The Legal Adaptation of China's Wind Power Development— A Game Theory Analysis

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Abstract

Legal adaptation is considered a crucial part and one of the most effective tools of the global energy transition. The energy transition process promotes the rise of the renewable energy industry and brings a tremendous challenge to the law. How could or should the law adapt to the challenge of this global trend? This article examine this question through the case of Chinese wind energy development. China is one of the fastest-growing countries in the world for renewable energy. Although the large-scale development of wind energy started in 2000, China's wind power installed capacity reached 300 million kilowatts by 2021, and power generation accounted for about 7% of the country's total electricity consumption. This year's installed capacity of coal power is approximately 1 billion kilowatts, but its power generation accounted for 71.27% of the whole country. Two energy sources with three times the difference in installed capacity have ten times the difference in power generation. Why is China's electricity market so biased towards traditional energy? How did such large-scale wind curtailment in China occur? And what role should the law play in China's energy transition game to adapt and regulate the development of the electricity market and guide China's energy transition? This article will use game theory to analyze China's power pricing system and the operation of China's national electricity transmission grid, so as to explore how the law has and should adapt to China's renewable energy development under its unique power market system and power administrative management system, to minimize the rent-seeking behavior generated in power transmission and support the development of wind energy. This article will propose solutions to the problem of wind curtailment in China's energy transition from a legal adaptation perspective.

Résumé

L'adaptation juridique est considérée comme une part essentielle et l'un des outils les plus efficaces de la transition énergétique mondiale. Le processus de transition énergique encourage la montée de l'industrie des énergies renouvelables, et apporte un challenge immense pour le droit. Comment pourrait ou devrait s'adapter le droit au challenge de cette tendance mondiale ? Cet article examine la question à travers le cas du développement de l'énergie éolienne chinoise. La Chine est l'un des pays au monde où la croissance en matière d'énergies renouvelables est la plus rapide. Bien que le développement à grande échelle de l'énergie éolienne ait débuté en 2000, la puissance nominale de l'énergie éolienne chinoise a atteint 300 millions de kilowatts en 2021, et sa production d'énergie représentait environ 7% de la consommation d'électricité totale du pays. La puissance nominale de l'énergie charbonnière pour cette année était d'environ 1 milliard de kilowatts, mais représentait 71,27% de la production d'énergie du pays entier. Deux sources d'énergie séparées par trois fois la différence de puissance nominale mais dix fois la différence de production d'énergie. Pourquoi le marché de l'électricité chinois est-il si biaisé en faveur des énergies traditionnelles ? Comment une telle limitation de grande échelle de l'énergie éolienne en Chine se produit-elle ? Et quel devrait être le rôle du droit dans le jeu de la transition énergétique en Chine afin d'adapter et de réguler le développement du marché de l'électricité, et de guider la transition énergétique chinoise? Cet article utilisera la théorie des jeux pour analyser la politique tarifaire de l'énergie en Chine et le fonctionnement du réseau électrique national chinois, afin d'étudier la manière dont le droit s'est, et devrait, s'adapter au développement des énergies renouvelables en Chine, dans le cadre de son modèle de marché de l'énergie et de gestion administrative de l'énergie unique, pour minimiser les

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comportements de recherche de rentabilité dans la transmission d'énergie et soutenir le développement de l'énergie éolienne. Cet article proposera des solutions au problème de la limitation du recours à l'énergie éolienne dans la transition énergétique de la Chine à travers une perspective d'adaptation juridique.

Introduction

Climate change has become one of the important issues for human society in recent years. Energy transition, a critical mitigation solution, has been written into the laws in many states. Taking China as an example, to promote and encourage renewable energy development, China has promulgated three renewable energy-related laws and regulations since 2015,[1] which have determined two ways of subsidizing wind power –wind power farm construction subsidies and wind power price subsidies.[2] Driven by this series of laws and policies, China has become one of the fastest-growing countries in the world for investing in renewable energy. In 2021, China's wind power installed capacity reached 300 million kilowatts; of power generation and accounted for about 7% of the total electricity consumption.[3] However, China also experienced an extremely high level of wind curtailment.[4] Between 2010 and 2017, the national average wind curtailment rate reached 16 %.[5] Before 2018, Gansu Province and Hebei Province's (two provinces with very developed wind power) wind curtailment rates peaked at 35%.[6] Wind plants have to bid at zero CNY[7] to access the electricity market at most times of the year, otherwise, they will either obtain very low quotas to sell the power or be restricted, which could completely stop their power

[1] 2005 Renewable Energy Law of the People's Republic of China（**中华人民共和国可再生能源法**，2006 Renewable Energy Power Generation Price and Expense Apportionment Management Measures（**可再生能源发电价格和费用分摊管理办法** and 2006 Interim Measures for the Management of Special Funds for Renewable Energy Development（**可再生能源发展专项资金管理暂行办法**）.

[2] 2005 Renewable Energy Law of the People's Republic of China（**中华人民共和国可再生能源法**） (Renewable Energy Law).

[3] Huang Haiyan, "The National Wind Curtailment and Power Curtailment Have Further Deteriorated, And The Extreme Power Curtailment Ratio Has Reached 79% in China" (People Law, 9 May 2015) <http://energy.people.com.cn/n/2015/1109/c71661-27792417.html> accessed 1 April 2022.

[4] Wind curtailment refers to the phenomenon where some wind turbines in wind farms are suspended due to their own characteristics, such as insufficient capacity of the local power grid, mismatched construction period of wind farms, and unstable wind power.

