# CGE Model Analysis of Energy and Environment Fiscal and Tax Policies

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**Keywords:** CGE model, economic-energy-environment system, renewable energy subsidy, taxation policies.

**Abstract:** This paper takes energy and environment fiscal and taxation policies as the research object, constructs China CGE model, and studies the impact of energy and environment fiscal and taxation policies under the constraints of economic-energy-environment system. Research on the Impact of Energy and Environmental Fiscal and Tax Policies: Based on the model analysis platform, different policy scenarios of fossil energy subsidy, renewable energy subsidy and carbon tax are set up, and different scenarios and combination of policy scenarios are simulated to study the impact of relevant variables in the economic-energy-environment system.

## 1. Construction of CGE Model of Energy and Environment Fiscal and Tax Policy

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CGE model of short-term energy and environmental fiscal and taxation policy mainly includes production function module, trade function module, resident function module, enterprise function module, government function module, closure and market clearance function module, social welfare function module and dynamic function module [1-3]. The detailed model structure is as follows.

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(1) Production Module Function

$$E_{clepi} = (\beta_{hyepi} \times E_{hyepi}^{\rho_l^{clep}} + \beta_{nuepi} \times E_{nuepi}^{\rho_l^{clep}} + \beta_{wiepi} \times E_{wiepi}^{\rho_l^{clep}} + \beta_{soepi} \times E_{soepi}^{\rho_l^{clep}})^{\frac{1}{\rho_i^{clep}}} \tag{1}$$

(2) Trade Module Function

$$QX_i = \gamma_{ei}(\xi d_i \times QD_{si}^{\rho ei} + \xi e_i \times QE_i^{\rho ei})^{\frac{1}{\rho ei}} \tag{2}$$

(3) Modular function of mechanism

$$YGT = \sum_i GINDTAX_i + \sum_i GTRIFM_i + GHTAX + GETAX + GWY \tag{3}$$

(4) Closing and Market Clearing Module Function

$$\sum_i PM_i \times QM_i + YMK + YMG = \sum_i PE_i \times QE_i + YHW + GWY + \overline{SF} \times EXR \tag{4}$$

$$RGDP = \sum_i HD_i + \sum_i GD_i + \sum_i INV_i + \sum_i STO_i + \sum_i [QE_i - (1+tm_i)QM_i] \tag{5}$$

$$GDP_i = R_i \times K_i + W \times L_i + t_{indi} \times PX_i \times QX_i \tag{6}$$

$$GDP = \sum_i GDP_i \tag{7}$$

$$PGDP = \frac{GDP}{RGDP} \tag{8}$$

(5) Social Welfare Function

$$EV = E(U^s, PQ^b) - E(U^b, PQ^b) = \sum_i PQ_i^b \times HD_i^s - \sum_i PQ_i^b \times Hd_i^b \tag{9}$$

(6) Dynamic Modular Function

$$KS_{t+1} = KS_t - \sum_i K_{i,t} \times depr_i + TINV_t \tag{10}$$

## 2. Data Base and Parameter Setting of CGE Model of Energy and Environment Fiscal and Tax Policy

Based on the national input-output extension table issued in 2018, according to the characteristics of industrial structure and the needs of research, the input-output table was adjusted to 23 departments. According to the adjusted input-output table of 2015, the theory of social accounting matrix and the basic structure of social accounting matrix, and referring to the relevant basic data of "China Statistical Yearbook of 2017" and "China Financial Yearbook of 2017", the basic data, i.e. China Microeconomic Social Accounting Matrix of 2015, are compiled.

The substitution elasticity coefficient of production function and trade function of the model refers to the values of Guo Zhengquan, Lin, Jia and Zhang [4]. The share parameters of production function, Armington function and CET function in the model are calibrated by the base year social accounting data, and the relevant share parameters are calibrated in the model program according to the basic data. According to the established model, the impact of energy and environmental fiscal and taxation policies on energy-economy-environment system is evaluated and analyzed by static model [5-7]. This paper mainly simulates the implementation of policies separately and the combination of policy scenarios.

## 3. Static Analysis of the Synergistic Effect of Energy and Environmental Fiscal and Tax Policies

### 3.1 Scenario Setting

Policy scenario 1: Assuming that the subsidy for oil and natural gas will decrease by 10%, and the subsidy for wind and solar power will decrease by 20%.

