Research activity on microgrids and multi energy systems @UnivPM

Gabriele Comodi, Flavio Caresana, Leonardo Pelagalli

Dipartimento di Ingegneria Industriale e Scienze Matematiche

Università Politecnica delle Marche

g.comodi@univpm.it

UNIVERSITÀ POLITECNICA DELLE MARCHE

"National Study Day on Mini Grids for Urban, Rural and Industrial Development"

Rome - 21 June 2018

STAFF

Faculty
Prof.Flavio Caresana (ING-IND/09)
Prof. Leonardo Pelagalli (ING-IND/09)
Dott. Gabriele Comodi (ING-IND/09)

Ph.D. Students
Emiliano Borri
Andrea Bartolini
Samuele Spedaletti

Cooperation with others group within UnivPM
Andrea Monteriù, Lucio Ciabattoni, Francesco Ferracuti (Computer Science)
Prof. Fabrizio Marinelli, Roberto Rosetti, Andrea Pizzuti (Operational Research)
Prof.ssa Graziella Pacelli (Mathematical Finance)

Research goal:
towards Net-zero multi-energy districts

Maximise districts self-consumption of renewable (thermal and electric) energy resources through optimal:

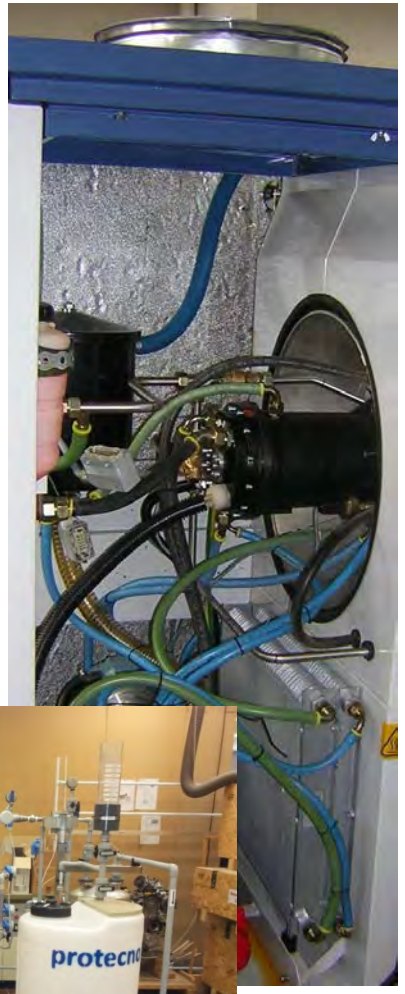
- District planning
- Energy systems operation and scheduling
- Demand management
- Sinergies among different networks (electric, natural gas, district heating and cooling, water,…)

From **single** user => **aggregation** of users

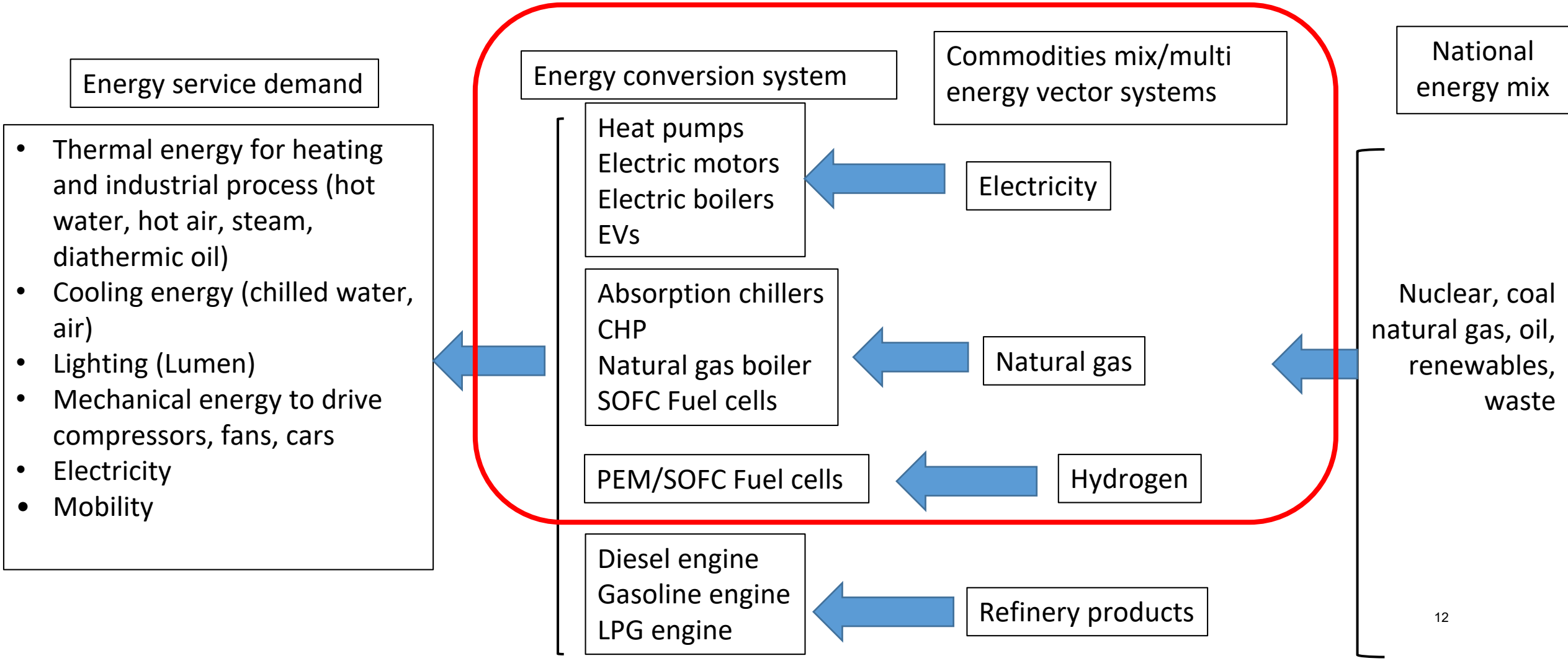
Experimental and modeling activities on single DG technologies:

UNIVERSITÀ POLITECNICA DELLE MARCHE

- CHP and CCHP
  - Internal combustion engines
  - Microgas turbines (TURBEC)
  - Small Stirling engines (tests are planned for next year)
  - SOFC
- Renewables
  - HCPV
  - PV plant
  - Solar thermal
  - CSP
- Energy storage technologies
  - electric,
  - Thermal
  - Liquid Air Energy Storage
- Desalination and water production



