# Applied Research on Offshore Oil Field Wind Energy

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# Outline

1、Introduction of applying offshore oil field wind power

2、Applied demonstrative research of offshore oil field wind power

3、Applicative prospect of offshore oil field wind power

# 1、Introduction of applying offshore oil field wind power

- As of 2008, capacity of the world's offshore wind power installed reach to nearly 1.473 million kilowatts, mainly concentrated in Europe
- First, up to now, as limitations of wind power,offshore wind power are essentially grid-based, while off-grid wind power is small
- Second，offshore oil production platforms need green power supply, reducing fossil energy consumption and emission, saving energy

# 1、Introduction of applying offshore oil field wind power

**The traditional view，when a large capacity of wind power access to the grid, after a certain proportion (over 10%)，would be some technical issues，mainly including：**

**（1）Stability of power grid**

- **When the capacity of wind power reach to a certain proportion of regional power grid,stability of voltage and frequency,power quality may be affected**
- **Likely to cause line voltage too low to enable the WTGs connected to the grid, or owing to the frequently action of the WTG's protection system and the WTG being frequently disconnected from the grid**
- **The grid operation maybe may be affected since the fluctuations of wind speed may affect the power grid's production**

# 1、Introduction of applying offshore oil field wind power

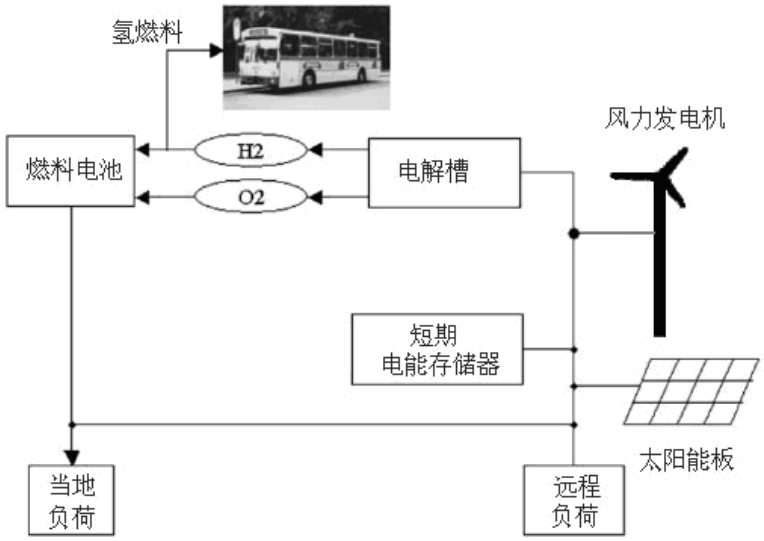
## （2）Possibility of Wind Farm Control

- Wind speed is random, making the production random fluctuant.
- When wind farm production is lower than the load, other power generators must response timely and contribute the grid a greater production.
- Wind speed is not controllable, the WTG's production is also not easy to control. The wind farm can not be as easy as conventional power plants to achieve a reliable scheduling.

# 1、Introduction of applying offshore oil field wind power

To eliminate the adverse effects on the stability of the grid caused by the large-scale development of wind power，Complementary systems of various energy appear，mainly including：

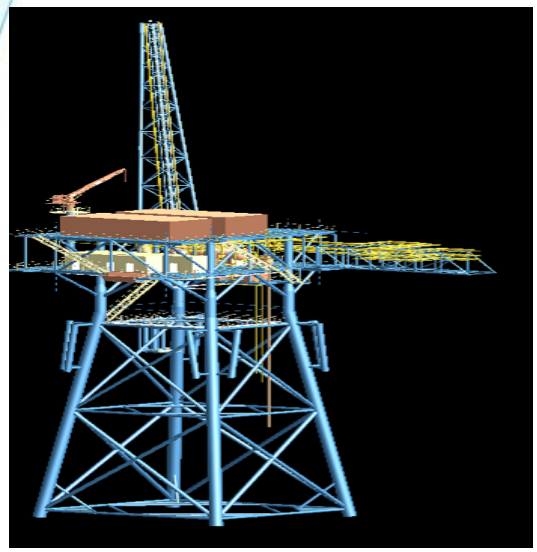
- Wind power - hydro ；
- Wind Power - Solar Power ；
- Compressed Air Energy Storage ；
- Wind Power - Diesel Power ；
- Wind power - hydrogen energy storage;
- Wind power - fuel cell hybrid generating;
- Wind power - Solar energy - fuel cell hybrid generating and so on.




Wind power - Solar energy - fuel cell hybrid generating system

# 1、Introduction of applying offshore oil field wind power

- Concrete embodiment of CNOOC comprehensive energy company strategy
- Explore new ways of wind power to supply offshore oil production



Smooth operation of power grid at offshore platform island

## Technical Difficulties：

- Wind power connection to the grid ;Selection and development of offshore WTG; The installation technology and equipment for offshore WTG.

