Microgrid Operation
Demand Response and related flexibilities

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Presentation outline

- Microgrid definition
- Demand response and flexibility
- The Smart Home concept
- Flexibility added by storage
- Electric vehicles
- Black-start capability
- Microgrid infrastructure
- Hands-on experience
- Conclusions
Microgrid definition /1

- Microgrids possess all the essential components of a power system in a small range
  - DG units
    - PVs, wind turbines, Micro-turbines, etc.
  - Critical, non-critical loads
  - Energy storage systems
    - Lithium-ion batteries
    - Supercapacitors
  - Supervisory control

Microgrid definition /2

- Microgrids can operate either grid-connected or islanded
- Ownership can be private, IPP, community etc
- Role and benefit for utilities
  - Grid support
  - Impact on the transmission system
- Role in power system restoration
- Operational/regulatory issues
  - Responsibilities and jurisdiction – right to disconnect
Vital aspect of microgrids: **Energy management!!**

How?? By using storage, demand response and smart buildings!

Source: https://www.energyprofessionals.com/
Demand response /1

- Offers services aiming to enhance power system stability
- Consumers modify their power profile, adjusting to the needs of the electrical grid
- How it works??

Source: Australian Renewable Energy Agency
Demand response /2


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Microgrid Operation: Demand Response and related flexibilities
The Smart Home concept

- Microgrid in grid-connected mode
  - All residential loads can be supplied by the utility
- Microgrid in islanded mode
  - Only local DG units are used
  - Generation < Load demand
  - Active control of loads
- Smart Home
  - Active control of electrical and thermal loads
  - Meet the operation signals received by the MG controller
  - Maintain the minimum living standards

**Flexibility** is defined as the extent to which a power system can modify electricity production or consumption in response to variability, expected or otherwise.


or in other words

Flexibility in the electricity system are the means that enable it to transition from one state of *equilibrium between generation and consumption* to another.

Flexibility makes it possible to maintain a stable electricity system, even with the growing role of variable renewable generation therefore it can be considered as an essential building block of a future power system with high (up to 100%!) RES penetration.
Growing demand for new Flexibility

More flexibility needed in the wholesale market to balance intermittent wind+PV generation

In balancing demand flexibility tackles forecast errors

Congestion mitigation results mainly by the timely character of grid reinforcing

Source: Tennet, Flexibility Roadmap NL 2018
Growing demand for new Flexibility

Interconnection provide sufficient flexibility at the transmission level.

Nevertheless, decarbonization (fuel switching) of the electricity generation is expected to create a gap in the availability of flexibility.

Despite the good efforts of several market players to provide increased flexibility by other means.

Source: Tenet, Flexibility Roadmap NL 2018
Flexibility and other services added by storage

- Optimization of self-consumption
- Peak load smoothing
- Black-start capability
- Voltage control
- Inertia reserve
- Back up energy
- Positive/negative control energy
- Reactive power compensation
- Off-grid supply
- Shifting excess energy to other sectors

Source: German Energy Storage Association
Flexibility and other services added added by storage /2

- Ancillary services provided by storage may vary in duration

- Grid forming: enables microgrid operation with pure RES generation

- Voltage and frequency regulation: Storage may compensate the fluctuations in RES ensuring operating limits

- Energy Shifting: continuous operation is achieved

Electric vehicles

• Promising application for microgrids flexibility...

• Utility scale: vehicle to grid (V2G) stations
  → peak shaving & valley filling

• Small scale: vehicle to building (V2B) application
  → regulate power consumption of the building

Source: Christos S. Ioakimidis, Dimitrios Thomas, Pawel Rycerski, Konstantinos N. Genikomsakis,
Black-start capability

• Important functionality of a microgrid

• Use of a battery energy storage system (BESS)

• Owned by the DSO

• Located at the interconnection point with the upstream grid

• Responsible for
  • Synchronization with the grid
  • Absorb/provide any power mismatch during the black start process

Source: H2020 EASY-RES Project, Website: http://www.easyres-project.eu/
Microgrid infrastructure

• Microgrids depend on data communication!

• All electrical systems should be monitored

• Systems are usually controlled centrally

• Microgrid central controller is able to adjust power profile at the interconnection point with the upstream grid

Experiences from μgrids – The Ameren μgrid

• Next to the University of Illinois campus in Champaign IL
• Primary Components
  Wind turbine  Energy storage battery
  Natural gas generators  Controllers
  Solar panels  Switch gear
• Supplies 200 residential & commercial consumers
• Set in operation 2nd half 2017
Experiences from μgrids – The Ameren μgrid

Successful 24 Hours - 100% Renewables

Source: Why Microgrids, A discussion on System design, Practicality & Benefits, IEEE ISGT Conference, Washington, DC, 2018
Experiences from μgrids – The Ameren μgrid

Successful Full-Island of Feeder loads

Source: Why Microgrids, A discussion on System design, Practicality & Benefits, IEEE ISGT Conference, Washington, DC, 2018
Experiences from μgrids – μgrids in China

• Use of demand-side management (DSM) in real-field implementations
  • Dongfushan island
    • Apply DSM to the seawater desalination system
  • Nanji island
    • Apply DSM to the electric vehicles

• Black-start in Nanji island
  • Load start capacity 1000 kVA
  • 3 BESSs of 500 kVA (each)
  • Use of centralized control for the BESSs

μgrids in Europe have been developed mainly by EU funded projects starting in the early 1995 – 2005 (microgrids, more microgrids projects etc)

Mainly in Laboratory environments or in small islands (most of them not interconnected to the main grids)

• Kythnos island, Greece
• Bornholm island, Sweden
• Madeira, Portugal
• Orkney Islands, United Kingdom
• Samsø, Denmark
• Tilos island, Greece
• Ag. Efstratios island, Greece
• Bronsbergen holiday park
Conclusions

• Microgrids are expected to develop further as “Non-Generator Resource” (NGR), resources that can move seamlessly between consuming and injecting energy at different times.

• They can evolve as a source of flexibility for the grid.

• Demand response is one of the key elements in this transition for the safe and reliable MG operation.

• Although a lot of research effort has been put, there exist several issues that must be effectively addressed to allow the widespread use of DR methods under real-field conditions.

• Energy storage systems can provide increased levels of flexibility to the MG.
Conclusions

• Energy storage systems can provide increased levels of flexibility to the MG

• Communication and control are requirements to achieve the desired operation

• The existing technology is mature enough to cover all issues related to protection, resilience, islanding and reconnection

• The new tools which are developing fast will also allow the peer-to-peer transactions

• However the regulatory framework is missing and we need it soon!

• To develop the necessary business models and seek for the options and functionalities that will be the best trade-off between costs and benefits
Thank you very much for your attention!!