Micro-Grid Technology
To improve Distribution Reliability and accessibility

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Agenda

What is Micro Grid

- What a Micro Grid IS
- Micro Grid : Components
- MicrO Grid Conceptual Structure
- Micro-Grid Technology Objective & Challenges

Typical Microgrid Architecture & Functionalities

- Typical Low-Voltage Microgrid Architecture
- How Does A LV Microgrid Work?
- Major LV Microgrid Functionalities
- LV Microgrid vs. Main Grid
- Micro Grid For 'Industries'
- SMART Grid – Micro Grid For Municipalities Value Proposition
- Microgrid Benefits

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What a Micro Grid IS

What a Microgrid IS !

❑ **A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources which as an integrated system can operate in parallel with the grid or in an intentional island mode**

Key Defining Characteristics

- ❑ Provides **sufficient and continuous energy to a significant portion of the internal demand**
- ❑ Possesses **independent controls and can island and reconnect** with **minimal service disruption.**
- ❑ Presents itself as a **single controlled unit** to the bulk power system.
- ❑ Offers **flexibility** in how the power delivery system is configured and operated
- ❑ Enables **optimization** of a large network of load, local Distributed Energy Resources and the broader power system

What a Microgrid IS NOT !

- ❑ One **microturbine** in a commercial building is not a Microgrid, but DG
- ❑ A group of individual generation sources that are **not coordinated**, but run optimally for a narrowly defined load
- ❑ A load or group of loads that **cannot be easily separated** from the grid or controlled
- ❑ Does not have to have thermal, whereas CHP by definition has thermal but note that **Microgrid very often includes CHP for efficiency and economic reasons**
  - E.g..: CERTS definition: A Microgrid assumes an aggregation of loads and micro sources operating as single system providing both **power and heat**

Source: DOE

Micro Grid : Components

Integrated Energy Systems and control

+

Distributed Energy Sources

Renewable gen.

Micro turbines

Fuel cells

Heat recovery (CHP)

Storage

+

Loads

Residential buildings

Commercial buildings

Industries

=

Microgrid

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Micro Grid Conceptual Structure

Scope of service

>20 MW

- Usually referred to as mini-grid
- Will include C&I plus residential. Up to several 100MW for large industrial complex

Feeder 5 to 20MW

- Many or large neighboring loads, typically C&I. Increased scale provides further cost advantages

Multi facility 2 to 5MW

- Small to larger traditional loads plus a few neighboring C&I loads. Increased scale provides cost advantages of DG.

Single facility <2MW

- Smaller individual facilities with multiple loads, e.g. hospitals, schools. Lack of a cost advantage over DG will limit market penetration

Owner

Landlord | **Municipality** | **Utility**

Generation

Value proposition

- Reduced Cost
- Independence / Security
- Service Differentiation (reliability, power quality, green power)

Source: DOE – Navigant consulting assessment

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Micro-Grid Technology Objective & Challenges

Objectives

- Tap the potential for renewable resources,
- Improve power access in rural area,
- Reduced carbon emissions
- Management of various combinations and proportions of wind, hydro and solar generation

Challenges

- Bi-directional flow of power –
- Dynamic response and advanced protection solutions
- Sudden connection & disconnection of RE sources – managing transients,
- Forecasting and scheduling of RE sources
- Islanded operation in case of disconnection from the grid

