Recent MARKAL related modelling activities

CHEN Wenying
(chenwy@tsinghua.edu.cn)

Tsinghua University, Beijing, China
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Outline

- Sustainable Energy Development Model for West China (W-SED)
- 4-region China MARKAL
- Beijing MARKAL
- China MARKAL
- Development of models for climate change mitigation assessment
Sustainable Energy Development Model for West China (W-SED)

Supported by Nature Science Fund of China
Fossil fuel energy resources in West China

Coal proved reserves (billion tons):
- Northwest: 600
- Southwest: 200
- Shanxi: 400
- Other East: 100

Oil exploitable reserves (billion tons):
- Talimu: 1.4
- Zhungaer: 1.2
- Erduos: 1.0
- Chaidamu: 0.8
- Other: 0.6

Coal bed methane resource:
- Shaan-Meng: 12
- Yun-Qui-Chuan-Yu: 10
- North Xinjiang: 8
- South Xinjiang-Gan-Qing: 6
- Shanxi: 4
- Other East: 2

Natural gas (billion cubic meters):
- Proven Reserves: 2000
- Proven Recoverable Reserve: 1500
- Exploited: 1000
- Remaining Proven Recoverable Reserve: 500

Explored: [West] [East] [Offshore]
Total proved: [West] [East] [Offshore]
Unproved (high): [West] [East] [Offshore]
Unproved (low): [West] [East] [Offshore]
Renewable energy resources in West China

![Graph showing hydropower resources in West China with bar chart and map indicating exploitable and developed areas.](image)
Structure of W-SED
Scenarios designed

- Base
- C1,E1,O1
- WC,ETL
- C1+WC, E1+WC, O1+WC
- C1+WC+ETL, E1+WC+ETL, O1+WC+ETL
Modeling results (Base)

- **Primary Energy/ Mtce**:
  - 2000: 0
  - 2010: 200
  - 2020: 400
  - 2030: 600
  - 2040: 800
  - 2050: 1000

- **Final energy consumption/ Mtce**:
  - 2000: 0
  - 2010: 200
  - 2020: 400
  - 2030: 600
  - 2040: 800
  - 2050: 1000

- **Electricity/ TWh**:
  - 2000: 0
  - 2010: 500
  - 2020: 1000
  - 2030: 1500
  - 2040: 2000
  - 2050: 2500

- **Other renewable**
  - 2000: 0
  - 2010: 500
  - 2020: 1000
  - 2030: 1500
  - 2040: 2000
  - 2050: 2500

- **Hydro**
  - 2000: 0
  - 2010: 500
  - 2020: 1000
  - 2030: 1500
  - 2040: 2000
  - 2050: 2500

- **Nuclear**
  - 2000: 0
  - 2010: 500
  - 2020: 1000
  - 2030: 1500
  - 2040: 2000
  - 2050: 2500

- **Coal**
  - 2000: 0
  - 2010: 500
  - 2020: 1000
  - 2030: 1500
  - 2040: 2000
  - 2050: 2500

Legend:
- Heat
- Electricity
- Gas
- Oil
- Coal

Legend:
- Agriculture
- Residential
- Commercial
- Transportation
- Industry
Modeling results (Base)
Modeling results (west energy to east)
Modeling results (west energy to east)

[Graph showing energy consumption and water consumption with various energy sources and energy consumption categories.]
Modeling results (west energy to east)

Investment cost

GDP

- 20%
- 10%
0%
10%
20%
30%
40%
50%
60%

- 20%
- 10%
0%
10%
20%
30%
40%

2010 2020 2030 2040 2050

Billion RMB

C1  E1  O1  C1-WC  C1-WC  E1  E1-WC  E1-WC  O1  O1-WC  O1-WC

Investment cost
Four region China MARKAL model

Supported by IEA
Scenarios

- Base
- CTAX50
- CTAX200
Final energy consumption (BASE)

CEN Base final energy consumption

EAST Base final energy consumption

NE Base final energy consumption

WEST Base final energy consumption
Primary energy consumption (BASE)

CEN Base primary energy consumption

EAST BASE primary energy consumption

NE BASE primary energy consumption

WEST BASE primary energy consumption

Primary energy consumption (BASE)
Carbon emission (BASE)

CEN BASE emissions

EAST BASE emissions

NE BASE emissions

WEST BASE emissions

- Supply
- Transportation
- Residential
- Commercial
- Industry
- Agriculture
Primary energy consumption (CTAX50)

CEN CTAX50 primary energy consumption

EAST CTAX50 primary energy consumption

NE CTAX50 primary energy consumption

WEST CTAX50 primary energy consumption
Energy trade

- BASE Electricity trade
- CTAX50 electricity trade
- CTA X200 Electricity trade
- CTAX200 Gas trade
4-region vs. single region model

- The 4-region model did provide some valuable results which the single region is not able to provide.
  - First is the regional picture of energy production and consumption, emission and etc.
  - Second is the energy trade among regions. The model shows energy trade among regions will change greatly under different scenarios. For example, coal trade among regions will significantly decrease while gas trade will have to increase dramatically in the carbon constrain scenarios compared with BASE, and electricity trade will also decrease in the carbon constrain scenarios compared with BASE since nuclear power will play important role to supply electricity for EAST when carbon is taxed.
Beijing MARKAL model

Supported by Stanford Univ.
Fig. 6. Beijing natural gas demand in 2003. [Source: Beijing Statistic Bureau, 2004].

Fig. 5. Natural gas consumption for all study areas: comparison of results for reference and SO2 constrained scenarios.

Fig. 7. Natural gas consumption in Beijing for reference, plausible, and aggressive SO2 constraint scenarios.
China MARKAL modeling
Former results from China MARKAL

MAC vs. reduction rate

% Reduction in Carbon Emission wrt Reference

US$/tC

EPAM
GETEM
POLS
IPAC
China MARKAL-MACRO

GDP loss rate (%)

0.0 0.5 1.0 1.5 2.0 2.5 3.0

0 5 10 15 20 25 30 35 40 45

% Reduction in Carbon Emission wrt Reference

US$/tC

 Former results from China MARKAL
New assumptions
New assumptions

![Graph showing industrial structure from 1990 to 2050]
ESD input to China MARKAL

\[ I = S \cdot e^{\alpha \cdot e^{\beta \cdot PGDP}} \]
Reference scenario
Reference scenario

- Energy Consumption (billion tce)
- CO2 Emission (billion t CO2)
- CO2 Emission per unit Energy Consumption (kgCO2/kgce)
- Energy Consumption /Population (tce per capital)
- CO2 /Population (t CO2 per capital)
- CO2/GDP (kg CO2/$)
Comparison of carbon emission per capita

- US
- Canada
- Russia
- Germany
- UK
- France
- China2050
- China2030
- China2020
- Mexico
- World
- India
- Non-OECD
Further work

- Further update Base scenario
- Simulate carbon constrain scenarios
- Assess CCS role
Models Development and application for climate change mitigation assessment
Models

- National models
  - China MARKAL
  - China CGE

- Global models
  - Global technology optimization model
    (based on ETSAP-TIAM?)
  - Global CGE model (based on GTAP)
Thank you for your attention