

An Highly Integrated and Reconfigurable Microgrid Testbed with Hybrid Distributed Energy Resources

Prof. Chengshan Wang

Tianjin University, Tianjin, China

Email: cswang@tju.edu.cn



Outline

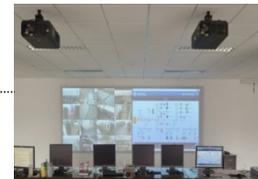
TUMT

Tianjin University Microgrid Testbed

Sec. I INTRODUCTION



Sec. II COMPOSITION AND STRUCTURE OF TUMT



Sec. III EXPERIMENTAL STUDY





Outline

TUMT

Tianjin University Microgrid Testbed

Sec. I INTRODUCTION



Sec. II COMPOSITION AND STRUCTURE OF TUMT



Sec. III EXPERIMENTAL STUDY





Demand & Pressures & Resources



Increasing Energy Demand:

China is still in the stage of

- ◆ Industrialization
- ◆ Urbanization

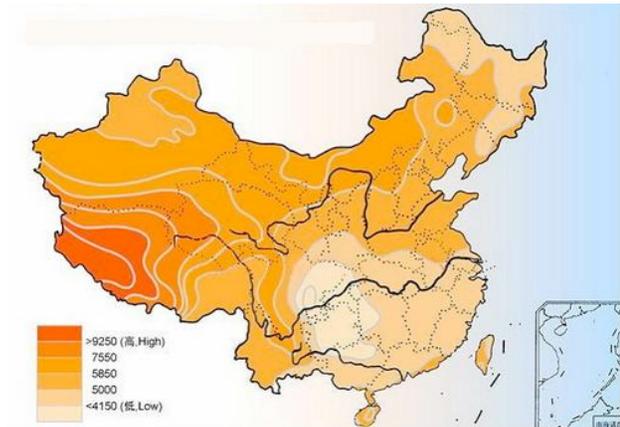
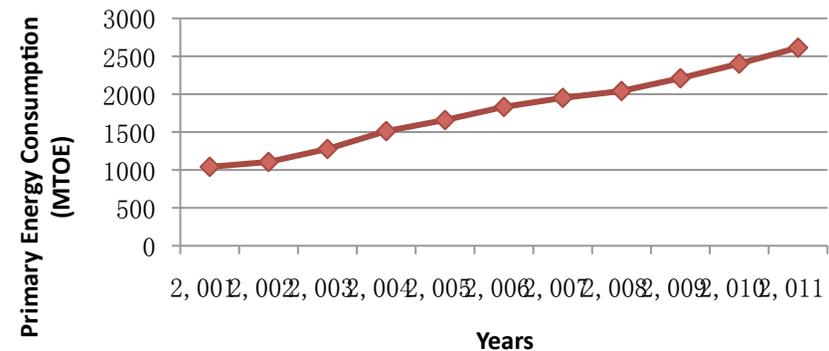
Environmental Problems:

Chinese Government:

40%~45% of GHG Emission for unit GDP will be reduced by 2020 compared to 2005.

Abundant Renewable Energy Resources

Primary Energy Consumption of China



Solar Energy Resources





The 12th Five-Year Plan of the Development of Renewable Energy

Motivated by:

- ◆ Increasing energy demand
- ◆ Depleting fossil fuels
- ◆ Environmental problems
- ◆ Abundant renewable energy

To further:

- ◆ Adjust energy structure
- ◆ Transform economic development pattern
- ◆ Achieve sustainable development

Goal: The percentage of **non-fossil energy** (to energy consumption) will increase to: **11.4% by 2015** and **15% by 2020**.





The 12th Five-Year Plan of the Development of Renewable Energy requires to promote the development of Distributed Renewable Energy.



By the year of 2015:



County:

- ◆ 200 Green Energy Demonstration Counties
- ◆ 1000 Solar Energy Demonstration Villages

City:

- ◆ 100 New Energy Demonstration Cities
- ◆ 1000 New Energy Demonstration Parks

Microgrids: 30 New Energy Microgrids

- ◆ Total investment is as much as 1800 billion Yuan (293 billion Dollars)
- ◆ Distributed energy is a vital part.

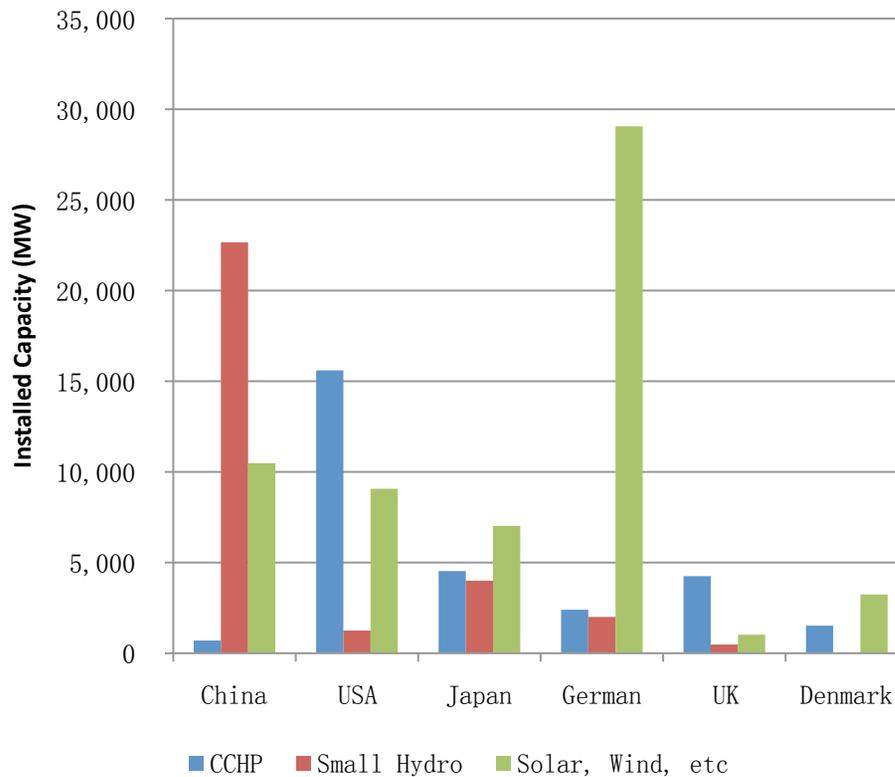




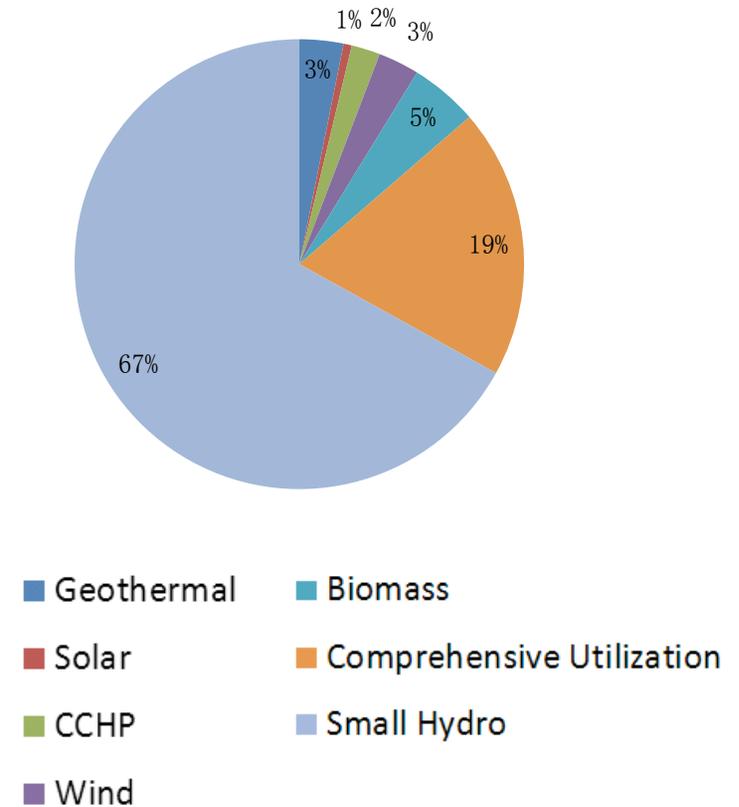
Status: Distributed Generations in China