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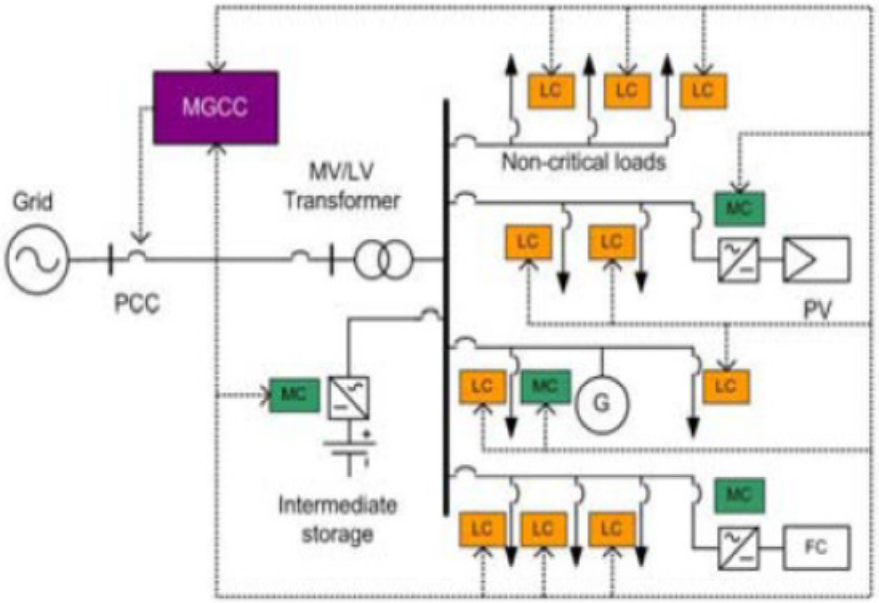
Typical Low-Voltage Microgrid Architecture

❑Microgrid architecture includes

- Energy management **within and outside of the distributed power system**
- Interface, control and protection **requirements for each micro source**
- **Management of** power flow constraints, voltage and frequency
- Islanding and interconnected **operation philosophy**
- Load sharing **during islanding**
- Protection **options for networks of variable configurations – adaptive protection systems e.g PMUs**
- Device and interface response **and intelligence requirements**
- **Next-generation** communications infrastructure.



PCC: Point of Commom Coupling
MGCC: Micro Grid Central Controller
MC: Micro source Controller
LC: Load Controller

Source: R. Lasseter – University of Wisconsin

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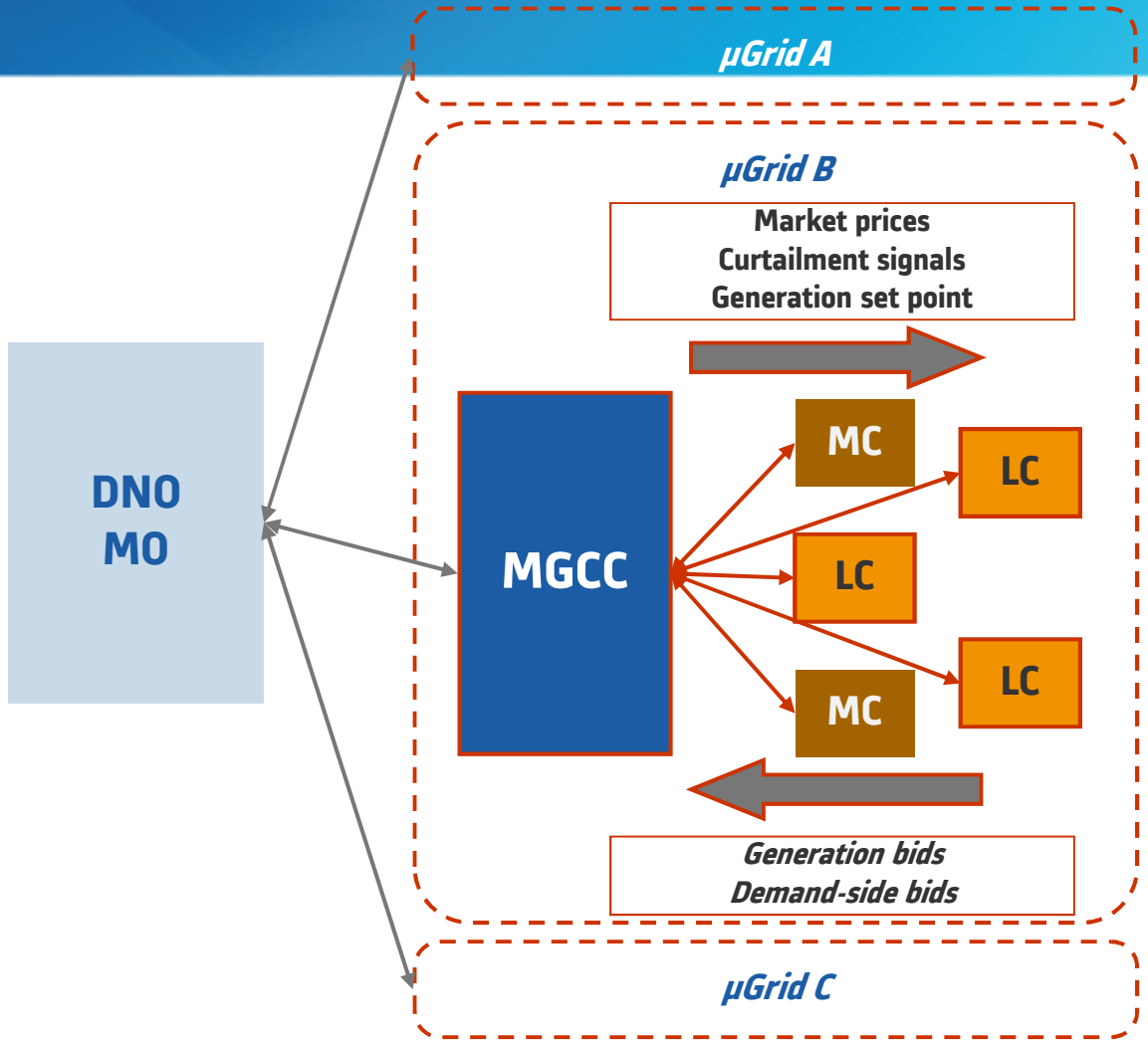
How Does A LV Microgrid Work?