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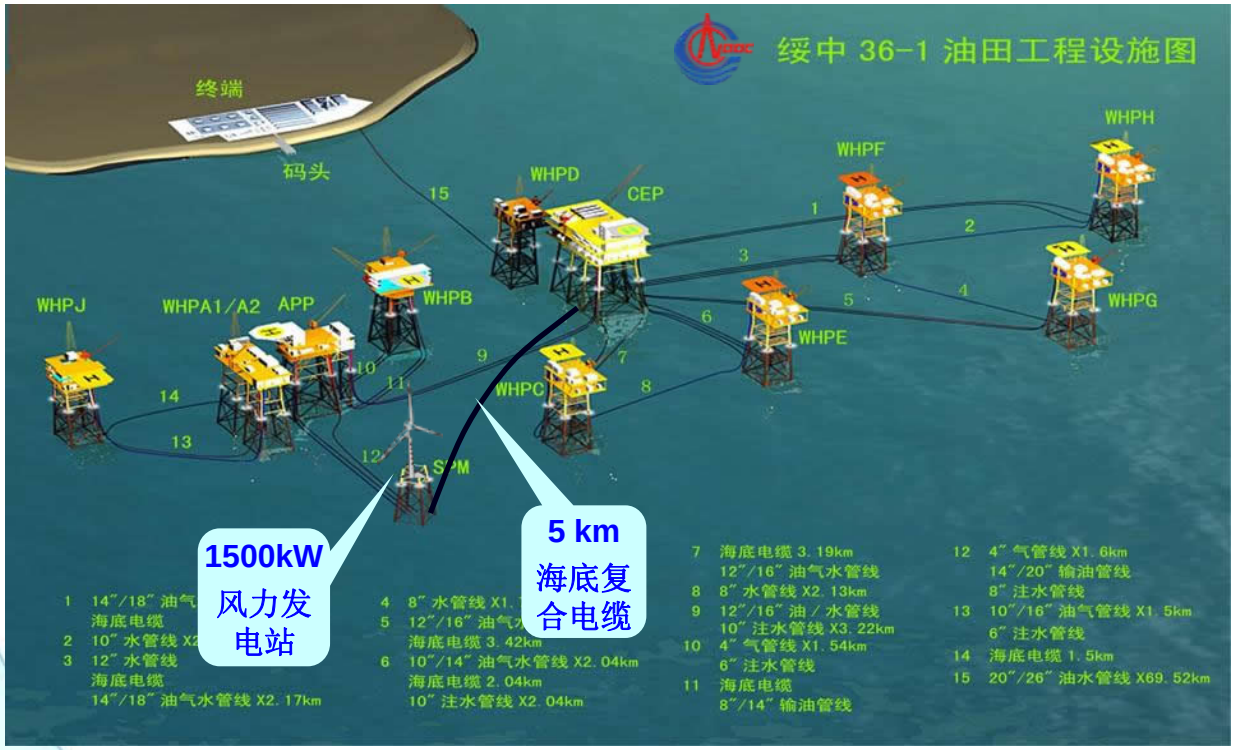
# 2、Applied demonstrative research of offshore oil field wind power

## Offshore oil field wind power demonstrative project selection




**Considerations：**

**Wind resource;**

**Oil Production;**

**impact;**

**Grid conditions;**

**Oil field load demand.**

# 2、Applied demonstrative research of offshore oil field wind power

## Overview of Offshore oil field wind power demonstrative project

- ✡ Location： Bohai SZ36-1 oilfield
- ✡ Capacity： 1500kW
- ✡ Distance to shore： 70km
- ✡ Hub height： 57m
- ✡ Water Depth： 31.5m

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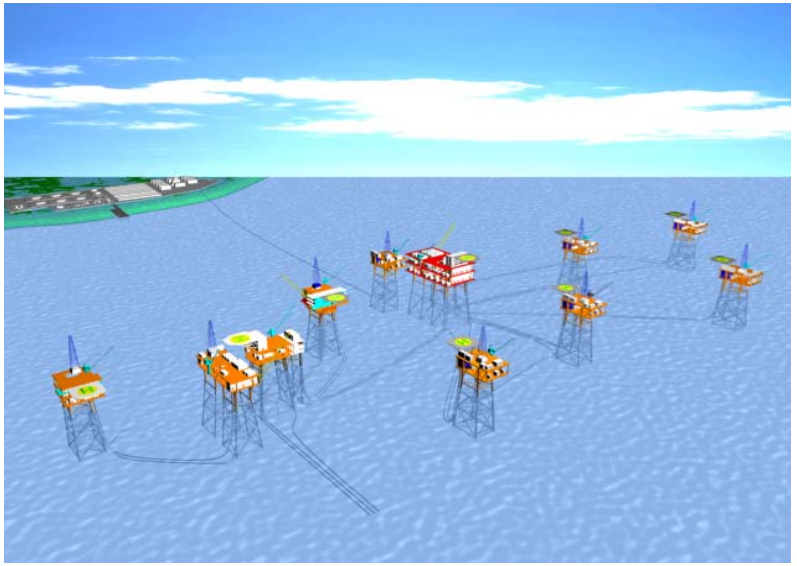
## Basic conditions of Offshore oil field wind power demonstrative project

- Annual average wind speed is 7.6m/s，Annual average wind power density is 552.2w/m$^2$，Maximum wind speed 23.3m/s，wind direction is stable
- A small island grid system, of which the neutral point of the three-phase three-wire grid is not grounded
- Voltage：6.3kV/10.5kV/400V/3.3kV
- 4 sets of 6300V turbine generators (10MW, 3 operation+1 spare)+2 emergency diesel



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## Technology research of offshore oil filed wind power ——WTG selection

- Considering the WTG's impaction to the grid, the WTG's capacity range:750-1500kW。
- According to the maximum wind speed on the 50m-70m mean sea level, the IEC Ⅱ and above WTG will be selected.
- Considering the demand of the oilfield power grid status，reducing the impact to the grid，the 1500kW Permanent magnet direct-drive type wind turbine was finally selected.

