

An empirical study on the evaluation of low-carbon development and low-carbon transformation of typical international power enterprises

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Abstract. Promoting low-carbon economic development to reduce greenhouse gas emissions has become a basic consensus and an important goal of public policy making around the world. In recent years, EDF, NG, E. ON, Enel, TEPCO and other internationally renowned power companies have taken positive measures in promoting the low-carbon transformation of enterprises, played a leading role in the demonstration, and created valuable reference value.

Keywords: Electric power enterprises, Low-carbon transition, Experience.

1. Introduction

At present, promoting low-carbon economic development to reduce greenhouse gas emissions has become a basic consensus and an important goal of public policy formulation around the world [1] [2]. In recent years, countries have put forward the goal of carbon peak and carbon neutrality, and many large multinational enterprises have actively responded to national policies and proposed enterprise-level carbon neutrality vision goals and transformation measures, in order to jointly promote the realization of low-carbon economic and social transformation goals. The energy field is the key field of carbon emission reduction, and the low-carbon transformation of energy has thus become the key field and key role of global low-carbon development [3]. In this paper, representative international power companies such as Electric Power Company of France, National Grid Company of Britain, E. ON Group, Electric Power Company of Italy and Tokyo Electric Power Company are selected, and the selection of evaluation indicators and development measures of their low-carbon development are combed and analyzed, in order to obtain useful enlightenment.

2. EDF

2.1. Low carbon evaluation

In general, EDF does not have a set of indicators specifically used for systematic evaluation of low-carbon, which has the following characteristics in low-carbon evaluation:

First, scientific and accurate calculation of greenhouse gas emissions is the core. In the carbon footprint report of EDF, various direct and indirect emissions are calculated according to scientific methods, taking full account of internal and external double counting and other problems, and subsidiaries holding minority shares are converted into indirect emissions according to the proportion of equity.

Second, from the comparison of emissions of each link, the proportion of emissions of the power grid link is low. EDF is a power company with integrated distribution and distribution, and also engages in natural gas business. Its CO₂ emissions in 2021 are 129 million tons equivalent, of which the indirect emissions generated by reselling natural gas and electricity are 101.8 million tons equivalent, and its own consumption of electricity and natural gas is 0.29 million tons equivalent. Electricity and heat production was 26.6 megatonnes equivalent. Its emission reduction contribution is mainly provided by the second type of indirect emissions, followed by power generation and heat production.

Third, low-carbon evaluation is mainly based on the comparison between enterprises and the comparison of changes in the time dimension. Through precise scientific calculations, EDF is able to compare with other companies worldwide, such as EDF's explicit mention of "EDF's 2021 carbon intensity level of 48g/kWh, which is nine times lower than the global average and five times lower than the European average." At the same time, based on the annual change of carbon emissions, the positive effect of enterprise emission reduction can be reflected.

2.2. Low carbon transition Initiative

First, formulate a vision for reducing emissions. EDF has formulated quantified carbon emission reduction targets and paths at the group level, within which the distribution subsidiary has further formulated its own stage targets [4]. EDF aims to be carbon neutral by 2050, reducing direct CO₂ emissions by 40% from 2017 levels and CO₂ intensity per unit of power generation by 36% from 2019 levels by 2030. The distribution subsidiary Enedis plans to reduce its carbon footprint by 20% by 2025, in line with the group's timeline for achieving carbon neutrality.

Second, strengthen the organizational guarantee and third-party evaluation of emission reduction. EDF has improved its responsibility for climate governance at the group level, and in the Group's board of Directors, two board members have been identified as climate leaders who are responsible for coordinating carbon reduction related matters to ensure that the vision is achieved on schedule. At the same time, EDF joined the "Business Ambition for 1.5 °C" initiative at the beginning of 2020 to independently verify the rationality and feasibility of carbon trajectory reduction targets with the third-party "Scientific Carbon Reduction Initiative (SBT)" and proactively disclose relevant information.

Third, we will promote business transformation and upgrading with a low-carbon orientation. In terms of power investment, EDF continues to increase its efforts in the development of clean energy, and plans to double the installed capacity of renewable energy from 2014 to more than 50GW by 2030. In terms of power grid investment, carbon emission costs and environmental benefits are clearly identified as important factors to determine the priority of projects, and priority is given to projects that reduce damage and save electricity and promote carbon emission reduction. In terms of energy consumption, we have developed and launched a number of customer-oriented carbon reduction and control services, including energy management, energy efficiency solutions, energy-saving products, energy storage batteries, and green electricity purchase. It plans to provide energy consumption monitoring and energy efficiency transformation services for 40 million customers in the future. At the same time, EDF plans to provide electricity for 600,000 electric vehicles by 2022, and its domestic charging market share will reach 25%, becoming the leader in the European electric vehicle charging market.

