Analysis on spatial transfer model of energy development layout and the ecological footprint affection

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Abstract. Consider the global energy interconnection, the global is concentrating on carrying out clean energy alternative, which is mainly focusing on using the clean energy to take place of fossil energy, and change the global energy layout and ecological atmosphere condition. This research gives the energy spatial transfer model of energy development layout to analyse the global energy development layout condition and ecological affection. And it is a fast and direct method to analyse its energy usage process and environmental affection. The paper also gives out a system dynamics model of energy spatial transfer shows, which electric power transmission is better than original energy usage and transportation. It also gives the comparison of different parameters. The energy spatial transfer can affect the environment directly. Consider its three environmental factors, including energy saving, climate changing and conventional pollutant emission reduction, synthetic combine with the spatial transfer model, it can get the environmental change parameters, which showed that with the clean energy wide usage, the ecological footprint affection will be affected significantly.

1. Introduction
The energy interconnection can be equivalent to the spatial distribution transfer of energy development layout. On the one hand, the global energy spatial transfer, can drive economic and social transformation; on the other hand, this spatial transfer layout, greatly improving global environmental pollution and reduce global environmental stress[1].

Energy transfer, spatial layout changes and ecological environment, can be affected by these three factors showed in Figure 1. Energy transferring combined with energy extraction, processing and transportation and other series of energy activities, will inevitably damage the ecological environment. Take the coal as example, coal transportation by railway, affecting on the ecological environment mainly includes the impact of coal mining, the occupation and destruction of land resources, water consumption and water pollution, air pollution, noise pollution, mining ecosystem damage and coal transportation process, long-distance transport dust and coal storage from dust[2,3].

The ecological environment provides the space and carrier for human beings. Due to the backwardness of economic development and the lack of environmental awareness, energy output is often excessive development and use of energy in order to seek rapid economic growth in the short term, leading to serious waste of energy and environmental pollution. Because of the non-renewable characteristics of fossil fuels, extensive energy consumption behaviour will lead to energy depletion.
Adopting the global energy interconnection, promote the development and utilization of renewable energy, use renewable energy to replace a large number of fossil energy consumption, reduce large amounts of pollutants and greenhouse gas emissions, fossil energy development and utilization to avoid the consumption of water and other resources and other resources damage to ecosystems. The global energy interconnection, mainly consider energy and resource conservation, climate change, conventional pollutants emission reduction[4-6].

2. The relationship of energy transfer and ecological environment stress transfer

Figure 2. Sources of the Ecological Environment Stress of Energy Resource Export

Figure 2 showed, take one area as the energy production, energy production is the input direction, the receiving area is the energy consumption direction, the positive direction is the energy transfer direction, while the opposite is the ecological environmental stress direction. The model is the relation of energy transfer and ecological environmental stress[7].

Energy transfer, changing by the “power alternative”, becomes an important way to transfer the ecological environment pressure. Energy input and consumption, energy production areas, the use of local energy, improve energy efficiency, the extensive use of direct energy consumption into clean, convenient intensive power consumption.

Ecological environment pressure: The ecological environment pressure of one region is composed of two parts, one part comes from the local, and another part comes from the field. Local ecological stress refers to the destruction of the ecological environment caused by resource exploitation, production activities and pollutant discharge to meet local living, production and socio-economic activities. The input of ecological environment refers to the destruction of the local ecological environment caused by the activities of resource exploitation and production which are carried out locally to meet the needs of other regions.

Thus, to the energy production areas, the output of resources means the input the ecological environment of the pressure generated by damage. Considering the large amount of wind energy and solar energy in the energy production area, on the one hand, to solve the local environmental pressure, on the other hand, considering the minimum cost of wind power and photovoltaic power generation,
the two kinds of energy are bundled to solve the fossil energy substitution in energy production areas and environmental pressures in the energy consuming regions.

3. System dynamics model of energy spatial transfer

From the perspective of the interaction between regional development and energy transmission, the impact of energy transmission on energy output includes both background variables, such as economic development and environmental pollution, as well as energy policy planning. It is a complex process involving multiple levels. Only by building a scientific and targeted dynamic analysis model, can the relationship between the various variables in the system and the results of joint research conducted in-depth study. In the development model of global energy interconnection, the energy transfer model of energy transfer is identified as shown in the following figure.

![Dynamics model of energy spatial transfer](image)

Figure 3. Dynamics model of energy spatial transfer

Figure 3 shows that, from the cost system flow of the energy transfer, consider the energy transfer process relative economic parameters, energy parameters, efficiency parameters and environmental parameters. Analysing the causal relationship between model variables is the initial stage of the system dynamics model, and it is convenient to describe the system structure non-technically and macroscopically. In the process of establishing the causal relationship between the model variables, the development of energy transfer system can be the main line to determine the variables involved in the model.

The system dynamics model of energy transmission impacts includes the following variables:

1. Economic variable: GDP, the cost of energy transfer, the income of energy transfer, energy price, unit economic cost of energy transmission, rail transportation scale under different modes of transport.