Installed Capacity of DGs of Major Countries in 2010



Composition of DGs in China





Status: Microgrids in China



Tens of Demonstration
Microgrid Constructed

- ◆ Voltage Levels
380V; 10kV
- ◆ Installed Capacity
1 MW; 1MW - 5 MW
5MW - 50 MW





Challenges & Solutions



The Integration of DGs and MGs into Smart Distribution Network:

Challenges:

Theories & Technologies

- ◆ Stability & Reliability
- ◆ Protection & Control
- ◆ Plan & Design
- ◆ Energy Management
- ◆ Cooperative Operation

Policies & Standards:

- ◆ Blank in many key links
- ◆ Non-unified

Solutions:

- ◆ Fund research programs on key theories and technologies
- ◆ Form a complete and unified policy & standard system
- ◆ Build new adapted management system & market mechanism



Outline

TUMT

Tianjin University Microgrid Testbed

Sec. I INTRODUCTION



Sec. II COMPOSITION AND STRUCTURE OF TUMT



Sec. III EXPERIMENTAL STUDY



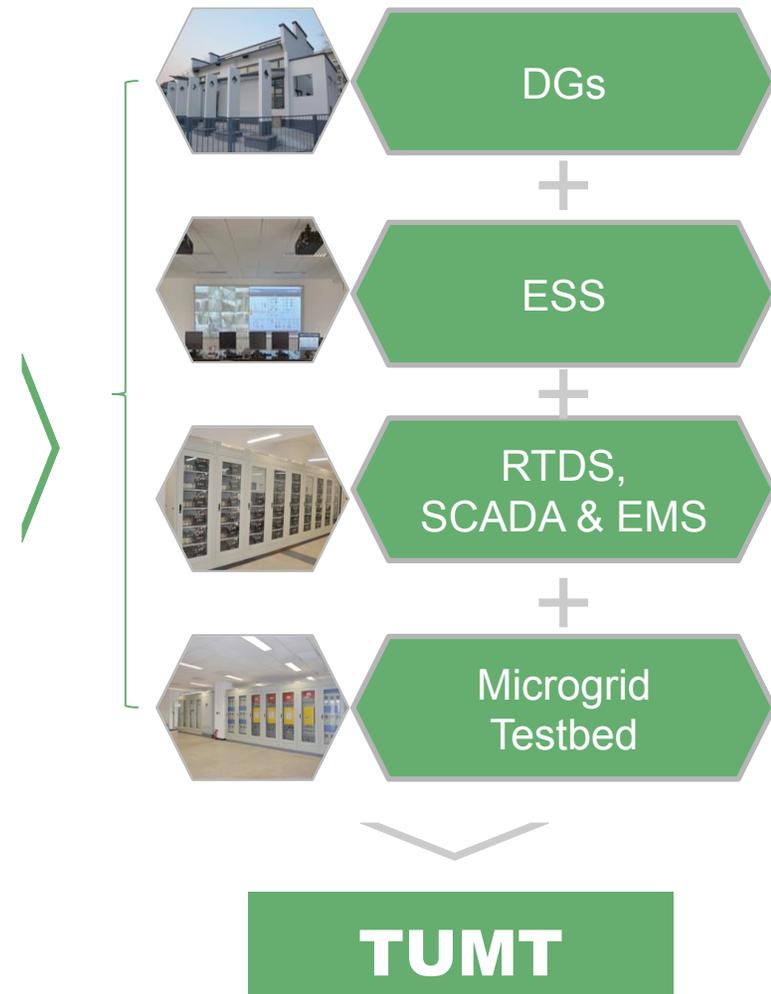
Composition

LSG

LSG was:

- Key **L**aboratory of **S**mart **G**rid, **MOE**
- Constituted by the **eight** Sublabs
- Supported in part by **the National Basic Research Program of China (973 Program)**
- Supported in part **by the National Natural Science Foundation of China**

The parts of LSG



Microgrid Testbed of Tianjin University



Distributed Generation Units:

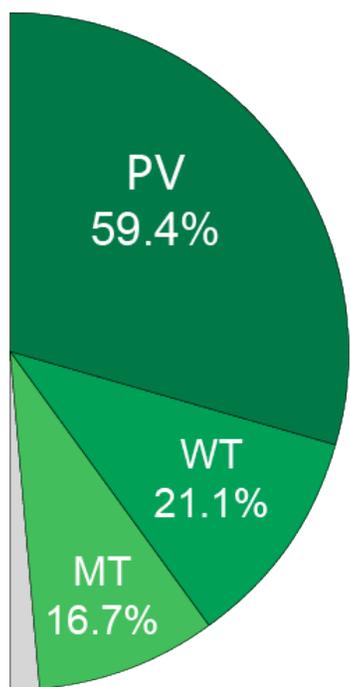
- ◆ PV: mono-Si, poly-Si, thin film
- ◆ Wind Turbines: PMSG, DFIG
- ◆ CCHP System with MicroTurbine
- ◆ Fuel Cell: PEM Fuel Cell System



Energy Storage Systems:

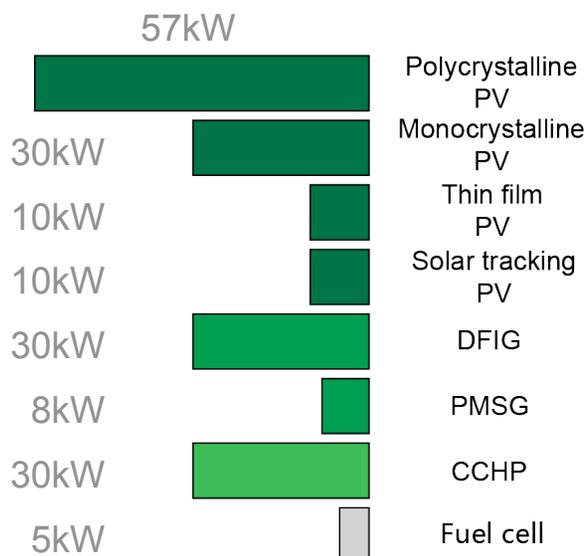
- ◆ Static ESS: Lead-Acid, Li-Ion, Redox Flow, Super Capacitors
- ◆ Rotating ESS: Flywheel, Compressed Air