[5] Zhu Mengye, "Wind curtailment in China and American experience" (Brooking, 4 April 2018) <https://www.brookings.edu/zh-cn/research/wind-curtailment-in-china-and-lessons-from-the-united-states-2/> accessed 1 April 2022.

[6] Xin Ke, <https://www.china5e.com/news/news-1053157-1.html> (Energy Report, 8 April 2014) accessed 1 August 2021.

[7] China's current electricity spot settlement system is a Pay as Bid system. Negative price quotations are not allowed, and the minimum quotation is 0 yuan. In the actual transaction, the trading institutions distribute the power generation load from low to high according to the quotation of the generator or generator, to balance the supply and demand in the system. The settlement will be made with the power plant according to the actual quotation within the agreed time.

generation.[8] This is not surprising as the energy transition process promotes the rise of the renewable energy industry and brings a tremendous challenge to the law. Legal adaptation is considered a crucial part and one of the most effective tools of the global energy transition.[9] This article will discuss how China's laws should adapt to the current social situation to deal with excessive wind power development and severe wind curtailment challenges. The first part presents the methodology; the second part will present the specific situation of wind power development in China; and the third part will use game theory to analyze the reasons for the excessive growth and wind curtailment. Through this game theory analysis, this article will present the conflict and games between China's administrative system and energy system and pave the way for legal adaptation. Earlier discussions will lead to how the law has and should adapt to China's renewable energy development under its power market system and power administrative management system. This article will propose solutions to the problem of wind curtailment in China's energy transition from a legal adaptation perspective, and potential examples to emulate for other countries.

Part 1. Methodology

This article will mainly use game theory and empirical analysis to argue that China's renewable energy development could benefit from legal adaptation.

Game theory studies the strategies of related parties in a game between multiple individuals or teams under specific conditions and implements complementary strategies.[10] In a society, the parties participating in the competition have different goals or interests.[11] To achieve their goals, each party must consider the opponent's possible action plans and choose the most beneficial or reasonable plan for themselves.[12] Through game theory, this article studies the interests and strategies of different players in China's wind power dilemma. In this way, it would propose how the law should regulate the key nodes of the power market to prevent excessive development and wild curtailment.

The empirical analysis methodology establishes and tests various theoretical propositions

[8] Zhu Zhongyi, "Research on the renewables curtailment in China" (2019 Energy Law Journal) <https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CAPJ&dbname=CAPJLAST&filename=DGJS20210803002&v=xNi65Yu5be7ruF%25mmd2BXCwBuH7PlxeE1q0mMzpI3Z49olQfHC5T9AllzkAn5ly0ezFq5> accessed 1 August 2021.
[9] Bruce A. McCarl, "Fairness in Adaptation to Climate Change" [2008] 40 AL 143–144.
[10] Ivana Barkovic Bojanic & Maja Eres, "Game Theory and Law" (2013) 29 Pravni Vjesnik 59.
[11] *Ibid.*
[12] Steven Tadelis, *Game Theory: An Introduction* (1st ed, Princeton University Press, 2013).

through observations and analysis of observable facts.[13] This article will adopt this method to analyze the reasons for the severe wind curtailment in China at different levels and provide solutions based on game theory and current laws and regulations.

Part 2. Status of Wind Power Development in China

In 2005, China promulgated the *Renewable Energy Law*, which promotes the leap-forward development of China's wind power industry.[14] This law regulates the responsibilities and obligations of the governments and other actors such as power plants and power transmission enterprises in developing and utilizing renewable energy. It establishes a series of systems, including the Renewable Target Policy System,[15] Feed-In Tariff[16] and Renewable Energy Fund System,[17] etc.[18]

In 2009, China promulgated an amendment to the *Renewable Energy Law*,[19] which clarified that the state guarantees implementing a complete purchase system for renewable energy power. The state finance department would establish a fund to support renewable energy development.[20] This law stipulates that power grid companies should purchase the total amount of on-grid electricity from renewable energy power generation projects to ensure the security of power supply.[21]

After this amendment, China promulgated the *First Measures for the Management of Special Funds for Renewable Energy Development*, the *Trial Measures for the Management of Renewable Energy Power*

[13] Cary Coglianese, "Empirical Analysis and Administrative Law" (2002) 2002 U Ill L Rev 1111.
[14] 2005 Renewable Energy Law of the People's Republic of China（中华人民共和国可再生能源法）(Renewable Energy Law).
[15] The Renewable Target Policy System means that the market share of renewable energy in energy consumption in a certain period must reach the specified target. This system enables the prescribed goals to be achieved on schedule by adopting mandatory policies and measures.
[16] The government power purchase system is a policy mechanism aimed at accelerating the widespread adoption of renewable energy. The government signs a 20-year long-term contract with an individual or company that uses renewable energy to generate electricity. During this period, the generator can earn a certain amount of subsidies for every kilowatt-hour of electricity it sends to the public grid, in addition to the original electricity price.
[17] That is, during the period from 2019 to 2033, special financial subsidies for the construction of renewable energy power stations will be given to different types of renewable energy and construction areas. For example, the reward standard for hydropower efficiency enhancement and capacity expansion is 700 yuan/kW in the eastern region of China, 1,000 yuan/kW in the central region, and 1,300 yuan/kW in the western region. The central financial incentive funds shall not exceed 50% of the total investment.
[18] (n 14).
[19] 2009 Renewable Energy Law of the People's Republic of China (Amendment) 中华人民共和国可再生能源法（修正案）.
[20] *Ibid.*
[21] *Ibid.* There are two power grid companies in China, and both are state-owned.