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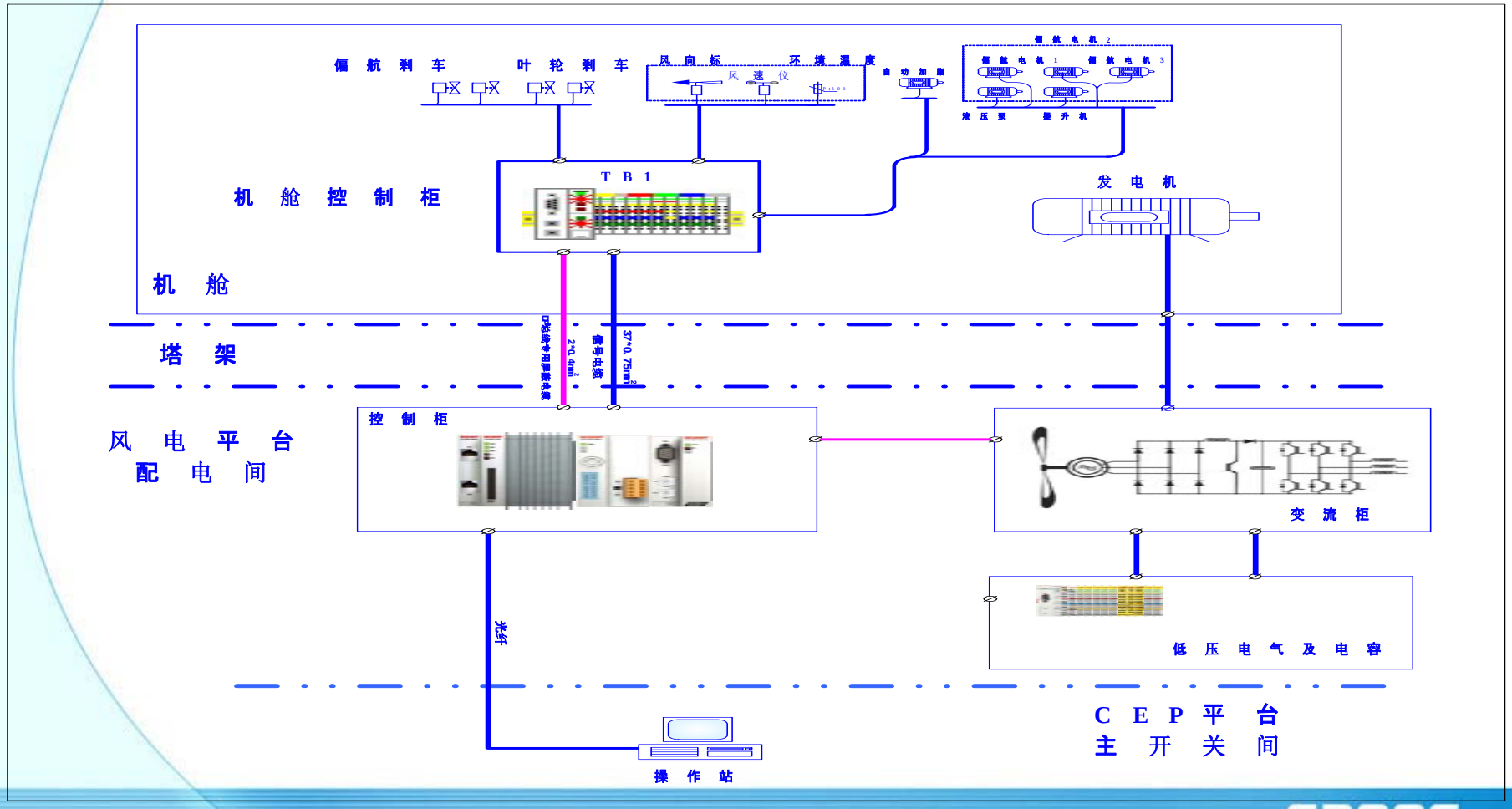
## Offshore oil field wind power demonstrative project——WTG control sys



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## Technology research of offshore oil filed wind power ——Grid connection

- WTG—Turbine generators merge operation is the first time in China. The key point to ensure the power quality and reliable operation is that if the GOV and AVR regulation performance of the existing turbine generators can match the WTG's output power and voltage changes complementally.
- WTG's cut in and cut out, as well as fluctuations of wind power will affect the power grid voltage and frequency, therefore, the response speed of AVR and GOV are very important to maintaining the stability of the grid's operation.
- Two important indicators to evaluate the impact of wind power on the grid of such a small isolated grid can be confirmed only through the actual running

