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The importance of flexible power plant operation for Jiangsu's wind integration

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Abstract: This paper presents the influence of different regulation strategies on wind energy integration into existing Jiangsu's energy system. The ability of wind integration is defined in terms of the ability to avoid excess electricity production, to conserve primary energy consumption and to reduce CO_2 emissions in the system. Firstly, a reference model of Jiangsu's energy system is built using the energy system analysis tool EnergyPLAN based on the year 2009. The model results then are compared to actual values from 2009 to validate its accuracy. Based on the reference model, different regulations of Jiangsu's energy system are compared and analyzed in the range of a wind input from 0% to 47% of the electricity demand. It is concluded that operating power plants of existing Jiangsu's energy system in a flexible way facilitates to promote more intermittent wind integration. In addition, ramping capabilities should be an important standard for developing future power plants in Jiangsu's energy system, in order to integrate more renewable energy.

Key words: reference model, EnergyPLAN, wind integration, Jiangsu

1. Introduction

By 2020, China has an obligation to supply 15% of its total primary energy consumption from non-fossil fuels[1]. In order to reach this goal, China is strongly promoting the use of renewable energy and nuclear power. An additional incentive is the aim of establishing a strong domestic industry in wind, solar, and nuclear energy. Recently, non-hydro renewable is stimulated by various policies including

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feed-in-tariffs and a renewable energy portfolio standard for grid and power companies. For wind energy this has resulted in a spectacular growth with total installed capacity doubling four years in a row. China emerged as the largest market for wind turbines in 2010. Although a large wind potential of about 300 GW onshore and 700 GW offshore has been estimated, significant challenges exist as well. The best onshore resources are located in northern and western provinces. A consequence is that considerable transmission capacity is needed to transport the wind energy to urban demand centers. Problems with connecting far-off wind farms to the grid and the intermittency of the electricity supply are impeding China's wind energy expansion already. It is estimated that 30% of all wind turbines in China are not connected to the grid by 2010[2,3]. Due to transmission capacity limits and rigid regulation strategies, substantial wind energy has to be discarded rather than utilized. Offshore wind resources have the advantage that they are located close to the densely populated coastal regions[4], and therefore are deemed as a promising solution to relieve the severity of energy shortage in coastal regions. The deployment of offshore wind in China just started with a 100 MW wind farm off the coast near Shanghai, but a rapid growth of offshore wind farm is expected[5]. This situation in return, however, is expected to pose great challenges to existing burdened transmission system. Therefore, how to make use of tremendously increasing wind energy is an emergent issue in China.

Located on the east coast (Fig.1), Jiangsu province is one of seven 10 GW wind power bases in China (the only one to include offshore wind development). Wind power is expected to play an important role in meeting Jiangsu's growing energy demands and lowering its fossil fuel share. However, little literature have investigated the issue that how can current Jiangsu's energy system accommodate more intermittent wind. In line with this, the aim of this paper is to develop a model of Jiangsu's energy system that analyzes the implications of wind integration, identifies possible barriers and challenges, and proposes future energy strategies from a technical perspective. The first step in this process is creating a reference model by simulating Jiangsu's energy system in the most recent year. The model results then are compared to actual values from 2009 to validate its accuracy. Finally, based on the reference model, different regulations of Jiangsu's energy system are compared and analyzed in the range of a wind input from 0% to 47% of the electricity demand.

2. The energy system of Jiangsu

Jiangsu is one of the nation's most prosperous provinces, with a total population of 78.66 million living on the area of 102,600 km^2 land. In 2010, its GDP was 4.09 trillion yuan (US$ 631billion), making it the second largest GDP of all the provinces and an annual growth rate of 12.6%. Its per capita GDP was 52,000 yuan (US$ 8,024), and the share of GDP of Jiangsu's primary, secondary, and tertiary industries were 6.2%, 53.2% and 40.6%. Parallel to its high level of economic development, Jiangsu consumes a huge amount of energy. In 2009, its total primary energy consumption was approximately 1920 TWh, which originated almost 100% from fossil fuels (Fig.2). The province has low self-supporting ratio of primary energy. It imported 88.9% of coal, 93.8% of oil and 99.1% of natural gas from other provinces and countries in 2009. More than 80% of the total final energy was consumed by industry sectors. Yet, in comparison with more developed countries, energy consumption by transportation and the residential and commercial sectors in Jiangsu are rather small, indicating the potential for growth in the near future (Fig.3).

Fig.4 shows the energy flow within Jiangsu's energy system in 2009. The electricity demand of Jiangsu was 331.4 TWh with a peak load of 52.3 GW. The installed capacity of power plants was 49.5 GW in which 45.2 GW was from thermal power plants. The share of hydro, nuclear and wind energy were 2.2%, 4.0% and 1.9% respectively. Generally speaking, Jiangsu's power system is almost a pure thermal power system, in which coal-fired thermal power accounts for approximately 83%[8]. 298.4TWh of electricity was generated within Jiangsu, with a net import of 33TWh from other regions including Shanxi, Central China and Three George Dams. The electricity loss percentage was 8.15% through transmission lines. As shown in table 1, average efficiency of thermal power plants in Jiangsu was 39.7%, which is higher than the nation's average energy conversion efficiency of 33.8%. The reason is that Jiangsu has been introducing new state-of-the-art Ultra Super Critical Power plants[1] at a significant scale, whose efficiency can be as high as 45-47%[5]. The heat demand in Jiangsu for 2009 was 108.5 TWh, in which 8.5% was supplied by district heating boilers, 18.4% by industrial CHP, and 73.1% by individual boilers. District heating and CHP mainly served for factories and public buildings[9]. The transport sector consumed 42.4 TWh of diesel, 43.3 TWh of petrol and 2.1 TWh of jet fuel in 2009. The other fuels used were coal, natural gas and electricity with a share of 2.54%, 1.05% and 2.67% respectively. In summary, the current Jiangsu energy system is coal-dominated, fragmented and inefficient.

Jiangsu power grid is one of the largest provincial grids of China, with a total power load of 56 GW in 2009. The 500 kV grid connects a number of large generators of over 600 MW with a total load of 16 GW, the 220 kV grid provides for generators of 135-300 MW adding up to 30 GW of load, and the 110 kV grid serves for generators below 135 MW with a total load of 10 GW[10]. Major sites for developing wind farms located on the east coast of Jiangsu, however, the load centers mainly locate in the south of Yangze River. Since August 2006, Jiangsu has been building the Coastal Power Passage of 500 kV grid, which will cover the whole coastal area, and increase the power transmission capacity by over 3 GW [10], but it is still less than the planned installed capacity[11]. According to the province's latest issued "12^{th} five year energy plan"[12], the energy sector development will focus on nuclear power, smart grid, and wind power in 2011-2015. The installed capacity of wind energy is expected to grow tremendously in Jiangsu. Therefore, this paper aims to analyze the effective strategies of adapting the existing rigid energy system with transmission limits to integrate more wind energy in future.

3. Modeling the energy system with EnergyPLAN

3.1 Overall structure of EnergyPLAN

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[1] In the quest for higher efficiency the trend for next generation of power plants is to go for higher operating pressures. It will operate with steam pressures in the range of 300 bar and at temperatures of 615 to 630 ^{o}C. These are the Ultra Super Critical Power plants.