Fourth, reduce line loss and SF₆ gas leakage through equipment updating, operation and maintenance optimization and other measures. EDF has reduced SF₆ leakage in substations and overhead circuit breakers through measures such as enhanced operations and maintenance, and plans to reduce line loss levels by 1.5% year-on-year in 2022. Since 2018, the "Remediation Excellence" action plan has been adopted, which plans to invest 630 million euros over 15 years to replace 20 aging substations and reduce the sources of leakage. Strengthen SF₆ positioning, measurement and equipment tracking, and grasp the total amount of SF₆ in real time.

Fifth, advocate green office and green travel. Strengthen the company's employee travel, transportation, office buildings and other aspects of carbon management. For employees of the company, a bicycle mileage allowance has been introduced to encourage employees to travel green. The company plans to replace all of its fleet vehicles with electric vehicles by 2030. Shaping the office space as a benchmark energy-saving building.

Sixth, we will continue to strengthen carbon asset management. The Group's carbon assets are professionally operated by specialized subsidiaries to hedge risks and improve returns through carbon finance and carbon trading markets. The subsidiary EDF Trading is responsible for forecasting the Group's carbon quota gap, developing CDM projects in developing countries and Europe to obtain

certified emissions, and developing carbon financial products and carbon asset trading strategies to meet the Group's emission reduction needs and increase market revenue.

3. NG

3.1. Low carbon evaluation

NG's low-carbon evaluation index has the following characteristics: First, similar to EDF, it also takes the scientific accounting of greenhouse gases as the core, adopts common calculation standards, and puts the cumulative carbon emission reduction as the core index into the annual social responsibility report and the official website for strong publicity; Second, although NG is a company headquartered in the United Kingdom, its current business in the United States accounts for a larger proportion. When calculating greenhouse gas emission reduction and evaluating low-carbon effects, NG includes all businesses at the same time, and does not carry out special treatment for international business. Third, in the official website publicity to promote the construction of a near-zero society, the narrative of "milestone events" has been adopted, which has greatly improved the affinity and appeal.

3.2. Low carbon transition Initiative

First, clearly state the corporate vision of emission reduction. As early as 2019, NG proposed quantified emission reduction targets and paths, and planned to achieve negative emissions in the power grid business earlier. NG plans to be carbon neutral at the company level by 2050. Among them, NG direct carbon emission reduction, by 2033 NG grid business net emissions will be negative.

Second, increase the construction of transnational interconnection power grids. In the transmission link, increase the construction of transnational interconnected power grids, and increase the cross-border input of zero-carbon electricity. In 2020, NG started the construction of Viking Link, a ± 525 kV HVDC project connecting the UK and Denmark, with a transmission capacity of 1.4 million kilowatts and a length of 765 kilometers, with an investment amount of about 2 billion euros. By 2030, 90 per cent of the electricity delivered to the UK by the project is expected to come from zero-carbon sources.

Third, improve the power grid's capacity to absorb clean energy. On the one hand, in the distribution side access to the transmission grid link, NG focuses on the integrated use of smart meters, high-speed communication, distribution automation and other three aspects to enhance the level of the grid, improve the power configuration and operation level of the main network and distribution network. On the other hand, to meet the needs of distributed energy network connection, NG supports the friendly interaction of the distribution network by improving the automation, intelligence and control level of the power grid. Since 2011, the UK has connected around 13GW of solar power (all connected to the distribution grid). By 2050, distributed generation could account for up to 58% of the total installed power system (approximately 136GW).

The fourth is to gradually eliminate SF6 emissions through equipment renewal. NG pledged to no longer install and use SF6-containing equipment by 2028, reduce total SF6 leakage by 50 percent by 2030, and eliminate all SF6 gas by 2050.

The fifth is to promote the popularization and use of electric vehicles within the company. NG plans to replace all of the company's light vehicles with pure electric vehicles by 2030, and actively seek zero-carbon alternatives for medium and heavy-duty vehicles.

