OPTIMAL SIZING OF DISTRIBUTED GENERATIONS IN MICROGRID SYSTEM

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0 Introduction

Crisis: carbon dioxide emissions

world energy-related carbon dioxide emissions rise from 30.2 billion metric tons in 2008 to 35.2 billion metric tons in 2020 and 43.2 billion metric tons in 2035----43%[1]. The low-carbon power technologies have aroused wide concerned.

What can Microgrid do?----

we concern:

1.How can Microgrid efficiently utilize wind , solar energy?

2.How can we provide electrical power with high reliability ?

3.How can user afford expensive renewable energy?

1. U.S. Energy Information Administration. International Energy Outlook 2011[R],2011.

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1 The Optimal sizing model of Distributed Generation in Micro-grid system

(1)Objective Function

This paper established objective function including low-carbon forms of energy and high-carbon energy , set object **of minimizing the full life cycle costs**, described below. :

C_{CF} full life cycle costs (J –Life cycle form)

I_{t_i} Initial investment costs

M_{t_i} Maintenance costs

F_{t_i} Carbon Punishment

r Discount rate

(2)Constraints

Output of power

Randomness of the local weather resources affect renewable energy utilization efficiency, and its output is often less than the capacity of the units

$$P_i \le p_i x_i$$

P_i Output of units

p_i Output of a single unit

x_i Number of one type of units

Reliability

$$R_{LPSP} = 1 - T_{miss} / T$$

R_{LPSP} Reliability of the system

T 8760h

(3)Problem

due to wind and solar randomly change with weather

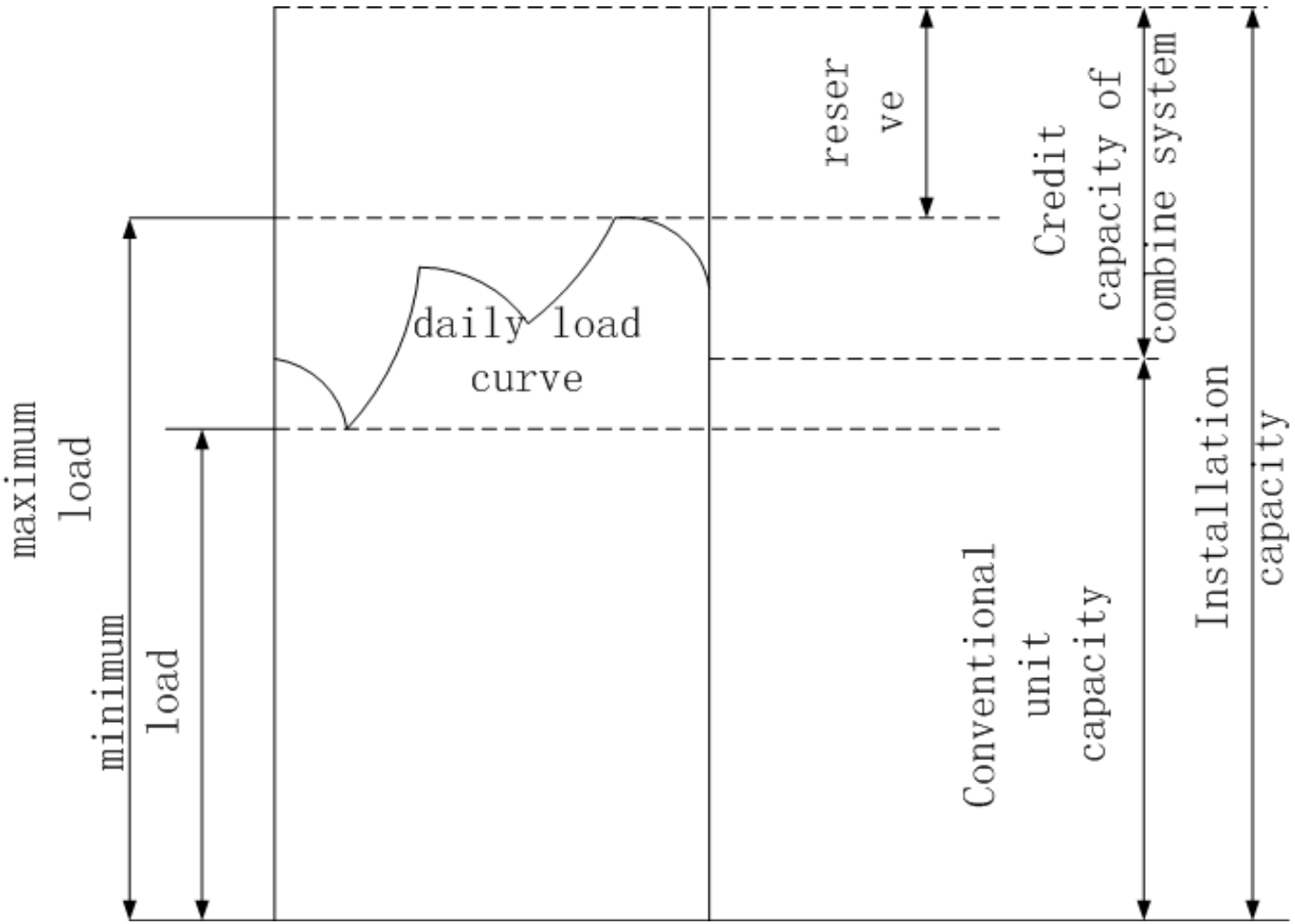
It is hard to calculate:

1. electric quantity that produced by each generation
2. reliability

To simulate the probabilistic production:

Method : Probabilistic Method

2.Method ----Probabilistic Method

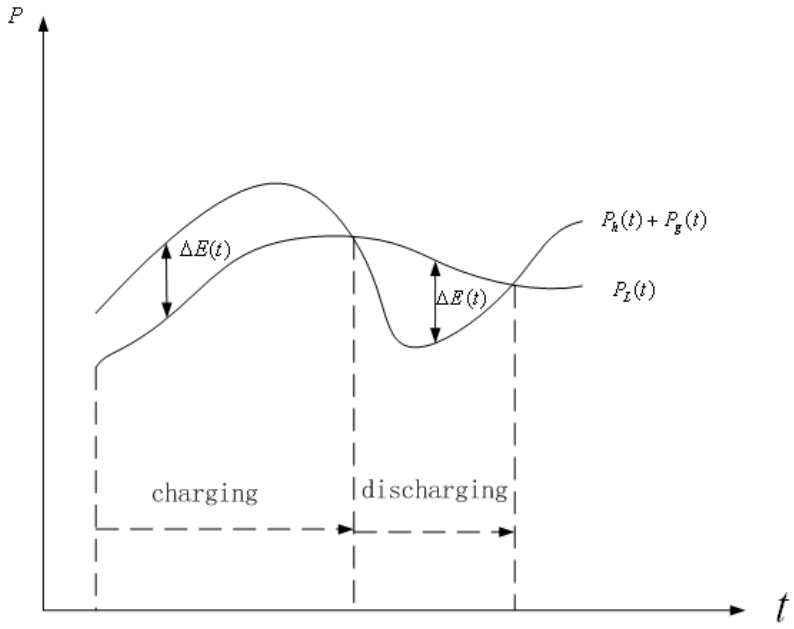


2.Method ----Probabilistic Method

to calculate:

1. **electric power that produced by each generator**
2. **Fuel costs**
3. reliability

According to the load and generation output curve，
Power Shortage is calculated as follows:



$$\Delta P(t) = | P_L(t) - P_h(t) - P_G(t) |$$

$P_L(t)$ Load curve

$P_h(t)$ Output of generation system integrated with wind farm and photovoltaic system

$P_G(t)$ Output of tradition units

2.Method ----Probabilistic Method

If the state of charge can not afford Power Shortage， the load will be lost.

$$X_{dc}(t-1)-\Delta P(t)<0$$

$X_{dc}(t-1)$ Charge of storage energy

$\Delta P(\mathrm{t})$ Power Shortage

accumulate the lost load hours T_{miss}

Reliability: $R=1-T_{miss}/T$

2.Method ----Probabilistic Method

Monte Carlo：

1. According to probability density function ψ(x) to generate random variable x, and calculate the output f(x)
2. accumulate f(x) at every turn , and average it.

