Pegasus Microgrids Summer School
Microgrid architecture for efficient energy communities (Berchidda Project)
Cagliari 30/05/2019

Emilio Ghiani
Department of Electrical and Electronic Engineering
University of Cagliari (Italy)
Outline

• Introduction on (Multi)Microgrid approach for efficient smart distribution networks
• LEC and Berchidda 4.0 Project
• Tecno-economic analysis of the project
• Conclusions
(Multi)Microgrid approach for SDN

- **Primary Substation**
- **Secondary Substation**
- **Tie Breaker**
- **CB**: Circuit Breaker
- **SS**: Sectionalizing Switch
- **IED**: Intelligent Electronic Device
- **DMS**: Distribution Management System
- **MEMS**: Microgrid Energy Management System
- **SCADA**: Supervisory Control And Data Acquisition
- **MV**: Medium Voltage
- **LV**: Low Voltage
- **DG**: Distributed Generation
- **DES**: Demand Side Management
- **MMG**: Microgrid (MV)
- **LV MG**: Low Voltage Microgrid

CB: Normally closed
SS: Normally open

Communication link

Microgrid

MV trunk feeder

MV lateral

LV MG
(Multi)Microgrid Benefits

The reorganization of the distribution system into MMGs can determine significant benefits:

- Deferment of investments
- Reliability and Power Quality
- Economic and market outlook
- Environmental impact
Microgrids for energy communities

• European Union approved the first part of a comprehensive legislative package entitled ‘Clean Energy for all Europeans (CEP)’ December 2018

• The EU Directive aims to put in place appropriate legal frameworks to enable the energy transition and give a special role to citizens and communities activities, introducing the Energy Community into the regulatory framework.

• The CEP should be transposed into the national laws by March 2020
Berchidda Energy 4.0 Project
Why “4.0”

• “4.0” is an acronym inspired by the concept now entered into the common language of Industry 4.0

• Tendency to integrate automation and other technologies within the productive infrastructures (industries, schools, companies, research institutions, energy systems, etc.) improve working conditions, create new business models and increase the productivity

• Requires the intensive use of cyber-physical systems (CPS), or physical systems that are closely connected with IT systems and that can interact and collaborate with other CPS systems.

• Smart Grids and Smart Buildings -> “4.0” concept applied to power distribution
Berchidda 4.0: towards a LEC

Local Energy Community (LEC) is the economic and operational participation and/or ownership of Distributed Generators and Energy Storage Systems by citizens or members of the community.

Typical aim of the energy community is the cooperation to:
• reduce the dependence on the utility grid
• minimize the energy bill
• enhancement of the self-consumption
• trade the overproduction of the energy with others
Berchidda 4.0: towards a LEC

Legend
- MV/LV substation
- MV power line
- LV distribution line

Urban Microgrid
Rural Microgrid

1 Urban MV/LV Microgrid
14 Rural LV Microgrid
Berchidda Power Distribution System
Urban network (Municipality Own)

17 MV/LV substations
4 km MV Cables
15.4 km LV Aerial Cables
21.6 km LV Cables
### Berchidda Power Distribution System Urban network (Municipality Owned)

<table>
<thead>
<tr>
<th>Customer type</th>
<th># Customers</th>
<th>Installed Power (kW)</th>
<th>Voltage Level</th>
<th>Energy Consumed (MWh/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (Household)</td>
<td>1051</td>
<td>3,209</td>
<td>LV</td>
<td>2,561</td>
</tr>
<tr>
<td>Public Buildings</td>
<td>259</td>
<td>797</td>
<td>LV</td>
<td>201</td>
</tr>
<tr>
<td>Public Lighting</td>
<td>12</td>
<td>246</td>
<td>LV</td>
<td>414</td>
</tr>
<tr>
<td>Other Usage (Commercial, Industrial)</td>
<td>292</td>
<td>1,666</td>
<td>LV</td>
<td>2,216</td>
</tr>
<tr>
<td>MV Customers</td>
<td>2</td>
<td>346</td>
<td>MV</td>
<td>369</td>
</tr>
<tr>
<td>TOTALE</td>
<td>1,626</td>
<td>6,264</td>
<td></td>
<td>5,762</td>
</tr>
</tbody>
</table>
Berchidda Power Distribution System - Future Rural network (Municipality Acquisition form DSO*)