4. Enel

4.1. Low carbon evaluation

Enel's low-carbon development effectiveness evaluation index has the following characteristics: First, it focuses on the scientific accounting of carbon dioxide emissions, and follows the universal

international standards, and takes this measurement index as the core index for disclosure and publicity; Second, as a multinational enterprise with business layout in 31 countries around the world, the business of each country is included in a unified evaluation system for accounting and disclosure; Third, as a vertically integrated power enterprise with power generation business, carbon dioxide emissions caused by power generation business account for the majority of direct emissions. Therefore, Enel also uses more relevant indicators of power generation in the evaluation of low-carbon development [5].

4.2. Low carbon transition Initiative

The first is to bring forward the realization time of the "net zero vision" from 2050 to 2040. In 2021, Enel further accelerated its decarbonization roadmap, bringing forward the net zero emissions target by 10 years from 2050 to 2040, and the new implementation plan is carried out in three phases: short (to 2024), medium (2024-2030) and long (2030-2040). Classification of the emission stage targets and corresponding measures. These targets are in line with the SBTi's 1.5 °C implementation path for electric utilities and do not take into account carbon storage measures or carbon storage methods such as afforestation.

The second is to gradually withdraw from coal-fired power generation and natural gas business. Traditional fossil energy is the main source of carbon dioxide emissions, and Enel needs to focus on achieving net zero emissions without the use of decarbonization technical measures. To this end, Enel has proposed a gradual phase-out of coal-fired power generation, with plans to reduce the share of coal-fired power generation from 7% to 4% in the 2022-2024 period and completely eliminate coal-fired units by 2030. At the same time, Enel continues to push gas customers to implement electricity substitution, in order to gradually reduce the gas business volume, by 2040 completely out of the gas business.

Third, vigorously develop renewable energy. The development of renewable energy sources such as wind and light are the most critical measure to achieve "net zero emissions", and Enel plans to increase investment in renewable energy. Over the 2021-2030 period, Enel plans to invest 65 billion euros to drive the addition of 75GW of renewable energy capacity, achieving the phased development target of 67GW of renewable energy capacity by 2024, 120GW by 2030 and a 100% renewable energy portfolio by 2040.

The fourth is to establish a sustainable development committee under the Board of directors. The main role of the Committee is to assist the Board in assessing and making decisions on issues related to the company's sustainable development. In relation to climate change, the Committee mainly reviews the following aspects: 1) the climate objectives set out in the sustainability Plan; 2) Methods and initiatives for implementing sustainable development policies; 3) Preparation methods and structure of the contents of non-financial statements and sustainability reports.

Fifth, establish a compensation incentive system for managers that is compatible with low-carbon development. Under the ENEL Compensation Policy for 2021, ceos/general managers and key executives will have a significant portion of their long - and short-term variable compensation tied to sustainability-related performance targets. For ceos/general managers and executives with strategic responsibilities, their long-term variable compensation has included quantified carbon reduction indicators, such as CO₂ emissions per kilowatt-hour, with a weighting of 10% since 2018; The inclusion of renewable energy as a share of installed capacity from 2020 will also have a weighting of 10% in long-term variable pay. In the short-term variable pay system, indicators related to low-carbon development are combined with the specific role of the manager.

5. E.ON

5.1. Low carbon evaluation

E.ON's indicators for the evaluation of the effectiveness of low-carbon development are much the same as those of major European power companies: First, strictly follow the methods and standards

determined by the GRI guidelines, scientifically calculate carbon dioxide emissions, and standardize the disclosure of sustainable development reports and ESG reports; Second, low-carbon development results are also based on carbon dioxide accounting as the core, and also include some indicators based on their own business considerations and closely related to carbon reduction, such as the number of smart meters installed; Third, as a multinational enterprise engaged in business in Germany, Sweden, Hungary, the Czech Republic, Poland and other countries, E.ON's evaluation indicators are comprehensive and unified.

5.2. Low carbon transition Initiative

One is to reset climate change targets. In 2020, E. ON adjusted the group's climate change targets, bringing forward the group's carbon neutrality target to 2040, while also proposing to promote carbon neutrality in the supply chain by 2050.

Second, actively promote the company's business transformation. Based on the trend of low-carbon energy development, E. ON intends to gradually focus its business on the two major areas of energy network and integrated energy services, and set the strategic goal of "becoming a sustainable platform for the low-carbon energy transformation in Europe". Under this goal, E. ON implemented the strategic transformation of its business in two steps: First, in 2015, a new company, Uniper, was established to take charge of traditional energy business and part of wind power business, and in 2016, all the equity was sold and the traditional energy business was completely withdrawn. In the second step, an asset swap agreement was reached with RWE, in which E. ON exchanged its renewable energy business for the grid and electricity sales business of Innogy, a subsidiary of RWE. As a result of the transition, direct carbon emissions within E. ON's scope I have been reduced from 80 million tonnes of carbon emissions in 2015 to 4 million tonnes in 2020.