The EnergyPLAN model is chosen for this study for the reason that it is a computer model for hour-by-hour simulations, which is very important for studying the fluctuation nature of wind energy. Besides, EnergyPLAN is a comprehensive model for regional or national energy systems including electricity, individual and district heating, cooling, industry and transport sectors. Thus, it enables to identify problems and make strategies for the whole energy system rather than specific sectors. General inputs are demands such as electricity and district heating, renewable energy sources such as hydro and wind power, power station capacities, costs, and a number of optional different regulation strategies emphasizing import/export and excess electricity production. Outputs are energy balances and resulting annual productions, fuel consumption, import/export of electricity, CO_2 emissions and total costs including income from the exchange of electricity (Fig.5).

Another important reason for using EnergyPLAN is that it has been widely applied to a variety of related topics and contexts, and has been proved an effective tool. Previous studies include analyses the large-scale integration of renewable energy[14-18], management of CHP and renewable energy[19,20], optimal combinations of renewable energy resources into an energy system[21], renewable energy strategies for sustainable development[22], the implementation of small-scale CHP[23,24], the role of district heating in future energy system[25], integration of renewable energy into transport[26-28], a 100% renewable energy system[29-31], the use of waste for energy purposes[32], the integration of thermoelectric generators(TEG) into thermal energy systems[33], the potential of fuel cells and electrolysers in future energy-systems[34,35], the benefits of energy storage[36-38], as well as electricity market auction settings[39]. Moreover, EnergyPLAN is capable of being adapted to simulate a wide variety of national/regional energy systems. For example, EnergyPLAN has previously been applied to analyze the energy systems in Denmark, Estonia, Germany, Poland, Scotland, Spain, Ireland, Croatia, the island of Mljet in Croatia, China and Romania.

EnergyPLAN is originally developed based on the Danish energy system; therefore, several differences need to be pointed out when using it to build the Jiangsu energy model. First of all, the possibility of integrating fluctuating wind into the electricity supply is expressed in terms of the ability to avoid excess electricity production and to reduce CO_2 emissions. Unlike the situation in Denmark, electricity trade value might be less important for Jiangsu energy system as electricity market of China is more regulated rather than market-based. Here the analyses have been made solely from a technical point of view, economic analyses are not included. Second, the ability of integrating renewable energy depends not only on the fluctuations in the renewable source but also of the fluctuations in the demand and the flexibility of the rest of the supply system. Economic growth of Jiangsu has been sustained by large amount of energy consumption, while this is not the case in Denmark. Danish Energy Policy has succeeded in stabilizing primary energy supply during a period of 30 years. Insulation of houses and an extensive expansion in the use of CHP has led to decrease in fuel consumption for domestic heating. This was achieved during a period of 30 years of economic growth, in which the number of houses increased. Therefore, the analyses of wind integration into future Jiangsu's energy system depend largely on its long-term energy strategies especially on the improvement of industrial energy efficiency, while Danish experience on residential energy conservation can be learned as well. Finally, the input data includes Jiangsu energy balance data from the Chinese energy statistical yearbook 2010[7], Jiangsu statistical yearbook 2010[6], Jiangsu electric power company[40], Jiangsu electricity regulatory commission[41]. Unfortunately, we cannot gather hourly distribution data of electricity demand and wind production in Jiangsu. Therefore, some conversions are made based on the monthly distribution data of Jiangsu and some empirical data from Denmark and other countries. For example, monthly distribution data for electricity consumption in Jiangsu is converted into hourly distribution data in the assumption that the general trend of electricity consumption between work days and weekends is the same as that in Denmark. One related issue is that Jiangsu has a high percentage of industry energy consumption, thus the hourly distribution data of electricity consumption is expected to be more stable compared to that in Denmark. Besides, hourly distribution data of wind energy production is created for Jiangsu taken the assumption of an average full-loaded hour of 2000-2200 h for onshore wind farms and 2500 h for offshore wind farms.

3.2 Validation of 2009 reference model

Once the inputs are gathered, the reference model is simulated on an hourly time resolution over the year 2009. One of the most important characteristic in the energy system model is the balance of electricity generation and consumption. The total electricity generated for 2009 (298.4 TWh) plus a 33 TWh net import is simulated correctly in the model. As seen in Table 2, the total electricity generated from various production units is very similar in both the actual 2009 figure and the results from the reference model. Thermal power plant contributed 91.4% of the provincial electricity supply and satisfied 82.3% of the total electricity demands. Also the distribution of the electricity generated over the year is simulated accurately, as indicated by the average monthly electricity demands displayed in Table 3. The maximum difference between actual value and simulation is 1.15% in September. Regarding heat balance of Jiangsu's energy system, the total heat demand of 108.5 TWh was supplied by district heating with boilers, industrial CHPs and individual boilers.

Another significant indicator is the balance of fuel consumption in the energy system. The total fuel consumption within Jiangsu's energy system is compared with those calculated in EnergyPLAN as showed in Table 4. It is clear that the model provides an accurate representation of the actual fuel consumption on the Jiangsu energy system in 2009, as the largest difference that occurred is 1.7%, which is for oil consumption.

4. Wind penetrations on Jiangsu's energy system

The potential of onshore and offshore wind in Jiangsu province is estimated to be 30 GW and 32 GW respectively, which can satisfy approximately 47% of the electricity demand in 2009. As mentioned above, import/export takes account of merely 10% of electricity demand in Jiangsu's energy system. Therefore, it is reasonable to consider existing Jiangsu's energy system as a closed system in this study. The ability of integrating fluctuating wind into the electricity supply is expressed in terms of the ability to avoid excess electricity production, to conserve primary energy consumption and to reduce CO_2 emissions in the system. Based on the 2009 reference model, different regulations are designed and compared for its ability of wind penetration:

- Regulation I: a minimum 10 GW of power plants are operating all the year around in the system and minimum 30% of the production must come from grid stabilizing power stations.
- Regulation II: a minimum 12.5 GW of power plants are operating all the year around in the system and minimum 50% of the production must come from grid stabilizing power stations.
- Regulation III: a minimum 15 GW of power plants are operating all the year around in the system and minimum 70% of the production must come from grid stabilizing power stations.

In Fig. 6, it compares critical excess electricity production under different regulations as more wind integration. Under regulation I, the minimum 30% of the grid stabilization share is based on the Danish TSO experience, and the minimum10GW of power plants operating all the year around equals that at least 52% of installed power plant capacities are utilized based on an annual average operation hour of 4700h in Jiangsu's energy system. CEEP[2] begins to appear as wind energy meets 10% of electricity demands in Jiangsu's energy system. A total amount of 24.25 TWh CEEP is expected to be produced as integrating the whole potential of wind energy into existing Jiangsu's energy system. Contrast to regulation I, a more rigid thermal-based energy system (78% of installed power plant capacities are utilized) will produce 126.47 TWh CEEP with a 47% of wind integration as showed in regulation III, that is, 82% of wind production is expected to be wasted due to rigid operation of power plants. An intermediate scenario is regulation II, the minimum 50% of the grid stabilization share is higher than the Danish experience, and 12 GW represents that only 65% of installed power plant capacities are rigid in the system while the other 35% are more flexible power stations. In this case, CEEP occurs as wind energy takes account of 6% of electricity supply in the system.