District Energy service demand, distributed generation, multi energy systems

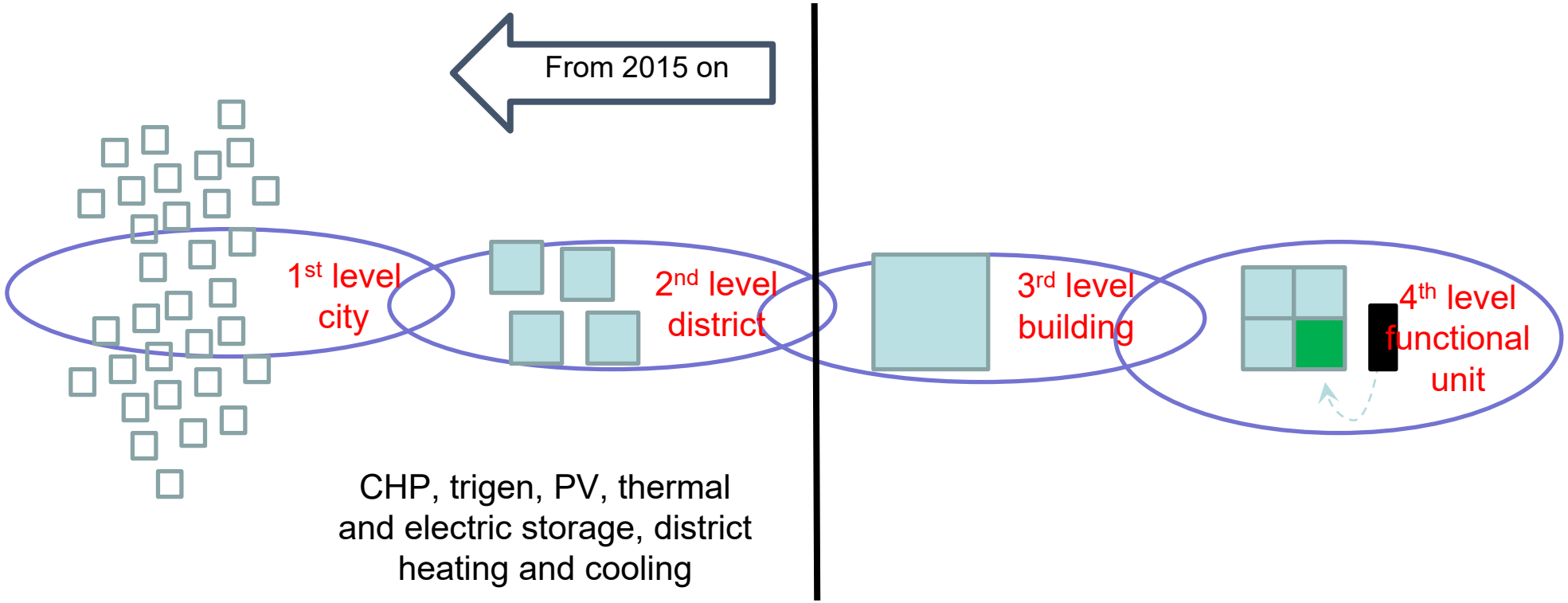


Present research activities:

1. Integration of DG energy systems in low carbon districts

UNIVERSITÀ POLITECNICA DELLE MARCHE

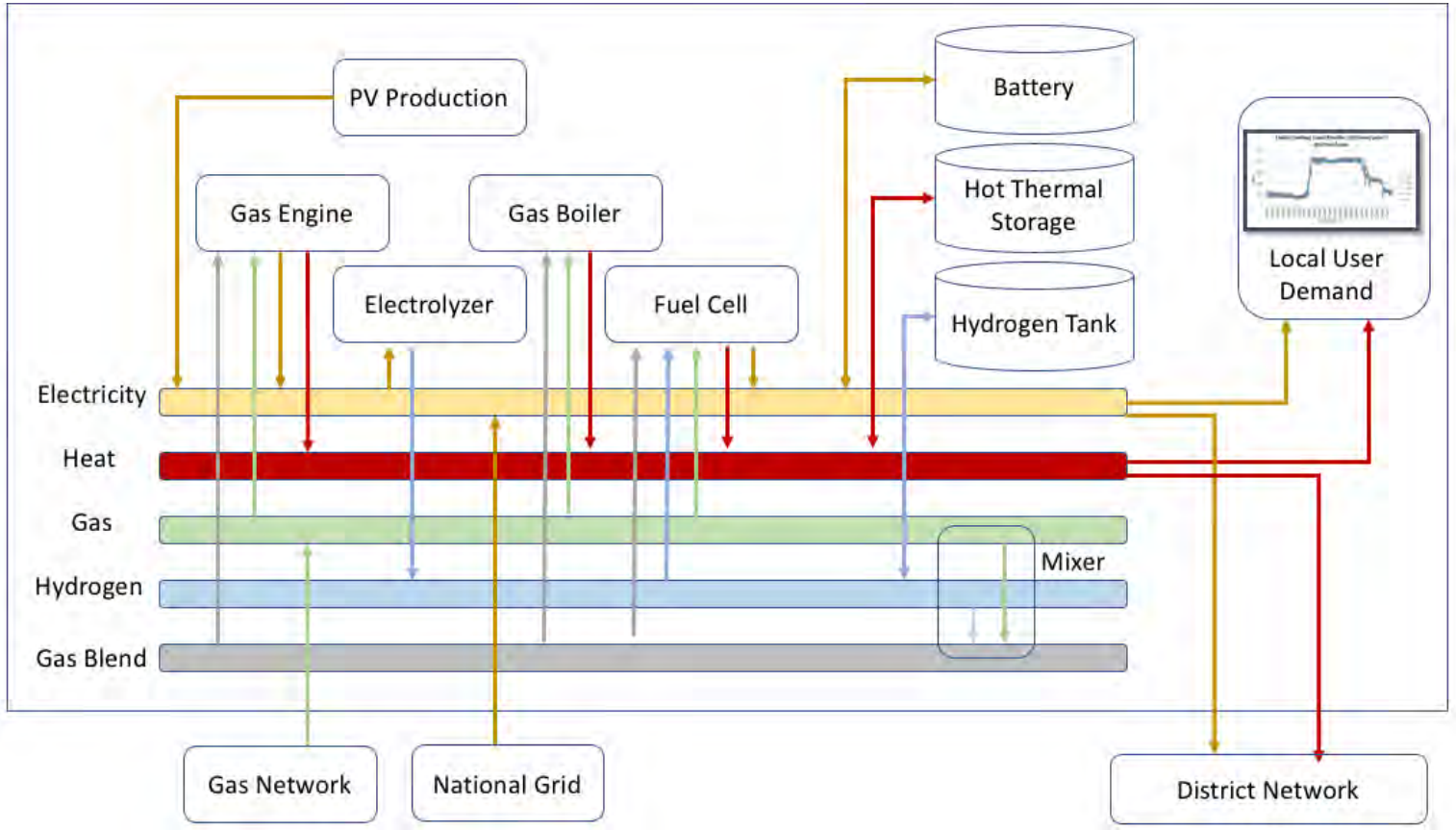
Energy planning for aggregation of users: Urban districts, Mini and microgrids,



Present research activities:
2. Optimal planning of multi-energy systems/microgrids with polygeneration

- Optimal design to minimize investment and operating costs
- Multiple energy vectors (electricity, heating, cooling)
- Role of energy storage in locally exploiting renewable energy generation
- Additional networks:
  - Water
  - H2

