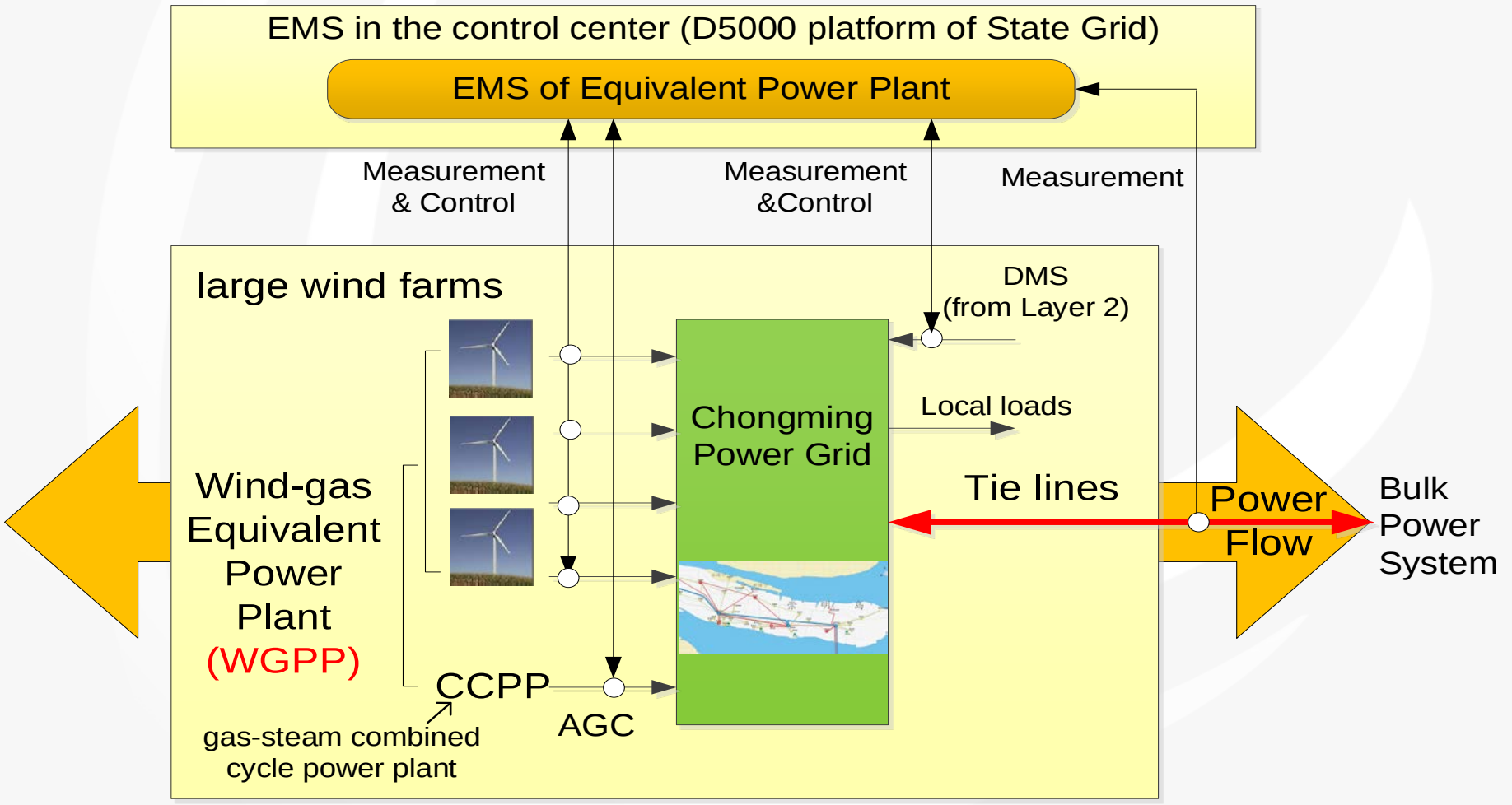
- DERs (wind, solar, biomass, storage), various types of microgrids
- ADN
- Hierarchical integration and aggregation of DERs

Flexible and Reliable Power Consumption

Layer III，0.4-10kV

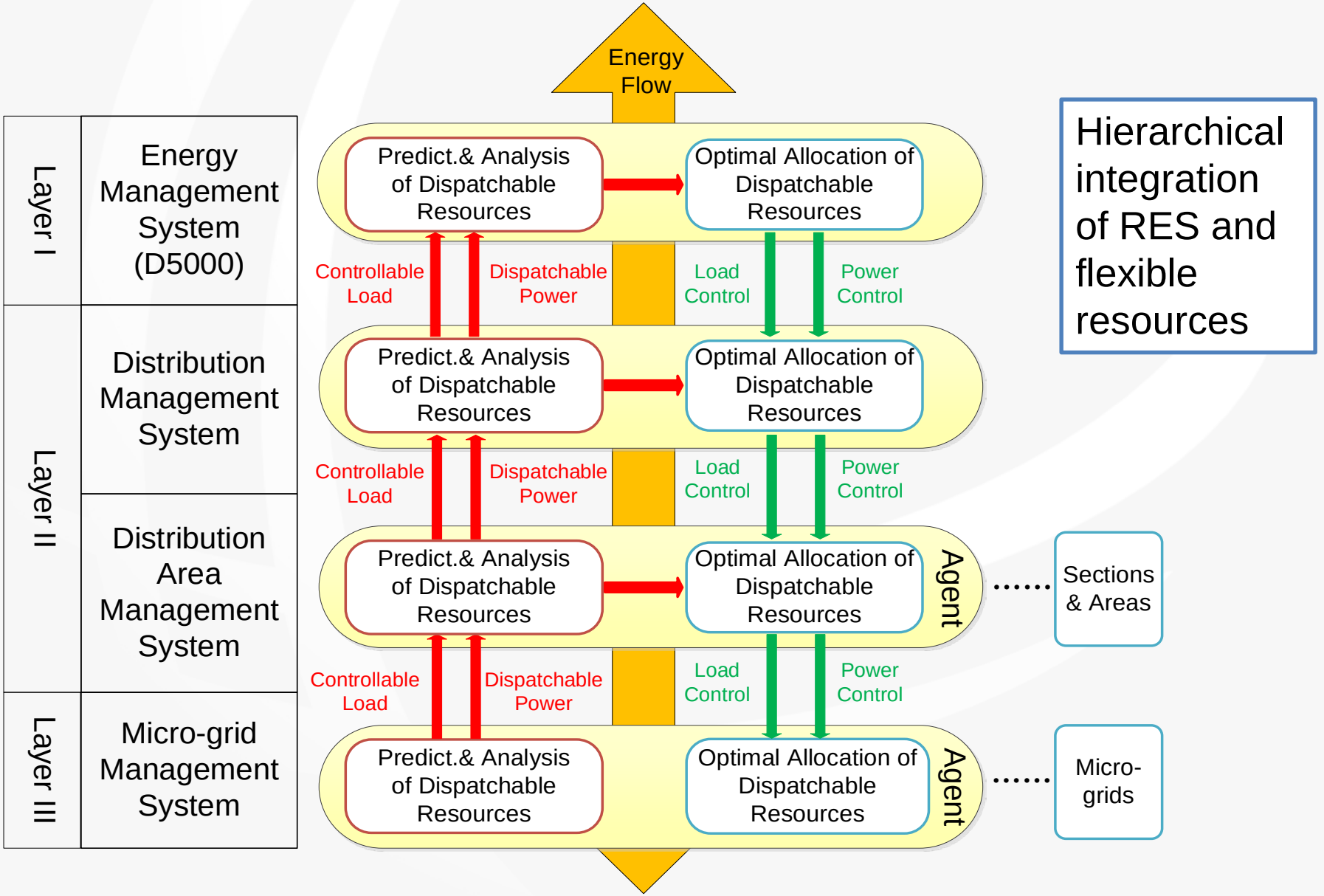
- Microgrid and demand response users
- Interaction between highly autonomous microgrids and users

Horizontal Coordination



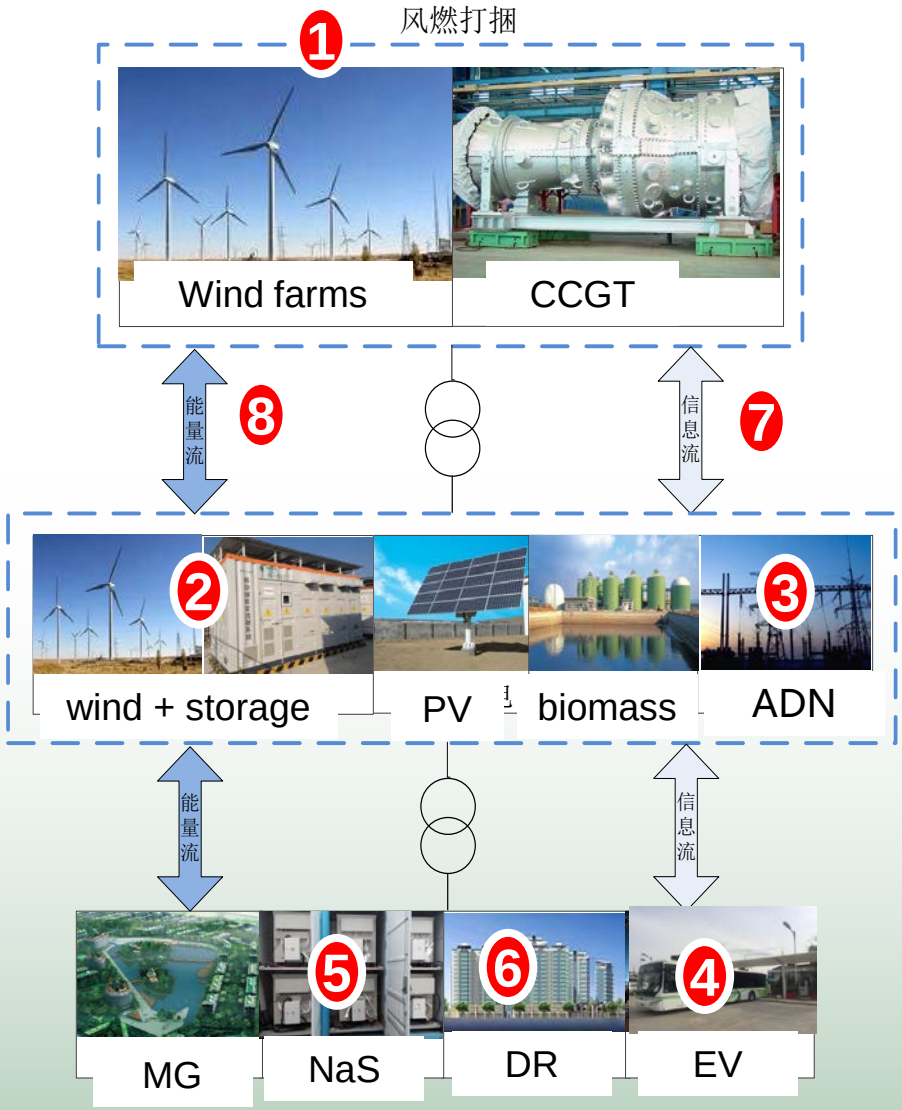
In the transmission level, two types of green energy, wind and gas, are bundled, making the WGPP schedulable, dispatchable and controllable.

