Cooperative Policy Mechanism to Promote China’s Renewable Energy Consumption based on CGE Model

Yongxiu He, Yuexia Pang
North China Electric Power University
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Research Background
The rate of cities below the standard in air quality

Data Sources: http://jcs.mep.gov.cn/
Average Number of Days of Air Quality in 2013

- **Excellent**: 22.90%
- **Good**: 12.90%
- **Severe contamination**: 8.00%
- **High pollution**: 6.20%
- **Middle pollution**: 2.40%

PM 2.5 in typical cities

- **Beijing**: 3.5
- **Tianjin**: 4.0
- **Shijiazhuang**: 4.5
- **Shanghai**: 2.0
- **Nanjing**: 2.5
- **Hangzhou**: 3.0
- **Guangzhou**: 2.5

Data Sources: http://jcs.mep.gov.cn/
_wind curtailment phenomenon

Data Sources: National renewable energy information management center ; National Energy Administration
Facing the so serious environment and renewable energy consumptive problem, it is important to research how to promote renewable energy consumption.

Solar curtailment in Gansu

Water curtailment in Yunnan

Prediction
Renewable energy price policy in China

One price one generator

Government guides the feed-in tariff.

Benchmark prices for different resources area

1991 2006 2009

Nuclear

2011

Wind power

Benchmark price is 0.43 Yuan/kWh (After January 1 2013).

2013.1

Solar power

Benchmark price for different production time

The benchmark price is implemented in province. The price is negotiated by both parties across different provinces.

2013.5

Hydropower

2014

Adjusted benchmark prices for different resources area

2016

Adjusted benchmark prices for different resources area
Electricity price in China
Renewable energy subsidy policy in China

<table>
<thead>
<tr>
<th>Year</th>
<th>Wind power/ Solar power’s subsidy per kWh</th>
<th>Wind power/ Solar power’s benchmark price</th>
<th>Coal-fired power Units desulfurization benchmark price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.2 Fen/kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov. 2009</td>
<td>0.4 Fen/kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 1, 2011</td>
<td>0.8 Fen/kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept. 2013</td>
<td>1.5 Fen/kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The total subsidy is from the electricity sell price uplift for renewable energy. And the renewable energy electricity price additional fund changes are as follows:
<table>
<thead>
<tr>
<th>Year</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>Participating in the cooperative exploitation of offshore petroleum resources of Chinese and foreign enterprises shall pay a concession.</td>
</tr>
<tr>
<td>1984</td>
<td>Resources tax would be levied for crude oil, natural gas and coal from October 1 in 1984. Threshold was set by profit rate, and the tax was progressive.</td>
</tr>
<tr>
<td>1994</td>
<td>According to the quantity of sales or self-use, resources tax was levied. For example, the coking coal rate is 6 Yuan/ton, the steam coal rate is between 2 Yuan/ton and 4 Yuan/ton.</td>
</tr>
<tr>
<td>2011</td>
<td>The resources tax of coal was levied by quantity of sales or self-use, however, the resources tax of crude oil and natural gas were levied by sales, and the rate is 5%~10%.</td>
</tr>
<tr>
<td>2014</td>
<td>The resources tax of coal, crude oil and natural gas were levied by sales, and the rate of coal is 2%~10%, the rate of crude oil and natural gas is 5%~10%.</td>
</tr>
</tbody>
</table>
Pollution Discharge Fee System is established.

1982 year

The pollution discharge fee is paid by polluters, according to species, the emission of pollutants.

2003 year

Environmental protection tax is studied.

2011 year

Pollution Discharge Fee System is improved.

2012 year

Levying Environmental tax at the right moment is proposing.

2014 year

Enterprises, institutions and other production operators, who discharge taxable pollutants into the environment directly, are taxpayers.

2015 year
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Research Contents

Structural framing

- Tax
- Renewable Energy Consumption
- Price
- Subsidy

- Resource tax
- Environment tax
- The highest price
- Marginal cost

- Environment depletion
- Resource depletion
3.1 Tax model

Resources tax

Taxation according to quantity

\[ T_{At} = Q_{At} \times \rho_{At} \]

Taxation according to price

\[ T_{Bt} = R_{Bt} \times \rho_{Bt} \]

- Further improve resources tax rates on the basis of the existing tax burden level.
Environment tax

\[ R_{\text{etax}} = [B_1 \times (Q_{\text{coal}} \times \alpha_{\text{coal}}) \times \theta_1 + B_2 \times (Q_{\text{coal}} \times \beta_{\text{coal}}) \times \theta_2 ] \\
+ [B_1 \times (Q_{\text{oil}} \times \alpha_{\text{oil}}) \times \theta_1 + B_2 \times (Q_{\text{oil}} \times \beta_{\text{oil}}) \times \theta_2 ] \\
+ [B_1 \times (Q_{\text{gas}} \times \alpha_{\text{gas}}) \times \theta_1 + B_2 \times (Q_{\text{gas}} \times \beta_{\text{gas}}) \times \theta_2 ] \]

