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The Co-Benefit of Employment during Low-Carbon Transformation: A CGE Assessment for China

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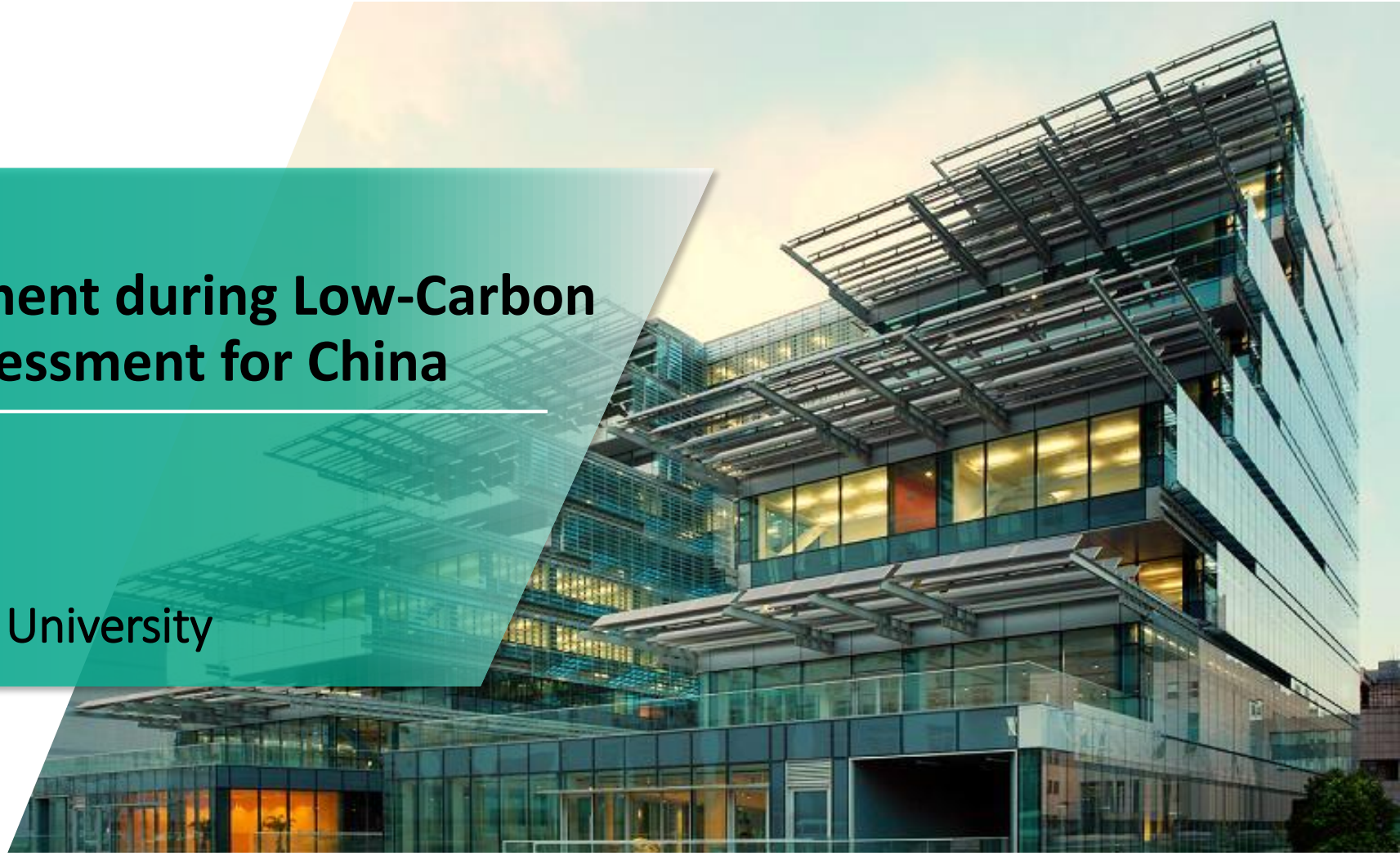


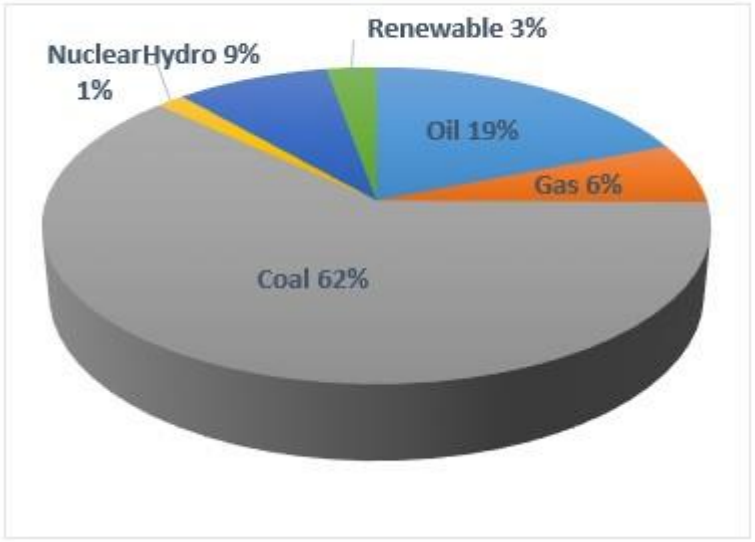
Contents

1 Introduction

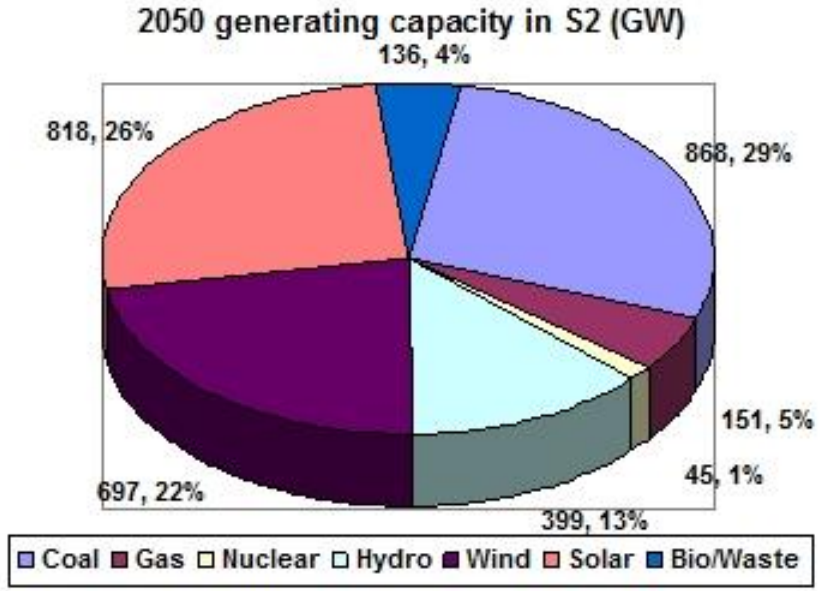
Introduction

China's low carbon development will bring about changes in energy structure and industrial structure.

