

# Renewable Energy in China: Policy analysis and macro economic impacts evaluation

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# Outline

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- ▶ Current Stage of China's Economy and Energy
- ▶ Policy Insight of China model
- ▶ Evaluating Renewable Energy plans: national economy and industrial development



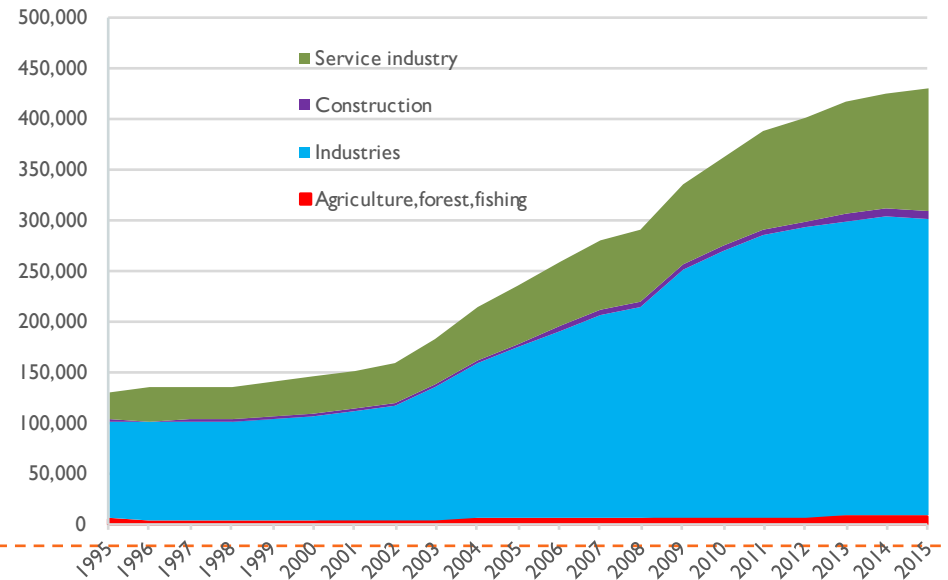
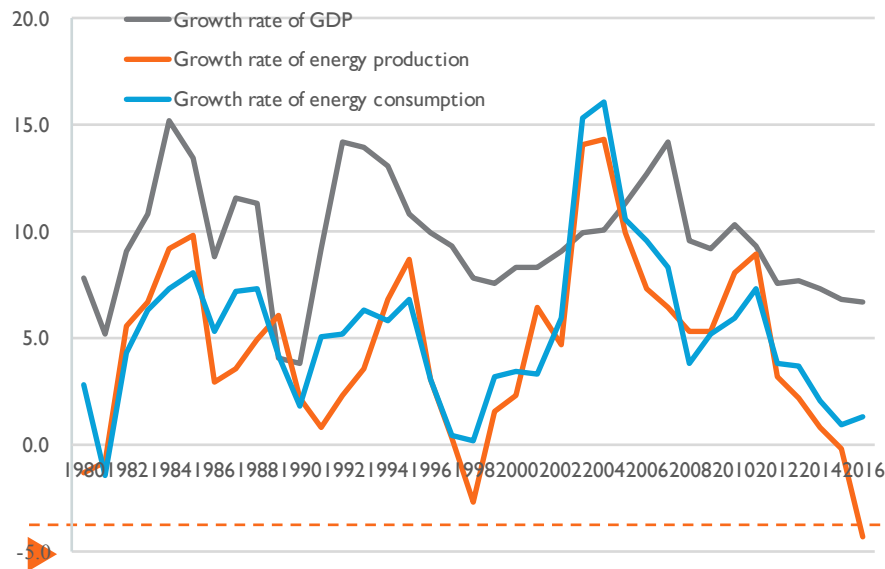
# Economic growth & energy consumption

**GDP per Capita 2017: (US\$ current): \$9480**

**Industrialization: 67%;**

**Urbanization: 58.52%;**

**Gini Coefficient: 46%;**

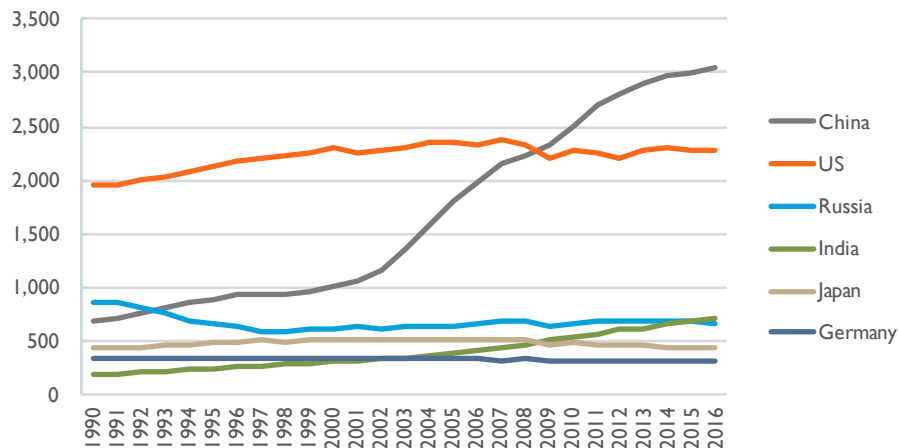


# Energy consumption & CO2 emissions

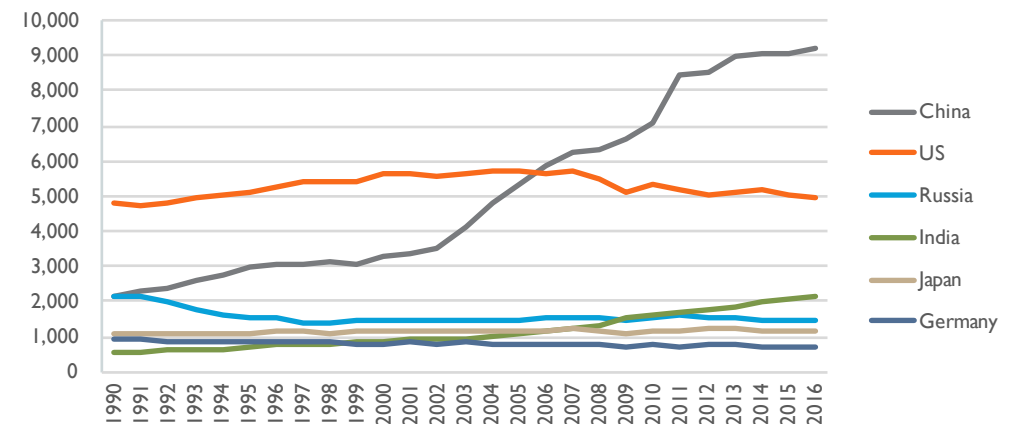
During the 1981-2016 period, China's energy consumption increased by 5.82% annually, underpinning the 9% annual growth of the national economy.

China is already the largest consumer of energy and the largest CO2 emitter, although by per capita consumption, it is about 1/5 of the USA.

Total Energy Consumption, mil.t.S.oil



CO2 Emission, mil.t.

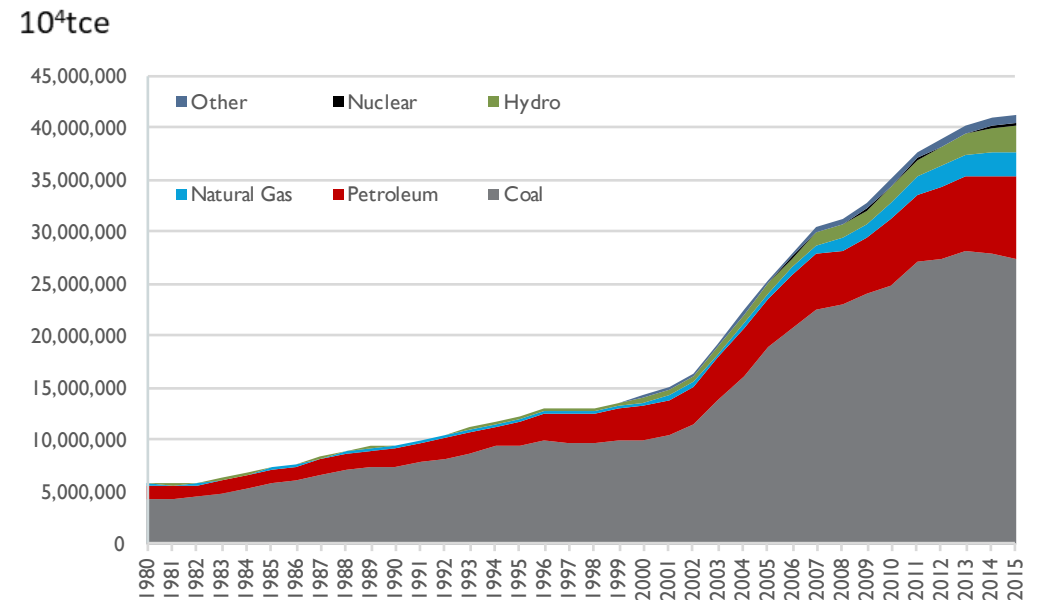
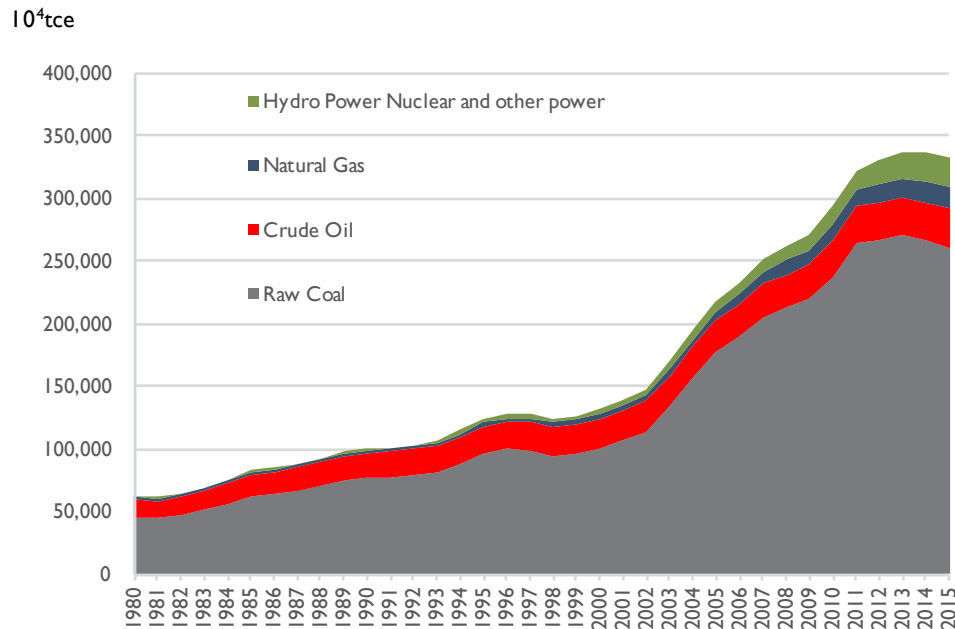