Then, comparisons of primary energy conservation and CO_2 emission reductions in the system for more wind penetration under different regulations are showed in Fig. 7 and Fig. 8 respectively. Under regulation I, the consumption of primary energy and CO_2 emissions keep decreasing as more wind penetrations in Jiangsu's energy system. The percentage of primary energy conservation is 13% and the

[2] CEEP is the amount of excess electricity production that could not be used or exported (due to inadequate interconnection capacity) in energy system. The consequences of CEEP is stopping the wind turbines to reduce production.

amount of CO_2 emission reductions is 85 Mt as wind integrated from 0% to 47% into the existing energy system. Different from the situation under regulation I, the lowest fuel consumption and CO_2 emissions of the system occurs at a wind penetration of approximately 34% and 15% respectively under regulation II and III. The percentage of primary energy conservation is 8% and 3% respectively, and the amount of CO_2 emission reductions is 50 and 21 Mt respectively under regulation II and III with the optimum wind penetration. Therefore, it can be concluded that the ability of wind penetration into existing Jiangsu's energy system are highly dependent on the flexibility of power plant operation.

Finally, the effects of increasing wind penetrations on conventional power plants under the above-mentioned regulations are showend in Table 5, 6 and 7 respectively. The hourly demand on power plants is analyzed for different wind penetrations, and the scale and frequency of power-plant ramping by hour is analyzed. The higher wind penetrations in the energy system, the more demands for ramping power plants both up and down. For a wind penetration of 42%, the power plants in Jiangsu's energy system would need to be able to ramp up by a maximum 20,746 MW in an hour, and ramp down by a maximum of 20,321 MW in an hour under both regulations I and II. In addition, the scale and frequency of regulating power plants in an hour increase greatly as more wind penetrations, but differs under designed regulation I, II and III. A general trend is that the higher the minimum share of grid stabilizing power stations, the lower scale and frequency of power-plant ramping in an hour as more wind penetrations. Taking the 42% of wind penetration as an example, the power plants need to be able to ramp up/down between 5,000 MW and 10,000 MW 375/190 times respectively, and between 2,000 MW and 5,000 MW 892/1355 times respectively under regulation I. But as for higher share of minimum power plants operation in regulation III, the number of ramping up/down is 309/216 times respectively between 5,000 MW and 10,000 MW, and 679/794 times respectively between 2,000 MW and 5,000 MW. It is evident that ramping capabilities of future power plants that are to be built in Jiangsu's energy system should be an important issue, in order to facilitate the integration of more renewable energy.

5. Conclusion

Wind integration into a location with high energy demands from a technical perspective has been discussed in this paper. With this goal in mind, an existing Jiangsu energy system has been built by using the energy system analysis tool EnergyPLAN based on the year 2009. Firstly, the accuracy of the model has been verified by comparing the calculated results from the model with actual statistics from the year 2009. After validating the accuracy of the reference model, different regulation strategies of Jiangsu's energy system are compared and analyzed in the range of a wind power from 0% to 47% of the electricity demand. The ability of wind integration is defined by the ability to avoid excess electricity production, to conserve primary energy consumptions and to reduce CO_2 emissions in the system. The existing energy system of Jiangsu is more in accordance with the condition under regulation III, thus the problem of critical excess electricity production would be quite severe as more wind integration in future. It is concluded that a flexible operation of power plants enables the existing energy system to avoid excess electricity production as more wind penetration, and thus conserve more primary energy consumption and reduce more CO_2 emissions in the system. In addition, ramping capabilities should be an important standard for developing future power plants in Jiangsu's energy system, in order to integrate more renewable energy.

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Figure Captions

Fig.1 Location of Jiangsu province

Fig.2 Percentage of different fuels in primary energy consumption of Jiangsu in 2009

Fig.3 Final energy consumption by sectors of Jiangsu in 2009 (TWh)

Fig.4 Energy flow of Jiangsu's energy system in 2009

Fig.5 The structure of EnergyPLAN 9.0

Fig.6 Excess electricty in the 2009 Jiangsu energy system for increasing wind penetrations

Fig.7 Primary energy supply in the 2009 Jiangsu energy system for increasing wind penetrations

Fig.8 CO_2 emissions in the 2009 Jiangsu energy system for increasing wind penetrations

Fig.1 For color and B&W reproduction

Fig.1 Location of Jiangsu province

Fig.2 For color reproduction

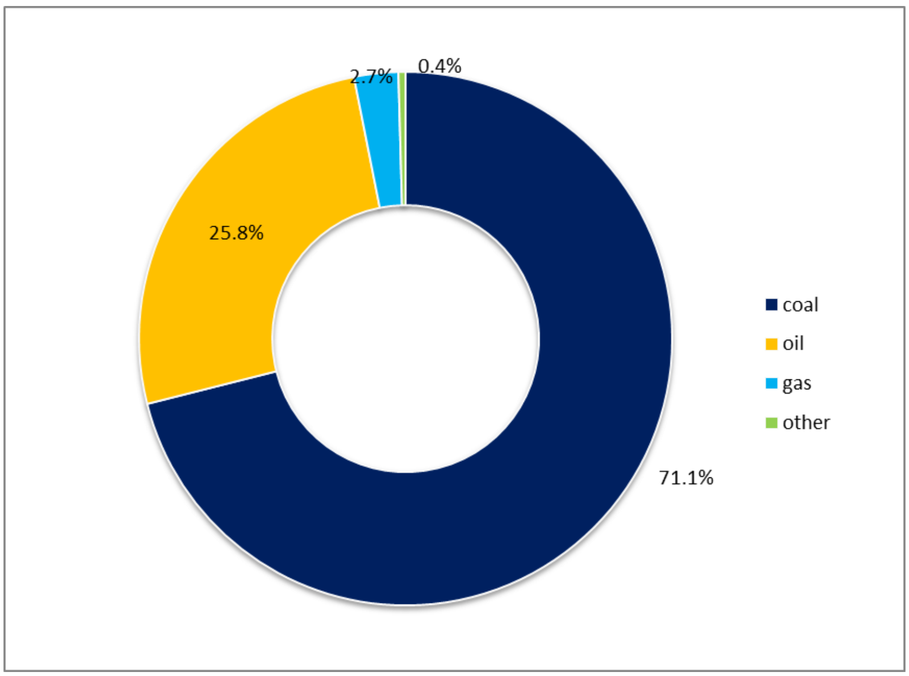

Fig.2 Percentage of different fuels in primary energy consumption of Jiangsu in 2009[6]