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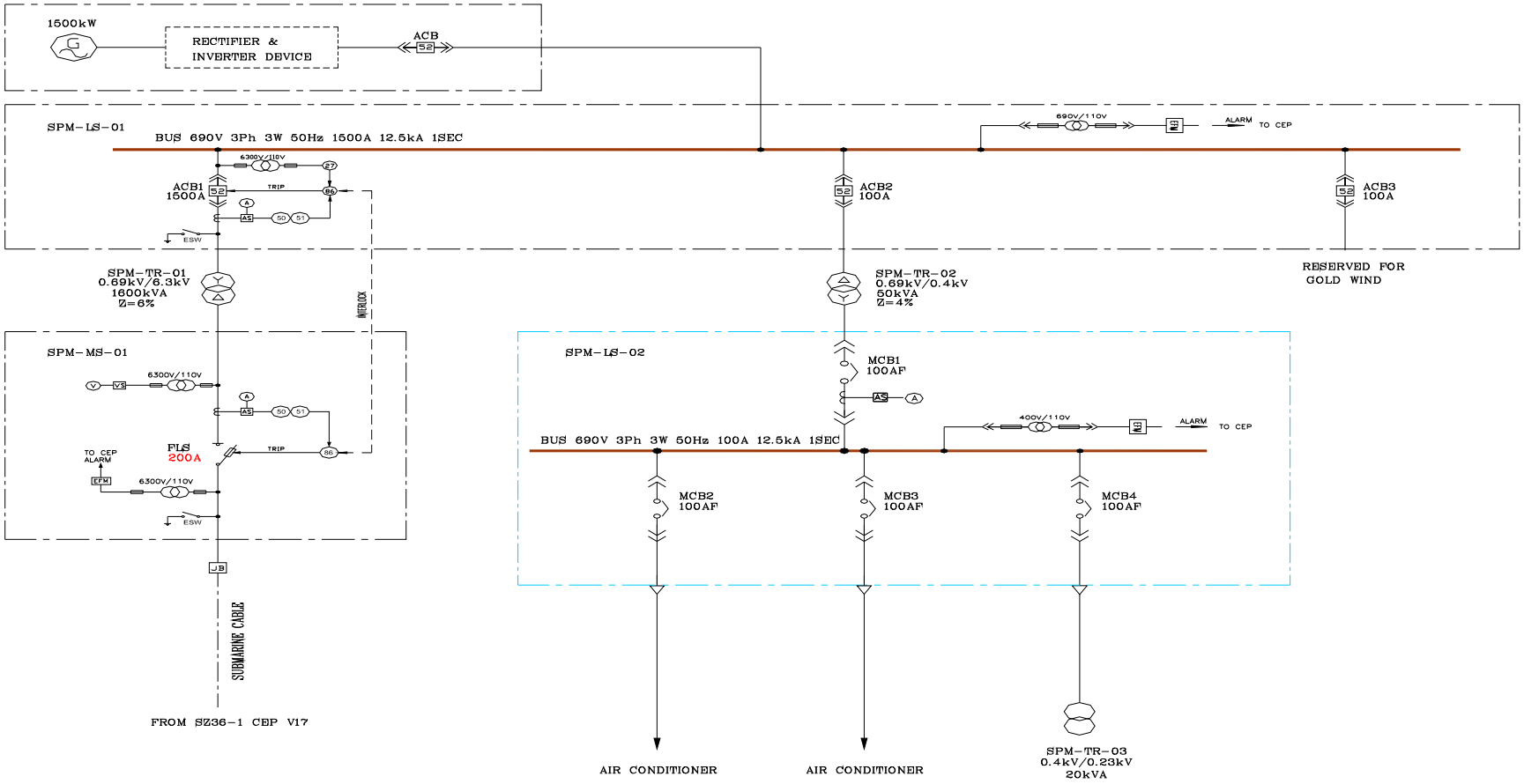
## Technology research of offshore oil filed wind power ——Grid connection




## Electrical single line diagram system

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## Offshore oil field wind power demonstrative project——On shore test of WTG-Turbine generator merge operation

- To observe the characters of WTG when connected to a small grid and forecast the effect of actual operation on shore, the WTG and a set of 1100kW diesel generator were connected together to carry out the onshore test，
- Through test，the system can keep balance during the transient impact and also the steady operation，illustrates the feasibility of diesel engines and WTG；the wind power penetration ratio broke the limit of 5% according to normal onshore wind farm experience, even more than 20%。