Policy scenario 2: Assuming that the subsidy for oil and natural gas will decrease by 10% and the subsidy for wind and solar power will decrease by 30%.

Policy scenario 3: Assuming that the subsidy for oil and natural gas will decrease by 10%, the subsidy for wind power and solar power will decrease by 20%, and the carbon tax policy will be implemented to levy a carbon tax of 10 yuan per ton of carbon dioxide.

Policy scenario 4: Assuming that the subsidy for oil and natural gas will decrease by 10%, the subsidy for wind power and solar power will decrease by 20%, and the carbon tax policy will be implemented to levy a carbon tax of 20 yuan per ton of carbon dioxide.



### 3.2 Analysis of the Impact of Policy Scenario Combination on the Gross Electricity Production and Structure

The following table reflects the impact of the combination of energy and environmental fiscal and taxation policies on the total amount and structure of electricity generation. Under scenario 1 and scenario 2, wind power, solar energy and other power generation declined, while the total power generation, as well as thermal power and Hydropower generation, increased. Under the policy scenario 3 and 4, the generation of wind power, solar energy and other electric power, thermal power and the total amount of power generation have decreased, while the generation of hydropower has increased. Basically, with the increase of policy intensity, the impact effect increases. The reasons are as follows: the reduction of investment by subsidy leads to the decrease of sector output, i.e. power generation; the substitution effect between electricity and other fossil energy sources; the imposition of carbon tax will lead to the increase of thermal power generation cost and the decrease of power generation; the substitution effect exists among different power sources, and the policy scenario under the combined effect of the above four factors Under scenarios 1 and 4, the total and structure of power generation show the effect of Table 1.

Table 1. The impact of policy scenario combination on power output and structure (unit: %)

| project | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|---|---|---|---|---|
| Gross Electricity Production | 0.1659 | 0.1456 | -0.0673 | -0.2919 |
| Thermal power | 0.3804 | 0.5085 | -0.1856 | -0.7381 |
| hydropower | 0.6552 | 0.7904 | 1.6735 | 2.6822 |
| Wind power | -11.8068 | -18.6479 | -10.9398 | -10.0810 |
| Solar energy and other electricity | -11.9256 | -18.8215 | -11.0611 | -10.2048 |

## 4. Dynamic Analysis of the Synergistic Effect of Energy and Environmental Fiscal and Tax Policies

(1) Scenario setting

Policy scenario 1: Starting in 2019, subsidies for oil and natural gas fell, resulting in a 10% decline in departmental yields; starting in 2019, subsidies for wind and solar power declined, resulting in a 20% annual decline in departmental yields over the benchmark scenario.

Policy scenario 2: Starting in 2019, subsidies for oil and natural gas fell, resulting in a 10% decline in departmental yields; starting in 2019, subsidies for wind and solar power declined, resulting in a 30% annual decline in departmental yields over the benchmark scenario.

Policy scenario 3: Starting from 2019, subsidies for oil and natural gas have fallen, resulting in a 10% decline in sector returns; starting from 2019, subsidies for wind power and solar power have fallen, resulting in a 20% annual decline in sector returns over the benchmark scenario; assuming that starting from 2021, a carbon tax policy will be implemented with a carbon tax of 10 yuan per ton of carbon dioxide.

Policy scenario 4: Starting in 2019, subsidies for oil and natural gas have fallen, resulting in a 10% decline in sector returns; starting in 2019, subsidies for wind power and solar power have fallen, resulting in a 30% annual decline in sector returns over the benchmark scenario; assuming that a carbon tax of 20 yuan per ton of carbon dioxide will be imposed from the implementation of the carbon tax policy in 2021.

(2) The table below reflects the impact of the combination of energy and environmental fiscal and taxation policies on electricity generation and structure. Policy scenario 3 and policy scenario 4 analyzed the effects of oil and natural gas subsidy reduction, wind power and solar power subsidy reduction, and carbon tax policy scenario combination on total power generation and structure. The reasons why subsidized consumption of oil and natural gas and reduction of subsidies for wind and solar power generation are no longer explained. The implementation of carbon tax will increase the use cost of fossil energy and decrease the consumption of fossil energy. Electricity will be used as an alternative energy source to supplement it. At the same time, due to the increase of fossil energy use cost, the cost of power generation and the amount of power generation will be reduced. The other four kinds of electricity will play a supplementary role because of the substitution of thermal power. Power generation has increased. Under the combined effect of the above policy factors, compared

with the benchmark scenario, the total power generation in policy scenario 3 is lower than that in benchmark scenario, and the total power generation in policy scenario 4 is higher than that in benchmark scenario. In terms of classified generation, wind power, solar energy and other power generation have decreased; hydropower generation has increased; thermal power generation is higher than the benchmark scenario under scenario 3 and lower than the benchmark scenario under scenario 4. Therefore, under the combination of the three policy scenarios, the changes of total and classified generation and structure will be more complex.

