Preliminary Operation Results of Experimental Power Grid Facility
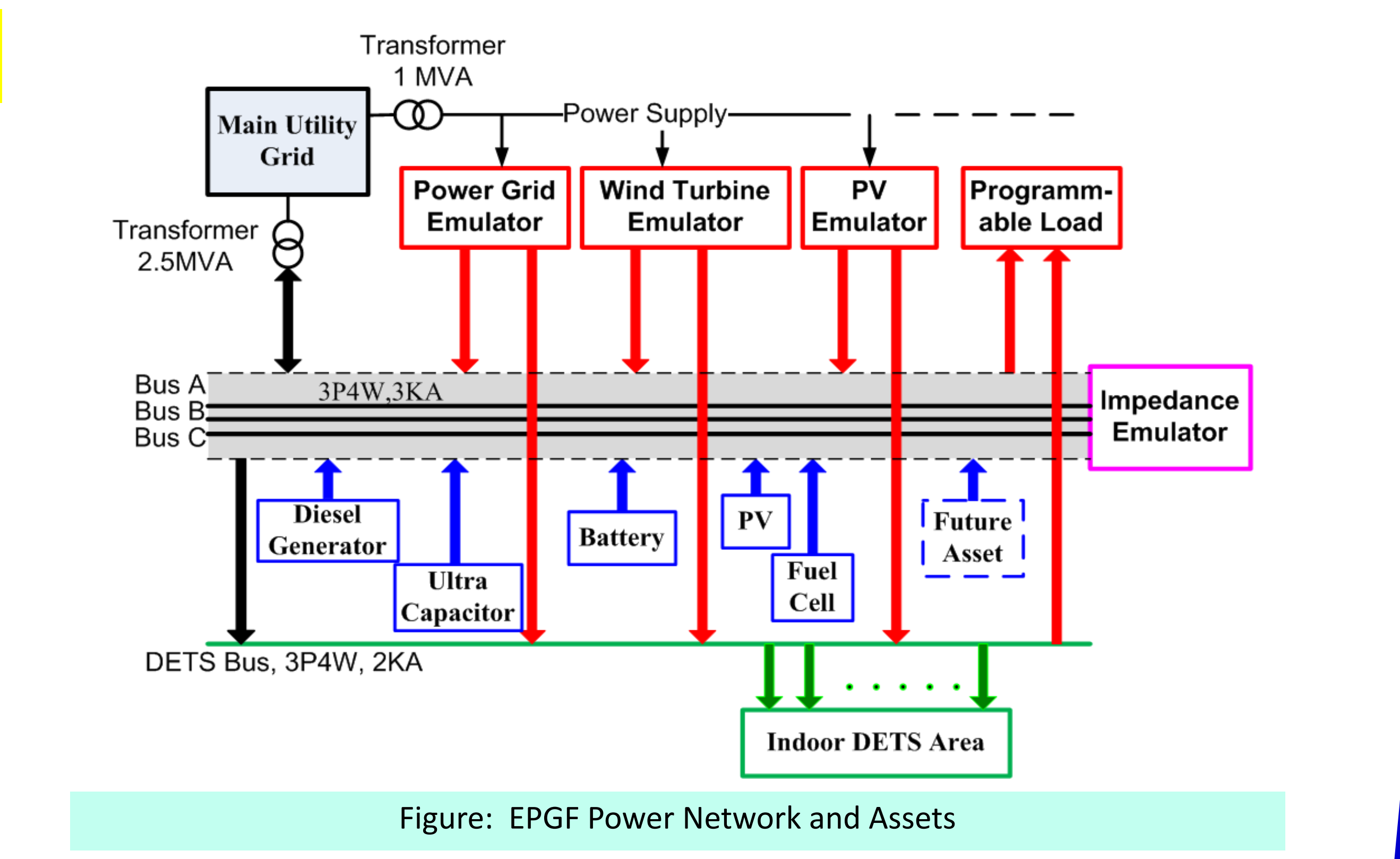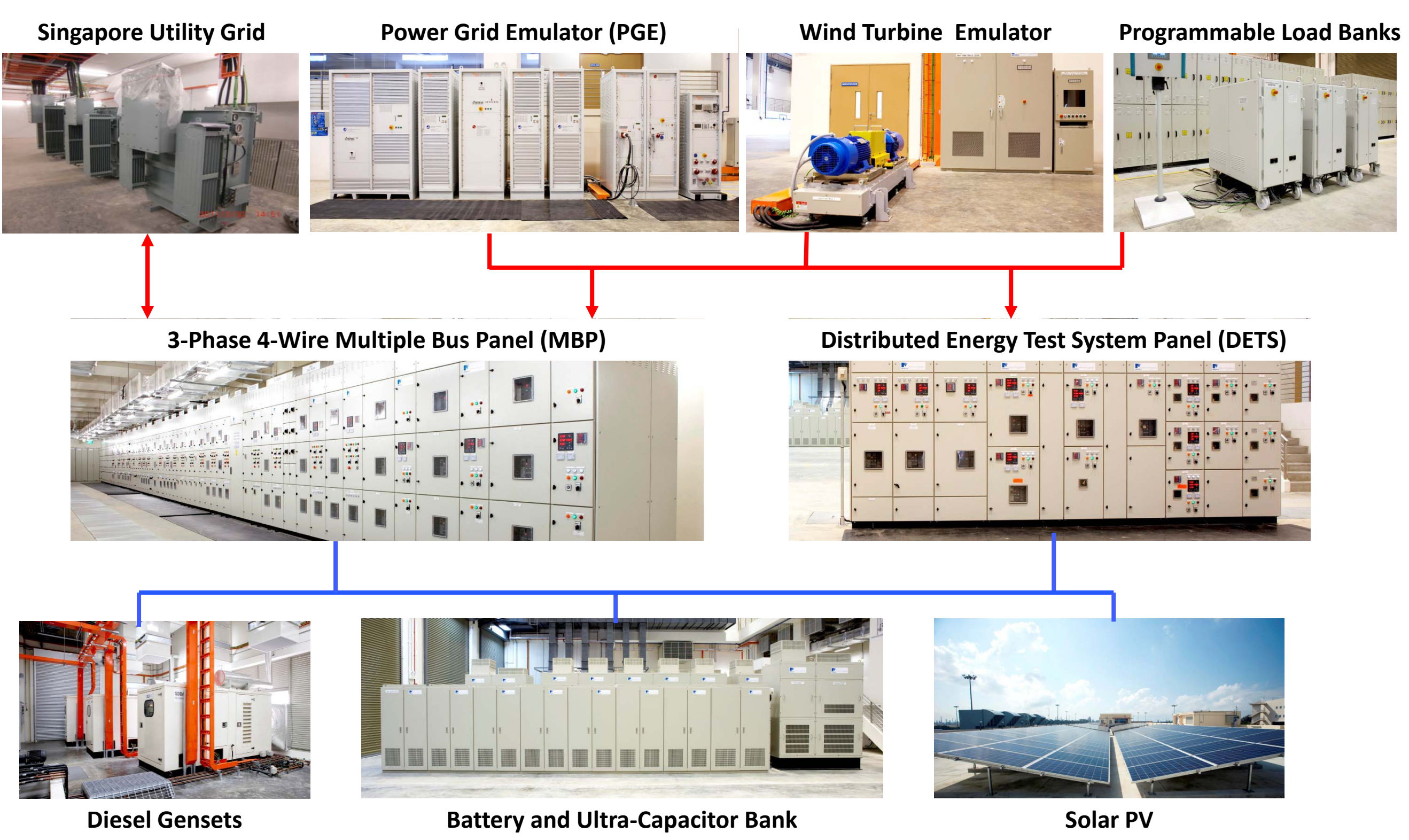