Capacity

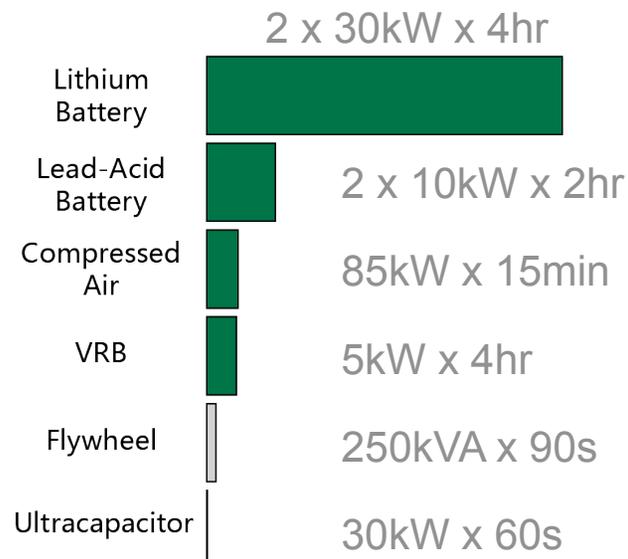


Fuel cell 2.8%

DG



ESS



Percent / Capacity

180kW

Capacity

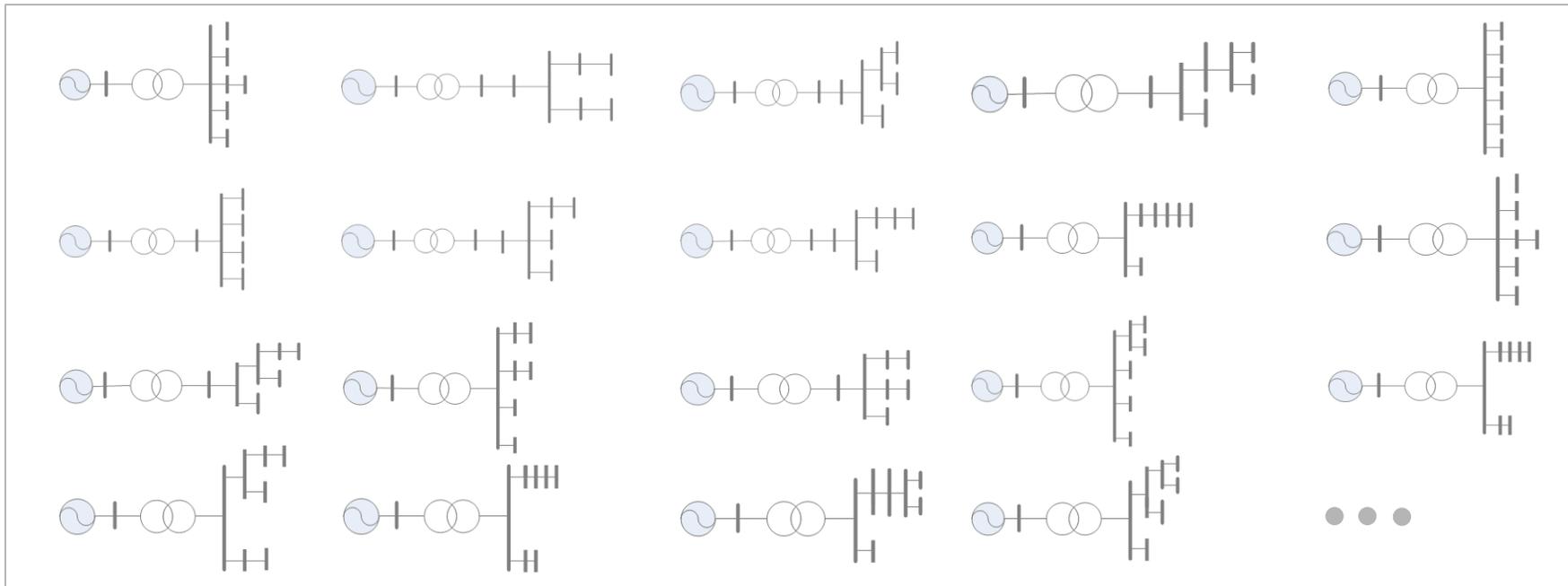
334.4kWh



Topologies

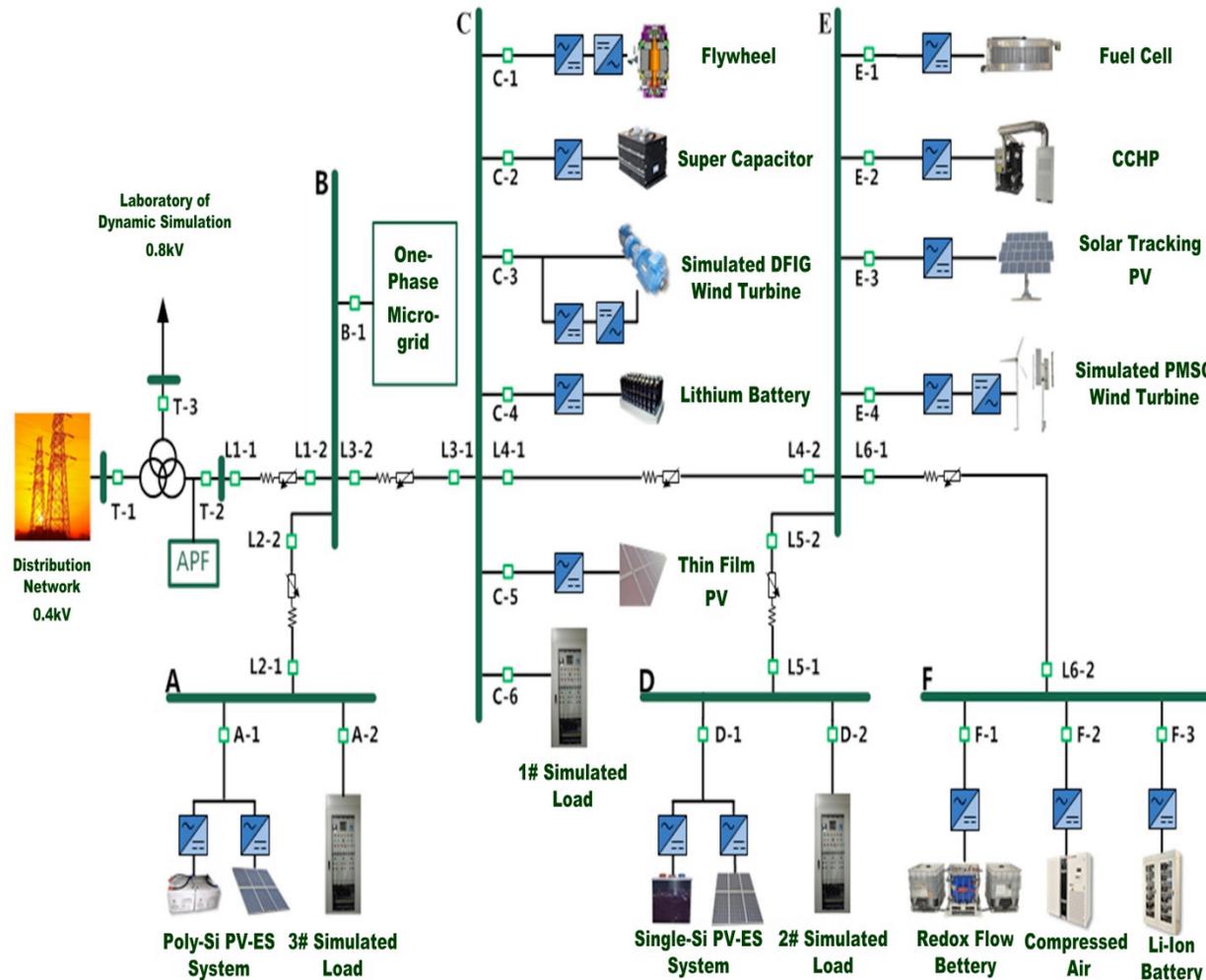
TUMT is **an highly reconfigurable microgrid testbed**

- consists of **6** busbars and **6** feeders
- with **adjustable** resistance and reactance to simulate different types and lengths of feeders.
- could form **43** topologies with different selections and combination of busbars and feeders