Fig 1. China's Energy Mix 2016



BP statistical review of world energy 2017



China’s Energy Transition

Introduction

Labor will move from traditional energy-intensive industries to new energy industries during low-carbon development.

Bottom-up

- (**Llera et al., 2013**) an analytical model to forecast the employment in the Spanish PV industry
- (**Sooriyaarachchi et al., 2015**) discussed the job potentials that were created throughout the value chain of renewable energy.
- (**Thornley et al., 2008**) focused on the potential job creation of rural economies by bioenergy systems.

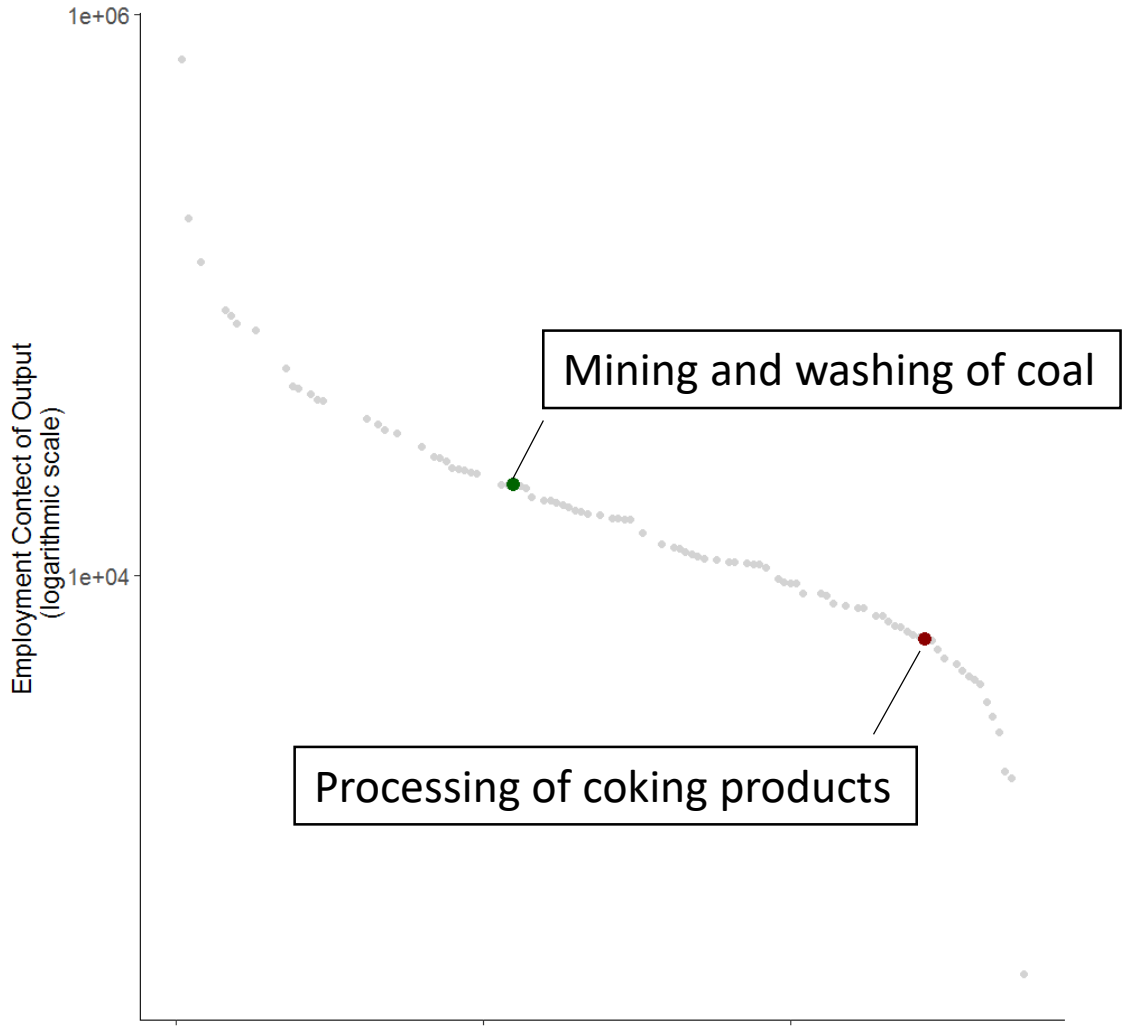
Top-down

- (**Mu et al., 2018**) quantified the full scope of job changes (direct, indirect and induced) brought by renewable development in China by using a CGE model.
- (**Siriwardana et al., 2011**) built a CGE model to analyze the impact of a carbon tax on Australia economy .
- (**Perrier and Quirion, 2018**) indicated that positive employment impacts can be achieved by shifting investment towards labor-intensive sectors in IO models.

Introduction

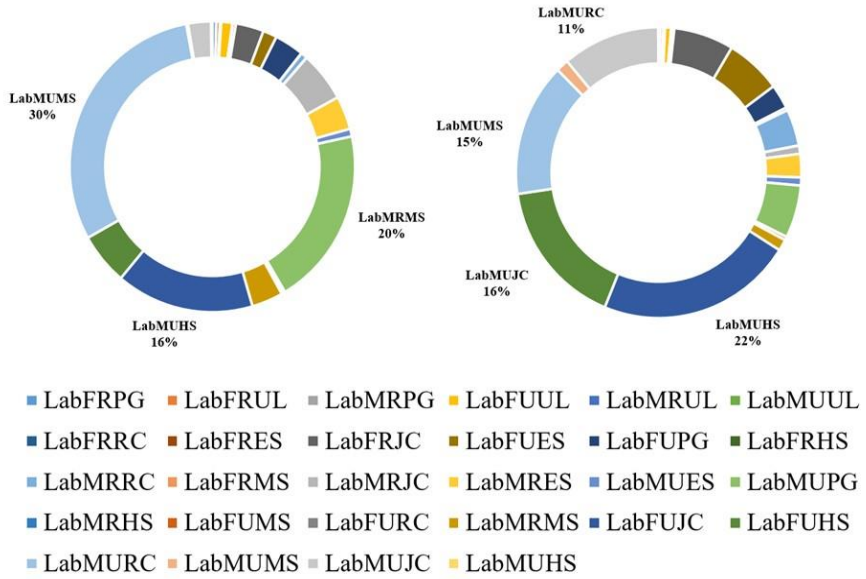
- Through the analysis of China's economic data, it is found that the **labor demand per unit of output** of the tertiary industry is generally higher than that of the secondary industry.