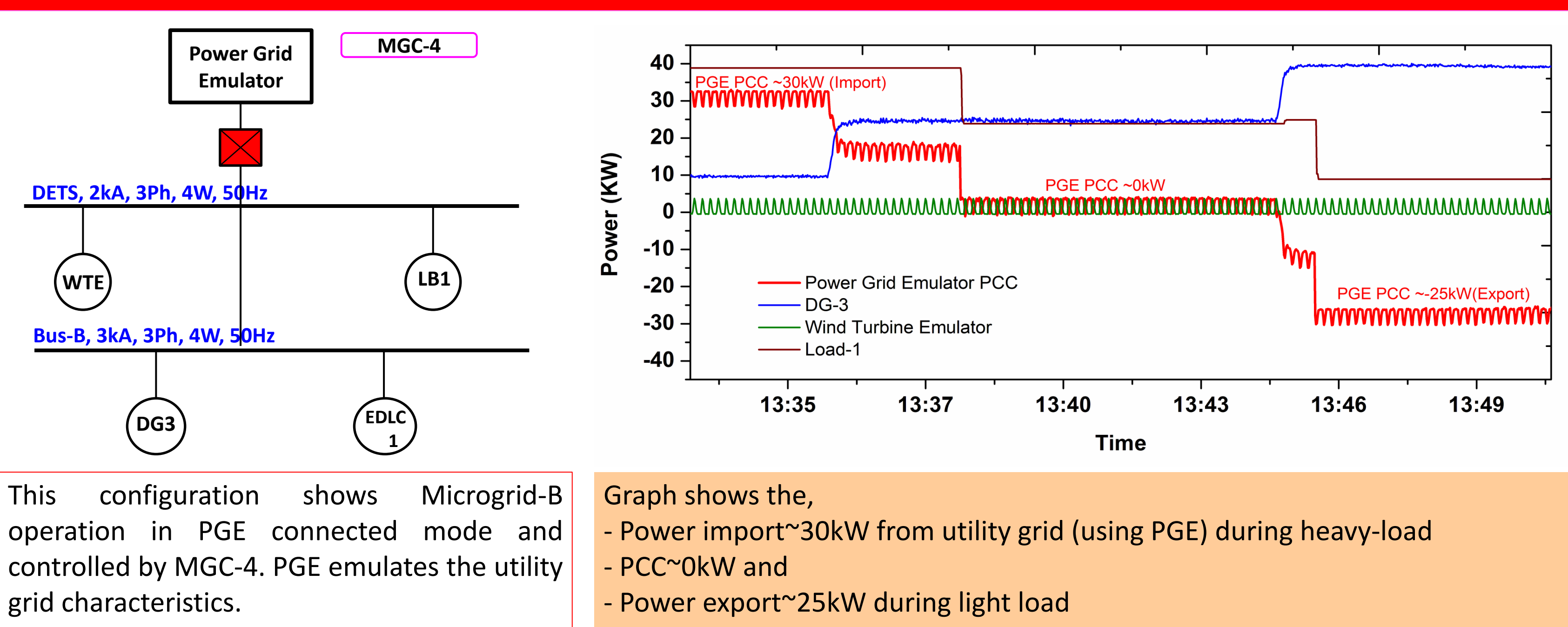
Mr. Inam Nutkani , Dr. Yu Xiao Xiao, Dr. Gao Zhiyong, Mr. Alex Chong, A/Prof Ashwin M Khambadkone, EPGC, A*STAR Singapore