Microgrid Testbed in Tianjin University



50 Operation Modes:

- ◆ Single DG Unit
- ◆ Multi-DG Units in Single Bus
- ◆ Multi-DG Units in Multi-Buses

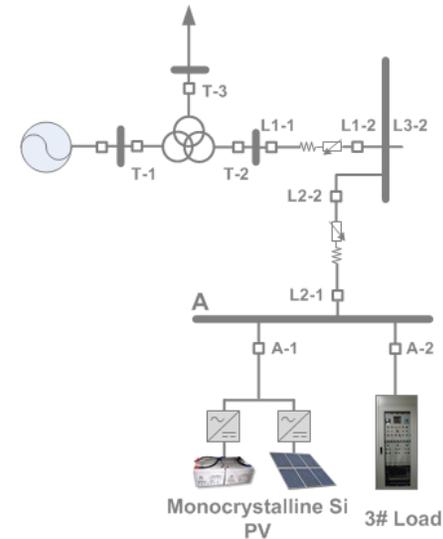
Equipped With:

- ◆ Protection System
- ◆ Monitor & Control System
- ◆ Microgrid Energy Management System

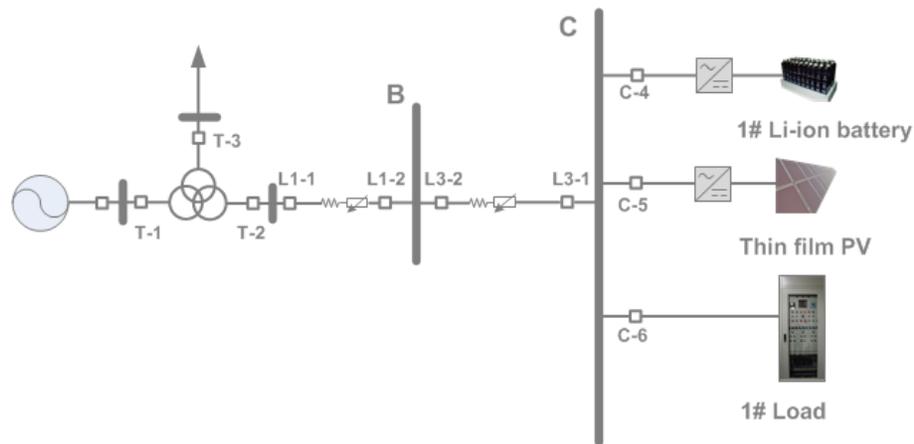
Operation modes

Operation modes vary according to research requirements by selecting DG and ESS, which could be divided into **3** categories:

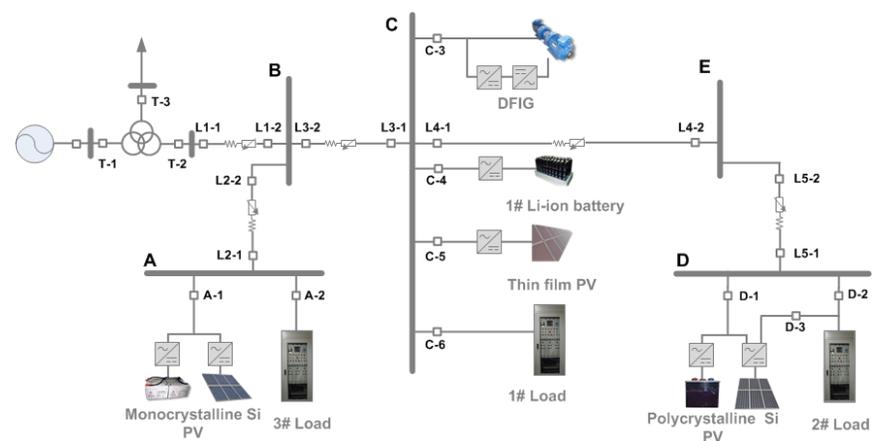
- Single resource
- Multiple resources in single busbar
- Multiple resources in multiple busbars



