MARKAL-Taiwan Application for Low Carbon Electricity Measures

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Outline

• Energy Overview of Taiwan
• MARKAL-Taiwan Model
• Scenarios Description
• Results and Discussion
• Conclusion
Structure of Energy Supply

- Energy supply went from a supply of 58.52 million kiloliters of oil equivalent in 1990 to 145.56 million kiloliters in 2010, an average annual growth of 4.66%.
- Of this total in 2010, indigenous energy contributed 0.61%, and imported energy occupied 99.39%.

Structure of Total Domestic Consumption (By Energy Form)

• Share of electricity increases gradually, while that of oil decreases.
• Total energy consumption has grown greatly over the past two decades, going from 50.99 million kiloliters of oil equivalent in 1990 to 120.31 million kiloliters in 2010, which is an average annual growth of 4.39%.

Electricity Production

- Installed capacity grew from 17,812MW in 1990 to 48,882MW in 2010, average annual growth rate is 5.3%.
- Electricity production grew from 90.2 TWh in 1990 to 247.0 TWh in 2010, an average annual increase of 5.17%.

Model Background

- ITRI established MARKAL-Taiwan model since 1993 supported by ETSAP Outreach Program and Bureau of Energy, Ministry of Economic Affairs.
- Major Application- Taiwan Annual Energy Outlook
  - The annual energy outlook is according to MARKAL-Taiwan model calculations.
  - The main analytic results includes:
    - Energy supply outlook, Energy demand outlook, Power capacity, Electricity Structure, Energy intensity, CO₂ intensity, Per capita CO₂ emission
- To evaluate the benefits and costs of CO₂ mitigation strategies, and make comparison with other nations.
- To analyze the impacts of energy conservations and renewable energy development strategies on the future energy structure and GHG emissions of Taiwan.
The Reference Energy System of MARKAL-Taiwan Model
Context of Technology Database

- 3 technology forms
  - Conversion technology: All electricity generation technology, including
    - Nuclear Power
    - Thermal Power
    - Cogeneration
    - Hydro Power
    - Renewable Power
  - Process technology:
    - Coke
    - Oil Refinery
    - LNG Gasification
Context of Technology Database

- 3 technology forms (Contd.)
  - Demand technology: including 3 demand sectors
    - Industrial Sector
    - Residential & Service Sector
    - Transport Sector
      - Cars, Buses, Motorcycles, Light trucks, Heavy trucks, Railways, Rail Rapid Transit system, Domestic aviation, Passenger ship, Freight ship.
Scenarios Description

• The energy related issues and challenges
  – High dependence on imported energy
  – Consider global requirement pressure of greenhouse gas emissions reduction

• Arguments over the use nuclear power since Japan's earthquake
  – The three existing nuclear power plants will not be considered for life extensions.
  – The fourth nuclear power plant put into use OR “nuclear-free homeland”.
## Scenarios Description

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Energy Service Demand</th>
<th>LNG</th>
<th>Nuclear*</th>
<th>Renewable Energy**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NOT Operate Commercially</td>
<td>Operate Commercially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>Low</td>
<td>20 million tons</td>
</tr>
<tr>
<td>Baseline 01-BASELINE</td>
<td>High ESD</td>
<td>11million tons</td>
<td>NOT Operate Commercially</td>
<td>3,145MW</td>
</tr>
<tr>
<td>Case 2 02-NLRLLM</td>
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<td></td>
<td>●</td>
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<tr>
<td>Case 3 03-NLRLLH</td>
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<td>●</td>
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<tr>
<td>Case 4 04-NHRRLH</td>
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<td>●</td>
<td>●</td>
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<tr>
<td>Case 5 05-NHRMLLH</td>
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<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Case 6 06-NHRHLH</td>
<td>High ESD</td>
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<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Case 7 07-NLRLLHDL</td>
<td>● ●</td>
<td>NOT Operate Commercially</td>
<td>3,145MW</td>
<td></td>
</tr>
<tr>
<td>Case 8 08-NHRLLHDL</td>
<td>● ●</td>
<td>●</td>
<td>3,145MW</td>
<td></td>
</tr>
<tr>
<td>Case 9 09-NHRHLHDL</td>
<td>● ●</td>
<td>●</td>
<td>●</td>
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</tr>
</tbody>
</table>

*Nuclear Power Plants#1-3 NO Life Extension.

**According to the planning of new energy development promotion association, renewable energy capacity will reach 10,858MW in 2030.
Assuming that the potential capacity of off-shore wind, PV, ocean power and fuel cell are 4, 3.5, 3, and 1 GW, renewable energy capacity will reach 17,208MW in 2030.
Among various cases, as the electricity install capacities of hydro, nuclear, oil-fired, LNG-fired, renewable and co-generation power plants are planned based on scenarios settings. Even consider nuclear and the potential of renewable energy (Case 6), thermal power ratio is 73%.
Electricity Generation in 2030

The difference of total electricity generation is caused by different nuclear power development trends and the substitution relationship of coal-fired power generation. With the increase of nuclear and renewable energy, Coal-Fired generation ratio will drop from 61.7% to 30.1%. When renewable power reach the potential level, renewable ratio is 17%.
In case 4, Nuclear power can provide more and cheaper electricity, so electricity ratio increase to 56.53%. But cost of renewable power is more expensive than others, electricity ratio in case 5 and 6 will not increase. Total energy consumption is lower in Low ESD cases. Nuclear and renewable power are planned based on scenarios settings, so electricity ratio is higher than high ESD cases.
The CO₂ emissions of BASELINE in 2030 is 374.9 million tons. By expand the use of LNG, the emission will drop to 368.4 million tons. When Nuclear Power Plant #4 operate commercially, the emission will drop to 356.3 million tons. When renewable power reach the potential level, the emission will drop to 325.7 million tons. The CO₂ emissions of Low ESD in 2030 is between 328.9 to 293.3 million tons.
There is no doubt in Low-Energy service demand cases, energy system costs is lower than the other cases. The expand use of LNG replace oil and oil product, energy system costs is lower than BASELINE, but the difference is small. When Nuclear Power Plant #4 operate commercially (Case 4), Coal-fired power plant capacity can be decrease. So case 4 energy system cost is lower than BASELINE. Renewable power cost is more expensive, case 5 and 6 energy system cost is higher than BASELINE.
Conclusion

• When the capacity of nuclear power increase, it can provide cheaper electricity. So electricity consumption will increase. But when more expensive renewable power increase, electricity consumption will decrease because cost advantage disappears.

• While the capacity of nuclear and renewable power increase, the ratio of thermal power is still as high as 73%.

• Taiwan has limited natural resource led to limited renewable energy development, so the potential level of renewable power is very high target in fact.

• Taiwan rely on clean energy measures to achieve carbon reduction target are difficult relative to the international conditions.
Thank you very much for your time & attention!