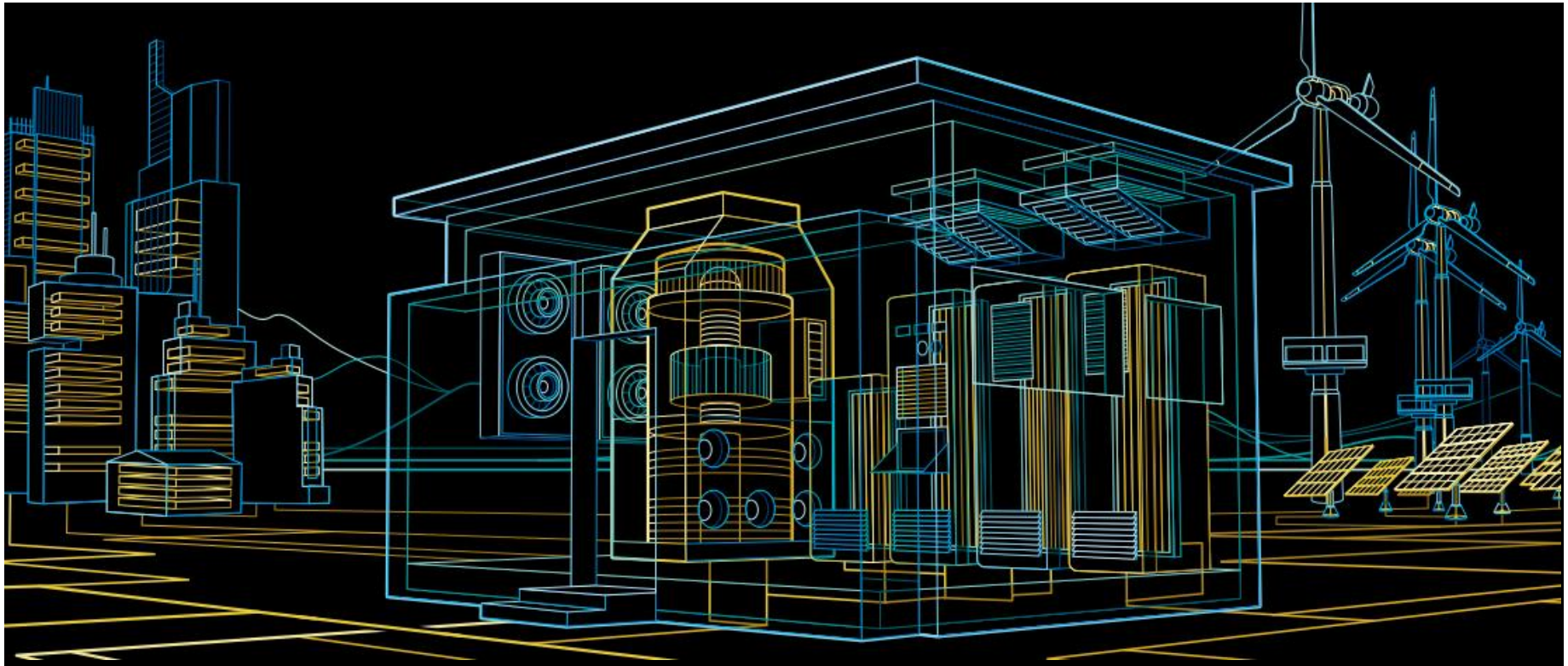

Dr. Alexandre Oudalov, ABB Switzerland Ltd.; IRENA Innovation Week, Bonn, May 11-13, 2016

The Future Grid – deep dive session 1

Smart Minigrids and Microgrids

Smart Minigrids and Microgrids
Definitions

Microgrids are *"electricity distribution systems containing distributed energy resources and loads that operate in a coordinated way either connected to the main power grid or in "islanded" mode".*