Vertical Coordination



Demonstration Applications

#	Application
1	Wind-gas equivalent power plant
2	Wind-storage combined generation
3	Active distribution network
4	Electric Transportation
5	Sodium-sulfur BESS
6	Demand response programs
7	Unified Information System
8	Island-wide Integrated EMS



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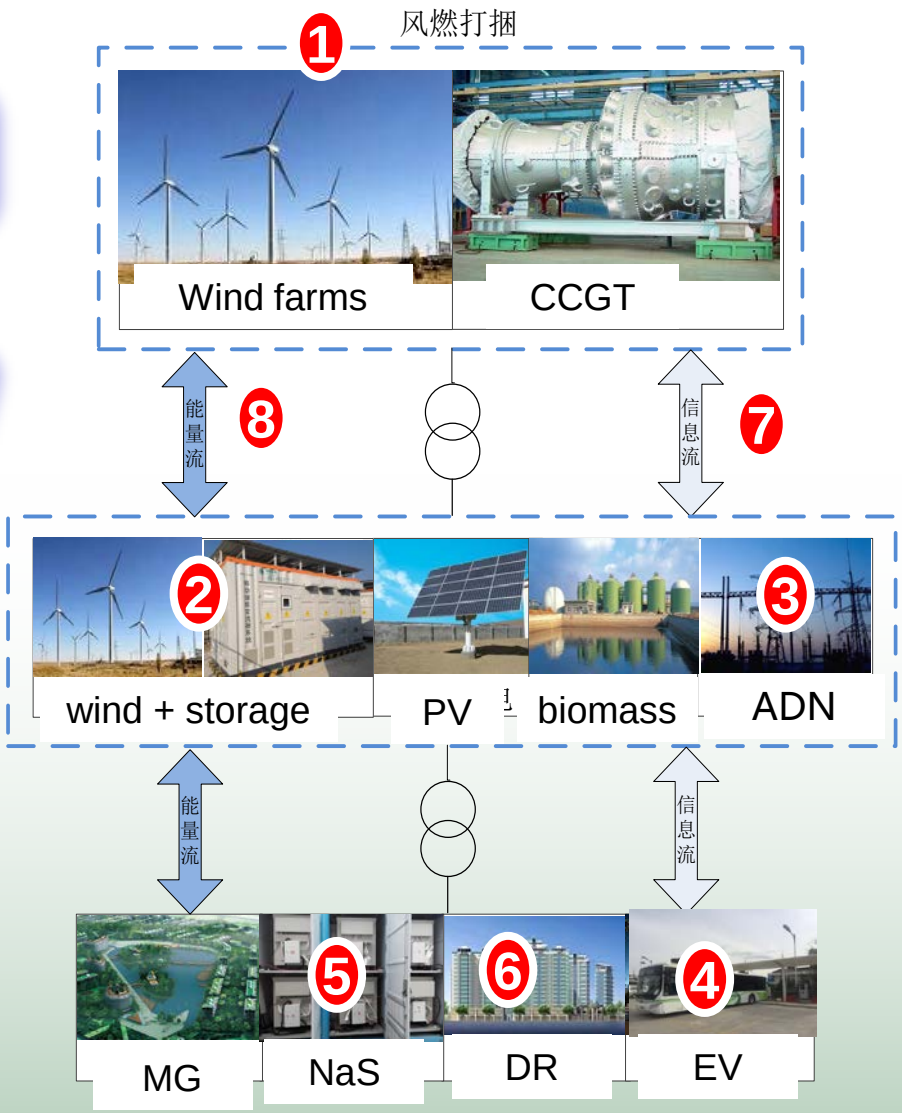
Transmission

Distribution

Consumption



Demonstration Applications

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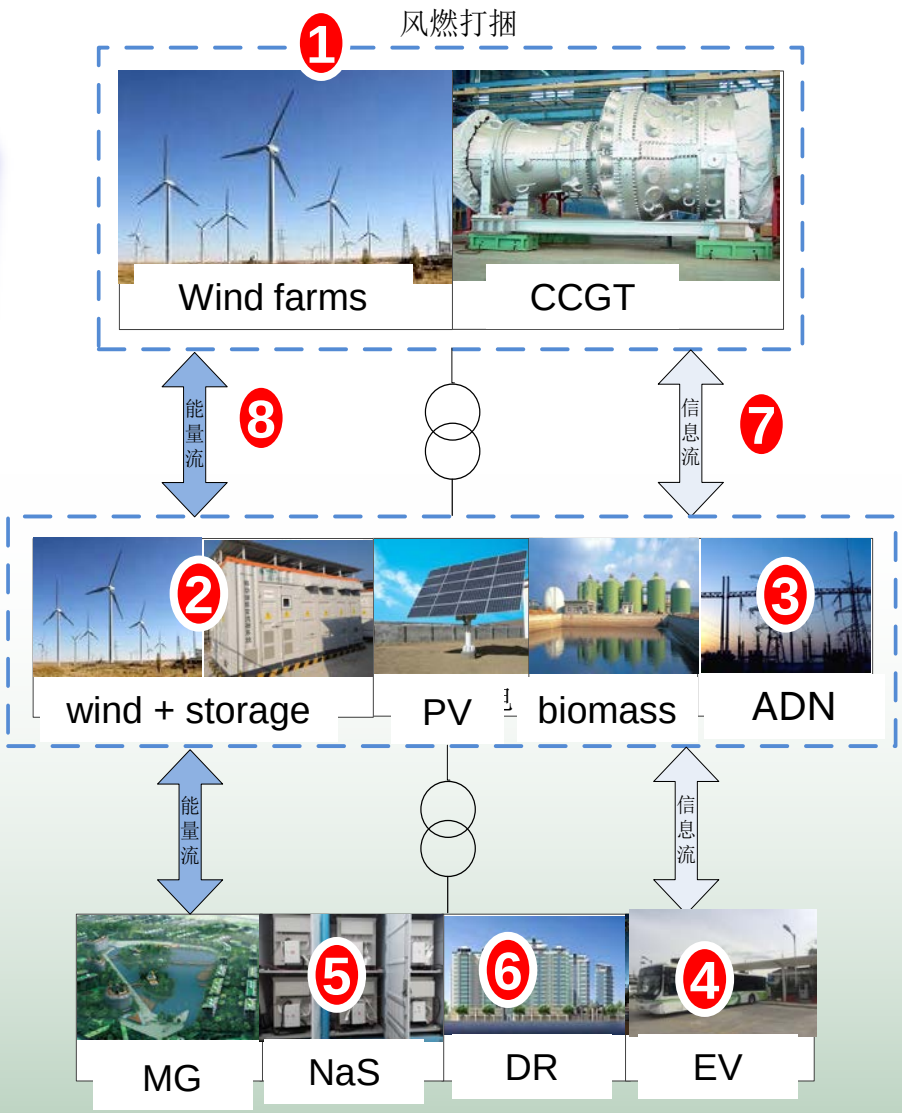
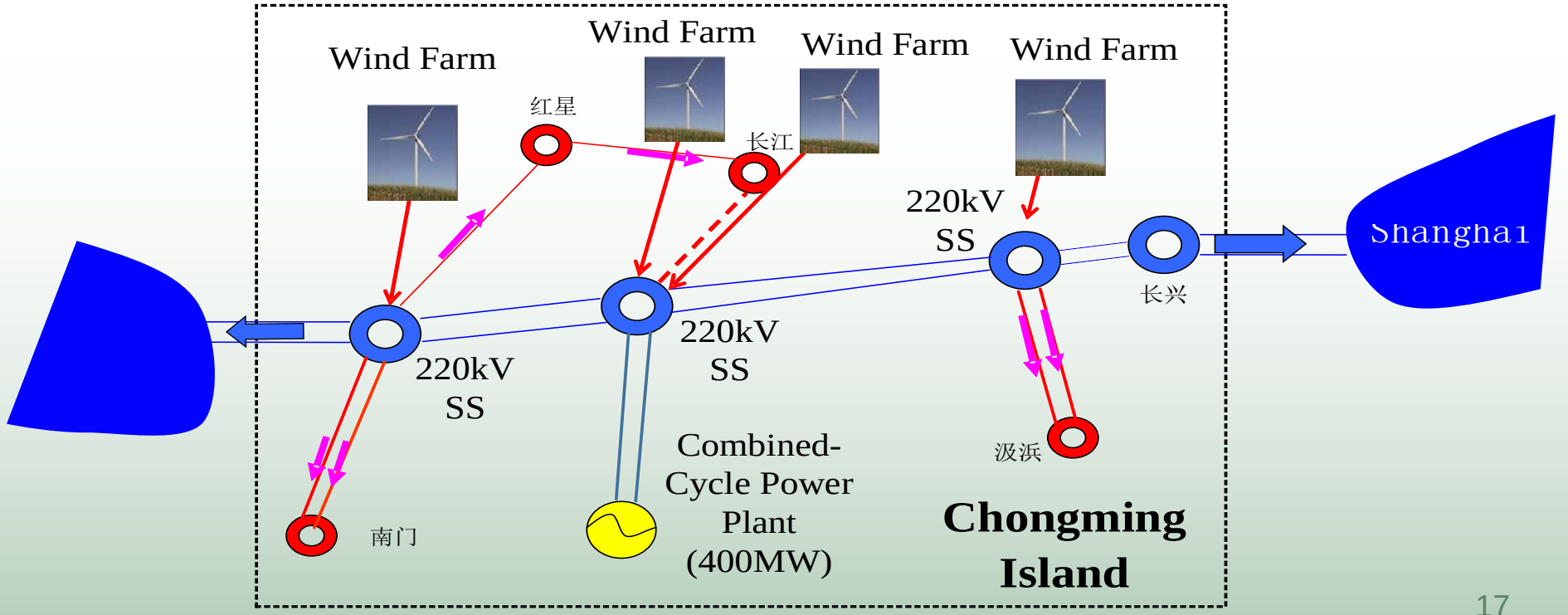
generator control