- During low-carbon transformation, employment demand will **not only migrate**, but the **total amount** will also change.



Introduction

There is a difference in the proportion of labor types (including gender, region and level of education) in different sectors.



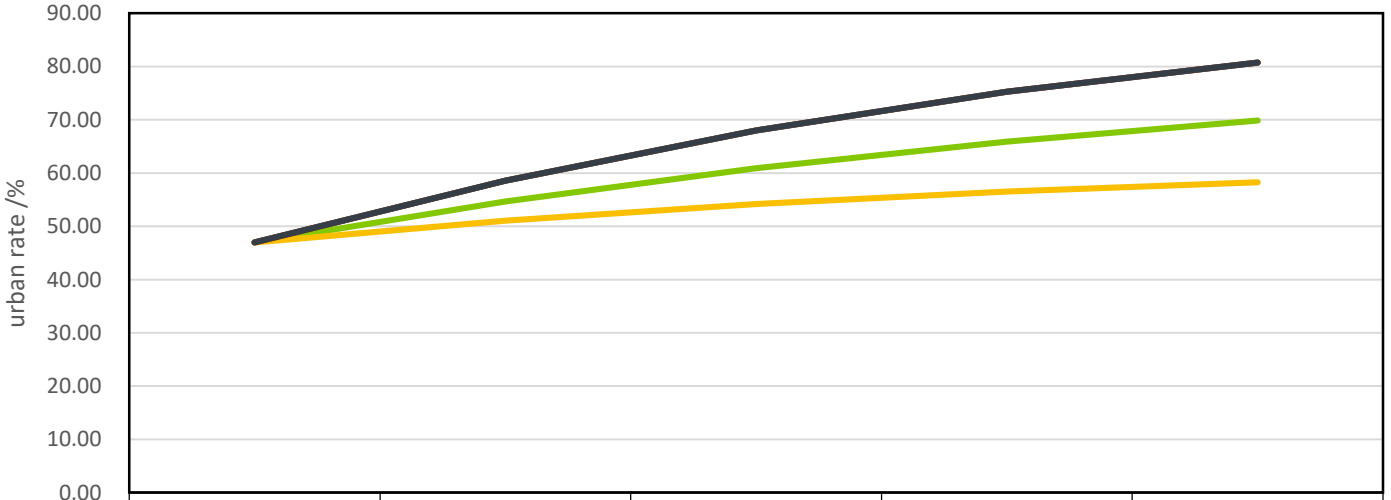
Labor types in coal (left), solar and wind (right) sectors

The highest proportion of the employed people in the **coal sector** is male urban middle school (30%) and high school (16%) graduates and male rural middle school graduates (20%). However, the highest proportion of the employed people in **the solar power and wind power sectors** are male urban high school (22%), Junior college (16%), middle school (15%) and regular college (11%) graduates

Therefore, it can be inferred that the demand for different types of labor will change with the migration between sectors during low carbon development.

Introduction

With the development of the economy and the increase of the urbanization rate, the employed people in China will migrate from agricultural sector to the secondary and tertiary industries.



	2010.00	2020.00	2030.00	2040.00	2050.00
SSP1	46.96	58.59	68.01	75.26	80.73
SSP2	46.96	54.67	60.93	65.90	69.85
SSP3	46.96	51.07	54.18	56.52	58.28
SSP4	46.96	58.59	68.01	75.26	80.73
SSP5	46.96	58.59	68.01	75.26	80.73