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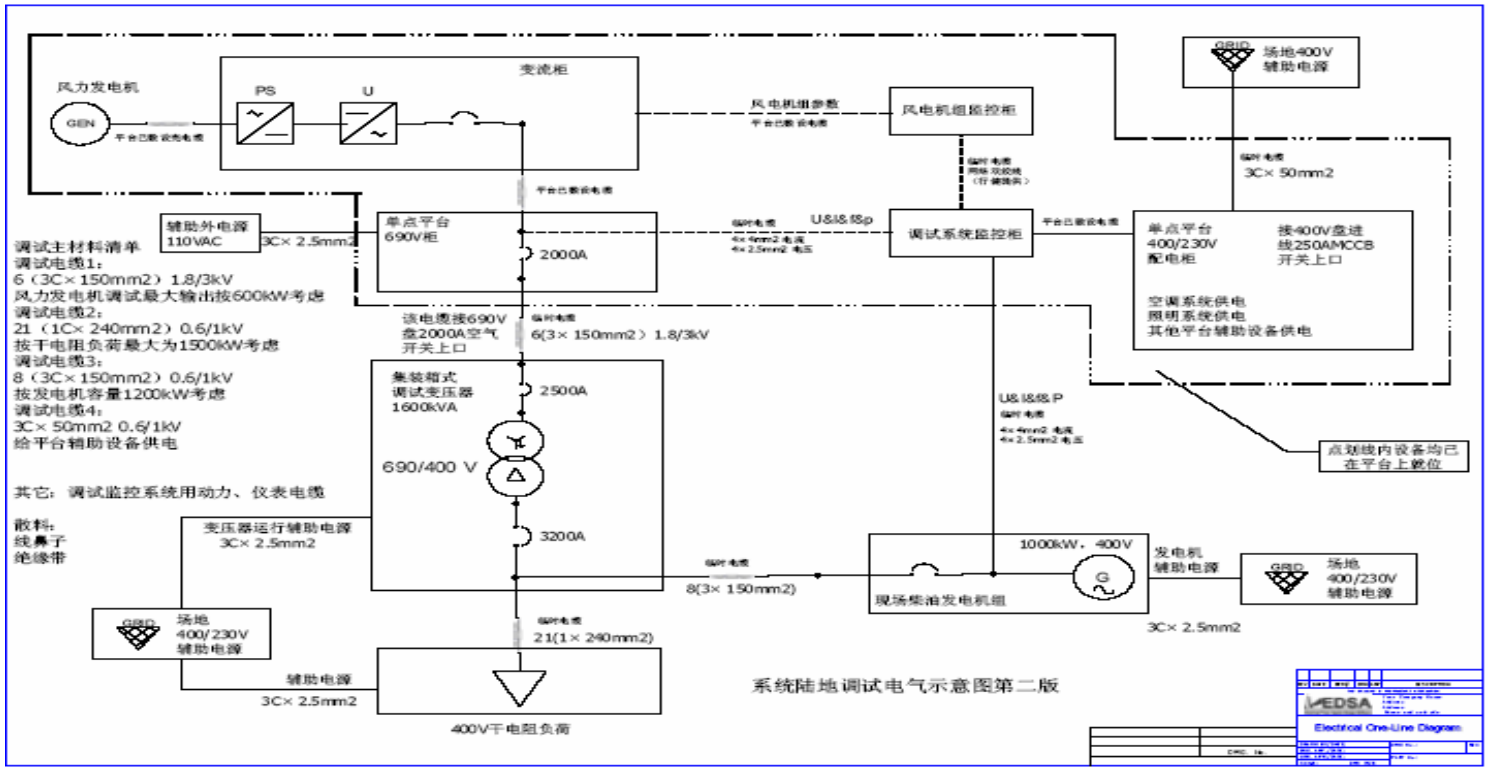
## Offshore oil field wind power demonstrative project——On shore test of WTG-Turbine generator merge operation




System Diagram

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## Offshore oil field wind power demonstrative project——Simulation of WTG-Turbine generator merge operation

- to simulate better the operation of offshore producing platforms, we conducted a diesel and wind hybrid power systems simulation.
- Use non-real-time simulation tool PSCAD/ EMTDC and real-time simulation tool RTDS/RSCAD to simulate and study the peration of platforms merged with wind power.
- Simulation results show：it is feasible to introducing wind power into power grid of offshore oil platforms, when the platform power grid operates stably, the 1500kW WTG cut-in, cut-out and emergently shutdown, the power grid can also be stable.