load control



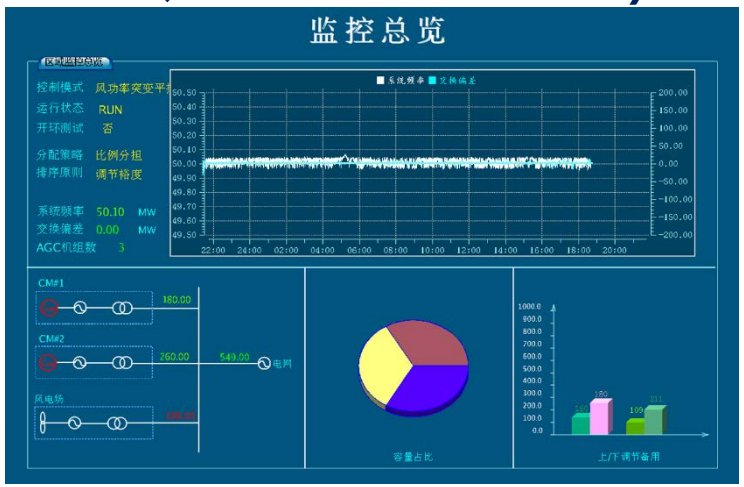
1. Wind-Gas Equivalent Power Plant

- **Thanks to the high ramp-rate of CCPP, the Area Control Error $ACE = \sum P_{tie\_line} - P_{schedule}$ can be kept within 2%, such that the island power grid as a whole can be dispatched like a traditional power plant.**
- **The purpose is making the large scale RES schedulable and dispachable.**



1. Wind-Gas Equivalent Power Plant

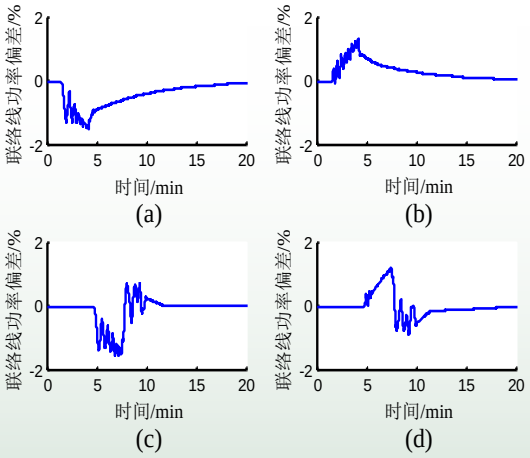
Wind-Gas Coordinated Dispatch (Embedded in D5000)



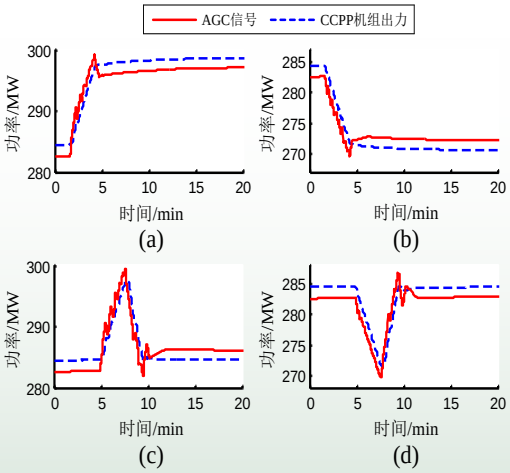
SCADA/EMS GUI

Control Parameter Settings

- The exchanged power of tie-line can follow the schedule curves even in case of large wind forecast errors and wind power events.



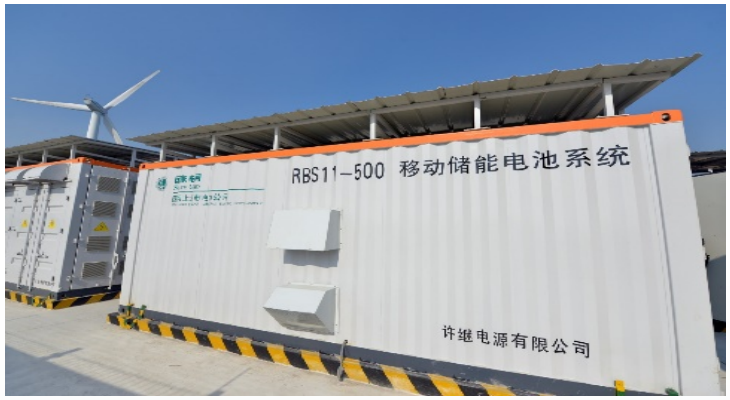
power deviation of tie-line during wind power events



AGC signal and CCPP power output

2. Wind-Storage combined generation

- **At the distribution level, a lithium iron phosphate BESS(2MW/2MWh) was constructed at the Dongtan wind farm (19.5 MW), which constitutes a combined power generation system.**



