

Analysis of Energy Saving Technology and Potential in China's Key Industries for the "Fourteenth Five-Year Plan" Period

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Abstract—The energy saving & emission reduction (ESER) is the main objective for energy-intensive industries, which will be accomplished with technological innovations and policy guidance. This paper compares the ESER technologies in six energy-intensive industries and analyzes their potentials. Based on this, an index system is established to evaluate the ESER effects for 2021-2025 (the "14th Five-Year" periods). Some valuable suggestions are provided which may be useful for technology selection.

Keywords—energy saving; emission reduction; technology and potential; Fourteen Five-Year Plan

I. INTRODUCTION

Actively tackling climate change and accelerating low-carbon development has become a global consensus and a general trend. China is the world's largest energy consumer. China accounts for 23% of global energy consumption and 27% of global energy consumption growth. China has listed energy saving & emission reduction (ESER) as an important part of the long-term national economic and social development planning, iron and steel metallurgy, non-ferrous metals, petrochemicals, building materials and other key energy-consuming industries have great demand for energy conservation [1].

The primary energy demand has increased by more than 160% since 2000 in China. Rising levels of economic activity (GDP growth, an increase in per capita housing area, an increase in electrical holdings, a shift in transport to inefficient modes of travel and a decline in vehicle carrying rates) have led to increased energy consumption. On the other hand, structural changes in the economy (that is, the transfer of economic activity from energy-intensive industries to services and non-energy-intensive manufacturing), as well as improved unit energy efficiency, reduce energy consumption [2]. The factors affecting overall energy consumption are complex, so it is very difficult to assess future energy consumption.

This paper analyzes the development of energy-saving technologies in key industries (transportation, construction, industry) during the "Fourteen Five-Year Plan" period, and evaluates the energy saving potential of key industries, which is helpful to promote ESER in China.

II. ENERGY SAVING ANALYSIS OF TRANSPORTATION DEPARTMENT

Transportation infrastructure (road, waterway) construction energy consumption will remain an important component of the

transport industry, and even the national total energy consumption during the "Fourteen Five-Year Plan" period. The energy saving of transportation infrastructure construction is an important means to realize and fulfill the goal and commitment of ESER in China.

A. Automotive Transportation

Because of the increase in activity levels (such as passenger kilometers), the total energy consumption of passenger transport terminals has increased. Among them, the reduction in vehicle carrying rate, that is, the shift from public transport to private cars (mode shift) and the increase in the proportion of larger vehicles (SUVs and passenger light trucks) are important sources of growth. In freight transport, rising activity levels and freight rail transfer are factors contributing to increased energy consumption, and the increase in vehicle energy efficiency and larger trucks with more load is a factor in reduced energy consumption. Overall, energy consumption in freight transport shows an increasing trend. The implementation and planning policy will enable energy consumption of passenger transport to continue to increase at an average annual rate of 2%, energy efficiency of freight transport at an average annual rate of 1.5% continuous improvement during the "Fourteen Five-Year Plan" period. The focus on energy efficiency improvement in passenger and cargo transport is achieved in small cars and vans, followed by Lorries.

B. Air Traffic

Aviation energy efficiency is commonly used to indicate energy consumption per passenger km. Aviation energy efficiency increased at an average annual rate of 3.6% over 2000-2016 years (reduced energy consumption per passenger kilometer); in 2015-2016, the rate of energy efficiency improvement declined to 1.6% per annum. In the last more than 10 years, energy efficiency improvements have come from technological advances in jet engines, improved aerodynamic characteristics and an increase in the number of passengers per flight. During the "Fourteen Five-Year Plan" period, if energy conservation is actively carried out in terms of new models and logistics (increasing the number of passengers on a single flight, optimizing flight routes, electric sliding at airports), it is expected to maintain an average annual rate of 1.6% or higher to improve aviation energy efficiency.

C. Rail Transport

The important ways of railway ESER include: developing railway heavy load transportation technology, improving power share, reducing fuel consumption and coal, increasing the use of new and renewable energy sources, passenger and cargo sub-line transportation, and ESER technology of railway station yard. By 2020, China's railway electrification rate will reach 70% [3]. The focus of ESER during the "Fourteen Five-Year Plan" period shifted gradually from traction energy consumption to non-traction energy consumption.

D. Waterway Transportation

The introduction of clean energy, energy efficiency design and management level of ships will become the focus of future ESER efforts, including: Ship Shore power installation and transformation, low sulfur oil technology, ship energy efficiency management technology, ship LNG technology [4].

III. ENERGY SAVING ANALYSIS OF CONSTRUCTION DEPARTMENT

A. Energy Saving for Building

Building energy consumption rose 20% over 2000-2017 years as floor space, building occupancy and building services increased, as well as higher levels of activity, including changes in population, climate and electrical use levels. Most energy-saving opportunities during the "Fourteen Five-Year Plan" period come from heating (more efficient heating equipment, better building insulation performance and windows), air conditioning and refrigeration (energy-efficient air conditioning and control systems and improved building insulation and windows), home cooking, high energy efficiency in hot water equipment, lighting energy saving. With rising temperatures and population and economic growth, building refrigeration energy consumption will become the fastest growing Terminal Services in the construction sector. The improvement of energy saving performance of refrigeration technology will become the main source of energy efficiency improvement of air conditioning refrigeration.

In the construction industry, the design, use and maintenance of these three links are currently disjointed. Through the development of energy efficiency management so that design, use and maintenance to form a complete closed-loop, building energy saving also has a great potential to tap.