Source: BP World Energy Statistics



# Energy supply & consumption structure

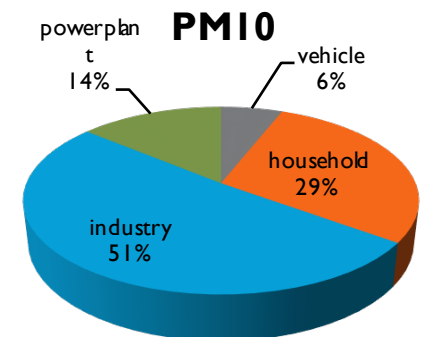
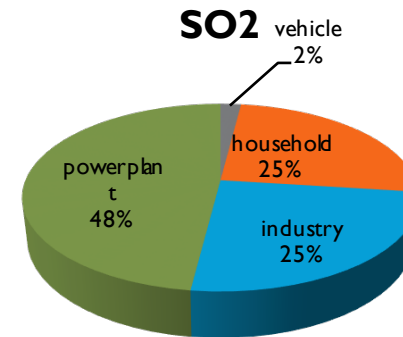
- ▶ In 2016, the output of primary energy was 3.46 billion tons ce
- ▶ With country's energy resource endowment, China may be the most difficult to achieve low carbon development by the change of energy structure.



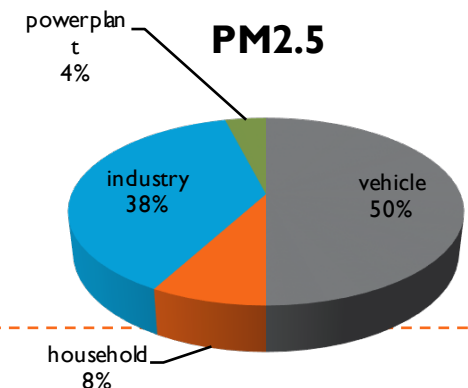
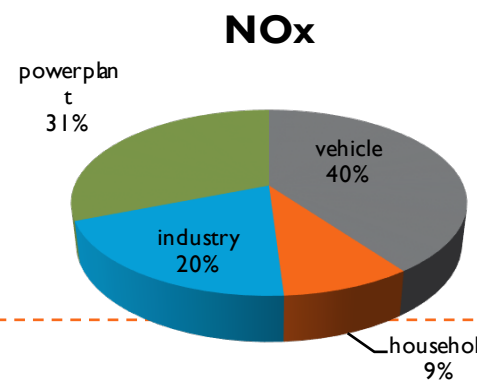
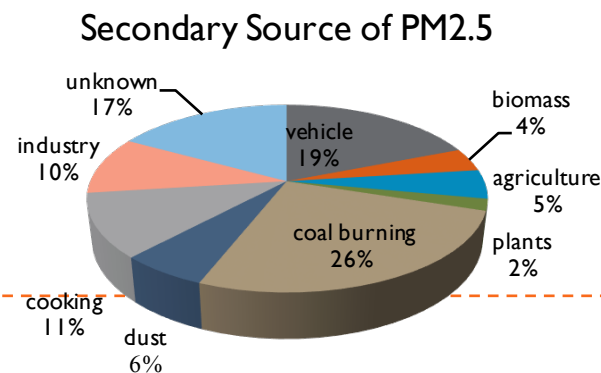
# Local environment

The local environment is deteriorating, while environment awareness is increasing with the growing middle class.

- Larger area suffer worse and worse haze and fog, with increasing PM2.5;
- The emissions of SO2 and other harmful elements are also on rise.
- The environment awareness is increasing and domestic political pressures on local environment protection and prevention become stronger.



Primary source of PM2.5



# CO2 emissions reduction and renewable energy Targets in the 13<sup>th</sup>-five year plan

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## ▶ **The 12th Five-Year Plan (2011-2015) :**

- ▶ By 2015 non-fossil energy will rise to **11.4 %** in the total primary energy consumption; by 2020 reaches **15%**.
- ▶ Energy consumption per unit of GDP will drop by **16%** from 2010, and CO2 emission per unit of GDP will decrease by **17%** from 2010.

## ▶ **The 13th Five-Year Plan (2016-2020) :**

- ▶ By 2020, the CO2 emission per GDP decrease **40-45%** compare to 2005
- ▶ The CO2 emissions will get to peaks around 2030
- ▶ By 2020, the energy use per GDP decrease **15%** compare to 2015

## ▶ **China's NDC:**

- ▶ By 2030, the CO2 emission per GDP decrease **60-65%** compare to 2005

## ▶ **Targets of Renewable energy:**

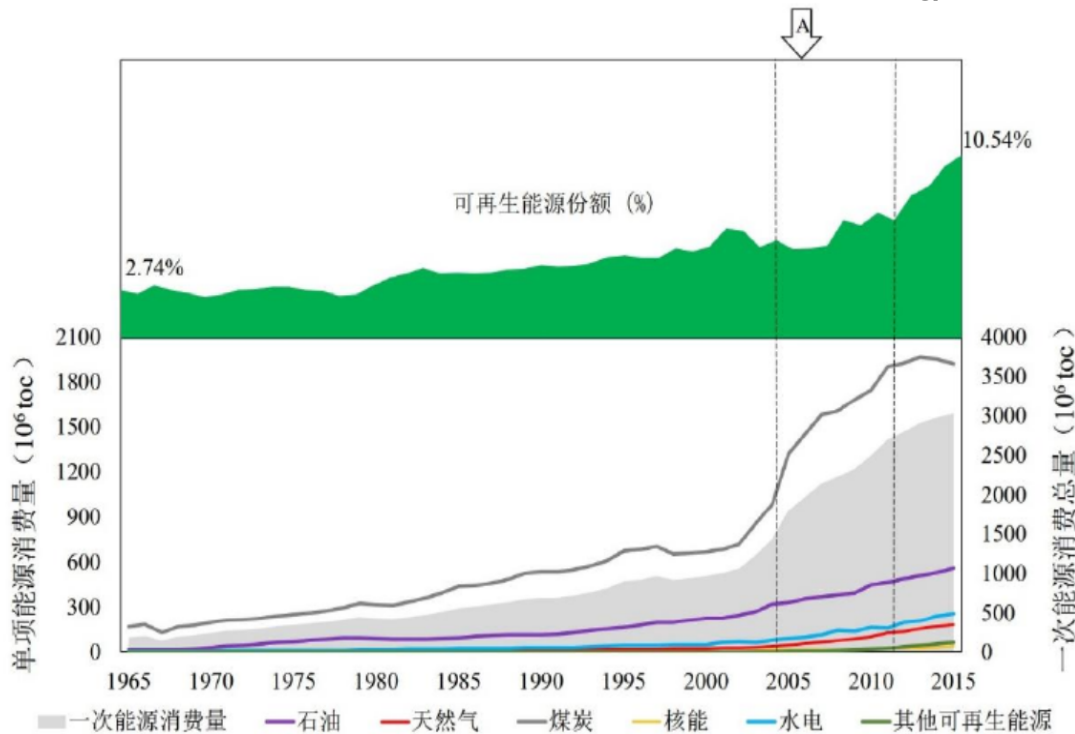
- ▶ By 2020, all utilization of renewable energy will be 730 million TCE.
- ▶ By 2020, all renewable energy power generation capacity will be 680 million kilowatts, generating capacity 1.9 trillion kwh, represents 27% of all generating capacity.