Urban rate in China

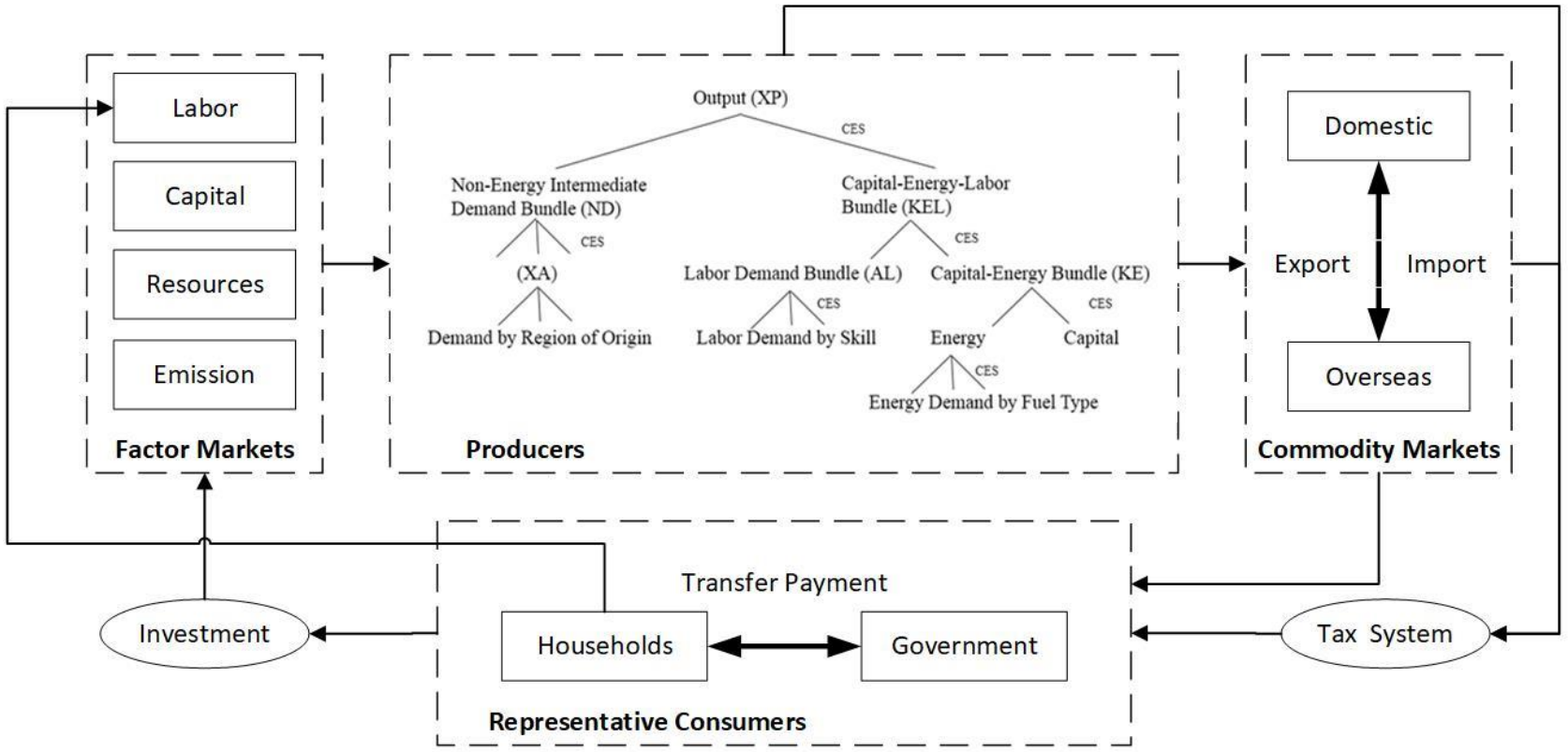
Introduction

Systematically analyze the labor migration and co-benefits in China's low-carbon transformation.

- Co-benefit of total labor demand during the transformation
- In-depth analysis of different labor groups (education level; gender; region)

2 Methodology

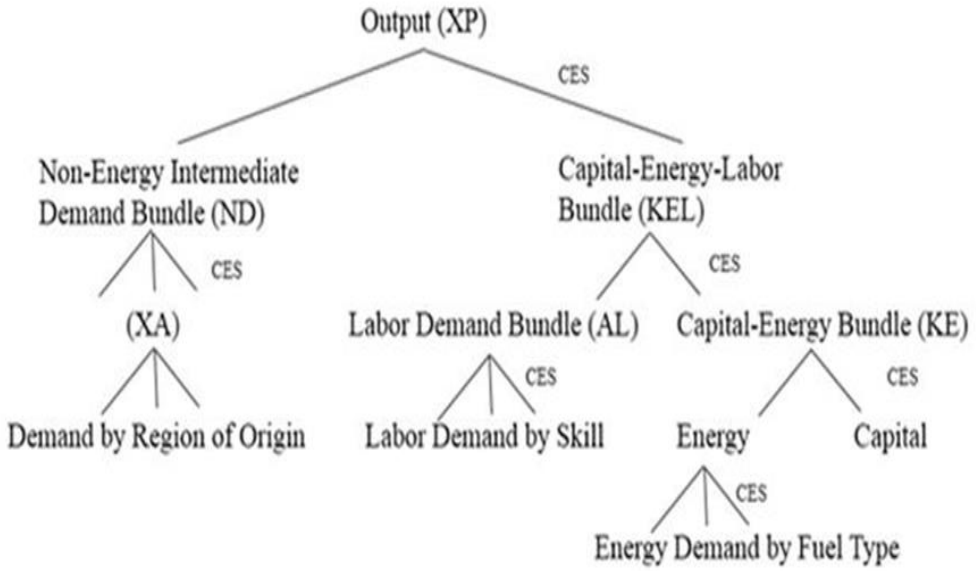
Methodology



Dynamic CGE model of the Chinese economy which is calibrated to the 2012 Input-Output table of China and the 2012 energy balance table with 42 aggregated production sectors

Methodology

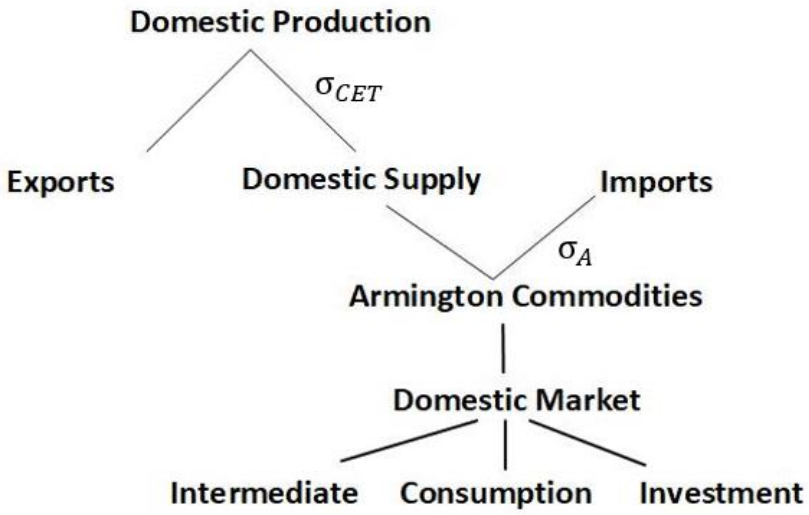
Production | **Consumption** | **Trade**



Government receives revenues from a variety of tax instruments, net of subsidies and transfers.

Household income is from labor wages, investment income, and transfer payments

Armington hypothesis



Methodology

Labor disaggregation and market

- Labor compensation is the product of **average wage** and **labor quantity** for a specific sector and labor type.
- The **labor quantity** for a specific sector and labor type can be directly obtained from available data.
- The **average wage** for labor type *l* in sector *i* ($LW_{l,i}$) can be calculated by the following equation:

$$LW_{l,i} = \frac{LAW_l^0}{\sum_l \sum_i (LAW_l^0 \times LQ_{l,i}^0 / \sum_l \sum_i LQ_{l,i}^0)} \times \frac{LAV_i^0}{\sum_i LQ_{l,i}^0}$$

  - LAV_i^0 represents the total value of labor compensation in sector *i*.
  - $LQ_{l,i}^0$ represents the employment quantity for labor type *l* in sector *i*.
  - LAW_l^0 represents the average wage for labor type *l*.

Methodology

Datasets:

(1) **the China Statistical Yearbook 2012**, which provides the household expenditure per capita and rural household income per capita data;
(2) **the China Urban Life and Price Yearbook 2012**, which provides the urban household income per capita data;
(3) **the 6th Chinese population census**, which provides the quantity of employment in sectors for different labor types;
(4) **the 2012 Chinese Input-Output table**, which provides the total value of labor compensation in sectors;
(5) **the Chinese Household Income Project (CHIP) database**, which was compiled by Beijing Normal University with 26,527 samples and provides the average wage for each labor type and the ratio of different labor types in household sectors.

