

1. Introduction

- ▶ Chinese government had announced the goal of reaching carbon emission peak by 2030 and achieving carbon neutrality before 2060
- ▶ Energy sectors are main contributors to GHG emissions, which are mostly produced by fossil fuel combustion particularly in electricity generation sectors.
- ▶ Improving the energy efficiency is one effective measure to reduce energy consumption and carbon emission
- ▶ We have developed series of models to simulate, **How many CO₂ emission can be reduction by improved energy efficiency (EE)?**

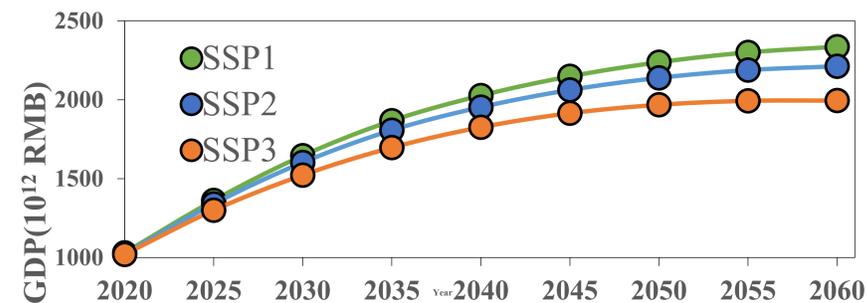
2. Description of Scope Areas

- ▶ Classification of the 30 regions of China and their summary statistics of economic and energy related data.

Categories	Regions	Average GDP per capital (Million RMB/person)	Average energy consumption (Mtce)	Average CO ₂ emissions (Mt)
Developed	D1.Beijing, D2.Tianjin, D3.Hebei, D4.Liaoning, D5.Shanghai, D6.Jiangsu, D7.Zhejiang, D8.Fujian, D9.Shandong, D10.Guangdong, D11.Hainan	7.64	60.38	140.25
Developing	D11. Shanxi, D12. Inner Mongolia, D13.Jilin, D14.Heilongjiang, D15.Anhui, D16.Jiangxi, D17.Henan, D18.Hubei, D19.Hunan, D110.Guangxi	3.96	55.87	140.1
Less Developed	LD1.Sichuan, LD2.Guizhou, LD3.Yunnan, LD4.Shaanxi, LD5.Gansu, LD6.Qinghai, LD7.Ningxia, LD8.Xinjiang, LD9.Chongqing	3.31	28.73	72.32

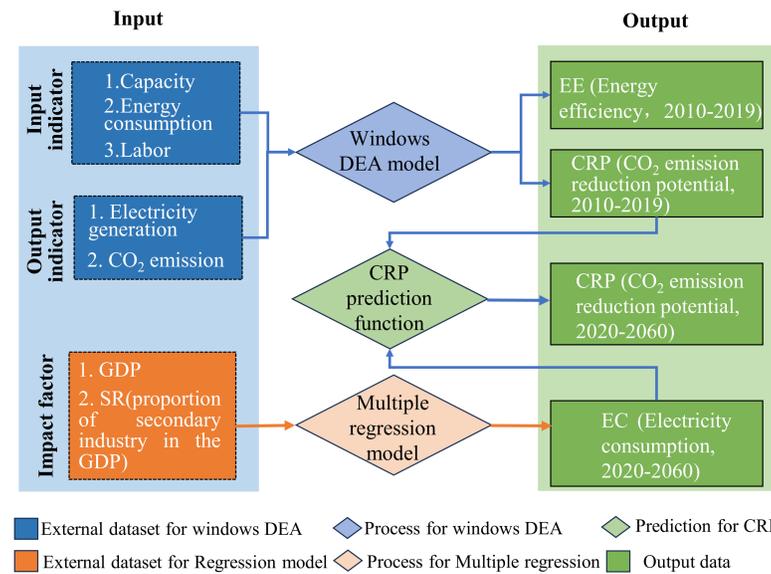
3. Future Scenario Setting

- ✓ **Scenario 1** : Electricity consumption under SSP1
- ✓ **Scenario 2** : Electricity consumption under SSP2
- ✓ **Scenario 3** : Electricity consumption under SSP3



4. Methodology

Systematic flow chart



4.1 Data Envelopment Analysis (DEA)

- DEA was used to evaluate EE and CRP

$$\theta_k = \frac{\text{Weighted sum of outputs}}{\text{Weighted sum of inputs}} = \frac{u_1 y_{1k} + u_2 y_{2k} + \dots + u_s y_{sk}}{v_1 x_{1k} + v_2 x_{2k} + \dots + v_s x_{sk}}$$

Three Input: installed capacity, energy consumption and labor.
Two Output: electricity generation and CO₂ emission.

