CO_2 Emission Reduction for Power System Based on Total Emission Control of CO_2 (II): A Case Study

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Abstract—Power industry as the main source of CO_2 emissions, is facing tremendous challenge of CO_2 emission reduction during the periods of "12th Five-year" and "13th Five-year". How to maximize the reduction of power CO_2 emissions under the premise of regional economic development and energy requirements is the significant manage ment objective for administrative department.

In this study, a mixed integer stochastic chance-constraint programming model based on CO_2 emission reduction from power industry is applied to the power system in Heilongjiang province, in order to obtain the CO_2 emission reduction schemes of energy conservation, reduction project and power structure adjustment in Heilongjiang province during the periods of the "12th Five-year" and "13th Five-year".

According to the model calculation and the results analysis, the power CO_2 emission growth in periods of the "12th Five-year" and "13th Five-year" are less than 23.82% and 20.13% respectively, significantly lower than the regional CO_2 emission growth. It means the power industry has made a great contribution to CO_2 emission reduction in Heilongjiang province. Meanwhile, the results of model application show that the developed model can meet the management target of maximizing the reduction of power CO_2 emissions, and provide reasonable reference to the administrative department.

Keywords: *CO_2 emission reduction;energy conservation; carbon capture and storage; generatingexpansion planning*

I. INTRODUCTION

On November 26, 2009, Chinese government has officially announced actions to control greenhouse gas emissions targetthat is to reduce 40%-45% CO_2 emissions per unit of GDP by 2020 from the 2005 level. Power industry as the main source of CO_2emissionsis the key object to reduce CO_2emissions in China.By making reasonableplan to maximize the CO_2 emission reduction and implement low-carbon power is the only way for the sustainable development of the power industry, and of great importance to achieve the overall objective of CO_2 emission reductioninChina[1].

The relevant scholars hascarried out a series of research on China's CO_2 emissions control [2-9]. Althoughthe achievement is diversified, the overall lack of the angle of the collaborative research on energy conservation, CO_2 reduction project and power structure adjustment.

The researchers in the article"CO_2 Emission Reduction for Power System Based on Total Emission Control of CO_2 (I): Modeling", regards the maximum reduction of CO_2 emissions from power industry during the planning phase through energy conservation,CO_2 reduction project and power structure adjustment as the objective function, a mixed integer stochastic chance-constraint programming model has been developed. In this paper, the established model application research is proceeded, and takes power system in Heilongjiang province as an example.

II. OVERVIEW OF THE CASE STUDY SYSTEM

Consideringperiods of "12th Five-year" and "13th Five-year" (2011-2015 is the first period and 2016-2020 isthe second period),The planning periodis ten years.

By the end of 2010, the total installed power generating capacity of Heilongjiang provinceis about 21.35 million kW, andthe installed capacity of coal-fired generating unitsis 16.97 million kW, account for 91% of the total. In addition, the installed capacity of wind power andhydropower are 2.4 million kW and0.95 million kW respectively. The CO_2 emission control targetsin planning periodare shown in table I.

TABLE I. TOTALAMOUNT CONTROL TARGRT BAESD ON PER UNIT OF GDP CO_2EMISSIONS INTENSITY

Planning period		**GDP （billion RMB）**	**CO_2 emissions intensity （ton CO_2/ million RMB GDP）**	**Falling target（%）**	**CO_2total emission （million ton）**
Base year	2010	10235	2.83	\	28989
Target year	2015	18038	2.38	16	42880
	2020	27753	1.95	18	54100

According to the statistical yearbook data of power industry in Heilongjiang province, the power consumption statistics from 2000 to 2012 is shown in table II. Through the Crystal software, by applying the Monte Carlo stochastic simulationmethod, regional electricity consumption probability distribution can be simulatedas shown in Fig. 1.

TABLE II. ELETRICITY CONSUMPTION OFHEILONGJIANG PROVINCE FROM 2000-2012. (Unit: hundred million/kW·h)

2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
350.73	371.52	382.07	391.57	412.95	525.5	555.9	597	628.9	669.9	688.7	747.8	802

The cumulativeelectricityprobability distributioncan be obtained through regional electricity probability distribution. This section will optimize targets of CO2 emission reduction of energy conservation, reduction project and power structure adjustment in Heilongjiang power system during the planning periods under three levels of default probability (0.01, 0.03,0.05).

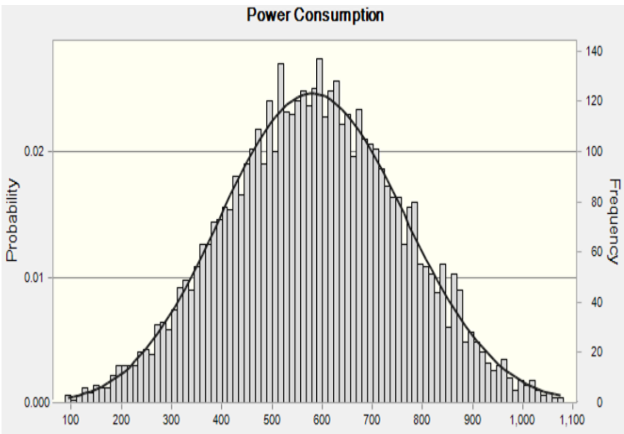

Figure 1. Regional electricity probability distribution.

III. RESULTS AND DISCUSSION

A. CO_2 Emission Reduction of Energy Conservation

According to the planning results,CO_2 emission reduction through the energy conservation in the first planning period is 1.5772 million tons, and further reduced1.3266million tons in the second period.

