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Multi-Agent Based Simulation for Microgrid Energy Management

Prof. Meiqin Mao

Hefei University of Technology
Hefei, Anhui Province 230009 China
pvcenter@hfut.edu.cn

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3. Design and Realization of MAS Based EMS-MG
4. Application of the proposed EMS-MG: Automatic Generation Control
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1.Introduction

Background of Research:

-One of sub-projects supported by MOST 973 (2009-2013)

Economic Operation Theory and Energy Management Methods for Microgrids

- Project NSFC (2010-2013)

Research on Agent- model- Based Intelligent Dispatch and Test-Bed for Multi-Microgrids

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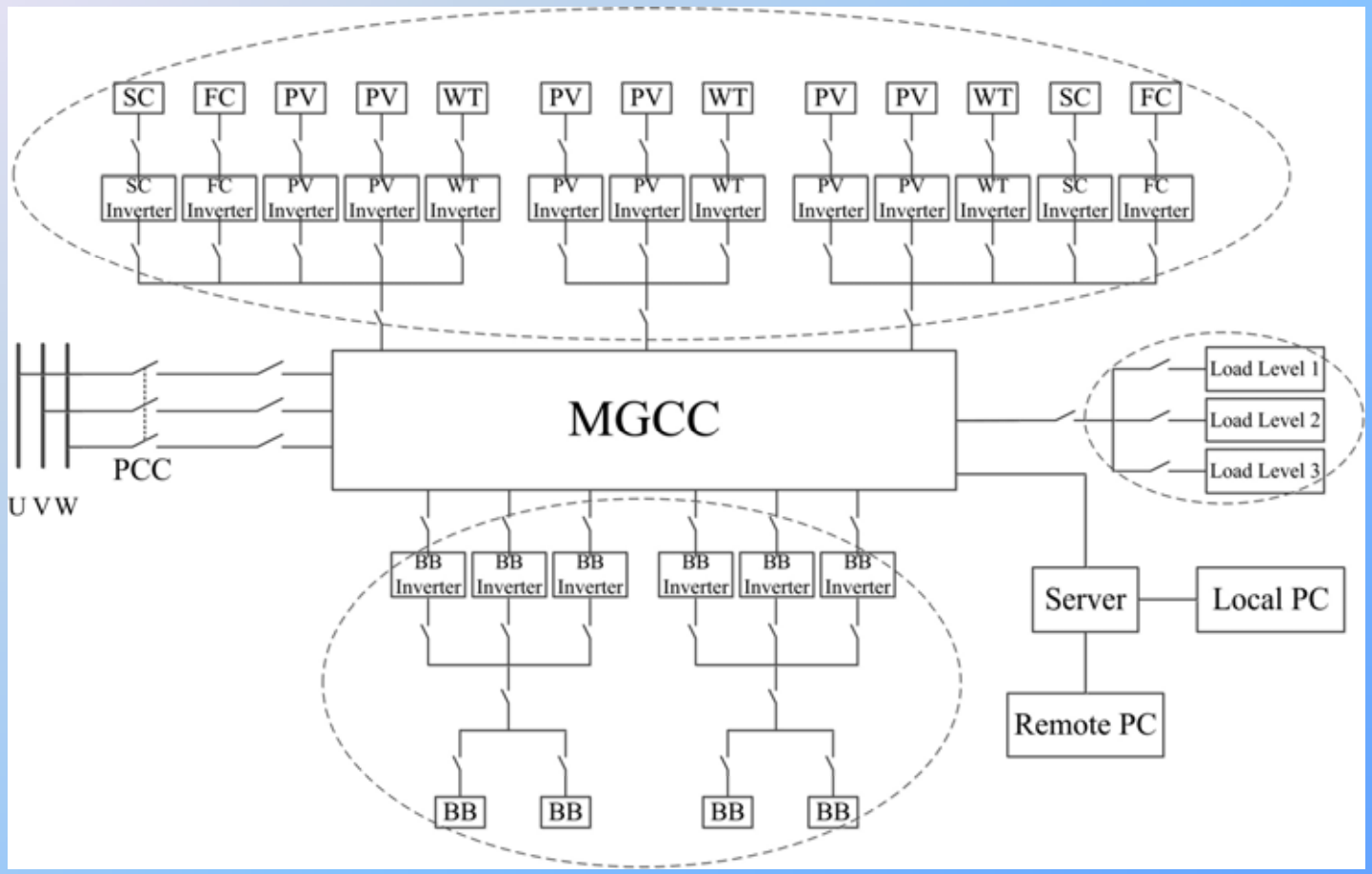
1.Introduction

Microgrid Testbed in HFUT

1.Introduction



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1.Introduction

1.1 Unique features of the Microgrid

1.Different characteristics of multi-generators

2.Fluctuation and complement of primary energy

3.Versatile infrastructures of the Microgrid

Figuer-1

1.2 MAS Based EMS-MG

A novel simulation based on MAS for the EMS-MG may be used to study the operation of Microgrid from different aspects of the Microgrid.

