

**China's long-term economic growth and carbon  
emission under fossil energy supply constraints:  
A simulation analysis of Energy-Economy-  
Environmental policy model**

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## **Introduction**

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- ❖ Dependence of economic growth on energy
- ❖ Fossil energy supply constraint to economic growth and carbon emission

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# Concerns on China's carbon emission trends

- China has been the largest CO<sub>2</sub> emitter in the world.
- *Durban platform negotiations: China's CO<sub>2</sub> emission peak attract all world attention*
  - Most of researches think of China's CO<sub>2</sub> emission peak will emerge in 2030-2040, around 7-14.1 billion tons (UNDP, 2009; Wang et al., 2009; IEA, 2010). Part of researches think the peak might come in 2020 under strengthened mitigation scenario.
- Researches on China's CO<sub>2</sub> emission trends
  - bottom-up energy technology model(Rivers et al., 2004)
  - top-down CGE model(Wang et al., 2009)
  - integrated bottom-up model and CGE model(Jiang, 2009)
- Bottom-up model needs to set mitigation target in advance.
- Top-down CGE model pay attentions to contribution of energy technological improvement and energy saving policy, but seldom consider energy supply constraint to CO<sub>2</sub> emission trends.

# Deep dependence of economic growth on energy

- Chinese economy deeply depends on resource, especially energy consumption.
  - In 2008, China makes up 11.7% of global GDP, but consumed 17.8% of global energy.
- Resource and environmental cost accounts for 13.5% of national GDP in 2005 and 12.3% in 2010.
  - The proportion of resource depletion cost to national GDP is steadily 9.1% from 2005-2010.
  - The cost of fossil fuel depletion accounts for 5.2% of national GDP in 2010.

	Resource and environmental cost		Proportion to GDP		Annual growth rate 2005-2010
	2010	2005	2010	2005	
Resource and environmental cost	49471.26	32664.57	12.3%	13.5%	8.7%
Resource depletion cost	36348.53	20638.53	9.1%	9.1%	12.0%
Environmental pollution cost	8397.31	6172.17	2.1%	2.5%	6.4%
Ecological degradation cost	4725.42	5853.87	1.2%	1.8%	

# Constraints of fossil energy supply to economic growth

- Limited fossil fuel supply will play an important role in future economic growth and CO<sub>2</sub> emissions in China.
- China energy-economy-environmental policy model is developed by integrating an exhaustible resource depletion module into a dynamic CGE model to verify the effects of fossil fuel supply constraints on economic growth and CO<sub>2</sub> emission.
- Supply of fossil fuel in each period is determined by the remainder reserves, the rate of discovery of new reserves, the rate at which resources are extracted from proven reserves, as well as energy price.

$$QFF_{pec} = \mu_{pec} \cdot RES_{pec}$$

$$NRES_{pec} = \lambda_{pec} \cdot YTFR_{pec}$$

$$RES_{pec}(t) = (1 - \mu_{pec}) \cdot RES_{pec}(t-1) + \lambda_{pec} \cdot YTFR_{pec}(t-1)$$

$$RES_{pec,n} / RES_{pec,0} = (1 - \mu_{pec})^n + \lambda_{pec} \cdot L(\mu_{pec}, \lambda_{pec}, n) \cdot (YTFR_{pec,0} / RES_{pec,0})$$

$$L(\mu_{pec}, \lambda_{pec}, n) = \sum_{k=1}^n (1 - \mu_{pec})^{n-k} \cdot (1 - \lambda_{pec})^{k-1} = ((1 - \mu_{pec})^n - (1 - \lambda_{pec})^n) / (\lambda_{pec} - \mu_{pec})$$

$$\lambda_{pec} = \alpha_{pec} \cdot (PQ_{pec})^{\omega_{pec}}$$

# China Energy-Economy-Environmental policy model

- China energy-economy-environmental policy model can describe energy technology-specific information much better compared with a general CGE model, through soft link between energy technology model and CGE model.
  - electricity sector is disaggregated and divided into eight technologies
  - the parameters of energy efficiency improvement used come from the output of energy technology model
- Fossil energy supply are subject to constraints of fossil fuel resource based on an exhaustible resource depletion model.