Methodology

Labor disaggregation

No.	Gender	Region	Education	Abbr.
L1	Male	Urban	Unlettered	LabMUUL
L2			Elementary	LabMUES
L3			Middle school	LabMUMS
L4			High school	LabMUHS
L5			Junior college	LabMUJC
L6			Regular college	LabMURC
L7			Postgraduate	LabMUPG
L8		Rural	Unlettered	LabMRUL
L9			Elementary	LabMRES
L10			Middle school	LabMRMS
L11			High school	LabMRHS
L12			Junior college	LabMRJC
L13			Regular college	LabMRRC
L14			Postgraduate	LabMRPG
L15	Female	Urban	Unlettered	LabFUUL
L16			Elementary	LabFUES
L17			Middle school	LabFUMS
L18			High school	LabFUHS
L19			Junior college	LabFUJC
L20			Regular college	LabFURC
L21			Postgraduate	LabFUPG
L22		Rural	Unlettered	LabFRUL
L23			Elementary	LabFRES
L24			Middle school	LabFRMS
L25			High school	LabFRHS
L26			Junior college	LabFRJC
L27			Regular college	LabFRRC
L28			Postgraduate	LabFRPG

Low-carbon policies

In order to simulate the development of different power generation technologies in China in the future, especially the development of renewable energy technologies such as wind power and solar power generation, our research disaggregates the power industry according to the technology categories, including coal power, gas power, oil power, nuclear, hydro power, wind power, solar power, biomass power.

$$GEN = \left(\sum_{t} \alpha_t^{TEC} \times TEC_t^{\frac{\sigma^{TEC}-1}{\sigma^{TEC}}} \right)^{\frac{\sigma^{TEC}}{1-\sigma^{TEC}}}$$

where

GEN = total electricity output

TEC_t = output of power technology t

α_t^{TEC} = share parameter of power technology t

σ^{TEC} = elasticity substitution coefficient between technologies

Methodology

Low-carbon policies

In addition, the **carbon market** is also simulated in the model.

The model first calculates the **carbon emissions** generated by different industries and consumers by multiplying carbon emission parameters.

In the **production block**, a carbon cost variable is added in the production function to simulate the increased cost due to the purchase of carbon credits.

In the **market closure part**, the carbon revenue is transferred to the government.

$$\mathrm{EFT} = \sum_i \sum_e emit_e \times xap_{i,e} \times (1 - feedstock_{i,e})$$

$$\mathrm{CR} = \sum_i \sum_e \mu \times emit_e \times xap_{i,e}$$

where

EFT	= total emission
$emit_e$	= carbon emission parameters of energy resource e
$xap_{i,e}$	= input of energy resource e in sector i
$feedstock_{i,e}$	= proportion of energy input that is not used as fuel
CR	= carbon revenue
μ	= shadow carbon price

3 Scenarios

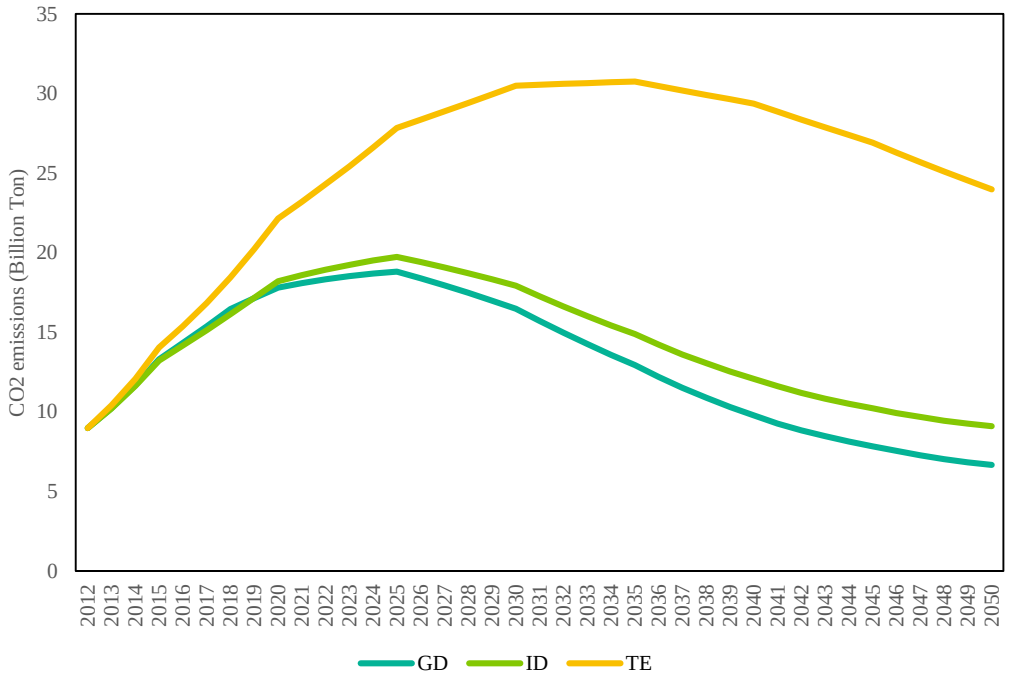
Scenarios

Our research adopts the economic and social forecast data in the IIASA SSP database (Riahi et al., 2017). and the low carbon policies in Reinventing Fire China Report when building future scenarios.

Scenarios	Description
Traditional Energy scenario (TE)	Social and economic data (GDP, population and urbanization) from SSP3 No restriction policy.
Intermediate Development scenario (ID)	Social and economic data (GDP, population and urbanization) from SSP2 Power structure adjustment, increasing the proportion of renewable energy; Reducing coal input in heavily polluting industries; Improving energy efficiency.
Green Development scenario (GD)	Social and economic data (GDP, population and urbanization) from SSP1 Power structure adjustment, increasing the proportion of renewable energy; Reducing coal input in heavily polluting industries; Improving energy efficiency. Emission Trading System (ETS)