Figuer-2

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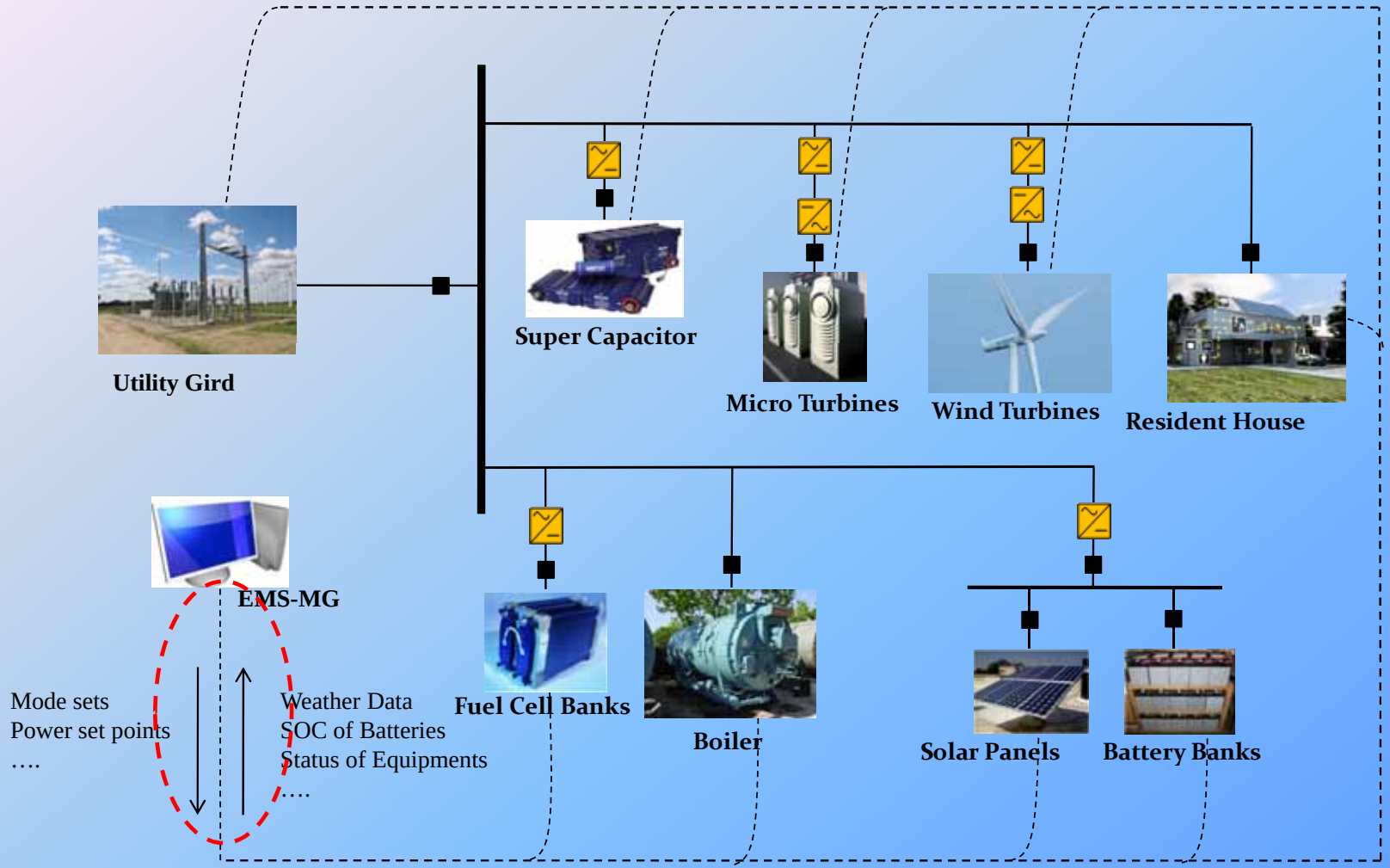
EMS-MG in traditional method



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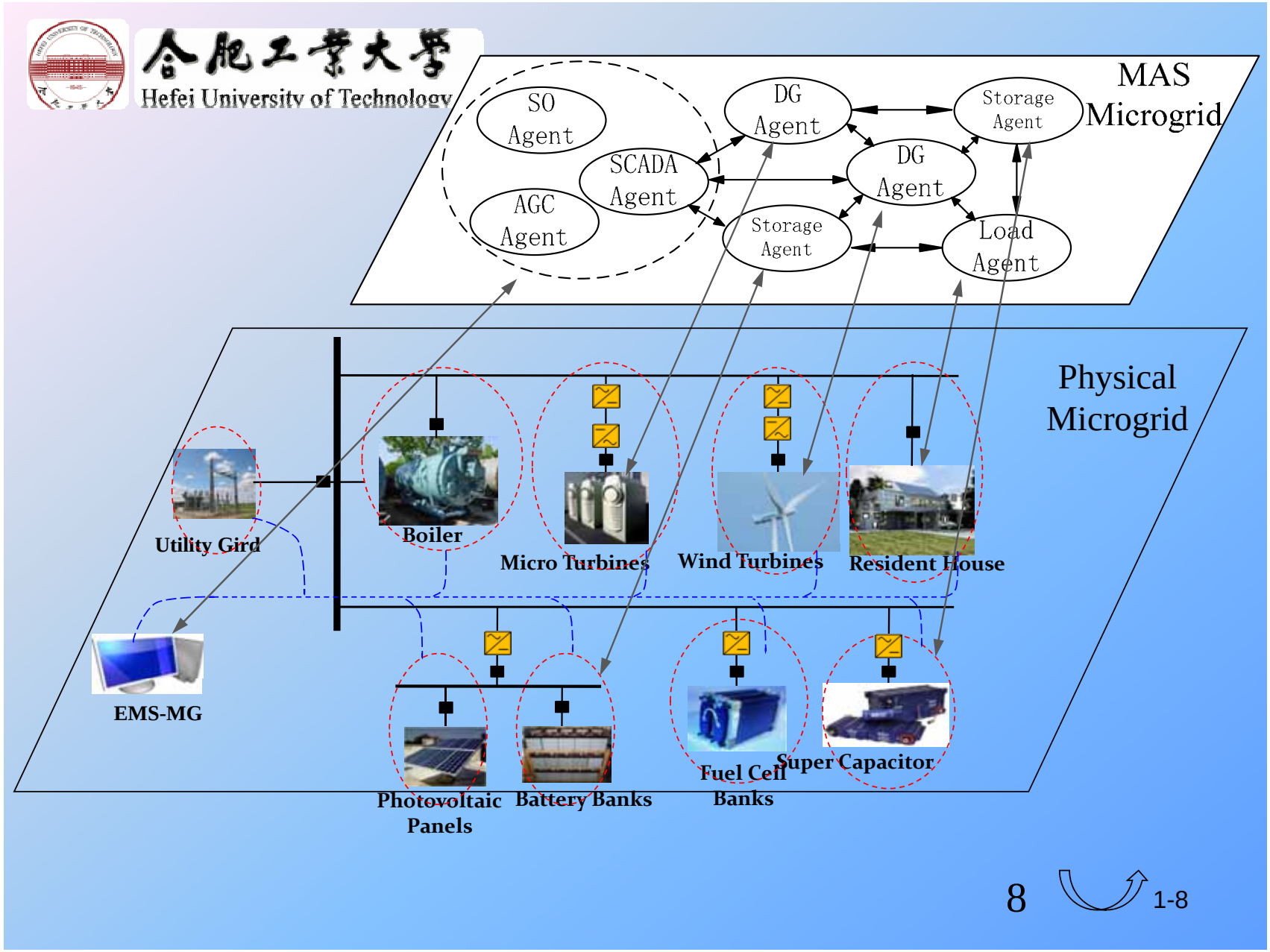
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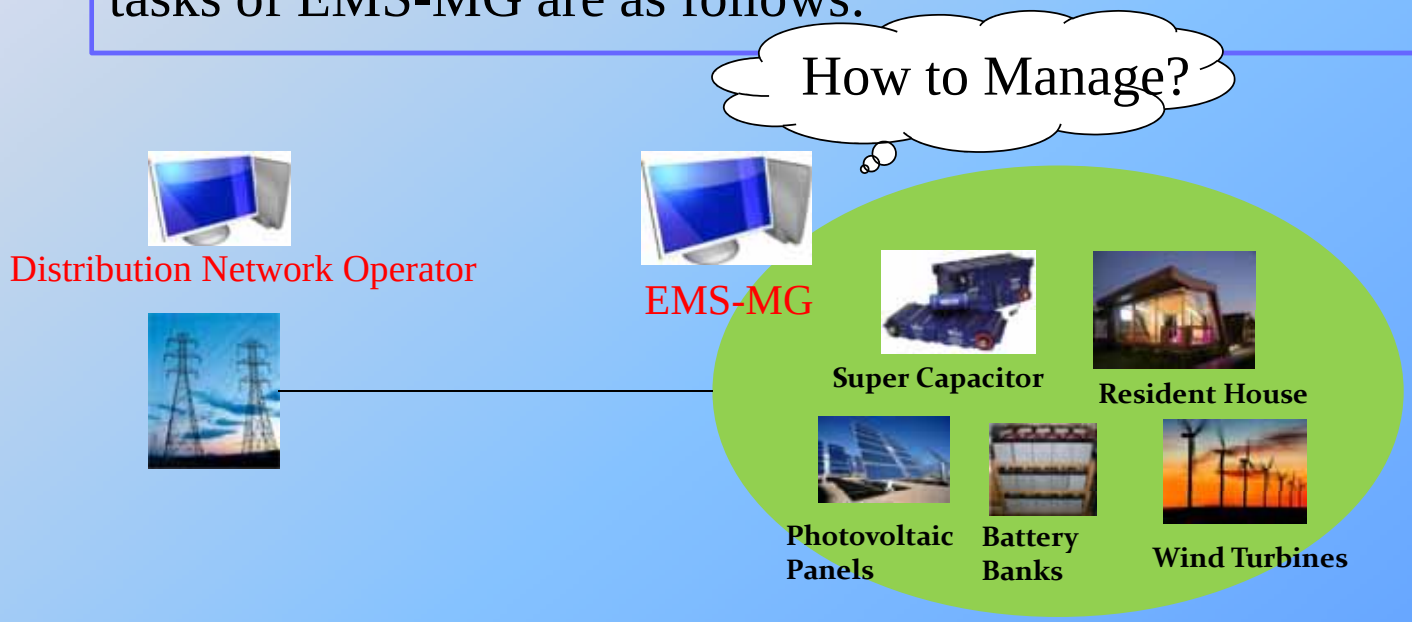
MAS
Microgrid
SO
Agent
SCADA
Agent
AGC
Agent
DG
Agent
DG
Agent
Storage
Agent
Storage
Agent
Load
Agent
Physical
Microgrid
Utility Gird
Boiler
Micro Turbines
Wind Turbines
Resident House
EMS-MG
Photovoltaic
Panels
Battery Banks
Fuel Cell
Banks
Super Capacitor
8
1-8