Tool:
- MILP
- GA



Present research activities:
3. Flexibility and aggregation of microgrids

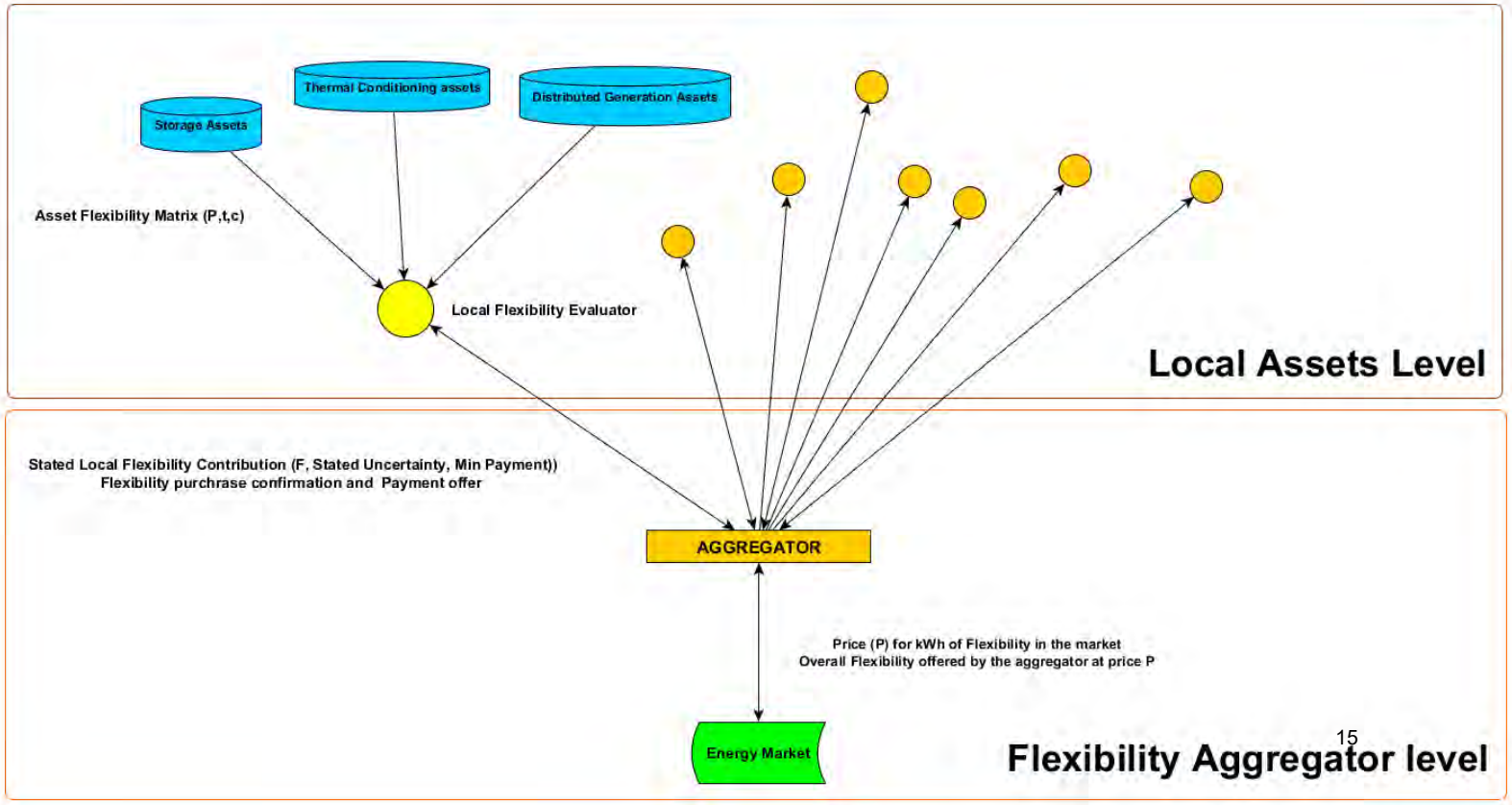
UNIVERSITÀ POLITECNICA DELLE MARCHE

- How to promote flexible assets penetration in residential, commercial and industrial microgrids
- Aggregation of microgrids for Ancillary Services Market and Balancing Markets

<u>Portfolio management problem</u>

how do we..

- ..prioritize flexibility assets?
- ..incentivize final users?
- ..take into account assets reliability?



Present research activities:
4. Drivers and Barriers to real implementation (marginal research activity)

UNIVERSITÀ POLITECNICA DELLE MARCHE

- Understanding of the interactions and interdependencies between energy supply networks (technical, economic and markets).
- The fragmented institutional and market structures of different energy systems is often a barrier to realise the benefits of synergies between energy networks (energy networks are often managed by different market Operators)
- How to overtake this barriers?

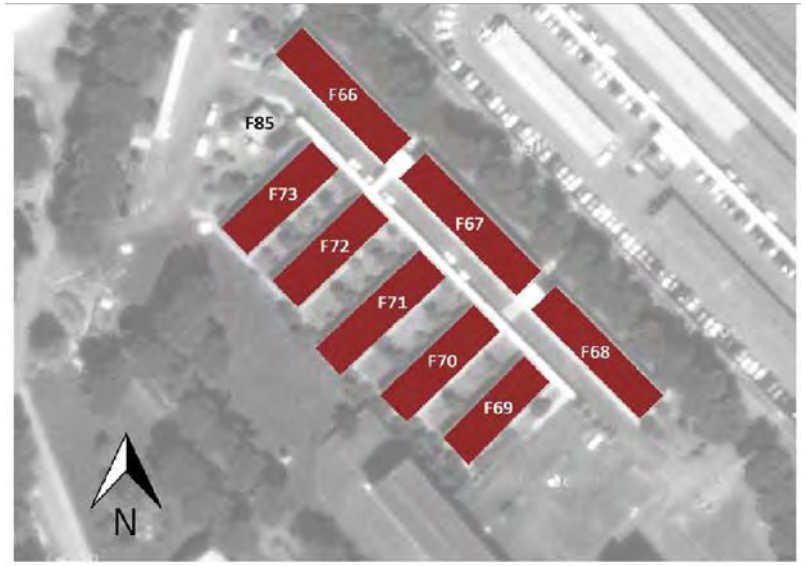
This is because we work on several microgrid “living labs”

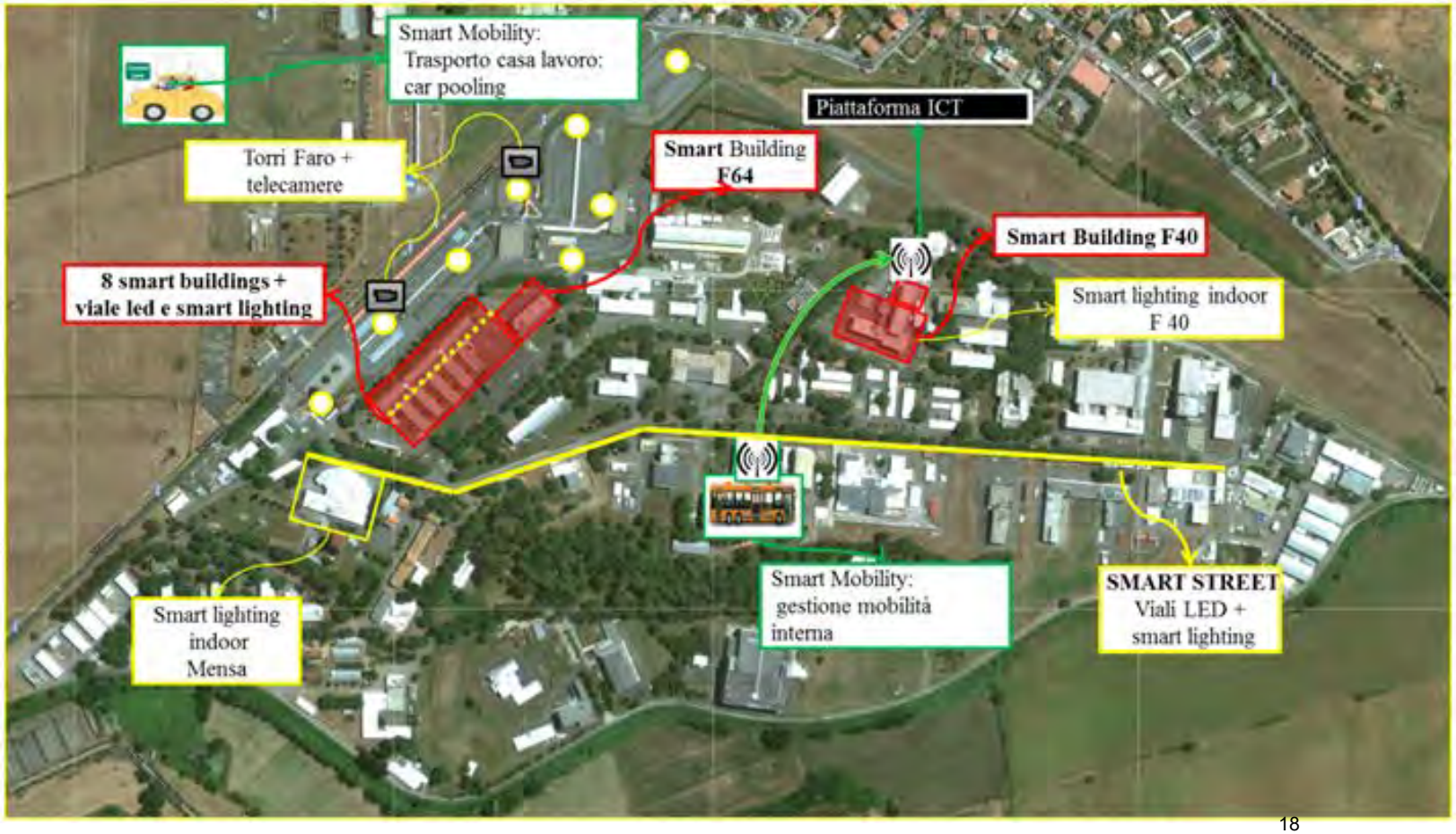
Applied research on real microgrids: four living labs

