Challenges and Industries Electrification Impacts on Large Renewables Integration in China

Dr. Chi Yongning
China Electric Power Research Institute, SGCC
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1. Status of Energy Utilization in China

2. Opportunities and Challenges of Industries Electrification to RE integration

1.1 Large RE Development in China

By the end of 2014:

- **Hydro power**: 302 GW, ranking No.1 in the world;
- **Wind power**: 96.37 GW, ranking No.1 in the world;
- **Solar power (PV)**: 28.05 GW, ranking No.2 in the world;

Wind and PV capacity growth from 2006 to 2014 in China
1.1 Large RE Development in China

- 9 large-scale wind power bases are in plan and under construction, each of them is over 10GW.
- Some goals have been achieved ahead of schedule.

2015

- Large PV station: 10GW (31.38GW)
- Distributed PV: 10GW (11.67GW)

2020

- Wind: 200GW
- PV: 100GW

Some goals have been achieved ahead of schedule.
1.2 Primary Energy Consumption

- The global reserve of fossil energy is limited;
- The large-scale utilization of fossil energy have caused more serious CO₂ Emission and pollutions to air, water, and soil.

![Energy Consumption Chart](chart.png)

The global and some countries’ energy final consumption structure

- **Year**: 1965, 2013
- **Total fossil energy consumption**: 5.1 billion, 15.8 billion (tons of standard coal)

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1.3 Energy Transition

- **Path:** replace fossil energy with clean energy, replace coal and oil by electricity in consumption;
- **Target:** Optimizing energy structure; increasing energy efficiency; achieve the transition from fossil energy dominant to clean energy dominant, increase the share of electric energy in end consumption.
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2.1 Challenges of RE Integration

- 80% of wind/solar resources, is located in North, Northeast and Northwest, 80% of the hydropower resources is located in Southwest.
- Over 2/3 of the power demand is located in East and Central China.
- Distance from energy bases to load centers: 800 km~ 3000 km

- China needs to develop large power transmission capacity to deliver the power to load center and optimize the power allocation nationwide.
2.1 Challenges of RE Integration

- Large power fluctuation of RE and lack of flexible power sources has brought great challenges to the power balancing capability of power system.
- By the end of 2014, the total installed generation capacity in China was 1360GW, including **67.32% thermal power**, **22.19% hydro power**, **7.04% wind power**, **1.46% nuclear power** and **PV power** of **1.95%**.

![Power Grid]

- **Wind power** 7.04%
- **Nuclear** 1.46%
- **Photovoltaic** 1.95%
- **Others** 0.04%
- **Hydro** 22.19%
- **Thermal** 67.32%

Fluctuation characteristics
2.2 Opportunities Brought by Industries Electrification

- Industries electrification will result in the growth of electricity demand which brings opportunities for RE grid integration.
  - Growth of industrial electricity provide a large market for RE;
  - Increase of the share of industrial load changes the load profile and decrease the peak-valley ratio (peak-valley difference/ total load) of load.

peak-valley ratio: 31.70%

peak-valley ratio: 20.13%
2.3 Challenges Caused by Industries Electrification

◆ Distribution grid upgrade required by industries electrification
  ◆ Impacts of DER and EV to distribution grid
  ◆ Demand for expansion of LV-Grid
  ◆ More smart control performance
◆ Interaction with industrial users
  ◆ Change of load characteristic
  ◆ User resource dispatching
  ◆ Information exchange between grid and industrial users
◆ Policy and business
2.4 Electricity replacement of SGCC

- **Electricity replacement projects**: 13000
- **Number of related policies**: 121

### 2014

- **Electric boiler**: 87
- **Klin**: 197
- **Heat pump**: 122
- **Electric storage-cooling**: 44
- **Port electricity**: 10
- **EV**: 19
- **Rail transit**: 212

**Unit**: TWH

- **Fired coal reduction**: 23.8 Million tons
- **CO₂ reduction**: 42.38 Million Tons
- **SO₂, NOₓ, Dust**: 0.91 Million tons

### Breakdown:

- **Electric boiler**
- **Klin**
- **Heat pump**
- **Electric storage-cooling**
- **Port electricity**
- **EV**
- **Rail transit**
- **Agricultural irrigation**
- **Scattered electric heating**
- **Domestic electrification**
- **Clean energy replacement**
- **Others**
### 2.4 Electricity replacement of SGCC

- **Potential electricity replacement** is about 1.8 trillion kWh.
- **Target of 2015**: 65,000 GWH(base), 75,000 GWH(challenge)