# Requirements on energy transition

Dual replacement: Coal → oil and gas  
Fossil → renewable

2006: Renewable Energy Law

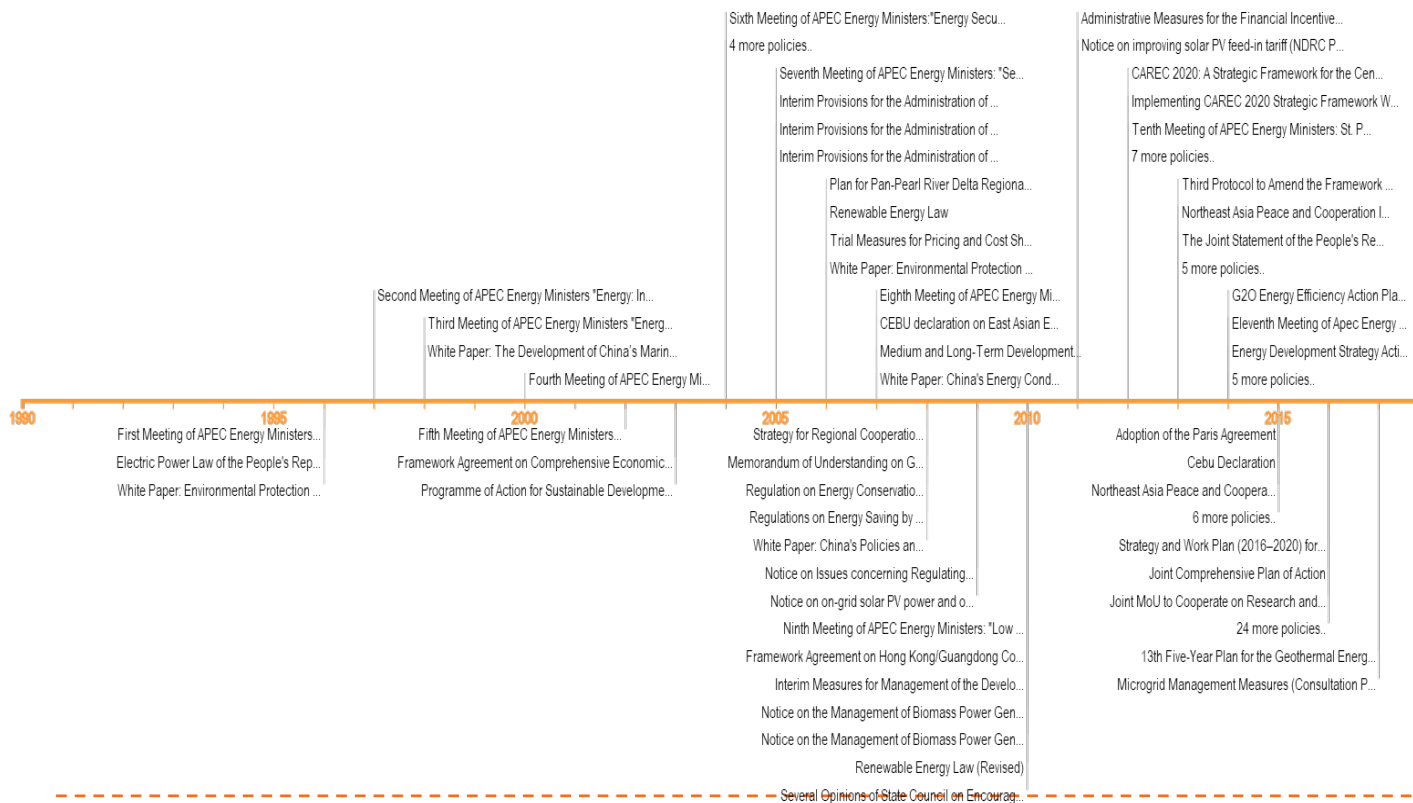


## Energy Development Targets in 2020

General guide	Targets	
Total energy consumption	Primary energy consumption	<5 billion tce
	Coal consumption	<4.1 billion tce, <62% in all
	Electricity consumption	6.8-7.2 trillion kwh
Energy security	Self-supply rate	>80%
Energy supply	Primary energy supply	4-4.2 billion tce
	Coal supply	3.9 billion tce
	Oil supply	0.2 billion t
	Natural gas supply	220 billion cu-m
	Non-fossil energy supply	0.75 billion tce
	Power generation installed capacity	2 billion kw
	hydro	0.35 billion kw
	wind	0.2 billion kw
Solar PV	0.1 billion kw	
Geothermal	0.05 billion kw	
Energy consumption	Proportion of non-fossil energy	>15%
	Proportion of Natural gas	10%
Energy efficiency	Coal	<58%
	Energy use per GDP	decrease 15% (compared to 2015)
	CO2 emission per GDP	decrease 40-45% (compared to 2005)



# China Energy Policy and Regulation 1990-2018



Renewable energy	No of policies
RE1: RE priorities	43
RE2: RE targets	21
RE3: RE action plans	26
RE4: RE prioritization, portfolio standards	7
RE5: feed-in tariffs	12
RE6: Net metering	1
RE7: Biofuels obligation/mandate	2
RE9: RE capital subsidy, grant, or rebate	9
RE10: RE investment or production tax credit	1

# Rapid development in renewable energy

- ▶ By the end of 2015, the installed generating capacity of hydropower reached 320 million kw, ranking first in the world.
- ▶ The installed generating capacity of wind power connected with the country's power grids reached 131 million kw, ranking top in the world.
- ▶ Photovoltaic power generation also reported speedy growth, with a total installed capacity of 43 million kw. Biomass power 13 million kw.
- ▶ Solar water heating covered a total area of 300 million sq m.
- ▶ Non-fossil energy accounted for over 10 percent of the total primary energy consumption, which means an annual reduction of more than 600 million tons of CO2 emissions.

	Small hydro	Wind	Solar
Policy, laws and plans	5	4	3
Governmental direct subsidies	×	2	1
R&D funding	×	2	2
Taxing preferential policies	3	5	1
Investment policies	4	3	1
Products subsidies	2	1	1
Special funds	1	×	×
Financial institution loaning	2	3	2
<b>Total</b>	<b>15</b>	<b>20</b>	<b>11</b>

<http://nyj.ndrc.gov.cn/nyfhb/nyf.htm>

## How about the impacts on national economy?

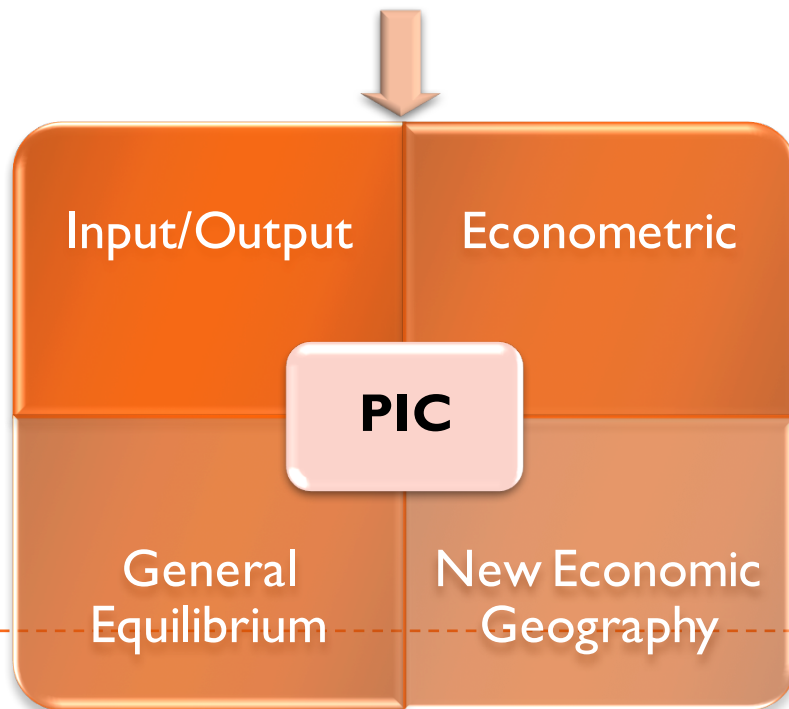
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- Use macroeconomic models to evaluate the total or general equilibrium impacts of the policies or plans to the national/regional economy
  - Micro side analysis of costs and benefits only pertains to the site of mitigation option application
  - Both increases and decreases in economic activity generate “ripple” impacts throughout the economy
  - Macroeconomic impact is some multiple of the original direct on-site impact
  - Price decreases and increases can also stimulate or mute the macro effects