Single resource



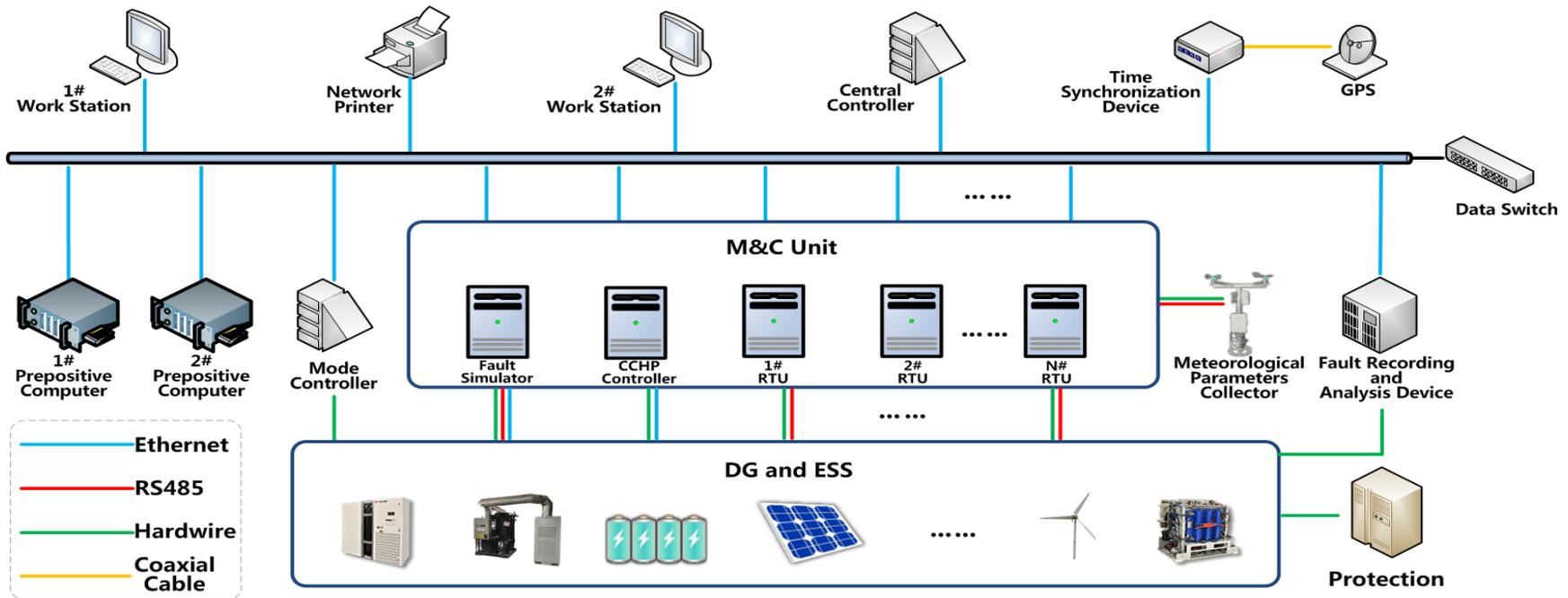
Multiple resources in single busbar



Multiple resources in single busbar



CMS

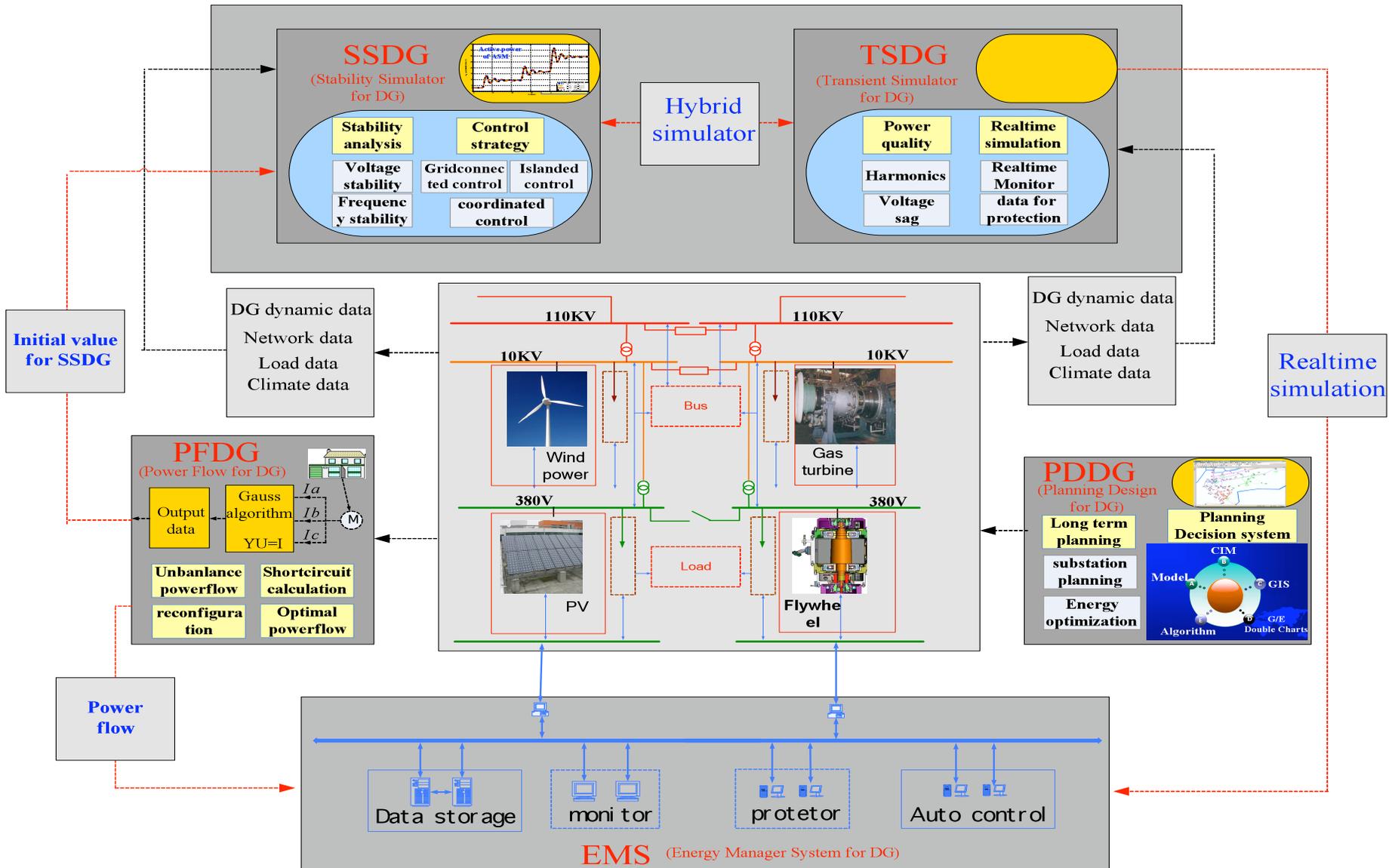


The function of **centralized management system(CMS)** with visual UI are categorized into **4** groups :

- SCADA
- protection and control
- Operation modes control
- Energy management



Relative Softwares Developed in TJU SG Lab.



Outline

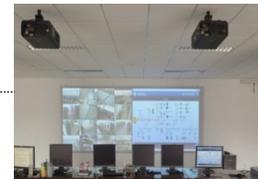
TUMT

Tianjin University Microgrid Testbed

Sec. I INTRODUCTION

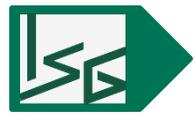


Sec. II COMPOSITION AND STRUCTURE OF TUMT



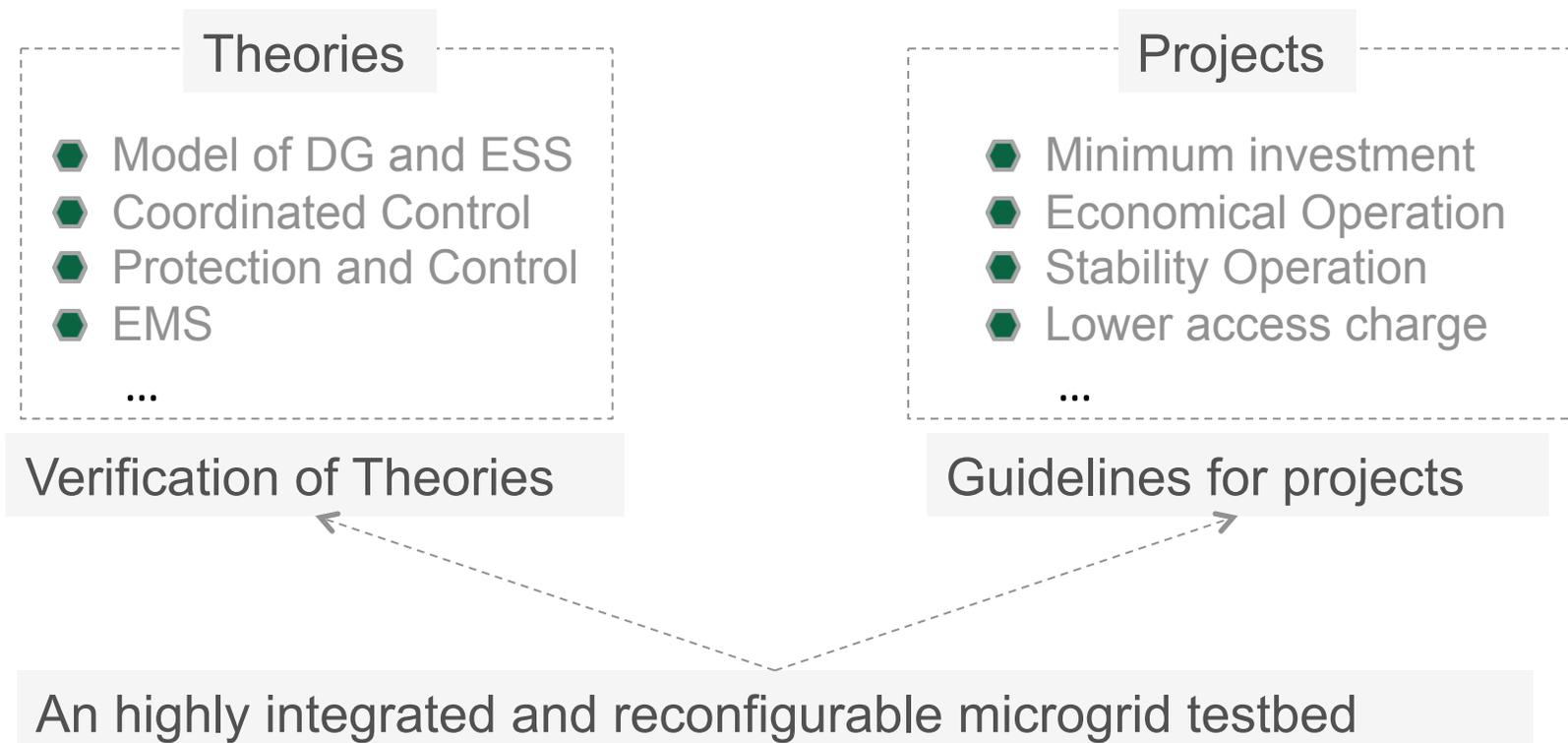
Sec. III EXPERIMENTAL STUDY

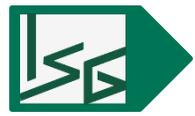




Experimental study

Plenty of experiments in many study fields of microgrids have been carried out to support microgrid theories and provide guides for engineering projects.

