Demand response in a group of buildings based on Artificial Neural Network power predictions and Genetic Algorithm optimisation

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Smart GEMS: Partners

Scope & Objectives

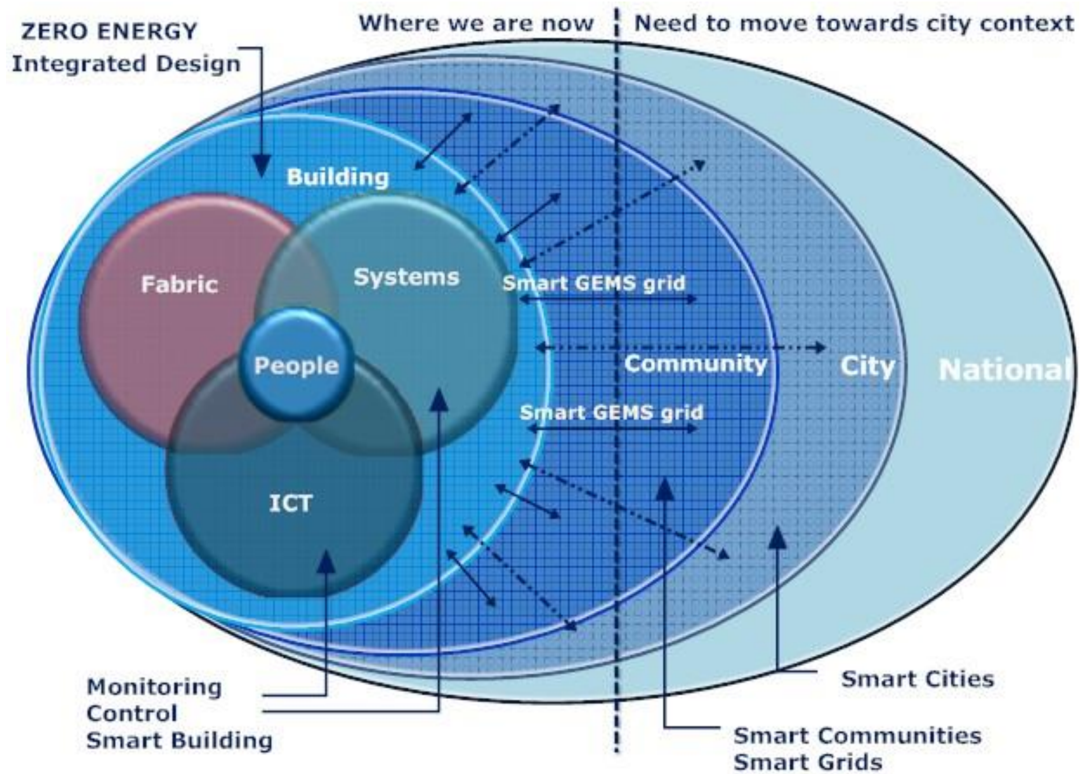
- Develop strong and sustainable synergies between academic community & industry experts in the field of smart grids and microgrids
- Draw coherent methodology for the development of smart grid applications
- Transfer knowledge and build new & complementary competences
- Investigate & disseminate advanced practices & modern techniques
- Foster process and product innovation
- Promote business initiatives
- Develop career opportunities through R&I activities

Smart GEMS: Project Overview

Phase 1: Smart and zero energy buildings performance
Users / consumers' aspects

Phase 2: Smart grid components to expand the cycle of the smart grid penetration to community or city level

Phase 3: Integration of components targeting to the development of smart applications and optimisation of smart grid performance



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Demand Response

- Demand Response: Operational, Regulatory and Technical framework for inducing changes in the power demand of buildings or settlements during the day.
- Minimization of investments necessary for modernising the power grid by enabling flexibility and advanced grid management options.
- Reduction of peak loads, maintaining grid balance, managing RES intermittency and high associated energy losses and increasing grid overall efficiency.

Demand Response: Explicit / Implicit

- **Explicit Demand Response:**
  - Demand competes directly with supply in the wholesale, balancing and ancillary services markets through the services of aggregators or single large consumers.
- **Implicit Demand Response**
  - Consumers choose *time-varying electricity prices* and react to those price differences depending on their own capabilities.