Generation Prices and Expenses[22] and other implementation rules. Coupled with the *Renewable Energy Law*, these regulations established a framework to regulate renewable energy, which has implemented comprehensive regulations on natural resources exploration, planning, research, investment, pricing, and wind energy taxation. More importantly, this framework clarified the governments and enterprises' responsibilities, rights, and obligations in wind development, encouraging various actors to participate in the development and utilization of wind energy. With the support of these laws and China's renewable energy policy, wind energy has become a hot investment industry capital leverage and policies are tilted towards wind power.[23] Since 2015, China's total installed wind power capacity growth rate has ranked first in the world.[24] But at the same time, wind curtailment has become a problem in China. In 2012, China's average wind curtailment rate was 17.12%, and the loss of electricity (because of the curtailment) reached 20.8 billion kWh. In 2015 and 2016, the average wind curtailment rate rose to 15% and 17.1%, respectively. Before 2018, Gansu Province's wind curtailment rates were over 37%.[25] China's wind power development problem is obvious. The growth of installed capacity has always been the first in the world, but the utilization rate of wind power is poor, resulting in a huge energy waste. Wind turbines are idle, and the income of wind power plants is worrying.

On the other hand, many new wind power plants are still being put into operation, resulting in excessive investment.[26] China's over-development of wind power and high levels of wind curtailment have become a significant challenge to China's decarbonisation path. This is an inevitable process in China's energy transition because wind power is highly volatile, and when and how much power can be generated cannot be accurately predicted.[27] Each city's power grid peaking capacity and transmission capacity are also different. The above parties need to carry out long-term coordination with national laws and policies to adopt wind energy development. Legal adaptation is one of the most effective ways to face this challenge and solve the wind curtailment problem in China.[28] Since legal adaptation should be based on the actual development of wind

[22] 2006 Renewable Energy Power Generation Price and Expense Apportionment Management Measures（可再生能源发电**价格和**费**用分**摊**管理**办**法**) and 2006 Interim Measures for the Management of Special Funds for Renewable Energy Development（可再生能源发**展**专项资**金管理**暂**行**办**法**）.

[23] Ma Haifeng, "A Brief History of China's Wind Power Industry in 35 Years" (2021) 1(1) CNKI <https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFDAUTO&filename=SLDL202205004&uniplatform=NZKPT&v=XLtp2qMcoWQJibef_G00Mk6buXX0Uj3jAhxWYfUcOxu-ISR3yhRYCLhKHn1ztrnN> accessed 27 July 2022.

[24] *Ibid.*

[25] Ke (n 6) 2.

[26] Ma (n 23) 14.

[27] Manwell, J.F., J.G. McGowan, and Anthony L. Rogers, *Wind Energy Explained Theory, Design and Application* (2nd ed. Chichester, U.K: Wiley, 2009) 25.

[28]Giorgio Zanarone, "Contract Adaptation under Legal Constraints" (2013) 29 J L Econ & Org 799.

power, figuring out the cause of China's wind power dilemma will be critical for the process to work. The next part of this article will focus on the analysis on the causes for wind curtailment.

Part 3. The Reasons for China's Wind Curtailment

There are various factors for large-scale wind curtailment in China, which can be summarized under three main categories: (1) local governments promote excessive construction of wind farms in order to increase fiscal revenue; (2) state-owned power generation enterprises invest in wind power to maintain the scale of enterprises and the competitiveness of their peers; and (3) China's power grid companies cannot meet the needs of wind power development. This part will focus on the local governments and why they recklessly encourage investing in wind power plants in the wind power construction game, resulting in excessive wind power construction and wind curtailment.

Local governments are the main driver of wind power development in China. In China, they are divided into four levels: provinces (municipalities, autonomous regions), cities (autonomous prefectures), counties, and townships (towns).[29] In addition, local governments in regions such as Hong Kong and Macau have been given more autonomy.[30] The local governments referred to in this article mainly refer to those in the first three levels.[31] The relationship between the central and local governments can be briefly summarized as having a high degree of economic decentralization and an extremely high degree of political centralization.[32] The central government directly affects local affairs by issuing orders or instructions. It also decides the promotion of local government officials according to their performance in implementing the central government's orders and policies and the growth of local GDP.[33] Local governments can also introduce policies consistent with the central government to manage related industries.[34] The local governments are under tremendous financial pressure thanks to China's fiscal decentralization system.[35] At the same time, the performance evaluation of government officials is dominated by regional GDP.[36] Therefore,

[29] Art 57 Constitution Law (China).
[30] Art 21 Constitution Law (China).
[31] Art 58 Constitution Law (China).
[32] Huang Wanhua, "Fiscal Decentralization, Political Promotion and Environmental Regulation Failure: An Analytical Framework of Political Economy" (2011) The Theory of Tribune, 4-6.
[33] *Ibid.*
[34] *Ibid.*
[35] Yin Weijie, 'An analysis of the rule of law in fiscal and taxation reform from the perspective of the merger of state and local tax agencies' (2018) 07 Development and Reform Theory and Practice <10.13814/j.cnki.scjjyjg.2018.07.015> accessed 1 May 2022.
[36] Sun Meixia, "The impact of the cancellation of GDP assessment by local governments on industrial transformation and upgrading ——Taking Fujian Province as an example" (2020) Northeast University Studies Research Paper 1/2020, <10.27006/d.cnki.gdbcu.2020.000264> accessed 18 May 2022.

local governments especially need subsidies and funds for wind power plants to stimulate the local economy and increase GDP. And there is a game of wind power development between the central and local governments in China.