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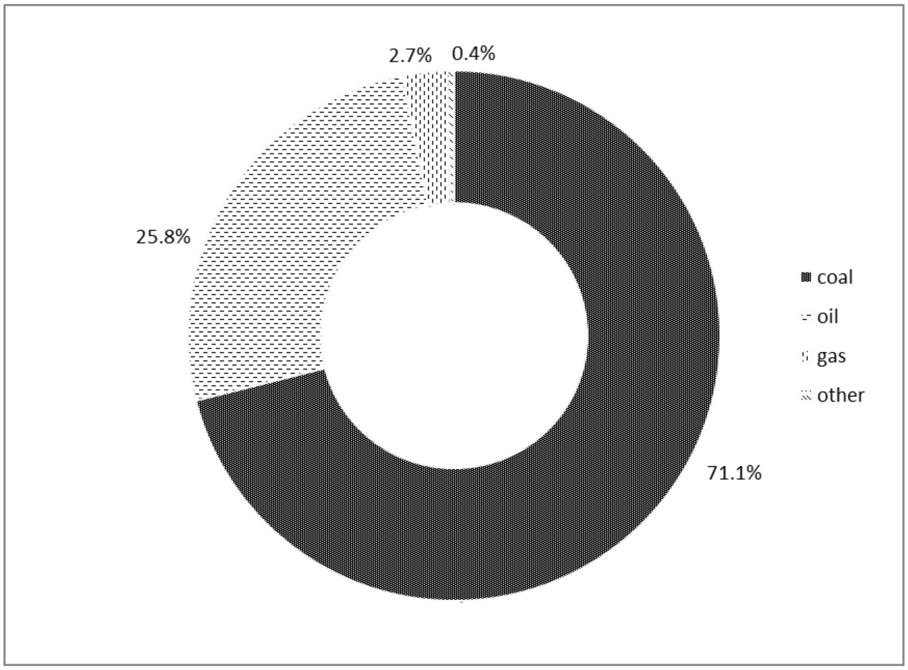

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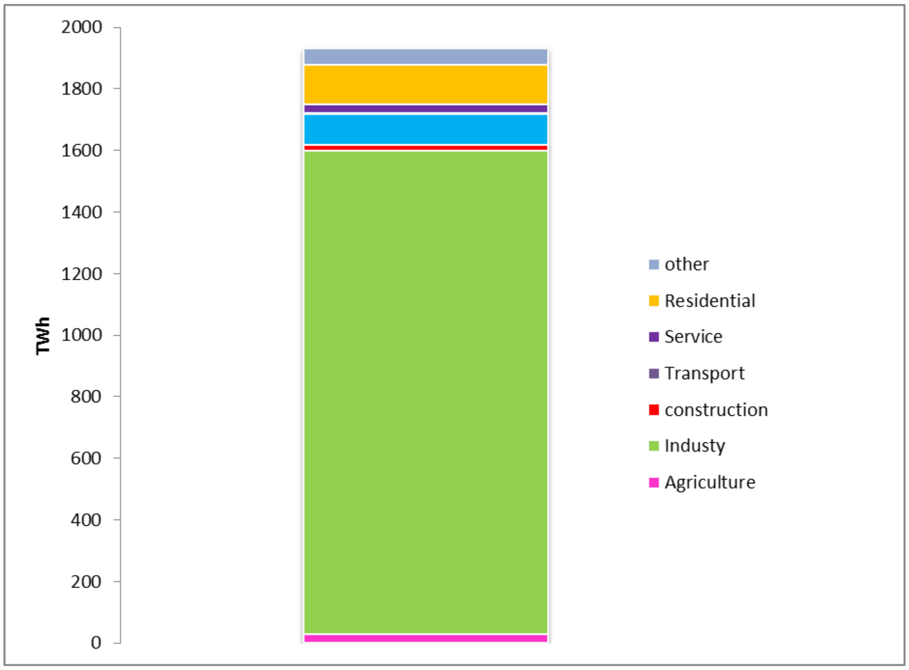

Fig.3 Final energy consumption by sectors of Jiangsu in 2009 (TWh)[7]

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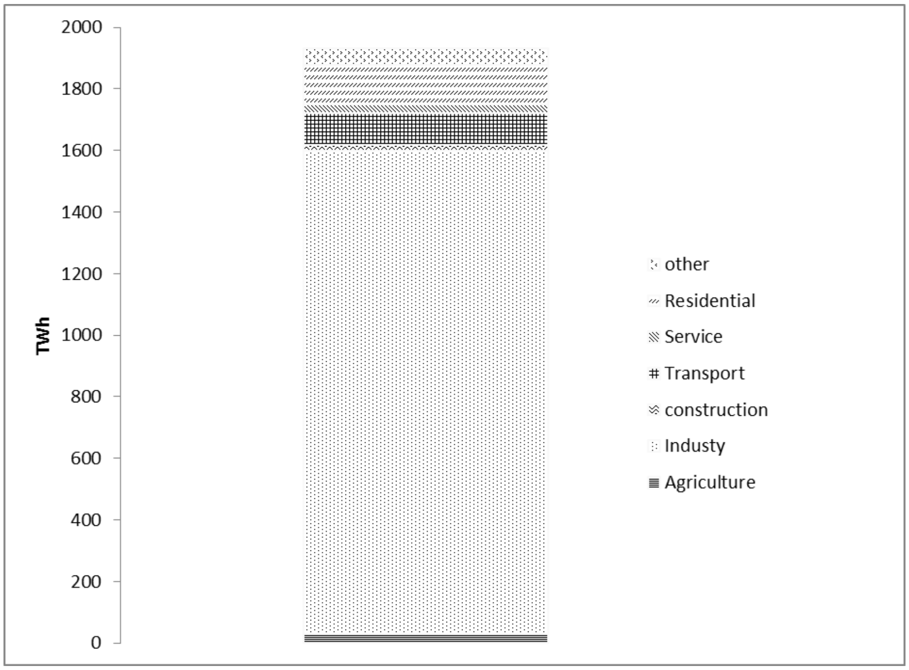