Case study: Leaf Community

- 48kWp micro-hydropower
- 4 rooftop PVs, 421.3kWp in total
- 18kWp, 2-axis solar tracker.
- 6 buildings connected to the micro-grid equipped with ground water heat pumps (GWHP)
- 224kWh electrical storage
- thermal storage with heat capacity 523.25kWh/K
- L4 – 35.4 kWh / m² year
- L6 - 46.85 kWh / m² year

Leaf community pilot buildings:
Leaf Lab (L4), Summa/AEA (L2/L3), Kite Lab (L5)

Technology	Advanced Envelope		HVAC			Lighting		RES		Energy Storage		Energy Management
Pilot Case Studies	Sky windows	Automated Shading	Heat Pumps	Advanced Monitoring	Advanced Controls	LED	Illuminance/ presence control	biPV	Geothermal	Thermal	Electrical	Storage My Leaf monitoring platform
Leaf Lab – Industrial (6,000m2)	x	x	x	x	x	x	x	x		x		x
Summa – Offices/Warehouse (1,037m2)			x	x	x	x	x	x	x		x	x
AEA - Offices / Laboratories (3,952m2)	x	x	x	x	x	x	x	x	x		x	x
Kite Lab (3,514m2) - Offices, Laboratories	x		x	x	x	x	x	x	x		x	x

European Commission · MARIE CURIE ACTIONS · SMARTGEMS energy network

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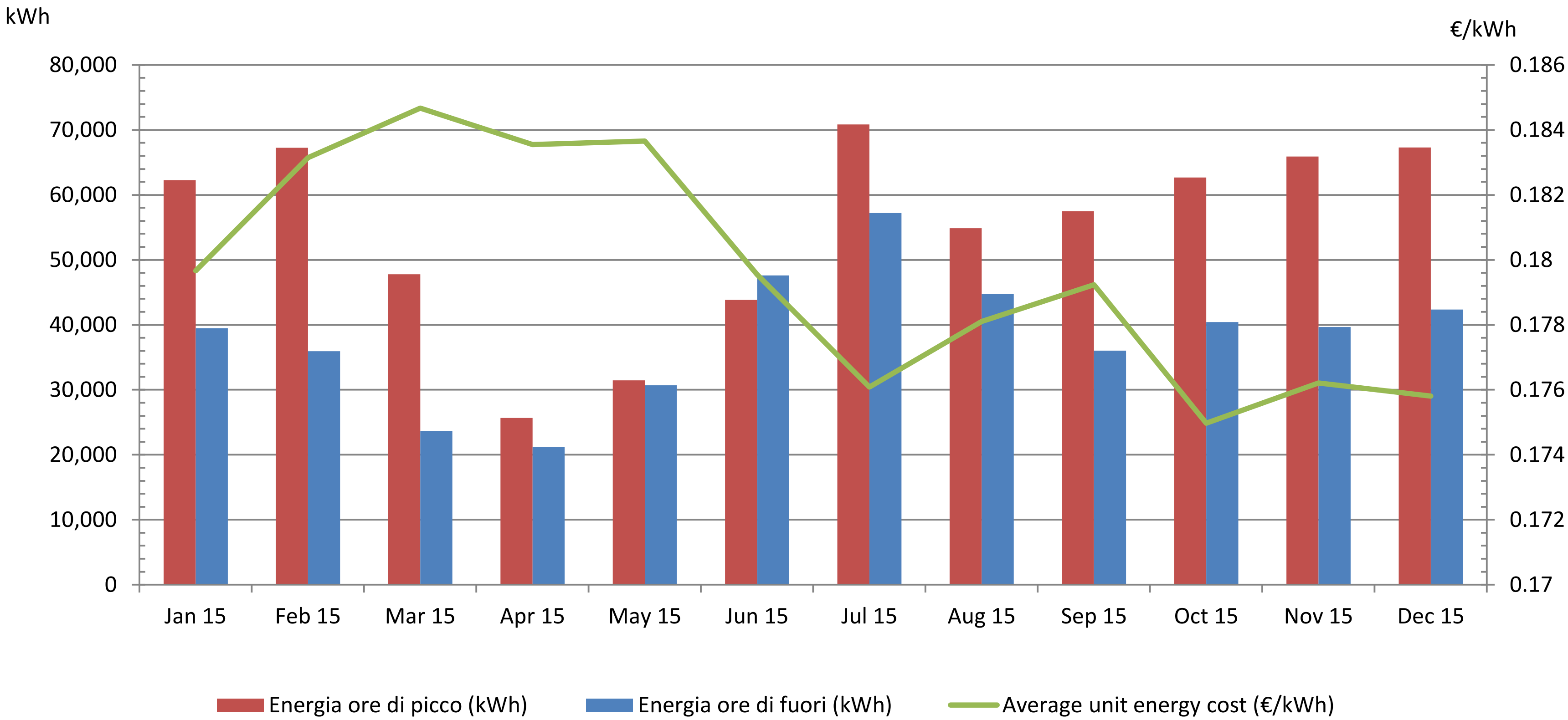
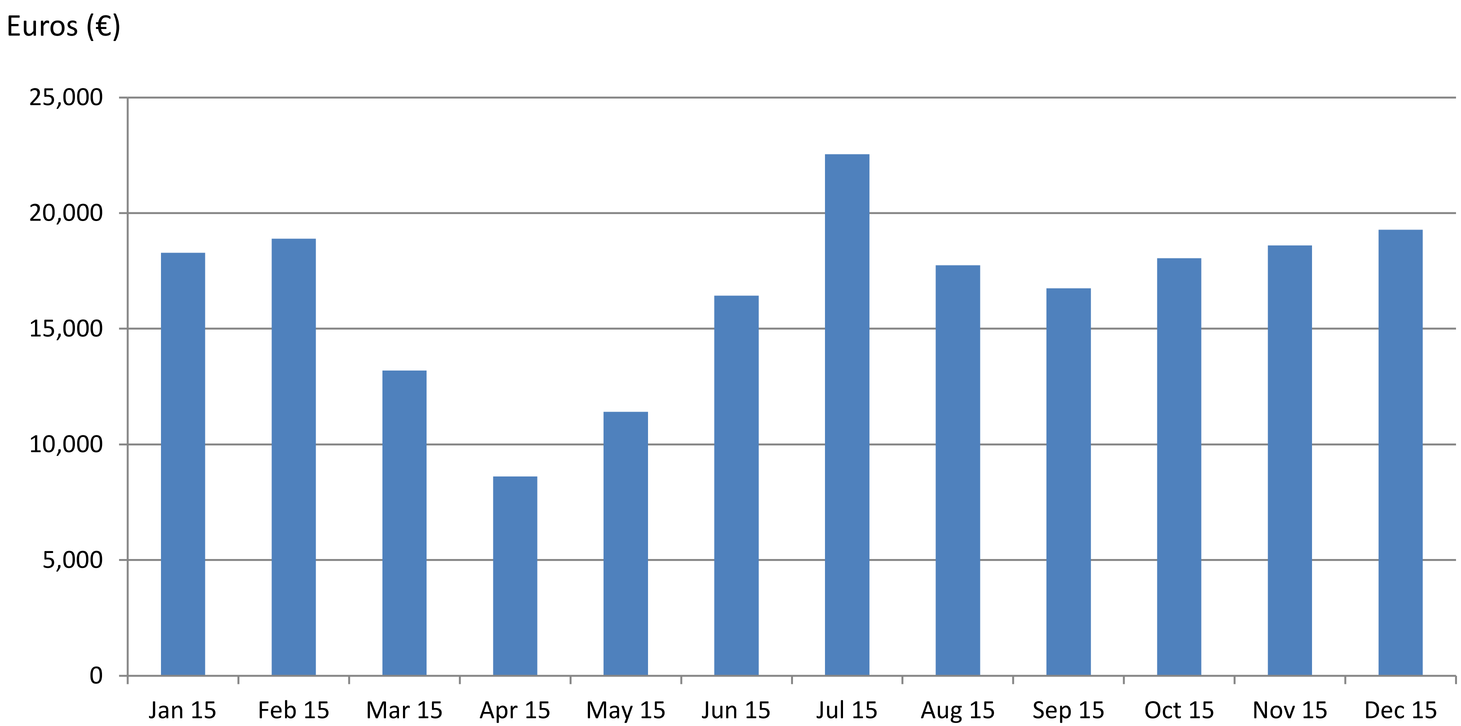
Leaf Community Electrical Energy Consumption & Cost