2. Energy variable: energy quantity demand, energy transmission quantity, the ratio of energy transmission.

3. Efficiency variable: energy transmission efficiency, the energy loss ratio of transportation.

4. Environment variable: carbon emission, carbon emission coefficient, transportation energy environmental cost coefficient, environmental carrying factor.

In the casual loop graph, there are two main feedback loops:

The first loop 1, energy transmission growth—→ energy production income growth—→ economic level increasing—→ energy transport channel scale enlarge—→ energy transmission growth. This loop circuit is the positive loop, which is the energy transmission and economic development between the causal feedback mechanisms.

The second loop 2, energy transfer growth—→ carbon emission growth—→ environmental carrying capacity reduction—→ energy transfer loss. This loop is the opposite loop, which shows energy
transmission and ecological environment interaction mechanism, environmental constraints is to adjust the energy transmission mode of the important factors.

4. The parameters of energy spatial transfer
Considering the affection of energy demand of energy consumption, transmission of fossil energy and power are both declining year by year, while the power transmission volume is increasing year by year. Fossil energy production in energy-producing areas has been declining year by year, and the amount of clean energy power generation has been increasing year by year.

Under the basic scenario, every continent power supply and demand is self-balance, while under the green scenario, and consider every continent get power connection. The structure of the power source showed above showed in Table 1[8,9,10].

|                  | Basic scenario | Green scenario |
|------------------|----------------|---------------|
|                  | 2020           | 2030          | 2040          | 2050          | 2020          | 2030          | 2040          | 2050          |
| Coal             | 7.27           | 6.13          | 5.22          | 4.56          | 9.07          | 8.78          | 6.44          | 2.13          |
| Oil              | 0.87           | 0.36          | 0.15          | 0.15          | 0.73          | 0.21          | 0.00          | 0.00          |
| Gas              | 6.16           | 6.86          | 8.60          | 8.54          | 8.34          | 10.51         | 11.97         | 4.98          |
| Hydro            | 4.79           | 8.27          | 9.57          | 11.53         | 4.96          | 7.40          | 9.28          | 10.08         |
| Nuclear          | 3.14           | 3.12          | 3.36          | 3.85          | 3.14          | 2.62          | 2.26          | 2.10          |
| Wind             | 1.91           | 5.80          | 12.07         | 18.23         | 0.81          | 4.55          | 12.62         | 22.37         |
| Photovoltaic     | 1.86           | 4.22          | 7.10          | 11.12         | 0.30          | 2.50          | 7.00          | 16.72         |
| Heat             | 0.92           | 1.80          | 5.55          | 9.19          | 0.04          | 0.52          | 2.55          | 9.32          |
| Biomass          | 1.30           | 2.66          | 4.24          | 4.95          | 0.84          | 2.13          | 3.74          | 4.42          |
| Ocean            | 0.01           | 0.18          | 0.62          | 1.01          | 0.01          | 0.18          | 0.62          | 1.01          |
| Total            | 28.23          | 39.40         | 56.48         | 73.14         | 28.23         | 39.40         | 56.48         | 73.14         |

From the parameters above, can see that coal power transmission ratio is declining, while the wind and photovoltaic power transmission ratio is growing. So it shows that the coal transmission amount is declining significantly, while the power transmission amount will grow. The change is calculated by (green scenario – basic scenario)/basic scenario *100% showed in Figure 4.
To the energy transmission efficiency, the transmission efficiency of the two energy type is not very different. This is mainly due to coal transmission loss rate. Power transmission loss rate is basically the same, so change the proportion of coal and electricity transmission ratio will not affect the energy transmission efficiency. Figure 5 gives out the energy transmission rate, according to the Table 1, and used the same rate to predict the energy transmission rate connected with the energy exploitation.

![Figure 5: Energy transmission rate change](image)

To the perspective of carbon intensity, because of the increasing of power transmission, coal-fired power generation produces more carbon dioxide, so the carbon emission intensity of the second coal transportation is significantly higher than the electricity power transmission.

To the energy transmission cost, power transmission is more economical than coal transportation, but the energy transmission cost of the second energy transmission mode is higher because of the more serious environmental pollution caused by power transmission to the energy output, and the environmental cost is increased higher.

To the energy transmission income, the two energy transmission incomes are not much difference, but over time, the income gap gradually expanded.

To sum up, to reduce the transmission of fossil fuels such as coal, increase the amount of power transmission, energy output to improve energy transmission revenue, but energy transmission costs and carbon intensity will be increased accordingly. To the energy input, the input power is more cost-effective than the input of coal, but also greatly reduces the environmental pollution caused by thermal power generation. However, to the energy output, the coal-fired power generation will cause land use, water consumption, pollution, gas emissions and other issues, increased environmental pollution. Energy transfer of space should be borne by the energy input to the ecological and environmental problems transferred to the energy output.