2. Requirements on the EMS-MG

2.1 Main Tasks of EMS-MG

The Microgrid may operate in an either grid-connected or islanding mode. By the Microgrid operating rules, the main tasks of EMS-MG are as follows:



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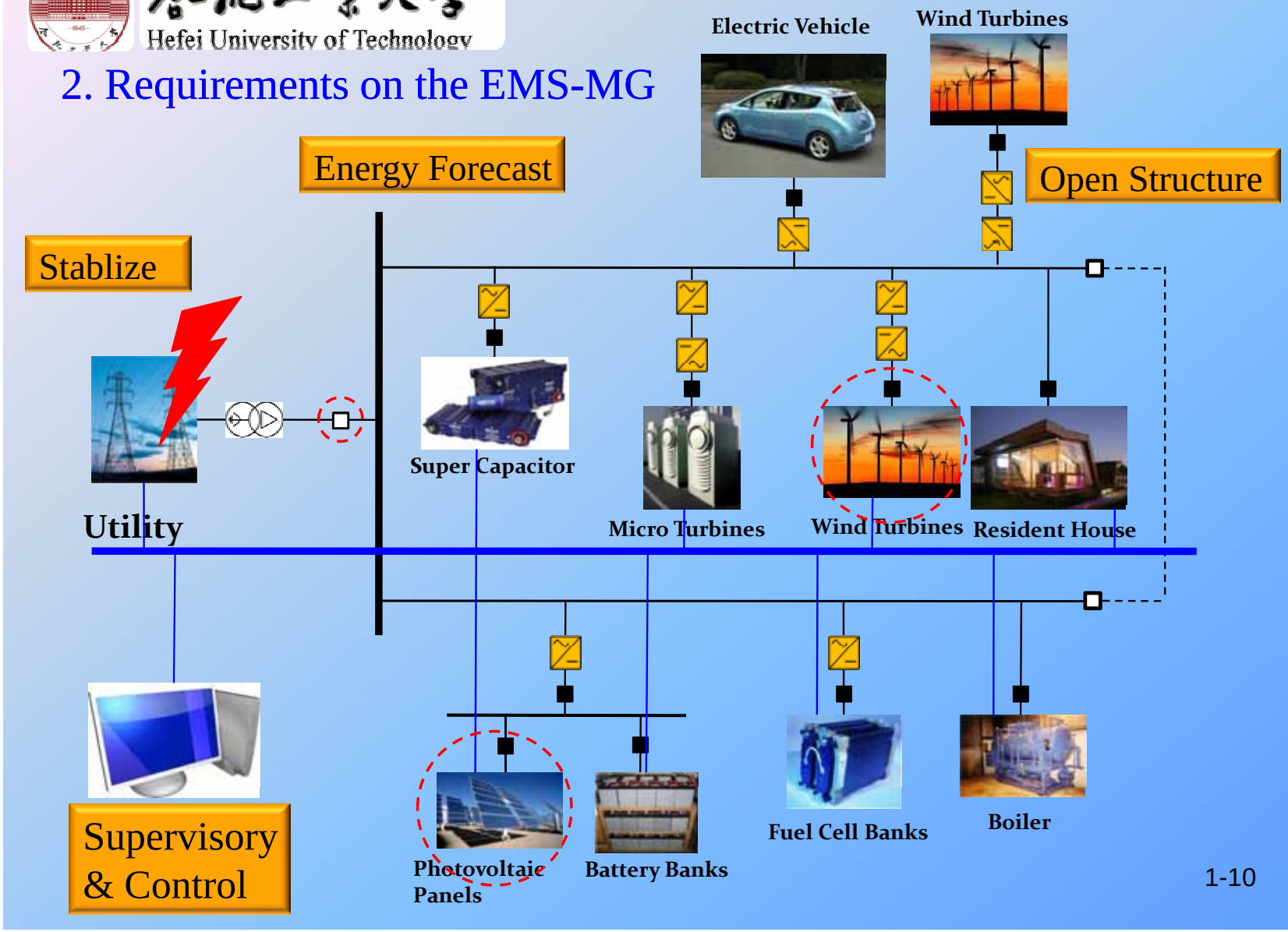
2. Requirements on the EMS-MG