The third is to take a series of targeted actions to reduce carbon. For the carbon emissions from power generation and heating, escape emissions, self-owned vehicles, and fuel combustion within Scope 1, E. ON mainly adopts measures such as investing in green energy, increasing the share of renewable energy in power generation, recycling and utilization of waste heat, upgrading energy transportation network, purchasing electric vehicles, and improving energy efficiency to reduce emissions. For Scope 2, E. ON's carbon emissions mainly come from distribution losses and power purchase, so it chooses to reduce distribution losses by increasing the proportion of renewable energy connected to the grid, innovating transmission and distribution technology, planning the grid structure, and reducing carbon emissions of purchased power through the use of green electricity and clean fuels, improving energy efficiency and other measures.

Fourth, establish a framework for sustainable investment. E. ON has set up a sustainable investment framework, investing in four key areas of power grid, renewable energy, energy efficiency and clean transportation, and has achieved good carbon reduction results. In terms of sustainable investment framework, E. ON identified four key investment directions for power grid, renewable energy, energy efficiency and clean transportation, and set corresponding investment standards and corresponding economic activities to ensure the carbon emission reduction of green investment projects. Among them, the power grid investment was the highest, reaching 16.675 billion euros. In terms of actual results, E. ON's investment in the power grid has the best carbon emission reduction effect, and the unit emission reduction cost is about 281.58 euros/ton, which is the lowest unit emission reduction cost among the four types of investment.

6. TEPCO

6.1. Low carbon evaluation

TEPCO's low-carbon development effectiveness evaluation indicators have the following main characteristics: First, it follows the international accounting and disclosure standards of GRI, scientifically calculates the carbon dioxide emissions of Scope 1, Scope 2 and Scope 3, and fully discloses them; Second, in addition to the calculation of carbon emissions, it also includes relatively

comprehensive relevant indicators, which can be seen from the large number of environmental performance indicators in TEPCO's ESG data; Third, as a vertically integrated power enterprise, the relevant indicators on the power generation side have made a greater substantive contribution to carbon dioxide emissions, while the relevant indicators on the grid side mainly reflect indirect carbon dioxide emissions.

6.2. Low carbon transition Initiative

First, determine the strategic positioning of "comprehensive energy service providers" to provide new energy services. TEPCO is highly concerned about the trend of energy transformation, proposing that power companies should shift from providing products to providing services, and from single services to integrated services. To this end, TEPCO is oriented to meet the comprehensive service needs of customers, and builds a business system integrating transmission and distribution platform, infrastructure platform, energy platform and data platform to fully support the development of its integrated energy service business. On the basis of expanding and strengthening traditional energy services, TEPCO has restructured its business, established the strategic positioning of an integrated energy service provider, and strives to provide a variety of power energy products and new energy services, striving to become a leader in the integrated energy service industry.

Second, develop renewable energy and optimize the energy mix. In the face of the growing energy tension in Japan's power industry, TEPCO has been committed to transforming renewable energy into one of its main energy sources in order to improve the company's enterprise value and optimize the company's energy structure. At the end of 2020, TEPCO proposed a net-zero emissions strategy by 2050. The main measures include restarting nuclear power, offshore wind and other renewable energy sources, and strengthening low-carbon alternative development on both the power generation side and the power consumption side. It plans to increase its green power generation capacity by 70% over the next 10 years, developing up to 7GW of offshore wind and hydropower projects by 2035. In addition, TEPCO is actively exploring hydrogen production from nuclear power and has set up a joint venture to build the largest hydrogen production station at 600 cubic meters per day in Tokyo. To develop its renewable energy business by investing in renewable energy projects and proposing renewable energy focused solutions, to diversify the company's energy use, and to respond to social decarbonization initiatives to protect the environment.

Third, actively carry out overseas renewable energy project mergers and acquisitions to achieve low-carbon development of overseas business. While participating in overseas projects such as thermal power generation, TEPCO actively pays attention to new trends in the global energy market, including the development of renewable energy, power infrastructure and information technology, and positions renewable energy investment as one of its future core businesses, such as wind power, hydropower, solar power and battery projects. At present, TEPCO has invested in wind power projects in the UK, India, Thailand and Vietnam, laid out hydropower projects in Vietnam, and acquired solar power projects in Thailand and India. In 2020, Tokyo Electric Power Company acquired 31.4% of the shares of JSC Dariali Energy, a Georgia hydropower company, to participate in the Dariali hydropower project. Through the acquisition of new energy projects, TEPCO will learn relevant knowledge and technical expertise, realize the transformation into an integrated energy service provider, and promote the low-carbon development of its overseas business.