B. Energy Saving for Household Appliances

In addition to the use of energy-saving technologies in the production and use of household appliances, new energy technologies need to be introduced into the field of household appliances to better respond to the national call for ESER. In the process of designing and using household appliances, manufacturers can fully integrate solar, wind, geothermal and other technologies to meet the need for ESER. For example, solar energy-based air conditioners, refrigerators, water heaters, automobiles and other products. The application of solar energy technology can achieve energy conservation, greatly improve the waste of non-renewable resources, and reduce the pressure on the use of energy resources.

At present, the integration of new energy technology in the field of household appliances is mainly reflected in the

development and use of HVAC (Heating Ventilating & Air Conditioning), which use solar energy resources to achieve energy conservation.

IV. ENERGY SAVING ANALYSIS OF INDUSTRY DEPARTMENT

Economic activity shifted from energy-intensive industries such as metals, cement, pulp and paper industries to services and non-energy-intensive manufacturing, reducing energy consumption. Key energy-saving technologies include the use of high-efficiency electric pumps instead of natural gas, coal or fuel boilers as low-temperature heat sources (below 100°C), and improved efficiency of motor drive systems. In addition, the steel manufacturing industry to improve the recycling rate of waste metal, the use of electric arc furnace for crude steel smelting; the chemical and petrochemical industries use efficient process heating and motor drive systems; and cement manufacturing reduces clinker cement ratios, which can also lead to energy efficiency improvements.

The following is a specific analysis of steel, non-ferrous metals, building materials, petrochemical, chemical and electric power, such as the six energy-intensive industries.

A. Steel Industry

The main energy-saving measures in the steel industry during "Fourteen Five-Year Plan" period include [5]:

- From process energy saving to system energy saving, enterprises achieve continuous, compact and efficient production process, improve the energy efficiency of iron and steel production process, reduce pollutant emissions.
- Enterprises improve gas, steam, electricity and other energy control system functions during the production process.
- According to the basic principles of circular economy, enterprises achieve the three functions of steel product manufacturing, energy conversion, waste disposal-elimination and re-recycling based on cleaner production.

B. Non-Ferrous Metal Industry

Enterprises should rely on scientific and technological progress to promote energy conservation technology and energy conversion, cascade utilization, so as to improve the degree of intensification [6]. ESER of non-ferrous metal enterprises focus on industrial boilers, kilns, tailings leakage and exhaust gas pollution control, the use of tailings reservoir seepage, the complete transformation of the original sewage treatment system. In the production process, non-ferrous metal enterprises should pay attention to strengthen the metallurgical furnace body insulation, such as aluminum silicate or rock wool insulation felt as furnace body insulation material.

C. Building Materials Industry

The main energy-saving measures in the building materials industry include popularization of new production process in cement industry to reduce clinker content, using hollow brick or aerated concrete brick instead of solid clay brick to build building wall, use of new environmentally friendly building materials, strengthening the use of various types of industrial

waste, improving building materials quality standards to extend service life.

D. Petrochemical Industry

Enterprises should improve processing technology and improve the utilization efficiency of machinery and equipment [7]. The focus of energy conservation in petrochemical industry is to improve the level of energy saving and environmental protection in the output, transportation, utilization and recycling of steam in the production process, and to do a good job in the utilization and recycling of water resources.

E. Chemical Industry

The focus of energy conservation in the chemical industry is to promote the application of heat pipe heat exchanger, heat pump, accumulator and other devices, and to promote chemical process technology with simple and convenient operation flow and maximum conversion energy. For example, short-range rectifier, crystallization separation and other related process technology [8].

F. Electric Power Industry

The achievements of China's power generation industry in ESER are mainly manifested in the decline of coal consumption during power supply, the obvious improvement of transmission line loss, the effective control of atmospheric pollutants such as sulfur dioxide, soot, nitrogen oxides, the increase of fly ash utilization rate and the reduction of water for power generation.

The electric power industry studies and establishes the long-term mechanism of power ESER, increases the proportion of hydropower, wind power and solar power generation, and promotes the transformation of ultra-low thermal emission.

TABLE I. DEPARTMENT ENERGY SAVING TECHNOLOGY AND ENERGY SAVING INDEX

Department	Energy-saving Technology	Energy Saving Index
TRANSPORTATION	Fuel efficiency improvements and electric vehicles	Fuel consumption per kilometer of passenger cars
		Transport fuel consumption per ton of road freight vehicles
	new models and logistics	Fuel consumption per passenger kilometer for commercial aircraft
	railway heavy load transportation technology, ESER technology of railway station yard	Energy consumption per ton of kilometers
CONSTRUCTION	Shore power, low sulfur oil, LNG	Ship Energy Efficiency Operating index
	better building insulation performance and windows	Unit building Area energy consumption,
	efficient heating equipment	heating energy intensity
INDUSTRY	energy-efficient air conditioning and control systems	air conditioning refrigeration energy intensity
	efficient motor drive systems	Output value per unit of energy consumption
	metal recovery utilization	
	Electric heating Pump (less than 100 °C)	

V. CONCLUSION

As the largest energy consumer and carbon emitter, China faces the double pressure from the international community and its own development. In order to solve energy shortage and reduce carbon emissions, and to ensure stable economic development, China must carry out ESER in line with national conditions. By analyzing the energy-saving technology and potential in transportation, construction and industrial fields, this paper makes industrial structure adjustment, technological progress and energy structure optimization as the main direction of ESER during the "Fourteen Five-Year Plan" period. Although the pace of technological progress has slowed, its contribution to ESER is still considerable. We need to pay attention to the contribution of technological progress to ESER, introduce advanced technology, carry out technological innovation, and increase investment in scientific research. The direction of energy structure optimization should be to increase the proportion of natural gas and non-fossil energy in energy consumption, to solve the problem of grid-connected new energy, to reduce the consumption of coal and oil, and to change the structure of energy consumption, which has always been dominated by coal.

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