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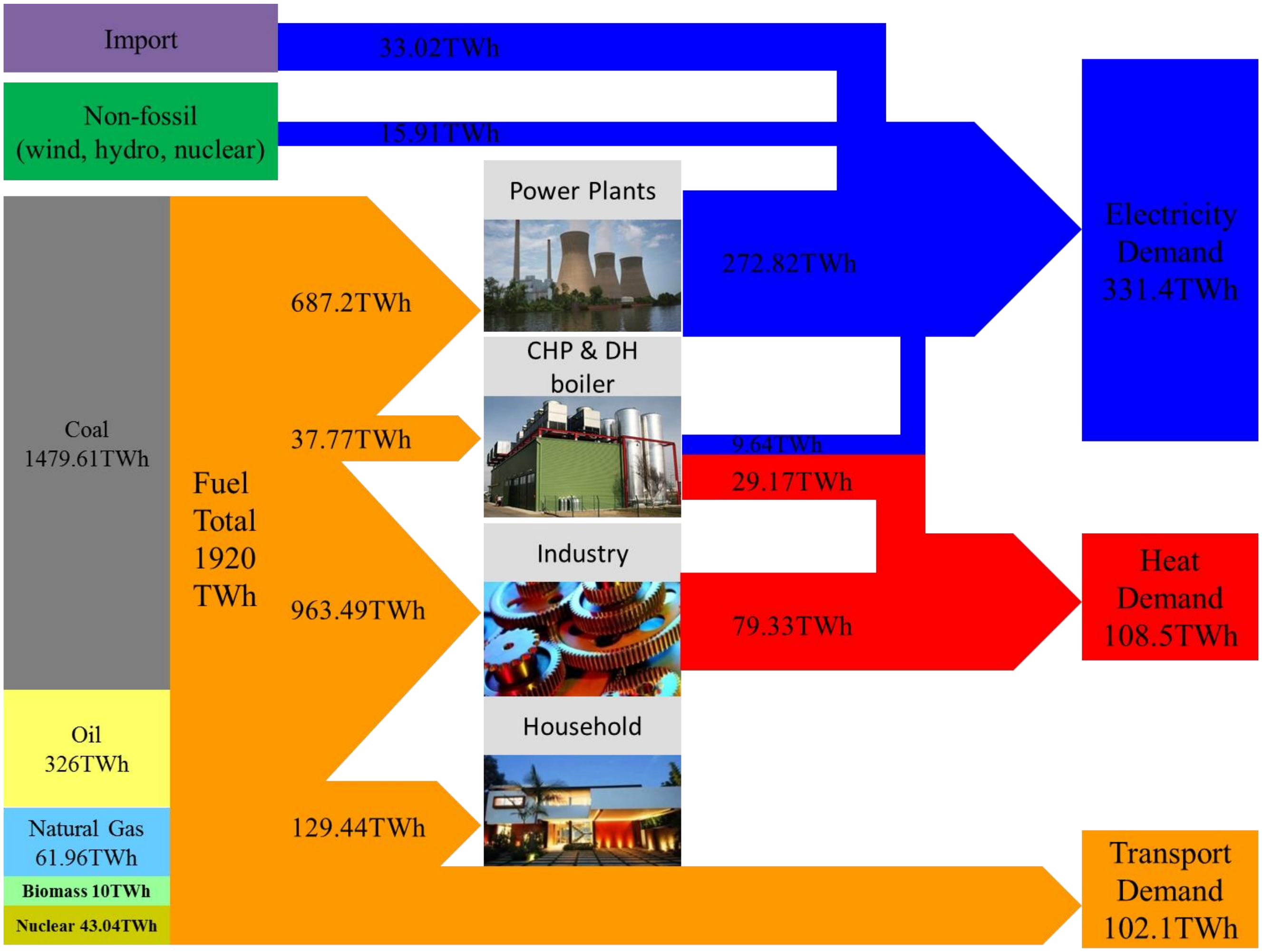

Fig.4 Energy flow of Jiangsu's energy system in 2009

Fig.5 For color and B&W reproduction

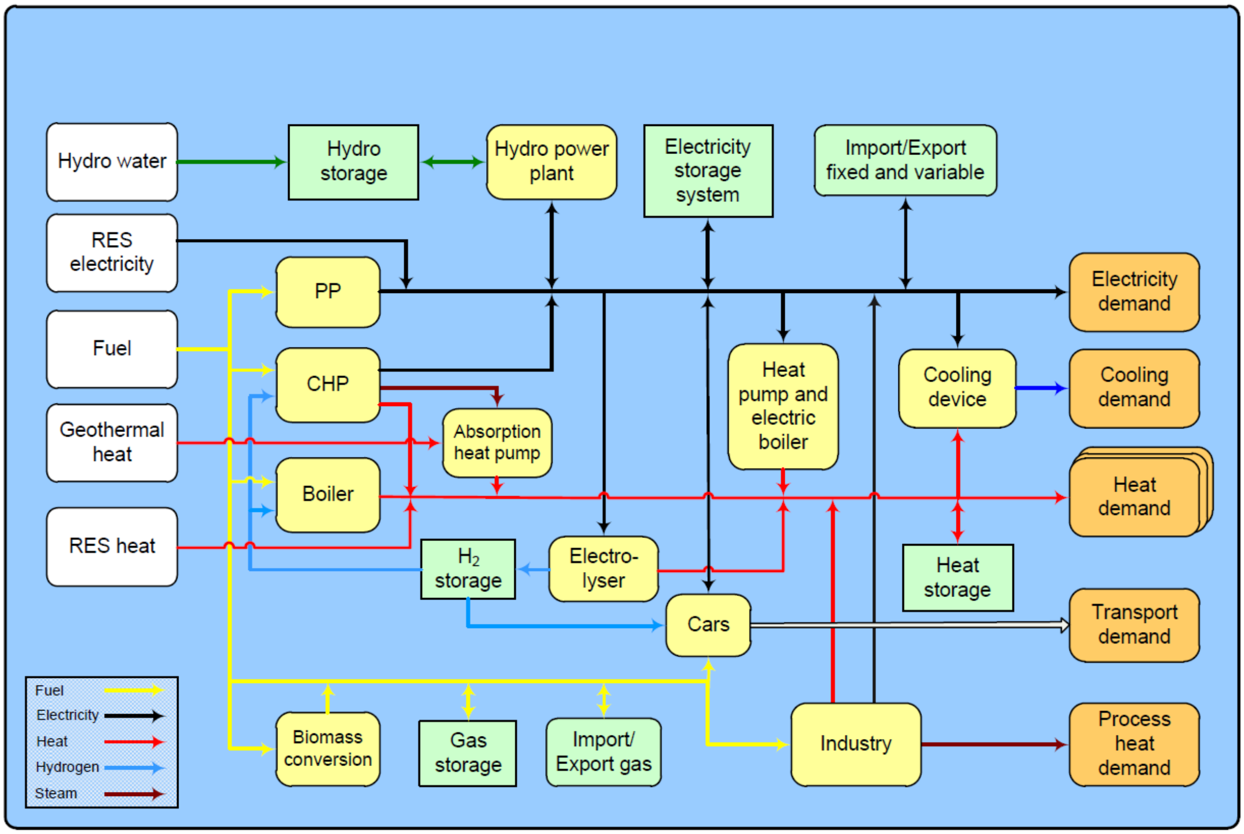

Fig.5 The structure of EnergyPLAN 9.0[13]

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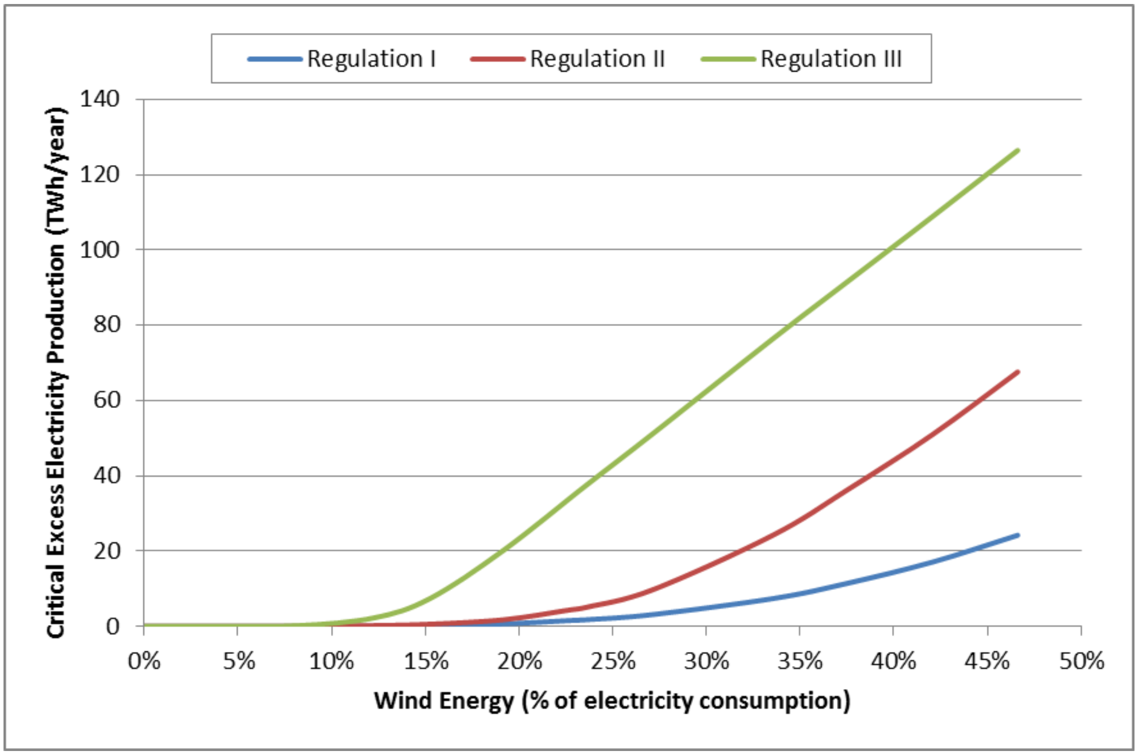