Experimental Power Grid Centre

Objective

To share the preliminary experimental results and key functionalities of the Experimental Power Grid Facility (EPGF) for different grid configurations and operation modes.
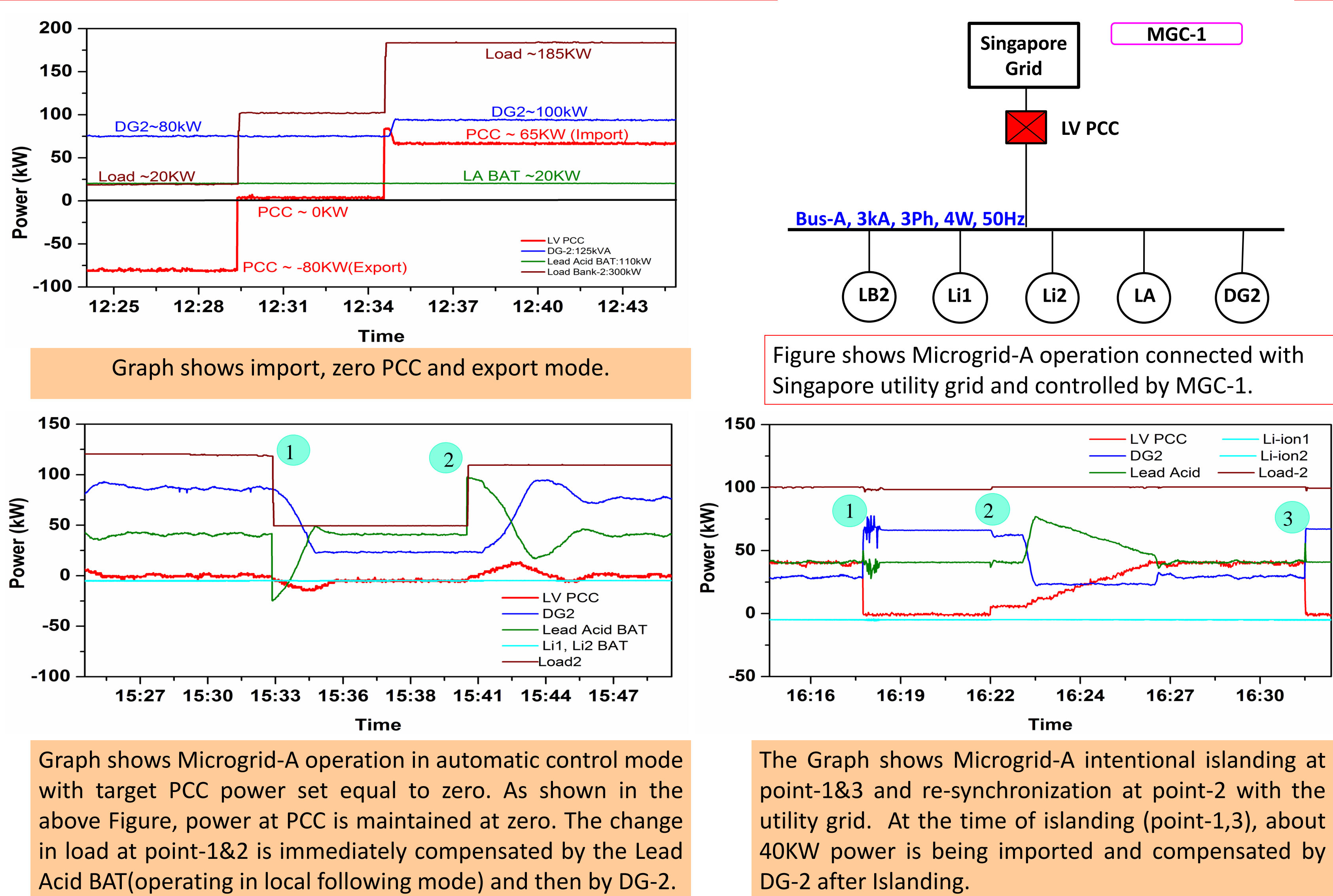
Introduction