4 Results

Results



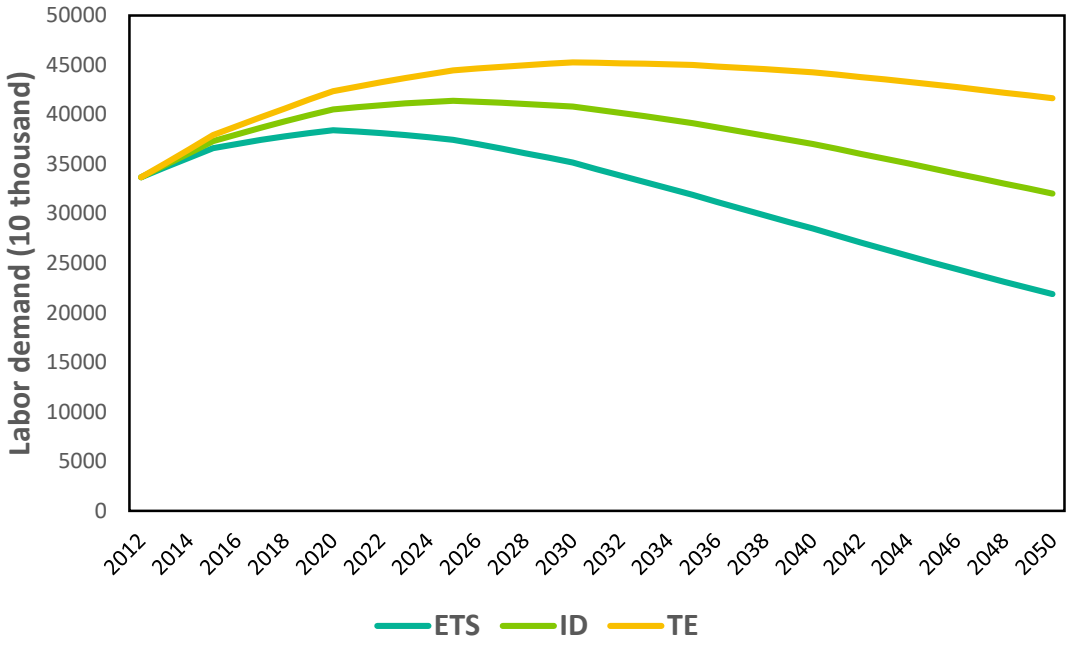
CO2 emissions

Due to the lack of environmental policy constraints in the TE scenario, the energy system is dominated by fossil fuels, which **brings a large amount of greenhouse gas emissions**.

In the ID and GD scenarios, carbon emissions **reached peaks** around 2025.

The carbon emissions under the GD scenario are even lower than those under the ID scenario, and by 2050 they are **26.7%** lower than the ID scenario. Because the ETS policy was simulated in the GD scenario, more stringent carbon emission constraints were set.

Results

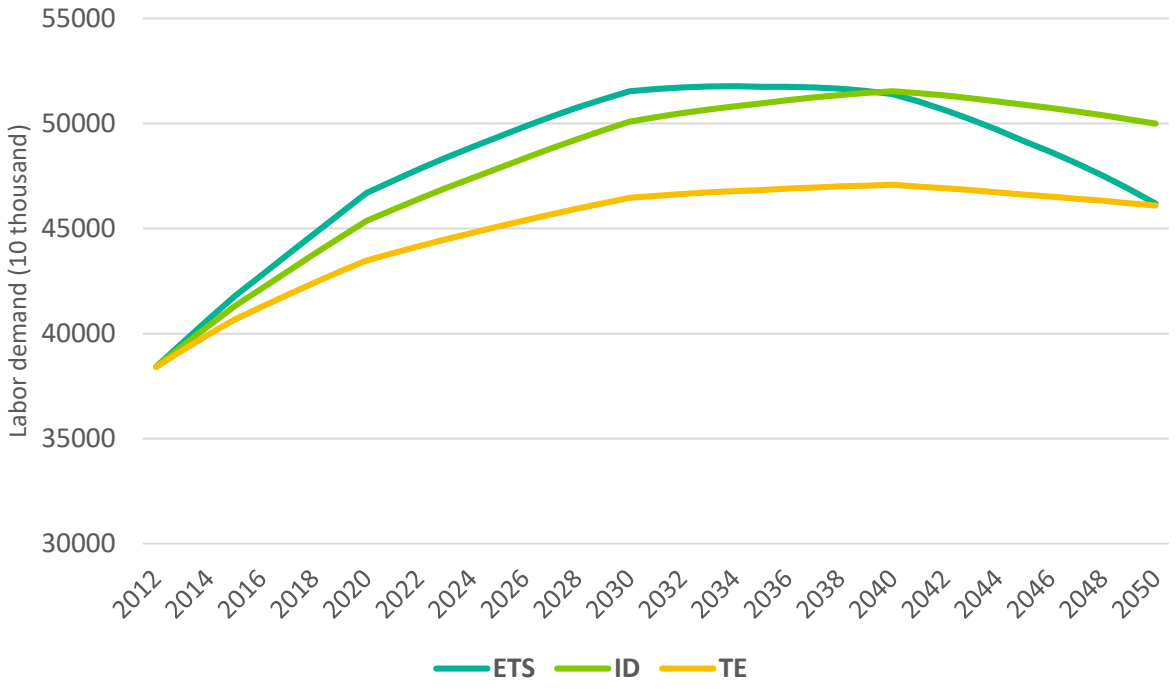


Labor demand in agriculture sectors

More and more rural people will leave the agricultural sector and choose to work in cities with the increase of urbanization rate. In the GD scenario, due to the highest level of urbanization, the employment in agriculture is lowest. By 2050, it is only **219 million**, which is 68.3% of the ID scenario and 52.6% of the TE scenario.

The proportion of capital and energy investment in the agricultural industry will also increase, which means that the level of modernization of agriculture will continue to increase, and the **income of agricultural employment** will also increase.

