Table 3: Correlation coefficient (r) among various studied parameters of Machna River Water During May.2020 to Apr.2021

	Temp	Tur	pH	Ele. Cond.	Ca - H	Mg - H	TH	TA	TDS	DO	BOD	COD	Cl ⁻	No ₃ ³⁻
Temp	1.00													
Tur	0.39	1.00												
pH	- 0.47	- 0.78	1.00											
Ele. Con.	- 0.30	- 0.88	0.94	1.00										
Ca - H	- 0.47	- 0.98	0.86	0.89	1.00									
Mg - H	- 0.62	- 0.80	0.98	0.92	0.87	1.00								
TH	- 0.63	- 0.71	0.98	0.86	0.82	0.99	1.00							
TA	- 0.62	- 0.77	0.98	0.90	0.85	1.00	1.00	1.00						
TDS	- 0.53	- 0.70	0.96	0.82	0.83	0.93	0.96	0.95	1.00					
DO	- 0.16	- 0.88	0.83	0.97	0.84	0.81	0.72	0.78	0.66	1.00				
BOD	0.11	- 0.83	0.59	0.83	0.73	0.55	0.43	0.51	0.40	0.93	1.00			
COD	- 0.03	- 0.88	0.78	0.94	0.83	0.74	0.65	0.70	0.62	0.99	0.96	1.00		
Cl ⁻	- 0.14	- 0.78	0.93	0.96	0.82	0.86	0.84	0.86	0.84	0.92	0.78	0.92	1.00	
No ₃ ³⁻	- 0.68	- 0.66	0.95	0.82	0.77	0.97	1.00	0.99	0.95	0.67	0.36	0.58	0.79	1.00

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Energy Legislation and Economic Transformation: The Case of the British Industrial Revolution

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Abstract: *The industrial revolution first occurred in Britain and was inextricably linked to its energy transformation. The land tenure system, the regulations of coal property rights and their changes have strongly contributed to the realization of this transformation. Therefore, based on the historical reflection on the origin of the industrial revolution, energy legislation should establish the primacy of energy transformation, gradually improve the institutional design of new energy, break the path dependence, promote energy innovation, and finally complete the historical task of economic transformation by structuring power and market with a dualistic view.*

Keywords: Energy legislation, Economic transformation, Industrial revolution.

1. Introduction

Why did the Industrial Revolution take place in England, but not in China? Since the “Needham Mystery” was proposed in the 20th century, it has been the focus of heated discussion at home and abroad, and has been interpreted in different ways by economics, history, sociology and even philosophy of science and technology[1]. However, some recent studies have returned the focus of the Industrial Revolution to energy, arguing that the fundamental change in energy use is the crucial reason why the Industrial Revolution first appeared in the UK[2-5].

Throughout human history, the Industrial Revolution was an economic transformation of extraordinary significance[6]. And now China is undergoing a similar change, the success of which has a bearing not only on the peaceful rise of China in the 21st century, but also on whether it can successfully enter a new stage of its development history. Thus, according to the above, if the role played by energy transformation in the industrial revolution is crucial, then examining how this change took place becomes a crucial point of decisive importance. The purpose of this paper is to focus on energy law policy, to analyze what role it played in the energy transformation that led to the industrial revolution in the UK, and to reflect on the importance of China's current energy legislation in promoting economic transformation.

2. The Role of Energy Transformation in Triggering the British Industrial Revolution

Before the Industrial Revolution, Britain, like the rest of the world, used firewood as its basic fuel[7]. Although coal reserves were abundant throughout England, with numerous coal fields in England, Wales and Scotland[8], no real coal industry was formed in England until 1700[9]. This is because on the one hand, the smell and smoke produced by burning coal was unacceptable to people at that time, and in the 14th century, King Edward I had issued a decree forbidding people to use coal as fuel, and violators were heavily punished[10]. On the other hand, and more importantly, the cost of coal was generally higher compared to charcoal[11].