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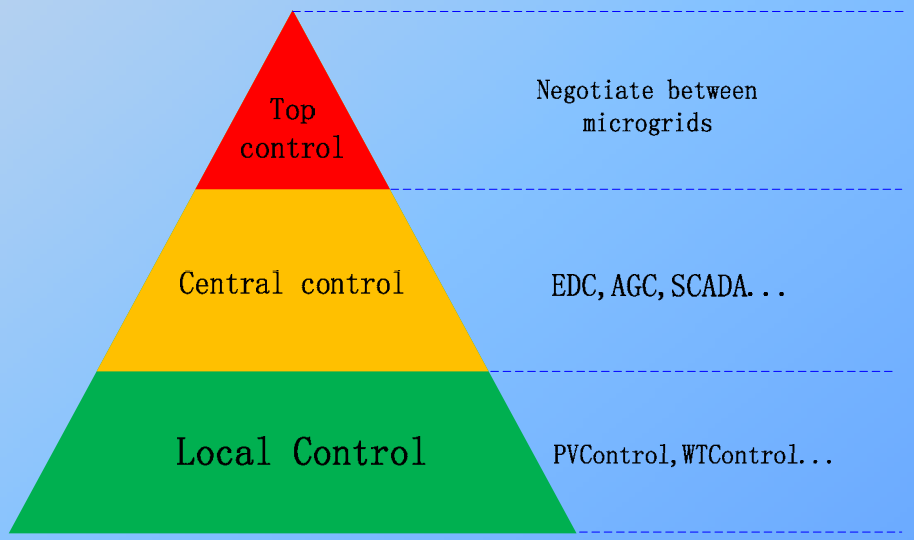
3. Design and Realization of MAS Based EMS-MG

3.1 Hierarchical layers of EMS-MG

The control of Microgrid is divided into three levels



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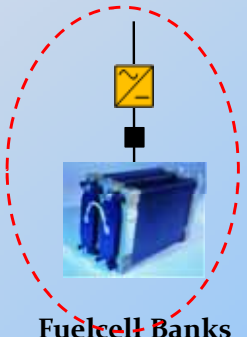
3. Design and Realization of MAS Based EMS-MG

3.2 Agent Definition of EMS-MG

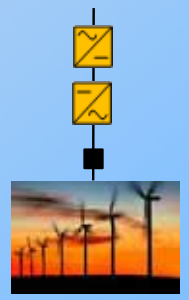
Local control Level

- Communication Agent
- Control Agent
- Status Agent



Fuelcell Banks

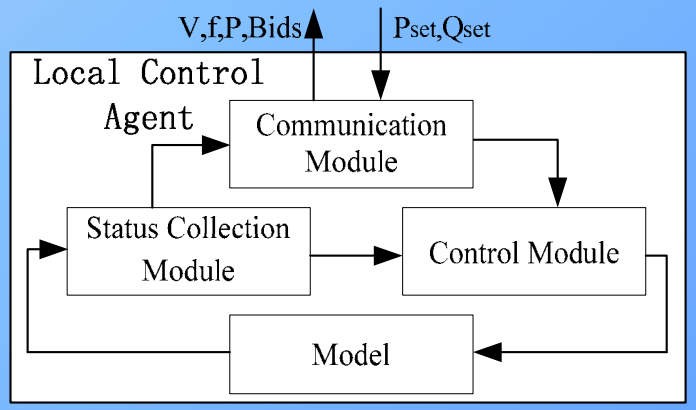
Electric Vehicle



Wind Turbines

…

Local Control

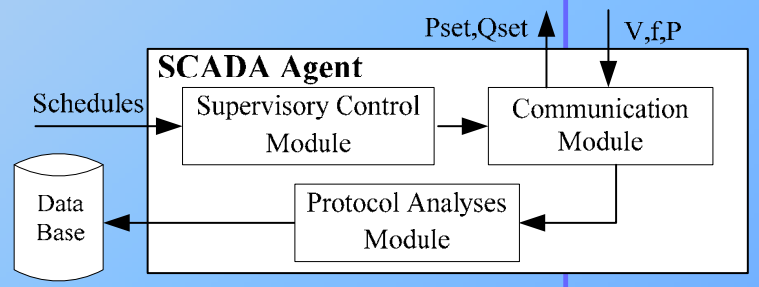


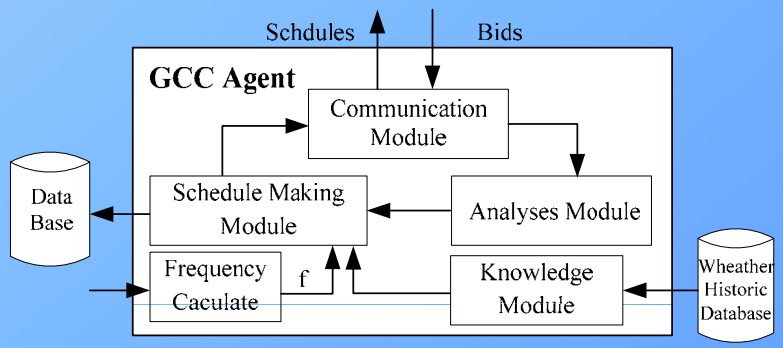
3. Design and Realization of MAS Based EMS-MG