Results



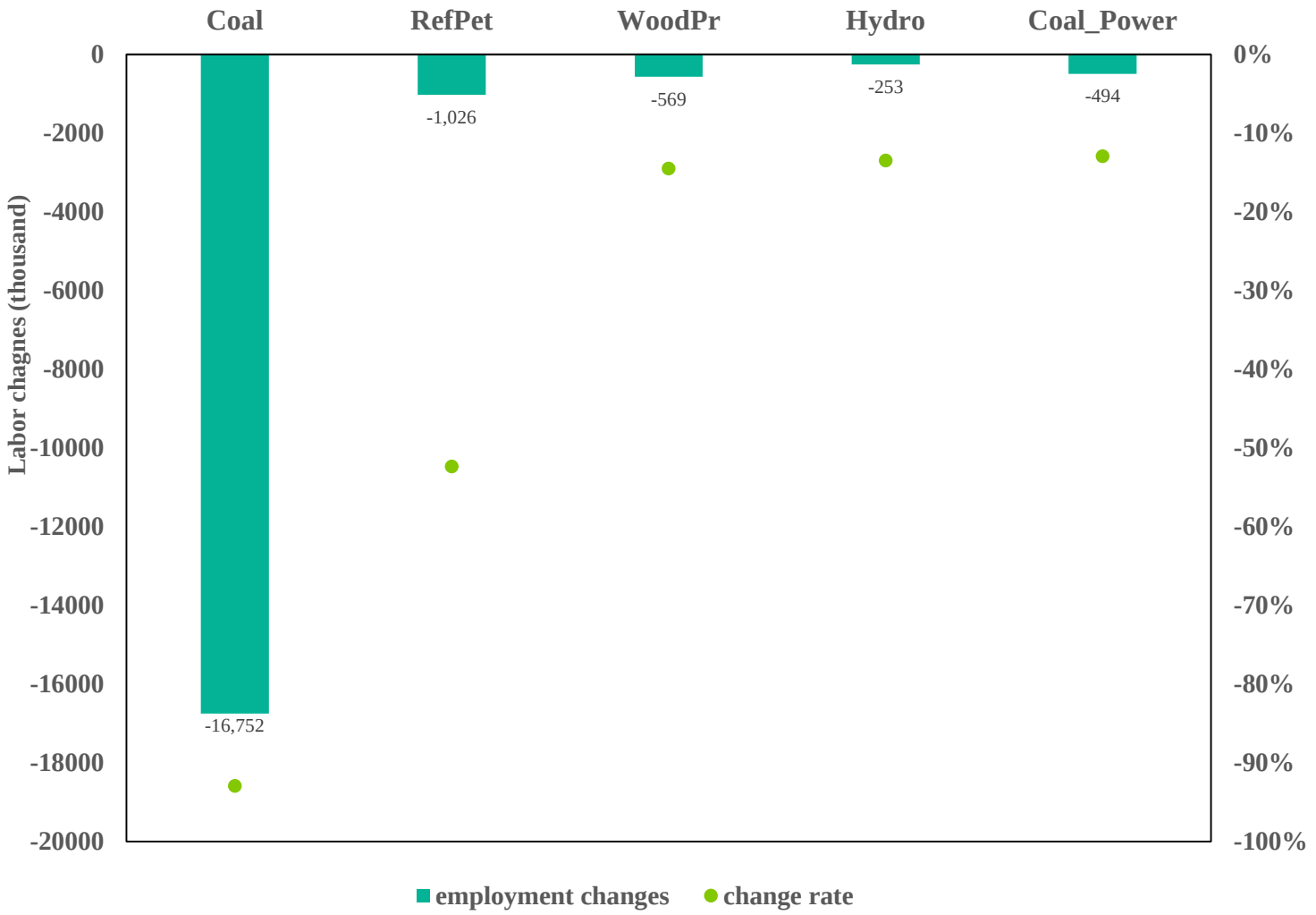
Labor demand in urban region

By comparing the employment of the second and third industries, we found that the employment in the TE scenario was the least, which was **7.8% lower** than the ID scenario. Through this we can see that China's green low-carbon policy will bring about a **co-benefit effect** of increased employment.

Results

ID

TE



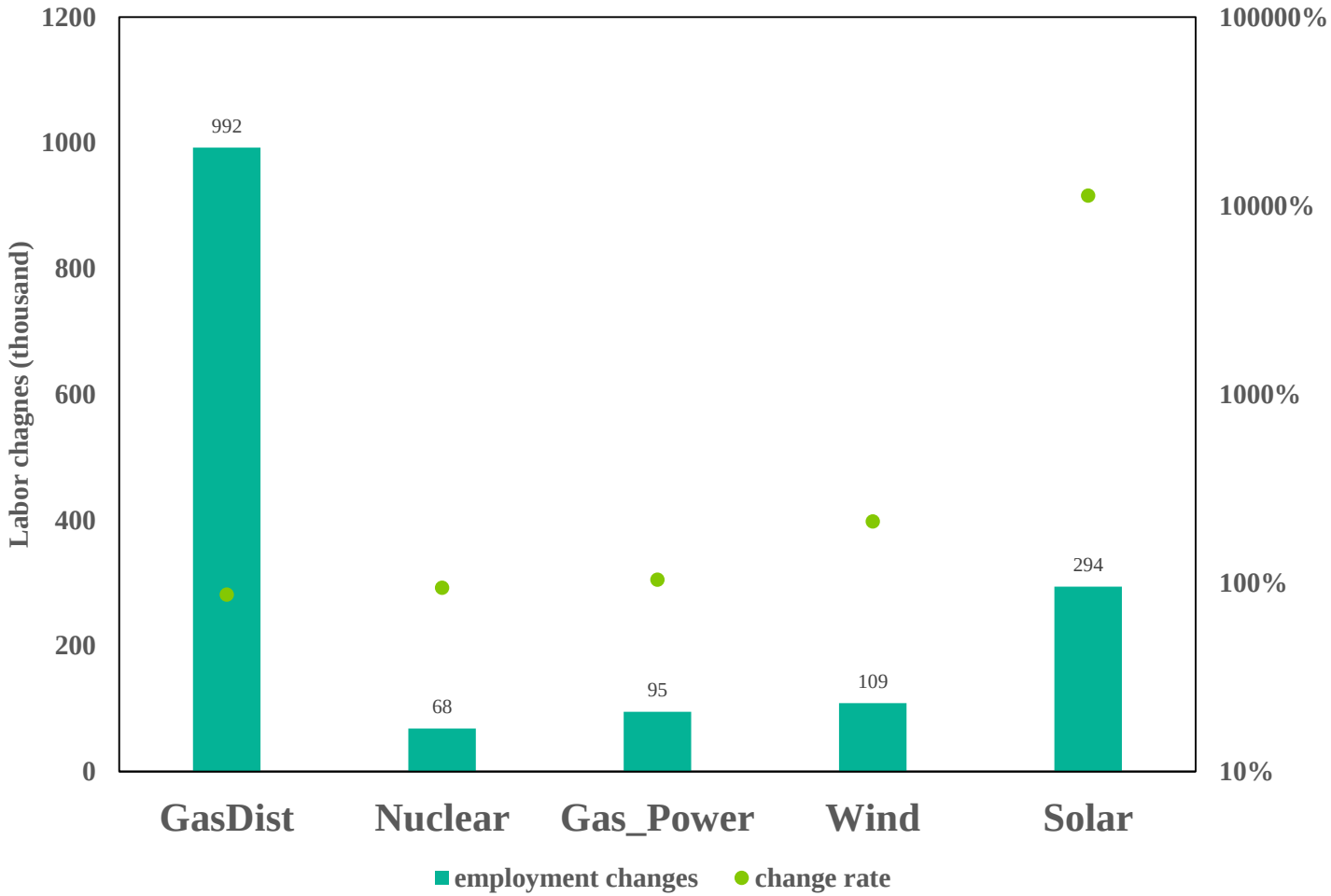
Compared with the TE scenario, the reduction in labor demand is mainly concentrated in the **traditional energy** production sector and **high energy consuming** sectors including coal mining products (92.96%), Petroleum (52.37%), wood products (14.51%) and coal power (12.96%) by 2050 in ID scenario. In addition, the labor demand in **hydropower** industry will also decrease significantly (13.51%) in this scenario.