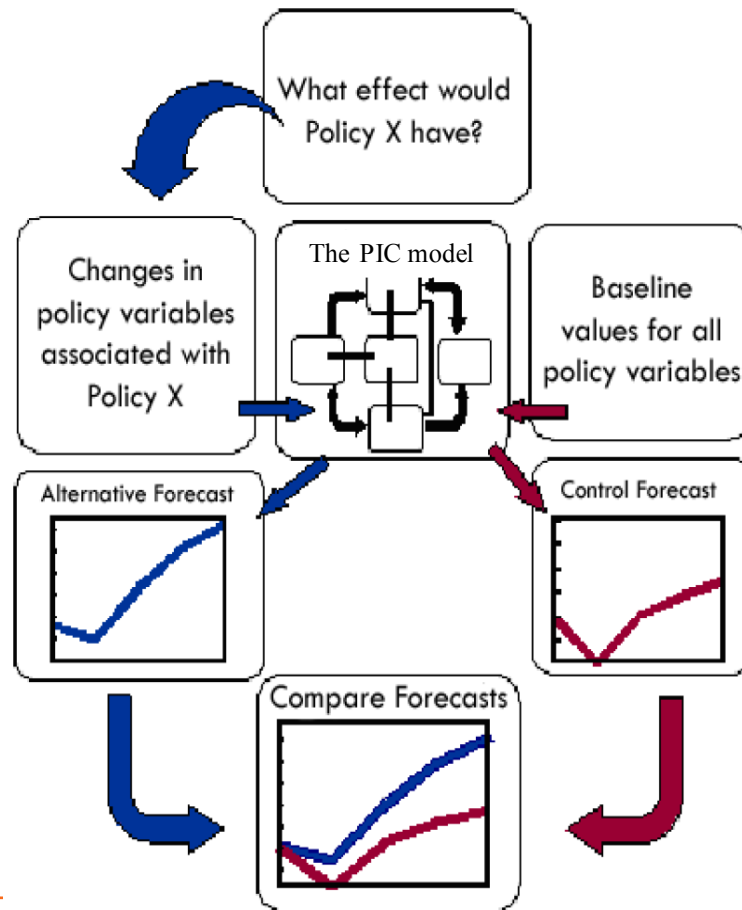
# Policy Insight of China (PIC) model

- Basic scenarios
- Sectors and Industries
- Cost-Benefit of policies



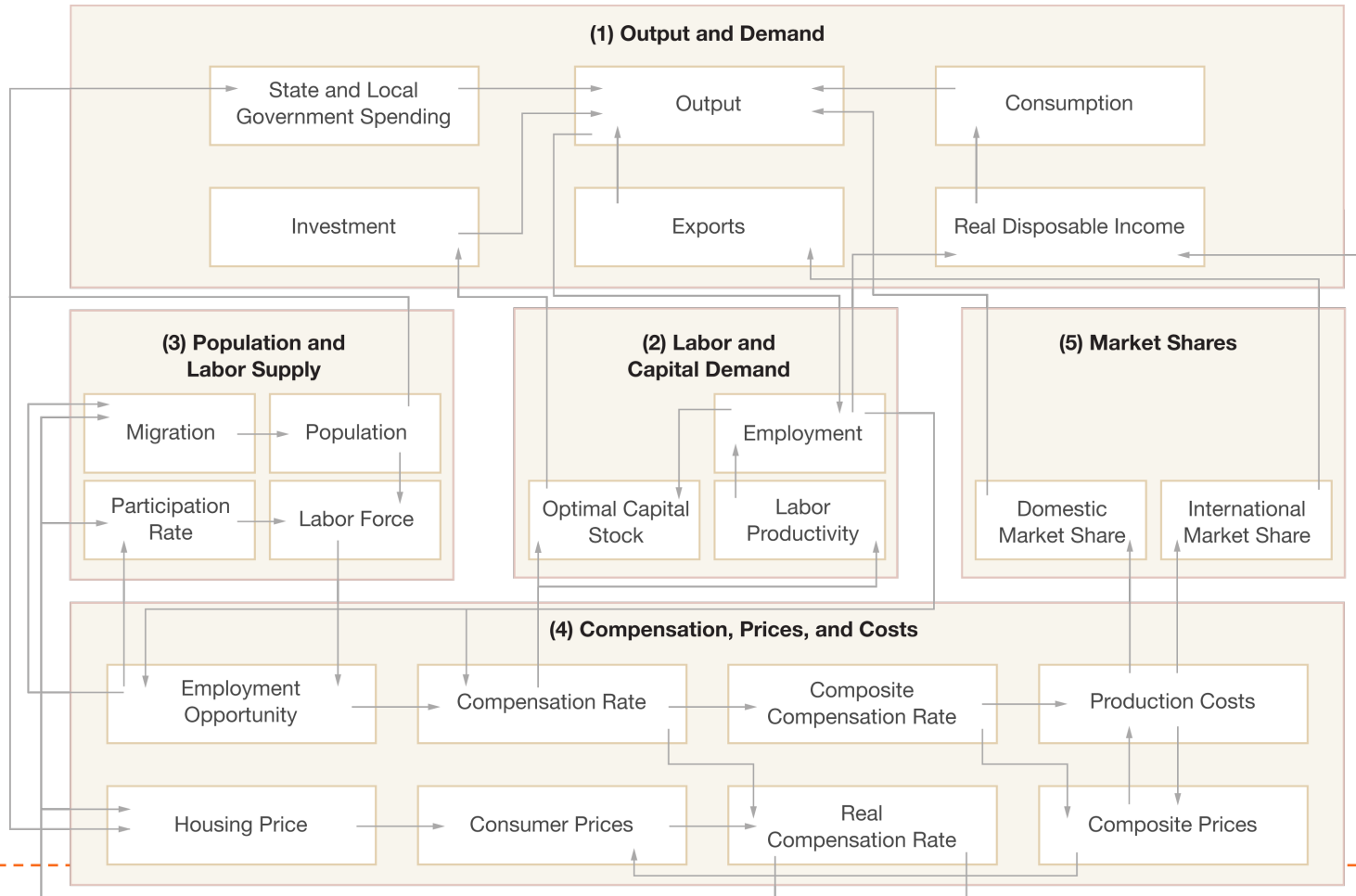
- Analyze the interactions between sectors
- Incorporate the responses of producers and consumers to price signals
- Bring into play economic geography linkages, evaluating changes in competitiveness over time
- 31 provinces \* 68 sectors
- 10 kinds of energies and 6 GHG/air pollutants accounts

# Steps of Macro Analysis with the PIC model

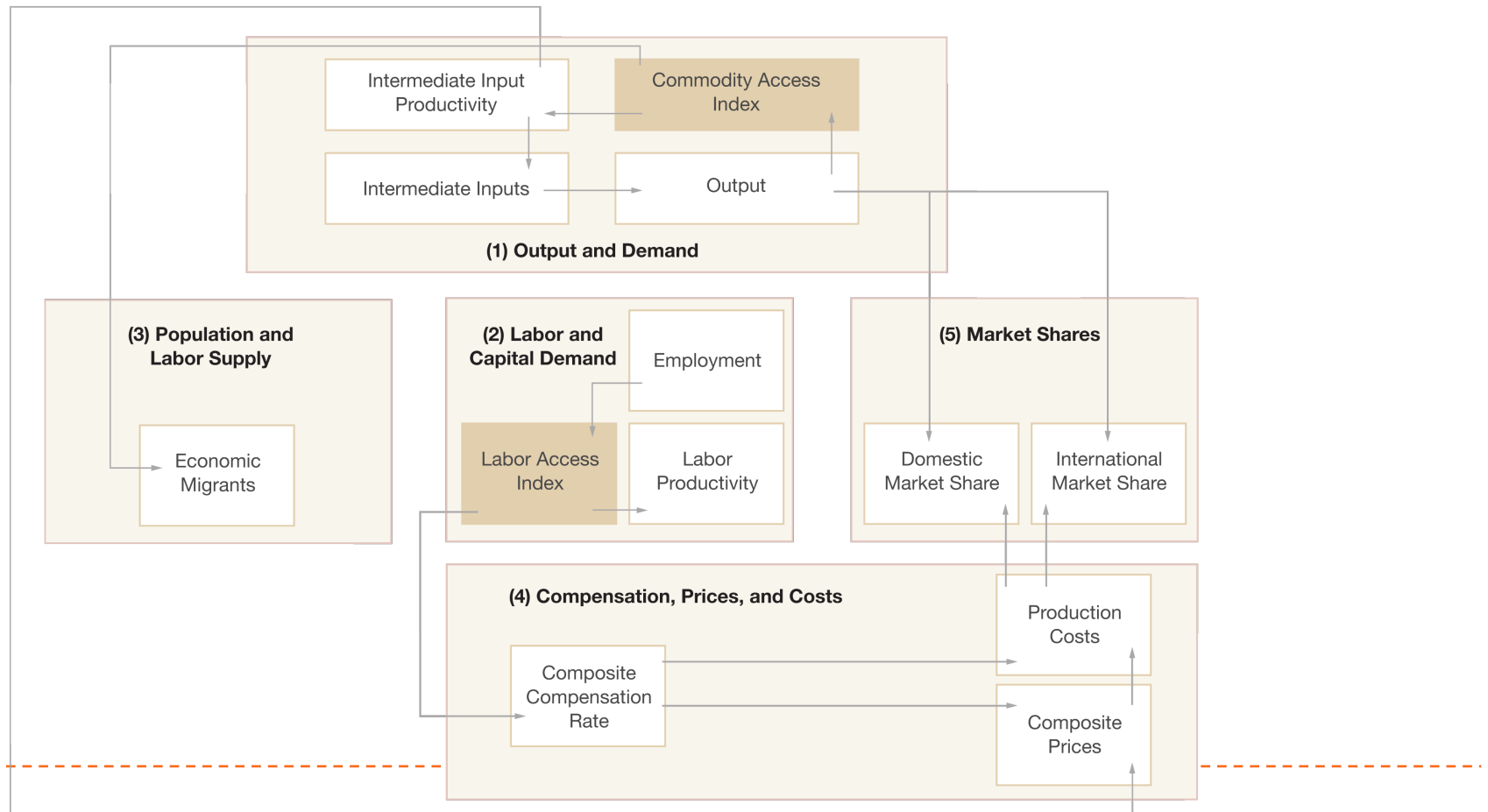


- Building and calibrating the macroeconomic model to forecast
- Obtain data on mitigation options from microeconomic analysis
- Translating the policies to economic variables
- Simulating a single policy to see impacts
- Simulating all the policies to see impacts
- Analyzing the results
- Evaluating the impacts on economy and industries

# PIC model Linkage



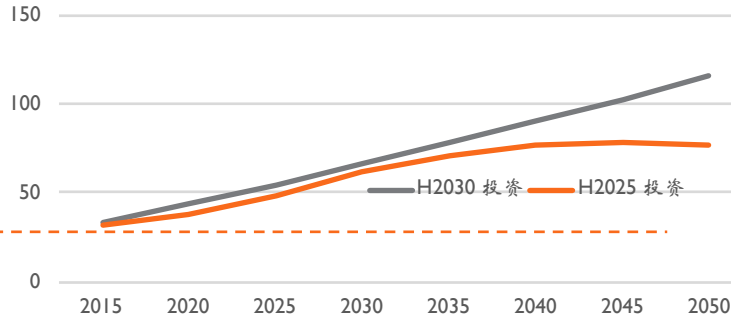
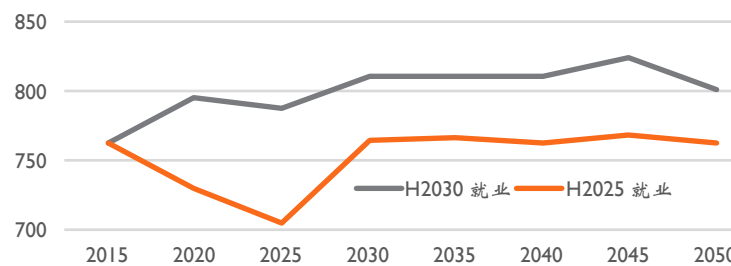
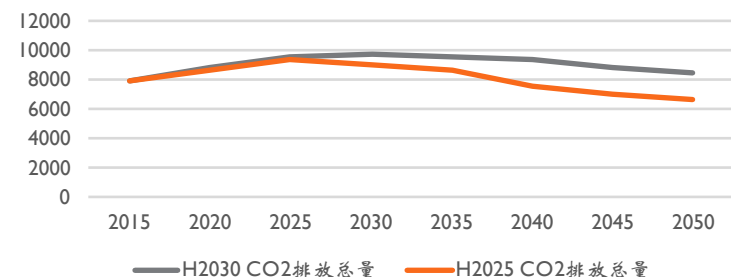
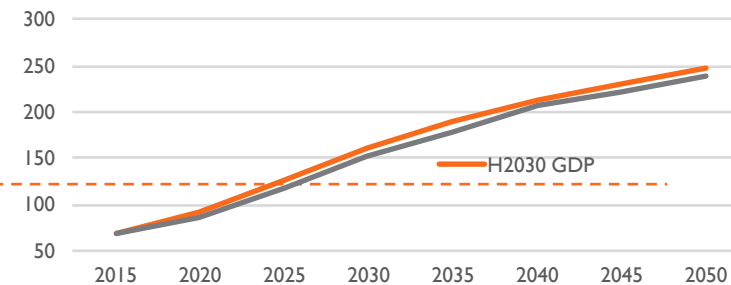
# PIC model Linkage (Economic Geography Linkage)