* According to CEP: Member States should put in place appropriate measures such as national network codes and market rules, and incentivize distribution system operators through network tariffs which do not create obstacles to flexibility or to the improvement of energy efficiency in the grid.
Berchidda 4.0: towards a LEC

The Berchidda Energy 4.0 project, is based on those fundamental pillars:

- distributed production of energy from renewable sources (PV), also using the roofs of the buildings of citizens and companies of the municipality of Berchidda, with concentrated and distributed storage systems, and managed according to the smartgrid paradigm (Communication+Smart Metering);

- encouragement of active consumer participation through the implementation of intelligent house appliances systems for demand management, including with storage systems;

- use of new energy vectors and / or alternative technological solutions for programmable energy production (gas/biomass fired).
Berchidda 4.0: towards a LEC

Local Energy Community

Smart Building automation

Renewable Energy integration

Smart distribution management

Demand Side participation

Reduction CO₂ emissions
Berchidda 4.0: towards a LEC

Current Montly Municipality Load Profile

Interreg Mediterranean
Current situation:
• 67 PV plants
• 600 kWp
• 1,626 LV+MV Customers
Berchidda 4.0: towards a LEC

Current Monthly Municipality Average Load Profile at PCC with DSO

Interreg Mediterranean
Berchidda 4.0: Smart Metering
(Multi)Microgrid Users Management

Prosumers & Responsive Loads

User EMS

LEC Aggregator/Manager

Cyber security
Cloud computing
Big Data
Forecasting
EMS - Users Management

Energy & Ancillary Services

DSO/TSO

User EMS

Energy
Communication
Monitoring
Commercial Transaction

Electric Vehicles & Storage

Renewable Energy Plants

Interreg Mediterranean
EUROPEAN UNION
Berchidda 4.0: Estimated Effects on Demand with Automation and SM

5% less due SM
Berchidda 4.0: Additional PV and Storage

- LV node/customer
- PV plant
- Storage device
- LV Energy links
- EMS: Energy Management System
- EMU: Energy Management User

Diagram showing connections between PV plants, storage devices, LV Energy links, EMS, and EMU.
Berchidda 4.0: Additional Programmable Generation

200kW Fuel Cell

200kW Microturbine
Berchidda 4.0: Project Proposals

- Additional PV: 1500kWp
- Additional Storage (Citizens/MV/LV Substations): 500kWh
- Home Automation & Intelligent home appliances
- Network automation and smart metering
- Demand Response and RES Management Platform
- Communication and ICT (Smart Grid)
- Additional programmable generation (Gas Methane Fired)

4.100.000€ investment cost
Berchidda 4.0: Project Effects
Berchidda 4.0: Project Effects

II trimester 2019
Gross Cost of Energy In Italy for Residential Customers= 19,89 c€/kWh

- Energy from Market: 33.35%
- Net cost of Energy: 42.29%
- Network Charges: 24.88%
- Transmission&Metering: 19.68%
- Fees: 13.15%

Gross Cost of Energy In Italy for Residential Customers= 19,89 c€/kWh
### Berchidda 4.0: Project Effects

<table>
<thead>
<tr>
<th>Smart Grid Actions</th>
<th>Reduction on energy purchased by the grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV &amp; Storage</td>
<td>-30 %</td>
</tr>
<tr>
<td>Demand/Response</td>
<td>-5 %</td>
</tr>
<tr>
<td>Smart Metering</td>
<td>-4 %</td>
</tr>
<tr>
<td>Network Losses</td>
<td>-5 %</td>
</tr>
<tr>
<td>Local Gas Fired Generation</td>
<td>-28 %</td>
</tr>
</tbody>
</table>
## Berchidda 4.0: Project Effects

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>632,000</td>
<td>177,000</td>
</tr>
<tr>
<td>Transmission &amp; Metering</td>
<td>239,000</td>
<td>67,000</td>
</tr>
<tr>
<td>System charges</td>
<td>471,000</td>
<td>376,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,342,000</strong></td>
<td><strong>620,000</strong></td>
</tr>
</tbody>
</table>

-722,000 €/year cost reduction for Municipality

-30% energy cost reduction for Citizens
Thank You

emilio.ghiani@diee.unica.it