绿色经济与区域发展丛书

## 低碳发展的 政策选择与区域响应

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# Scenario design

## ➤ **Baseline scenario(BAU)**

GDP growth rate and CPI under baseline scenario (%)

	2012-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2050
GDP growth rate	7.2	5.6	4.7	3.8	3.3	2.4
CPI	2.2	1	1			
Total Factor Productivity	3.6	3.1	2.7	2.5	2.2	1.7

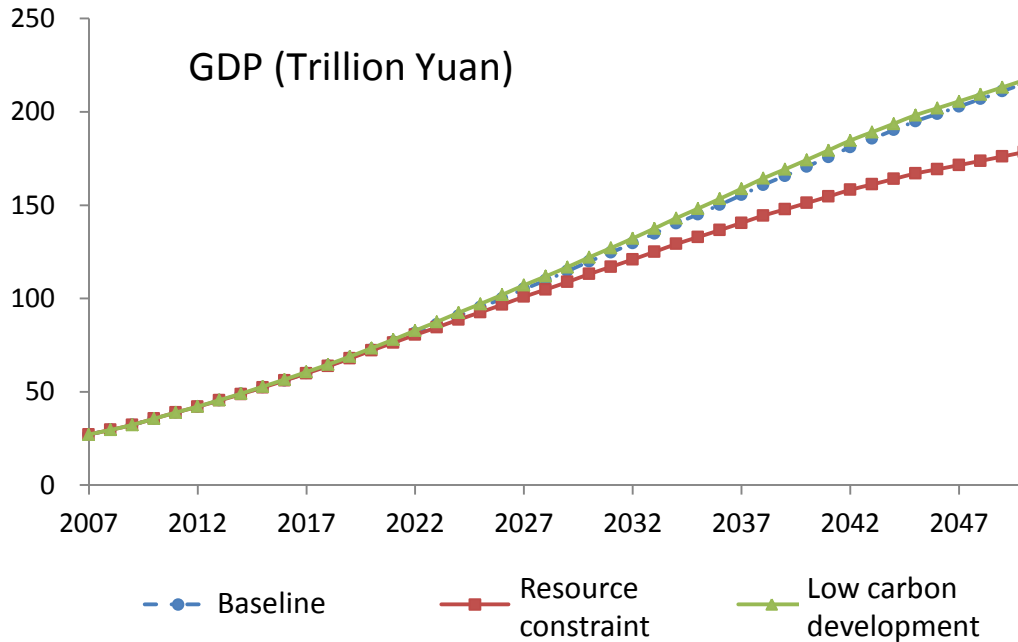
## ➤ **Resource constraint scenario**

- Incorporating constraints of fossil energy supply based on an exhaustible resource depletion model
- Supply of fossil fuel in each period is determined by the remainder reserves, the rate of discovery of new reserves, the rate at which resources are extracted from proven reserves, as well as energy price.

## ➤ **Low carbon development scenario**

- Take into consideration change of household consumption pattern, upgrading of industrial structure, change of fixed capital formulation composition, as well as higher energy efficiency improvement, compared with resource constraint scenario.

# Economic growth towards 2050



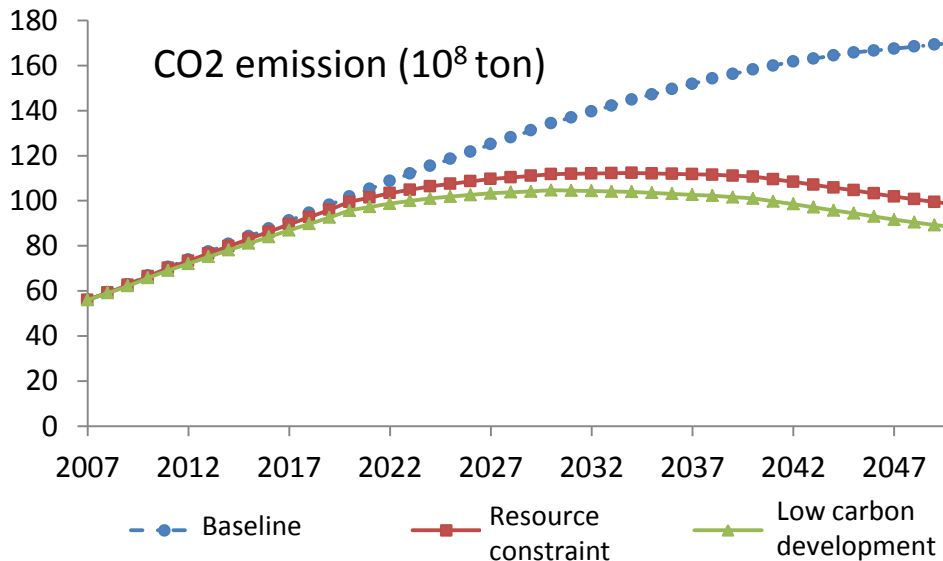
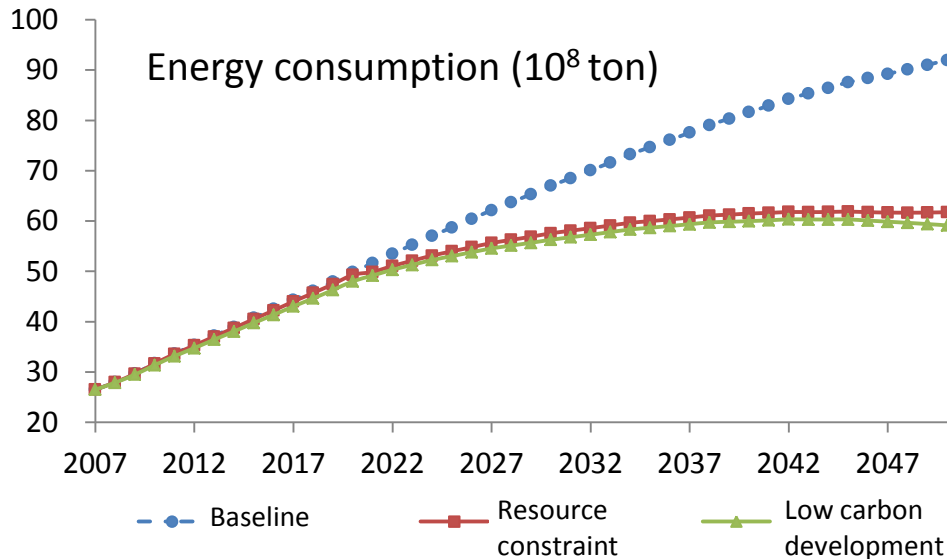
Annual growth rate of GDP (%)