Fig.6 Excess electricty in the 2009 Jiangsu energy system for increasing wind penetrations

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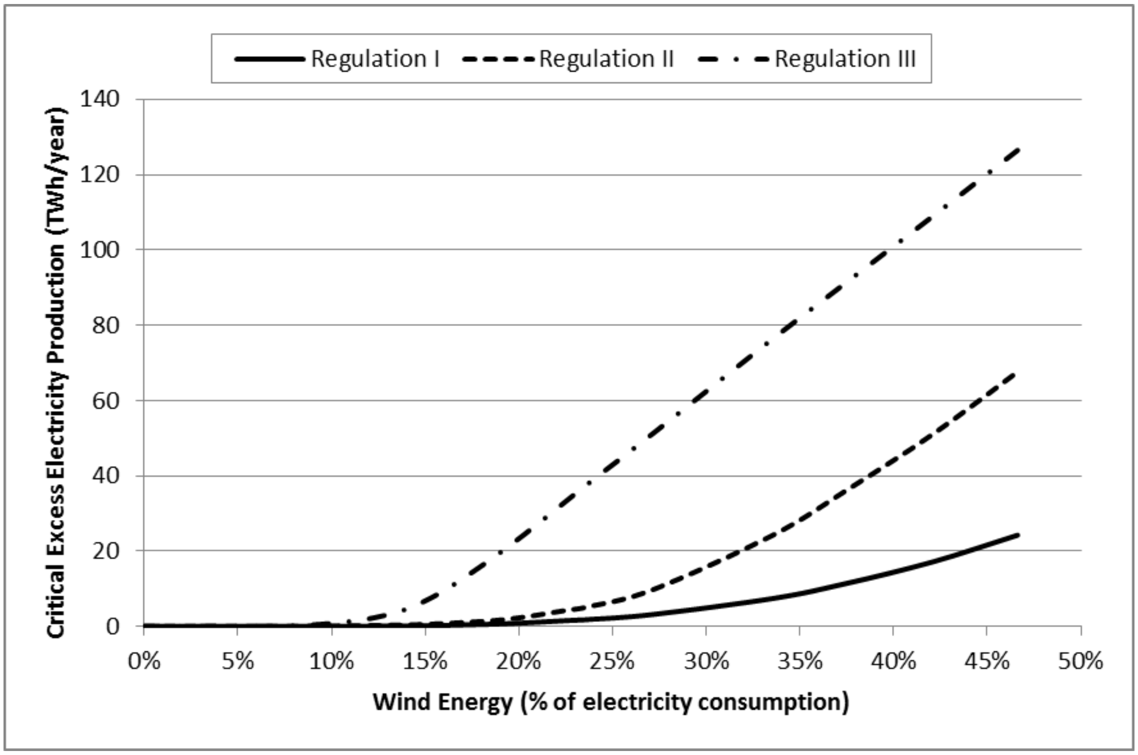

Fig.6 Excess electricty in the 2009 Jiangsu energy system for increasing wind penetrations

Fig.7 For color reproduction

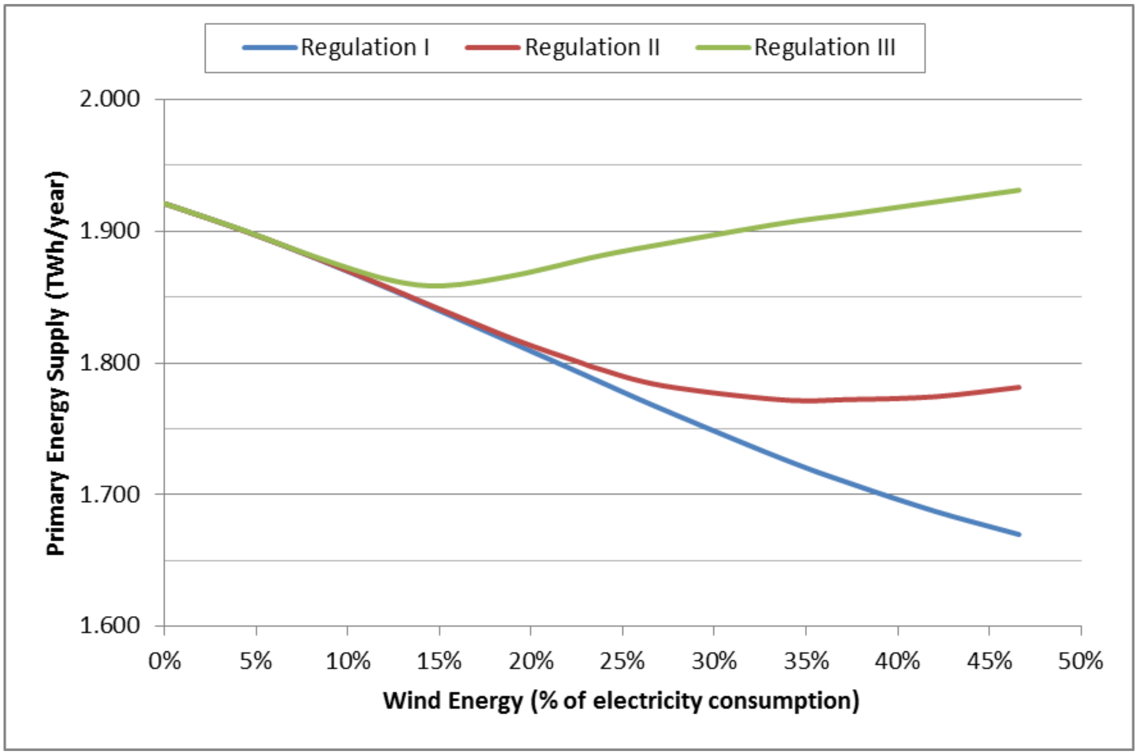

Fig.7 Primary energy supply in the 2009 Jiangsu energy system for increasing wind penetrations