<table>
<thead>
<tr>
<th>NO.</th>
<th>Alternative energy</th>
<th>Alternative technology</th>
<th>Potential quantity (TWh)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>17939</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>Replace coal by electricity</td>
<td>Electric heat-storage boiler</td>
<td>6480</td>
<td>36.12%</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Heat pump</td>
<td>1814</td>
<td>10.11%</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Electric heat-storage boiler</td>
<td>1800</td>
<td>10.03%</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Electric cooking appliance</td>
<td>1000</td>
<td>5.57%</td>
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<tr>
<td>5</td>
<td>Replace oil by electricity</td>
<td>EV</td>
<td>176</td>
<td>0.98%</td>
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<tr>
<td>6</td>
<td></td>
<td>Electric railway</td>
<td>242</td>
<td>1.35%</td>
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<tr>
<td>7</td>
<td></td>
<td>Urban railway system</td>
<td>125</td>
<td>0.70%</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Kiln</td>
<td>40</td>
<td>0.22%</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Electric pump</td>
<td>280</td>
<td>1.56%</td>
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<tr>
<td>10</td>
<td>Replace gas by electricity</td>
<td>Electric cooking appliance</td>
<td>1806</td>
<td>10.07%</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Electric water heater</td>
<td>798</td>
<td>4.45%</td>
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<tr>
<td>12</td>
<td></td>
<td>Electric heater for house</td>
<td>106</td>
<td>0.59%</td>
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<tr>
<td>13</td>
<td></td>
<td>Electric heat-storage boiler</td>
<td>672</td>
<td>3.75%</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Electric heat-storage boiler</td>
<td>2600</td>
<td>14.49%</td>
</tr>
</tbody>
</table>
1. Status of Energy Utilization in China
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3.1 China’s Energy Innovation Strategy

- Replace coal by electricity
- Replace oil by electricity
- Electricity coming from North West
- RE electricity

Over 20%
3.2 Reinforcement of Power Grid --- UHV Power Transmission

- **Build national UHV power grids:** form a UHV AC backbone network and UHV DC transmission channels connecting large energy bases and load centers.
- **Engineering construction:**
  - 3 AC and 4 DC UHV projects have been completed
  - Delivered over 200TWh electricity

China’s plan for UHV grids by 2020
3.3 Improved Generation Flexibility
--- RE power prediction

- Physical, statistical and hybrid prediction methods
- Numerical weather prediction operational center
3.4 Demand Side Management --- EV and smart meters application

- Built over 500 EV charging and battery swap stations, 20,000 charging poles, and many inter-city charging and battery swap service network;
- Installed 220 million smart meters, and realized automatic data collection of power use information for 230 million customers.
3.4 Demand Side Management
--- Demand response

**Demand response**

539 households in 4 cities

<table>
<thead>
<tr>
<th>Type</th>
<th>Type</th>
<th>Beijing</th>
<th>Shanghai</th>
<th>Yinchuan</th>
<th>Nanchang</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infor push</td>
<td>information push</td>
<td>35</td>
<td>48</td>
<td>34</td>
<td>50</td>
</tr>
<tr>
<td>AC controlling</td>
<td>information push and load control</td>
<td>48</td>
<td>36</td>
<td>38</td>
<td>50</td>
</tr>
<tr>
<td>baseline</td>
<td>data collection only</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

**Load/kW**

- **Information push group:**
  - peak-valley difference: 32kW
- **Baseline group:**
  - peak-valley difference: 34.68kW
- **AC controlling group:**
  - peak-valley difference: 19.42kW

**Information push group:**
Reduction rate of peak-valley difference: 7.73%

**AC controlling group:**
Reduction rate of peak-valley difference: 44%
3.5 Policy and Related Incentives
--- Policy

Policy

- China Renewable Energy Law
- 2005
- 2006
- 2007
- 2009

No systematic RE policies before 2005

China Renewable Energy Law released

China Renewable Energy Law takes effect

China Renewable Energy Law amended

By 2020
- Wind 30GW
- Solar power 1.8GW
- Biomass 30GW

General targets
- Classified tariffs
- Cost share (RE surcharge 0.04 CNY/kWh)
- Compulsory grid-connected

Strengthen planning
- Power utility’s duty
- RE fund established

Renewable Energy Law
### 3.5 Policy and Related Incentives

--- **Policy**

**Renewable energy electricity quotas**

- **Making a mandatory RE quota** in each province, encourage each region actively develops and utilizes local RE resources;
- **Will be issued this year or next.**

<table>
<thead>
<tr>
<th>Type of Regions</th>
<th>Given Ratio of RE Quotas</th>
<th>Including Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>10%</td>
<td>Inner Mongolia, Shaanxi, Ningxia, Gansu, Xinjiang, Tibet, Liaoning, Jilin, Heilongjiang</td>
</tr>
<tr>
<td>Type 2</td>
<td>7%</td>
<td>Beijing, Tianjin, Hebei, Qinghai, Yunnan, Shanxi, Shandong</td>
</tr>
<tr>
<td>Type 3</td>
<td>4%</td>
<td>Jiangsu, Shanghai, Guangdong, Hunan, Fujian, Henan, Anhui, Hubei, Guangxi and Hainan</td>
</tr>
<tr>
<td>Type 4</td>
<td>2%</td>
<td>Zhejiang, Guizhou, Sichuan, Jiangxi, Chongqing</td>
</tr>
</tbody>
</table>

**Generation** ➔ **Transmission** ➔ **Consumption**

- RE generation enterprises ➔ Power grid ➔ Provincial government
Future Outlook

By 2022

- National UHV grid will be formed with more than 20 UHV lines;
- Cross region power transmission: 450GW;
- Clean energy power transmission: 550GW;
- Annual clean energy consumption: 1.7 trillion kWh;
- Replacement of raw coal: 700 Million Tons
- CO\textsubscript{2} emission reduction: 1400 Million Tons
- SO\textsubscript{2} emission reduction: 3.9 Million Tons

Thanks for your attention!

chiyn@epri.sgcc.com.cn