A. Local Governments' Wind Development Choice

Since the implementation of the *Renewable Energy Law* in 2006, the installed capacity of wind power in China has increased significantly.[37] This growth is inseparable from the vigorous promotion of local governments. The local government uses the project approval power to develop their local wind energy infrastructure. In China, wind power projects of 50,000 kilowatts (kW) and above shall be approved by the National Development and Reform Commission (NDRC); projects smaller than 50,000 kW shall be approved by the provincial people's government and reported to the NDRC.[38] This threshold has led to a peculiar situation: local governments issued a large number of wind power licenses for wind farms, and most of the installed capacity is 49,500 kW.[39] These small wind power plants are built in large numbers over a short period of time, which directly leads to a substantial increase in the installed scale of local wind power.[40] In 2008, China's newly installed wind power capacity reached 6.154 million kW. Small wind power projects (smaller than 49,500 kW) accounted for 82% of this power.[41] These projects are inconvenient for grid planning and construction, making it difficult for wind farms to connect to the grid.[42] One of the most expensive parts in a power system is the power transmission construction (to build the power grid).[43] Therefore, power grid companies are more inclined to set up power grids in areas with dense and rich power resources to maximize the efficiency of the power grid. However, in the above situation, small wind farmers' priority is building within their jurisdictions per the local government licences, not being close to the primary electricity grid. Therefore, many small wind farms are far from the power grid, which is not conducive to the overall planning and accessibility of the power grid.

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[37] Ma (n 23) 15.
[38] 2011 Notice of the National Energy Administration on Issuing the Interim Measures for the Administration of Wind Power Development and Construction(风电开发建设管理暂行办法).
[39] Ma (n 23) 21.
[40] *Ibid.*
[41] Zhu Zhongyi, "Research on the renewables curtailment in China" (2019)1 Energy Law Journal <https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CAPJ&dbname=CAPJLAST&filename=DGJS20210803002&v=xNi65Yu5be7ruF%25mmd2BXCwBuH7PlxeE1q0mMzpI3Z49olQfHC5T9AllzkAn5ly0ezFq5> accessed 1 August 2021.
[42] *Ibid.*
[43] Ma (n 23) 15.

The local governments' choices are not difficult to understand. They provide strong support for small wind projects, mainly because of their own financial pressures. They must use less than 20% of their local revenue to maintain and pay for 80% of local affairs.[44] So, to develop their own economy, obtain more tax revenues and political capital, they must find ways to set up projects supported by national policies to get more central government financial allocations (such as special funds for wind power). At the same time, wind farm investment involves large equipment investment, bringing considerable value-added tax, business tax and other income to the local government. The wind farm investment cycle is short, but the GDP increase is enormous. Even if no actual on-grid electricity is generated, it will bring tax revenue to the local government. To ease the pressure on fiscal expenditure, local governments must expand tax sources, among which corporate income tax is one of their primary sources of fiscal revenue.[45]

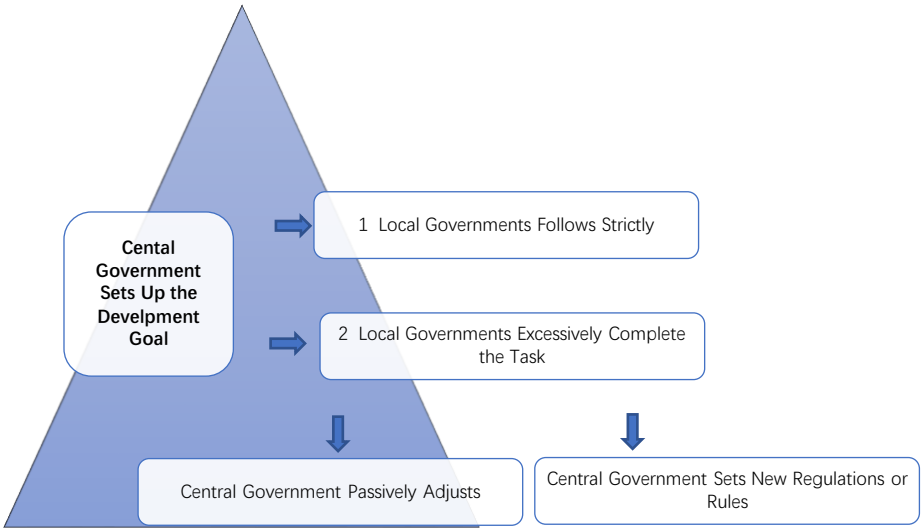
To sum up, the central government of China formulated a series of policies and laws for clean energy subsidies, hoping that all localities will develop wind power according to their goals and obey unified planning. In reality, the local governments chose to overfulfill their tasks to obtain more fiscal income. They regard wind power as a main industry that drives their tax revenue, and so strive to expand the scale of local wind power, and promote investment in wind farms and wind turbine equipment. In the end, the installed capacity of wind power production is expanding rapidly, but it has great difficulty in accessing the grid, which leads to wind curtailment. Both sides want to obtain their best interests under the existing rules. The central government is concerned about energy transition and carbon emission reduction, while local governments' first priority is to obtain enough fiscal revenue and seek to increase GDP and get promotions for their government officers. As a result, the two sides have formed a game in wind power development.

[44] Wu Guoguang, *China's Party Congress: Power, Legitimacy, and Institutional Manipulation* (1st ed, Cambridge University Press, 2017) 115.

[45] Li Shuo, "Research on the legal guarantee of the development of wind power industry behind the phenomenon of abandoning wind power in China" (2006) Xibei University Research Paper 1/2007, 8 <10.27408/d.cnki.gxmzc.2019.000057> accessed 18 May 2022.