5. Energy spatial transfer affection to the environment

5.1. Energy source saving

Energy spatial transfer can accelerate the development and utilization of renewable energy, alternative to traditional fossil fuels, fossil energy conservation development and utilization. Global interconnection can use more resource-rich areas of energy, out of the economically developed areas of their own energy supply constraints, saving fossil energy development and utilization. In some regions, economic development needs a lot of energy support, but is limited by local resources. Considering the ecological environment capacity, resource endowment, geographical traffic conditions and energy demand pattern, the energy spatial transfer will form a more scientific and rational energy distribution pattern. Some resource-rich areas, its energy transcontinental transport, can better protect the economic stability of the affluent areas.

Consider the global energy spatial transfer, with a large amount of development and utilization of renewable energy. According to the forecast, in the global energy interconnection to accelerate the development of scenarios, in 2050, non-fossil energy power generation will reach 66 trillion kilowatts,
an increase of nearly 60 trillion kilowatts, accounting for 90% of the total generating capacity. If use the WEO 2014 in the proportion of clean electricity, the 2050 global energy green scenarios, the clean energy electrical quantity will be 29 trillion kilowatts * hour. The equivalent carbon dioxide, sulfur dioxide, nitrogen oxides and soot emissions will reach 25 billion tons / year, 53.7 million tons / year, 56.4 million tons / year, and the annual output of carbon dioxide, Year, 9.4 million tons / year, saving water 70 billion tons / year.

5.2. Conventional pollutant emission reduction
Energy spatial transfer, changing the supply structure of resources in the two regions, the development and utilization of renewable energy alternative to a large number of fossil fuels, coal-fired power generation is no longer leading to improve the proportion of direct consumption of coal, direct impact on conventional pollutant emissions. Of the major pollutants in the atmosphere, about 80% of sulfur dioxide, 60% of nitrogen oxides, 50% of the fine particulate matter comes from coal combustion, while nearly half of the coal emissions from direct-fired coal, this unreasonable energy consumption structure and consumption patterns, serious damage to air quality. By optimizing the allocation of the global energy supply structure, can effectively reduce the conventional pollutant emissions. To the industrial SO$_2$, NO$_x$, the largest contributor to the total thermal power industry, accounts for 45%, 65%, 23%.

According to the development progress of the energy base, it is estimated that the electric power output scale of "one pole and one pole" of 2030, 2040 and 2050 will be 0.9 trillion, 4.2 trillion and 12 trillion kilowatt. If calculated by the same amount of coal equivalent power generation, can reduce the consumption of 300 million standard coal, 1.3 billion, 3.8 billion tons, equivalent to reduce carbon dioxide emissions by about 800 million, 3.7 billion, 10.5 billion tons / year. Reduce annual emissions of sulfur dioxide 1.8 million, 7.9 million, 22.3 million tons, reduce nitrogen oxide emissions 1.9 million, 8.3 million, 23.4 million tons, reduce soot emissions of about 300,000, 1.4 million, 3.9 million tons / year, save water use of about 20 billion, 100 billion, 29 billion cubic meter.

5.3. Affection to the climate change
Energy spatial transfer change the global power industry and energy industry development pattern, the development of clean energy development can reduce greenhouse gas emissions. The power industry in the energy conversion process emissions of carbon dioxide emissions, accounted for about 50% of the total global emissions of carbon dioxide, which is one of the key industries. As the global total installed capacity and the rapid growth of power generation, power sector energy consumption growth is the overall energy consumption and emissions growth of the main driving factors. However, with the rapid development of various clean energy technologies and the rapid maturation of new technologies, the future development of electricity will greatly affect the emission of greenhouse gases.

According to forecasts, relying on the global energy Interconnection, by 2050, clean energy can replace the equivalent of 24 billion tons of standard coal fossil energy, abatement of carbon dioxide 67 billion tons, sulfur dioxide 580 million tons. It is assumed that the global energy carbon emissions 11.5 billion tons, only 33% in 2013 and 2009, about 50%. According to the IPCC report, To achieve the "United Nations Framework Convention on Climate Change," proposed in 2050 will be the global average temperature increase within 2 °C in control "target, a fundamental solution to glacier melting, sustainable development.

The energy spatial transfer can realize the temperature control. Taking into account the "Paris agreement" clearly put the global temperature control within 2 °C target, while temperature control within 1.5 °C at effort ; as soon as possible to achieve greenhouse gas emissions peak, the second half of this century to achieve zero net greenhouse gas emissions. From 2011 to 2011, the case of clean energy spatial transfer development scenarios, the cumulative global emissions of greenhouse gas emissions of about 1.4 trillion tons; to reach the peak carbon emissions by 2020, about 55 billion tons of carbon dioxide equivalents; in 2060, energy and related industries will achieve net zero emissions.
6. Conclusion
This research gives the energy spatial transfer model of energy development layout to analyse the global energy development layout condition and ecological affection. And it is a fast and direct method to analyse its energy usage process and environmental affection. It gives out a system dynamics model of energy spatial transfer showed, which electric power transmission is better than original energy usage and transportation. The energy spatial transfer can affect the environment directly. Energy saving, climate changing and conventional pollutant emission reduction, synthetic combine with the spatial transfer model, it can get the environmental change parameters, which showed that with the clean energy wide usage, the ecological footprint affection will be affected significantly.

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