Pilot 1: Smart village ENEA

UNIVERSITÀ POLITECNICA DELLE MARCHE

- Smart building
- Smart district heating
- Smart street/Public Lighting
- Test of DSM strategies

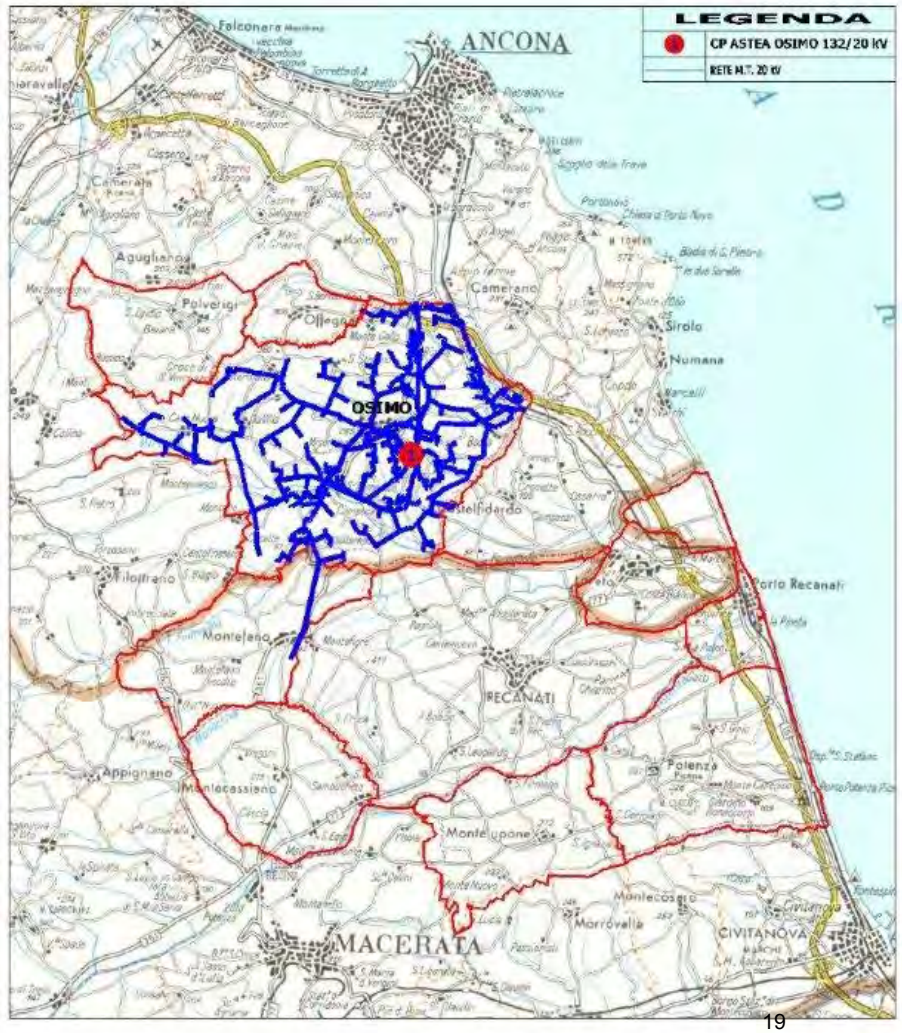




Pilot 2: Municipal Minigrid Osimo

UNIVERSITÀ POLITECNICA DELLE MARCHE

- 1 PCC with National grid
- CHP/DH system with: 1,2 MWe ICE
- >30 MWp PV installed (100% renewable during summer weekends)
- 400 kW mini-hydro power plant
- Electric mobility program (2 charging stations and Utility fleet conversion to EV)
- It experienced ISLAND OPERATION during national blackout in 2003



H2020 Proposals submietted and under evaluation:

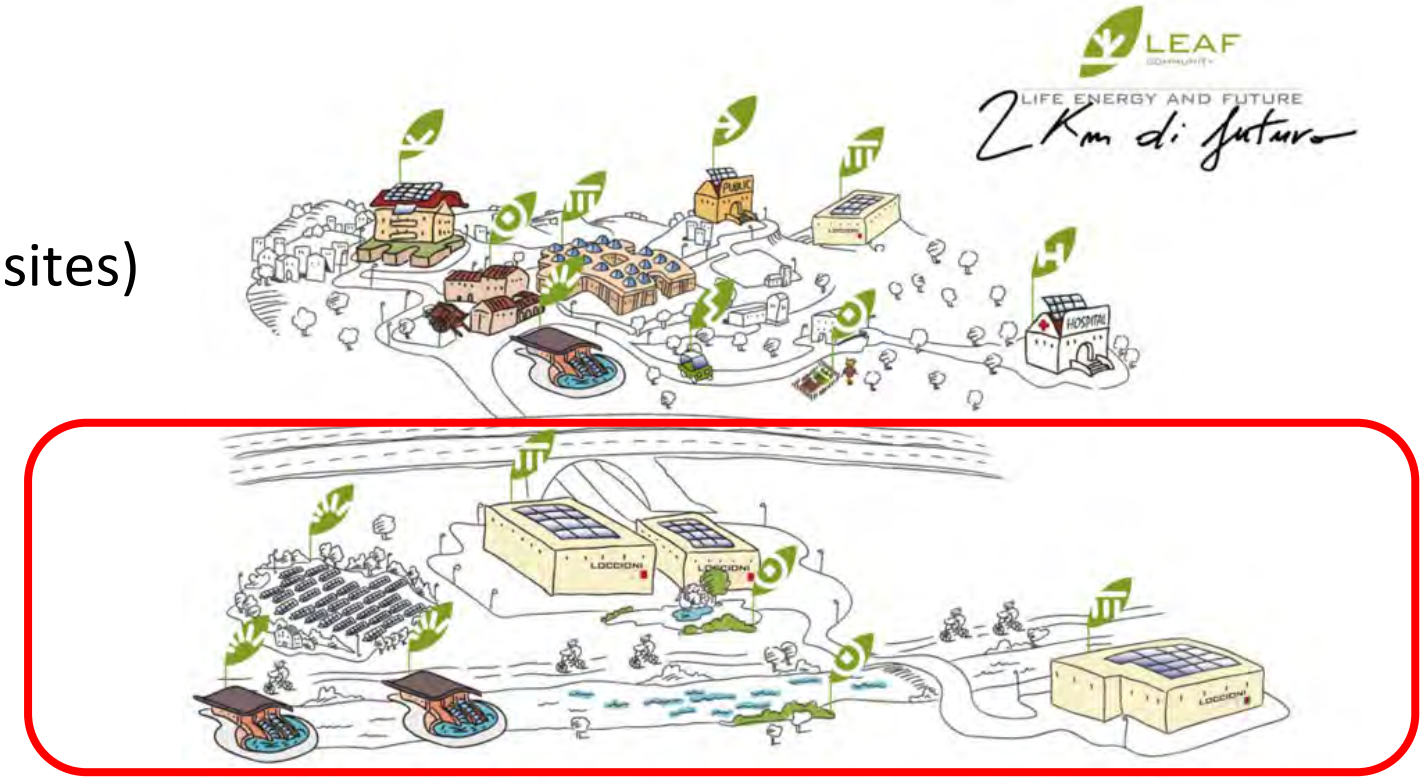
LC-SC3-ES-3-2018-2020: Integrated local energy systems (Energy islands)