Leaf Community Electrical Energy Cost (2015)

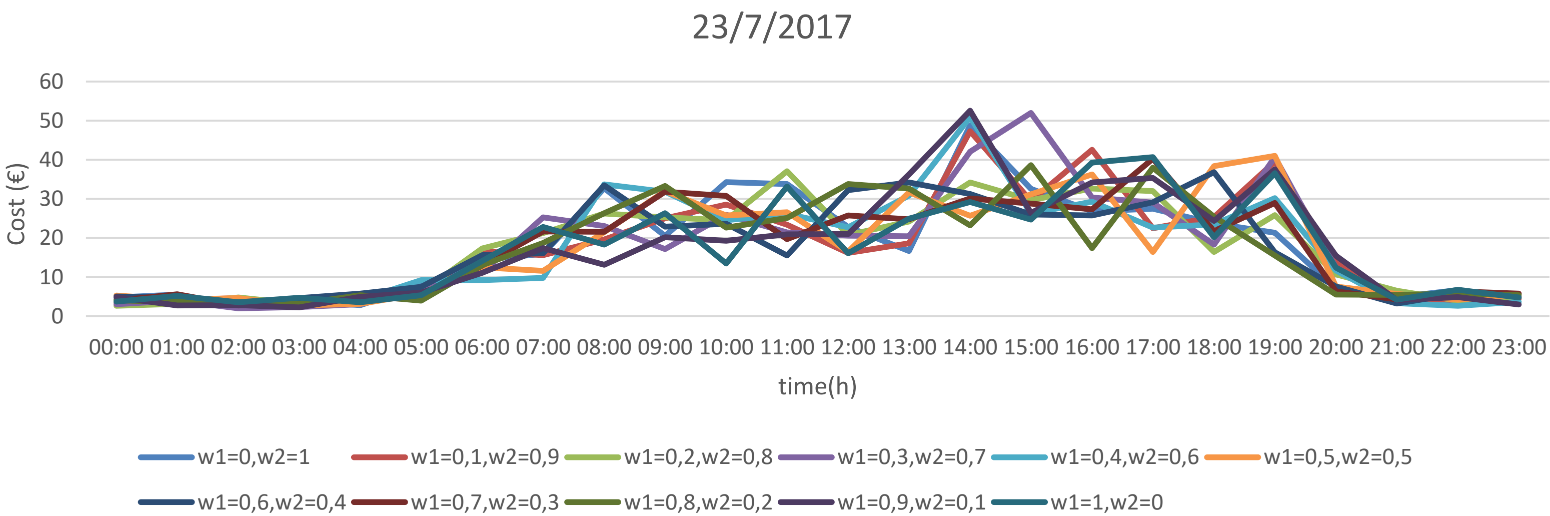


SMARTGEMS energy network

Methodology

Day-ahead prediction of power based on ANN → Day-ahead cost of energy dynamic pricing → GA Optimisation

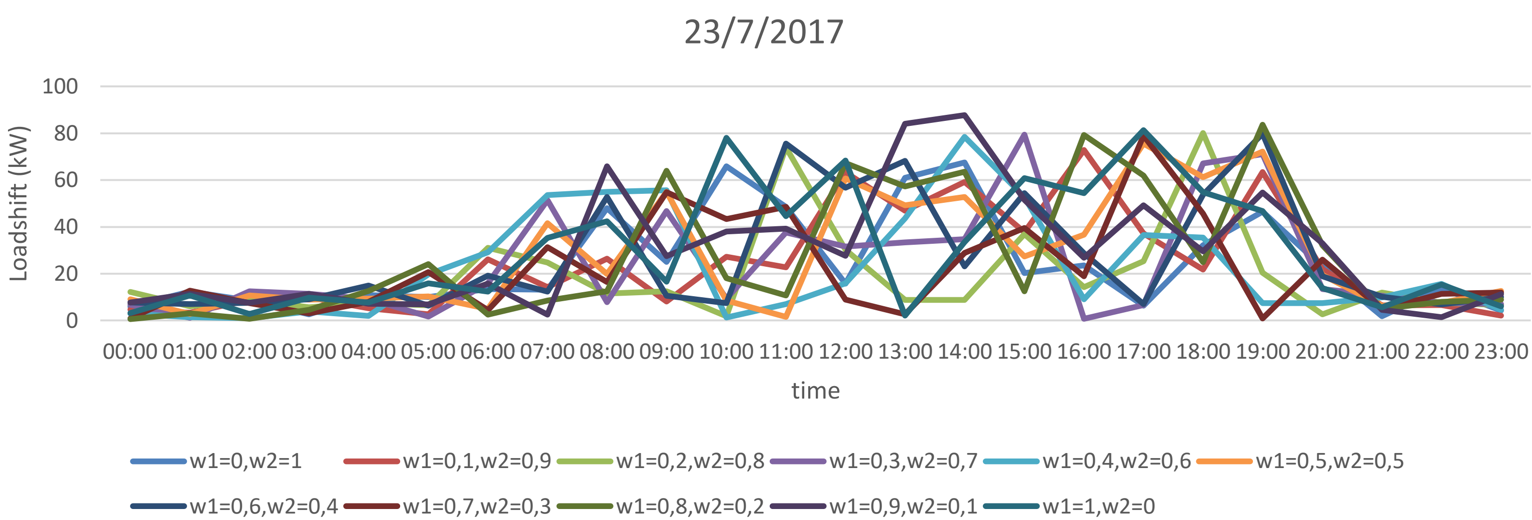
→ Pareto optimal solutions at district level in 2 criteria → **Daily cost of energy**