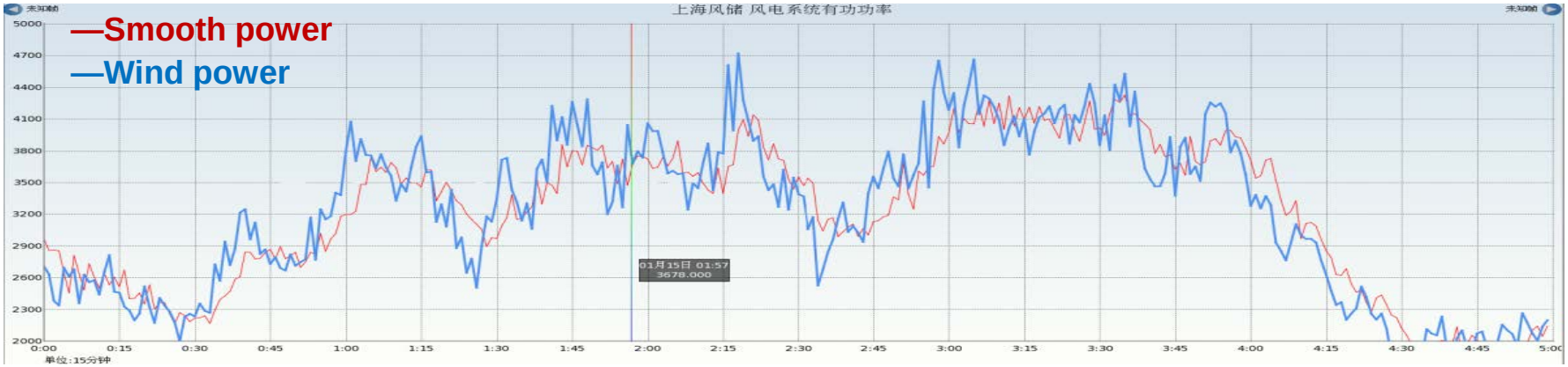
4*500kWh Battery Containers

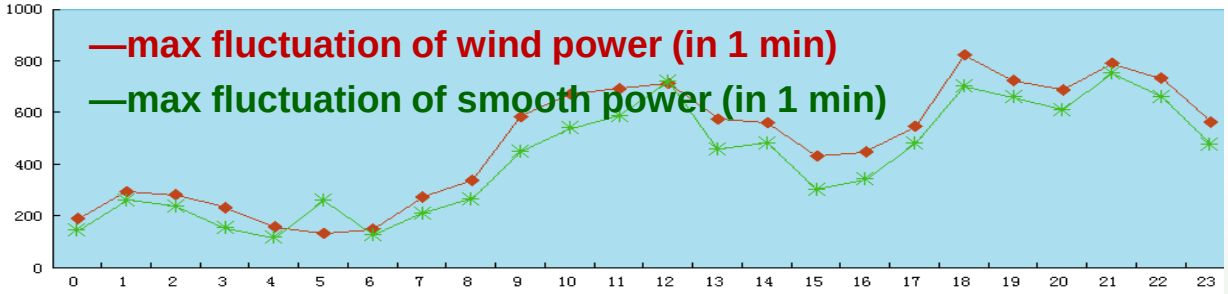
1 Monitor & Control containers

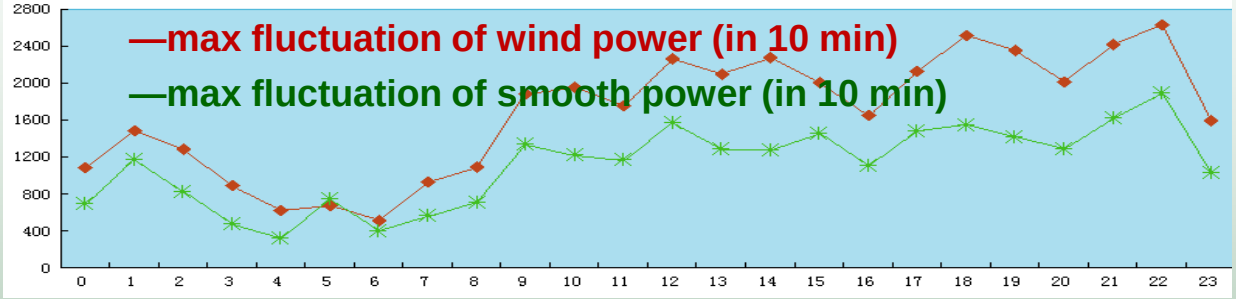
2 PCS containers

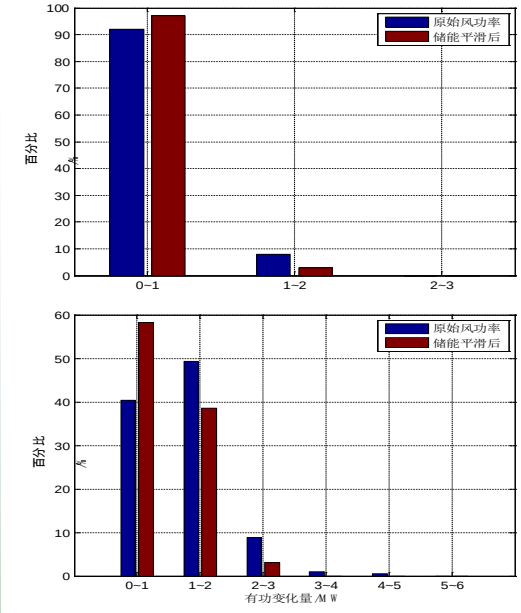
2. Wind-Storage combined generation

- **Max fluctuation decreased by 22% in 1 min, and 31% in 10 min**





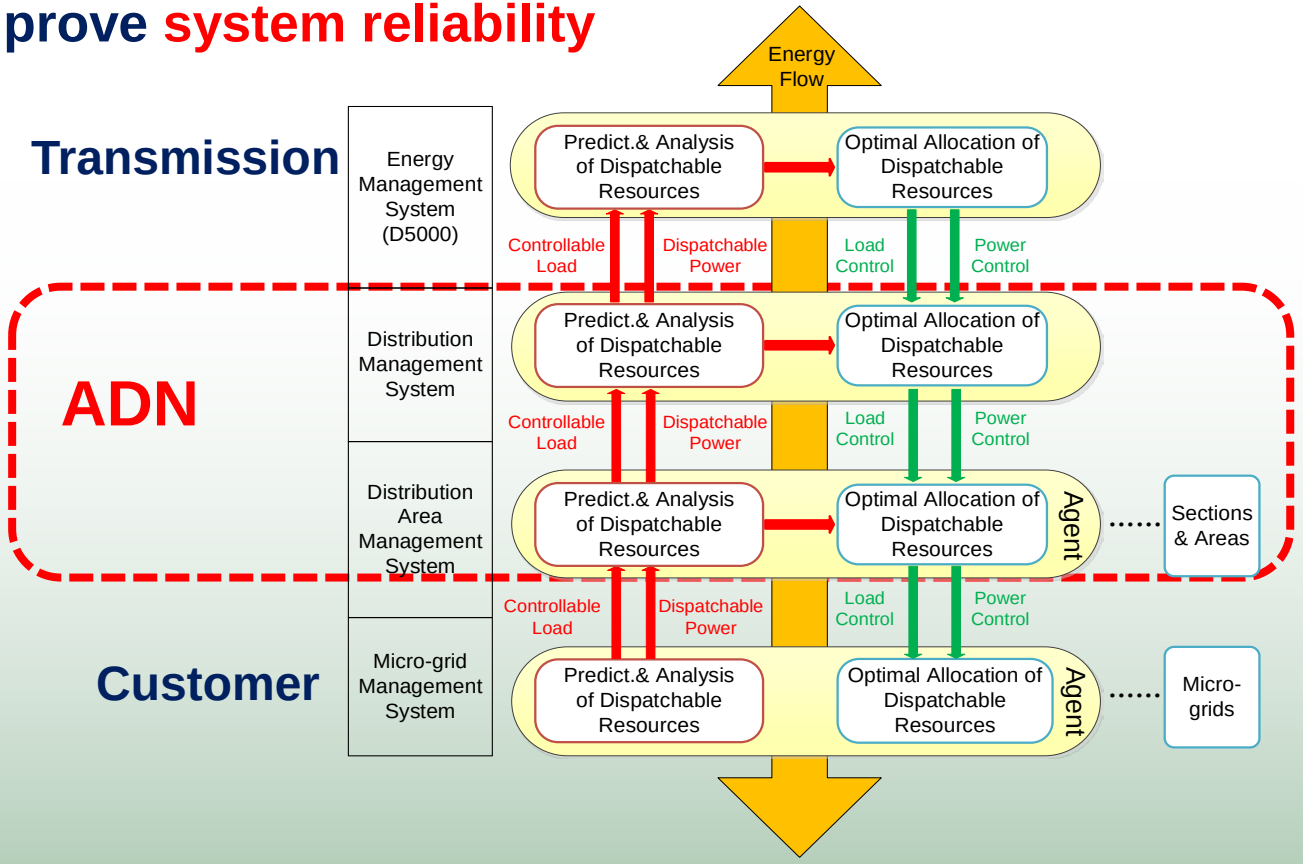




3. Active Distribution Network

Main purposes of the ADN demonstration are:

- **To promote accommodation of RES and support hierarchical integration of DERs**
- **To make DSO act as interface between the transmission and DERs, to ease dispatch of DERs**
- **To improve system reliability**



3. Active Distribution Network

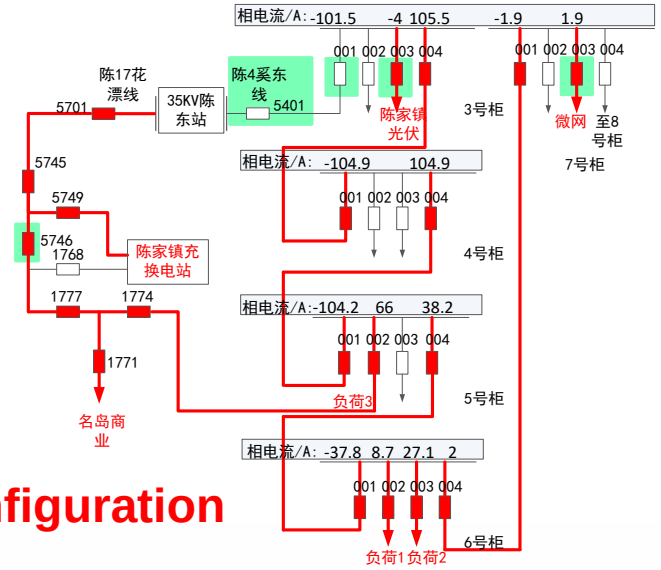
Planning software for ADN

规划指标	Traditional planning	ADN planning
负荷率	59.16%	58.10%
容载比	1.88	1.91
10kV平均主干长度	4.2km	4.7km
Total Investment	17960万元	15725万元

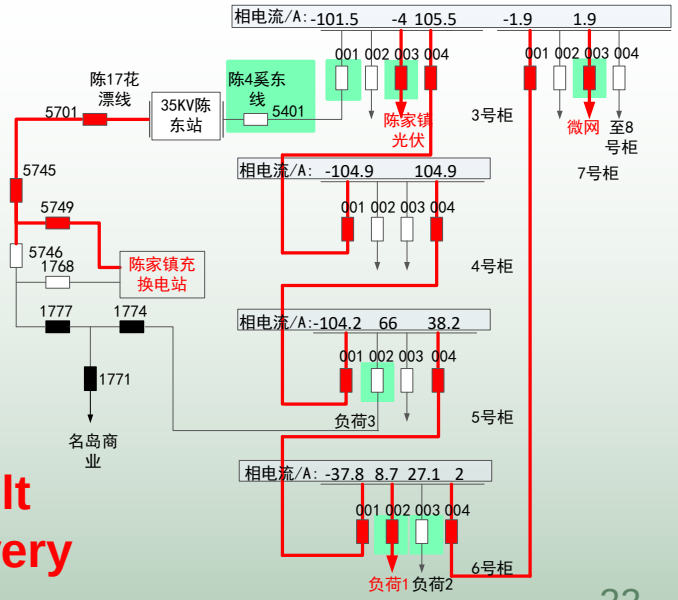
Distribution EMS

时间段	分布式电源出力（kW）			
	光伏1	光伏2	风机	充换储电站
0:00-6:00	0.000	0.000	0.498	-7.49
6:00-13:00	40.95	95.08	0.451	-2.24
13:00-16:00	58.95	148.56	0.575	-1.43
16:00-19:00	10.13	25.52	0.795	-2.33
19:00-24:00	0.000	0.000	0.414	-4.33

序号	开关状态 K1	K2	K3	K4	有功网损(kW)	无功网损(kVar)
1	×	√	√	√	928	680
2	√	×	√	√	412	320
3	√	√	×	√	358	310
4	√	√	√	×	478	410



Reconfiguration



Fault recovery

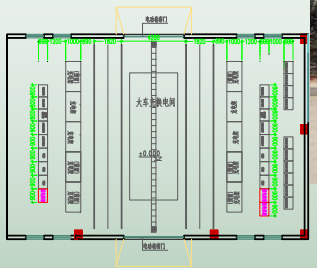
4. Electric Transportation

- **Completed an island-wide EV energy supply system with 1 charging-swapping-storage integrated station, 10 bus charging stations, 13 public charging stations, and 343 charging piles.**