Based on Monte Carlo method，calculate the above value：

$$f(x) = \frac{\sum_{i=1}^{N} f(x_i)}{N}$$

3. Simulation example

Take an independent island micro-grid at China as an example. the maxmum of the system load is 7.5MW

Nature resources of this places is as followings:

Table 1 Data of wind speed

month	1	2	3	4	5	6
Wind speed（m/s）	9.4	7.2	7.0	6.0	7.3	7.3
month	7	8	9	10	11	12
Wind speed（m/s）	7.0	5.4	5.8	9.2	6.4	7.9

Table 2 Data of solar radiation

month	1	2	3	4	5	6
Solar radiation(kWh/m2/d)	2.993	3.323	3.798	5.279	5.825	5.113
month	7	8	9	10	11	12
Solar radiation(kWh/m2/d)	5.495	5.083	5.706	5.111	3.626	3.449

Case1: Limit the capacity of tradition units

Table 3. Optimization results with approximate LOLE(Loss Of Load Expectation)

LOLE（h）	Wind	photovoltaic	Storage energy	Tradition units	Virtual units
9.15	0	0	0	7Mw	1.4 Mw
9.22	0	0	0	8.9 Mw	0
9.28	9.1Mw	0	0.95 Mwh	7 Mw	0
9.24	4Mw	2.1Mw	0.95Mwh	7 Mw	0
9.18	0	11.35Mw	0.95Mwh	7 Mw	0

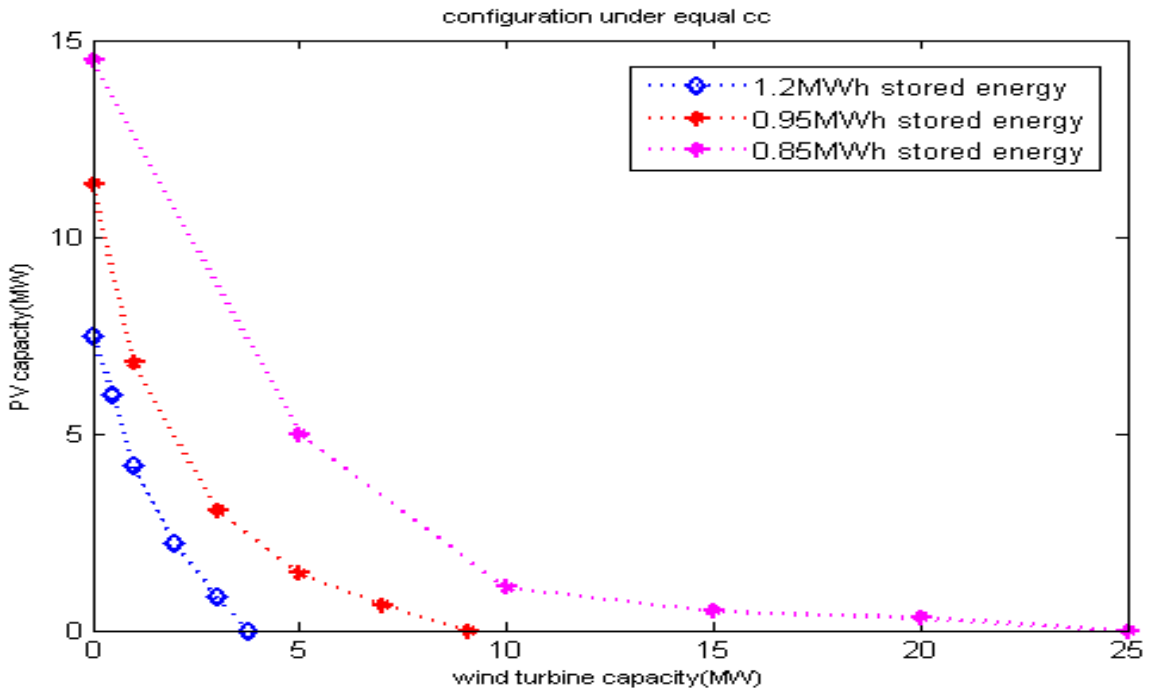
When 7Mw Tradition units is set, 1.4Mw Virtual units Or 1.9Mw Tradition units to grid can achieve the equal reliability. The demand of credit capacity of combined power generation system of wind turbine and photo voltaic is 1.4Mw.