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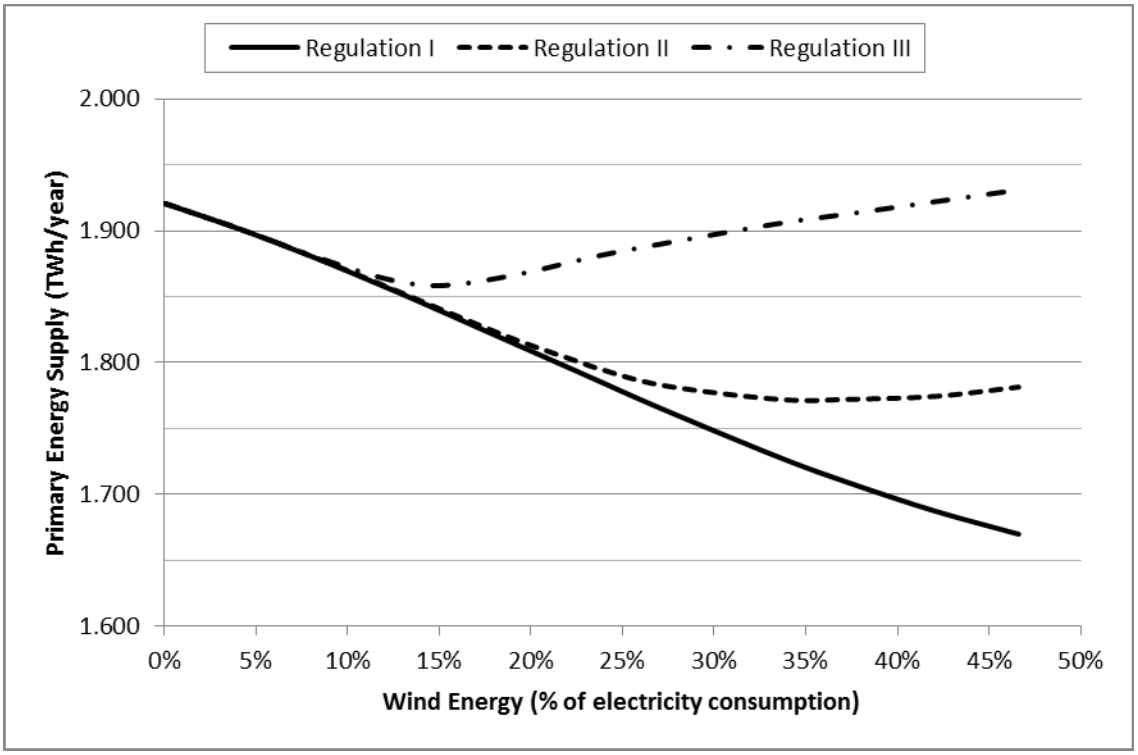

Fig.7 Primary energy supply in the 2009 Jiangsu energy system for increasing wind penetrations

Fig.8 For color reproduction

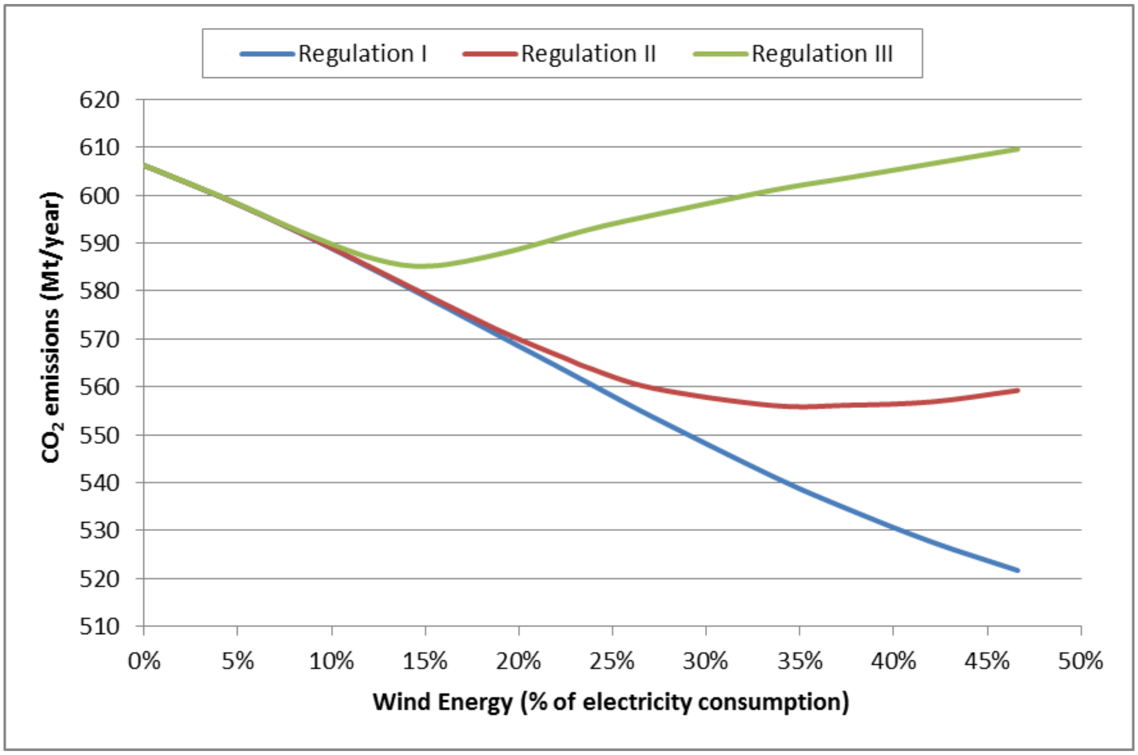

Fig.8 CO_2 emissions in the 2009 Jiangsu energy system for increasing wind penetrations