DNO: Distribution Network Operator
MO: Market Operator
MGCC: Micro Grid Central Controller
MC: Micro source Controller
LC: Load Controller

❑4 key functions

- Microgrid Central Controller (Energy Manager): **promotes technical and economical operation, provides operational control through the dispatch of power and voltage set points to each MC (time response in minutes), interfaces with loads, micro sources and DMS.**
- Micro source Controller: **provides fast response (milliseconds) to disturbances and load changes without relying on communications by using locally measured voltages and current to control micro sources.**
- Load Controller: **interfaces with control interruptible loads**
- Protection: **responds both to systems and MG faults, requires special functionalities**

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Major LV Microgrid Functionalities

Connection to grid
(PCC, Separation device e.g PMU)

Interface with DMS
(receives market prices, curtailment signals, generation set points / sends generation bids and demand-side bids)

Micro Source management
Dispatch of power / voltage set points
Protection
…

Load management
Load sharing during islanding
Demand response
Critical loads
…

Steady state and dynamic performance simulation

Protection
Fault current interruption
Coordination (normal vs. reconfigured)
Under/ over voltage
Fault isolation
Auto-synchronization with grid
Black-start capabilities

Management of power flow constraints, voltage and frequency

Management of power quality

Grid code compliance

Switching capabilities

Communication infrastructure
(slow / fast control)

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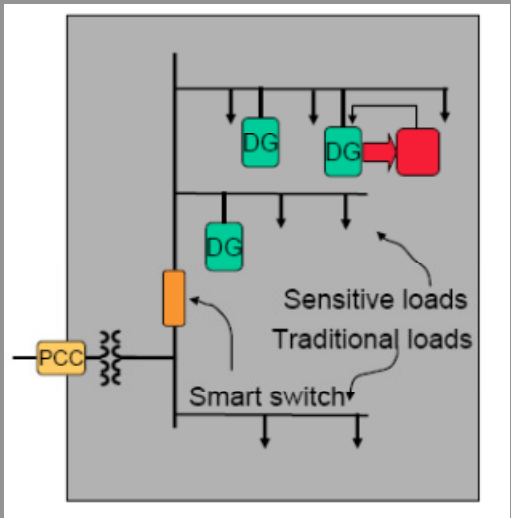
LV Microgrid vs. Main Grid

