PVPMC-9

中国科学院·电工研究所
IEECAS

Innovation towards High Penetration of RE

Strategies, Trends and Exertions

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IEE CAS



06/12/2017 · Weihai · China

OUTLINES

1 Trends and Strategies

2 Innovation of Regional Grid

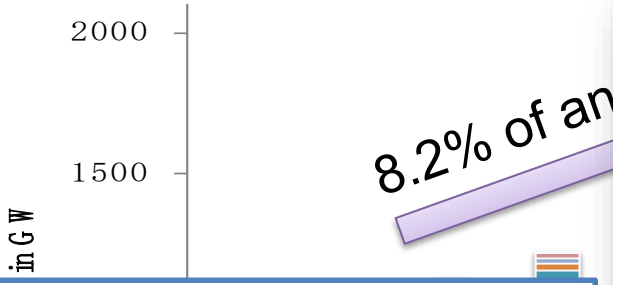
3 Innovation of Distribution Grid

4 Innovation of Micro-grid

5 Exertion toward HP RE

Global Trends

RE trends on large-scale & high-penetration deployment.



Share of RE in Energy Mix

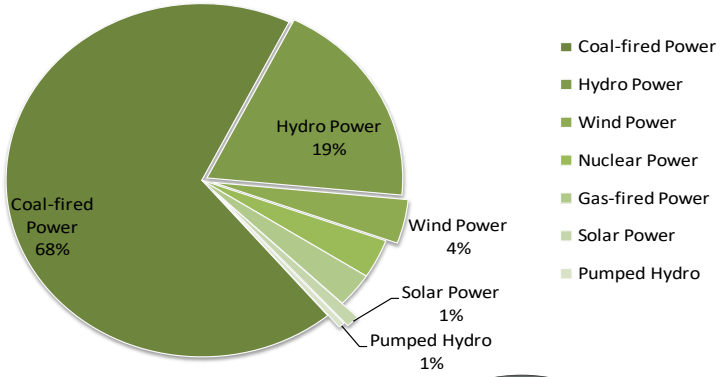
- UK: 30% by 2020
- US: 25% by 2025
- EU: 27% by 2030
- CN: 33% by 2030

Source: IRENA, Renewable Capacity Statistics 2017

2/3 of new installation will be renewable in globe during 2015 to 2040.

China

2016 Electricity Generation of China (in kWh)



2020

680 GW of RE electrical installation shares **27%** of electricity generation.

Partial Supplement

2030

1440 GW of RE will share 60% of electricity capacity.

Element Energy

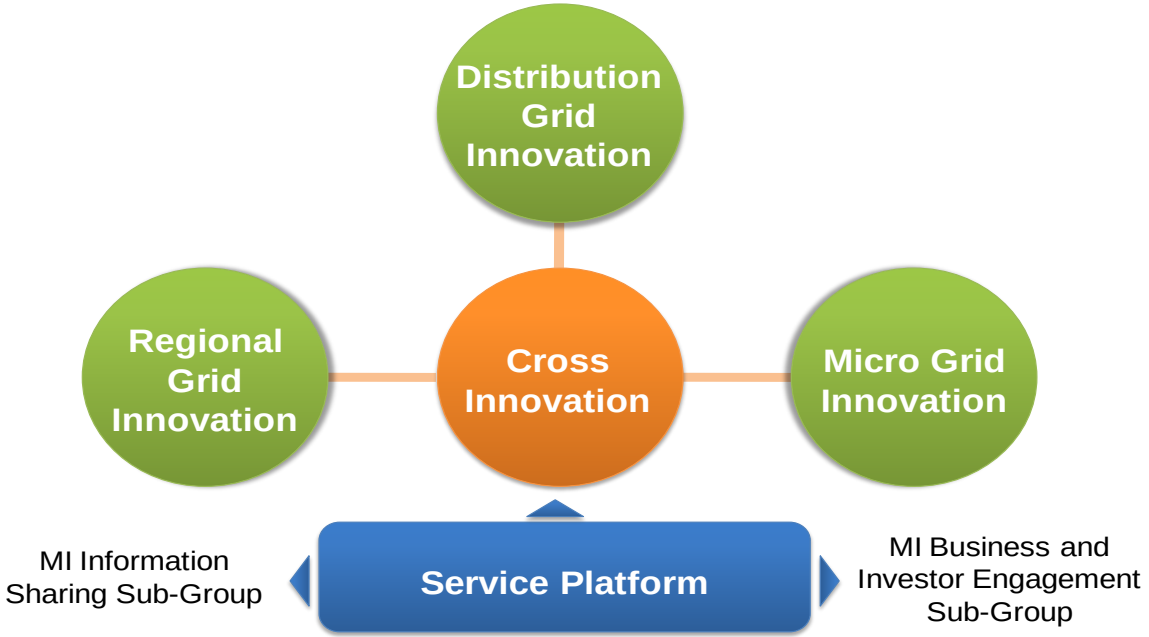
Source: RE Development 13th Five-Year Plan, NRDC;
Energy Outlook 2030 of China, CERS

International Collaboration

Innovation Trends

MI IC#1 Smart Grids:

To enable future grids that are powered by **affordable**, **reliable**, and **decentralised** renewable electricity systems.



