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Pollutant Emission Reduction of Thermal Power Units with the Integration of Electric Vehicles

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Abstract. In recent years, *electric vehicles* (EVs) are very popular with the masses. The integration of EVs leads to 50% additional power capacity on thermal power units. More pollutant emission is produced in the process of power generation to meet the demand of EVs, which cannot be ignored. This paper discusses the problem of pollutant emission reduction that thermal power units produce with the integration of electric vehicles, analyzes the impact on the integration of EVs and sums up four pollutants which are sulphur oxides, nitrogen oxides, soot and residues. In addition, existing key technologies and new countermeasures, as well as data on emission reduction are provided. Two aspects are presented to get methods. One is to make improvements in power system. One is to burn proper coals, select corresponding methods on desulfurization and denitration system and improve the material of pressure and combustion parts. Another one is to make promotion of external energy aiding power generation. By integrating renewable energy with thermal power units, and integrating*co-generation of heat and power* (CHP) with *demand side management* (DSM), *circulating fluidized bed* (CFB). Analysis of the data on pollutant emission is based on *energy consumption analysis method*. It shows decrease on their emission and increase on removal. Data on residues demonstrates inevitable increment on its emission. It canbe concluded that methods above are effective and combination of technologies above may lead to a new direction on emission reduction. Besides, more attention is expected to be paid on residues reduction in the future.

Introduction

Electric vehicle (EV) is a kind of new car that complies with energy conservation and emission reduction, two keywords in recent years. EVs are popular with the masses and have a good prospect. [1,2] As such，50% additional power capacity on thermal power units is needed to meet the demand of EVs, which produces more pollutants included sulphur oxides（SO_x）, nitrogen oxides（NO_x）, soot and residues.

EVs actually cause an urgent problem to thermal power units' consumption and the future development. [3] The studyfocuseson pollutant emission reduction of thermal power units with the integration of EVs. In this paper, existing key technologies and new countermeasures to reduce pollutant emission are provided and concluded, which are from two aspects. To make improvements in power system and to make promotion of external energy aiding power generation. Some technologies are noteworthy just as *co-generation of heat and power* (CHP), *demand side management* (DSM) and *circulating fluidized bed* (CFB). The results could be beneficial to the public to briefly know about pollutant emission reduction on thermal power units. This combination may be new on emission reduction, which probably leads to new direction on emission reduction.

Literature Review

Ways to reduce pollutant emission has been proposed. In the late 80s, Lurgi Company in Germany firstly put forward a novel dry process desulphurization technology named *circulating fluidized bed-flu gas desulphurization* (CFB-FGD). The most common reaction might be acid-base reaction. To add limestone or sodium sulfite after burning can help absorb SO_2. This simple process covered less area, with low investment and calcium sulfur radio. Comprehensive utilization of by-product could be realized and the desulfurization reached 95%. [4] *Selective catalytic reduction*

(SCR) which is now commercially implemented world-wide is proved the most maturely technology of flue gas denitration. [5] And the CHP[6] refers to a group of proven technologies that operate together for the concurrent generation of electricity and useful heat in a process that is generally much more energy-efficient than the separate generation of electricity and useful heat. DSM [7] refers to the management of consumer. It helps to optimize the way of power demand. CFB [8] is a new clean coal combustion technology that is of high efficiency and low pollution.

Prospect and impact of EVs

Through the way of questionnaire, we find that more people choose to use the EVs to travel, because this kind of new car is clean, smart, environment friendly, and electricity replaces fossil fuels used as driving force. Through the investigation, *North China Electric Power University* also starts a project on EVs as rental cars for the college students and teachers. The following photo is taken in the school. [Fig. 1]

Fig. 1Electric vehicles in North China Electric Power University

How much impact do EVs have with their integration? [Fig. 2] is daily load distribution on EVs in Shenzhen Power Grid. [9] We analyzed the impact about the integration of EVs. The horizontal axis represents time. We find that the peak of curve is from 7 to 9 p.m. after work. This is because most people choose to get their EVs charged during that time zone in the evening when after work. Additional50% power capacity is in demand for EVs.

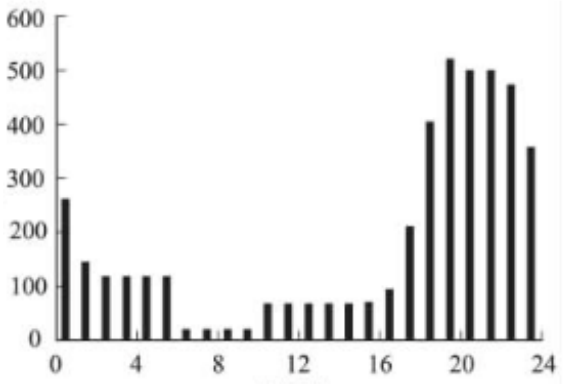

Fig.2 Daily load distribution

As [Table 1] shows, additionalcoal consumption and distribution of 1000MW power unitunder different working conditions is based on *Energyconsumption analysis method*. The first line represents different working condition of boiler and turbine. Valve whole open rating (VWO) corresponds to boiler maximum continuous rating (BMCR) of the generator under the condition of

valve whole-opening and turbine maximum continuous rating (TMCR), as well as the condition of turbine heat acceptance (THA). By subtracting the theoretical consumption from additional coal consumption, increment 144.87, 145.19, 145.23 can be clearly calculated. So, quite a few coals are expected to be burnt. More pollutant emission is to be produced.