LC-SC3-ES-5-2018-2020: TSO – DSO – Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation

Pilot 3:
Loccioni Group Industrial Microgrid

UNIVERSITÀ POLITECNICA DELLE MARCHE

- 1 PCC
- 5 buildings (offices and production sites)
- PV
- Heat-pumps
- Thermal Storage
- Electric Storage
- Mini-hydro
- EV
- Smart Energy management system (**MyLeaf** – developed by Loccioni)



Partners

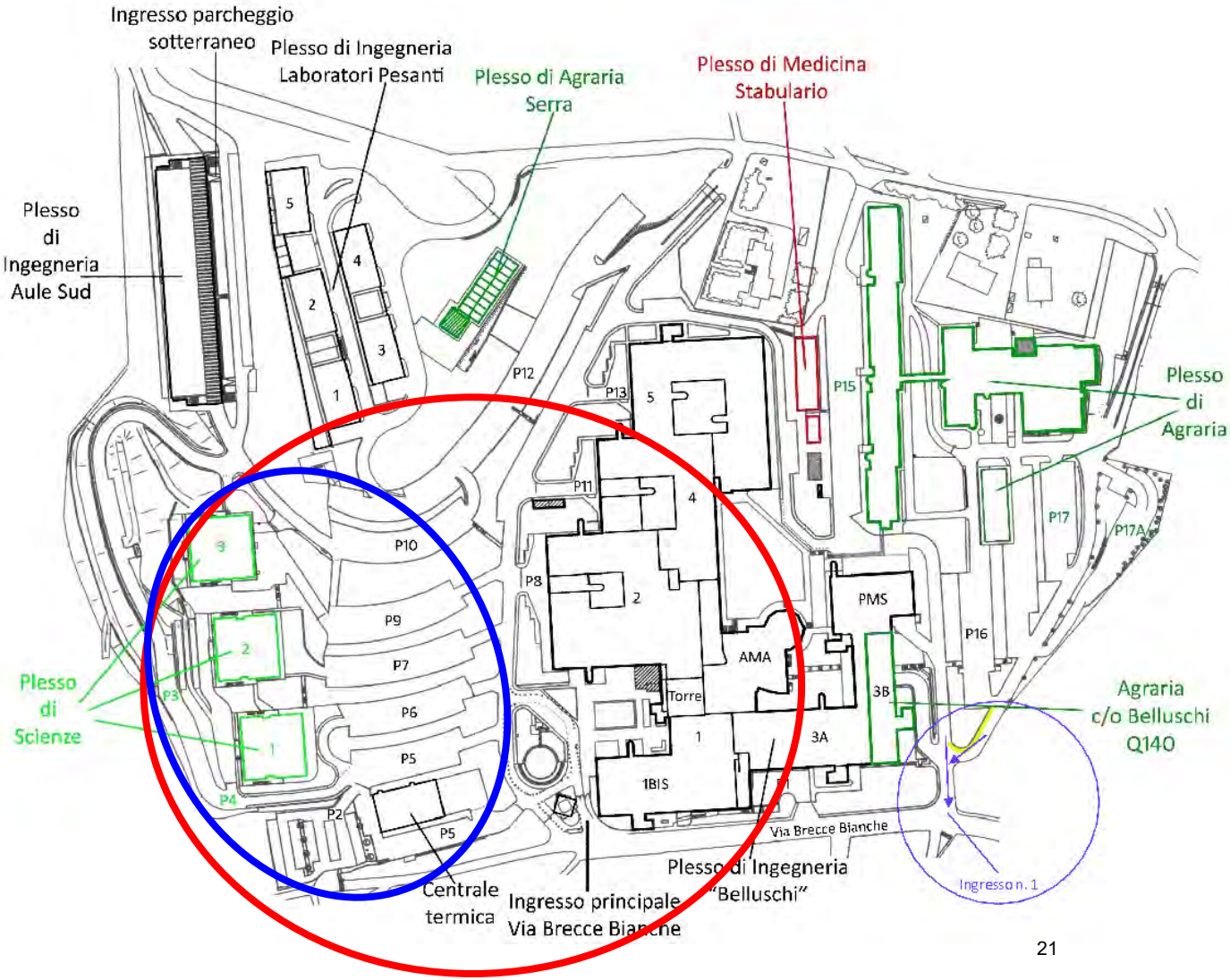
Pilot 4: University Microgrid UNIVPM

UNIVERSITÀ POLITECNICA DELLE MARCHE

Within the framework of the **Deprtment of Excellence on «Industry 4.0 and additive manufacturing»,** it will be implemented an IoT monitoring and management system for the microgrid of UnivPM.

Existing assets:

- 600 kWe CHP/Trigen coupled with District heating and cooling network
- 20 kWp PV
- 7 kWp HCPV
- Natural gas boilers
- IoT platform for energy monitoring, data analysis and management system
- Electric energy storage (to be purchased)



Opportunities of cooperation

Next H2020 calls we are addressing:

- RES-8:Combining Renewable Technologies for a Renewable District Heating and/or Cooling System http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/lc-sc3-res-8-2019.html
- LC-SC3-ES-1-2019: Flexibility and retail market options for the distribution grid http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/lc-sc3-es-1-2019.html

National and International Cooperation:

- Interest in investigating Rural microgrids
- Join other research groups to exploit common synergies and diversities
- Future UnivPM microgrid as a living lab available for common research with other groups
- Exchange of students and experiences

Thanks for your attention

Gabriele Comodi

UNIVERSITÀ POLITECNICA DELLE MARCHE

"National Study Day on Mini Grids for Urban, Rural and Industrial Development"
Rome - 21 June 2018

Some results

Osimo Mini Grid

Reduction of supply temperature

New scenarios with CHP-TES-HP

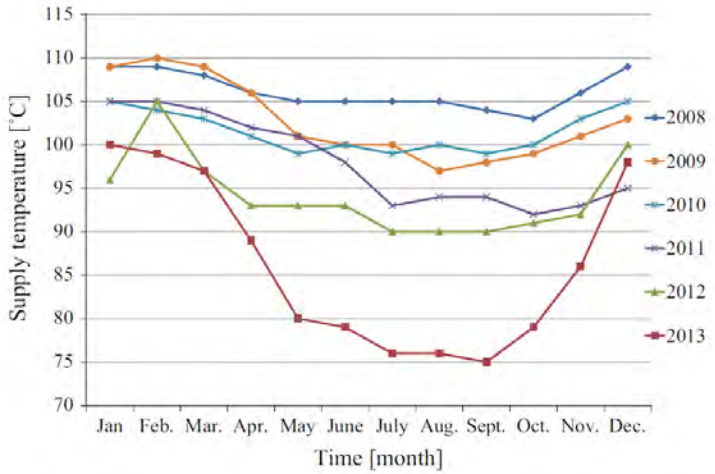


Fig. 6. DH water supply temperature trend for the period 2008–2013.