Table 2. The impact of policy scenarios on power generation and structure (in gigawatt hours)

| Scenario setting | Forecast/change | Particular year | Total Power Generation | Classified generation capacity | | | |
|---|---|---|---|---|---|---|---|
| | | | | Thermal power | hydropower | Wind power | Solar energy and other power generation |
| Benchmark scenario | Forecast | 2020 | 68989.52 | 47075.08 | 12089.47 | 4393.50 | 2547.69 |
| | | 2025 | 75017.80 | 47118.48 | 12481.94 | 7156.56 | 5011.69 |
| | | 2030 | 82866.32 | 48203.27 | 12990.30 | 10593.45 | 7418.53 |
| | structure | 2020 | —— | 68.24 | 17.52 | 6.37 | 3.69 |
| | | 2025 | | 62.81 | 16.64 | 9.54 | 6.68 |
| | | 2030 | | 58.17 | 15.68 | 12.78 | 8.95 |
| Policy scenario 1 | Forecast | 2020 | 68612.76 | 47616.25 | 12279.59 | 3696.11 | 2099.83 |
| | | 2025 | 73886.35 | 47771.54 | 12707.43 | 5999.71 | 4105.89 |
| | | 2030 | 80881.97 | 48965.02 | 13251.46 | 8870.18 | 6064.07 |
| | structure | 2020 | —— | 69.40 | 17.90 | 5.39 | 3.06 |
| | | 2025 | | 64.66 | 17.20 | 8.12 | 5.56 |
| | | 2030 | | 60.54 | 16.38 | 10.97 | 7.50 |
| Policy scenario 2 | Forecast | 2020 | 68232.19 | 47808.70 | 12332.08 | 3304.15 | 1853.36 |
| | | 2025 | 73080.46 | 48023.51 | 12775.82 | 5350.12 | 3610.24 |
| | | 2030 | 79585.14 | 49270.70 | 13334.31 | 7900.25 | 5323.04 |
| | structure | 2020 | —— | 70.07 | 18.07 | 4.84 | 2.72 |
| | | 2025 | | 65.71 | 17.48 | 7.32 | 4.94 |
| | | 2030 | | 61.91 | 16.75 | 9.93 | 6.69 |
| Policy scenario 3 | Forecast | 2020 | 68612.76 | 47616.25 | 12279.59 | 3696.11 | 2099.83 |
| | | 2025 | 74397.16 | 47448.05 | 13114.70 | 6189.85 | 4235.04 |
| | | 2030 | 81955.69 | 48492.25 | 13887.69 | 9302.58 | 6356.25 |
| | structure | 2020 | —— | 69.40 | 17.90 | 5.39 | 3.06 |
| | | 2025 | | 63.78 | 17.63 | 8.32 | 5.69 |
| | | 2030 | | 59.17 | 16.95 | 11.35 | 7.76 |
| Policy scenario 4 | Forecast | 2020 | 68612.76 | 47616.25 | 12279.59 | 3696.11 | 2099.83 |
| | | 2025 | 74883.58 | 47146.24 | 13500.57 | 6369.00 | 4356.43 |
| | | 2030 | 82930.54 | 48068.88 | 14465.95 | 9692.08 | 6618.48 |
| | structure | 2020 | —— | 69.40 | 17.90 | 5.39 | 3.06 |
| | | 2025 | | 62.96 | 18.03 | 8.51 | 5.82 |
| | | 2030 | | 57.96 | 17.44 | 11.69 | 7.98 |

Generally speaking, under the circumstances of oil and natural gas subsidy reduction, wind and solar power subsidy reduction and carbon tax policy implementation, the total electricity output and power structure optimization under the three kinds of policy combination scenarios are carried out because of the difference in the direction of action of different policies and the difference in the intensity and intensity of policy implementation. Surface, the impact will be more complex.

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