# Baseline forecast

➤ Cost → Target → Investment Demand → impacts

	2015	2020	2025	2030	2035	2040	2045	2050
<b>1. economic growth</b>								
GDP growth rate (%)	7.1	6.8	6.2	5.2	4.6	4	3.7	3.5
GDP (in trillions RMB, )	59	82.37	112.18	147.98	185.91	228.51	276.3	328.86
<b>2. population</b>								
Annual growth rate (%)	0.53	0.47	0.41	0.11	-0.06	-0.11	-0.13	-0.23
Total amount (in millions)	13.77	14.1	14.49	14.57	14.53	14.45	14.36	14.2
<b>3. urbanization rate</b>								
(%)	56.4	60	63	66	68.3	70.5	72.8	75
<b>4. economy structure</b>								
Agriculture (%)	8.45	6.8	5.55	4.3	3.7	3.1	2.8	2.5
industry (%)	47.09	45.7	44.1	42.5	41.1	36.7	33.5	32.3
Service (%)	44.46	47.5	50.35	53.2	55.2	60.2	63.7	65.2





# Cost estimate of renewable energy

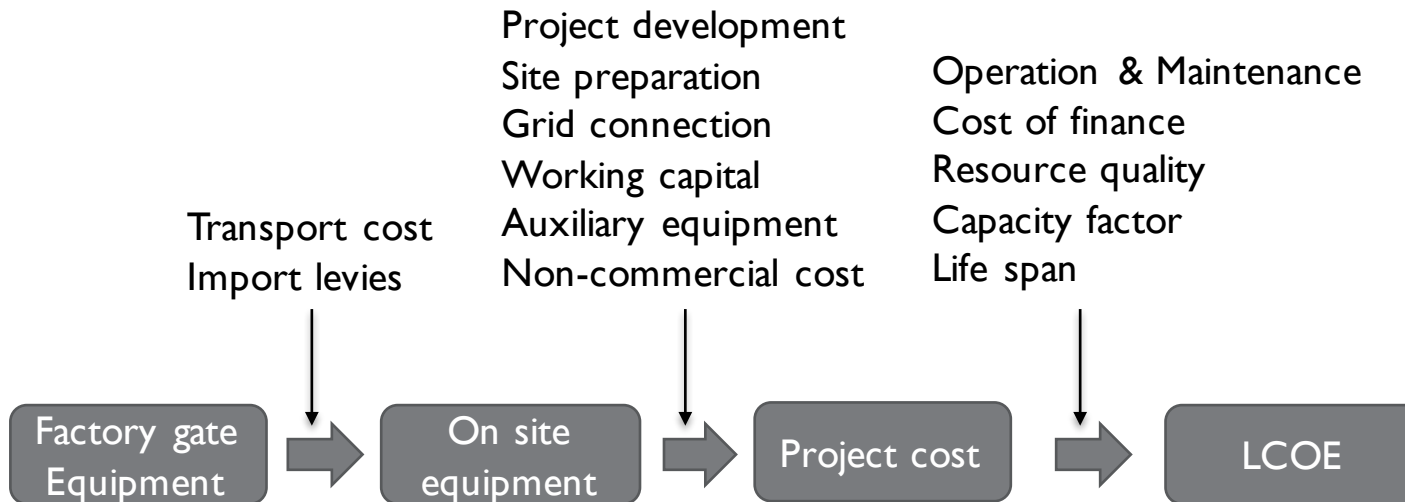
▶ NPV

$$NPV = \sum_{i=1}^n \frac{C_t}{(1+r)^t} - C_0$$

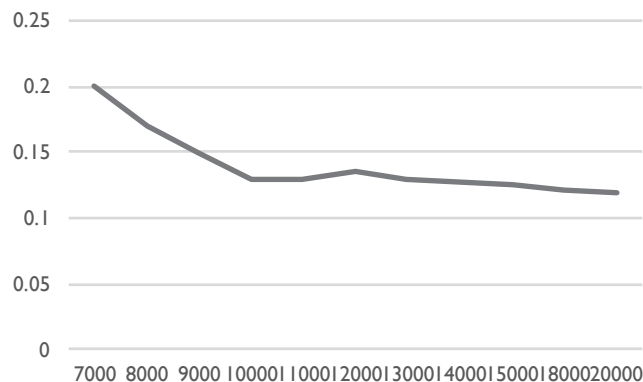
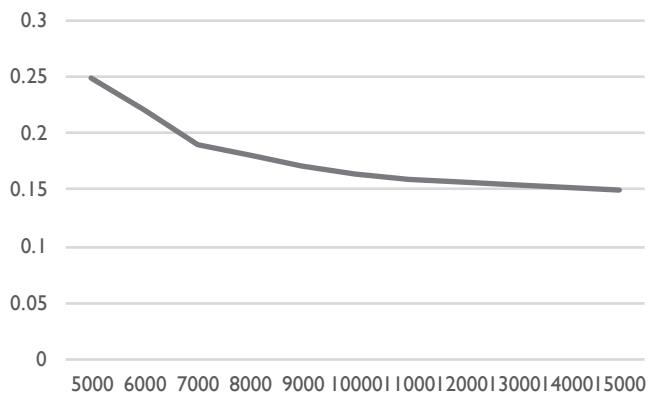
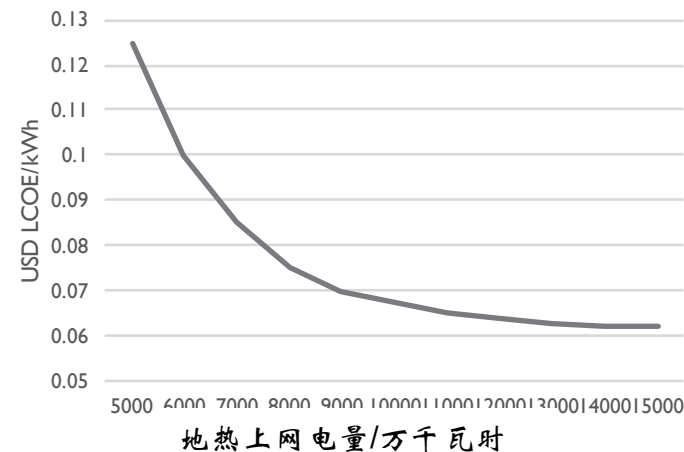
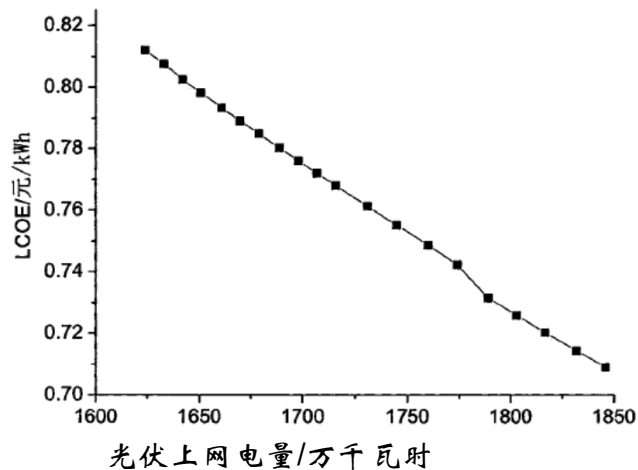
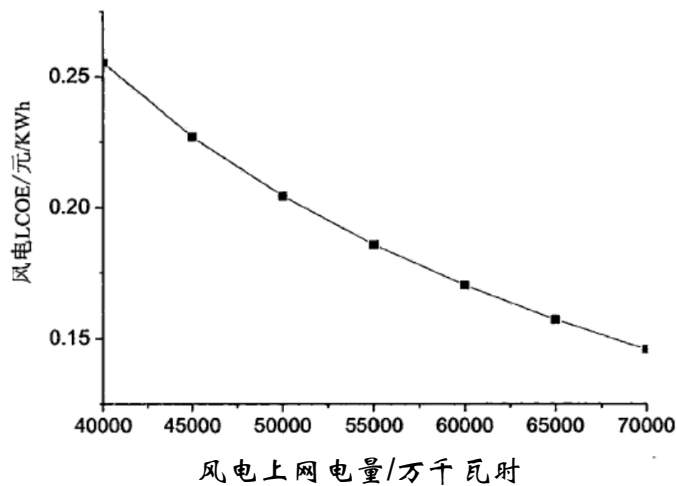
▶ LCOE

$$P_n = \frac{\sum_{n=0}^N (C_n - B_n)(1+r)^{-n}}{\sum_{n=0}^N A_n (1+r)^{-n}}$$

- Onshore wind:  
USD 0.06 to USD 0.09/kWh
- Solar PV:  
USD 0.06 to 0.08/kWh without financial support
- Large-scale hydro:  
USD 0.02/kWh to USD 0.05/kWh
- Biomass:  
USD 0.05/kWh to USD 0.25/kWh
- Geothermal:  
USD 0.1 to 0.14/kWh