Results

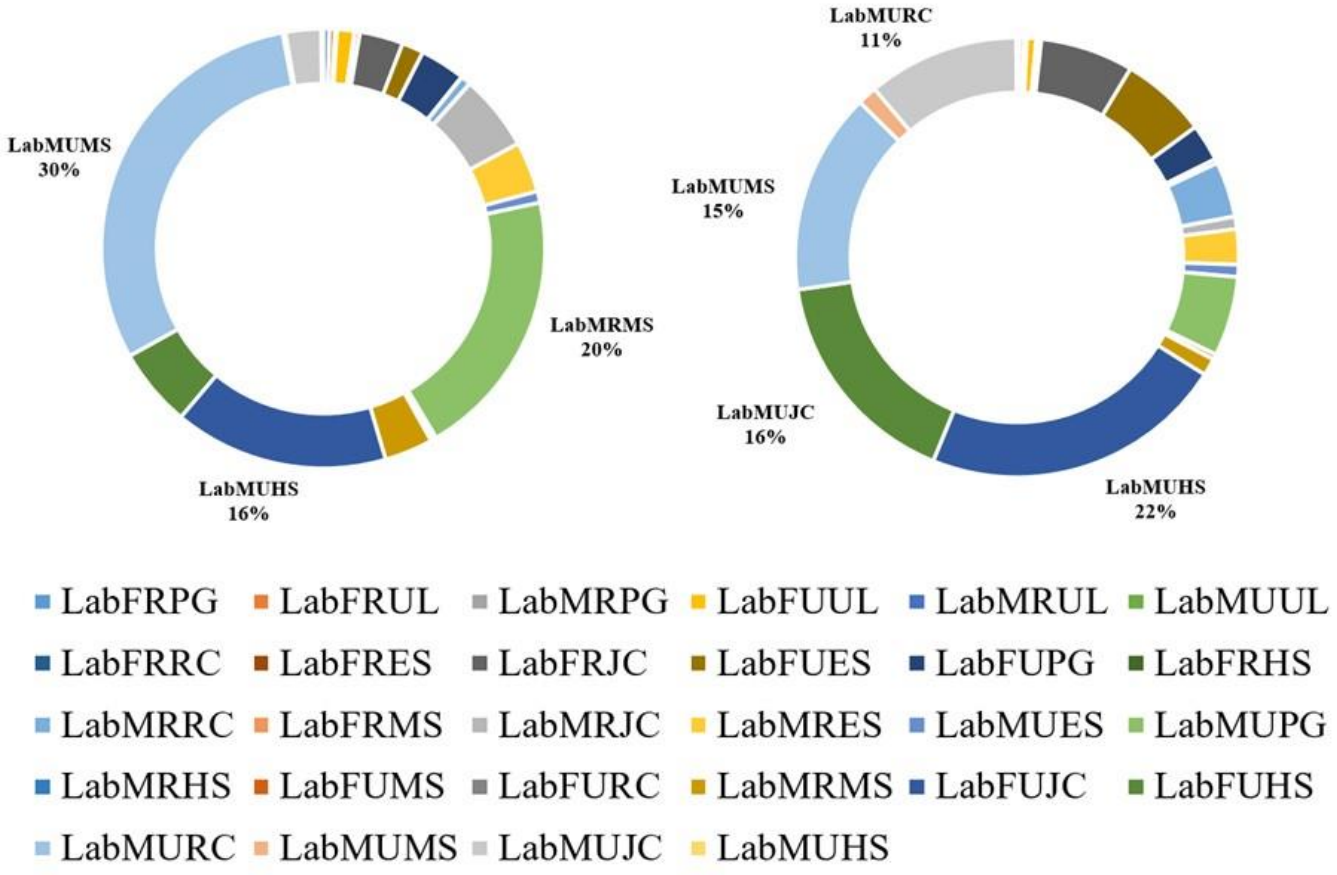
ID

TE

The increase in labor demand is mainly concentrated in the **new renewable energy industry** and natural gas-related industries. The five sectors with the largest growth rate are solar power (11315.49%), wind power (211.60%), natural gas power (103.71%), nuclear power (94.21%) and gas production and supply (86.68%).



Results



Coal workers are mainly **male urban junior high** and **middle school graduates** and **male rural junior high school** graduates and they are most affected.

Compared with traditional energy sectors, the demand for labor types in wind and solar has certain requirements for **male urban junior college** and **regular college graduates**. in addition to **male urban junior high** and **middle school graduates**.

Results

	Coal	Solar power	Wind power
2012	4842.8	0.6	14.2
2050	1268.9	296.4	160.2

The reduction in production only in the coal sector will result in a **loss of 3.57 million jobs**, while the labor types **with high school education level and below will account for 87.8%.** In contrast, due to the development of renewable energy such as **solar power and wind power**, it will increase the number of jobs for labor types with junior college education level or above by **182 thousand**.

Main findings

- Under the low-carbon policy scenario, the employment population in China will be transferred from rural to urban areas, and the **urbanization rate** will increase rapidly, reaching 80.73% by 2050. The **income of agricultural employment** will also increase.

- China's low carbon development will generate the greatest **positive impact on employment in the energy industries** such as natural gas and other new power generation sectors.

- As the economic structure changes, the demand for highly educated employment types in the labor market will continue to increase, highlighting the importance of education.

Limitation

This study lacks an analysis from the perspective of labor supply.

- The **improvement of education in China** may lead to changes in the types of employed people and increase the degree of matching with employment demand.
- The **aging problem** that may arise in China in the future will also have a certain impact on the job market.

The understanding of the labor market in this study is still based on existing technologies and perspectives.

- For **the artificial intelligence technology** that may appear in the future, due to the lack of reliable scenario prediction, this study did not take it into account, presenting a challenging area for future research.


Thank you!