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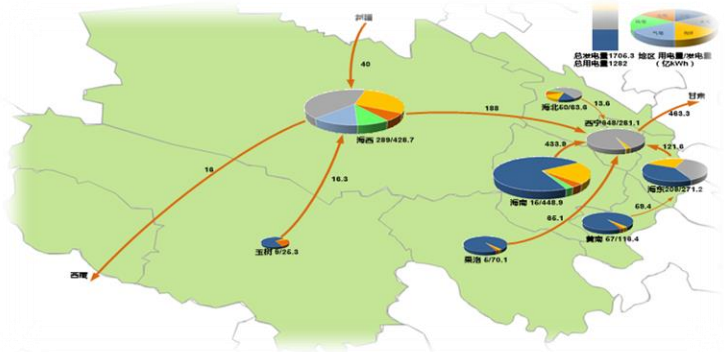
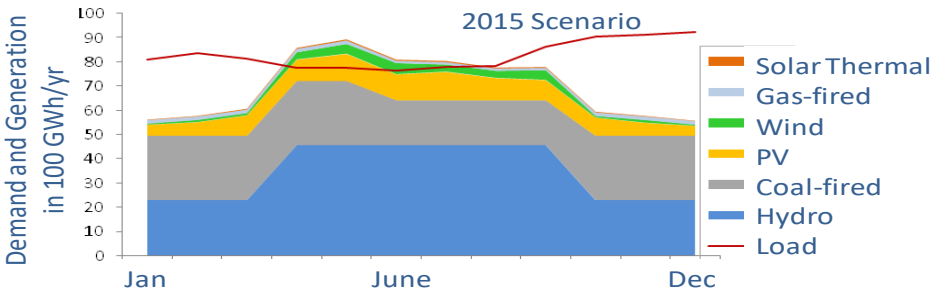
Challenges in Regional Grid

- **Regional Grid: How to enable regional grid to scale up proportion of renewable electricity with few energy waste and reasonable security?**
  - RE system: more cost-effective, friendly grid integration
  - Transmission: stability and lower cost
  - Plan, Forecast, Schedule and Security related to HP RE.



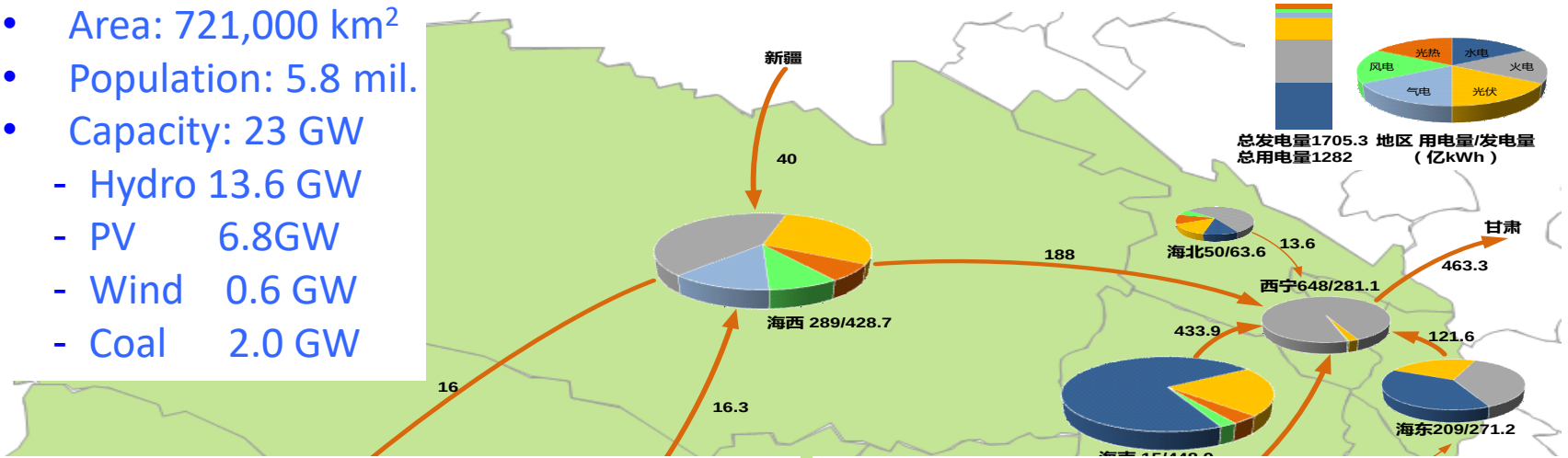
Qinghai Province 2015: 91% power capacity from renewable energy