3.2 Agent Definition of EMS-MG

Center Control Level

- SCADA Agent
- AGCC Agent
- EDC Agent
- Energy Prediction Agent
- Power Flow Analysis Agent
- History Analysis Agent



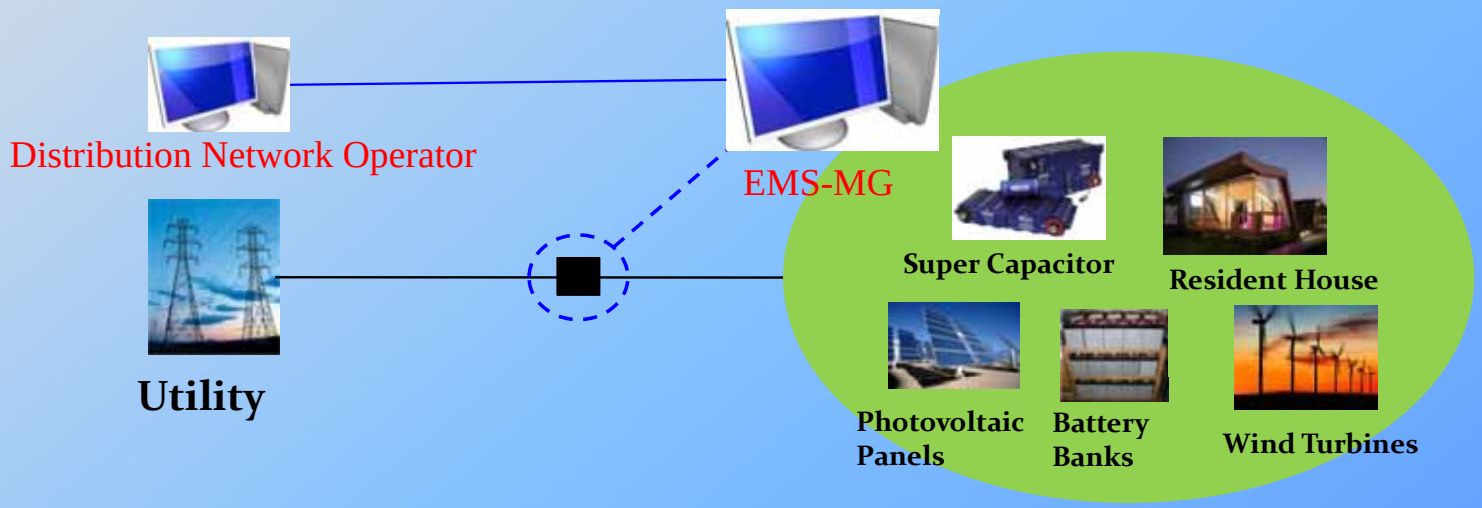


3. Design and Realization of MAS Based EMS-MG

3.2 Agent Definition of EMS-MG

System Control Level

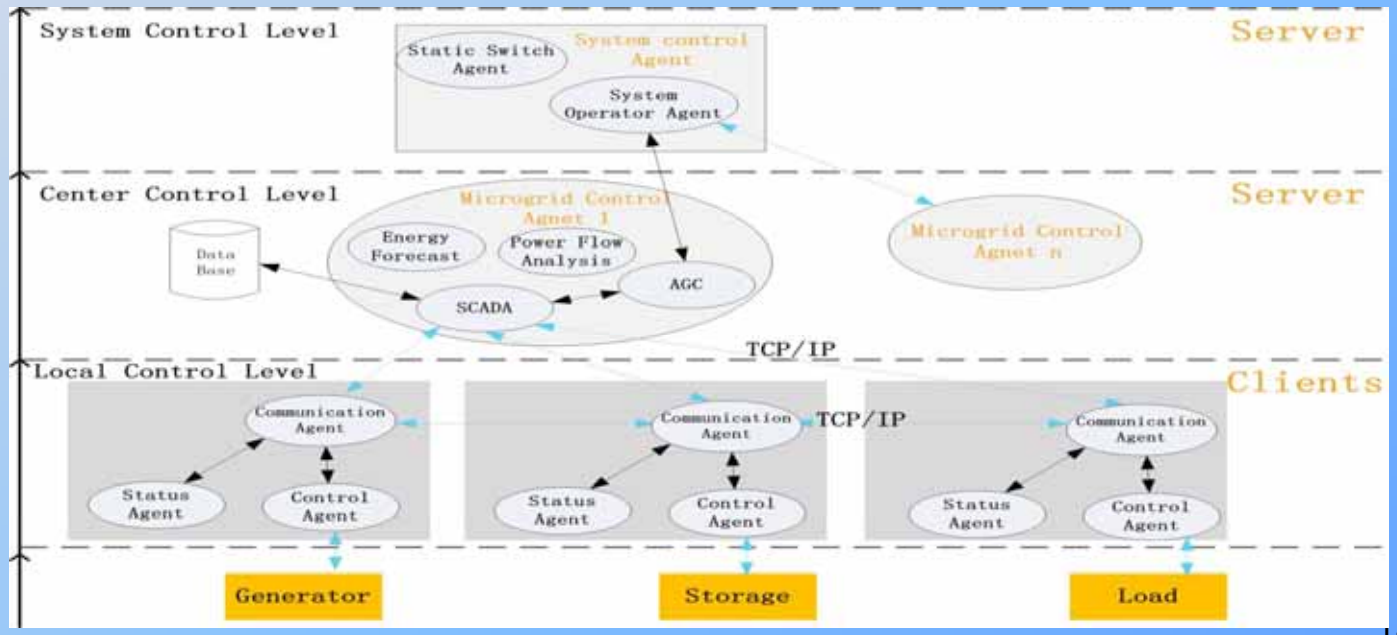
- System Operator Agent
- Static Switch Agent



3. Design and Realization of MAS Based EMS-MG

3.3 Implement of the proposed EMS-MG

The MAS based EMS-MG is integrated together in client- server model under the C++Builder development environment.