B. Scenarios of Wind Power Development Goals Under the Game of Central and Local Governments

Introduction and Basic Assumptions of the Game between Central and Local Governments



Generally speaking, in the game process, the central and local governments follow the below assumptions:

1. The central and local governments adopt rational behaviors to maximize interests;
2. While there are many local governments, the behaviors of the local governments are the same, the scale of the local governments is the same, and the benefits of the central government are the simple sum of the benefits of the local governments.
3. The choice of the central and local governments conforms to a single rule: when the benefits matrix remains unchanged, the choices of the central and local governments in each round of the game remain unchanged.
4. When local governments "strictly implement" the goals set up by the central government, there will be no social costs, while "excessive completion" will incur social costs, including management costs, technical costs, opportunity costs, and environmental costs.
5. This game process is a complete information game; that is, it is assumed that both the central government and the local government have all the accurate information about the other party's characteristics, strategies and benefits functions.

C. Central and Local Government Game Process in the Wind Development

There are two rounds in the central-local government game in wind development. In the first round, the central government proposes a wind power development goal, and local governments can choose "strict implementation" or "excessive completion" based on their best interests. In terms of cost, if the local governments "strictly implement" the goal, in addition to the investment cost of wind power, they also need to bear the time cost of waiting for the wind power project to generate enough benefits to support their local government officers' promotions. Therefore, the utility function of the local government's "strict implementation" target is:

$$u_1(A, r, C) = Ae^{-rt}(1+r)^{n-1} - (C + C_t)$$

A is the current wind power investment amount, set as a fixed value; r is the interest rate; C is the current wind power investment cost; C_t is the time cost; u_1 is the benefit of local governments strictly enforcing central wind power targets.

If the local governments choose "excessive completion", their income will increase part of the income (ΔT) based on the previous function, and the cost of paying will increase the excess investment cost (ΔC), but there will be no time cost. In this scenario, the utility function of the local government is: (u_2 is the benefit of the local government over-fulfilling the central wind power target)

$$u_2(A, r, C) = [Ae^{-rt}(1+r)^{n-1} + \Delta T] - (C + \Delta C)$$

After the central government proposes the goal, the local governments will compare the net benefits of "strict implementation" and "over-fulfillment", and then choose the favorable course of action. That is, if $u_1 > u_2$, they will choose "strict execution", otherwise, they will choose to over-complete.

Comparing the two functions gives the following situation:

1. If ΔC > Ct + ΔT, the local government will choose "strict implementation", that is, when the local government's cost of "excessive completion" of the target of wind power investment is greater than the time cost of "strict implementation" + potential income increase, the local government will choose to strictly implement the target.
2. If ΔC − ΔT < tC, the local government will choose "excessive completion." This includes

two situations: one is when $\Delta C - \Delta T < 0$, that is, when $\Delta C < \Delta T$, the local government will choose "over-completion" if the revenue growth obtained by increasing the current wind power investment is greater than the cost it pays. The second is when $0 < \Delta C - \Delta T < Ct$, that is, although the increased investment cost of wind power by the local government is higher than its revenue growth, the difference is less than the time cost of "strict implementation" of the target, the local government will also choose "over-completion."

In this round of the game, if the local governments choose "strict implementation" of the target, the central government can choose to "actively adjust" or "not to adjust" the target. In either case, there will be no social cost. This article assumes that this situation will not affect the wind power industry. To analyze the impact of the local government's opportunistic behaviour on the wind power development goals, the following analysis will focus on the situation when the local government chooses "over-completion" as the goal.

In the second round of the game, the central government examines its benefits based on the local government's choice, which is equal to the local government's revenue from developing wind power minus the social cost that the central government has to bear. If the local government "strictly implements" the goal, the utility function for the central government is: (the central government does not have to pay time costs for waiting for promotion):

$$U_1(A, r, C) = N[Ae^{-rt}(1+r)^{n-1} - C]$$

If the local governments "over-complete" the target, the utility function of the central government is:

$$U_2(A, r, C) = N\{[Ae^{-rt}(1+r)^{n-1} + \Delta T] - (C + \Delta C)\} - S_c$$

At this time, the central government needs to bear the social cost of local governments not developing wind power as planned.

When the local government "strictly implements" the target, the central government can choose the "not to adjust" target, and the "actively adjust" the target; if the choice is "not to adjust", the game is over. Suppose the central government "actively adjusts" the goal according to the single behaviour rule. In that case, the local government will choose "strict implementation" in the next phase so that China can solve the excessive wind power construction problem without conflict.

If the local governments "over-complete" the target, the central government can choose to punish the local government and "passively adjust" the target by measuring its benefits. If the punitive measures changed the local governments' income in this game and made them "strictly implement" the target, the game will end, and the wind power target formulation will enter the standard track. If the target is "passively adjusted", the wind power target will significantly increase. When the social cost caused by the rapid target increase changes the benefits of the central government, the central government will choose to "take measures" to punish the local government and make the wind power target. The formulation tends to be reasonable, and the game is over. If the central government "passively adjusts" the target, China's wind power construction target will significantly increase. When the social cost brought by the substantial increase in this target reduces the central government's benefit, the central government will choose to take measures to punish the local governments and make wind power goal setting more reasonable, and the game is over.

In the game process, the central government can use two methods to restrict local governments: increasing u_1 or decreasing u_2, so that they will no longer over-build wind power. (u_1 is the benefit of local governments strictly enforcing central wind power targets; u_2 is the benefit of the local government over-fulfilling the central wind power target).

To increase u_1, the central government can increase the benefits of local governments' "strict enforcement" of wind power targets and reduce the costs of doing so. These can include tax rebates and financial subsidies. In this way, after making up for the time cost of the latter, the subsidy benefit is still more significant than the net benefit ($\Delta T - \Delta C$) that the local government may obtain by "over-fulfilling" the target. Therefore, the local governments will prefer to choose to "strictly implementing" the target.