credit capacity of combined power generations

set the credit capacity of combined power generation .Calculate all the configuration

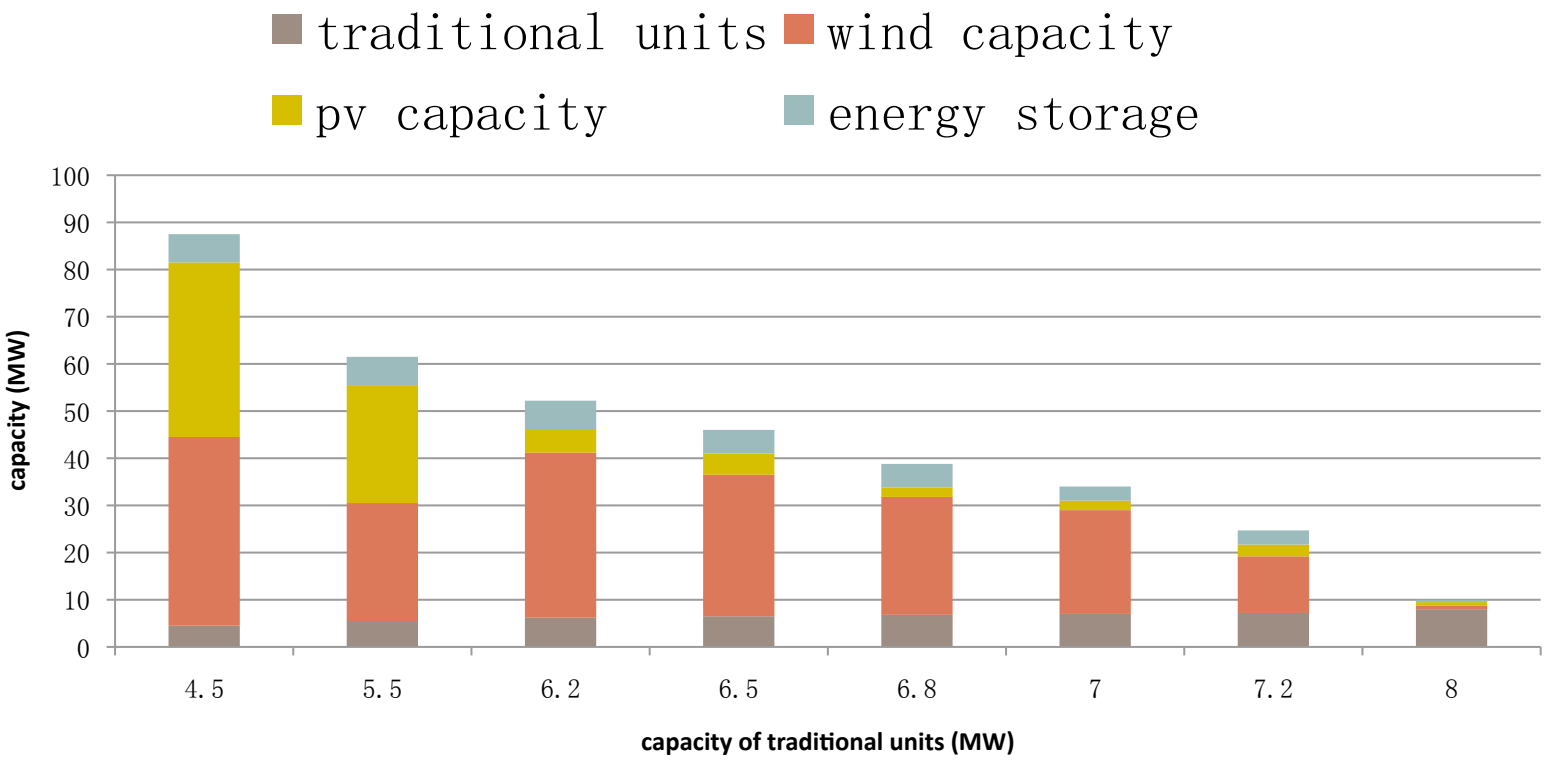
For example, when capacity of storage energy is 1.2MWh、0.95MWh、0.85MWh， the capacity of wind turbine and PV will be as