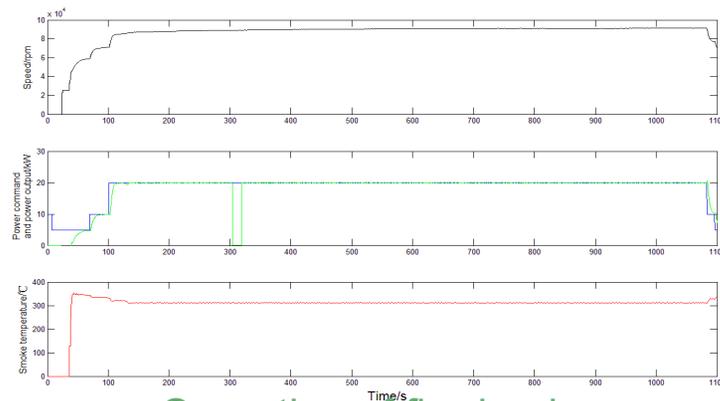




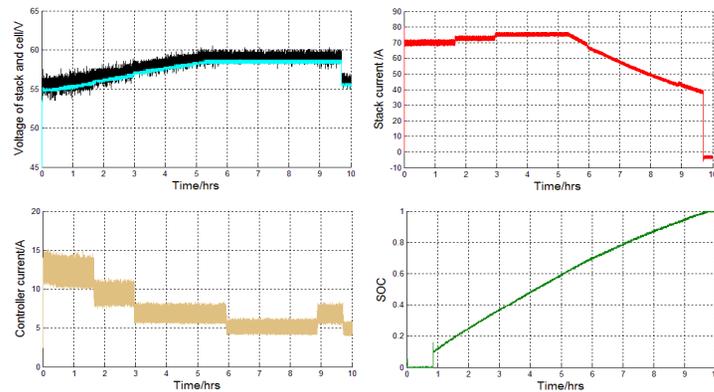
Experimental study

Researches on performance of DG and ESS

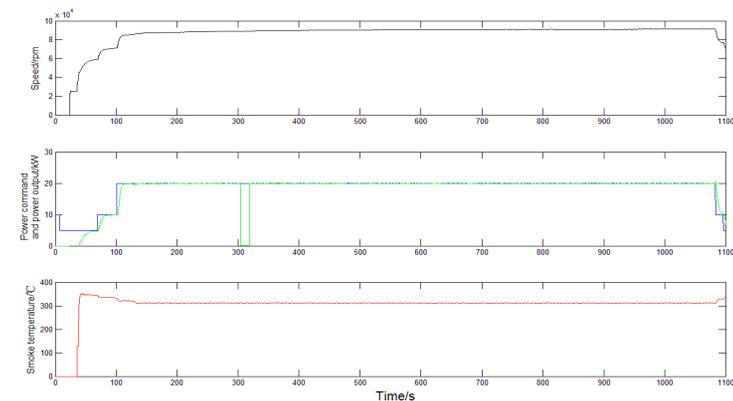
Steady-state and Transient performance of all the devices are acquired via these researches, which could be used to validate digital simulation models



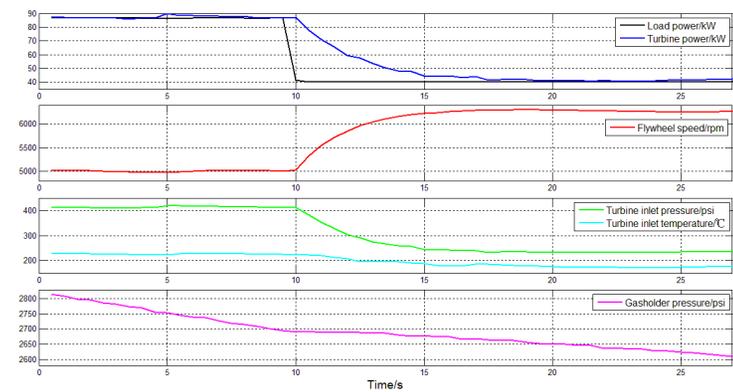
Operation of flywheel



Charge-discharge of VRB



Start of micro turbine in CCHP



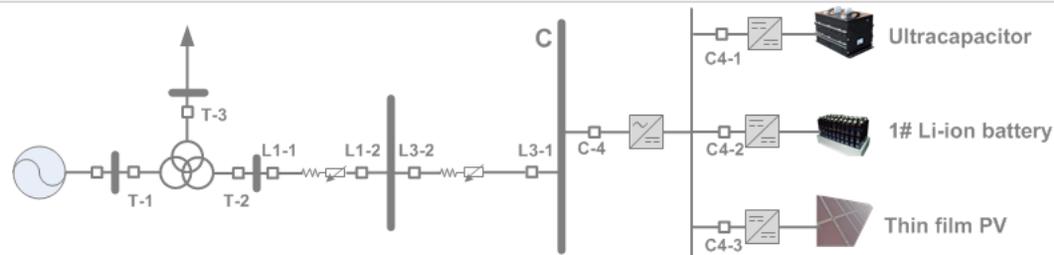
Load response of compressed air



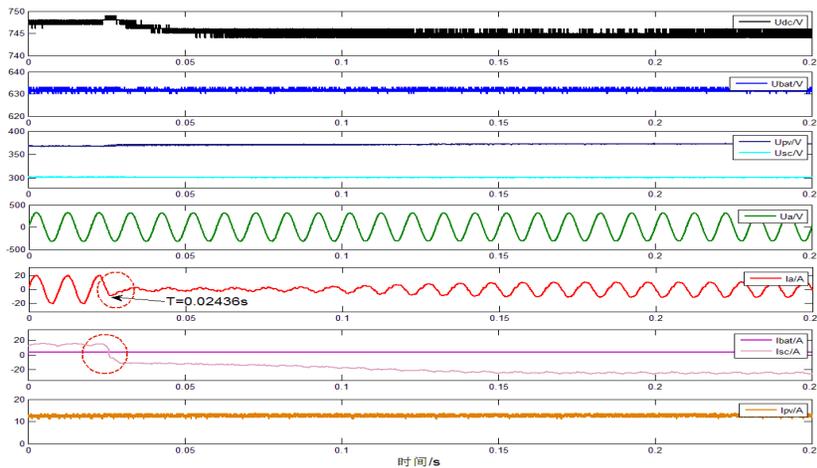
Experimental study

Coordinated control of DG and ESS

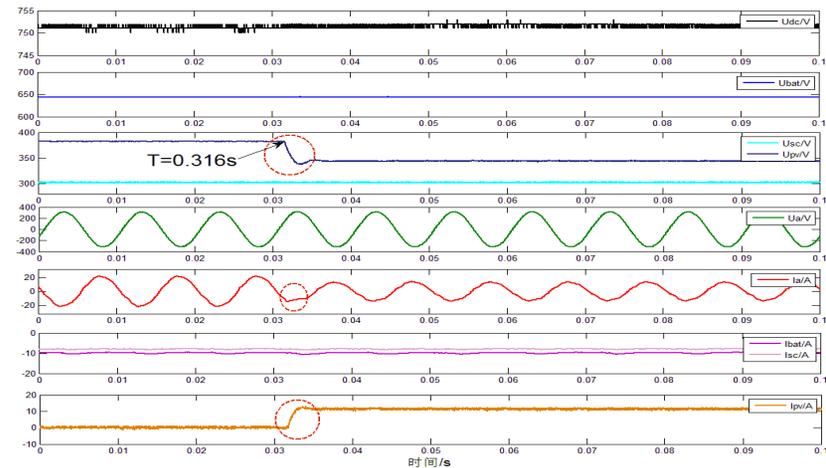
Control strategies are studied and verified for some key issues in microgrid control, such as eliminating voltage fluctuation, improving dynamic response, compensating the intermittence of DG, etc. in AC/DC hybrid microgrid