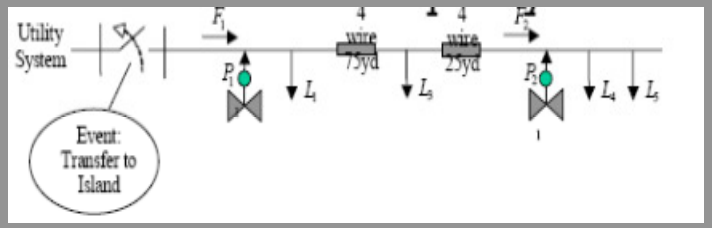
Normal Interconnected Mode

- Connection with the main MV grid
- Supply, at least partially, the loads or injecting in the MV grid
- In this case, the MGCC:
  - Interfaces with MC, LC and DMS
  - Perform studies (forecasting, economic scheduling…)



Island Mode

- In case of failure of the MV grid;
- Possible operation in an isolated mode as in physical islands
- In this case, the MGCC:
  - Changes the output control of generators from a dispatch power mode to a frequency mode
  - Primary control – MC and LC
  - Secondary control – MGCC (storage devices, load shedding,…)
  - Eventually, triggers a black start function.



Micro Grid For 'Industries'

Customer	Customer Issue	Value Proposition
• TRANSCO ☐ • DISCOM ☐ • INDUS ☑ • Others: _ _	• **Avoid production stop** due to energy outage • **Avoid interruption of critical service delivery** due to energy outage	• **Island from the grid** (with no disturbances) **and switch to local generation,** in case of grid **black-out** • **Auto-reconfigure the local MV**, in case of **local issue** • Continuously **self-balance the production and demand.**
	• **Reduce Cost (OPEX)** • **Respect CO_2 quota** (Contribution to grid efficiency)	• **Reduce the cost** of energy thanks to the **optimum usage of local Generation**

- **Turn Key** Solution.
- **Micro Grid Controller** which provides unique functions (auto load shedding, auto-reconfiguration in case of internal problem, auto restoration, auto load and frequency mgt. clean islanding from the grid,… based on topology, spinning reserve calculations,…)

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SMART Grid – Micro Grid For Municipalities
Value Proposition

Customer	Customer Issue	Value Proposition
• TRASCO • DISCOM • INDUS • Others: Municipalities • + Interest for Utilities to reduce the peak	**Municipality:** • **Reduce its energy bill** • eventually energy reselling • **Increase reliability & security** (hospital, industries…) • **Attract industries (employment)** and people **by lowering the cost of energy** • enhance its image by using green power (funds?)	• **Control and optimize the usage of microGeneration** (PV, µTurbine,…) and local storage in order to **reduce the cost of energy, and guarantee a better reliability**, independency. • **Turn Key** Solution. • **MicroGrid Controllers** located in Substations which can optimize the production/demand balance in terms of cost, but also guarantee a clean power quality to both the municipality and the grid operator • The MicroGrid controller of the city **embeds a D/R system**.
	Utility: • **Reduce the peak** (cost) • Avoid 'voltage swings' caused by islanding	• The municipality **resells MegaWatts to the grid operator** during peaks. • **Regulate the voltage during islanding**

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Note: refine 'uniqueness' and estimation of gain

Microgrid Benefits

❑Microgrid value propositions

- **Energy efficiency**
- **Minimization** of overall **energy consumption**
- Improved **environmental impact**
- Improvement of energy system **reliability and resilience**
- Services **differentiation**
- **Cost efficient** electricity **infrastructure** replacement strategies
- Management of **energy volatility**

❑Key elements providing advantages to the MG

- Improvement of **DG integration & economics**
- **Joint optimization of local generation and load:** generator and consumer are one and the same decision maker

Source: US Department of Energy – Evaluation Navigant consulting

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