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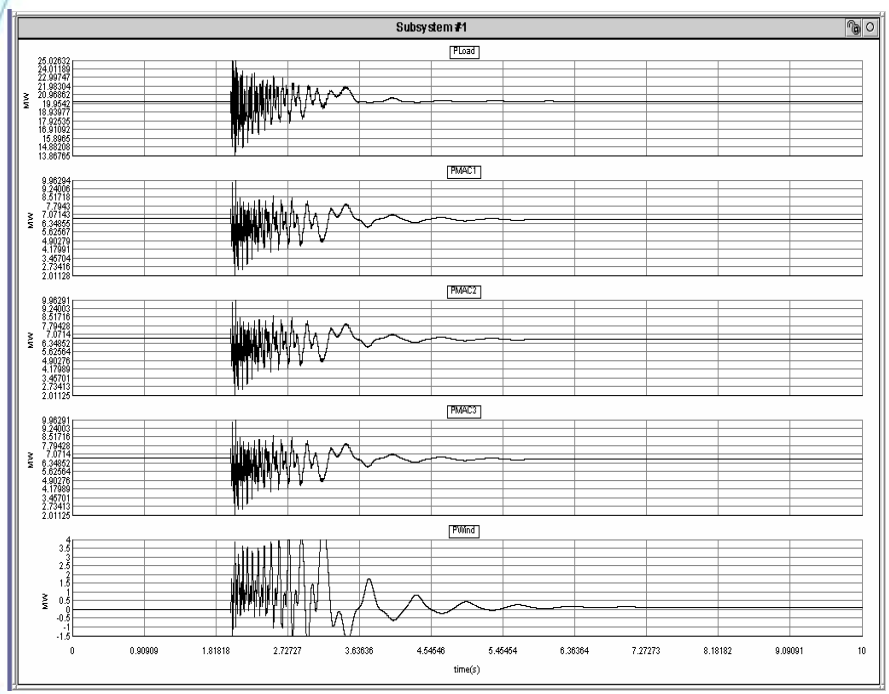
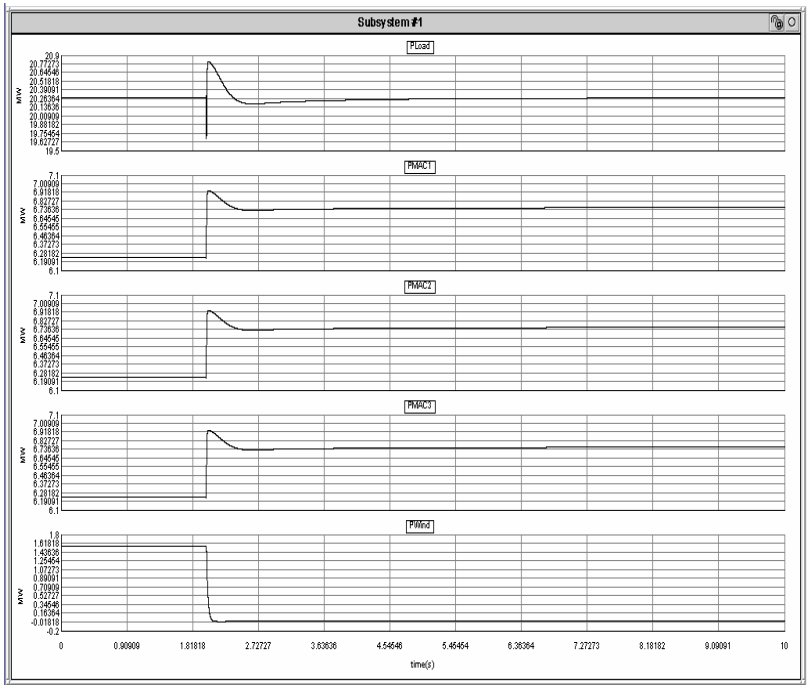



RTDS simulation of wind turbine putting into operation




RTDS simulation of all cut off process

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## Offshore oil field wind power demonstrative project——offshore test of WTG-Turbine generator merge operation

- After the WTG's pre-commissioning completed, it was only connected with one turbine generator; after it succeeded, the test was conducted gradually; at last, the power grid was configured by WTG and all the turbine generators, to supply the oil platform's load.
- Results show: when the oil platform power grid operates stably, the 1500kW WTG cut-in, cut-out and emergently shutdown, the power grid can also be stable.
- The maximum wind power capacity in the SZ36-1 oil platform power grid is 3 sets of 1.5MW wind turbine

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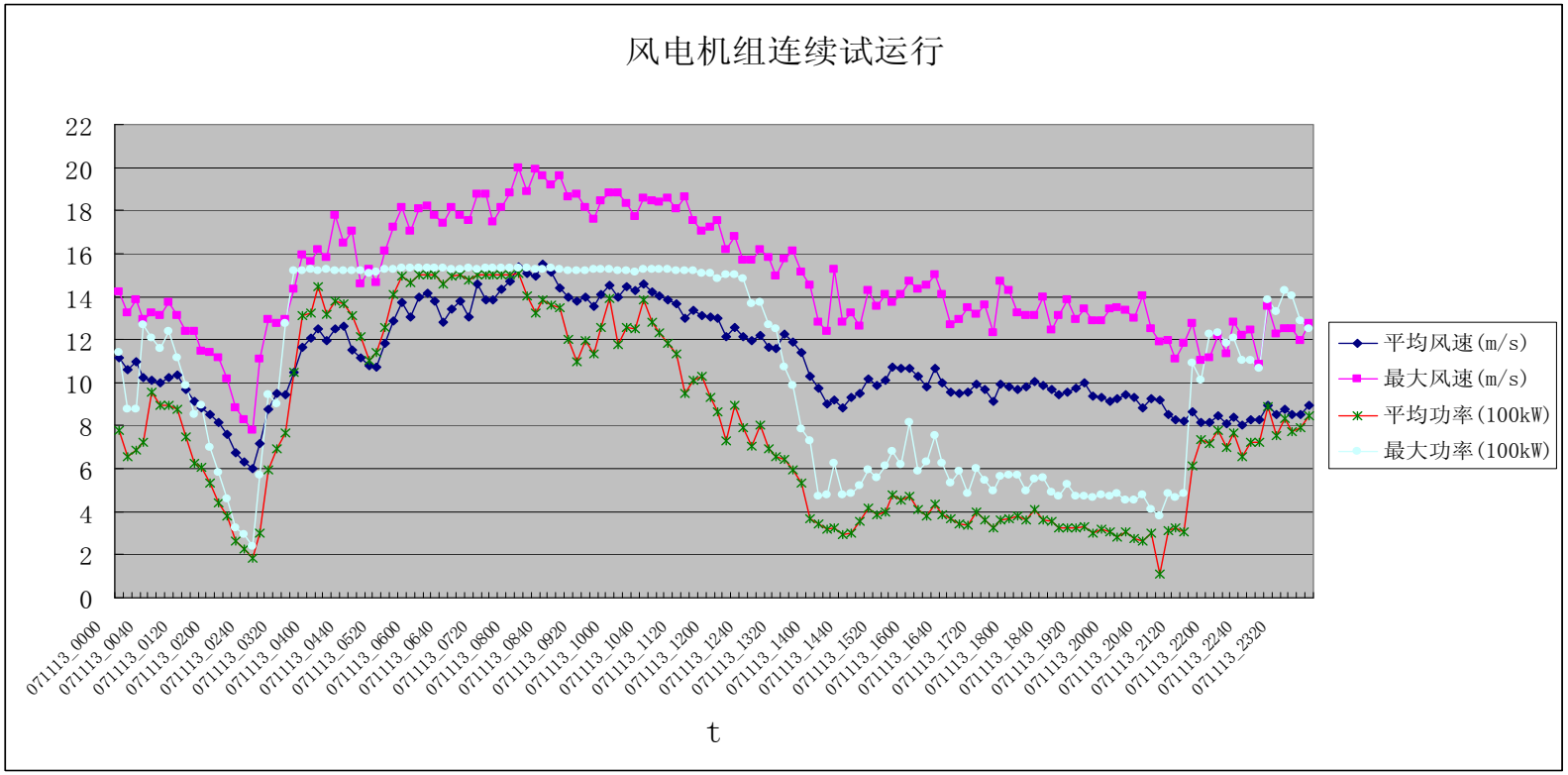
## Offshore oil field wind power demonstrative project——offshore test of WTG-Turbine generator merge operation