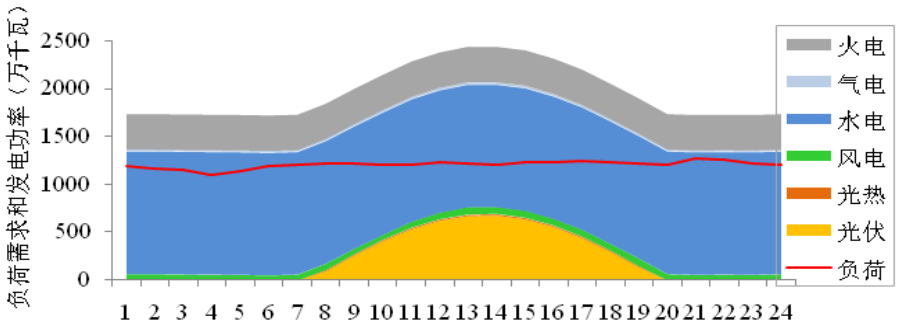


Seasonality, intermittence and fluctuation in a renewable power system

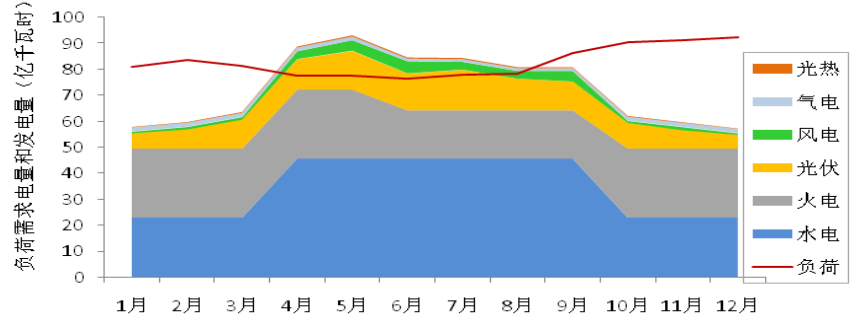
Case · HP-Scenario of Qinghai Province

- Area: 721,000 km^2
- Population: 5.8 mil.
- Capacity: 23 GW
  - Hydro 13.6 GW
  - PV 6.8GW
  - Wind 0.6 GW
  - Coal 2.0 GW



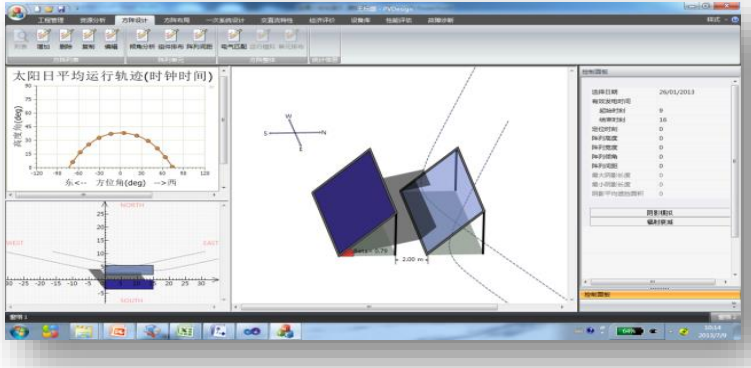


Improving schedule strategy of the grid



Seasonal balance issue arising

RE System · Lower-Cost Oriented



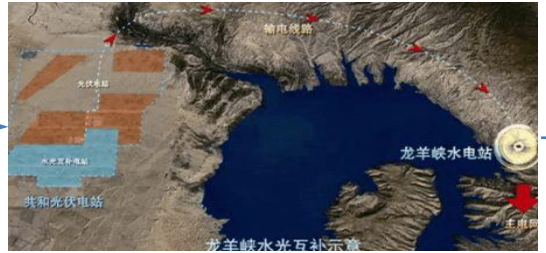
Precise design

Unmanned Aerial Vehicle (UAV)