Quick Charging Station

Public Charging Station

Bus charging station

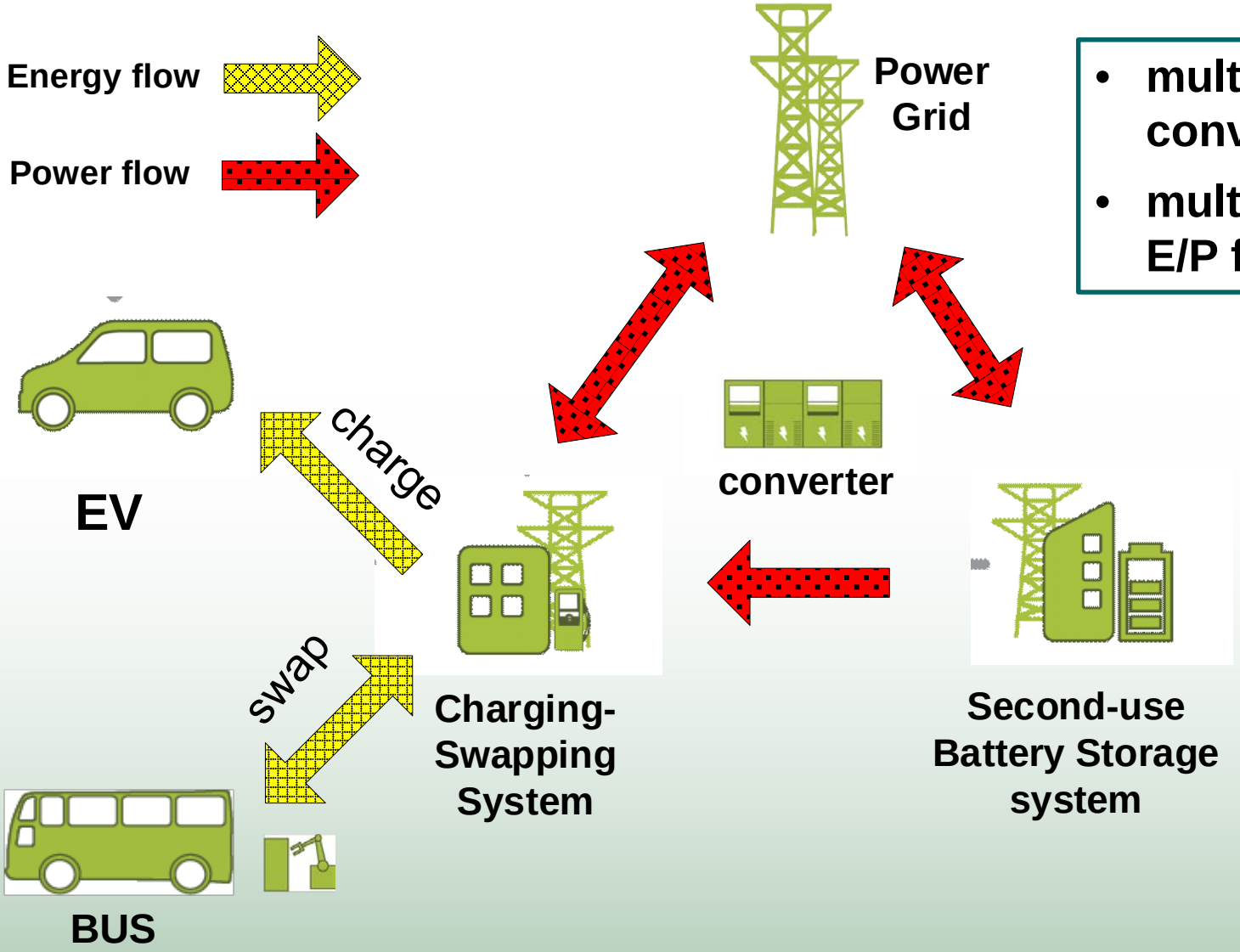


Charging-Swapping-Storage Integrated station

Charging-swapping-storage integrated station

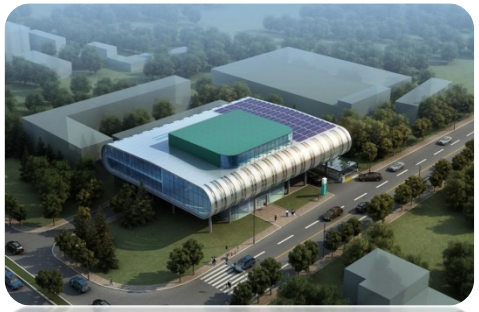
Integrated Station	Capacity
Total Capacity	1.25MW/2.25MWh
Charging System	2 quick charging points 19 slow charging points
Swapping System	40 cars per day 20 buses per day

Charging-swapping-storage integrated station



Charging-swapping-storage integrated station

- EV Charging Station
- Battery Swapping Station
- Second-use Battery Storage Station



Achieving intensive construction, saving land resources

Improving battery efficiency, lowering battery use-cost

Benefits

Shifting peak load, improving energy quality, Increasing renewable energy penetration

Benefitting auto companies, gird companies ,battery companies and EV users

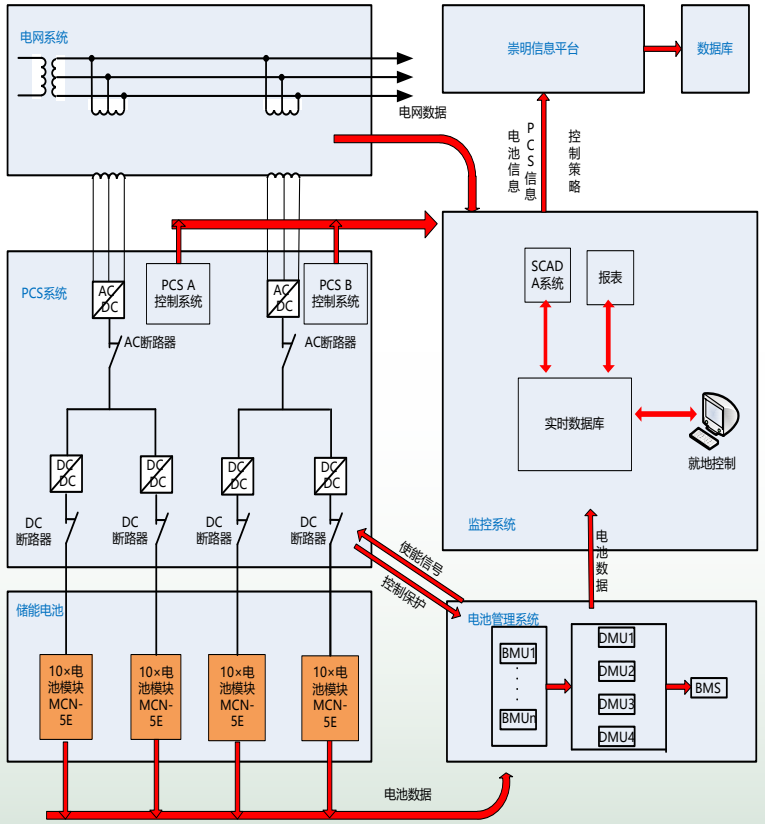
5. Sodium-sulfur BESS

- **A Sodium-sulfur BESS (200kW / 1MWh) was installed to mitigate the impact load caused by industrial users.**

Sodium-sulfur BESS Station

Batteries

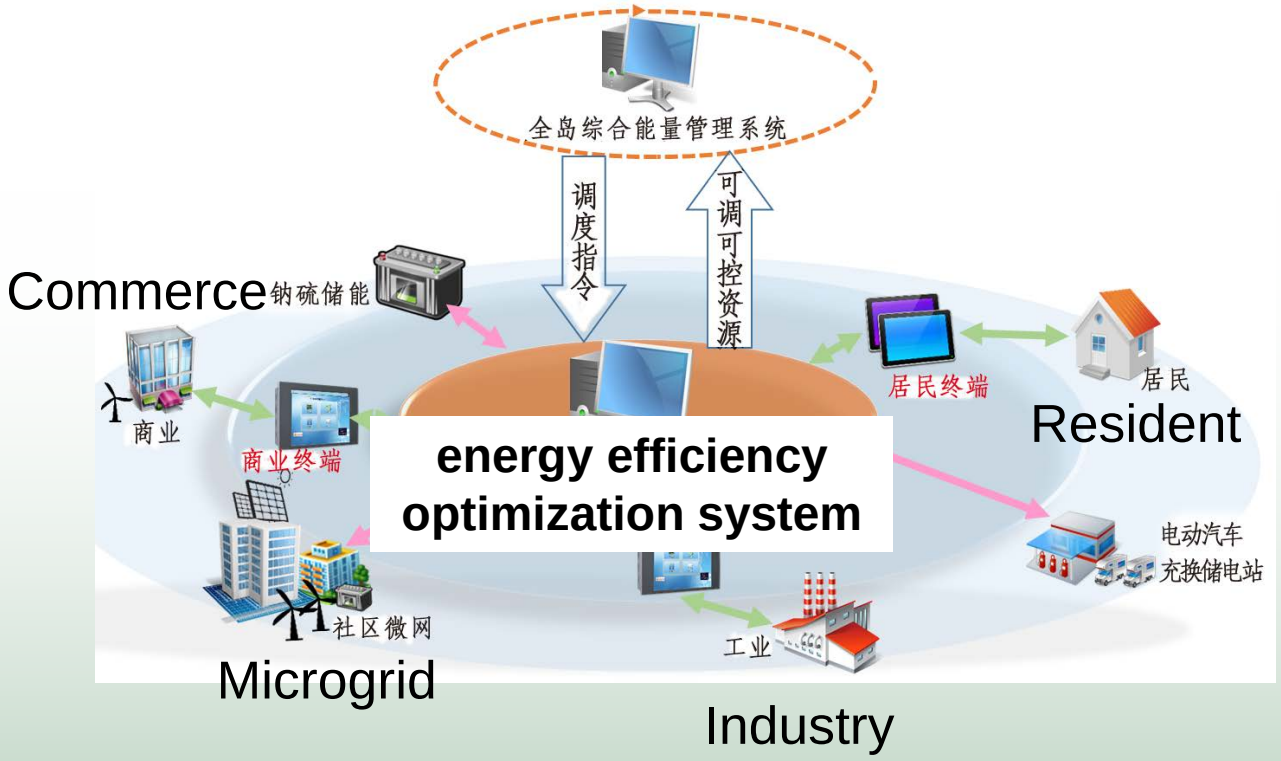
PCS



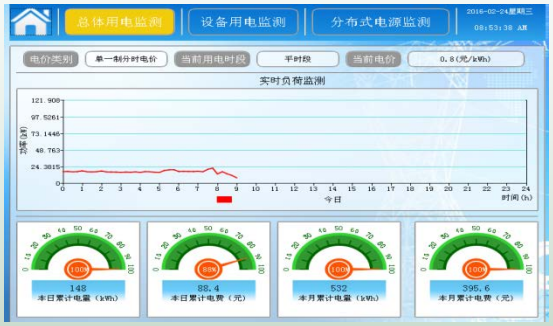
System Structure

6. Demand Response Programs

- **Constructed a demand-side energy efficiency optimization system to realize unified access and coordination of DR resources such as residents, industrial & commercial buildings and community microgrids.**



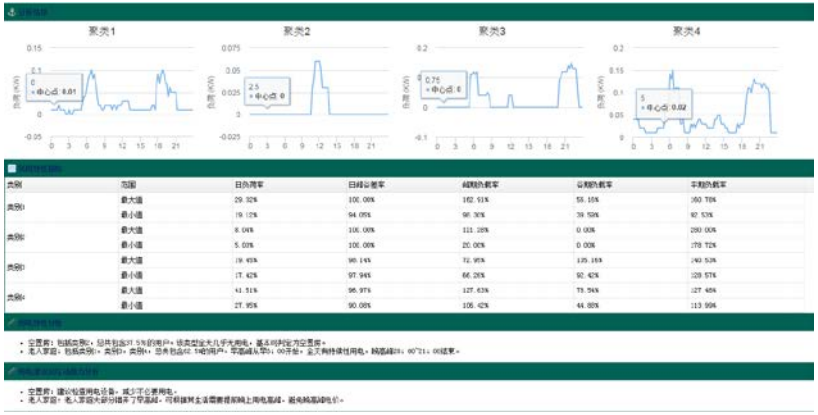
energy efficiency optimization system



Intelligent Control Terminal

6. Demand Response Programs

Effects of demand response:



- Residential users: account for 23~33% of expected DR potential, by direct control of ACLs;
- Industrial & commercial users: account for 64%~73%.

- Purposes of DR: promoting local accommodation of RES, peak shaving;
- Measurements: DLC, IL, TOU, Personalized bill services;
- The DR programs increased the energy efficiency by 5% during commissioning.