# Cost change trend and investment demand (to 2020)

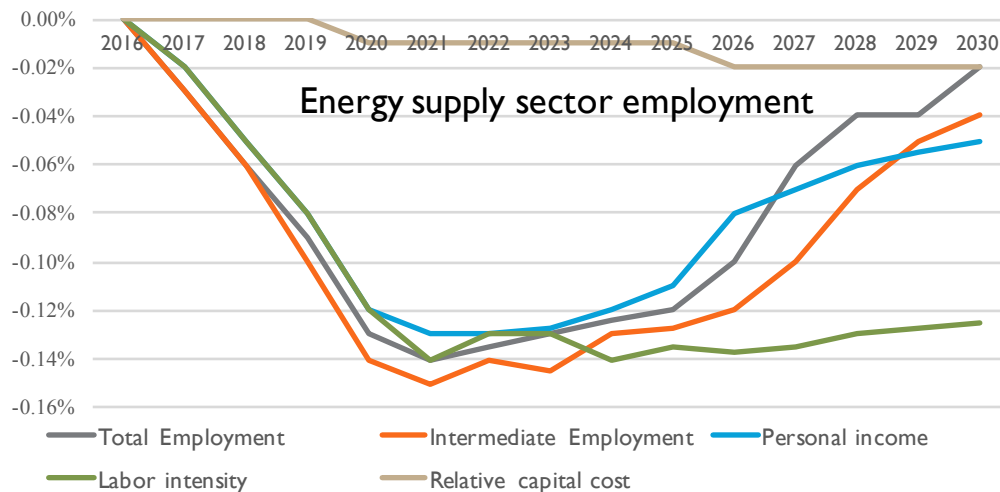


Billion USD	2016-2020	2021-2030
All renewable energy	384.6	169.2
Wind	107.7	46.2
Solar	92.3	30.8
Hydro	24.6	13.1
Biomass	53.8	38.5
Geothermal	46.2	30.8

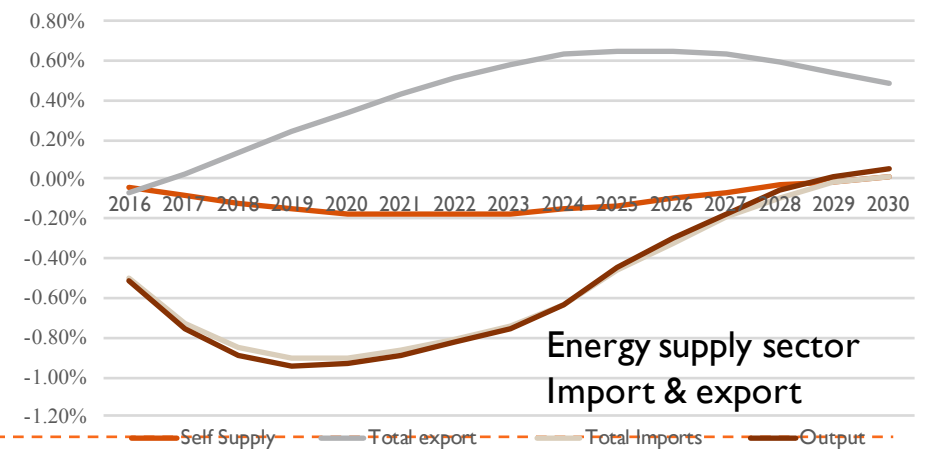
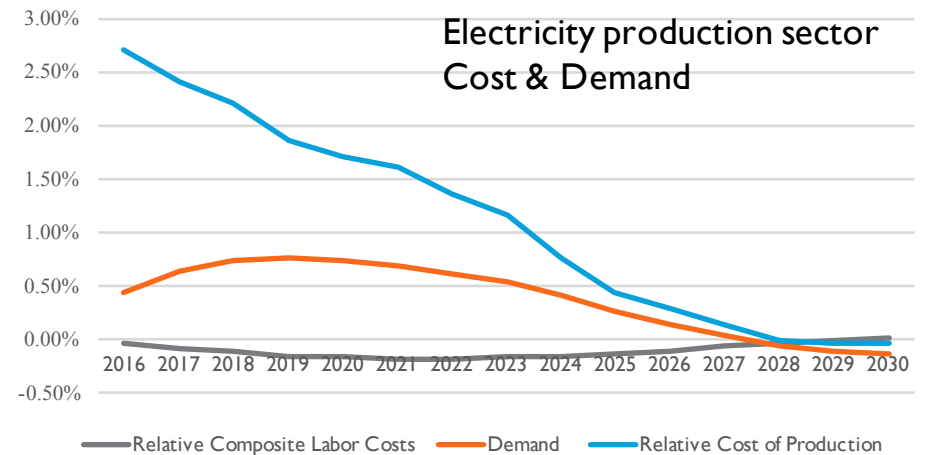
▶ 生物质能上网电量/万千瓦时

水电(小)上网电量/万千瓦时

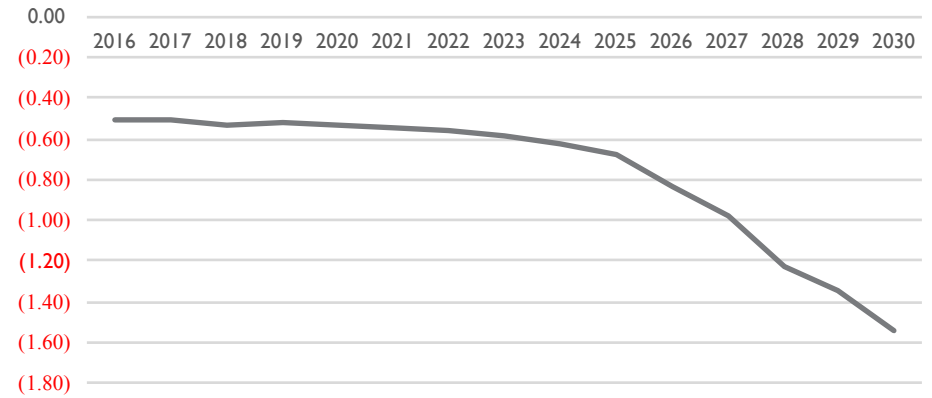
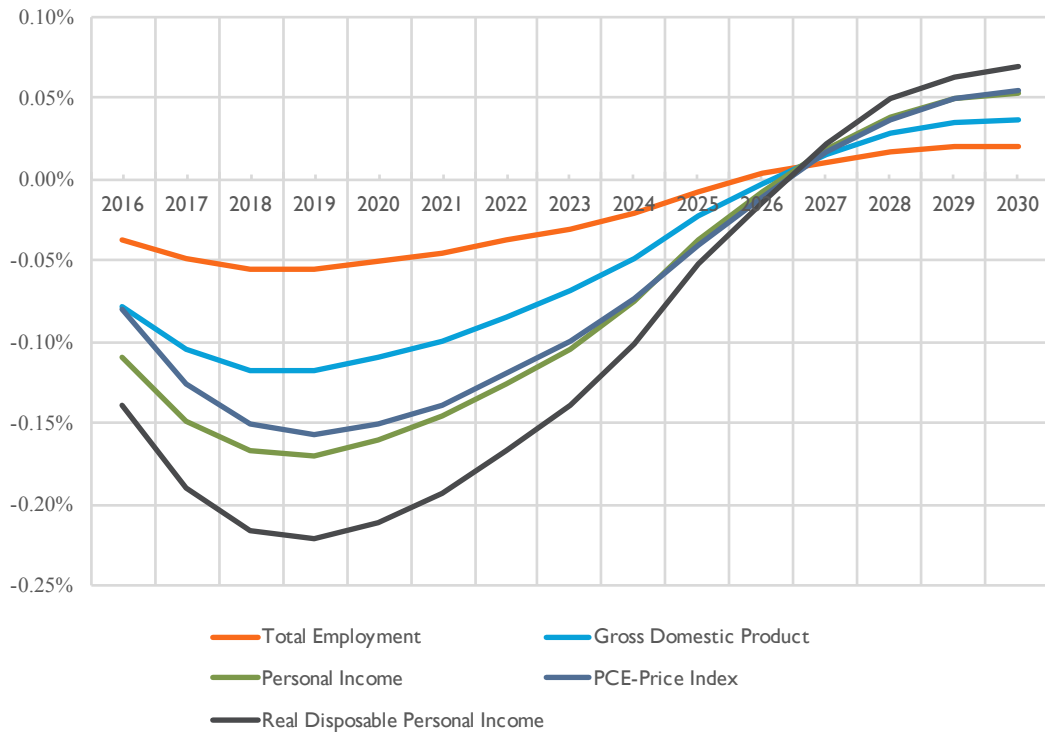
# Impacts on energy sectors



- ▶ Labor cost in energy supply sector decrease slightly, due to the shrink of coal fire plants and the less labor intensed in renewable power.
- ▶ Demands on electricity increased a bit, caused by the equipment manufacturing for renewable power generation and storage.
- ▶ The general production costs increase at the beginning and then decrease
- ▶ the increment of electricity supply effectively stimulate the exports of other energy, mainly fossil, as well as lower the import demands.



# Impacts on the economy and emission intensity - nation wide average



Negative impacts on the national wide economy in short term, but positive ones in long term.

By 2030, the employment and GDP both higher than baseline.