Following figure:



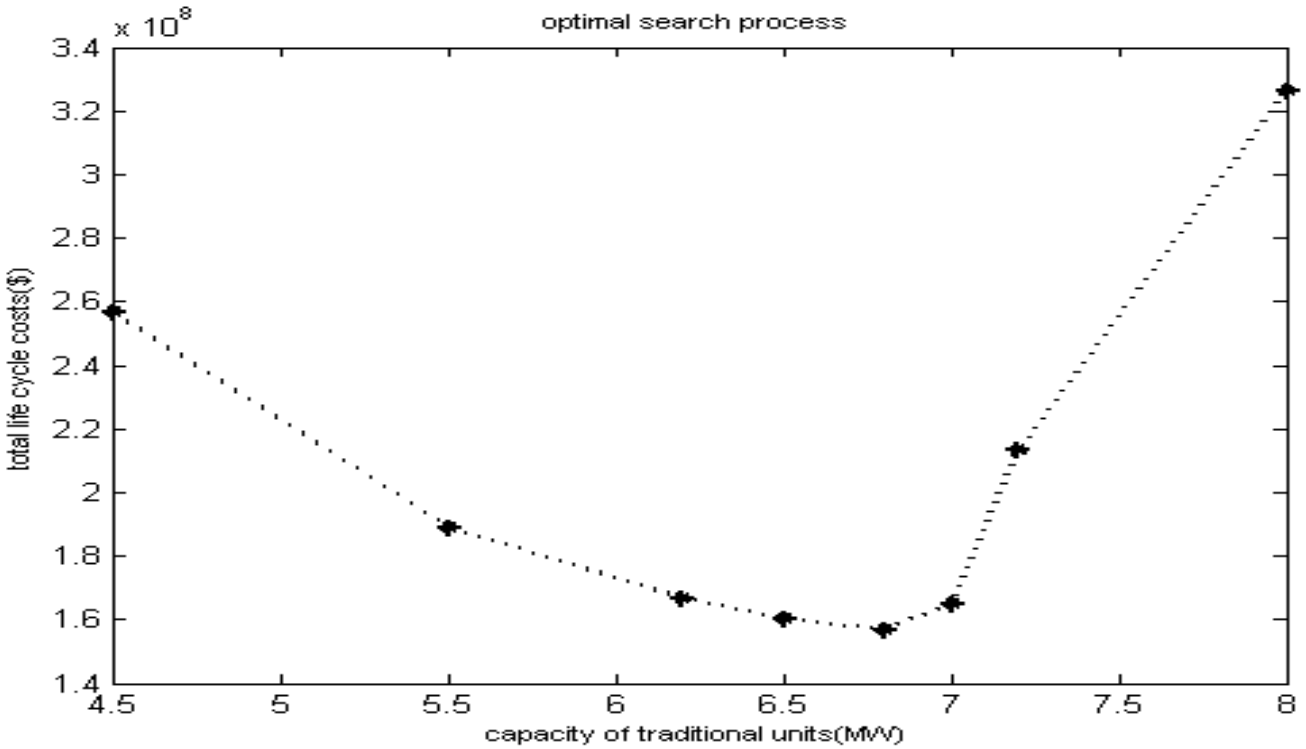
different capacity of tradition units with sameLOLE