Trend Chart of wind turbine output power change with wind speed

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## Offshore oil field wind power demonstrative project——grid connection and operation

- This project was successfully connected to the grid on November 8, 2007，and there was no negative affection；
- This unit passed performance test on January 11, 2008；
- Up to now，the project operated stably，and total production reaches 6 million kWh after several trials；
- Energy-saving and emission reduction:5300 tons of $CO_2$

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## Offshore oil field wind power demonstrative project——results

- Completed a merge system design and stability analysis, mathematical simulation model.
- Successfully built a physical simulation system.
- Successful implement the WTG connected with a oilfield weak power grid.

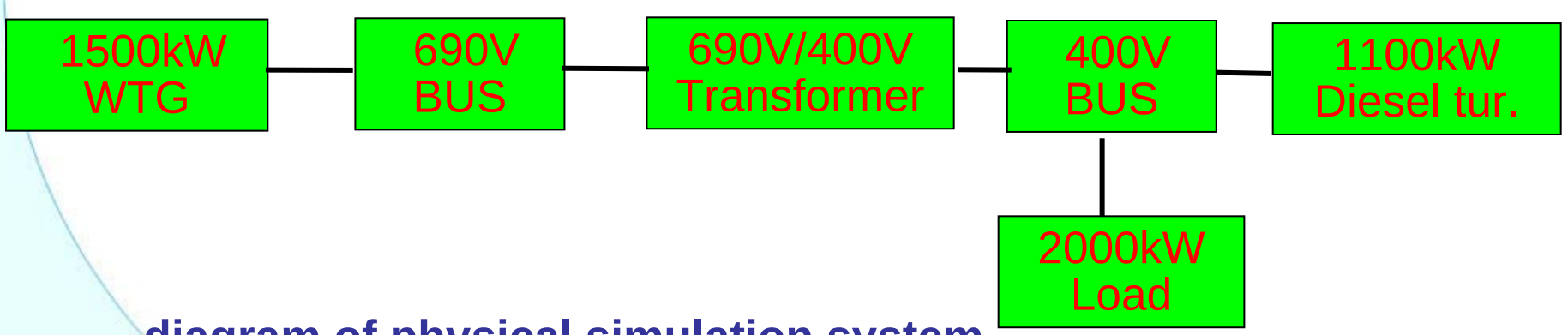


diagram of physical simulation system

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In addition, we also carried out the following research：

- ✡ Offshore wind turbine foundation infrastructure Model；
- ✡ Offshore wind turbine Installation/Transportation technology；
- ✡ Research of WTG adaptability to the offshore environment；
- ✡ Research of Operation and Maintenance Management ；