7. The main conclusions

In this paper, five influential power enterprises in the world are selected as samples, and the selection of indicators for evaluating low-carbon development and the practical strategies for promoting low-carbon development are sorted out. In general, the following enlightenment can be extracted:

First, the low-carbon evaluation of international power enterprises generally takes scientific measurement of carbon dioxide emissions as the core. In the social responsibility reports or ESG

reports issued by EDF, NG, Enel, E. ON, TEPCO and other internationally renowned power companies, carbon dioxide emission reduction is basically taken as the core indicator of their low-carbon development orientation and effectiveness publicity. In addition, the above enterprises are measured in strict accordance with the GHG Protocol, the greenhouse gas accounting system proposed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), and are divided into scope 1, Scope 2, and scope 3. Accurate data are displayed in relevant reports such as corporate social responsibility reports or ESG reports. Relatively speaking, domestic power enterprises have not been accurately measured in this respect.

Second, from the accounting results, the production side emissions occupy the largest proportion and is the focus of emission reduction. The above international power enterprises have power grid business, but there are differences in the business of power generation, gas and other businesses, resulting in a large difference in direct emissions of greenhouse gases. As shown in Table 1, when EDF and Enel jointly engage in power generation business, their greenhouse gas emissions in Scope 1 are significantly larger; NG is not engaged in power generation business, and the proportion of E. ON power generation business is low, and the greenhouse gas emissions of both Scope 1 are low. Since TEPCO became independent from the restructuring of its fossil fuel power generation business in 2019, its Scope 1 emissions have decreased from 81,604 ktCO₂e in 2018 to 191 ktCO₂e in 2019. SF₆ on the grid side is also a greenhouse gas from direct production, but its scale is small and its proportion is low, such as in 2021, NG emissions are 263 ktCO₂e, EDF is 50.51 ktCO₂e, and TEPCO is 63 ktCO₂e.

Third, some common indicators are generally formed around carbon emissions to form a "three-dimensional portrayal" of low-carbon development. Although different enterprises have different evaluation index systems related to low-carbon development, there are also some general indicators, including carbon dioxide emissions, SF₆ emissions, line loss rate, installed capacity of renewable energy, renewable energy power generation, and the proportion of electric vehicles in light vehicles within enterprises. It can promote the outside world to produce a three-dimensional vivid impression of the low-carbon development of enterprises.

Fourth, in the adoption of low-carbon development measures, the power enterprises have greater commonality. Common practices include: accelerate the development of renewable energy such as wind power and photovoltaic, and eliminate fossil energy generator sets; Speed up the construction of interconnected power grids and import more clean energy; Reduce SF₆ emissions through technological progress, equipment renewal, management optimization and other measures; Advocate green office and gradually replace corporate light vehicles with electric vehicles within the group; Accelerate comprehensive energy services, implement electric energy substitution, and promote energy-saving transformation; Let's wait.

Fifth, fully disclose information related to low-carbon development through ESG and social responsibility reports. As a large multinational enterprise and a public enterprise, it has become a "standard" to fully disclose corporate information to the society in order to provide relevant information to stakeholders (shareholders, employees, communities, governments, investors, etc.). Among them, low-carbon information has become more and more important, and is generally disclosed through ESG reports, corporate social responsibility reports, green development reports and other ways. In contrast, the low-carbon information of EDF, NG, TEPCO and other internationally renowned power companies is more fully disclosed and more specific, which is worth learning from.

Table 1. Greenhouse gas emissions of major international power enterprises

Enterprise	Greenhouse gas emissions		
	Scope 1	Scope 2	Scope 3
NG	5271 ktCO ₂ e	2194 ktCO ₂ e	30088 ktCO ₂ e
Enel	51.6 Mt CO ₂ e	4.3 Mt CO ₂ e	69.1 Mt CO ₂ e
EDF	27.38 Mt CO ₂ e	0.29 Mt CO ₂ e	101.8 Mt CO ₂ e
E.ON	3.71 Mt CO ₂ e	5.73 Mt CO ₂ e	100.38 Mt CO ₂ e
TEPCO	192 ktCO ₂ e	6108 ktCO ₂ e	102137 Mt CO ₂ e

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