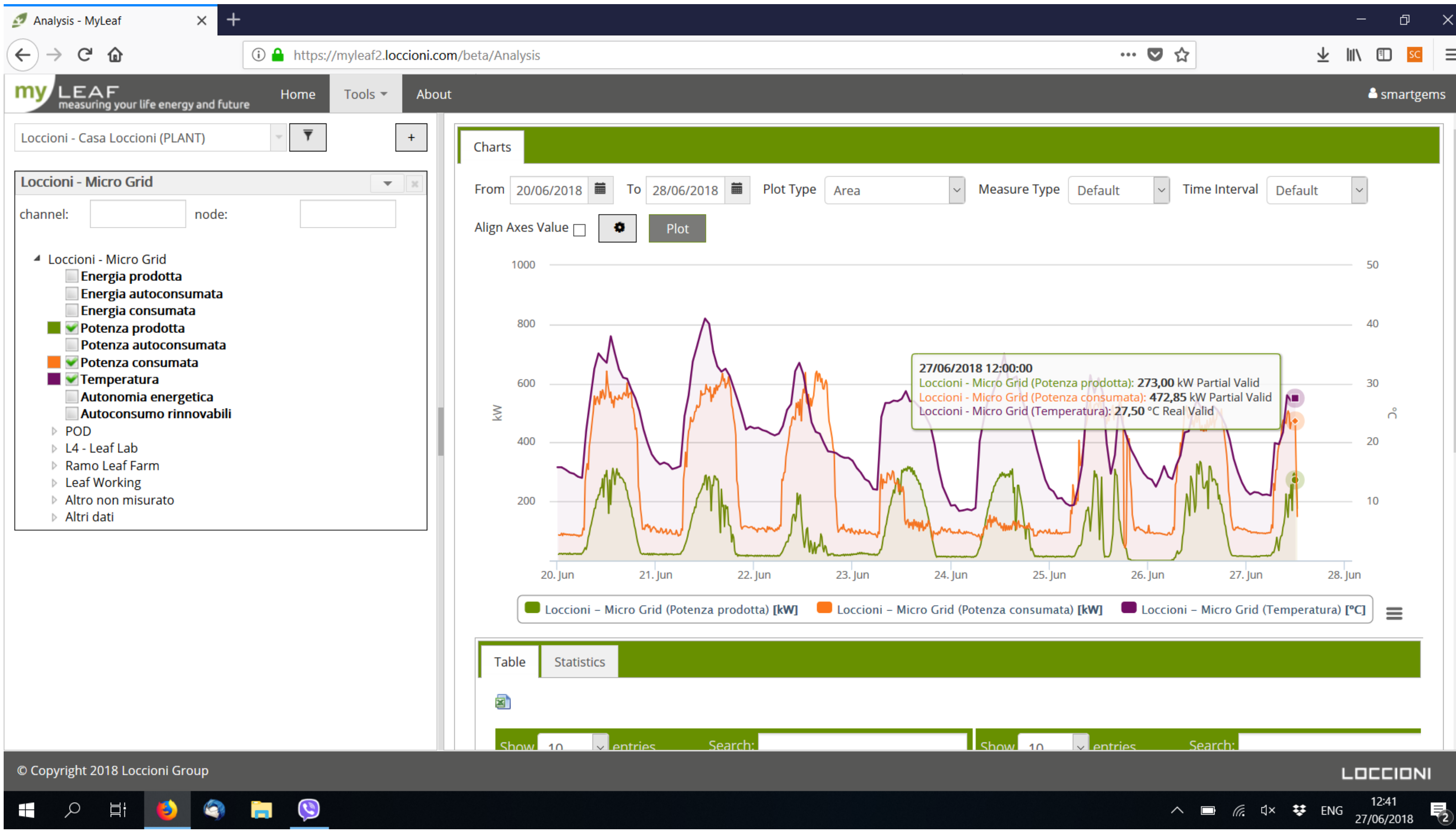
Methodology

Day-ahead prediction of power based on ANN → Day-ahead cost of energy dynamic pricing → GA Optimisation