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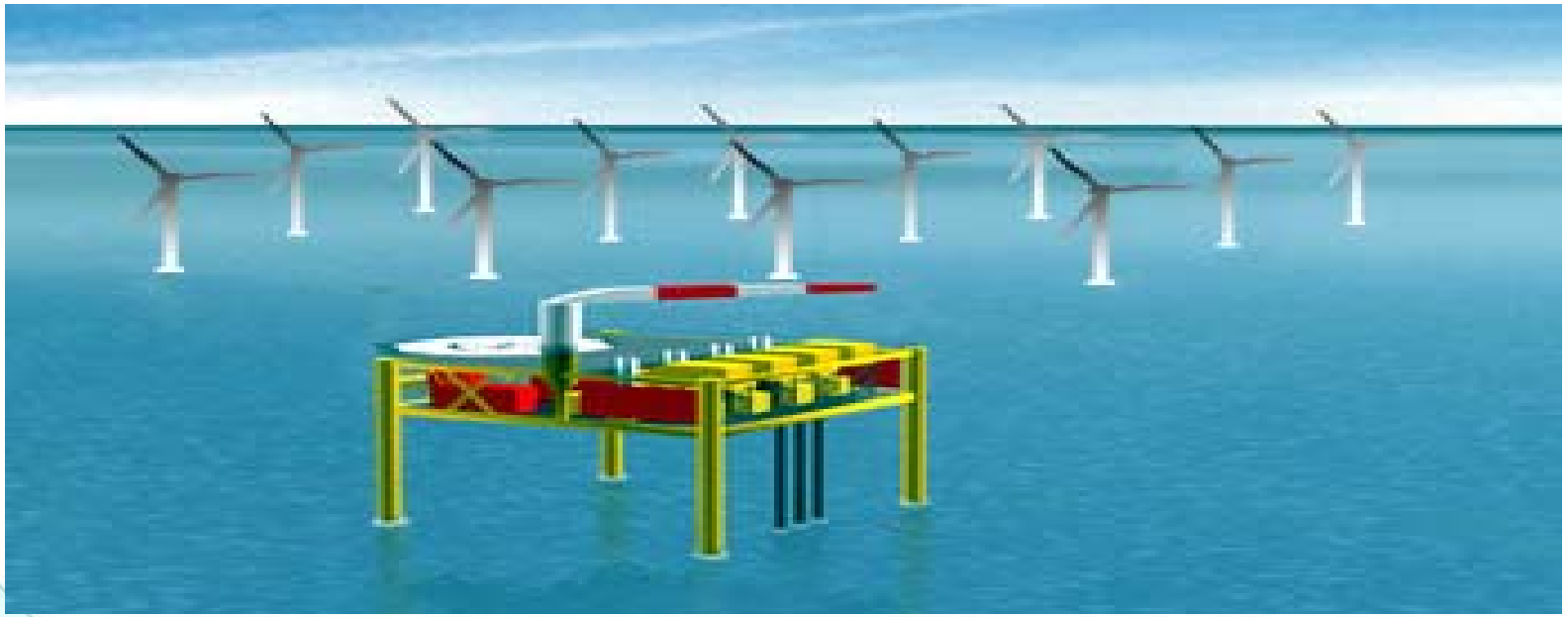
- Up to now，oilfield grid electric indicators reach to requirements，WTG operates safely and smoothly. Achieved improvement of a variety of power sources in the offshore platform, and promote rich experience for future wind energy utilization project.
- There are thousands of oil platforms completed and under construction in the world， If we can reduce fuel consumption effectively or provide other forms of new energy，it will greatly reduce production costs and promote energy-saving and emission reduction activities.

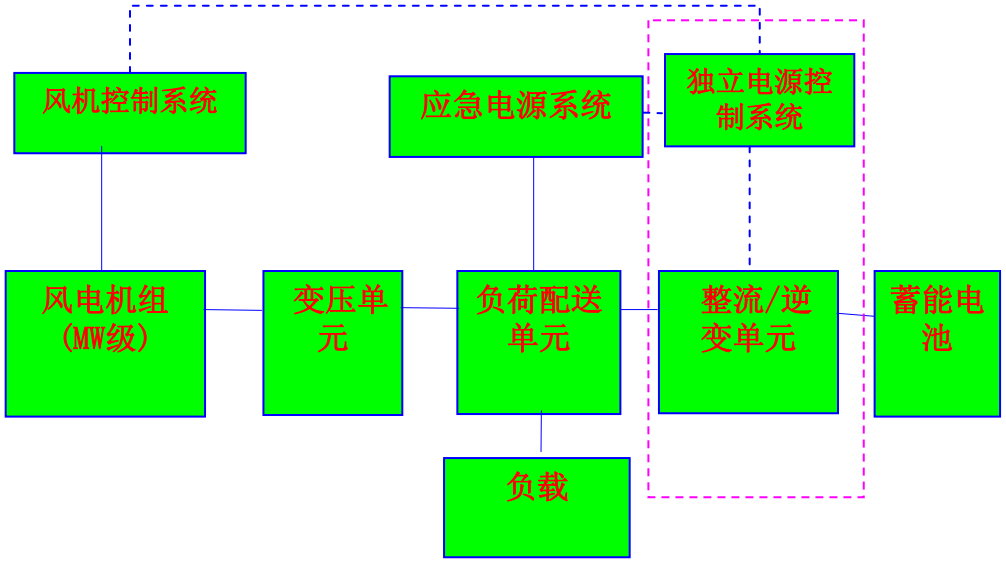
# 3、Applicative prospect of offshore oil field wind power

- CNOOC is developing a stable set of independent wind-power and battery combination power systems，and applied to offshore production platforms, explore the feasibility of making wind power as a additional power to platform ， explore roads of effective using of the rich wind energy resources at sea and alternating part or all oilfield fuel some or all of the alternative fuels oil in the future



# 3、Applicative prospect of offshore oil field wind power

- At present, the system has entered a substantial research and development stage, and has achieved good results.




- Diagram of an independent wind power and battery combination power supply system

# THANK YOU!

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