Different traditional units-wind-PV-Storage configuration is as following



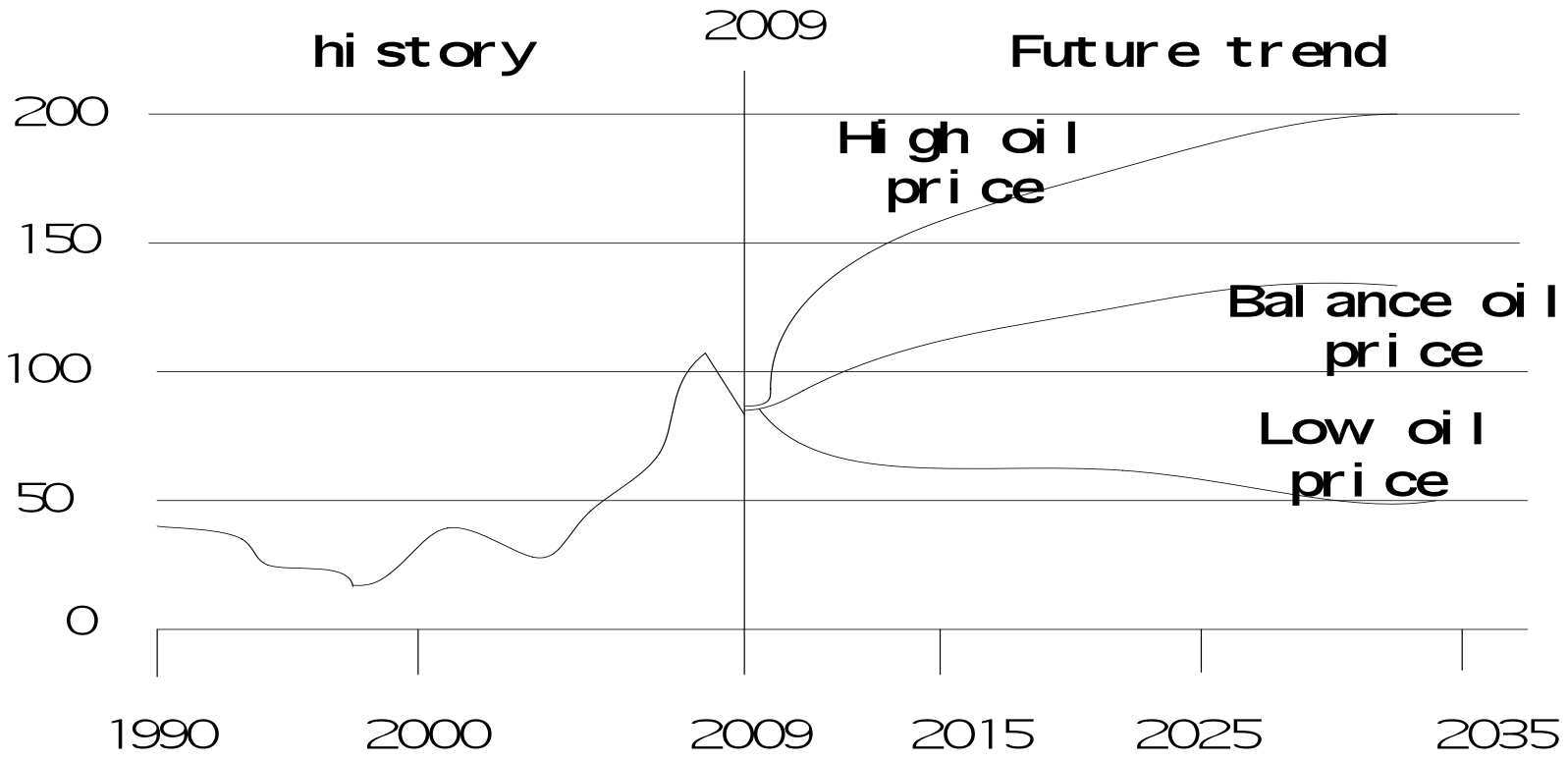
Case2: Optimal sizing of different capacity of tradition units

Case 2 can be seen composed by lots of case 1, then search the optimal point. and set power dispatching sequence as: wind-solar-energy storage-traditional units, We can see, when take 6.8 traditional units, the result is optimal.