To lower u_2, the central government can reduce the benefits of local governments for "over-fulfilling" wind power targets, by increasing the probability of detection and the magnitude of punishment of their opportunistic behaviour. This can be done through tax penalties and levy pollution taxes, with associated enforcement. These methods can reduce the net benefit of local governments from the over-development of wind power so that the sum of the net benefit and the time cost saved by the local government for "over-fulfilling" the target is less than the penalty imposed by the central government.

To conclude, the local governments are the main drivers behind China's excessive wind power development. They are so keen to build wind power plants because they need to gain an edge in their respective games to earn more economic revenue and political capital. Through the above game theory analysis, the central government needs to adjust the net income of the local government's "strictly implementing" and "over-fulfilling" their wind power goals to reduce over-construction behaviours.

Part 4. How Should China's Current Laws Adapt to the Central-Local Government Game in Wind Power Development?

The factors behind China's large-scale wind curtailment are multiple; local governments are one of the main drivers, motivated to gain more financial support in the game with the central government and accumulate promotion costs for local officials. Limiting the over-construction of wind power can be achieved by adjusting the net income (u_1 and u_2) of the local government's "strict implementation" and "over-completion" behaviours. From the current situation, legal adaptation is one of the most important and feasible ways to adjust these two values. Because the games between central and local governments will exist for the long-term, the wind power development and energy transition suggest a need for intervention. The actions of local governments are governed by laws that operate in a complex web of interrelationships.[46] In such a web, efforts to correct or alter societal problems must operate through law and must complement the system within which the law resides.[47] This suggests that the legal system itself is a good vantage point from which to view the challenges that energy transition may bring and perhaps is the primary tool to adapt to those changes.[48] In China, this tool is especially significant. To bridge the contradiction between the excessive development and the difficulty of connecting all this new wind power to the power grid, China's legal system must balance and coordinate the interests of all players flexibly,[49] so that all parties in the wind power game can make the best choices to regulate wind power development. The question is, how should the Chinese legal system adapt to this situation?

Due to the energy transition situation in China, this article suggests that legal adaptation for

[46] Victor B. Flatt, "Adapting Laws for a Changing World: A Systemic Approach to Climate Change Adaptation" (2012) 64 Fla L Rev 269.
[47] Joseph Wenta, Jan McDonald & Jeffrey S. McGee, "Enhancing Resilience and Justice in Climate Adaptation Laws" (2019) 8 TEL 89.
[48] *Ibid.*
[49] Mi Wei, "Adaptive Analysis of Law" (2012) Southwest University of Political Science and Law Research Paper 246.

the wind power overbuild and the wind curtailment problem should mainly focus on two aspects. Firstly, starting from the *Renewable Energy Law* and its related regulations, formulate and set more reasonable goals and punish excessive wind power construction. Secondly, in the context of decarbonisation, China's administrative regulations should improve the assessment standard of local governments and include the actual emission reduction amount into the assessment system.

A. Legal Adaptation - A Renewable Energy Law Perspective

From an energy law perspective, China's legal adaptation to wind curtailment should focus on two aspects. Firstly, adjust and reduce the local governments' net income from excessive development of wind power, that is, to increase the cost of excessive wind power development and reduce the income or potential income from any excessive wind development.[50] Secondly, increase the local governments' net benefit from strict central wind power plan implementation.[51] In general, the following legal adaptations could be taken.

Firstly, China's energy laws should assist China in realizing the total wind power target control, which needs to start with establishing a total target system and an evaluation feedback mechanism. The laws supporting wind power development in China mainly include the Renewable Energy Law,[52] the Electricity Law, the Energy Conservation Law,[53] and the Meteorological Law.[54] The Renewable Energy Law specifically stipulates the purpose, principles, planning, regulatory system and legal responsibilities of renewable energy development and utilization.[55] However, all of these clauses are based on principles, and no corresponding judicial interpretation has ever been issued.[56] Therefore, the Renewable Energy Law cannot address specific problems encountered in the energy transition, such as wind curtailment and excessive wind construction. It also has no role in restraining the local governments from over-building wind energy. Therefore, the legal adaptation of energy law should start by formulating specific and feasible development goals.

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[50] Mi (n 49) 7.
[51] Mi (n 49) 24.
[52] 2005 Renewable Energy Law of the People's Republic of China (n 2).
[53] 2002 Electricity Law of the People's Republic of China (中华人民共和国电力法) and 2007 Measures of the People's Republic of China for the Administration of electricity Retail（中华人民共和国电力零售管理办法）.
[54] 1999 Meteorological Law of the People's Republic of China (中华人民共和国气象法).
[55] 2005 Renewable Energy Law of the People's Republic of China (n 2).
[56] Zhang Yi & Zhang Yang, "Renewable energy access and transmission system planning practices in North American power systems" <https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFD2011&filename=DLJJ201108000&v=MlB%25mmd2BkiU6sR%25mmd2B%25mmd2F1le7VgJwtr9f%25mmd2F7zpT%25mmd2Fd0HE9ks%25mmd2FPyh1ODLKelKRhLu765kYvpVGgv> accessed 20 May 2022.

The Renewable Energy Target Policy (RETP) is an important system to promote renewable energy development, which means that the market share of renewable energy in energy consumption in a certain period must reach the specified target. This system, through the mandatory policies and measures of the central government, gives the market a clear signal, explaining what the state supports, encourages, and restricts, and when, which can play a role in guiding the direction of investment. The total target system needs mandatory legislative support. The national medium and long-term renewable energy development strategic goals are incorporated into the legal framework to provide a strong guarantee for one or several types of green energy, providing solid security for the entire renewable energy industry.