Water-free cleaning Robot

Advanced O&M

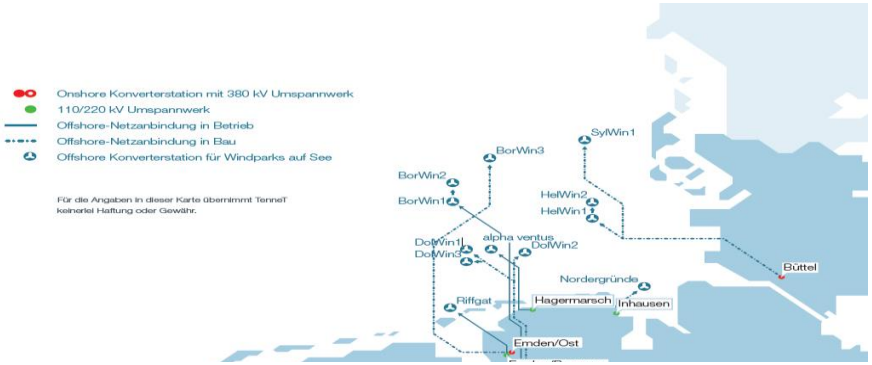
3.2 GW PV station



1.28 GW Hydro Power with seasonal reservoir

Large-scale Hybrid Generation

Transmission· HVAC → HVDC & HVAC Hybrid

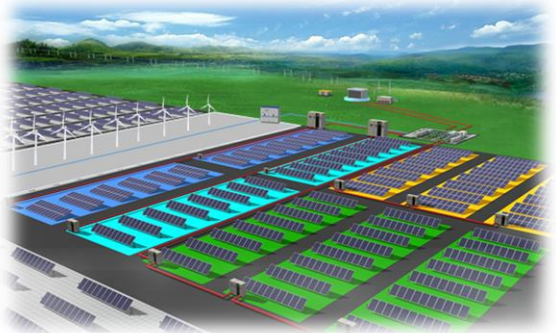


VSC HVDC is used for electricity transmission of 12 Wind farms located in the North Sea, Europe.

DolWin1 Converter Station

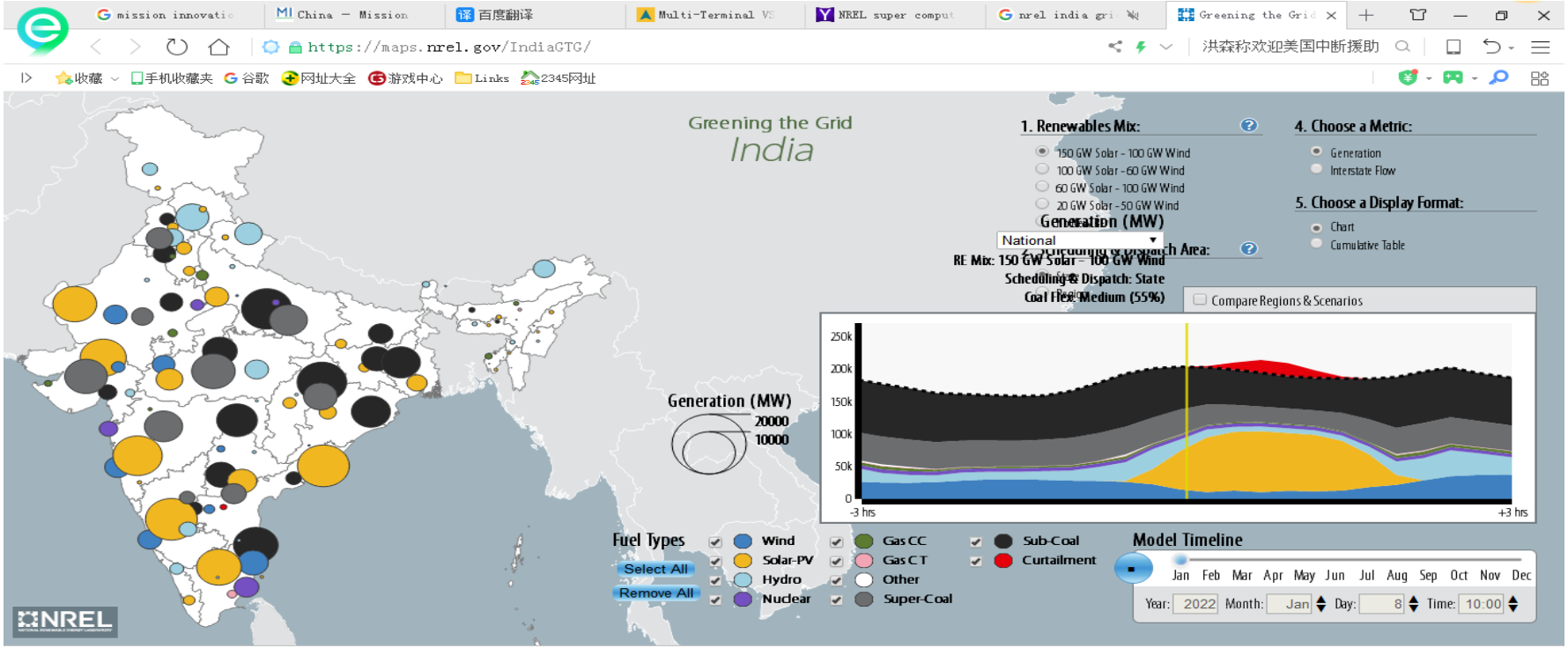
Dörpen West Converter Station

±160kV/200MW-100MW-50MW 3-Terminal VSC-HVDC for wind power, Nanao, China



A demonstration of DC-DC grid integration of PV is under developed.