However, as the population and economy grew, Britain faced increasing fuel scarcity, particularly in the wool industry, which required larger pastures, in the shipbuilding industry, which required more wood, and in the steel industry, which was fueled by charcoal. It caused Britain's forests to decline sharply, and by the end of the 18th century its forest cover was only 5%-10%[12]. As the British economic historian Clapham has appropriately claimed, on the eve of the railroad era, Britain was already a forest-free country. And coal, as an alternative energy that had to be accepted, entered the British energy stage. In the ten years from 1550 to 1560, the British coal production was only 210,000 tons, and in the ten years from 1680 to 1690, the output increased to 2.982 million tons, which is 14 times that of the former[13]. By 1700 coal production in England had reached 2.5 to 3 million tons, more than 30 times the production of France, and it is estimated that this production was even five times the combined coal production of the entire rest of the world at that time[14].

It goes without saying that “for many parts of this country, the 17th century was a period of energy crisis”[15]. Since the forests were dying, an alternative energy source had to be found, so it was inevitable that the energy crisis triggered the British Industrial Revolution. Of course, the use of coal as an alternative energy source is purely accidental and not the result of human design. As the French historian Braudel pointed out when he explained the Industrial Revolution, “The decisive and purely British feature of this revolution was the increasing use of coal, and coal burning became the main feature of the British economy. The choice was made because coal made up for a glaring weakness in Britain.”[16]

However, the massive use of coal prompted Britain to start corresponding technological innovations, and the steam engine was first applied in the process of pumping water from mines, which accelerated the amount of coal mined[17]. Secondly, the invention and improvement of the Coke ironmaking method successfully solved the problem of pig iron being easily broken and not processed by the sulfides released during coal combustion, thus enabling coal to be widely used in the steel industry[18]. As a result, coal, iron and steel and steam engines together formed the most epochal character of the Industrial Revolution.

In short, the industrial revolution is an epoch-making process of mankind's transformation from organic to inorganic energy. The British historian Ridgely argued that while "other sources of energy could temporarily free mankind from the constraints of the organic economy, coal offered the prospect of a long-lasting, at least on the time scale of human history, solution to the constraints of the organic economy". Therefore, this "energy-intensive economy based on mineral energy is a new type of economy in development. In this economy, inorganic raw materials are of great importance. In England in the 17th and 18th centuries, a new and completely different economy was slowly taking shape in the midst of the transition to an organic economy"[19]. Therefore, it is reasonable to believe that it was the energy transformation in Britain that triggered the Industrial Revolution, and it was the massive use of coal that enabled Britain to complete an economic transformation of modern significance[20-24]. The English philosopher Whitehead said with emotion about this process, "The progress of civilization is not exactly like a giant stream that rushes forward and gets better every day. If we look at the whole history of mankind, which stretches over tens of thousands of years, the emergence of new ages is often quite sudden. Silent peoples sometimes suddenly appear in the mainstream of things; technological discoveries can change the conditions of human life."[25].

3. Energy Legislation Triggered by Energy Transformation in the Industrial Revolution

There is no denying that the law has played a crucial role in driving and facilitating energy transformation in the UK. However, the process has not been a smooth one, and it has gone through a process from prohibition of coal to free mining.

3.1 Expiration of the Coal Ban

The French economic historian Mantou, speaking of the Industrial Revolution in England, has pointed out that "what seeks to prevent or delay this change is not only a multitude of vested interests and old-fashioned forces, but also whole traditions and habits established by habit, and a set of systems recognized by law"[26]. This shows that there is always one way or another resistance to social change, and the Industrial Revolution is no exception, especially from institutional obstacles and delays, as evidenced by the coal ban before the Industrial Revolution.

Legislation banning the use of coal dates back as far as the reign of Edward I. Beginning in 1285, the King set up a number of commissions in London to address the problem of soot, which was complained to be "polluting and corrupting" the air. In 1306, because blacksmiths, brewers, and others who needed hard fuel burned too much coal and caused widespread public protest, the government issued a decree banning coal burning, imposing heavy fines on those who burned it, and destroying their furnaces[27].

History has indeed shown that the use of coal in England declined steeply in the 14th and 15th centuries. Of course, the ban on coal did have some effect, but more than that, the plague (Black Death) that ravaged Europe repeatedly decimated England's population, leaving only 3 million

inhabitants in the 15th century, about half the population before the plague[18]. This allowed England's forests to provide enough fuel without the use of "dirty and smelly" coal.