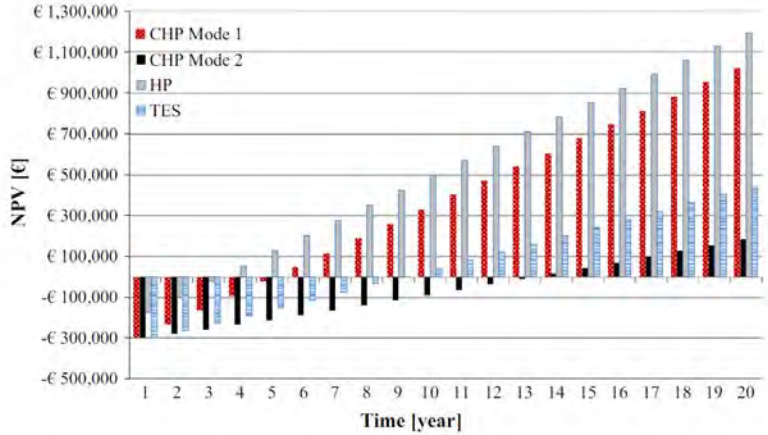
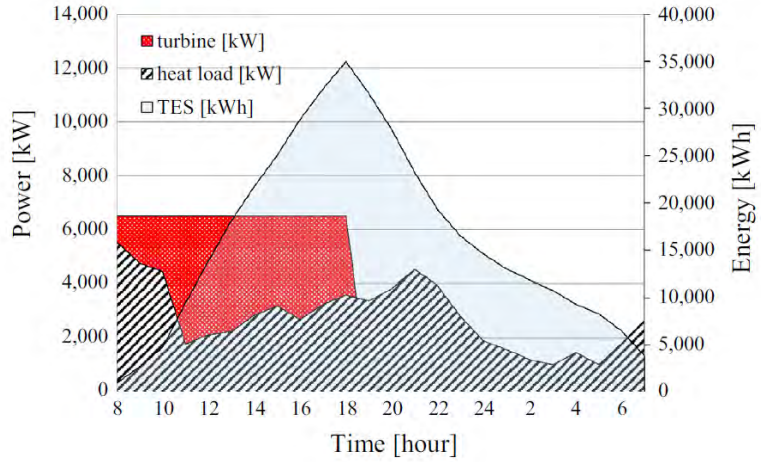


Fig. 9. NPV for the considered configurations with CHP gas engine (two management strategies Mode 1 and Mode 2), HP and TES.



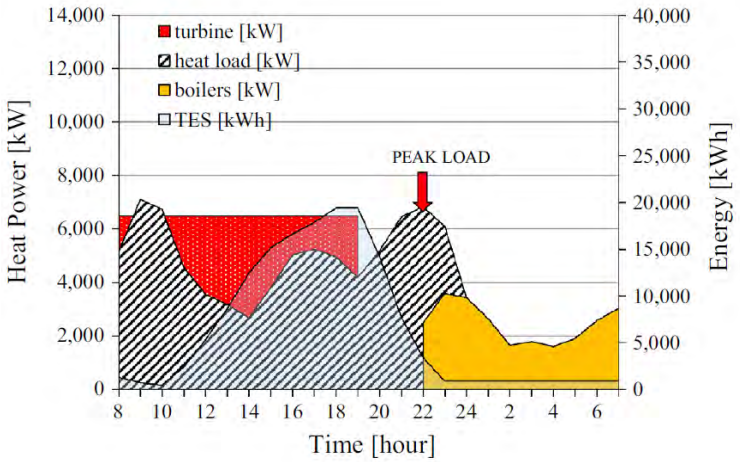
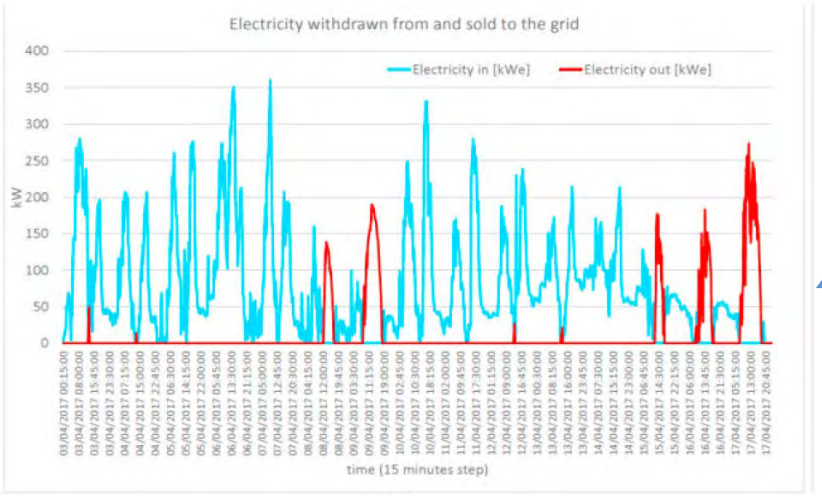


Fig. 11. TES energy management in a typical (a) summer day and (b) winter day.