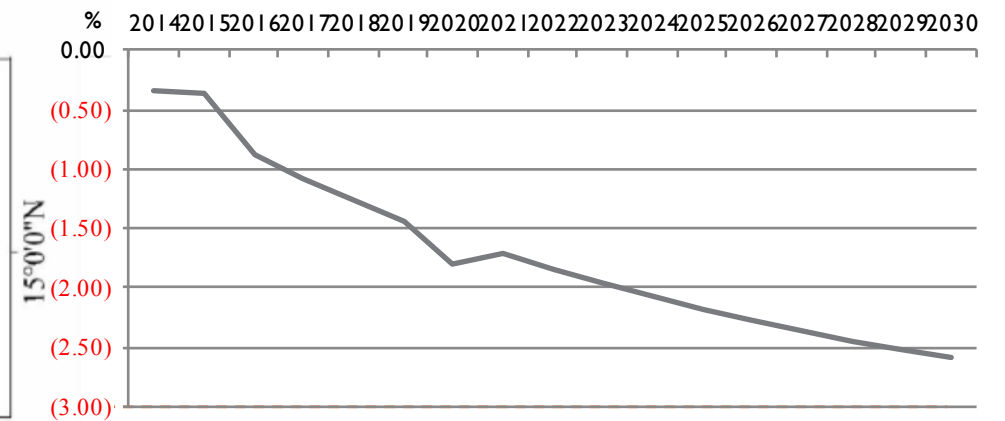
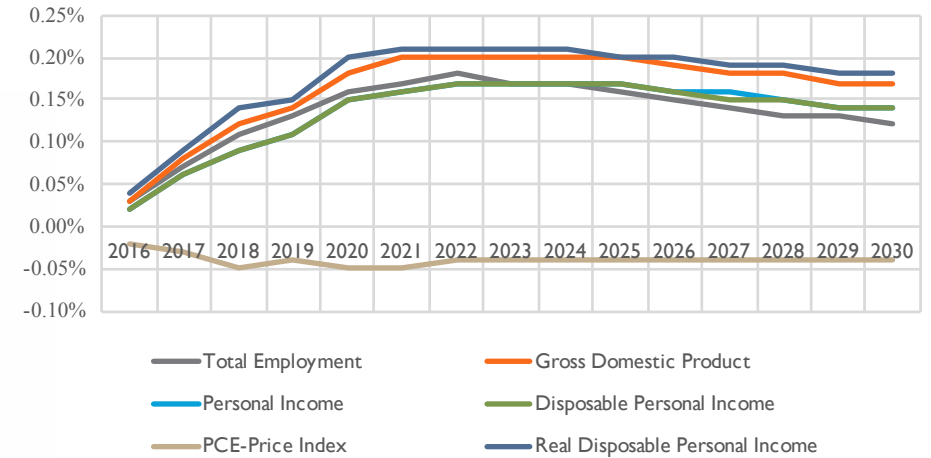
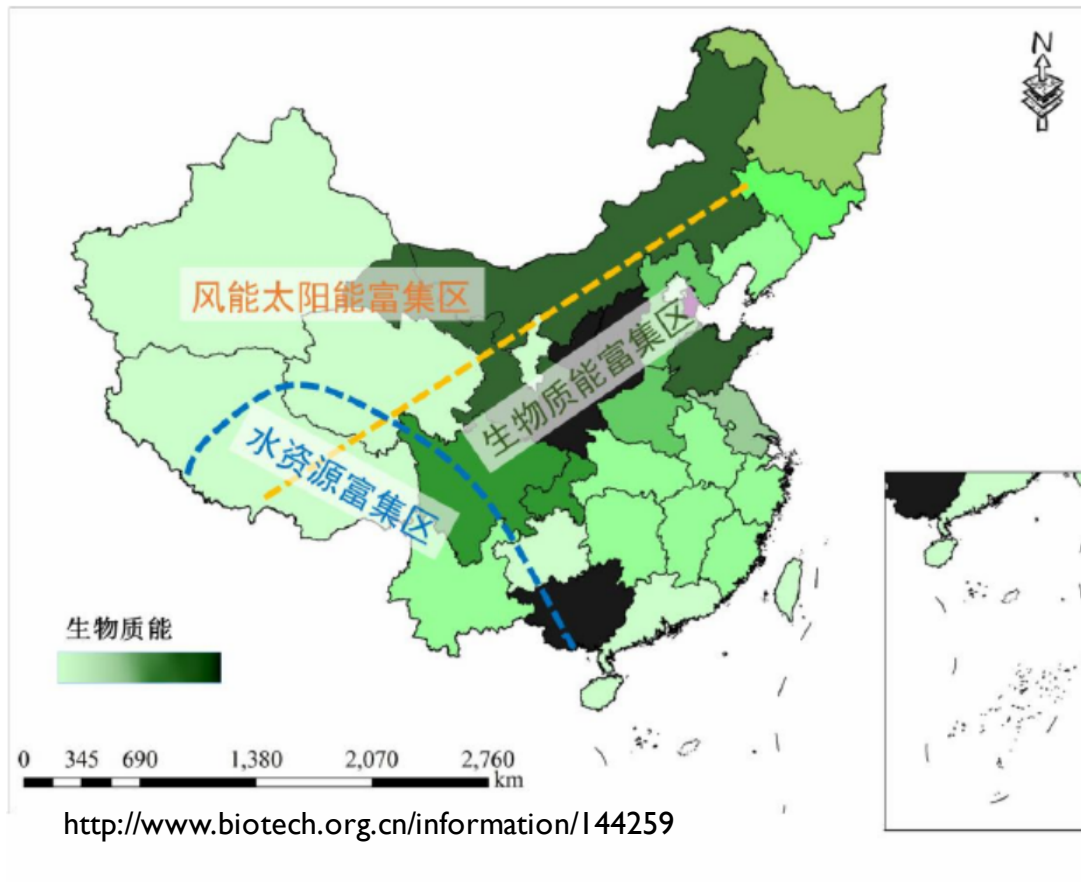
Personal income increases >0.05%

Real disposable personal income >0.08%

The CO2 emission intensity decreases 1.71% average annually.

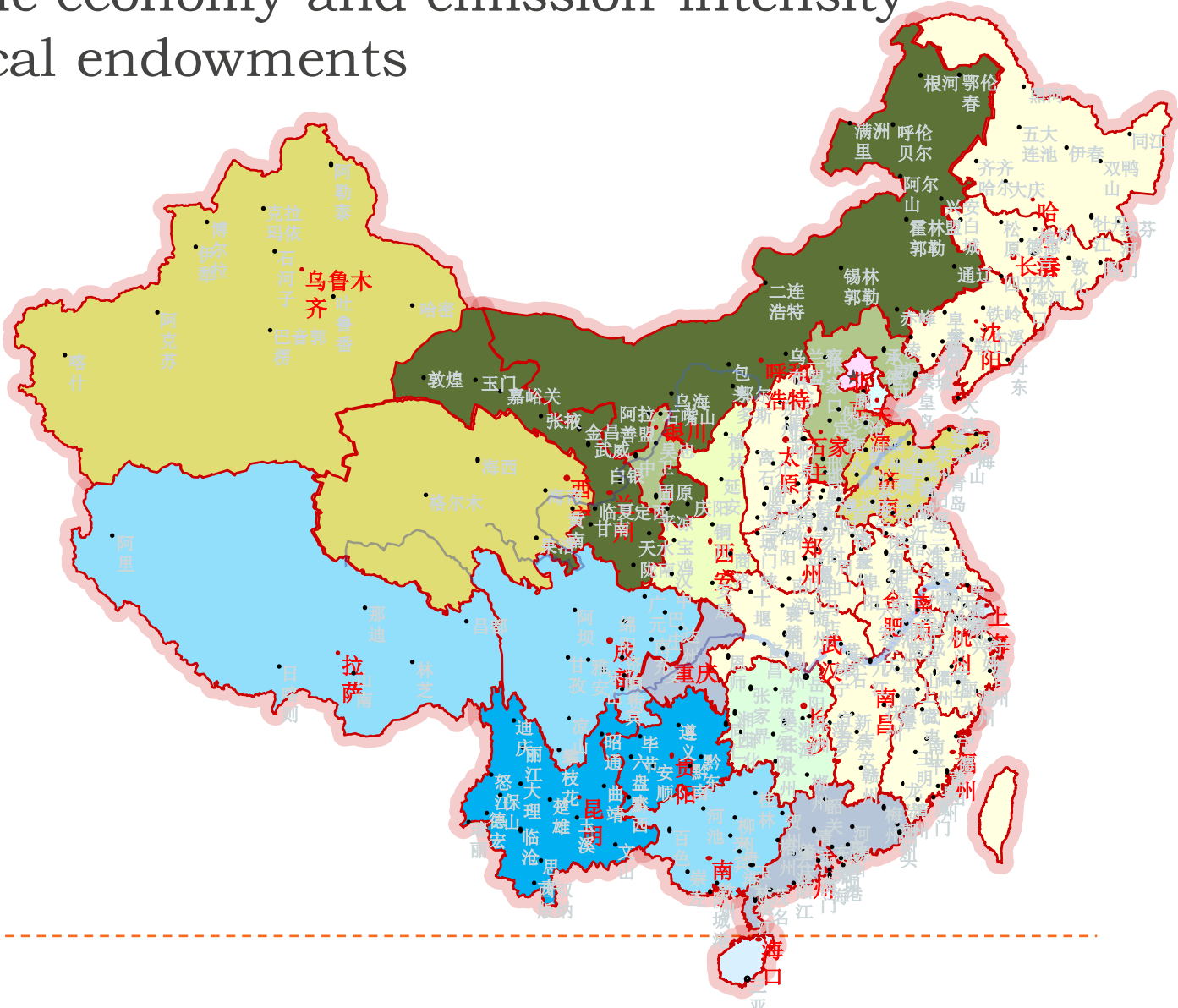


# Renewable energy development to local endowments



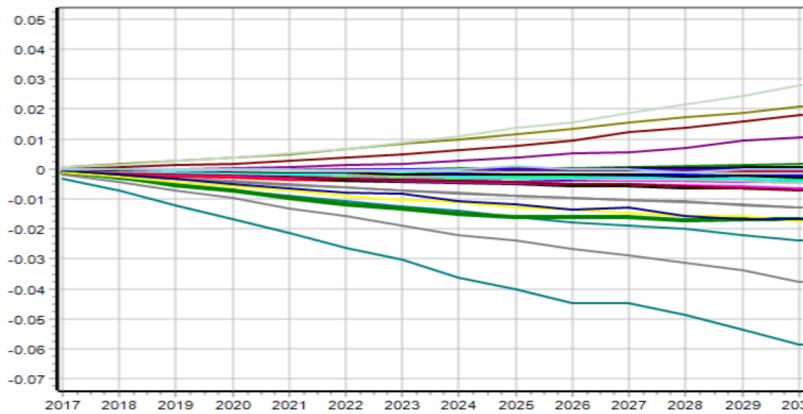
# Impacts on the economy and emission intensity - based on local endowments