	2012-2020	2021-2030	2031-2040	2041-2050
Baseline	7.2	5.2	3.6	2.4
Resource constraint scenario	7.1	4.6	3	1.7
Low carbon development scenario	7.3	5.3	3.7	2.2

- National GDP in 2050 under baseline will be 215 trillion yuan. It will decrease to 178 trillion yuan under resource constraint scenario.
- GDP growth rate will decline 0.6-0.7 percent while taking fossil energy supply constraint into account in contrast with baseline scenario.
- GDP growth rate under low carbon development scenario will go up to the level of baseline.
- **Low carbon development can offset the negative impacts of fossil fuel supply constraint on economic growth.**



# Trends of energy consumption and CO2 emission



## Resource constraint scenario:

- Energy consumption will increase by a growth rate of 2%, and reach at a peak of 6.2 billion tons in 2050.
- CO2 emission will reach at a peak of 11.2 billion tons in **2034**, and then decline to 9.8 billion tons in 2050.

## Low carbon development scenario:

- Energy consumption will reach at a peak of 6.03 billion tons in 2042, and then decrease to 5.9 billion tons in 2050.
- **CO2 emission** will reach at a peak of 10.5 billion tons in **2030**, and then decrease to 8.8 billion tons in 2050.

# Industrial structural change

- Low carbon development includes not only higher energy efficiency improvement, but also adjustments in industrial structure.
- Higher energy efficiency improvement and industrial structural changes may lead to decrease in demand for energy and energy intensive sectors.
- Decrease in demand for energy intensive sectors will lead to decline of the proportion of secondary sector, as well as rise of the proportion of tertiary sector, in contrast with resource constraint scenario.

		2007	2020	2030	2040	2050
<b>Baseline</b>	Primary sector	10.6	7.2	5.6	4.7	4.1
	Secondary sector	51.6	48.3	47.8	47.5	47.5
	Tertiary sector	37.9	44.5	46.6	47.9	48.5
<b>Resource constraint scenario</b>	Primary sector	10.6	7.3	6.1	5.6	5.5
	Secondary sector	51.6	48.3	46.5	45.9	46.5
	Tertiary sector	37.9	44.4	47.4	48.5	48.0
<b>Low carbon development scenario</b>	Primary sector	10.6	6.3	4.4	3.3	2.6
	Secondary sector	51.6	48.3	46.3	44.2	41.9
	Tertiary sector	37.9	45.4	49.3	52.5	55.5



## Findings and conclusions

- Economic growth in China will go down in future. Limitation of fossil energy supply will slow down China's economic growth furthermore and then alleviate increase of CO<sub>2</sub> emission.
- Fossil fuel supply constraint will play a key role in determining CO<sub>2</sub> emission trends in future China.
- Low carbon development may offset negative impacts of fossil fuel supply constraint to China's economic growth without additional increase of CO<sub>2</sub> emission. It can also help China to make much more contribution to global CO<sub>2</sub> mitigation action.
- China's efforts towards low carbon development should be encouraged and supported by the world.
  - Energy efficiency improvement
  - New energy (renewable energy)
  - Low carbon transport and urban planning

Thanks for attention!