The Experimental Power Grid Center (EPGC) was set up as a research programme by the Agency for Science, Technology and Research (A*STAR) [Singapore] to carry out research in the area of intelligent and decentralized power distribution, interconnection and utilization. EPGC works with its research partners from Industry, Universities and Public Agencies on projects that range from analysis, modeling and simulation to technology demonstrators. EPGC has a 1 MW low voltage (LV) distribution network that can be configured in radial, loop, series or as three independent networks. It can be operated in grid connected mode or as an islanded grid. It has generation assets such as Diesel Generators and Photovoltaic (PV) Arrays with scope for further expansion. In addition, it has storage in form of Batteries and Ultracapacitors. Emulators for Wind Turbine and PV are available that can be programmed to simulate different weather conditions. A Power Grid Emulator can also be used to emulate the LV grid characteristics. The whole facility is controlled using central controllers. The controllers can be programmed to operate the LV grid in grid connected mode or islanded mode. In summary, the facility offers a flexible platform to carry out research and development in the areas of renewable integration, DER and Microgrid control systems.

Singapore Utility Grid | Power Grid Emulator (PGE) | Wind Turbine Emulator | Programmable Load Banks

3-Phase 4-Wire Multiple Bus Panel (MBP) | Distributed Energy Test System Panel (DETS)