Energy Efficiency Control Terminal for Residential Users

Intelligent Socket

Infrared remote controller

◆Information collection

◆Remote Control

Home Gateway

◆Protocol conversion

◆Information Transmission

Interactive Terminal

◆Data Presentation

◆Information Interaction

Energy Efficiency Control Terminal for Industrial & Commercial Users

Efficiency monitor terminal

◆Information Collection

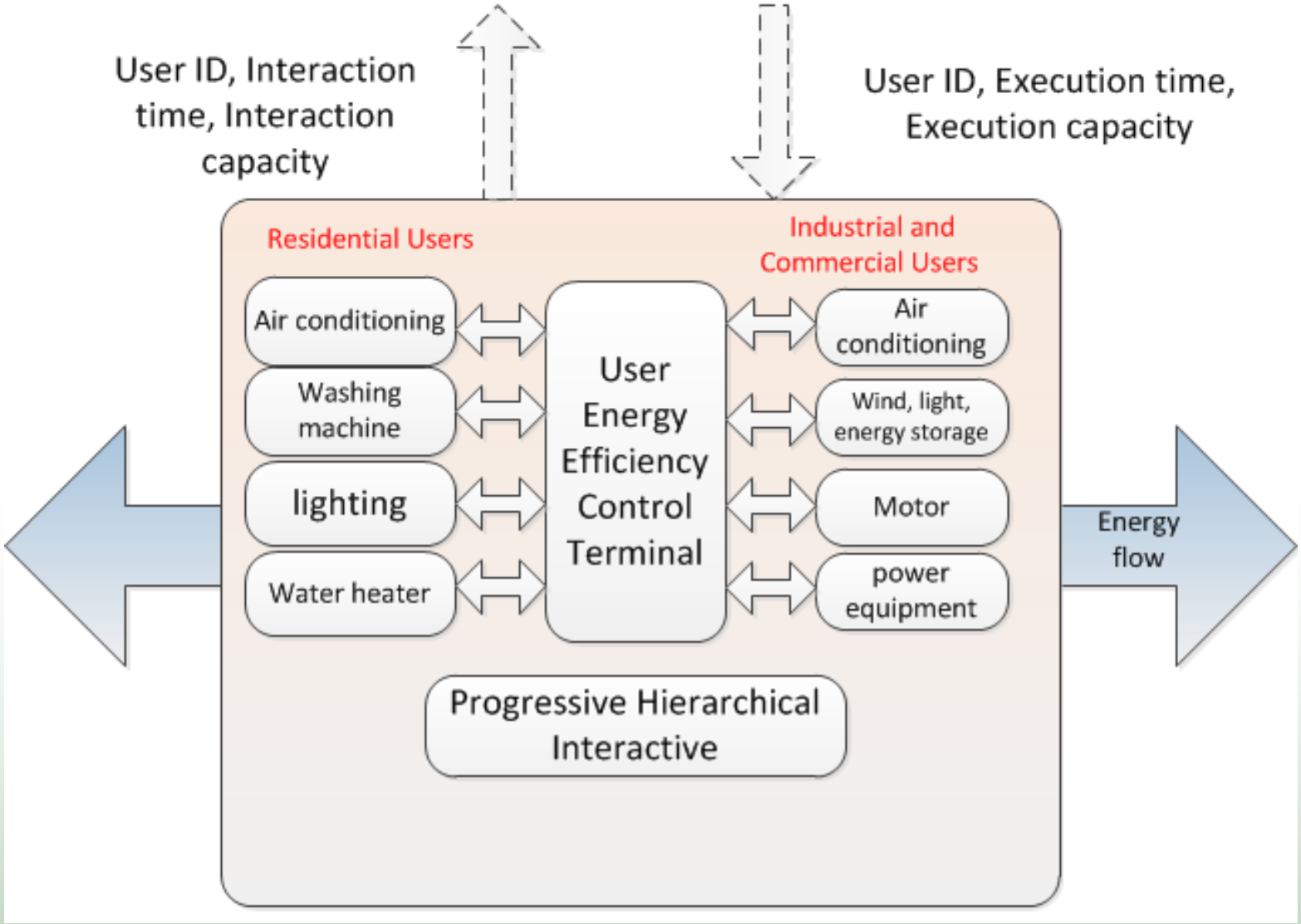
◆Remote Control

Intelligent control terminal

◆Equipped with 14 'LCD touch screen, industrial protection grade

◆Data Presentation, information transmission

Energy Efficiency Control Terminals



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Demand-side Energy Optimization System

能效指标展示

时间	日负荷	峰谷差率	谷电占比	可再生能源自消纳率	CO2减排量	互动用户数
今日	89%	60%	89%	80%	68952吨	20
昨日	89%	70%	89%	80%	68952吨	20

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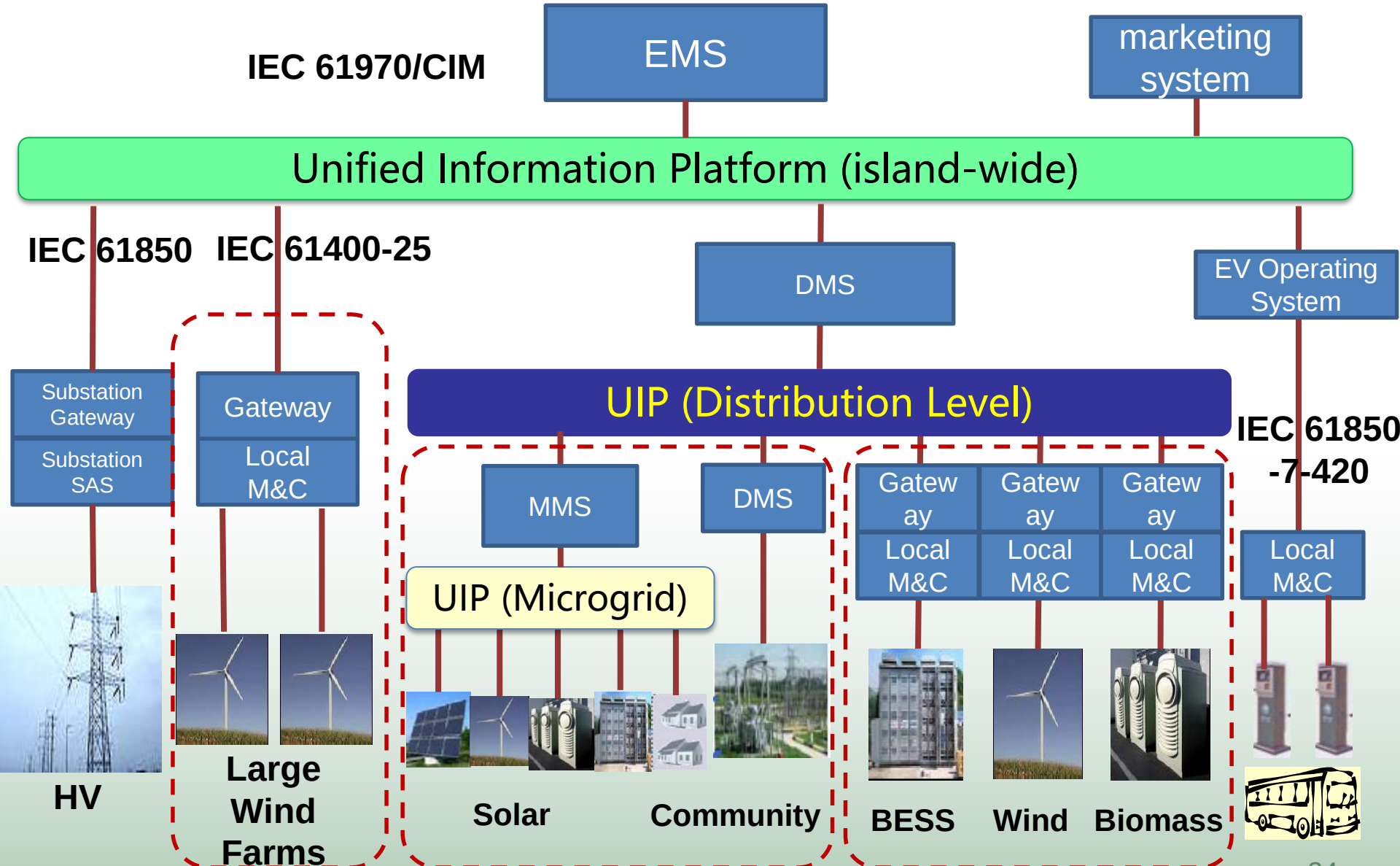
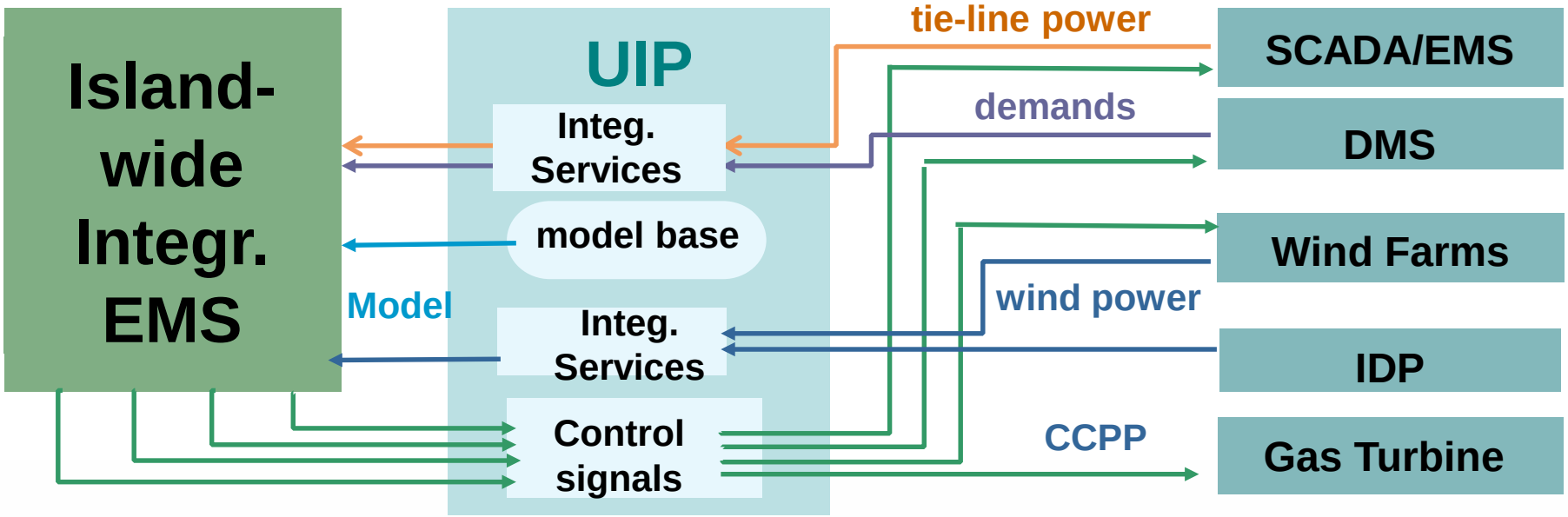
7. Unified Information Platform (UIP)