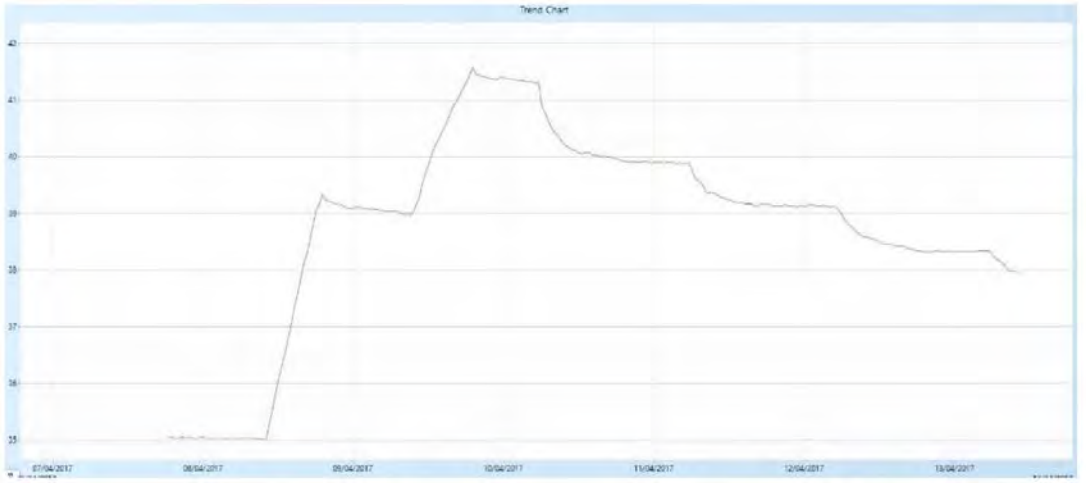
Some results

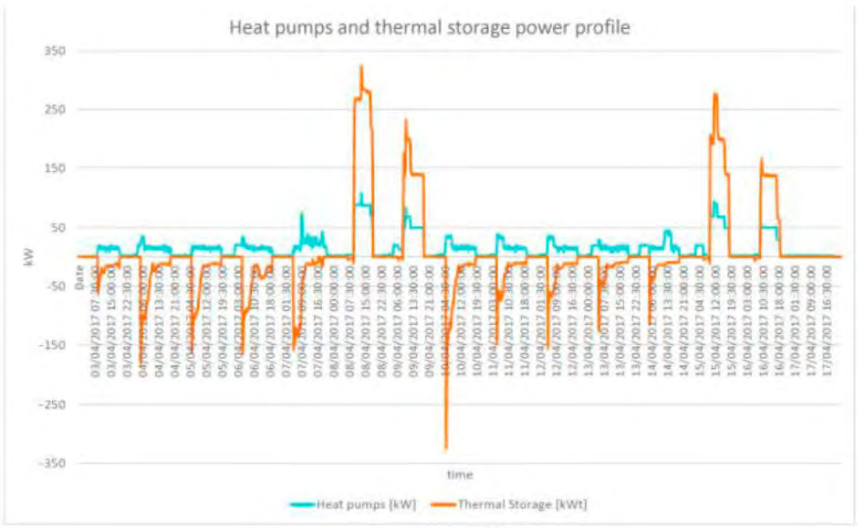
Loccioni microgrid: tests on flexibility



(a)

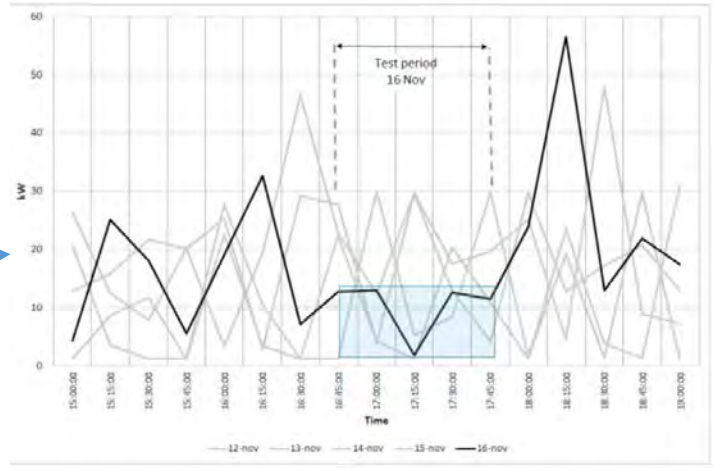
Charging and discharging of TES With excess of renewable energy (PV)





(b)

Flexibility with Thermostatically Control Load



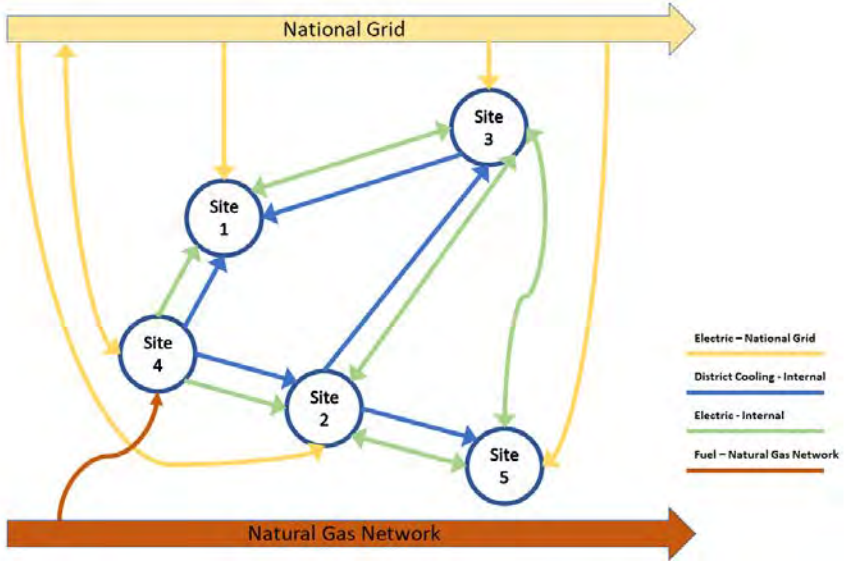
(b)

Some results

Smart Campus NTU: optimal planning

Campus Site	Boiler (kW)	CHP/Genset (kW_e)	Absorption Chiller cooling capacity (kW_c)	Electrical Chiller cooling capacity (kW_c)	Electric Storage (kWh_e)	Thermal Storage capacity (kWh_c)
U1	-	-	-	3600	-	-
U2	-	-	-	8000	-	-
U3	-	-	-	1600	-	-
U4	-	-	-	3300	-	-
U5	-	-	-	7000	-	-
Total				**23500**		

Table 1. Actual configuration of the cooling power installed on each site



Campus Site	Boiler (kW)	CHP/Genset (kW_e)	Absorption Chiller cooling capacity (kW_c)	Electrical Chiller cooling capacity (kW_c)	Electric Storage (kWh_e)	Thermal Storage capacity (kWh_c)
U1	-	-	-	4853	-	-
U2	-	5200	1238 + 2170	1033+1795+2426+4853	-	-
U3	-	-	-	-	-	-
U4	-	-	-	-	-	3000
U5	-	-	-	1795+2426	-	-
Total	-	**5200**	**3408**	**19181**	-	**3000**

Table 2. Selection of energy systems installed in each site of the campus with an economical optimization