For B&W reproduction

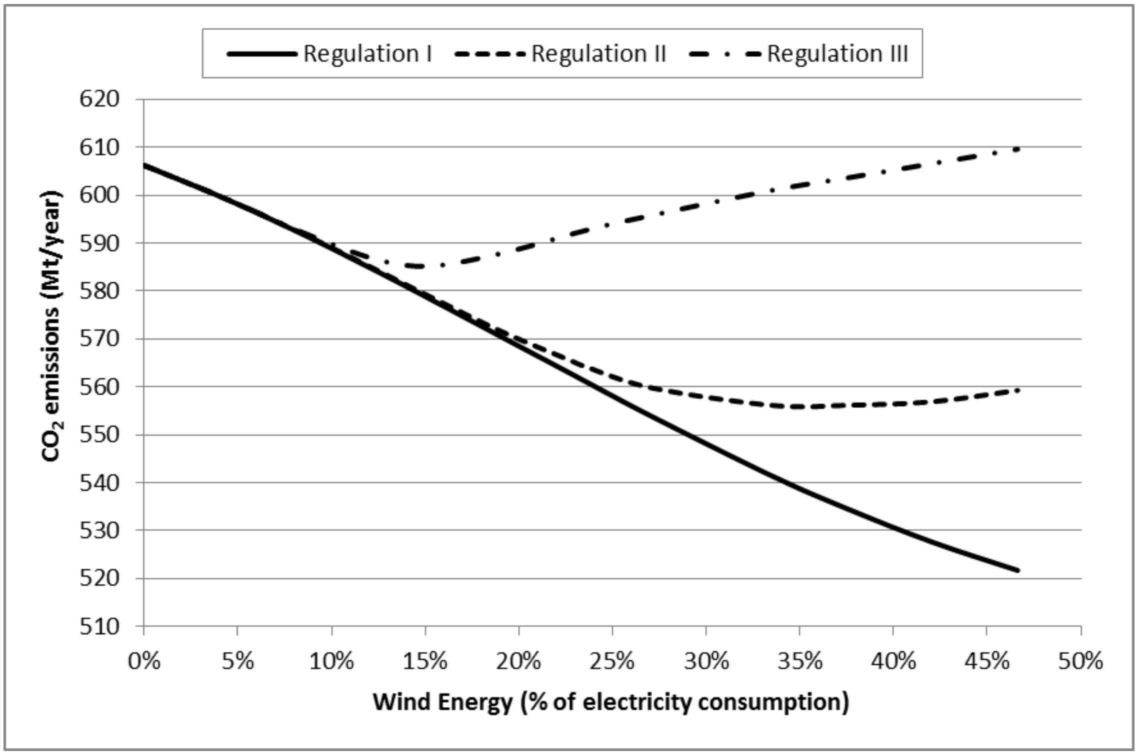

Fig.8 CO_2 emissions in the 2009 Jiangsu energy system for increasing wind penetrations

Table Captions

Table 1 Efficiencies calculated for power plants of different fuel types

Plant type	**Capacity (MW)**	**Electricity generated(TWh)**	**Fuel used (TWh)**	**Efficiency (%)**
Thermal PP[a]	45252	272.84	687.20	39.70
Industrial CHP[b]	1500	9.64	33.60	28.69
Wind	945	1.45	-	-
Hydro	1100	0.27	-	-
Nuclear	2000	14.20	43.04	32.99
Net import	-	33.00	-	-

[a] Fuel used in thermal PP includes coal, natural gas, waste and biomass.

[b] Industrial CHP are coal-fired with an average thermal efficiency of 51.5%.

Table 2 Comparison of electricity and heating generation in 2009 and the EnergyPLAN simulation

Plant type	Generation (TWh)		Difference (TWh)	Difference (%)
	Actual 2009	EnergyPLAN 2009		
Electricity				
Thermal PP	272.84	272.82	-0.02	-0.01
Industrial CHP	9.64	9.64	0.00	0.00
Wind	1.45	1.45	0.00	0.00
Hydro[a]	0.27	0.27	0.00	0.00
Nuclear	14.20	14.20	0.00	0.00
Net import	33.00	33.02	0.02	0.06
Heating				
District heating by boilers	9.17	9.17	0.00	0.00
Industrial CHPs	20.00	20.00	0.00	0.00
Individual boilers	79.33	79.33	0.00	0.00

[a] Including both normal and pumped hydro.

Table 3 Comparison of actual average monthly electricity demands and calculated values from the EnergyPLAN in 2009

Month	**Average monthly electricity demand(MW)**		**Difference (MW)**	**Difference (%)**
	Actual 2009	EnergyPLAN 2009		
January	28,892	28,812	-80	-0.28
February	32,967	33,080	113	0.34
March	35,735	35,433	-302	-0.85
April	35,054	35,125	71	0.20
May	35,477	35,626	149	0.42
June	39,969	39,685	-284	-0.71
July	42,949	42,981	32	0.07
August	42,691	42,437	-254	-0.59
September	39,299	38,846	-453	-1.15
October	36,712	36,998	286	0.78
November	40,626	40,626	0	0.00
December	43,243	42,890	-353	-0.82

Table 4 Comparison of total fuel consumptions and the EnergyPLAN simulation in 2009

Type	**Total fuel consumptions(TWh)**		**Difference (TWh)**	**Difference (%)**
	Actual 2009	EnergyPLAN 2009		
Coal	1470.60	1479.00	1.39	0.09
Oil	331.65	326.00	-5.65	-1.70
Natural gas	61.96	61.97	0.01	0.02
Biomass & Renewable	10.00	10.00	0.00	0.00
Nuclear	-	43.04	-	-
Total	1917.25	1920.01	2.76	0.00

Table 5 Hourly fluctuation in power-plant output for various wind penetrations under regulation I

Wind energy (TWh)	Wind integration (%)	Max ramp up (MW)	Max ramp down (MW)	Number of hours with ramp ups			Number of hours with ramp downs		
				>10000MW	>5000 & <10000 MW	>2000 & <5000 MW	>10000MW	>5000 & <10000MW	>2000 & <5000MW
5	1.50	13,799	14,767	1	174	698	1	2	805
10	2.99	14,124	15,048	1	191	713	1	2	838
20	5.99	14,562	15,375	1	232	719	1	4	937
40	11.97	15,438	16,028	3	288	755	1	15	1084
60	17.96	16,178	16,526	6	338	860	2	48	1299
80	23.94	17,191	17,421	14	373	880	3	79	1389
100	29.93	18,451	18,414	28	381	904	2	128	1388
120	35.92	19,396	19,146	36	384	911	2	159	1425
140	41.90	20,746	20,321	35	375	892	2	190	1355

Table 6 Hourly fluctuation in power-plant output for various wind penetrations under regulation II

Wind energy (TWh)	Wind integration (%)	Max ramp up (MW)	Max ramp down (MW)	Number of hours with ramp ups			Number of hours with ramp downs		
				>10000MW	>5000 & <10000 MW	>2000 & <5000 MW	>10000MW	>5000 & <10000MW	>2000 & <5000MW
5	1.50	13,799	14,767	1	174	698	1	2	805
10	2.99	14,124	15,048	1	191	712	1	2	838
20	5.99	14,562	15,375	1	232	719	1	4	936
40	11.97	15,438	16,028	3	288	746	1	15	1074
60	17.96	16,178	16,526	5	334	848	2	46	1278
80	23.94	17,191	17,335	15	352	882	2	79	1358
100	29.93	18,451	18,414	26	338	939	2	98	1366
120	35.92	19,396	19,146	26	351	982	2	131	1455
140	41.90	20,746	20,321	23	340	1099	3	189	1428

Table 7 Hourly fluctuation in power-plant output for various wind penetrations under regulation III

Wind energy (TWh)	Wind integration (%)	Max ramp up (MW)	Max ramp down (MW)	Number of hours with ramp ups			Number of hours with ramp downs		
				>10000MW	>5000 & <10000 MW	>2000 & <5000 MW	>10000MW	>5000 & <10000MW	>2000 & <5000MW
5	1.50	13,799	14,767	1	174	697	1	2	805
10	2.99	14,124	15,048	1	191	712	1	2	838
20	5.99	14,562	15,375	1	232	713	1	4	934
40	11.97	15,438	16,028	4	285	769	2	18	1083
60	17.96	16,178	16,526	4	323	890	3	74	1236
80	23.94	17,191	17,335	6	320	935	8	120	1209
100	29.93	18,451	18,414	11	308	839	12	164	1042
120	35.92	19,396	19,146	17	312	747	17	188	953
140	41.90	19,784	19,784	23	309	679	24	216	794