Bulk System· Plan, Forecast, Schedule and Security



SC-assisted planning tool for national renewable energy, developed by NREL

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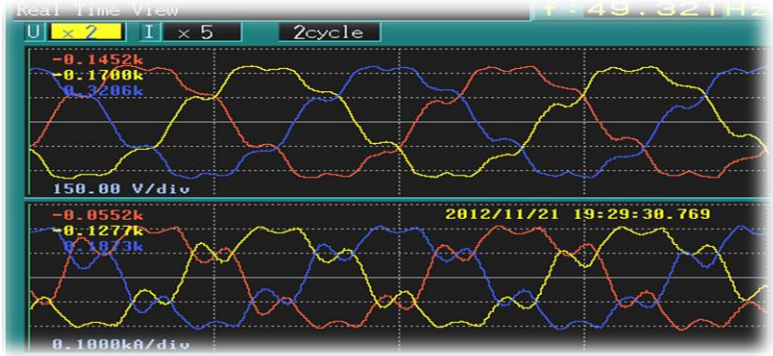
Challenges in Distribution Grid

- **Distribution Grid: How to enable distribution grid to accommodate high-penetration and large-scale distributed renewable electricity?**
  - DG in diverse grid: industry, village, island, …, etc.;
  - Power quality issue arising in weak grid;
  - Combination with DSM, ICT and EV for improving penetration.

A distributed PV system installed in a fish pool, China.



Harmonics resonance is observed in a weak grid after integrating DGPV.

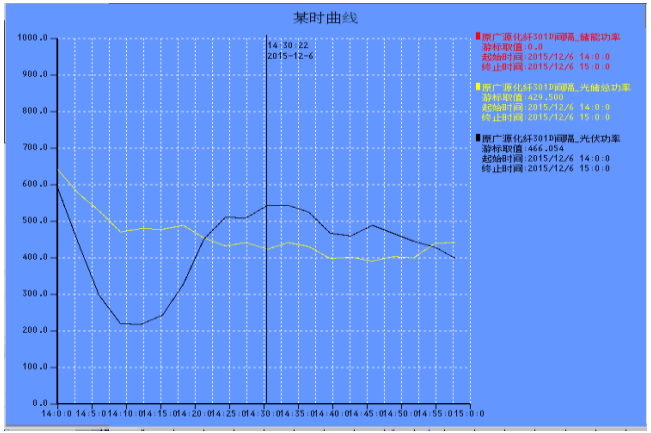
Case: HP-Scenario of Haining City

200 MW of PV installation supplies **~20% peak load** of Haining city, in which inhabits 640,000 population.

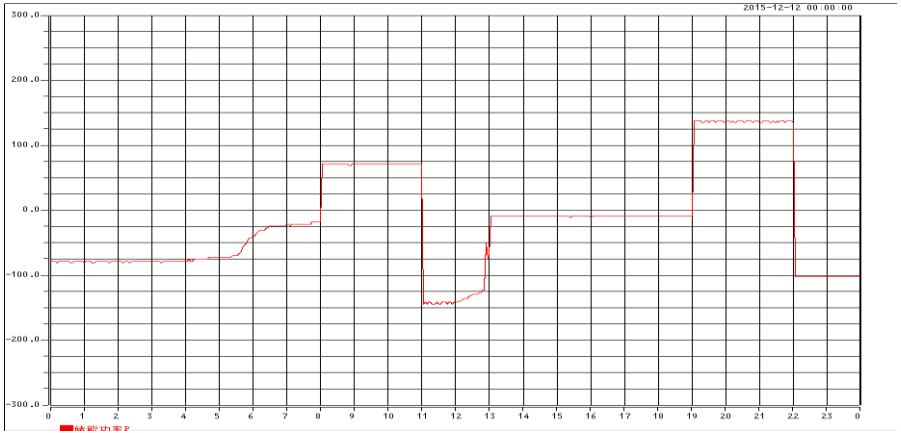
RE System: Auxiliary service and added-value

2 MW PV rooftop

1 MWh Battery



The ramp rate is lowered down to 25.7%/10min.

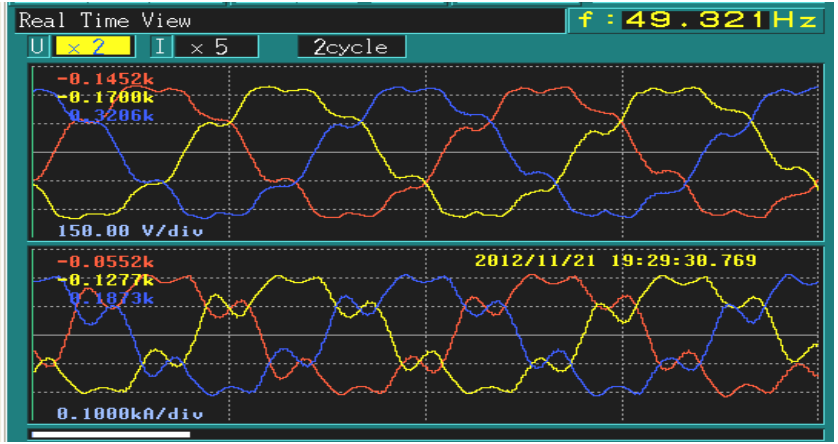


The Profit by following electricity price reaches RMB 770/day.