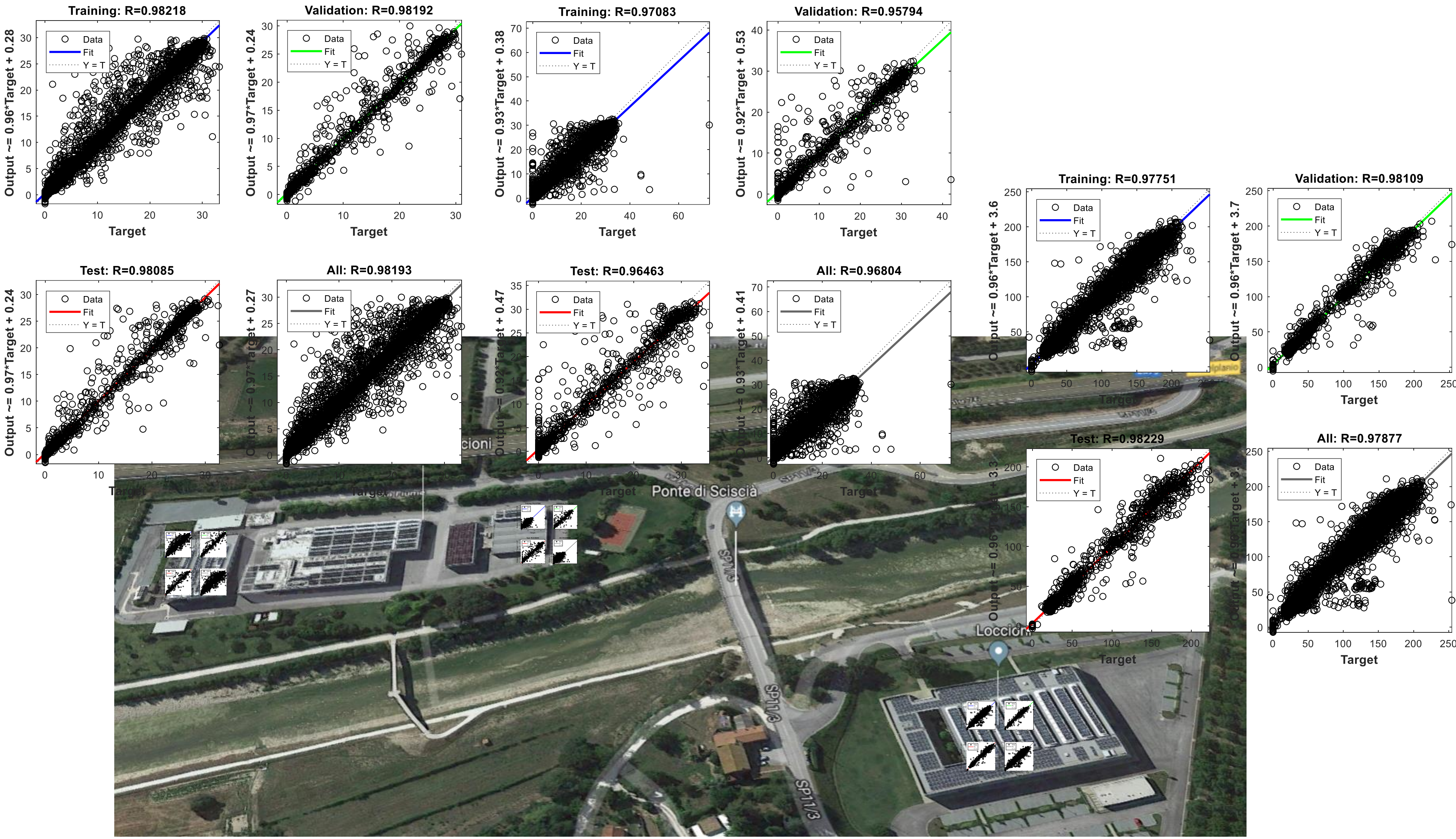
→ Pareto optimal solutions at district level in 2 criteria → **Loadshift**