Diesel Gensets | Battery and Ultra-Capacitor Bank | Solar PV

Figure: EPGF Power Network and Assets

EPGF configured as three Independent Microgrids operating simultaneously

Microgrid-B: Connected with Power Grid Emulator (PGE)
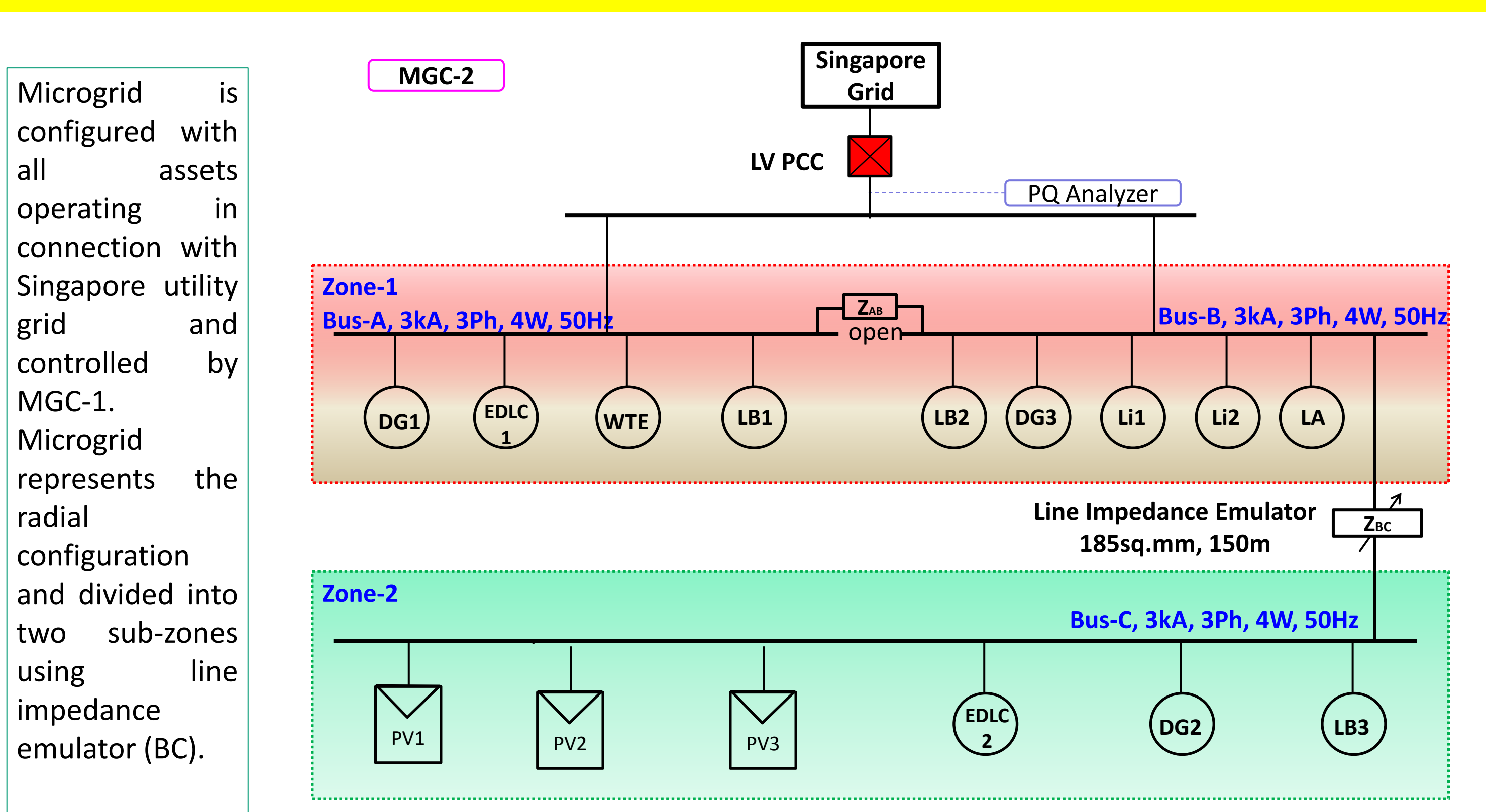

This configuration shows Microgrid-B operation in PGE connected mode and controlled by MGC-4. PGE emulates the utility grid characteristics.

Graph shows the,
- Power import~30kW from utility grid (using PGE) during heavy-load
- PCC~0kW and
- Power export~25kW during light load

Microgrid-A: Connected with Singapore Utility Grid

Graph shows import, zero PCC and export mode.

Figure shows Microgrid-A operation connected with Singapore utility grid and controlled by MGC-1.

Graph shows Microgrid-A operation in automatic control mode with target PCC power set equal to zero. As shown in the above Figure, power at PCC is maintained at zero. The change in load at point-1&2 is immediately compensated by the Lead Acid BAT(operating in local following mode) and then by DG-2.

The Graph shows Microgrid-A intentional islanding at point-1&3 and re-synchronization at point-2 with the utility grid. At the time of islanding (point-1,3), about 40KW power is being imported and compensated by DG-2 after Islanding.

Microgrid-C: Islanded Grid

The Graph shows an islanded grid operation and controlled by MGC-2. The change in PV and load power is being compensated by DG-1.

The Graph shows the voltage at DG-1 and PV terminals.

The Graph shows the frequency at DG-1 and PV terminals.

EPGF Configured as a Single Microgrid

Microgrid is configured with all assets operating in connection with Singapore utility grid and controlled by MGC-1. Microgrid represents the radial configuration and divided into two sub-zones using line impedance emulator (BC).

The Graph shows the power import and export from the utility grid. During heavy load ~200 kW is being imported and during light load ~440KW is being exported to the Singapore utility grid.

The Graph shows the voltage in Zone-1 (LV PCC) and Zone-2 (PV & Load-3). Voltage variation is due to PV and load change.