- Environment tax is the sum of carbon tax and sulfur tax.
- They are levied based on the carbon/sulfur content of the fuels in accordance with the standard specific duty in consumption links to compensate environment cost.
3.2 Subsidy model

Renewable energy subsidy mechanism

Environment cost

- governance environment cost
- governance environment cost of carbon dioxide
- governance environment cost of sulfur dioxide

Health cost

- governance environment cost of nitrogen oxide compound

Illness cost

Death loss

resource depletion cost
3.2 Subsidy model

Governance environment cost

\[ C_g = a_{CO_2} \times q_{CO_2} + a_{SO_2} \times q_{SO_2} + a_{NO_x} \times q_{NO_x} \]

Health cost

\[ C_h = \frac{P_{eo} \times H_L \times (1 - r_d)}{q} + \frac{P_{eo} \times r_d \times HC_m}{q} \]

\[ HC_m = \sum_{i=1}^{n} \frac{R_f (1 + \phi)^n}{(1 + r)^n} \]

Resource Depletion Cost

\[ D = \frac{R}{(1 + r)^T} \]

Subsidy for per kWh renewable energy

\[ C = C_g + C_h + D \]
## 3.3 Price model

### Basic principles

- During the initial stages of power system market, because of the oversupply of renewable energy, it can be accepted the electricity prices that could maintain a litter profit or compensate for the cost of electricity by electricity suppliers.
- The demanders can get benefits by using renewable energy compared with the use of fossil energy.

### The theoretical payoff matrix

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>main body</th>
<th>demanders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The highest price</td>
<td>Purchase renewable energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$(P_0Q_d - b_1Q_d - C_d, P_iQ_i - P_eQ_e)$</td>
</tr>
<tr>
<td></td>
<td>The lowest price</td>
<td>$\left{ (k_1 - 1)b_1 + B \right}Q_d - C_d, P_iQ_i - P_eQ_e \right}$</td>
</tr>
</tbody>
</table>
4.1 Environment tax of carbon dioxide policy

With the increase of the carbon tax rate, the emissions of carbon dioxide, sulfur dioxide and nitrogen oxides gradually reduce, the consumptions of renewable energy gradually increase, and the ability that electricity power and renewable energy instead of fossil fuels gradually increases.

The degree of substitution of electric power to fossil fuels

The degree of substitution of renewable energy to fossil fuels
4.2 Carbon dioxide policy and subsidy policy

### Comprehensive scenarios of carbon tax policy and subsidy policy

<table>
<thead>
<tr>
<th>Scenario</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>A</th>
<th>Base Scenario (V)</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>The rate of carbon tax</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10 Yuan/t</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The change rate of subsidy</td>
<td>-30%</td>
<td>-20%</td>
<td>-10%</td>
<td>---</td>
<td>0</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>subsidy (Yuan/kWh)</td>
<td>0.169</td>
<td>0.193</td>
<td>0.217</td>
<td>0.24</td>
<td>0.241</td>
<td>0.265</td>
<td>0.289</td>
<td>0.313</td>
<td></td>
</tr>
</tbody>
</table>
4 Scenario analysis by CGE model

- The maximum amount of unit subsidy cannot exceed the environment cost of renewable energy.
4.3 Environment tax of carbon dioxide policy, subsidy policy and price policy

**Comprehensive scenarios of carbon tax policy, subsidy policy and price policy**

<table>
<thead>
<tr>
<th>scenario</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
</tr>
</thead>
<tbody>
<tr>
<td>The rate of carbon tax</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10 Yuan/t</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Unit subsidy</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>0.24 Yuan/kWh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
</tr>
</tbody>
</table>
In order to promote renewable energy consumption, the renewable energy market price should gradually reduce.

Although the lower price of wind power is benefited to the stable of social economy, however, the minimum price should be marginal cost of unit subsidy to achieve sustainable development.
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5 Conclusions

1. Hydropower can be drew into Renewable Portfolio Standard, in order to promote the development of renewable energy in China.

2. Energy price, tax and subsidy policy should be maintained coordination in consideration of the balance of market supply and demand, including the coordination of administrative authorities.

3. In order to promote renewable energy consumptive, price, subsidies and tax policies should conform to the requirements of different development stages in the process of the gradual marketization of the power industry.

4. The coordination among tax, prices, subsidies, RPS, carbon trading, financial support and other policies can promote sustainable energy source system construction.
Thank you for your attention!