Experimental structure in TUMT



sharply increase of PV output



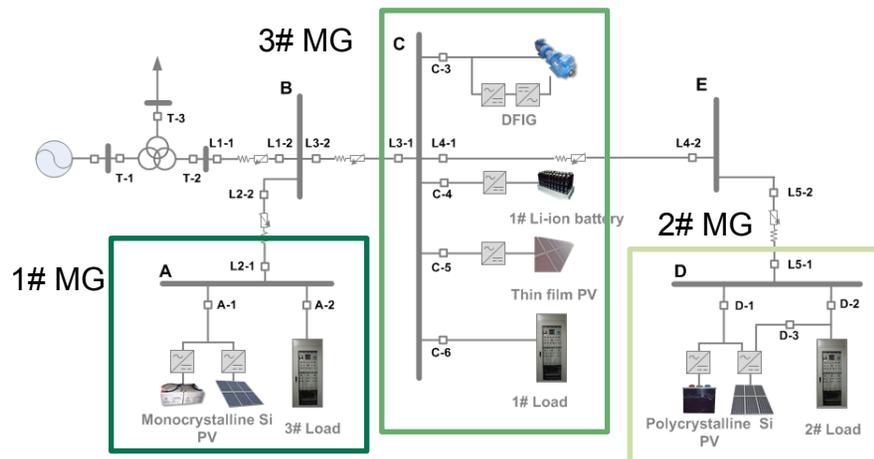
Transition of charge-discharge



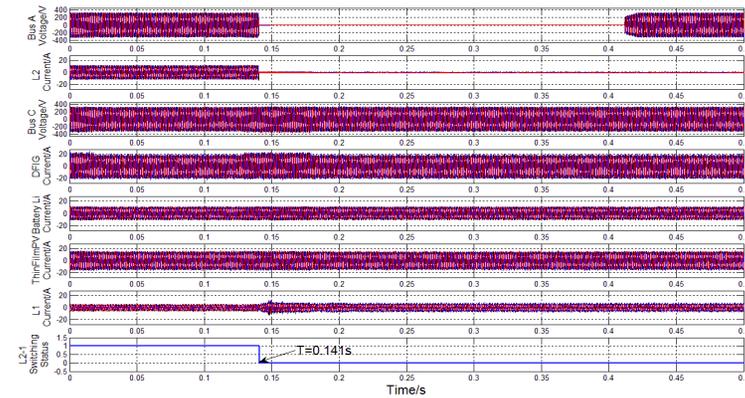
Experimental study

Researches on mode transition of multi-microgrid

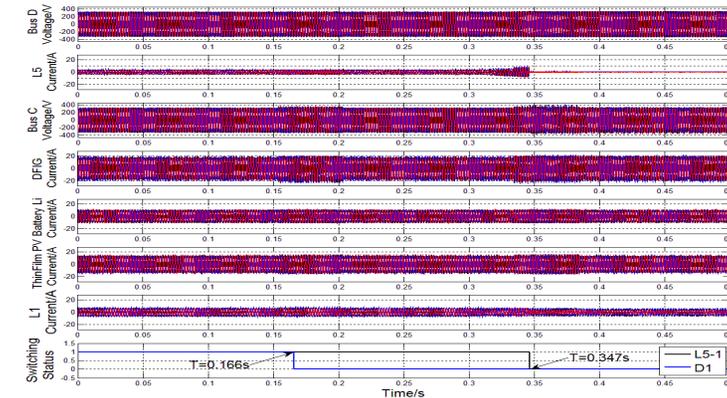
The research work concentrates on control strategies of mode switching between grid-connected mode and islanded mode



Experimental structure in TUMT

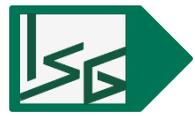


Grid-connected mode to islanded mode of 1# MG



Grid-connected mode to islanded mode of 2# MG

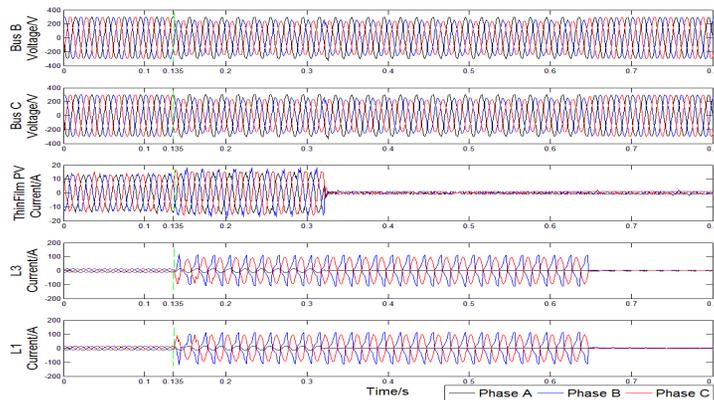




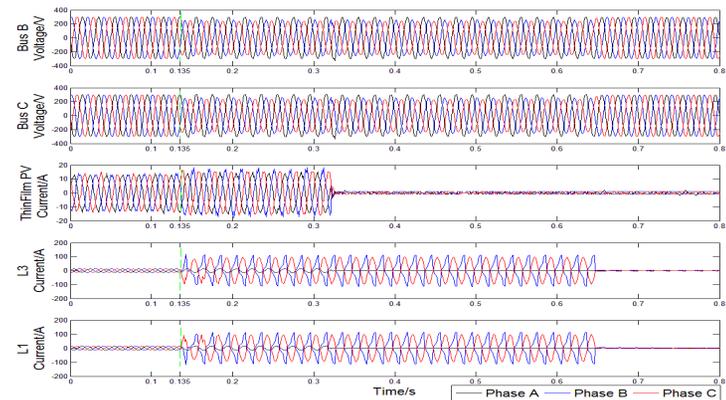
Experimental study

Fault characteristics and protection of microgrid

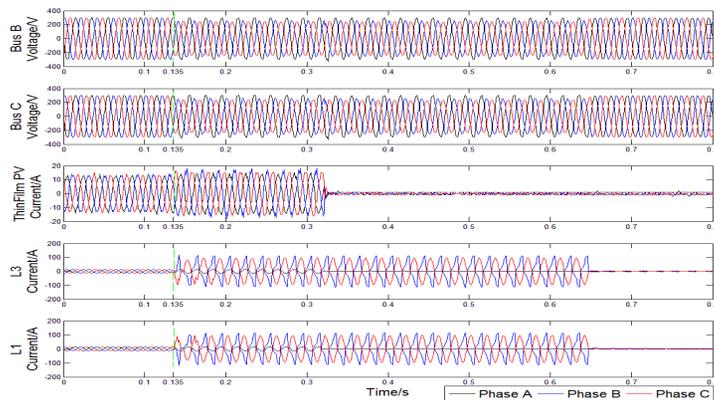
The fault characteristics of microgrid can be acquired via a series of experiments with distinct fault types, locations, and failure duration