3. Design and Realization of MAS Based EMS-MG

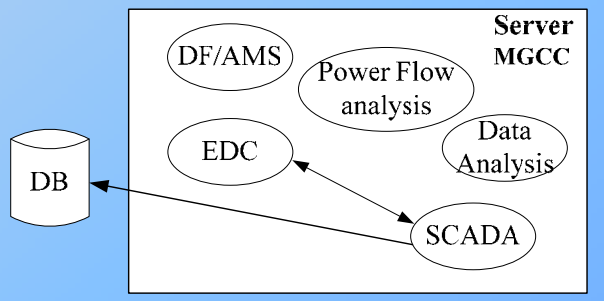
3.3 Implement of the proposed EMS-MG

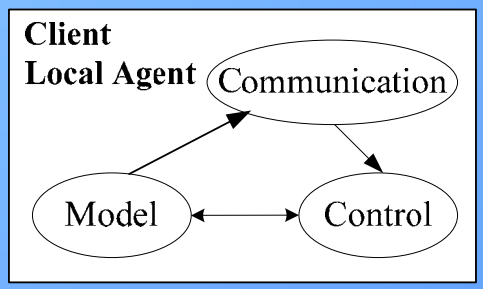
Agent Server

- To offer an open environment for the local Agent Clients
- The other is to manage the operation of Microgrid by coordinate the local Agent Clients

Agent Client

- To realize the local level control different Agent client control different local devices
- Besides, there is also a specific numerical model integrated with each Agent Client, whose parameters could be customized.



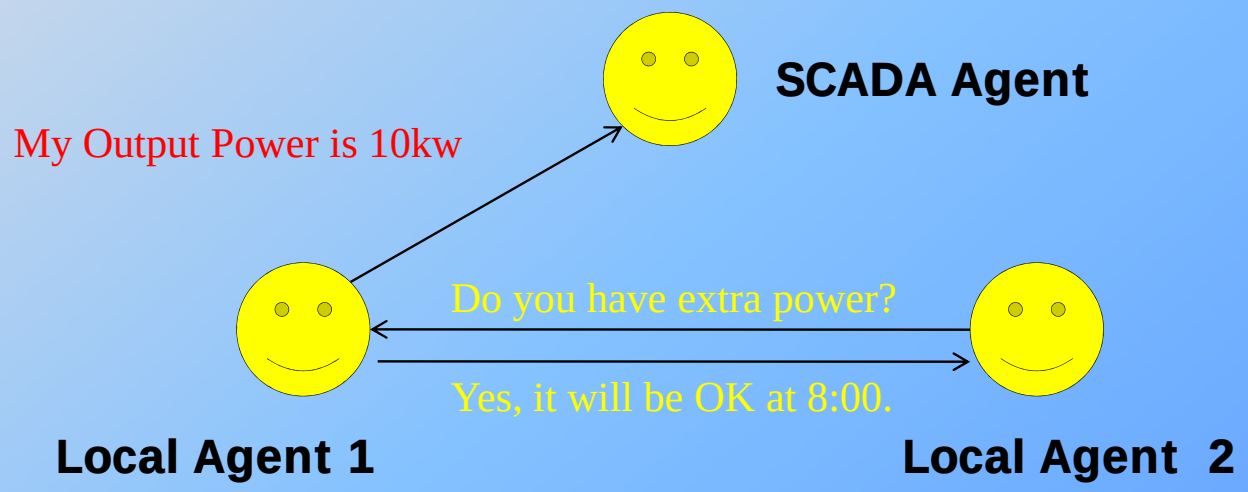


3. Design and Realization of MAS Based EMS-MG

3.3 Implement of the proposed EMS-MG

Agent communication

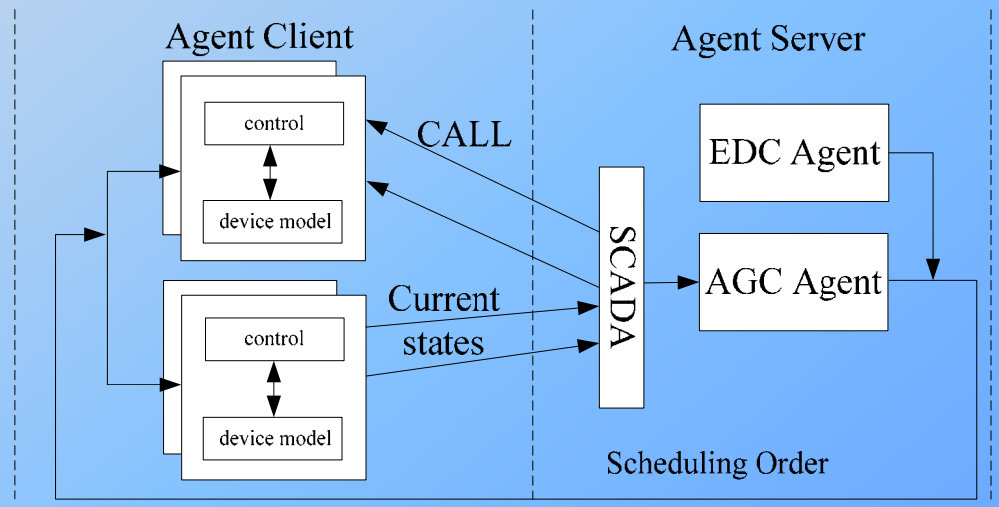
- To coordinate different local agents to complete a more complex task.
- To send the numerical simulation results of local agents to the server.



4.Application of the Proposed EMS-MG: Automatic Generation Control

4.1 Proposed scheme

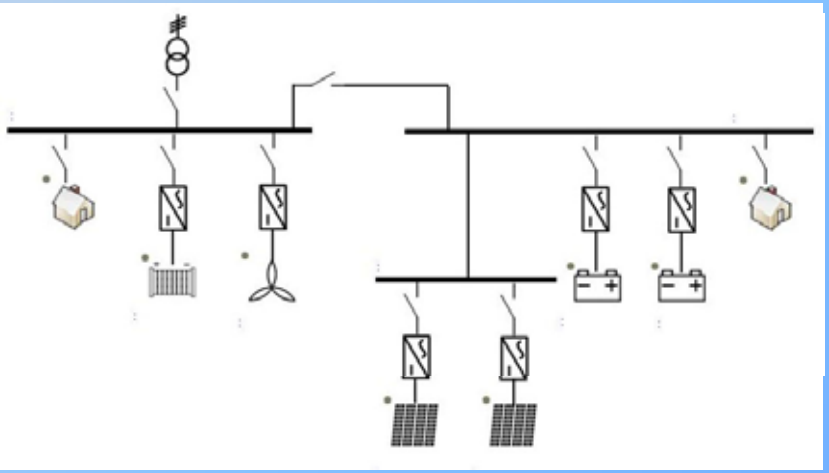
This platform uses the primary and secondary frequency regulation methods but the difference is the frequency regulation is completed by agents, shown as in follow figuer:



4.Application of the Proposed EMS-MG: Automatic Generation Control

4.2 A model of a typical microgrid

The model of an typical Microgrid is developed in EMS-MG platform



Device Name	PV-01	BB-01	WT	PV-02	BB-02	FC
Rating Power (kW)	12	10	17	12	10	25

4.Application of the proposed EMS-MG: Automatic Generation Control

4.3 Primary frequency control

Some generating units, such as battery banks , fuel cells have the ability of primary frequency control. They are in charge of restrain the fluctuation of frequency in microgrid.

$$P_{out} = P_{set} - k(Fre2 - Fre1)$$

4.4 Secondy fequency control

Figure

Microgrid Regulation Error (MRE)

$$MRE = \Delta P^{PCC} + m(Fre1 - Fre2)$$

Where ΔP^{PCC} is the power difference at the Public Connecting Point (PCC)

NEXT

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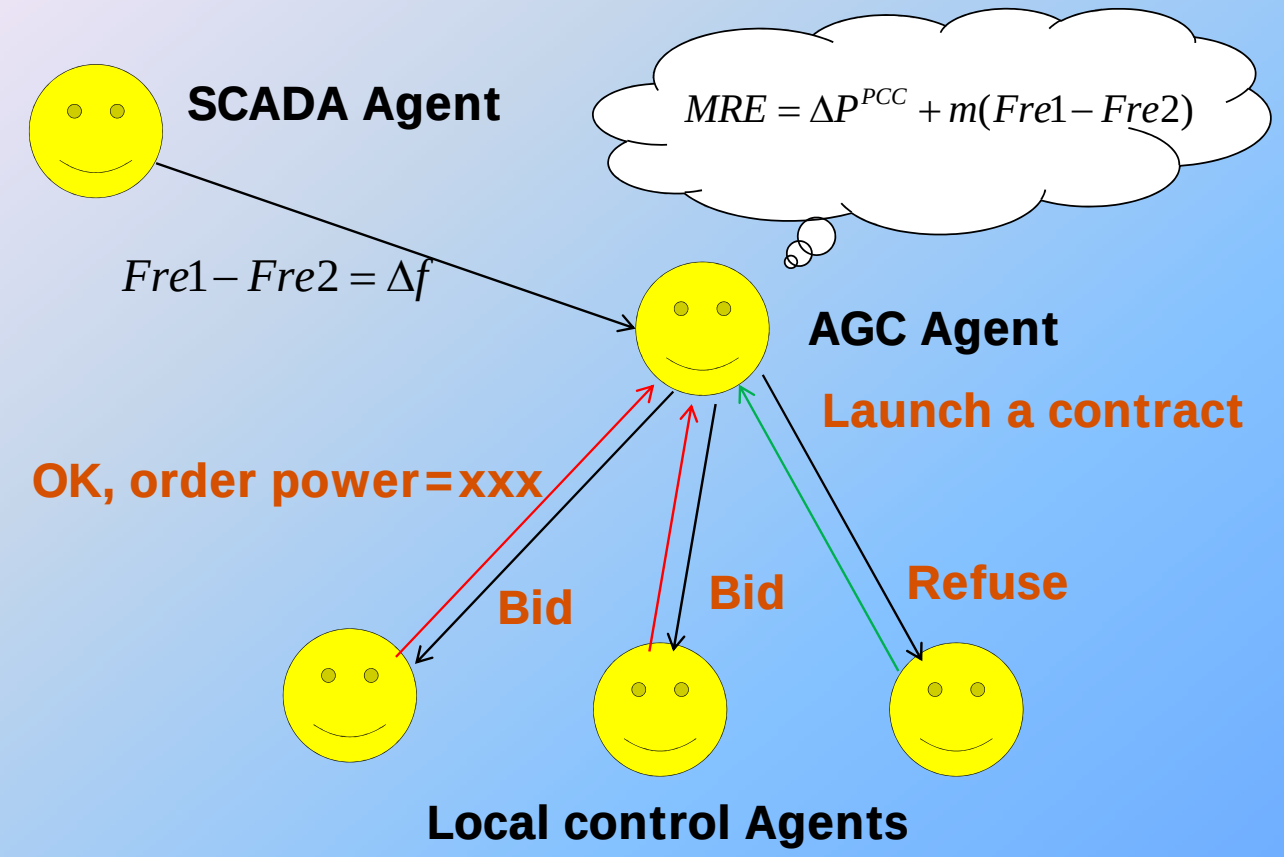
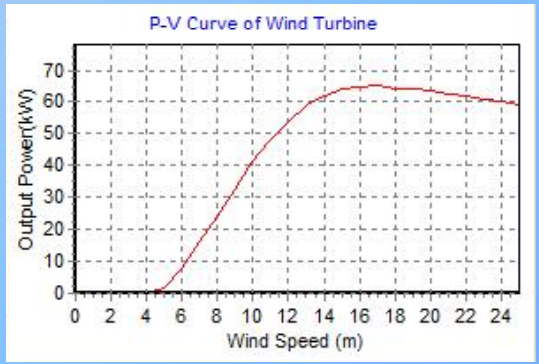


4.Application of the proposed EMS-MG: Automatic Generation Control

DG Power Models



- Photovoltaic Array Model

$$I_{\mathrm{PV}} = I_{sc}(1 - C_1(e^{\frac{V-DV}{C_2 V_{oc}}} - 1)) + DI$$

- Wind Turbine

the curve of power versus the wind speed

- Fuel Cells

$$V_{\mathrm{FC}} = E - (J + J_{\mathrm{in}})r - X\ln(\frac{J + J_{\mathrm{in}}}{J_0}) + Y\ln(1 - \frac{J + J_{\mathrm{in}}}{J_{\mathrm{L}}})$$