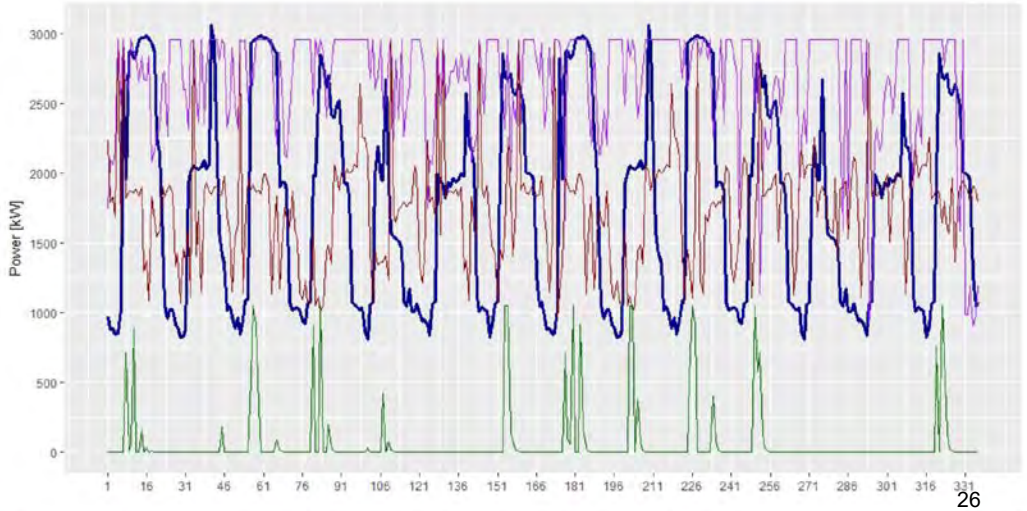
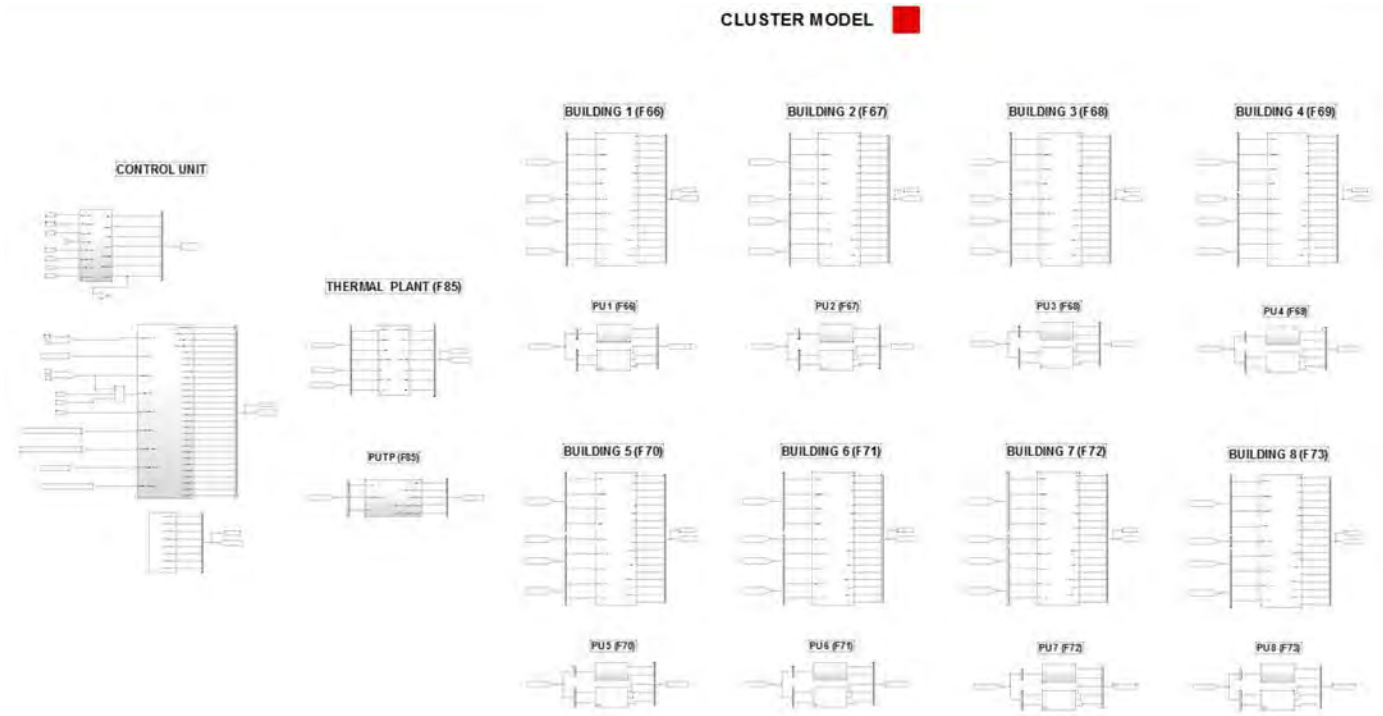


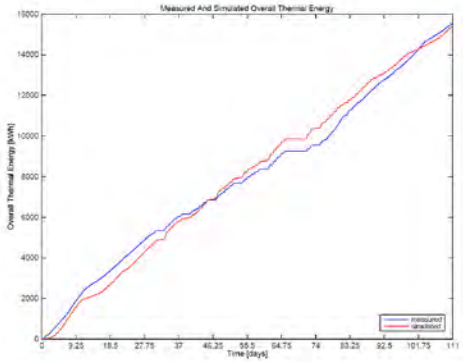
Figure 1. Supply of the cooling demand (in blue) for User 4: power flowing from district cooling network in purple (flow from user 2) and red (flow from user 3); energy provided by the CTES.

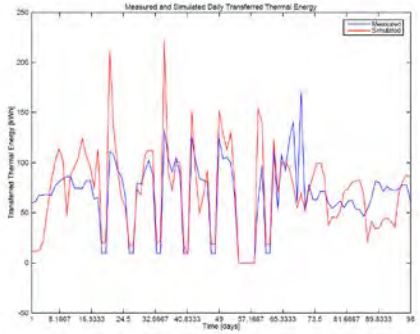
Some results

Smart Village ENEA

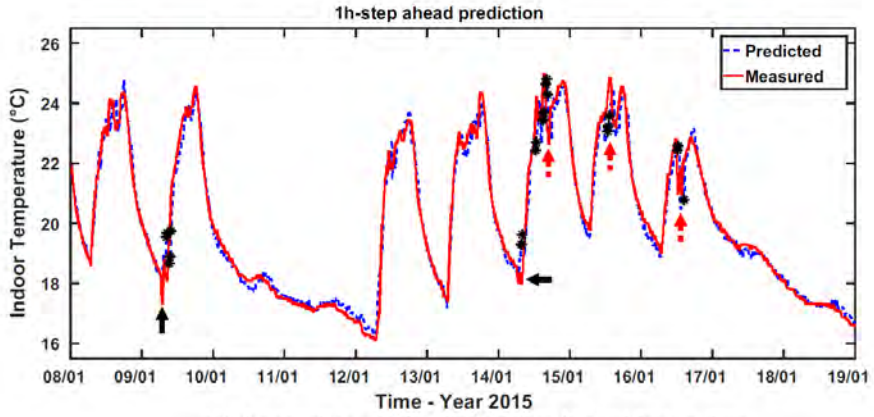
White box model







Black box model (Data driven)



(a) Anomalies and bad behaviors for valdation data.

Fig. 7. Anomalies and bad behaviors for 1-h ahead prediction (ARX model).

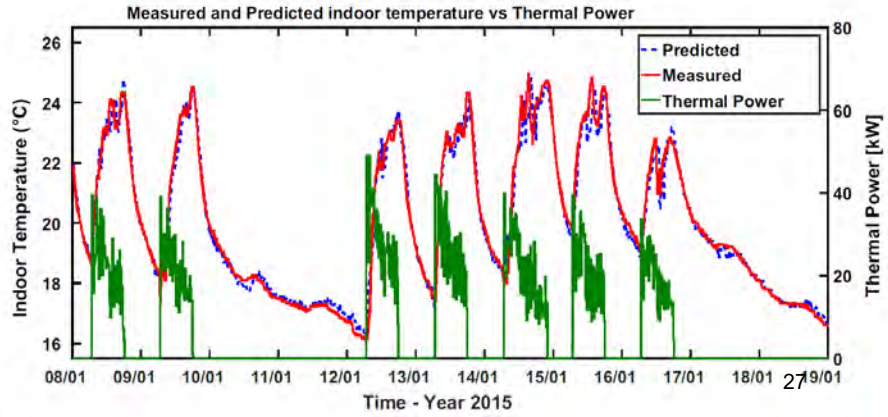


Fig. 8. Trend of measured and predicted indoor temperature (ARX model) together with the thermal power provided to the building.

Thanks for your attention

Gabriele Comodi

UNIVERSITÀ POLITECNICA DELLE MARCHE

"National Study Day on Mini Grids for Urban, Rural and Industrial Development"
Rome - 21 June 2018

Other research activities

UNIVERSITÀ POLITECNICA DELLE MARCHE

- IoT monitoring systems for microgrids
- Cloud platform for data collection and storage
- Data analysis on energy systems:
  - Investigation of networks losses (thermal, water…)
  - Investigation of energy systems performance losses: DG systems, batteries,
  - Predicitive maintanance and fault detection of Energy systems
- Barriers for microgrids and optimal synergies…