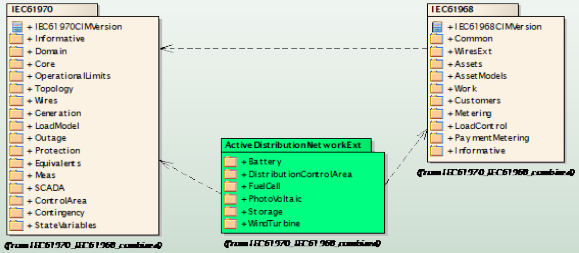


7. Unified Information Platform



Information Flow

IEC61970 IEC61968



Transmission

- wind farm
- CCGP

Distribution

- PV power station
- storage

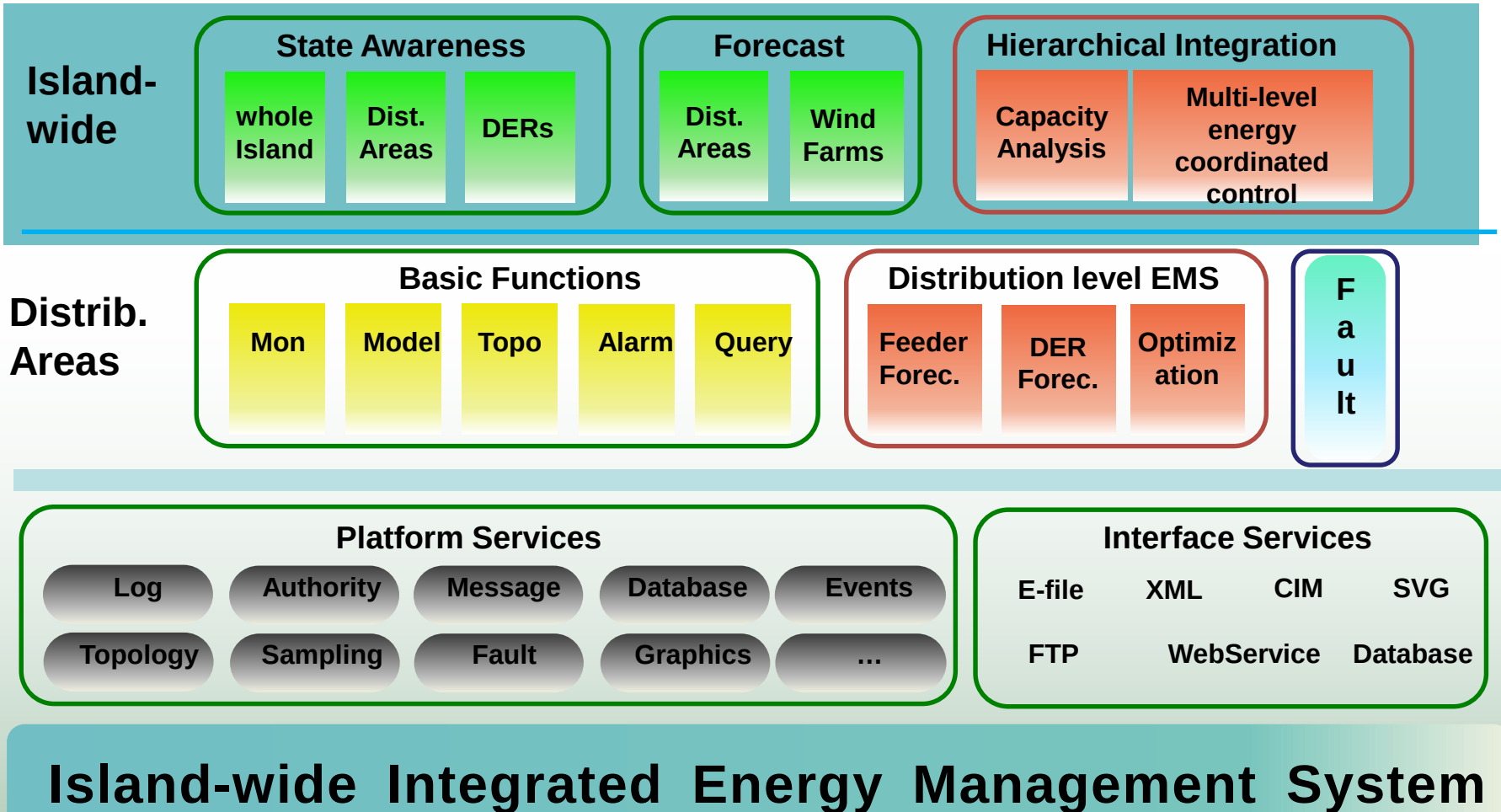
Demand

- micro-grid
- EV
- DR users

Model Profile & Extension

8. Island-wide integrated EMS

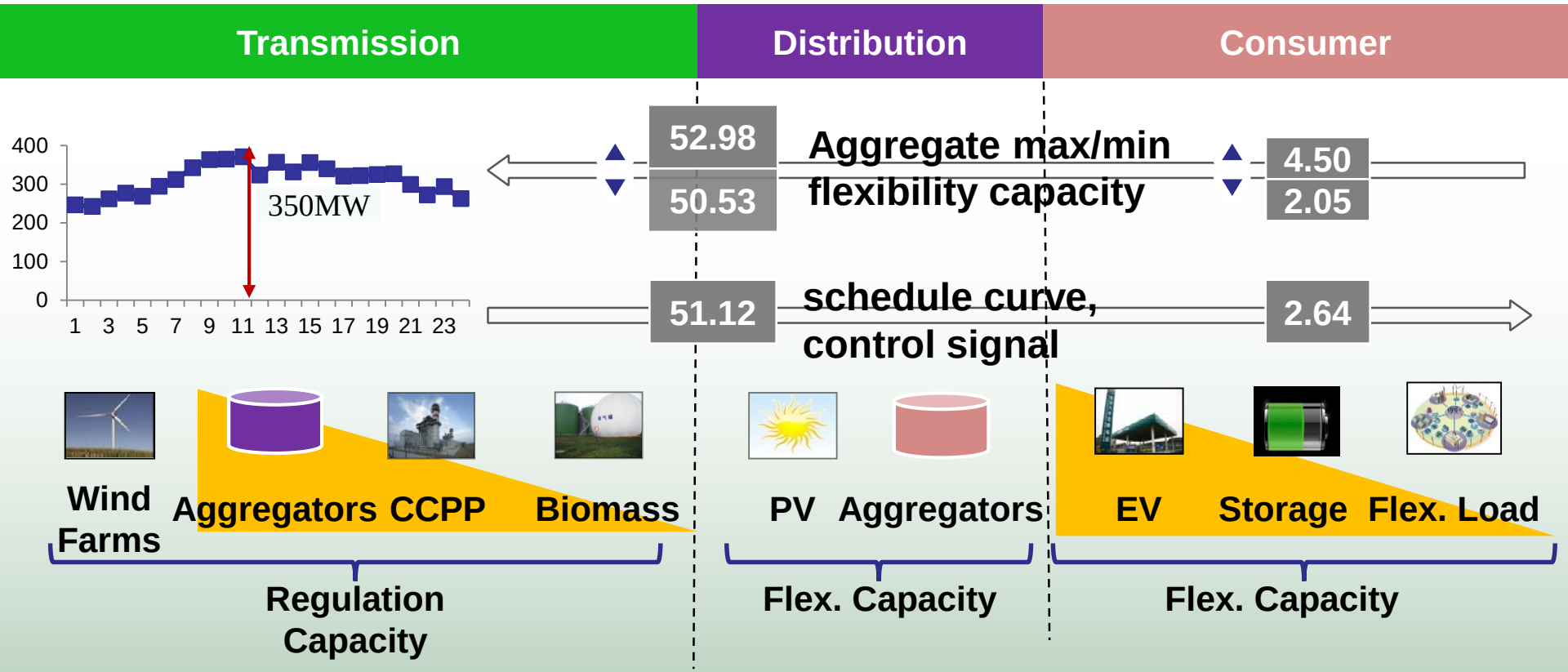
- **Based on UIP, the integrated EMS provides multi-level energy coordination control for the whole island.**