4.2 Multiple regression model

- Multiple-regression was used to forecast the electricity consumption

$$\ln(EC_n) = \alpha + \beta \ln(GDP_n) + \gamma SR_n + \varepsilon$$

where **EC** represents electricity consumption, **GDP** is in RMB, and **SR** is the proportion of secondary industry in the GDP. α is a constant term, n is individual province, β and γ are coefficients of the variables, and ε is the error term

4.3 Estimation of CO₂ reduction potential (CRP)

$$CRP_{n,t} = \frac{TR_{n,t} \times EG_{n,t}}{EG_{Tn,2019}} \times CRP_{n,2019} \quad EG_{n,t} = EC_{n,t}$$

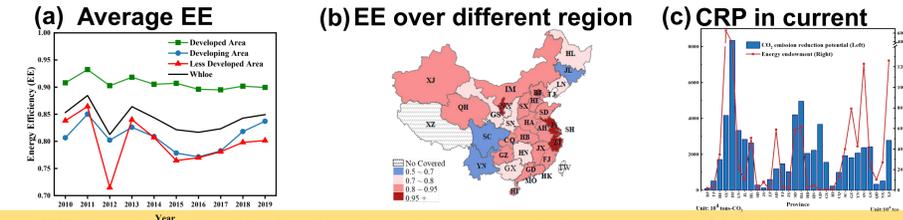
where **CRP** is CO₂ emissions reduction potential, **TR** is the ratio of thermal power plant in total electricity generated plant, **EC** is the electricity consumption, **EG_T** is the electricity generation from the thermal power industry, n is individual province

6. Conclusion and future work

- From 2010-2019
 - Energy efficiency → As high as 0.85
 - CO₂ reduction potential → Average of 624.04 Mt-CO₂/year
- From 2020-2060
 - Electricity consumption → Increase 1.7 - 2 fold
 - CO₂ reduction potential → Reduce 39%-45.8%, of the total CO₂ emissions from China's electricity sector in 2020
- Future work
 - ✓ Combine with other countermeasure to reduce CO₂ emission

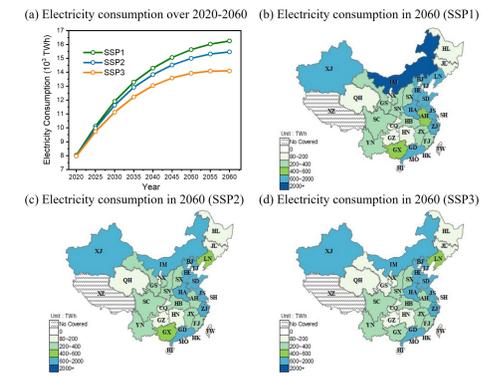
5. Result and Discussion

5.1 Energy efficiency and CO₂ reduction potential



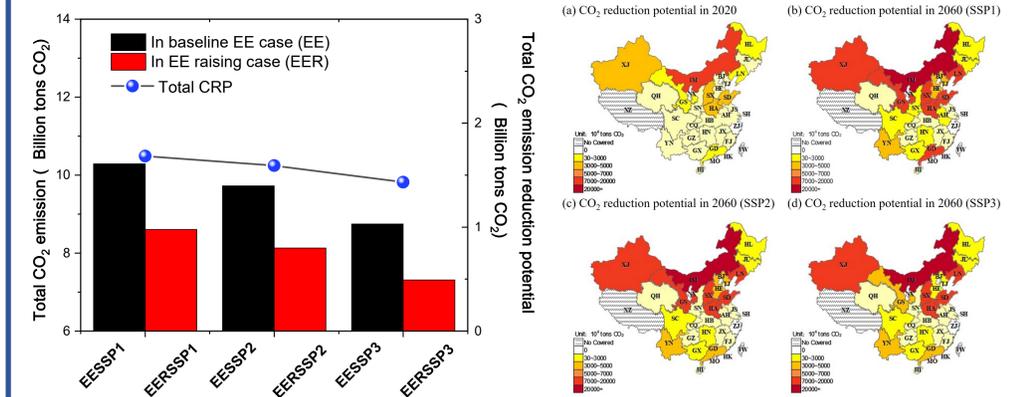
- EE scores above 0.9 for developed areas and close scores of 0.71-0.86 for developing and less developed areas
- EE score in Beijing, Shanghai, Jiangsu, Ningxia, and Zhejiang are higher than others
- The CRP is 624.04 Mt-CO₂ by improved energy efficiency

5.2 Prediction of electricity consumption



- The total electricity consumption of China exhibits a significant **increase**, ranging from 0.8×10^4 TWh in 2020 to 0.63×10^4 , 1.55×10^4 TWh and 1.41×10^4 TWh in 2060 under SSP1-SSP2, respectively
- In SSP1, electricity consumption is more than 1000TWh in Guangdong, Jiangxi, Inner Mongolia, and Zhejiang

5.3 Prediction of CO₂ reduction potential



- CO₂ emission reduction potential : **IESSP1>IESSP2>IESSP3**
- Total CO₂ emissions gap up to 1.68, 1.59 and 1.43 billion t-CO₂ for shifting from baseline EE case to EE raising case
- Inner Mongolia, Xinjiang, Henan, and Shanxi achieve the largest CRP among the 30 provinces/municipalities.

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