However, after the succession of Queen Elizabeth I in 1558, the population and economy of England began to emerge from the post-plague doldrums. Shipbuilding and wool spinning became the most important pillar industries before industry in the UK. The expansion of pastures and the logging of timber caused forests to gradually disappear. In order to avoid the shortage of timber and maintain the economic security of the UK, the Queen has introduced a series of laws to limit the logging of timber and impose heavy penalties on those who steal forest trees. As a result, population growth, economic development, and consequent fuel shortages made the coal ban a dead letter[29]. Although Elizabeth herself was extremely reluctant to accept coal, the United Kingdom had to face the reality of an "energy crisis", and coal gradually became the most important source of fuel for the United Kingdom[30].

3.2 Legislation on Free Coal Mining

3.2.1 Coal ownership and mining rights provisions

In 1066 William, Duke of Norman, who conquered England, emphasized that the king was the sole and final owner of all lands[31], and immediately established a unique English land tenure system in which all but the king had only the right to possession and use of land but not ownership. After that, in order to better understand the land servitude, he started a detailed land survey in England, and in 1086 he completed the Domesday Book (known as the Land Servitude Survey Book after the 12th century), in which he recorded everything of economic value, land, woods and even cattle and sheep, including the mining of lead and iron, but only the mining of coal and coal was not recorded[32]. This historical fact suggests that coal was not considered an economically valuable mineral in England at the time. However, this unique system of land tenure and property rights created a suitable legal climate for free coal mining in pre-Industrial Revolution England.

Until 1568, Queen Elizabeth and the Earl of Northumberland disputed the ownership of minerals. When the court finally ruled that the royal family owned all precious metal minerals, it reiterated the long-established fact that the Queen had no right to own all non-metallic minerals Fact[33]. This is the first time that the ownership of coal is clarified in the British common law, and it has laid a legal basis for the free mining of coal.

3.2.2 Changes in British Coal Mine Ownership—the Reformation

Although the law affirmed the freedom to mine coal, without a vision for mining, it would have been difficult to develop a coal industry. The 16th century English Reformation acted as a catalyst for such a change in land ownership, which eventually led to the active mining of coal in England. During the reign of William I, 1/4 of the land belonged to the Church. By the time of the Reformation, the Church owned 1/3 of

Englands land[34]. In particular, most of the land that was rich in coal seams belonged to the church[35]. However, the church was not keen on coal mining. This is because, on the one hand, the doctrine of the Church does not advocate the active use of land resources. "Property for subsistence, tithe for profit" is the most basic tenet of the Church in terms of income[36]. Therefore, bound by this traditional philosophy, the clergy never devoted their main efforts to the land, which naturally included coal mining. Moreover, according to church law, church land could not be bought and sold freely, which in turn restricted coal mining from a market perspective. On the other hand, the church had no control over the trade of coal. Despite the fact that the Church possessed a large number of coal fields, the right to trade was monopolized by the municipal authorities, which were autonomous in nature. In the Middle Ages, there were many disputes over the right to trade in coal, and the Church was repeatedly at a disadvantage, a situation that seriously discouraged them from mining coal[37].

In 1529 King Henry VIII convened the Council of Religion, which initiated the English Reformation, aimed at depriving the church of its political power. In 1536, the Parliament passed the Act for the Dissolution of Small Monasteries, followed by the Act for the Dissolution of Large Monasteries in 1539. Thus, after the Reformation, church lands were greatly reduced, and the English historian R.H. Tawney investigated the distribution of land in England in 1561 and found that the church had only 7.2% of the land, the crown had 9.5%, and the nobles and gentry had 80.2%[38]. For England as a whole, the nobles and gentry owned 79% of the land in England by 1873[39]. Thus, there is no doubt that the change in land ownership caused by the Reformation contributed greatly to the active mining of coal in England.

In addition, the enclosure movement of the 15th and 16th centuries and the large sums of money brought back by overseas colonial trade prepared the necessary preconditions for the large-scale mining of coal in England. However, land tenure system and coal ownership regulations and their changes directly drove the energy transformation in England from the legislative perspective.