Power Quality

- **Power quality is much complicated**
  - Power factor, voltage rising and voltage flicker can be coped with reasonable approaches.
  - **Harmonics resonance** in weak grid is arising.

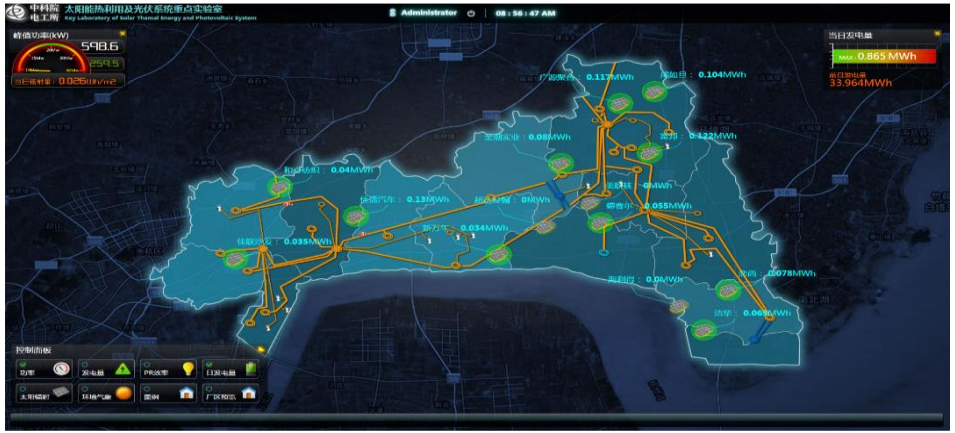
The power factor can be improved to 0.90-0.99 by smart inverters of PV & battery.



The harmonics resonance is measured when HP PV is integrated in a weak grid.

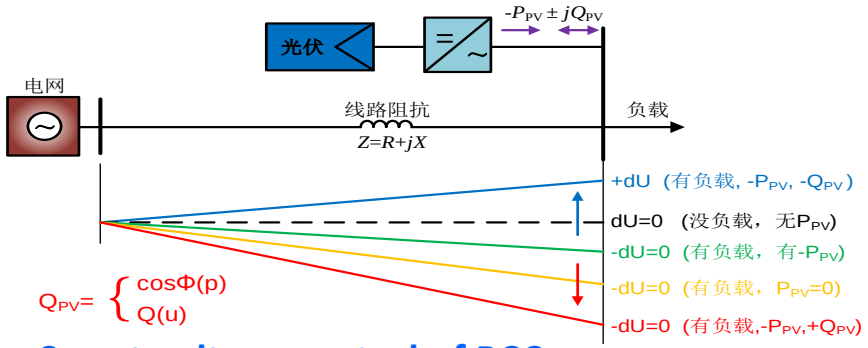
Smart Technology

App for iPhone



O&M system based on Cloud Platform

Distributed RTU



Smart voltage control of PCC

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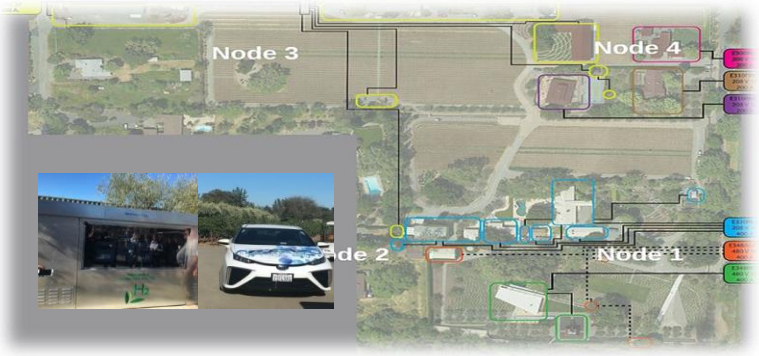
Challenges in Micro-grid