Island-wide Integrated Energy Management System

8. Island-wide integrated EMS

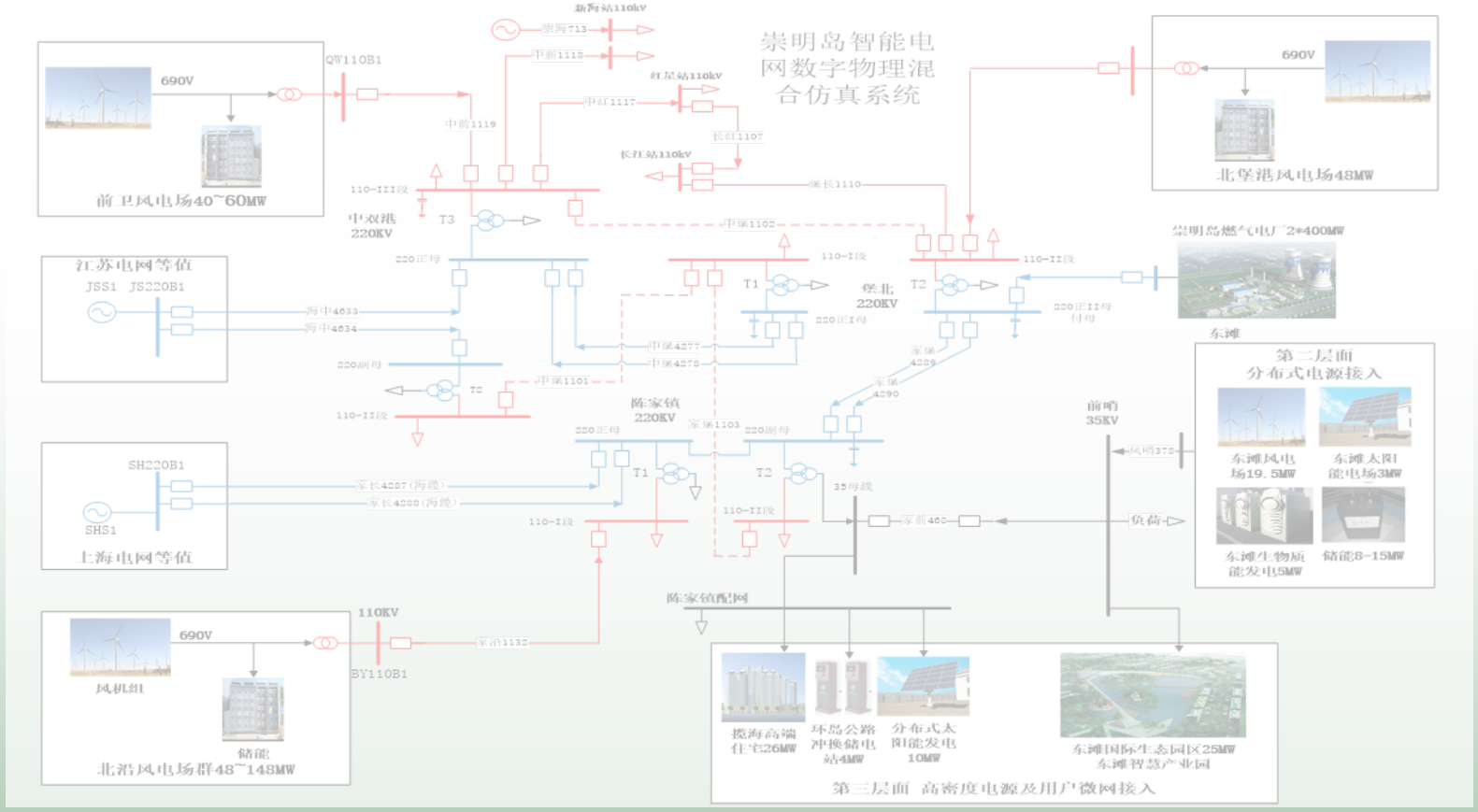
- multi-level energy coordination & control
- Upward: aggregate demands, flexibility (up/down reg.)
- Downward: schedule curves, control signals



9. Real-time Digital Simulation & Validation

A hardware-in-the-loop test bed was built based on RTDS

- **validate strategies and test controllers before commissioning;**
- **validate concepts that cannot be realized at present.**



9. Real-time Digital Simulation & Validation

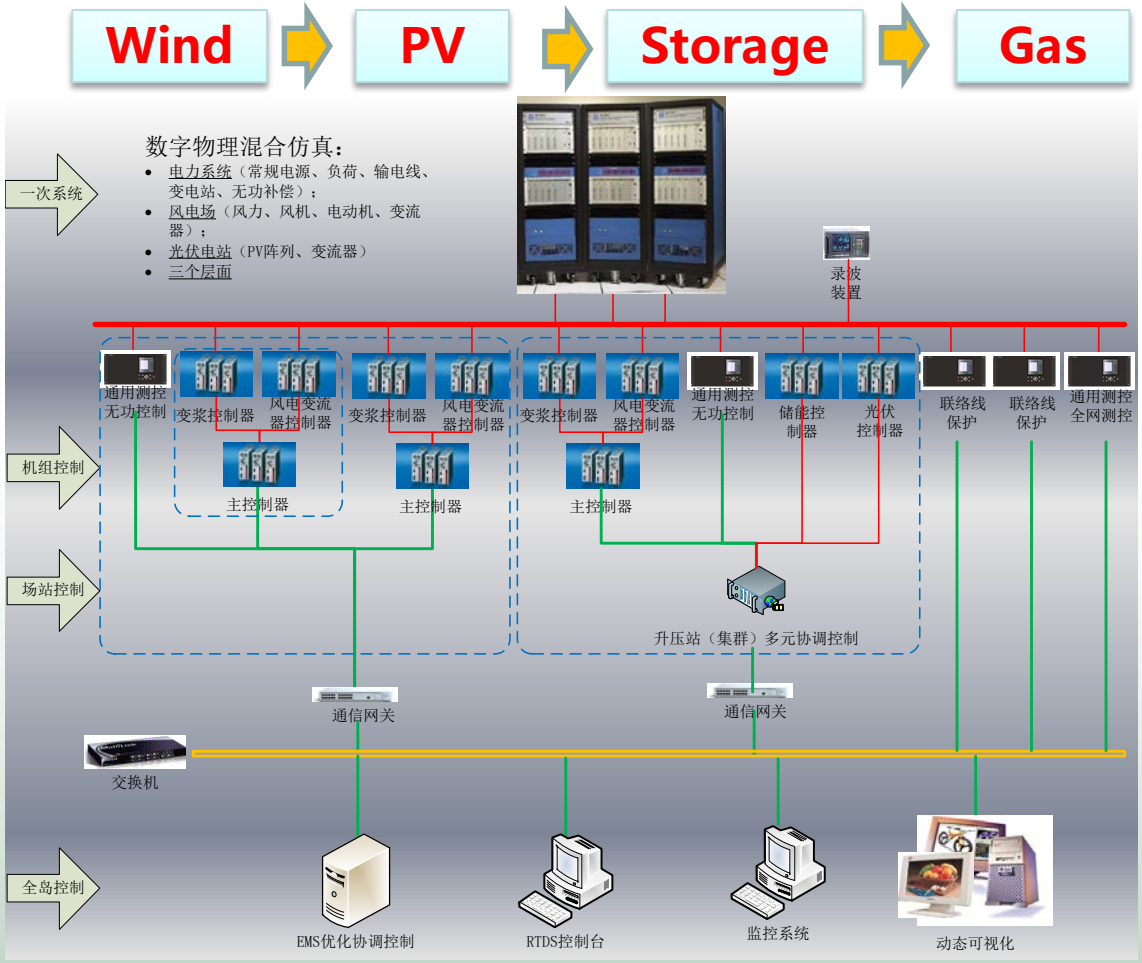
Lab configuration.

Wind farms

Substation

Island-wide

Bulk system



RTDS

Controller

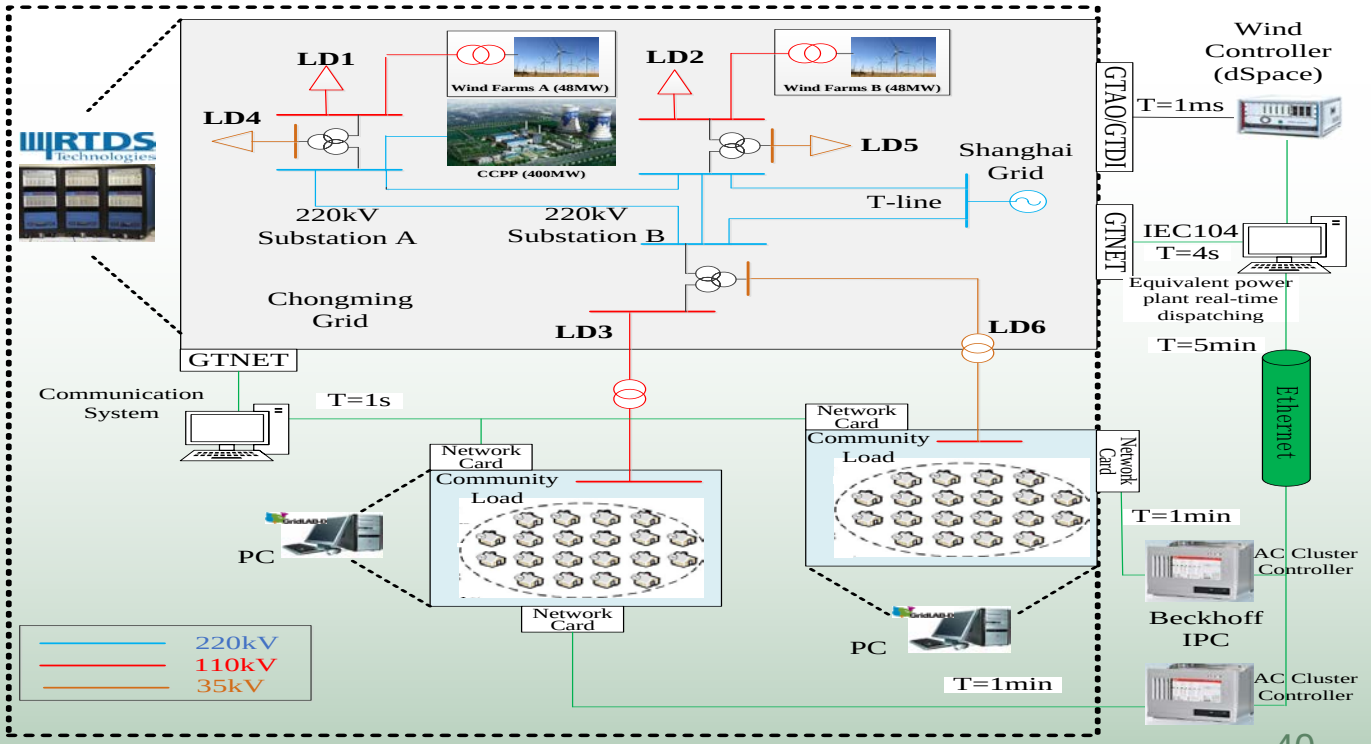
EMS

9. Real-time Digital Simulation & Validation

- **A cluster of PCs was used to simulate residential users, which runs in parallel with RTDS.**
- **The co-simulation system can operate continuously and check different test scenarios, e.g., different wind penetration levels & profiles, user preferences.**

RTDS

PC (Gridlab-d)



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Future prospects

EV and Storage

Further promote the demonstration application of energy storage in renewable energy integration; promote the development of EVs.

Policy & Regulation

Promote the introduction of policies and regulations, standard development; From technical feasibility to economic feasibility and mode replicable.

Internet + Power Supply

Based on UIP, promote the big data application in distribution; explore the new business mode of "Internet + power supply".

Regional Energy Internet

Build a green, interconnected, shared and flexible regional EI to achieve comprehensive utilization of large-scale renewable energy.

International ecological island

Construction of smart city in Shanghai; green, ecological and sustainable development of Chongming Island.

Thanks