	GDP	Employment	
Beijing		0.020%	0.025%
Tianjin		0.030%	0.033%
Hebei		0.030%	0.061%
Shanxi		0.020%	0.057%
Inner Mongolia		0.070%	0.078%
Liaoning		0.020%	0.067%
Jinlin		0.030%	0.054%
Heilongjiang		0.043%	0.074%
Shanghai		0.020%	0.028%
Jiangsu		0.020%	0.044%
Zhejiang		0.020%	0.060%
Anhui		0.030%	0.062%
Fujian		0.030%	0.030%
Jiangxi		0.059%	0.065%
Shandong		0.063%	0.078%
Henan		0.060%	0.075%
Hubei		0.062%	0.067%
Hunan		0.064%	0.097%
Guangdong		0.043%	0.011%
Guangxi		0.061%	0.060%
Hainan		0.051%	0.016%
Chongqing		0.056%	0.147%
Sichuan		0.056%	0.138%
Guizhou		0.060%	0.091%
Yunnan		0.056%	0.069%
Tibet		0.084%	0.008%
Shaanxi		0.060%	0.071%
Gansu		0.059%	0.075%
Qinghai		0.058%	0.062%
Ningxia		0.059%	0.062%
Xinjiang		0.070%	0.056%

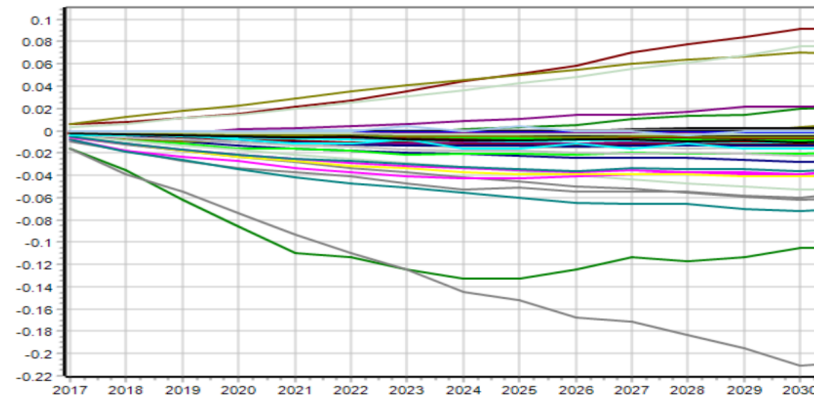


# Impacts on industries

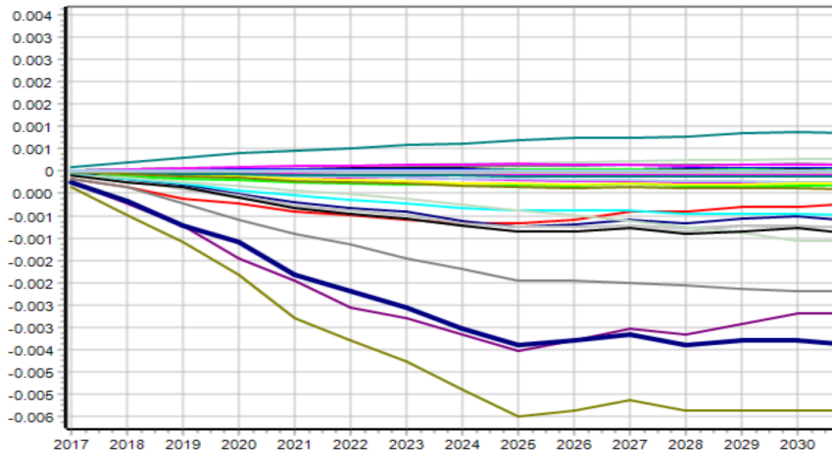
## Change of value-added of industries



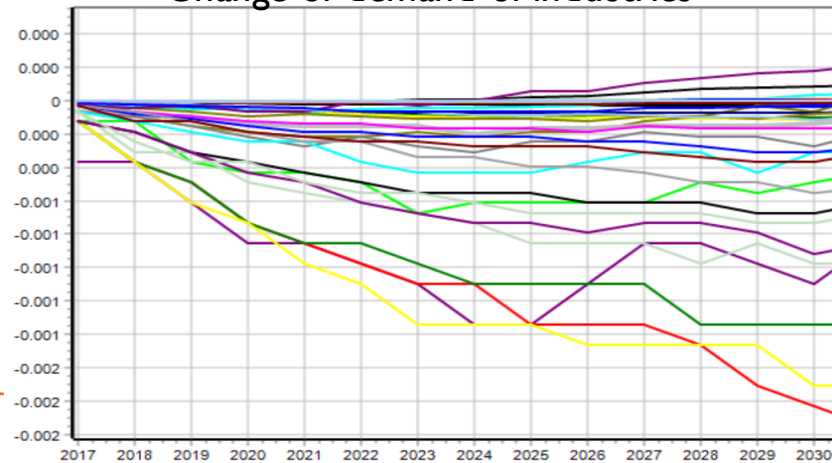
## Change of employment of industries



## Investment demand of industries



## Change of demand of industries



- Agriculture, Forestr...
- Mining and Washing o...
- Coal
- Cleaned Coal
- Other Cleaned Coal
- Petroleum and Natura...
- Crude Oil
- Natural Gas
- Mining of Metal Ores
- Mining and Processin...
- Foods, Beverage and ...
- Textile Manufacturing
- Apparel Manufacturin...
- Timbers Processing a...
- Paper Manufacturing...
- Petroleum Processing...
- Gasoline
- Kerosene
- Diesel Oil
- Fuel Oil
- LPG
- Other Petroleum Prod...
- Coke
- Coke Oven Gas
- Other Coking Products
- Chemical Industry
- Non-metallic Mineral...
- Metal Manufacturing ...
- Metal Product Manufa...
- Machinery Manufactur...
- Transportation Equip...
- Electrical Machinery...
- Communication Equipm...
- Measuring Instrument...
- Artwork and Other Ma...
- Recycling and Dispos...
- Electricity and Heat...
- Heat
- Electricity
- Production and Distr...
- Production and Distr...
- Construction
- Transit, Transportat...
- Postal Services
- Information Transfer...
- Wholesale and Retail...

# Summary

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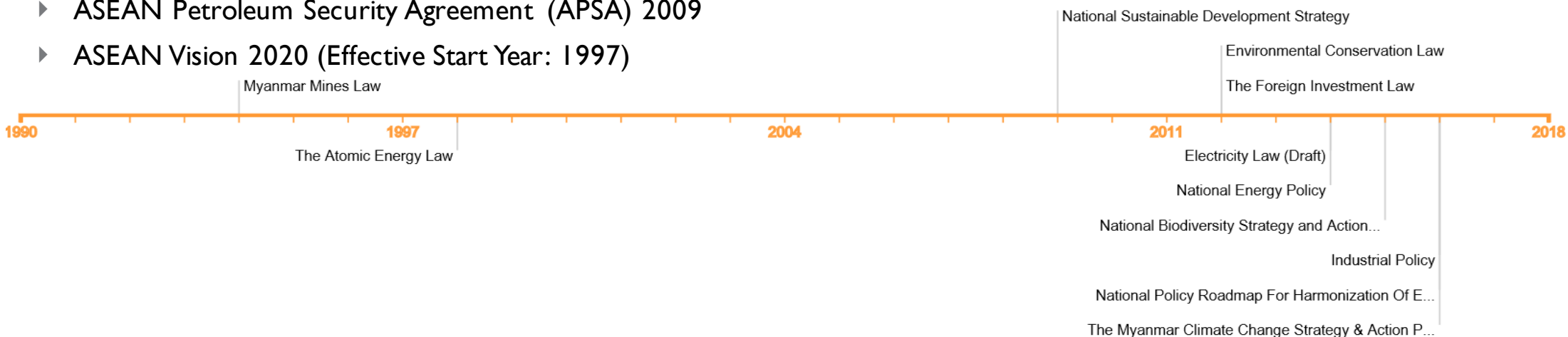
- ▶ From the overall analysis, renewable energy consumption growth will cost a certain amount of economic growth, but renewable energy consumption influence on economic growth may exist differences in different situations.
- ▶ Renewable energy consumption growth in different areas and different industry lead to different impacts on economic growth. Residential, industrial and transportation industry bear negative impacts while service industries have positive impacts. Therefore, it is necessary to formulate differentiated energy substitution policies based on the energy substitution rate of various industries, so as to achieve balanced development of renewable energy in various industries.
- ▶ For different types of renewable energy, the impact of consumption growth on economic growth is different. The economic cost of biomass energy growth is relatively high, followed by water energy, while the impact of wind energy growth on economic growth is positive.
- ▶ China's target of 20 per cent renewable energy consumption by 2030 will also pose challenges to economic growth. China needs to formulate different renewable energy policies for industries and regions.





# Myanmar Renewable Energy related Policies and Plans

- ▶ National Energy Policy (Effective Years: 2014-)
- ▶ Programme of Action for the Least Developed Countries for the Decade 2011-2020 (Istanbul Programme of Action) (Effective Start Year: 2011)
- ▶ National Sustainable Development Strategy (Effective Start Year: 2009)
- ▶ ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 - Phase I: 2016-2020
- ▶ The Myanmar Climate Change Strategy & Action Plan (MCCSAP) 2016-2030
- ▶ National Biodiversity Strategy and Action Plan 2015-2020
- ▶ ASEAN Economic Community Blueprint 2025 (Effective Start Year: 2015)
- ▶ ASEAN Petroleum Security Agreement (APSA) 2009
- ▶ ASEAN Vision 2020 (Effective Start Year: 1997)



Thank you!

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# Structure of economy

		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Inventories
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
Basic Flows	$C \times S$	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	$C \times S \times M$	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	$C \times S$	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O	V1LAB	<b>C = Number of Commodities</b> <b>I = Number of Industries</b> <b>S = 2: Domestic, Imported</b> <b>O = Number of Occupation Types</b> <b>M = Number of Commodities used as Margins</b>				
Capital	1	V1CAP					
Land	1	V1LND					
Production Tax	1	V1PTX					
Other Costs	1	V1OCT					

Joint Production Matrix	
Size	← I →
↑ C ↓	MAKE

Import Duty	
Size	← 1 →
↑ C ↓	V0TAR