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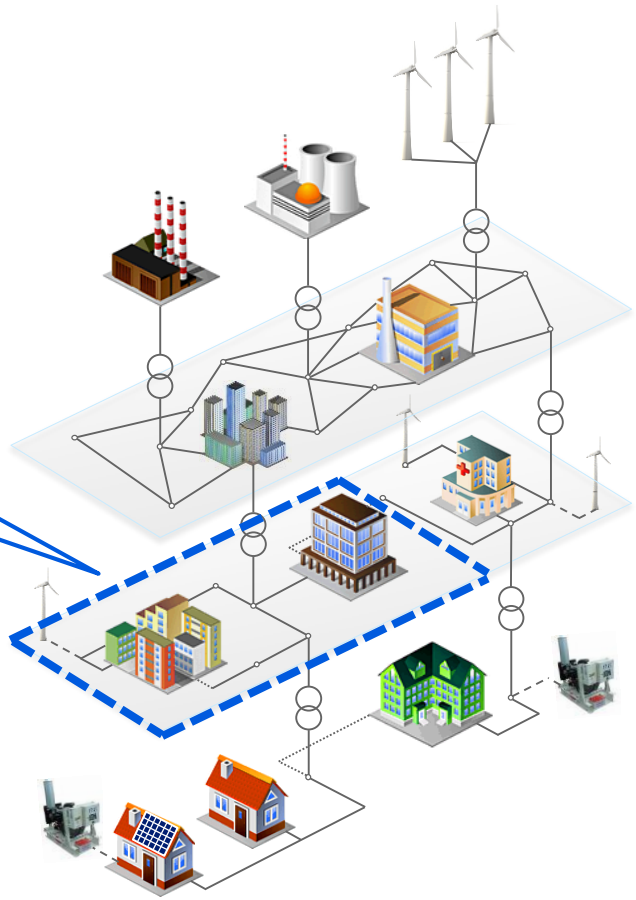
Minigrids are *"a set of electricity generators and possibly energy storage systems interconnected to a distribution network that supplies electricity to a localized group of customers".*

