Renewable Energy Target Study in China
Economic Optimal Quantity vs. Government Targets

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- Objective of the Study
- Methodology, Assumptions and Findings
- Recommendations

- Replicate in other countries?
Historical RE Development in China (1990-2008)

- **Small Hydropower:**
  - Stable growth since 1980s
  - World’s leading country in hydropower development

- **Wind Power:**
  - Stagnation before 2000
  - Fastest growth in the world after 2005 (double each year in 2006, 2007, 2008)

- **Biomass Power:**
  - Boomed since 2006

- **Solar PV:**
  - Promoted by government’s programs
  - Early development stage
Increasing RE Targets in China

- **9th FYP (1996-2000):**
  - Target of wind power in 2000: 1 GW
  - Not met, total capacity of wind power in 2000 was 0.34 GW.

- **2004 Bonne RE Conference:**
  - RE share 10% of primary energy needs by 2010
  - 20GW wind power by 2020
  - Increase to 30 GW of wind power by 2020 in 2005 Beijing RE conference

- **2007 RE Medium and Long term Plan:**
  - RE share 15% of primary energy needs by 2020
  - 2020 targets: wind power 30 GW, biomass 30 GW, Solar 1.8 GW, Small hydropower 75 GW

- **Envisaged RE Target (not announced yet):**
  - Wind power 150 GW by 2020
  - Solar PV 20 GW by 2020
Objectives of the Study

- Are the ambitious RE Targets are economically and environmentally justified?
- Are the current policies consistent with the GTs?
- Incremental Cost and Who pays for it?

The Objectives of this study are to answer above Qs:

- Evaluation of the government RE targets against the optimal solutions
- Review of the current policies

A model was developed in about 2000 when CRESP was prepared – an update study based on the same approach and updated RE database.
Methodology (1)

- To determine the optimum share of RE in the total electricity generation considering the economic and environmental assumptions (economic analysis)
  - Build cost supply curve of RE projects
  - Compare with cost of coal-fired thermal
  - Incorporate the environmental externalities (local + global)
- How to apply the method in China:
  - Province by province analysis (huge differences among provinces)
  - Capacity penalty of RE (wind, PV)
  - Combined into the national supply curve based on incremental cost
  - Policy analysis: feed-in tariffs, MMS
  - Impact to different stockholders: winners & losers
Methodology (2)

Provincial Curve (Levelized Cost)  ➔  National Curve (Incremental Cost)
Major Assumptions

- RE type: grid-connected
  - wind power, small hydro, biomass, and solar PV
- Alternative option: coal-fired thermal (China)
- Social discount rate: 8% (NDRC)
- Technical & Economic Indices
  - capital cost, fuel price, efficiency, capacity factor, ...
- Externality – lower/upper limits (uncertainty)
- RE database – Key !!!
Major Assumptions – RE Database

- RE database was established by ERI:
  - Existing, under-construction, and planned RE projects – both national and provincial
  - About 1900 RE projects in 31 provinces

<table>
<thead>
<tr>
<th>RE technology</th>
<th>RE resources (MW)</th>
<th>Investment (Y/kW)</th>
<th>Fuel cost (Y/ton)</th>
<th>Capacity factor (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>173,393</td>
<td>8,700–10,800</td>
<td>—</td>
<td>21–37</td>
</tr>
<tr>
<td>Small hydropower</td>
<td>128,045</td>
<td>3,548–9,965</td>
<td>—</td>
<td>13–50</td>
</tr>
<tr>
<td>Hydropower rehabilitation</td>
<td>5,243</td>
<td>Avg. 2,870</td>
<td>—</td>
<td>13–50</td>
</tr>
<tr>
<td>Biomass</td>
<td>25,364</td>
<td>9,500</td>
<td>260–350</td>
<td>80</td>
</tr>
<tr>
<td>PV</td>
<td>22,670</td>
<td>24,000</td>
<td>—</td>
<td>10–25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>354,715</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The RE potential in the table is based on identified or extrapolated grid connected electricity projects, and does not reflect the full RE potential in China.
Analytical Framework

- Four RE development Scenarios:
  - Government Targets – Current, Envisaged (2)
  - Optimal Solutions (2)
    - To incorporate the high and Low limit of environmental externalities

- Analysis of Current RE Policies
  - Feed-in Tariff: wind power, biomass, solar PV
  - MMS: with trade vs. without trade
  - Impact on electricity tariff (cost of generation)
Major Findings (1)

a. Cost Supply Curve of RE in China

- RE Cost Supply Curve
- Current GT (Optimal Solution)
- Dark Green
- Envisaged GT (Optimal Solution)
- Bright Green

Key points:
- Levelized Increment Cost (Y/kWh)
- RE Generation (TWh)
- Key generation points: 533, 637, 857, 1079
Major Findings (2)

b. Capacity Structure

- Wind
- SHP
- SHP Rehab.
- Biomass
- Solar PV

RE Generation (TWh):
- Current GT
- Drak Green
- Envisaged GT
- Bright Green

RE Installed Capacity (GW):
- Current GT
- Drak Green
- Envisaged GT
- Bright Green
c. Implicit or Assumed Environmental Cost

- **Current GT**: 0.354
- **Dark Green**: 0.354
- **Envisaged GT**: 0.354
- **Bright Green**: 0.354