- Battery Bank

$$V_{\mathrm{BB}} = E_0 + AX + \frac{CX}{D - X}$$

4.Application of the proposed EMS-MG: Automatic Generation Control

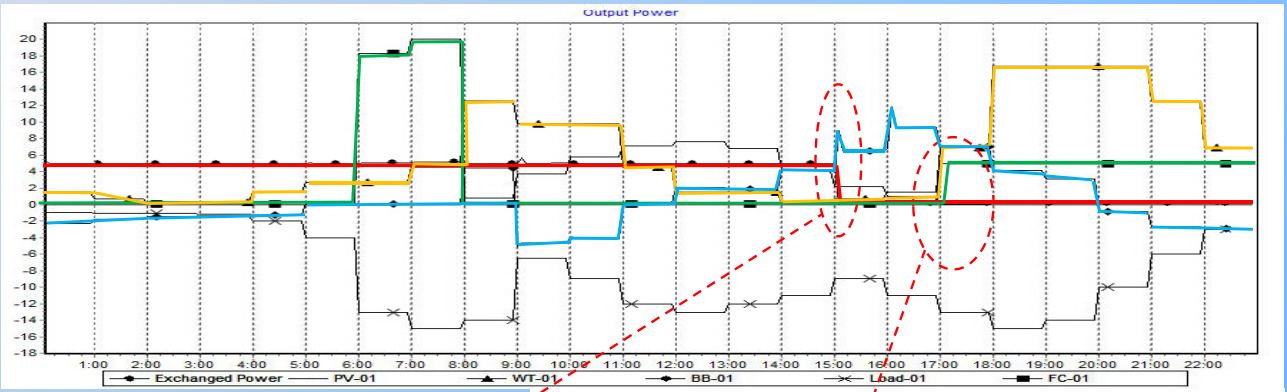
4.5 Simulation results

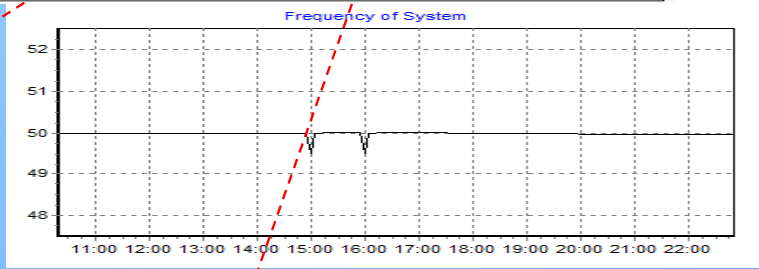
Fuel Cell

Wind Turbine

Battery Bank

Grid



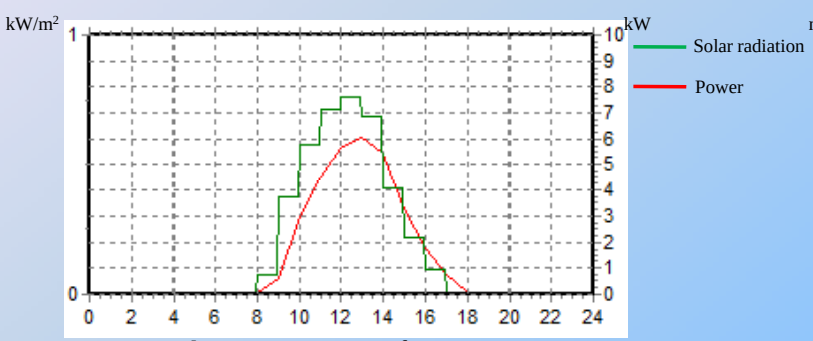


➢the primary frequency control of Control Agent of batteries increased the output power.

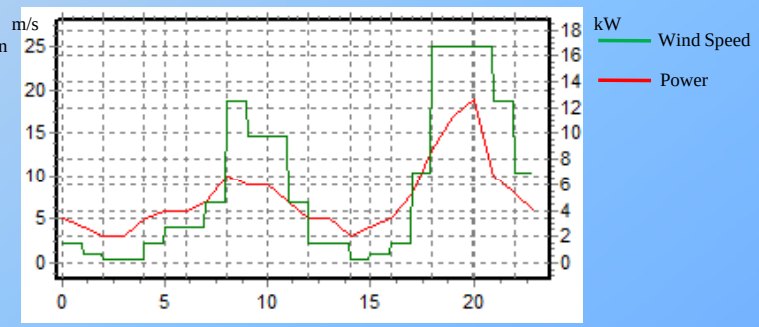
➢the GCC Agent in center control level have not ordered the fuel cells to start up until 17:00

4.Application of the proposed EMS-MG: Automatic Generation Control

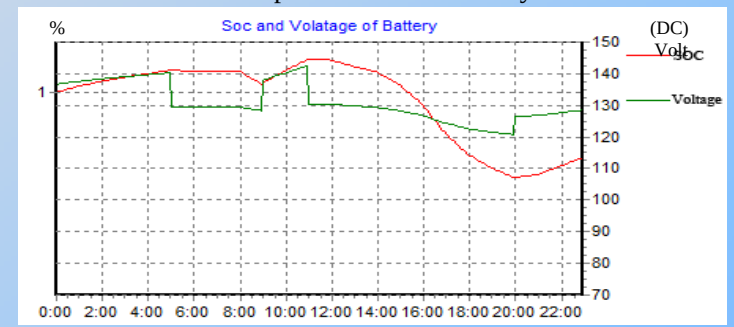
4.6 Outputs of the Models



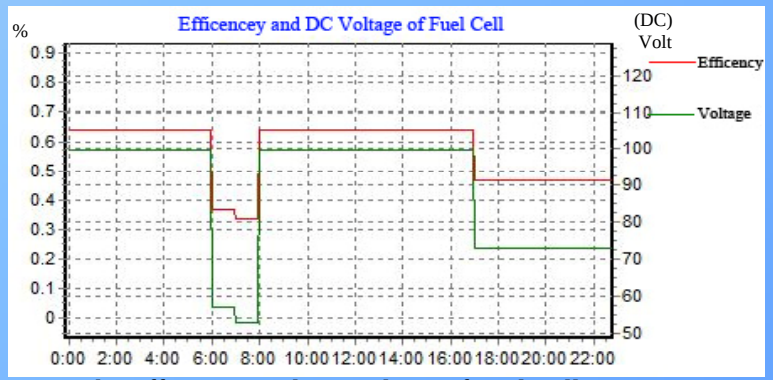
The output Power of PV Array



The output Power of Wind Turbine



The SOC and DC Voltage of Battery



The Efficencey and DC Voltage of Fuel Cell

V. Conclusion

This paper presents a novel platform for the study of EMS-MG based on MAS and uses a structure of Client-Server to implement it.

1. It is convenient to simulate and validate different functions of EMS-MG and the DGs in Microgrid.

2. The simulation results show a generation coordination control method is valid in operating the Microgrid in islanding mode or grid-connected mode.

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Thanks