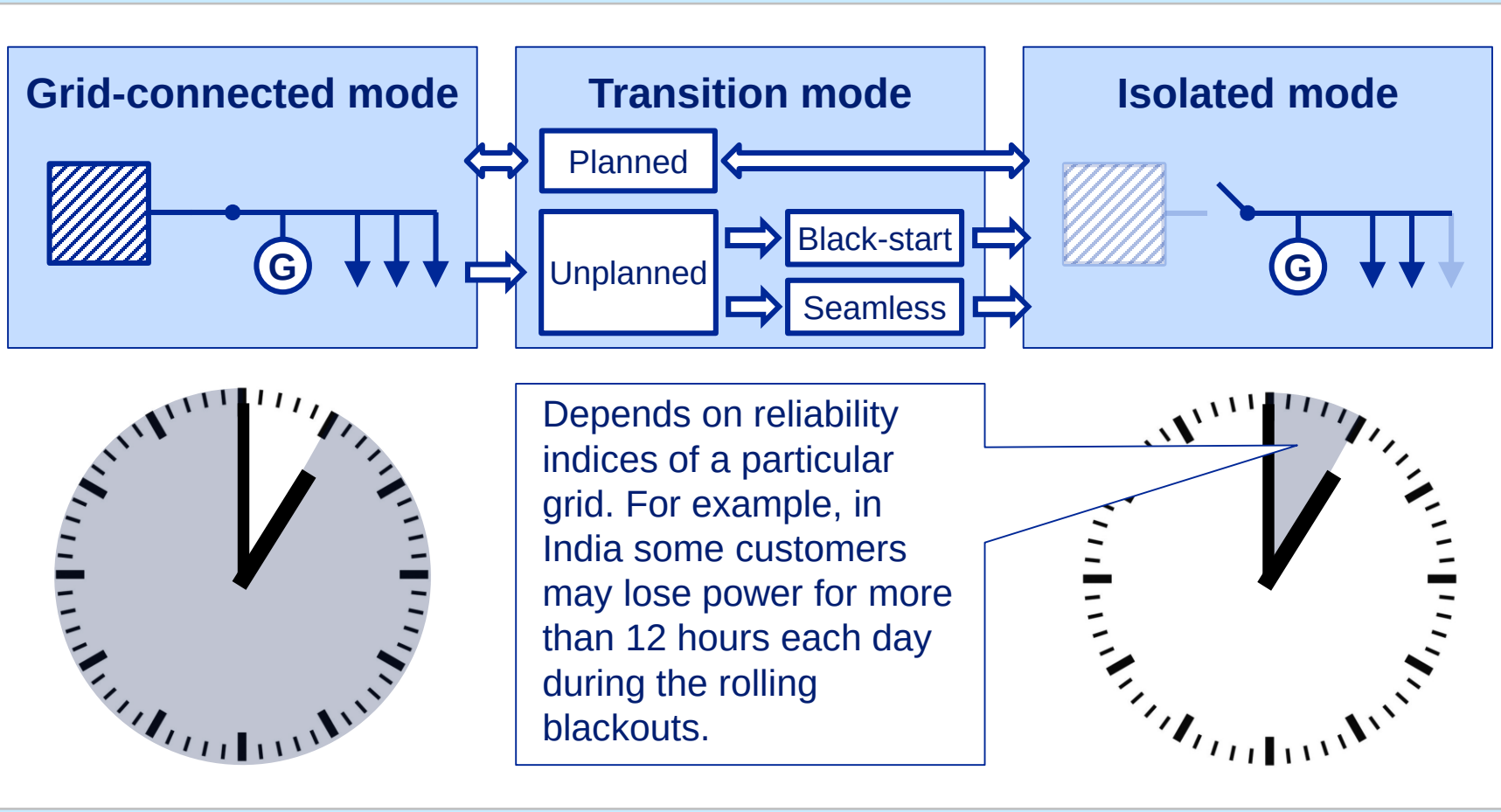


Smart Minigrids and Microgrids
Market Segments and Key Drivers

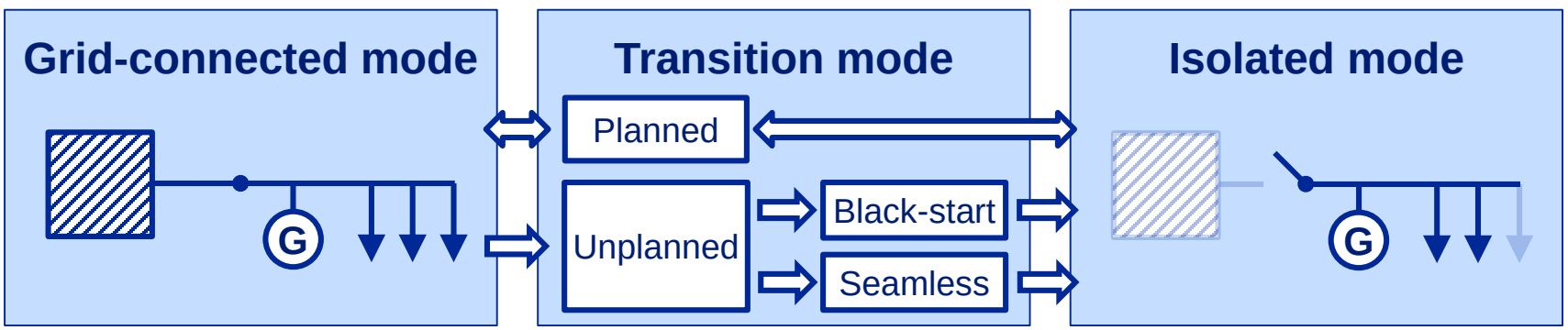
✓: *Main driver*
(✓): *Secondary driver*
IPP: Independent Power Producer

			Main drivers				
			Social	Economic	Environmental	Operational	
	Segments	Typical customers	Access to electricity	Fuel & cost savings	Reduce CO2 footprint and pollution	Fuel independence	Uninterrupted supply
Off-grid	Island utilities	(Local) utility, IPP*		✓	✓	✓	(✓)
Off-grid	Remote communities	(Local) utility, IPP, Governmental development institution, development bank	✓	✓		✓	
Grid-connected	Industrial and commercial	Mining company, IPP, Oil & Gas company, Datacenter, Hotels & resorts, Food & Beverage		✓	(✓)	✓	✓
Grid-connected	Defense	Governmental defense institution		(✓)	(✓)	✓	✓
Grid-connected	Communities	(Local) utilities			(✓)		✓
Grid-connected	Institutions and campuses	Public and private education institutions		(✓)	✓		(✓)