The RETP has never appeared in the energy laws and regulations in China. Some scholars believe that this is mainly due to technical or administrative problems because the NDRC and the Energy Administration often propose China's general wind power goals.[57] In fact, these two agencies cannot use the data they hold for sharing, coordination, or goal-sharing to regulate the local governments and State Owned Enterprises (SOE).[58] This is where the law needs to be adapted. China's energy law should set up a total target system and make mandatory regulations on the total development volume of renewable energy and the entire development volume of different renewable energy within a certain period. The provisions should practice due diligence, be specific, and work province-by-province. Because the law needs to be clear to be enforceable,[59] through this total target system, the central government can draw a red line for local governments whilst allowing them to invest and build wind power within reasonable limits, rather than treating wind power as a tool for increasing local income and political capital.

The premise of establishing the total target system is to have a suitable evaluation mechanism and agency. The NDRC and the Energy Administration formulate China's current wind energy development goals; these two departments need to establish a suitable mechanism to develop the total amount target of wind power development and realise the sustainable development of wind power. This mechanism should include a feedback mechanism on electricity consumption and wind curtailment[60] because incorporating this information into the next total target can assist the

[57] Yu Weizhen, "Legal analysis of wind curtailment in China's wind power industry" Energy and Economy, Vol 44 No 12, 2019.
[58] 1997 Regulations of the State Council on the Administration of the Establishment and Compilation of Administrative Organizations (国务院行政机构设置和编制管理条例).
[59] "Comparative Legal Philosophy" (1912-1913) 26 Harv L Rev 383.
[60] Zhao Zhonglong, *A Research of Renewable Energy Law and Its Governance Mechanism*, (1st ed, Beijing Intellectual Property Press, 2018) 12.

central government in planning the optimal development of wind power. Through the laws and regulations related to the Energy Law, China can establish an energy evaluation and feedback mechanism and empower the NDRC and the Energy Administration to control the total amount of wind energy and reduce excessive construction and wind curtailment.

According to the game analysis earlier, China's local governments' impulse to invest in wind power stems from their benefit matrix.[61] Therefore, the energy law should take measures to change this matrix, such as upgrading subsidy plans. On the other hand, by levying penalties, the central government can reduce the income level of local governments' excessive and impulsive development of wind power. The central government may require local governments to provide more detailed and comprehensive wind power development plans, and have objective and comprehensive information on local wind power resources, power grid construction, local industrial layout, electricity load, etc.[62] Suppose the targets proposed by local governments are unrealistic. In that case, the central government will eliminate subsidies and require local governments to surrender renewable energy development funds to reduce the income of excessive local development of wind power. Conversely, policy support and tax subsidies should be provided to local governments who practice careful planning, orderly development, and deploy technology to increase local governments' income from the appropriate development of wind power.[63] Through the above measures, China will significantly increase the actual utilisation rate of wind power and reduce the waste of resources caused by idle wind turbines.

B. Legal Adaptation - An Administrative Law Perspective

The second argument of this part is the case for control of the excessive development of wind power in China through administrative regulations. It does not sound straightforward, but it would be effective in China. Due to the complexity of the social relations dealt with by law, any law cannot have only a single social function.[64] It must integrate many different roles to regulate complex social problems effectively. However, in solving a specific issue, societies may not require all law functions to work simultaneously.[65] Therefore, to be able to choose the function of each

[61] Tadelis (n 12) 100.
[62] Flatt (n 46) 261.
[63] *Ibid.*
[64] Zhou Shaohua, "Adaptability: Legal Propositions in Changing Societies" (2006) Dongnan University Law Research Paper 2013. <https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFD2010&filename=SFAS201006012&uniplatform=NZKPT&v=pLFrWPOlt3wQe2TLJ_IJvWIf_moG-ARYk6fuItbPoBh7kcsVVm9WAhQY96G9sxPj> accessed 20 May 2022.
[65] H.L.A. Hart, *The Concept of Law* (1st ed, Oxford University Press, 1976).

law, the legal system needs to balance certainty and flexibility, stability and development.[66] Legal adaptation is a derivative of flexibility. In the common law system, predictability and stability are provided by legal rules developed by case law and by the principle of precedent.[67] In China, a country with a civil law system, predictability and stability are guaranteed by written rules, while flexibility and development are achieved by legal adaptation.[68] In a way, the beauty of legal adaptation is that it allows the law to play a unique role in different aspects of society.

To solve the wind curtailment problem in China, administrative regulations can play a pivotal role by changing how the local governments are evaluated. China's administrative legislation needs to support and regulate wind energy construction and take the actual emission reduction as the evaluation criterion for local government and local officials.

China's current administrative system is the most critical indicator in the central government's assessment of local governments and local government officials in local GDP.[69] Wind power is a significant investment. Suppose the scale of the industry can be rapidly expanded. In that case, it will not only bring about an increase in economic scale, but also bring considerable tax revenue, thereby stimulating the growth of local GDP.[70] Therefore, in this performance appraisal mechanism, the local government eagerly pursues the development of wind power installed capacity and has less consideration for the emission reduction side of economic growth.