Table1Additionalcoal consumption and distribution of 1000MW power unit

Item	Unit	VWO	TMCR	THA
Theoretical consumption	g/kWh	123	123	123
Addition in boiler	g/kWh	123.25	123.57	123.76
Addition in pipes	g/kWh	2.1	2.384	2.074
Addition in turbine	g/kWh	17.882	17.585	17.727
Addition in machine	g/kWh	0.4	0.41	0.43
Additional in generator	g/kWh	1.24	1.24	1.24
Coal consumption	g/kWh	267.87	268.19	268.23

There are four pollutants by examining the emission of coal-fired power plant which are SO_x,NO_x, soot and residues through analyzing the data according table 2, 3, and 4. Specific data of tables is obtained from coal-fired power units according to the data center of Chinese Ministry of Environmental Protection [10].

Table 2 SO_2 and NO_xproduction

Year	SO_2 production /(10kilo-ton)	NO_xproduction /(10kilo-ton)
2010	2267.8	2273.6
2011	2217.9	2404.3
2013	2043.9	2227.3

Key Technologies and Countermeasures

Emission reduction can be realized from two aspects with existing technologies and new countermeasures.

One is to make improvements in power system.Burning proper coals is helpful. Through the experiment of *ultimate analysis* and *proximate analysis*, it can befound that coals of low ash and high calorific value are supposed to be chosen. This is because the sulphur is an important composition of ash. In order to reduce sulphur oxides, we can choose to burn lignite. Methods related to equipmentson de-SO_x and de-$NO_x$is carefully selected, because de-SO_x can be treated before, during or after burning. The de-NO_x is usually treated during or after burning. Each process corresponds to different chemical reactions. The most common reaction can be acid-base reaction. Through experiment, to add limestone or sodium sulfite after burning can help absorb SO_2. And improving the material of pressure and combustion parts can help to burn fully.

Another one is the promotion of external energy aiding power generation. Integrating renewable energy with thermal power units like solar power, wind power, biomasses, and integrating CHP with DSM, CFB are effective. CHP refers to a group of proven technologies that operate together for the concurrent generation of electricity and useful heat in a process that is generally much more energy-efficient than the separate generation of electricity and useful heat. DSM helps to optimize the way of power demand, smooth the power load curves and lead us to use power, which is useful on power management and generating in a planned way. CFB is a new clean coal combustion technology that is of high efficiency and low pollution. This combination may be new on emission reduction.

Result and Discussion

This paper discussed the problem of pollutant emission reduction of thermal power units produce.It is possible that the integration of electric vehicles causes more pollutant emission. The emission can be reduced with existing technologies and new countermeasures from two aspects. To make improvements in system proper and promotion of external energy aiding power generation. In more detail, it is recognized to choose proper coals, select corresponding existing technologies on de-SO_2 and de-NO_x. Rather, they reduce pollutant emission as expected.Integrating technologies CHP with DSM, CFB may be somewhat effective. They help to smooth the power load curves and lead us to use power, which is useful on power management and generating in a planned way. This combination may be new on emission reduction.

[Table 3] is from China energy news. [11] By analyzing the data we can find total emission of SO_2 and NO_x is of 5.8% and10.9% year-on-year decline in 2015. In year 2011~2014, by contrasting the data we can clearly find that the emission of SO_2, soot and dust presents a downward trend. On the contrary, the soot and residue emission increases rapidly, for which the total emission rebounds. However, the four major pollutants still present a downward trend.

From the absolute reductions, in 2014, four major pollutants is of 243.8 ten thousand tons year-on-year increment. However, the thermal power units decrease 264.1 ten thousand tons. The contrast of the raise and the drop is obvious. This reflects the power industry makes remarkable effect and great contribution on emission reduction.

Combine the tables and the figures above; we conclude that key technologies and countermeasures are effective on soot reduction, de- SO_2 and de-NO_x. And treatments on residue also help to its reduction. Even so, the fast increment on residue production is inevitable, for which we may pay more attention on residue reduction.

Table 3Pollutant emission of power industry

year	SO_2		NO_x		Soot and Residue	
	Environment ministry	CEC	Environment ministry	CEC	Environment ministry	CEC
2011	--	913	--	1003	--	155
2012	--	883	--	948	--	151
2013	782.7	780	964.6	834	218.8	142
2014	683.4	620	783.1	620	235.5	98

Conclusion

To a large extent, the EVs indeed lead to more pollutant emission to our environment in the process of power generation on the thermal power units. It is urgent to reduce pollutants like SO_x,NO_x, soot and residues. Improving in coal-fired system and promoting of external energy aiding power generation will help a lot. Recommendations for further work may be on residue emission reduction.

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