Grid Connected Microgrids
Operating Modes



Grid Connected Microgrids
Key Functionalities per Mode



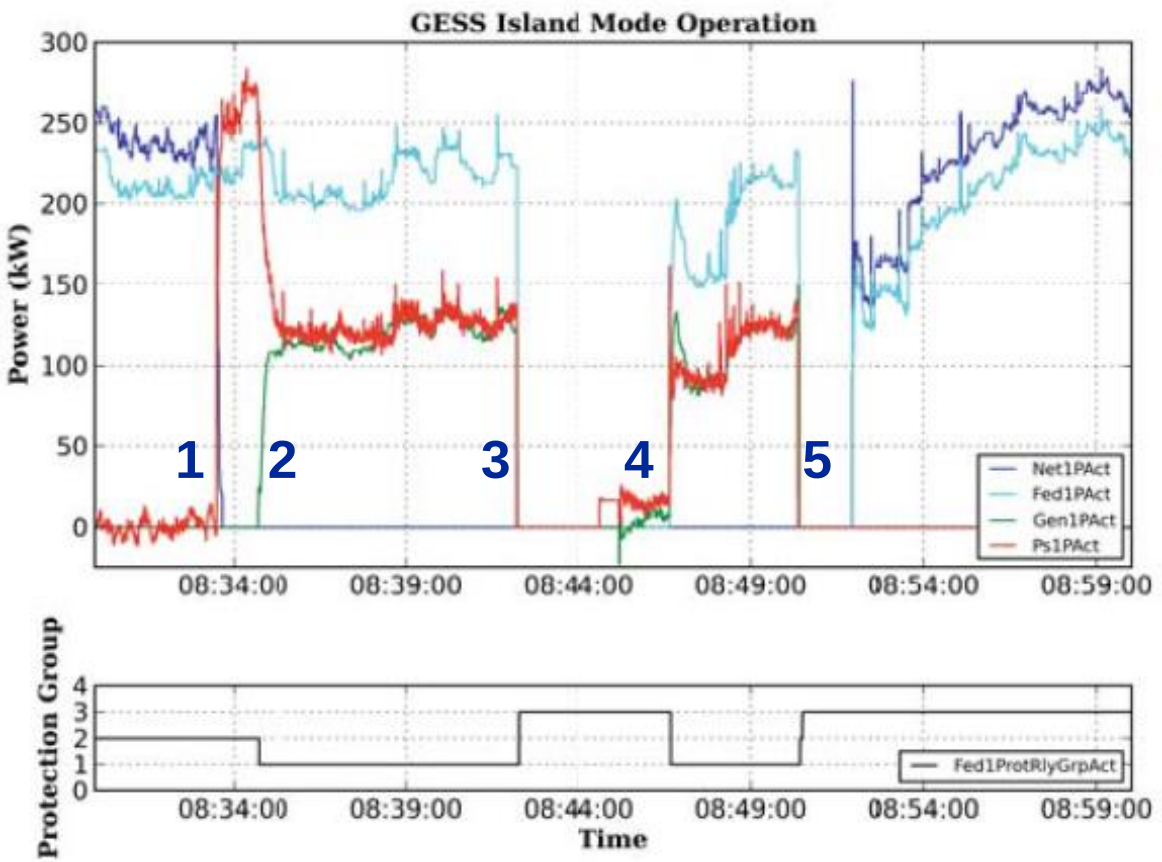
- Optimize energy cost
- Provide grid services
- Maintain sufficient reserves for a seamless transition

- Remotely controlled
- Control power flow at point of coupling
- Emergency load shedding
- Generator control mode switching

- Control frequency and voltage
- Manage demand
- Adjust protection
- Optimize energy cost

Energy cost reduction and improved reliability are the key objectives.

Real Microgrid Example
Different Operation Modes

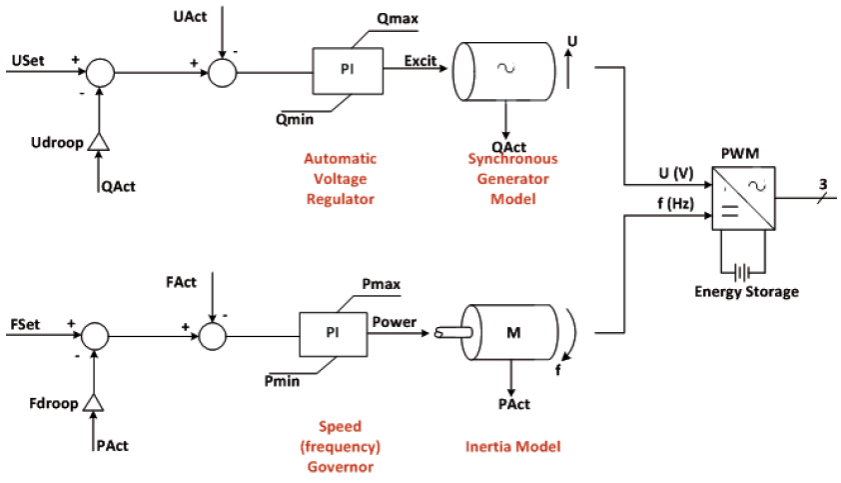


1. Planned grid separation – storage picks up the load.
2. Microgrid control system starts a back-up generator and optimally shares the load between sources.
3. Microgrid is shut down.
4. Microgrid is restarted (black-start).
5. Microgrid is shut down and the load is re-connected to the grid.