The adaptation and change of the relevant government and government officials' assessment mechanism in the administrative laws and regulations is essential to the success of energy transition. For more than 20 years, the Chinese government has been accustomed to the assessment mechanism focusing on the total economic volume,[71] which has contributed to the over-construction and curtailment of wind power to some extent.[72] As long as there is large-scale project construction, GDP growth can be boosted in the short term despite long-term failure. China's administrative law needs to establish a performance appraisal system based on the scale of renewable power cumulative installed capacity, on-grid installed capacity, and downstream power

[66] *Ibid* 60.
[67] Edgar Bodenheimer, *Jurisprudence: The Philosophy and Method of the Law* (Rev. ed, Harvard University Press, 1974).
[68] *Ibid.*
[69] He Jianfeng, 'Research on the government's differentiated performance appraisal system from the perspective of two mountains theory' (2006) Zhejiang University of Technology Research Paper 1/2007, 8 <http://10.27463/d.cnki.gzgyu.2020.000096> accessed 20 May 2022.
[70] *Ibid.*
[71] Yu (n 57).
[72] Ju Ge, Shasha Luo & Chen Chen, "Research on ancillary service management mechanism in the smart grid" Wuhan: IEEE Power Engineering and Automation Conference, 2011: 429-432.

consumption, and upgrade the current mechanism that simply uses wind power installed capacity as the assessment indicator.

In fact, the Chinese government has piloted a new assessment mechanism, the general ecological product (GEP)[73] in Guangdong,[74] which should be rolled out nationwide. The GEP assessment mechanism's principle is that energy projects' performance is based on the amount of emission reduction and cumulative installed capacity, rather than the installed capacity of renewable energy. By upgrading the evaluation mechanism, Guangdong has dramatically reduced the curtailment rate of offshore wind power.[75] Suppose the central government could also adopt this method, to change the assessment criteria for local governments and government officials in the administrative regulations. In that case, legal adaptation will ensure that local governments make reasonable investments in wind power and prioritise promoting renewable energy consumption, rather than overbuilding. According to the inferences in the game theory model in the previous part, this legal adaptation can significantly reduce the local government's net benefit of "over completion" (u_2) and increase the benefit of "strict implementation" (u_1), which is one of the most effective measures to change the current over-construction situation and curtailment of wind power. Through this measure, China's local governments will no longer encourage excessive investment in wind power, thereby reducing wind curtailment and achieving sustainable development.[76] Wind farms that have been idle before will also find ways to build energy storage facilities or introduce large power-consuming enterprises such as data storage centres to consume previously excess electricity. In this way, the wind curtailment problem caused by the previous excessive development can be partially solved.

Conclusion

As decarbonisation has become a global trend, legal adaptation is an effective tool to help states realise their energy transition.[77] Because there is no one size for all solution for all countries, the energy transition processes in countries have brought tremendous challenges to the law. And those challenges are varied. This article focused on China's wind energy development laws, and games between the central government and local governments, arguing that the legal framework

[73] Shenzen Local Government, "深圳发布全球首个GEP核算制度体系" <http://www.sz.gov.cn/cn/xxgk/zfxxgj/zwdt/content/post_8645955.html> accessed 20 May 2022.
[74] Guangdong is the most powerful province in southern China in terms of economic development and is at the forefront of China's economic reforms. Many meaningful reform measures have been proposed.
[75] Ma (n 23) 22.
[76] Yu (n 57) 12.
[77] McCarl (n 9) 144.

of decarbonisation in China could be improved by flexibility or adoption under the current gaming situation.

China's renewable energy installed capacity growth ranks first in the world,[78] but China's carbon emissions have not decreased significantly, and the utilisation rate of wind power is lower than other countries. One of the reasons for this is Chinese local governments' over-exploitation of wind power for their own gains. By continuously increasing the installed capacity of wind power, local governments can obtain more financial subsidies and taxes, boosting regional GDP and political influence.

Through the game theory analysis of the behaviour of the central and local governments in the development of wind power, this article argues that by adjusting the net benefit that local governments obtain from "strict implementation" and "over-fulfilling" the wind power targets set by the central government, China's central government can slow down excessive wind power development and reduce wind curtailment. And one of the most important and feasible ways to adjust these two variables is legal adaptation.

Legal adaptation is a valuable tool to adjust and balance the energy transition. It can adjust the legal framework related to wind power through administrative law and energy law to limit the excessive development of wind power by local governments, such as punitive fiscal regulations and changing the evaluation and promotion standards for local government officials and SOE managers, to eliminate the improper intervention of the local government on the power generation enterprises and prevent over-exploitation and the resulting levels of wind curtailment.

Compared to the laws that address mitigation, legal adaptations focused on environmental change may be more complicated.[79] When the law moves beyond analysis requirements to actual environmental regulation and natural resource management, it will find itself in a complex and variable world. In this world, there are political games and commercial considerations. Therefore, as a tool for managing social interests, how a law ought to make changes, adapt and manage becomes particularly important. It needs to incorporate a far more flexible view of the natural world, because in China's 2060 carbon neutrality scenario, the regulatory objectives and objects to

[78] Economic Daily, "the world's largest installed capacity for 12 consecutive years, how much potential does China's wind power have?" (Economic Daily, 1 May 2019) <https://news.cctv.com/2021/12/05/ARTI0dIrJp3F60vCTYVQ0MnN211205.shtml> accessed 20 May 2022.
[79] Jedediah Purdy, "Our Place in the World: A New Relationship for Environmental Ethics and Law" (2013) 62 Duke LJ 857.

be protected by wind energy legislation will change with the times and technology,[80] and the law must adapt to this through its own improvement, which is the essence of legal adaptation. This article provides suggestions on how China's laws should improve and adapt to the long-term development of decarbonisation policies and reduce wind curtailment at the current time point. It will also provide a reference for the legal adaptation of the energy transition in other countries.

[80] Zhou (n 64) 7.