Case3: Take the fuel price trend into concern

in the future,cost of renewable resources will reduce, the fuel price will increase, operation costs will be as following:



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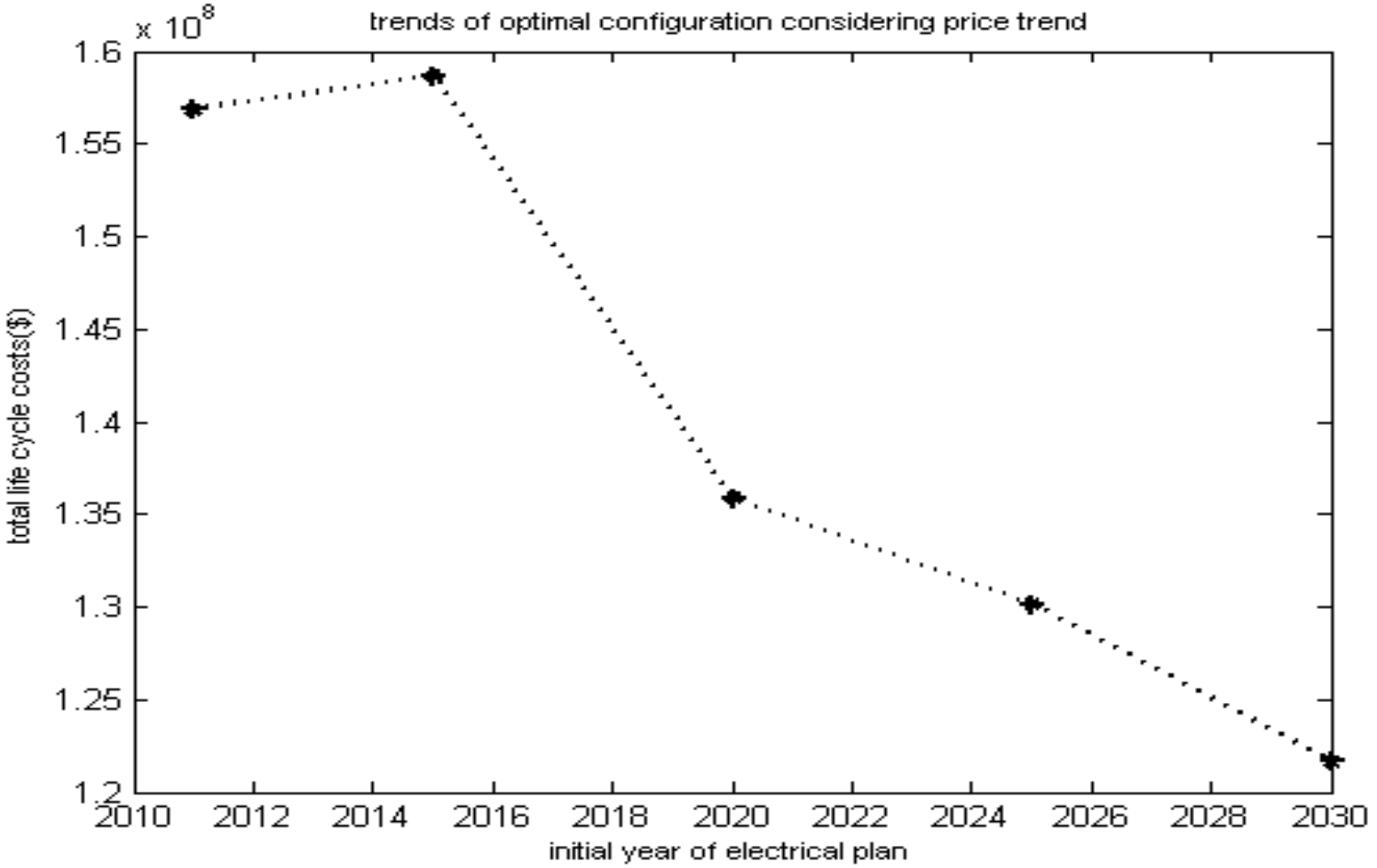
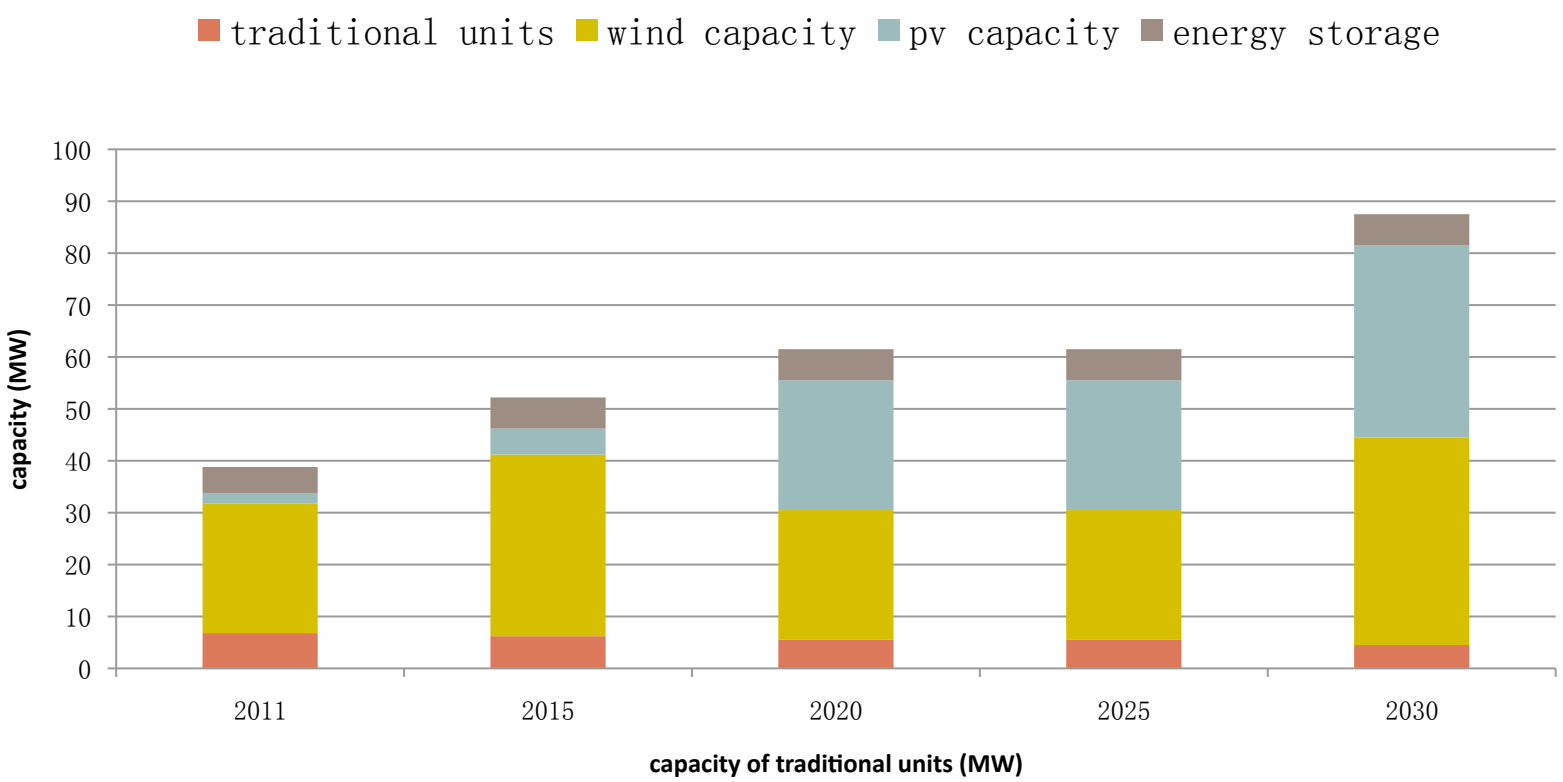
Take the low carbon scenario for example

In the low carbon scenario , the trends of optimal configuration are as following Fig.



Traditional units-wind-PV -Storage configuration Capacity



4. conclusion

(1).Obtaining the credible capacity of wind-solar-battery power system is very important, a probabilistic method is proposed.

(2). This method could consider the uncertainty factors, include the randomness changes of unit's output caused by fluctuations of wind speed and illumination intensity.

(3) This proposed optimal sizing of hybrid wind-solar-battery power was selected so that the entire life cycle of the total investment cost lowest.



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Thanks !

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