4. Positioning of Energy Legislation in the Current Economic Transformation of China

We believe that from the perspective of energy use, there are two basic modes of economic transformation: a fundamental economic transformation, such as the industrial revolution in Britain, from organic to inorganic energy; and a gradual economic transformation, such as the post-industrial revolution in the United States and other industrial countries, which is still a fossil energy-based economic transformation. Although the impact of the post-industrial revolution is no less than that of the industrial revolution, the industrial revolution is a "qualitative" transformation.

Countries around the world can not escape this framework, and the current development of new energy is more similar to the industrial revolution period of economic transformation, is an attempt to undergo a fundamental economic transformation in the direction of development, for example, the use of wind and solar energy is a spiral return to a higher level of organic

energy use.

Of course we cannot predict that this global and revolutionary economic transformation will necessarily favor the United States, China, or any other country in the world, even if that one country invests more money, time, and effort than the others. This is because fundamental economic transformation is coupled in terms of the course of the industrial revolution. As the British historian Ridgely said of Britain's debut industrial revolution, "Britain found a way to escape the constraints, which at first was purely accidental and not by intentional design"[40]. The famous French historian Brodeur was even more outspoken, stating that "it was not so much a deliberate choice, but rather a choice made because coal compensated for an obvious British weakness"[41].

Therefore, focusing on new energy development does not necessarily lead to a fundamental economic transformation. However, this does not in any way mean that new energy investments should be abandoned, because there is a possibility that investments in new energy will trigger a fundamental economic transformation. At the same time, even if it does not lead to economic transformation, the former will quickly bring the country into the transformation track and beyond the first country, the industrial revolution followers of the United States, Germany is a clear example. After a certain level of economic development, the first-mover countries become path-dependent and are held back by many of the disadvantages retained from earlier economic transformations. As the British economic historian Clapham pointed out, the backwardness of the British electrical industry at that time was due to "the status quo of the law and the indifferent or hostile attitude of the local authorities"[42].

It is worth emphasizing, however, that not all latecomer countries have succeeded in achieving progressive economic transformation; China and Japan in the late 19th century are a stark contrast. Therefore, to take the lead in achieving fundamental economic transformation, or at least progressive economic transformation in latecomer countries, it is particularly important to consider the dimension of institutional design.

4.1 Establishing the Premise: Economic Transformation is a Dualistic Structure

"The industrial revolution is inherently dualistic." [43] This assertion by Rigley profoundly reveals that the industrial revolution was a dualistic structural economic transformation based on markets and energy.

4.1.1 The role of the market is to drive the economy to the tipping point of transformation

Undoubtedly, economic transformation is the product of market development to a certain stage. Looking back at the pre-industrial Britain, it was precisely based on the saturation of domestic and foreign markets that a fundamental economic transformation took place when the economy developed to a stage where it could no longer be accommodated by the market. Reaching this critical point means that economic development has reached a peak, and it is often accompanied by economic crises, but more importantly, from the

perspective of energy, this critical point should mean that a particular energy source can no longer meet the transformation that must take place in response to the needs of the market. For example, it was mentioned earlier that charcoal no longer meets the needs of the UK domestic market.

Moreover, the decline of the British economy in the late Industrial Revolution also reveals that it was difficult for Britain to move quickly into the post-Industrial Revolution phase when coal was still able to satisfy the market. Therefore, when the market still has the capacity to accommodate an economy with some room for growth, especially when a particular energy source can still provide what the market needs, economic transformation often does not occur quickly.

4.1.2 Energy transformation triggers economic transformation

The market can drive an economy to a tipping point of transformation, but it cannot support the completion of the transformation alone. History has proven countless times that when an economy reaches a certain level of growth, it often goes into a period of decline, or even the demise of the country, if a corresponding energy transformation does not occur. As Landers points out, because the economy lacks the essential changes that would fundamentally increase productivity, quantitative growth alone is unlikely to provide solid security, and this economic advantage will soon decline[44]. Therefore, market saturation and energy transformation are two essential prerequisites to complete the economic transformation.

4.2 The Key to Economic Transformation: Institutional Optimization of Energy Legislation

As mentioned earlier, because of the coupled nature of fundamental economic transformation, it is impossible to predict which country will be the first to undergo such transformation. Therefore, we should pay more attention to the incremental economic transformation and be prepared to achieve and surpass the first country as a "latecomer country". Moreover, the history of the industrial revolution also reveals that the UK also had a large number of inputs for the incremental transformation before the fundamental economic transformation. The key to progressive economic transformation lies in the optimization of the energy legislation system, as evidenced by the industrial revolution when the United States and Germany surpassed the United Kingdom.