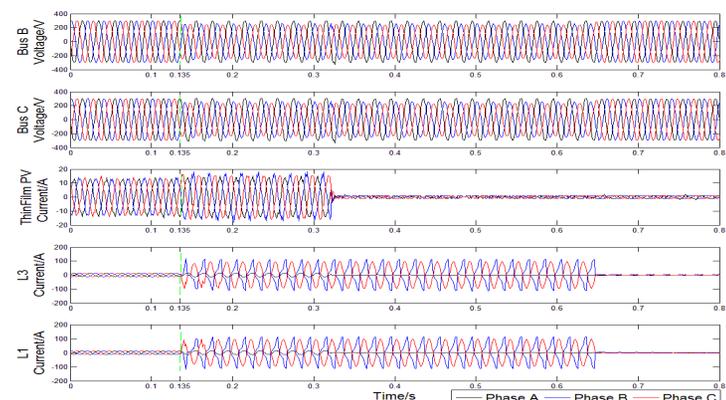
Phase A single phase fault on B bus, fault depth 30%,duration 0.1s



Symmetrical fault on A bus, fault depth 70%,duration 1s



Double phase-to-earth on C bus, fault depth 80%,duration 0.5s



phase-to-phase fault on C bus, fault depth 50%,duration 0.25s



Dongfushan Island Microgrid

Past : Residential electricity shortages , and electricity supplied by diesel generation is expensive. Drinking water is produced from rain purification & shipped from Zhoushan Islands.



Wind: 210kW (7X30kW)

Lead-acid batteries : 2V/1200Ah (No.480)

Seawater Desalination: 24kW

PV : 100kW

Diesel G: 200kW

MG with clean energy power sources and seawater desalination system, to supply local electricity & water.

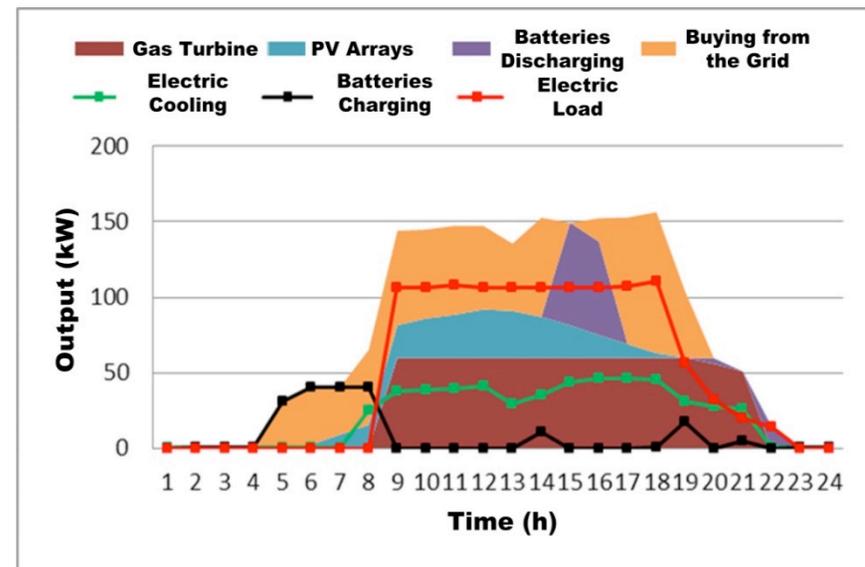


Sino-Singapore Tianjin Eco-city: Energy Station Microgrid

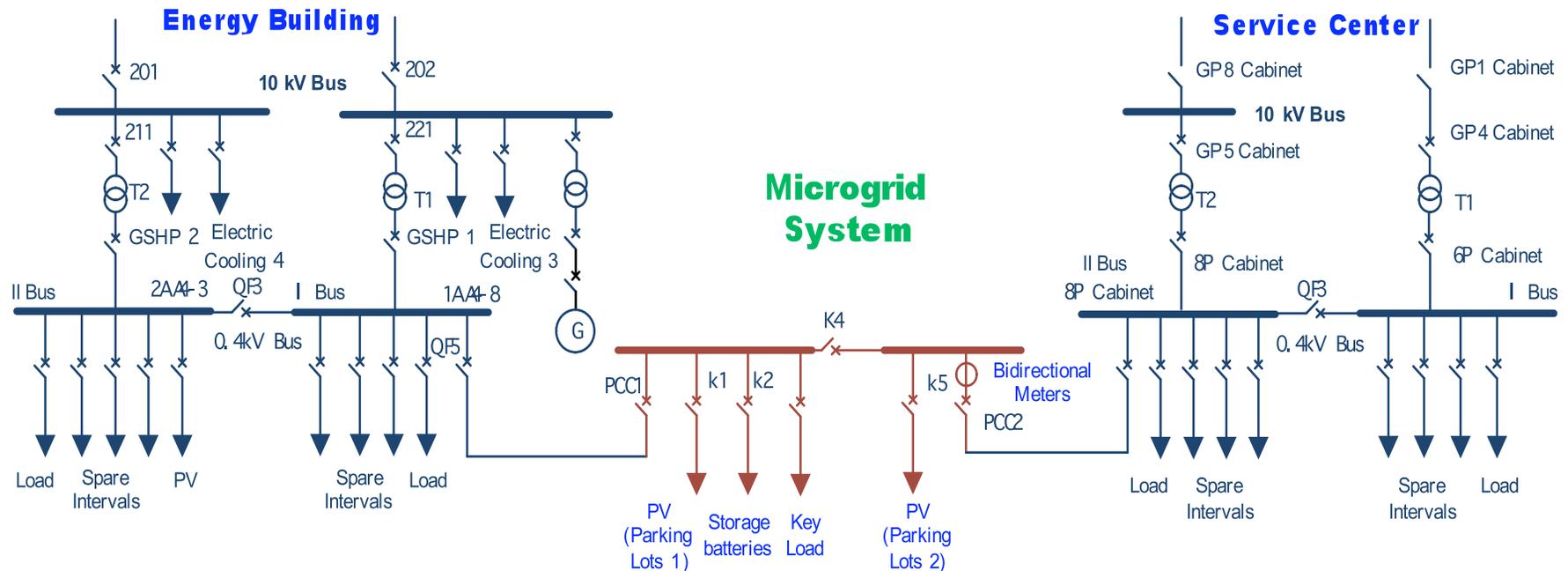


Components:

- ◆ Gas Turbines (1489 kW)
- ◆ PV Arrays (470 kW)
- ◆ Battery Storage
- ◆ Thermal Storage
- ◆ Ground Source Heat Pump



System Structure of Energy Station Microgrid



Operational Modes:

Switch	Heating & Cooling Seasons	Other Seasons	Fault Situations
K4	On	Off	On
PCC1	On	On	On
PCC2	Off	On	On



THANK YOU

Prof.Chengshan Wang

Email: cswang@tju.edu.cn

Tianjin University,China

Introduction of Tianjin

- largest port city in North China
- Financial, Logistic and Industrial Center in North China
- 11,900 km² total area and Permanent Population 11.76 Million
- Key Programs during the past 5 years
 - ✓ Sino-Singapore Tianjin Eco-city
 - ✓ Airbus A320, with total planned investment of 3502.08 billion yuan
 - ✓ 1 million tons ethylene
 - ✓ National aerospace manufacturing base
 - ✓



Introduction of Tianjin

The name of "Tianjin", meaning "a port for the emperor", was first adopted in the early stage of Ming Dynasty (1403). As a famous historic city in China, Tianjin is well-known for its profound cultural heritage.



Colorful cultures and cuisines





汇图网 www.huitu.com

编号: 20120615202852540383 汇图网正版商业图库 (www.huitu.com) by: 热风摄影

Welcome to Tianjin