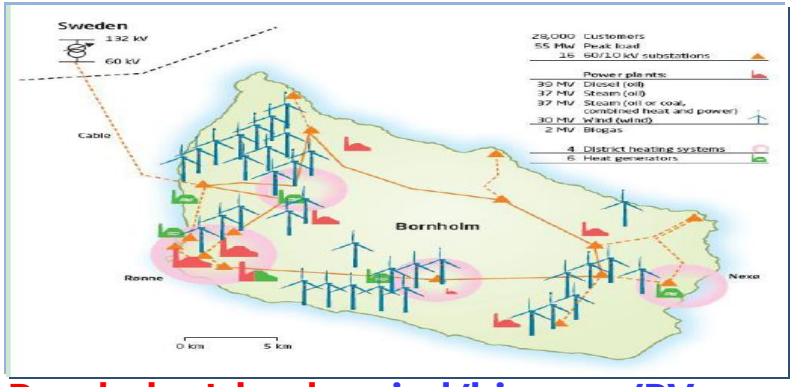
- **Micro-grid:** How to enable renewable-based micro grid to be **affordable** and **valuable**?
  - Business model of micro grids for resilience and critical loads (like data center) starts to practice in market.
  - Micro energy grids, combining power with heat, cool, hydrogen and etc., shows large potential of economics and market.

Microgrid for resilience in Sendai, Japan

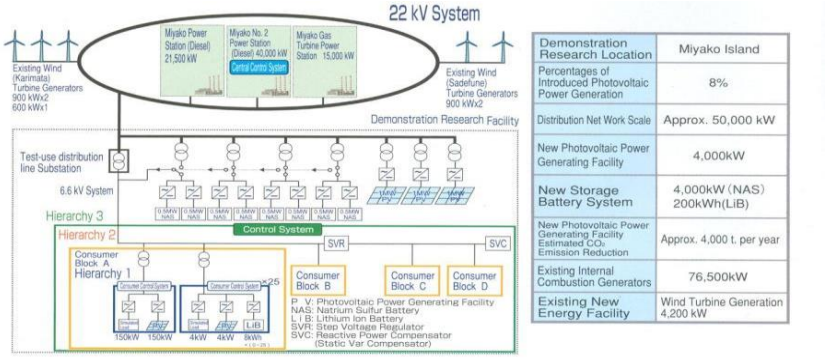


Microgrid for CCHP&H2 in Stone Edge Farm, USA

Micro-grid: Supplement of Utility Grid



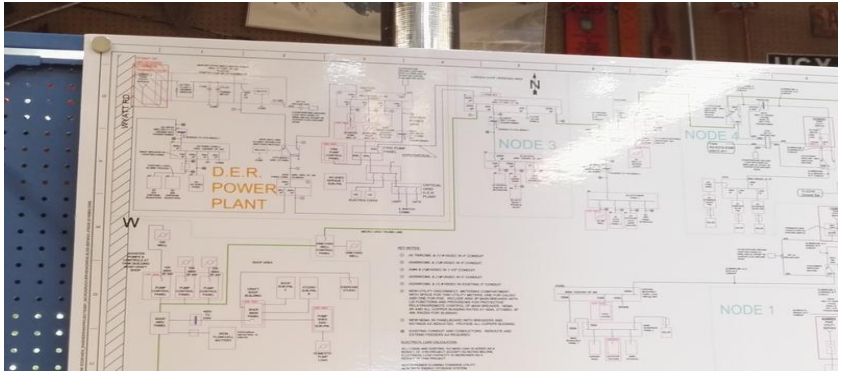
Bornholm Island – wind/biomass/PV



Demonstration Research Location	Miyako Island
Percentages of Introduced Photovoltaic Power Generation	8%
Distribution Net Work Scale	Approx. 50,000 kW
New Photovoltaic Power Generating Facility	4,000kW
New Storage Battery System	4,000kW (NAS) 200kWh(LiB)
New Photovoltaic Power Generating Facility Estimated CO_2 Emission Reduction	Approx. 4,000 t. per year
Existing Internal Combustion Generators	76,500kW
Existing New Energy Facility	Wind Turbine Generation 4,200 kW

Miyako Island-wind/PV/biomass/battery

Sendai-PV/battery for resilience



Stone Edge Farm, US- PV/CHP/hydro/battery

Micro grid depends on site, and some commercial cases appears.