Reflecting on Britain's catch-up in the late Industrial Revolution, the British economic historian Clapham pointed out that Britain was not inferior to the United States and Germany in terms of technological innovation, but that the delay was mainly in mass production and distribution, and that the reason for this delay largely stemmed from the current state of the law. As an example, the British Electricity and Lighting Regulations of 1882 and 1888 were the main legislation for the development of electricity, both of which were designed to promote the early municipalization of the electricity business, or at least to give all convenience. But both ordinances gave local authorities the facility to resist any power plan and complete control over the transmission of

electricity (digging streets and laying wires) for the benefit of the public. One of the reasons why the United States was so quick to get ahead of the curve is that such controls are relatively lax in the United States. These controls may not have been excessive in urbanized England, but they contributed to delays; and it was already obvious in the early 19th century that the existing units of local government (those with extended powers) were not necessarily the proper units for producing electricity[45].

There is no doubt that Britain was overtaken not because of the lack of technological innovation, but the irrationality of the existing system. So, this is another way of saying that institutional advantage is the key to the rapid overtaking of the first-mover countries by latecomers. The same situation is also proved by China's economic reform and opening up, without the institutional changes that began in the 1970s and 1980s, it would have been difficult to see the rapid economic development that the world is now witnessing.

Therefore, after recognizing that economic transformation is based on the premise of a dual structure combining market and energy, and after clarifying that institutional optimization is the key to economic transformation, the following characteristics of energy legislation are required.

4.2.1 Establish the primacy of the principle of energy transformation and actively promote the development of new energy sources.

The energy crisis will inevitably generate demands for change, and the energy transformation in the 21st century has to consider the impact of climate change on human beings. However, this energy model based only on crisis and environment must be static and passive. Once the crisis is eased and the climate improves, people will indulge in inertia again. Based on this analysis, energy transformation should be placed on a higher level - economic transformation. Needless to say, the energy reform is to achieve better and faster transformation and realize the country's historical rise in the new era. This requires that legislation must explicitly recognize, affirm and safeguard energy transformation, and build an open model that absorbs all variable elements, rather than resting on the status quo. Therefore, it is very important to establish the primacy of the principles of energy transformation. As long as it is conducive to energy transformation, it should be encouraged; as long as it can change the energy status quo, it is worthy of recognition; accept and encourage all systems, technologies and funds that can promote the development of new energy. new energy concept.

4.2.2 Construct energy legislation according to the dual view of social order rules.

The dualistic view of the rules of social order is a legislative purpose proposed by the British economist Hayek. According to him, social order is either generated or constructed: the former is a "self-generated and spontaneous order", while the latter is an "organization" or "artificial order"[46]. The two correspond to internal rules and external rules. Internal rules are the rules that are formed spontaneously by society in the long process of cultural evolution, which is what Hayek called

law in the strict sense. External rules, on the other hand, are those rules that are made according to the will of the organization or the governor and that apply only to specific people or serve the purposes of the ruler, which is what Hayek meant by legislation in a narrow sense[47].

This dualistic view of the rules of social order holds that internal rules are fundamental to the evolution of society, while external rules serve mainly to complement the spontaneous order rather than to interfere with or upset the balance of the internal order[48]. This is Hayek's basic perception of legislation in the broad sense.

Theory and practice have amply demonstrated the unparalleled superiority of the market in driving economic development. And this is precisely the kind of internal order that Hayek identified with. He pointed out that "the market order is extremely useful to us for our own purposes: not only does it give us guidance in our actions and bring about a certain correspondence between different human expectations, as all other self-generated and spontaneous orders do, but it also expands the prospects or opportunities for each individual to have a greater degree of dominion over goods (goods and services) than would be possible by any other. We cannot do this in any other way"[49]. Therefore, in energy legislation, if energy transformation is to be promoted, it is essential to guarantee the dominance of the market in the energy sector, as well as to ensure that the market becomes the basic instrument for resource allocation, while limiting government intervention to the provision of a general opportunity only, rather than the pursuit of a specific outcome or end.