B. CO_2 Emission Reduction of Reduction Project

"12thFive-year" period, as a result of CCS technology is still in the stage of development, cost and energy consumption is higher, does not yet have the application level to industrialization. As issued by the ministry of science and the "12thFive-year" national carbon capture use and storage of science and technology development plan ", by the end of the "12thFive-year", breakthrough a batch of carbon capture, utilization and storage (CCUS) basic theory and key technologies, realize cost and energy consumption significantly reduce, form a megaton CCUS system design and integration capabilities[10], CCS is expected to be applied in"13thFive-year" period.

According to the result of model calculation, "13thFive-year" period in each level of the probability of default, CO_2 emission reduction is 4.1425 million tons, 3.8257 million tons and 3.8257 million tons by adopting CCS technology, involving coal unit 1.465 million kW, 1.3602 million kW and 1.3078 million kW.

C. CO_2 Emission Reduction of Structure Adjustment

CO_2structure emission reduction is relative reduction, raising the proportion of clean energy power generating by adjusting the power structure, and indirectly reducingCO_2 emissions. CO_2structure emission reduction under default probability levels in each planning period is shown in the table III.

In each default probability level, CO_2structure emission reduction is 6.5185 million tons in the first planning period through the development of clean energy generating units, the second planning period reduce CO_2 emission42.363 million tons relatively. Due to nuclear power get development in the second planning period, so CO_2relative emission reduction in the second planning period is significantly higher than the first planning period.

In particular, CO_2 emission reduction of the coal power and gas power in the planning period in the table III in bold is negative, indicating CO_2 emissionsis new incremental.

Generating capacity of thermal power and clean energy power during each planning period under default probability levels is shown in Fig. 2.

TABLE III. CO_2STRUCTURE EMISSIONS REDUCTION RESULTS IN PLANNING PERIOD

Default levels	Relative reduction（ten thousand tons）	Planning period of "12th Five-year"							
		Coal power	*Gas power*	*Water power*	*Wind power*	*Photovoltaic power*	*Biomass power*	*Geothermal power*	*Nuclear power*
0.01	651.85	**-3507.46**	**-38.78**	97.09	288.00	64.46	198.81	3.48	0
0.03	651.85	**-2869.74**	**-14.45**	97.09	288.00	64.46	198.81	3.48	0
0.05	651.85	**-2550.88**	**-8.55**	97.09	288.00	64.46	198.81	3.48	0
Default levels	**Relative reduction（ten thousand tons）**	**Planning period of "13th Five-year"**							
		Coal power	*Gas power*	*Water power*	*Wind power*	*Photovoltaic power*	*Biomass power*	*Geothermal power*	*Nuclear power*
0.01	4236.30	**-22.41**	**0**	269.70	630.00	122.78	441.81	6.97	2765.04
0.03	4236.30	**-22.41**	**0**	269.70	630.00	122.78	441.81	6.97	2765.04
0.05	4236.30	**-22.41**	**0**	269.70	630.00	122.78	441.81	6.97	2765.04

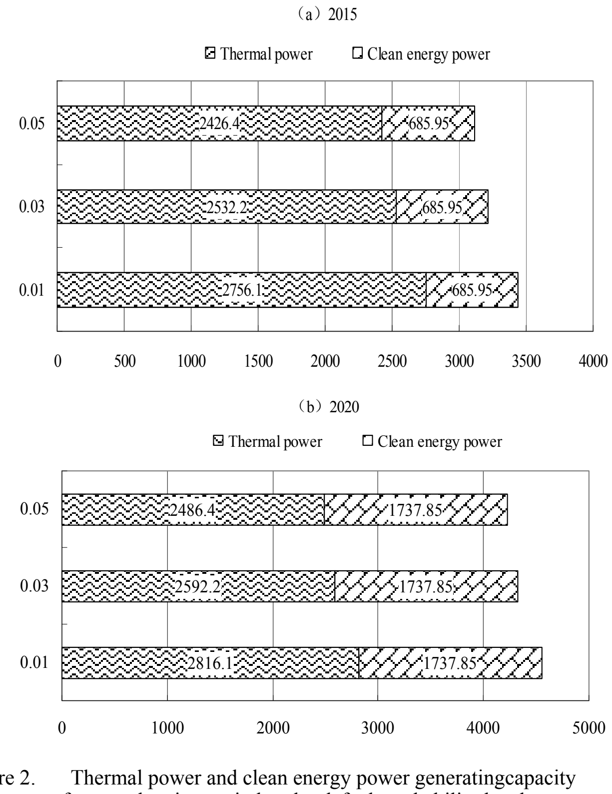

Figure 2. Thermal power and clean energy power generatingcapacity of every planning period under default probability levels. (Unit:ten thousand kW)

IV. SUMMARY

In this paper, a mixed integer stochastic chance-constraint programming model based on CO_2 emission reduction from power industry through ways of energy conservation, reduction project and power structure adjustment is applied to the power system in Heilongjiang province. According to the model calculation and the results analysis, CO_2 emission control targets of energy conservation, reduction project and power structure adjustment of Heilongjiang province during the periods of the "12thFive-year" and "13thFive-year" are obtained

Through the model recommendation, power CO_2 emissiongrowth in periods of the "12thFive-year" and "13th Five-year" are less than 23.82% and 20.13% respectively, significantly lower than the regional CO_2 emission growth, which are 47.92% and 86.62%. That is to say, the power industry has made great contribution to CO_2 emission reduction. Meanwhile, the results show that the developed model canmeetthe management target of maximizing the reduction of power CO_2 emissions,under the premise of regional economic development and energy requirements, which can provide reasonable reference to the administrative department.

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