Islanded Micro-grid

Yushu-12 MW hydro/PV/diesel

Lasha—PV/battery for household

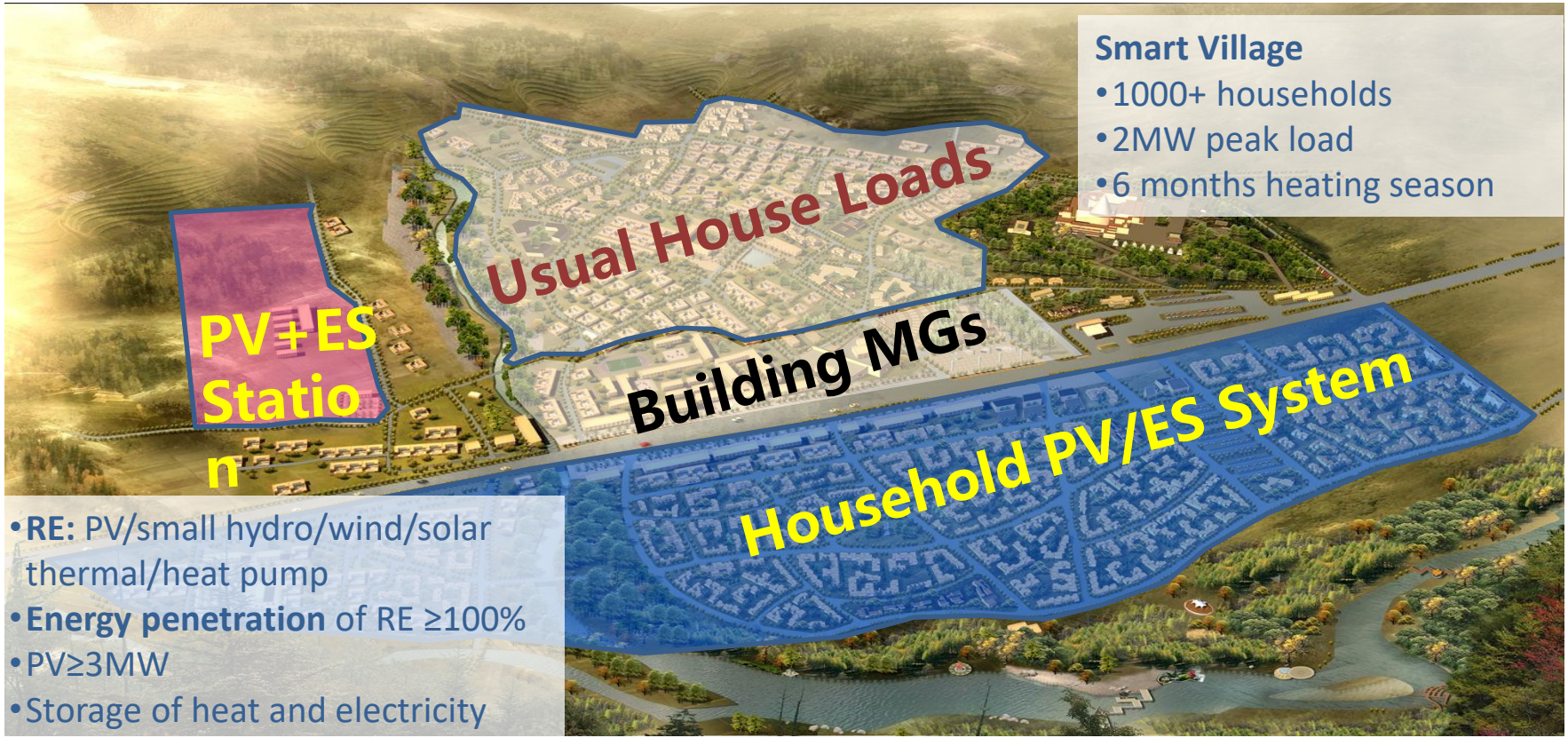
Dawanshan Islands

Tuergan village by RE-based CCHP

Donfushan Island-
PV/wind/diesel/desalination

Islanding micro-grid is under demonstration in China.

Micro Energy Grid



- **RE:** PV/small hydro/wind/solar thermal/heat pump
- **Energy penetration** of RE ≥100%
- PV≥3MW
- Storage of heat and electricity

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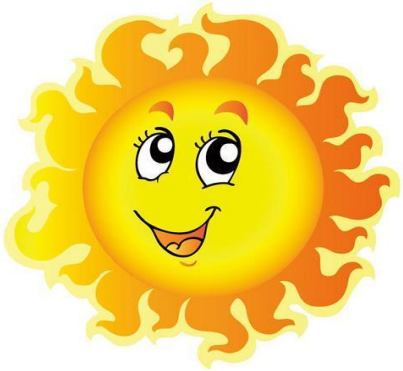
ST Programs of China

- **National Key R&D Program of RE and Hydrogen:**
  - Solar **(PV)**, wind, biomass, marine, geothermal, hydrogen, and renewable hybrid system
- **National Key R&D Program of Smart Grids:**
  - Grid integration of renewable electricity, flexible interconnection, interaction of prosumers, crosscutting

Opportunities of MI Smart Grids

MI Smart Grids: to accelerate the development and demonstration of smart grid technologies in order to facilitate the **cost effective uptake of RE**.

	Tasks		Tasks
10	**storage integration** at all time scales	8	Developing **regional electricity highways** with both AC and DC
9	Use of **demand response** for system services	5	Study and demonstrate **new grid architectures**
6	Identify and support improvements of suitable **flexibility options**	+	Novel / Advanced **power electronics** technology
7	**New planning tools able to account for the full complexity**		



Thank you!

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