4.2.3 Take institutional design as the core task of energy legislation.

From the perspective of historical development, it can be found that in different periods, the basic values for judging society are different. Before the Industrial Revolution, land was the central issue of all values, while after the Industrial Revolution, the market became the master of judging society. As the American economist North pointed out when discussing the institutional changes in Western countries, "In the Western world before the nineteenth century, agricultural production dominated, which led to a struggle for state control of landed property and the distribution of landed income." "The market, on the other hand, is the most basic institution of the modern Western economy and also constituted the central nerve of previous economic activity." [50] Especially so far, we have not found a judging standard that can outperform the market. Therefore, the market concept is not just a simple economic concept, but a more cultural social concept. This requires us not to focus on discussing market issues, but to focus more on the level of market-based rules, in other words, what kind of institutional rules can be constructed to maximize the role of the market.

At the same time, comparative political theory has repeatedly reiterated that because each political phenomenon or country is unique and unreproducible, and because phenomena have specific relevance to situations, the relevance of the same phenomenon in different situations are different, so it is meaningless to simply copy the institutional rules of other

countries. As historical institutionalism attests, Britain, the United States, and France all follow the idea of the market, but the paths they take are vastly different, and even the United Kingdom and the United States, both of which implement a free economy, have very different legal policies[51]. This requires that energy legislation should be based on the national context, absorb regular institutional rules, and form energy laws and policies that reflect the national paradigm.

5. Discover the Path Dependence of the Country and Promote Energy System Innovation

Path dependence is an institutional reality that is bound to exist in any country. In essence, it is the result of human nature. Through it, human beings can reduce transaction costs and increase returns, as the British economic historian Hicks argued that the "customary economy" is the best expression of this[52]. However, once path dependence is formed, it is difficult to be broken, thus preventing the entry of new technologies, ideas and even institutions, causing social and economic development to stagnate and decline. Path dependence is very different in each country, and is strongly influenced by geographic culture, customs, and traditional institutions.

In England, for example, land tenure system and the privatization of coal mining rights greatly facilitated the early coal mining in England and contributed to the origin of the Industrial Revolution in England. However, the legal stipulation that coal mines belong to landowners made it difficult to mechanize coal mining in the UK in the later period, and new technologies, economies of scale and bureaucratic management could not be widely used, which in turn became a shackle to the development of the British coal industry.

Needless to say, the path dependence on the legal system is the main reason for the early development of the British coal industry and the hindrance in the later period. It can be seen from this that finding and breaking the path dependence of domestic energy development is the key to energy legislation. And this depends to a large extent on the regulations of energy legislation on institutional innovation, because continuous institutional innovation is the only way to avoid path dependence and develop new energy. As American economist Schumpeter pointed out when discussing innovation theory, innovation is an "internal factor" and the fundamental phenomenon of economic development[53]. Therefore, the core task of energy legislation is to find the path dependence of the country and build its own energy innovation.

6. Effectively Reflect Changes in Power and Interests in the Energy Sector

Establishing energy reform, constructing energy legislation according to a dualistic view and realizing energy innovation are the basic purposes that we strive to achieve, but it must be recognized that only the correct response to changes in power and interests is the most core part of the entire energy legislation. Because only when they are incorporated into the benign track of energy development, can the economic

transformation be realized effectively, balanced and smoothly in the end.

This can also be seen in the British Industrial Revolution, as the British scholar Parkin pointed out, "The Restoration in 1660 and the subsequent social and political changes are most suitable for the Industrial Revolution. The principles of social establishment after the Civil War are wealth and status. The quality of life at that time was determined not only by what economists call consumption, but also by the relative position of the individual in the social hierarchy. No rational person would pass up the opportunity to make money easily. Opportunities are fleeting, and there were plenty of opportunities to make a fortune during the Industrial Revolution. In Britain wealth interacts with social influence, social status, and people don't have to give up the former to get the latter." [54]

So there is no doubt that it was the owners with the power and interest that profited from the Industrial Revolution and ultimately drove this transformation to completion. Therefore, only by effectively reflecting the changes in power and interests in the energy field, carrying out effective institutional design, and incorporating them into the market track, can energy legislation be truly constructed, thereby contributing to the realistic transformation of the economy.

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