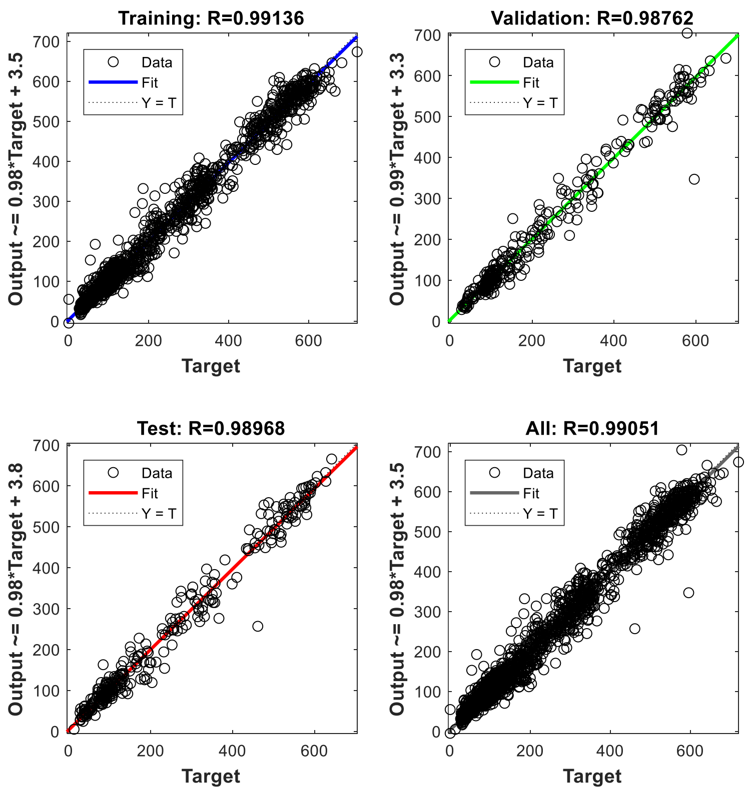
MyLeaf Platform by Loccioni



Smart meters / Leaf Community / Neural Network model predictions

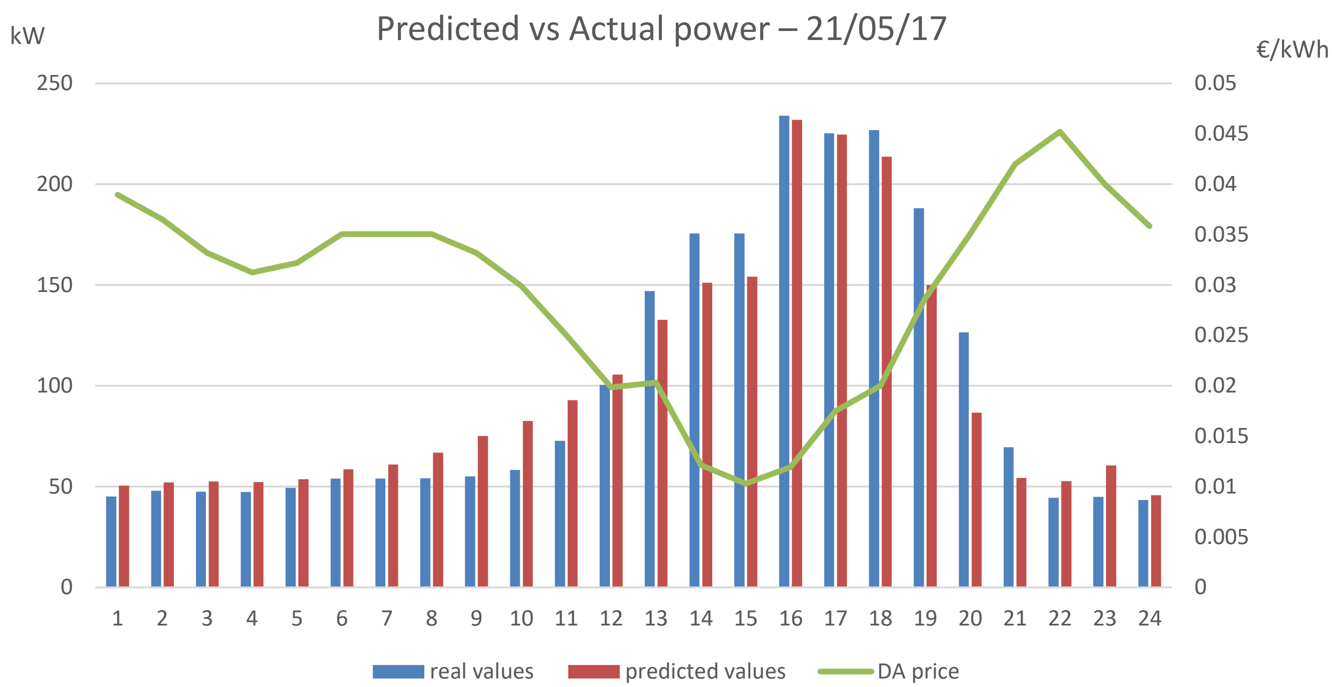


Microgrid level NN day ahead (24h) consumption power prediction



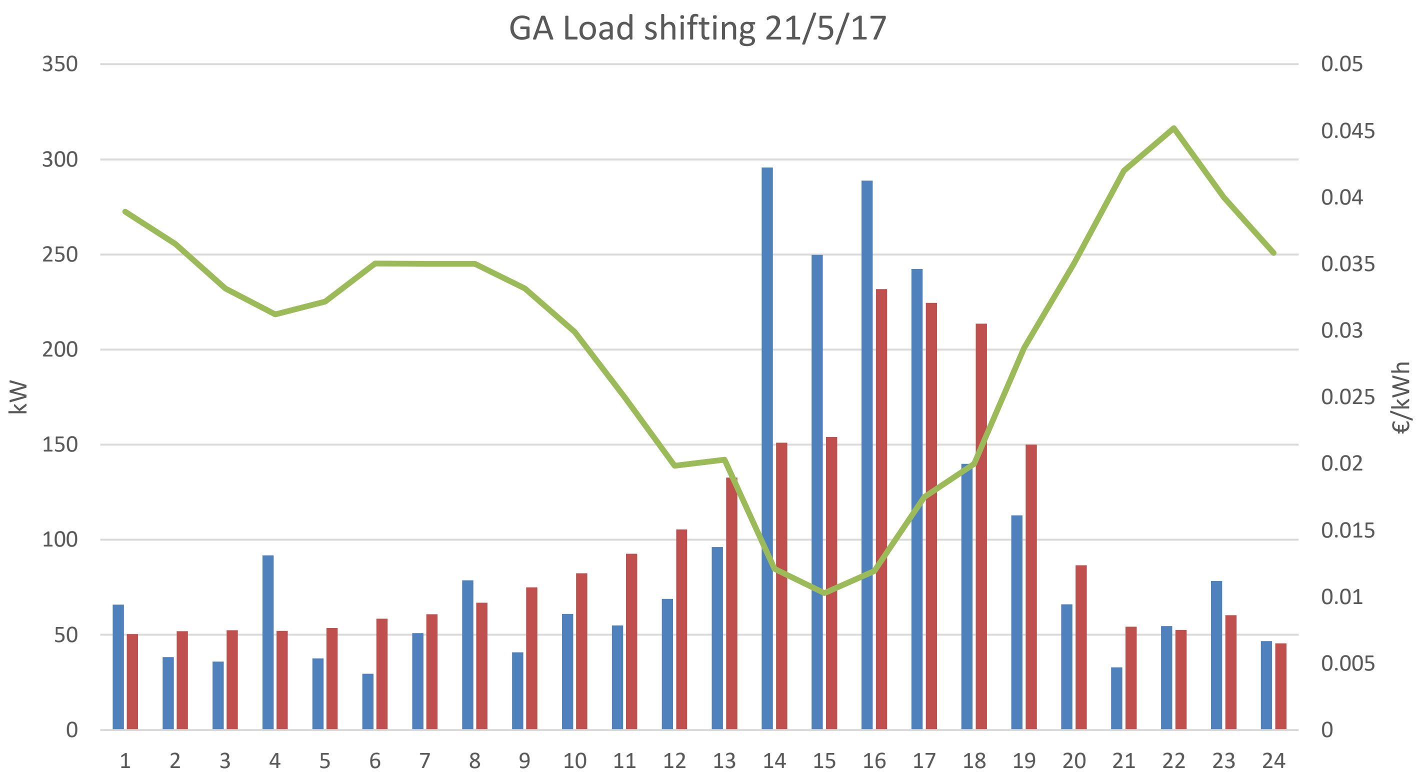
Predicted vs Actual power - 21/05/17

Microgrid level



GA Optimisation - 21/05/17

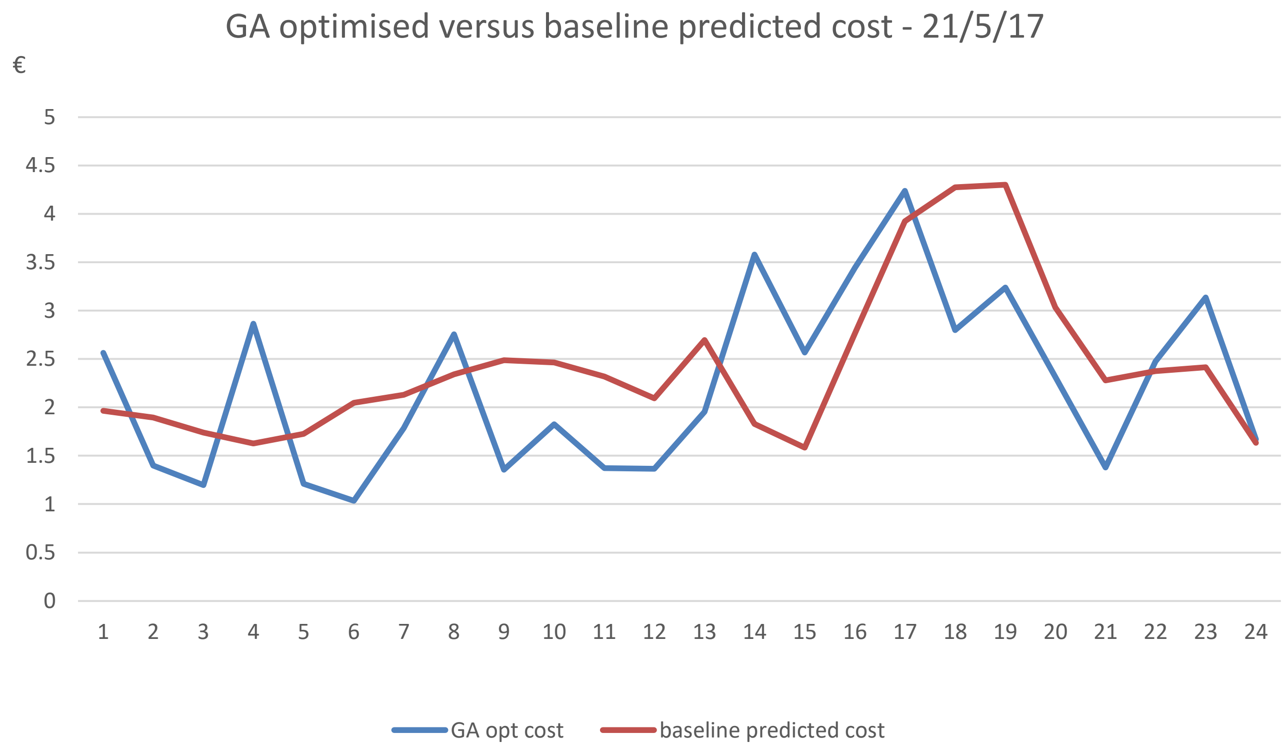
Microgrid level



total load shifting of 807 kWh at microgrid level

GA Optimisation - 21/05/17

Microgrid level



6.8% cost of energy reduction

Conclusions

- ANN models can be successful in predicting day-ahead loads and renewable energy generation at building and community level.
- GA optimisation is a useful tool to generate and evaluate alternative load shifting solutions.
- DR implies that prosumer effectively manage DER (loads, RE generation, storage)

Future steps

– Relate GA solutions to loads (baseload, fixed, flexible) and storage capabilities
– Evaluate complex DR dynamic pricing schemes / evaluate margin of profit
– Examine various case studies
– Quantify impact of prediction on DR solutions
– Fine tune and further develop GA based on new knowledge

Thank you for your attention