**Cost Reduction for Optimal Solution**

- **Coal-fired Thermal**: 0.873
## Whether the 15% target is achievable?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Current GT 2020</th>
<th>Envisaged GT 2020</th>
<th>Dark Green 2020</th>
<th>Bright Green 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RE Generation</strong></td>
<td>GWh</td>
<td>532914</td>
<td>856900</td>
<td>636849</td>
</tr>
<tr>
<td>Large Hydro (1)</td>
<td>GWh</td>
<td>922500</td>
<td>922500</td>
<td>922500</td>
</tr>
<tr>
<td>Other Biomass Generation (2)</td>
<td>GWh</td>
<td>37358</td>
<td>37358</td>
<td>37358</td>
</tr>
<tr>
<td>Total RE Supply from electricity</td>
<td>mtce</td>
<td>477.7</td>
<td>581.4</td>
<td>510.9</td>
</tr>
<tr>
<td>Other RE Supply (3)</td>
<td>mtce</td>
<td>137.7</td>
<td>137.7</td>
<td>137.7</td>
</tr>
<tr>
<td>Total RE Energy Supply</td>
<td>mtce</td>
<td>615.4</td>
<td>719.1</td>
<td>648.7</td>
</tr>
<tr>
<td><strong>RE Share (%)</strong></td>
<td>%</td>
<td>12.9%</td>
<td>15.1%</td>
<td>13.6%</td>
</tr>
</tbody>
</table>

| Nuclear Power                  | GW             | 40                | 70               | 70                | 70               |
| Non-Fossil Fuel Share (%)      | %              | 14.8%             | 18.4%            | 16.9%             | 19.8%            |

### Assumptions:
- Energy demand in 2020: 4,772 million tce (China’s Low Carbon Development Pathways by 2050, ERI 2009)
- Other REs are assumed to follow 2007 RE plan.
Impact of Feed-in Tariff

To be met by:
- Increasing tariff, or
- Cost reduction by 17%

<table>
<thead>
<tr>
<th>Source</th>
<th>Current</th>
<th>Envisaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gov. Targets</td>
<td>0.25 Y/kWh</td>
<td>0.35 Y/kWh</td>
</tr>
<tr>
<td>Feed-in Law</td>
<td>0.35 Y/kWh</td>
<td>0.25 Y/kWh</td>
</tr>
</tbody>
</table>

Wind Power

Biomass Power

Solar PV

Required tariff:
- 3 Y/kWh, or
- 2 Y/kWh @ 30% cost reduction
- 1 Y/kWh @ 80% cost reduction
Impact of Trade in Mandatory Market Share

- Two options in meeting the same national Mandatory RE target of EGT - with trade vs. without trade
- With Trade Option:
  - RE transaction – 360 TWh (42% of EGT)
- Without Trade Option:
  - Sizable number of provinces can’t meet its share with their own resources identified to date
- Cost comparison:
  - Huge Cost saving: about 56-72%
## Impact on Electricity Generation Cost (2020, fen/kWh)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Dark Green</th>
<th>Bright Green</th>
<th>Current GT</th>
<th>CGT Optimal</th>
<th>Envisaged GT</th>
<th>EGT Optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>0.18</td>
<td>1.79</td>
<td>0.19</td>
<td>0.13</td>
<td>1.59</td>
<td>0.60</td>
</tr>
<tr>
<td>Small hydro</td>
<td>-0.82</td>
<td>-0.77</td>
<td>-0.82</td>
<td>-0.82</td>
<td>-0.76</td>
<td>-0.81</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.23</td>
<td>0.65</td>
<td>0.58</td>
<td>0.02</td>
<td>0.61</td>
<td>0.60</td>
</tr>
<tr>
<td>Solar PV</td>
<td>0.00</td>
<td>0.03</td>
<td>0.07</td>
<td>0.00</td>
<td>1.01</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>-0.41</td>
<td>1.70</td>
<td>0.02</td>
<td>-0.67</td>
<td>2.45</td>
<td>0.39</td>
</tr>
</tbody>
</table>

- Small hydropower development – reduction of 0.8 fen/kWh
- Wind and biomass contribute significantly to the increase of the total generation cost
- PV contribution is negligible in most cases because of low penetration
- For Reference, average electricity tariffs in the regional grids – 20.1 ~ 42.4 fen/kWh (2009, VAT excluded)
- Current surcharge of 0.4 fen/kWh is inadequate to meet EGT → 2.5 fen/kWh is required by 2020
Who pay the Incremental Cost?

Incremental Generation Cost

- Taxpayers
  - Compensation of off-takers
  - Subsidies to Developers
- Ratepayers
  - Voluntary “Green Electricity” Scheme
  - Mandatory pass-through tariff
- RE Fund
- Selling CERs

Could reduce IC

Pilot in Shanghai
Recommendations

- The government targets could be achieved in a more effective manner by:
  - Developing hydropower faster
  - Improving rapidly the performance of wind power
  - Promoting trade among provinces when quota is applied
  - Developing green electricity schemes at the provincial or national level
Replication in Other Countries:

- **Peer Reviewers:**
  
  “The Policy Note discusses an important issue and its analysis has *relevance to many other countries* that are currently in the process of setting new targets for 2020 and 2030”

- **Press Release after the report publication:**
  - Widely quoted by both domestic and international news
  - Interview requests

- **Many request for reports from both internal and external readers**
Replication in Other Countries:

- Ideas on further dissemination – a product?
  - Methodology Report
  - Two Cases studies – a Province in China, Indonesia (geothermal)
  - Manual + Model
  - CD for dissemination
  - Cross support to other countries

? Additional resources to support above work
Thanks!

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For Questions and Discussions.