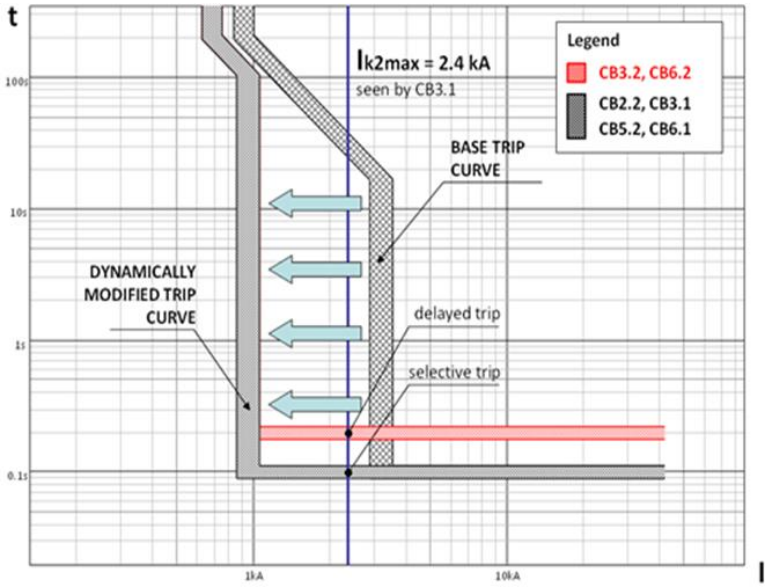
Protection system is tuned according to a microgrid configuration by switching between setting groups.

Technology Innovation
Achieving Stable and Safe Microgrid Operation

- Virtual generator mode of a battery storage
- Operates similar to a traditional synchronous generator
- Provides exceptional response time
- Acts as a grid-forming generation source



- Adaptive protection system monitors microgrid configuration
- Configuration changes result in an automatic update of protection relay settings



Examples of Grid-Connected Microgrids
Biogas & Battery Based Autonomous Building

Project name	Legion House
Location	Sydney, Australia
Customer	Grocon, KLM group
Completion date	2014

Solution

- 2 x 180 kW gas engines.
- 1 x 80 kW, 320 kWh lead-acid battery.
- Distributed control system.
- On-site biomass gasification.

Customer benefits

- The battery stabilizes the internal power network against fluctuations in frequency and voltage.
- Excessive energy is exported to the neighboring buildings.
- Building can operate:
  - in isolated mode, or
  - without gas engines overnight.

Examples of Grid-Connected Microgrids
Ancillary Power System Services for Distribution Grid

Project name	Grid Energy Storage
Location	Melbourne, Australia
Customer	AusNet Services
Completion date	2014

Solution

- 1 x 1 MVA diesel generator.
- 1 x 1 MW, 1 MWh lithium-ion battery.
- Distributed control system.
- Transportable containerized solution.

Customer benefits

- Active and reactive power support during high demand periods.
- Delay of power line investments.
- Transition into isolated operation without supply interruption:
  - on command (planned) or
  - in emergency cases (unplanned)

Grid Connected Microgrids
Technology Innovation Trends

- Electric and thermal grids co-optimization (CHP, heat pumps, etc.)
- Seamless transition (faster controls, high C-rate storage).
- Hybrid energy storage systems (from millisecond to season)
- Smart self-configuring, self-tuning and faster protection.
- Smart converters (communication, grid services).
- Open standards for interoperability (plug and play components).
- Interaction with a hosting grid operator (DSO or TSO).
- Meshed topologies w/ multiple points of coupling to a hosting grid (interconnecting multiple microgrids via b2b DC, nested microgrids).
- Data analytics (RES and demand predictions, asset health mgmt.).
- Integration of electric vehicles (a significant new controllable load).

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