INSTITUTE
MIHAJLO PUPIN

Data Analytics for Energy Efficiency in H2020 Research

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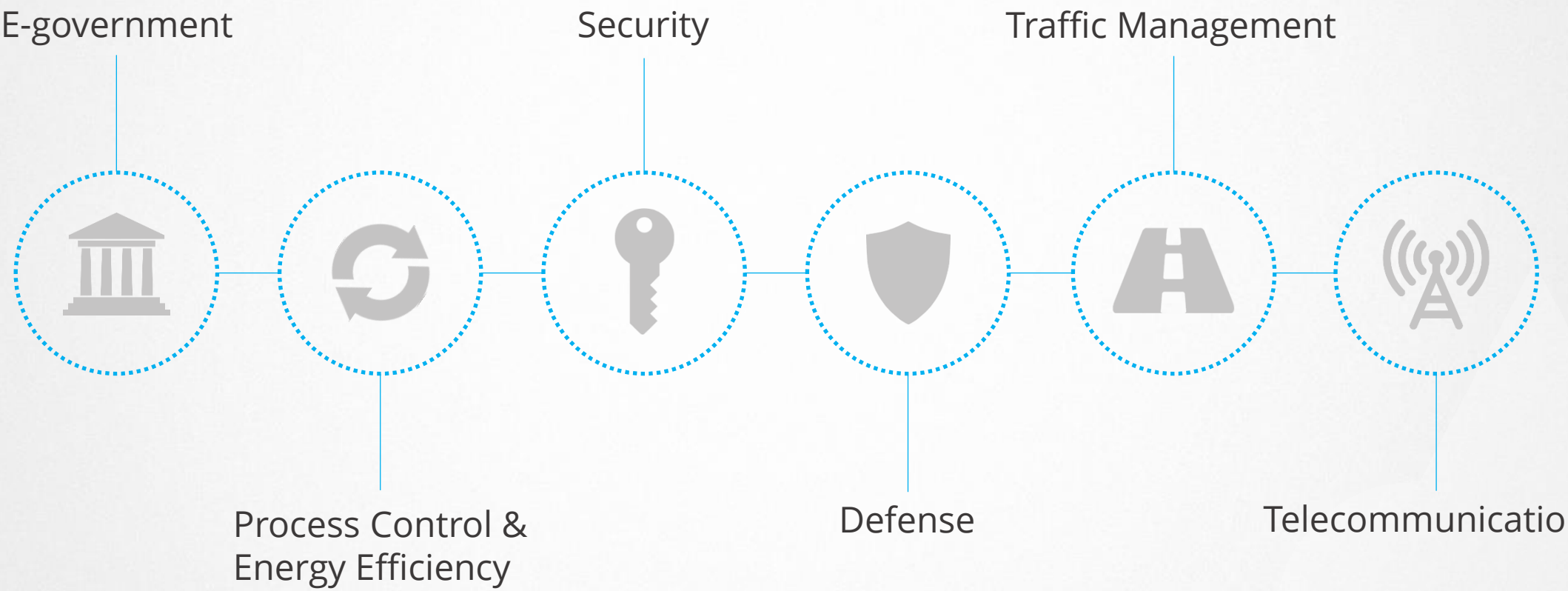
INSTITUTE MIHAJLO PUPIN

- Leading Serbian R&D institution in information and communication technologies (ICT)
- The biggest and oldest (1946) R&D Institute in ICT area in whole Southeastern Europe
- Around 450 employees, with 250 of them being researchers
- EU Commissionaire – “Pupin as the best practice example for bridging academia and industry”
- 90% of turnover via TT

KEY RESEARCH AND DEVELOPMENT AREAS



OUR SOLUTIONS

MAIN PROGRAMS

- **Information Systems:** E-government solutions, Document Management Systems, Decision Support Systems
- **Process Control Systems:** Power Production, Transmission and Dispatching Control and Supervision Systems, Water Supply and Management Systems
- **Traffic Management Systems:** Urban Traffic Control, Tunnel Management, Highway Pay-Toll Systems,
  Access control system, AVL Systems
- **Railway Program:** Axle Counter, LED signals, HMI solutions
- **Defense Program:** Simulation and Training Systems, Air War Gaming Systems, ESM Radar signal processing systems, Electronic Surveillance Systems, Ballistic Analyzer
- **Other Programs and Activities:** Robotics, Security, Embedded Systems, Center for Gas Technique, Surveillance, Alert & Warning Systems, etc.

JOINING FORCES WITH EU-BASED R&D PARTNERS

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83 International Research Projects, over 300 partners

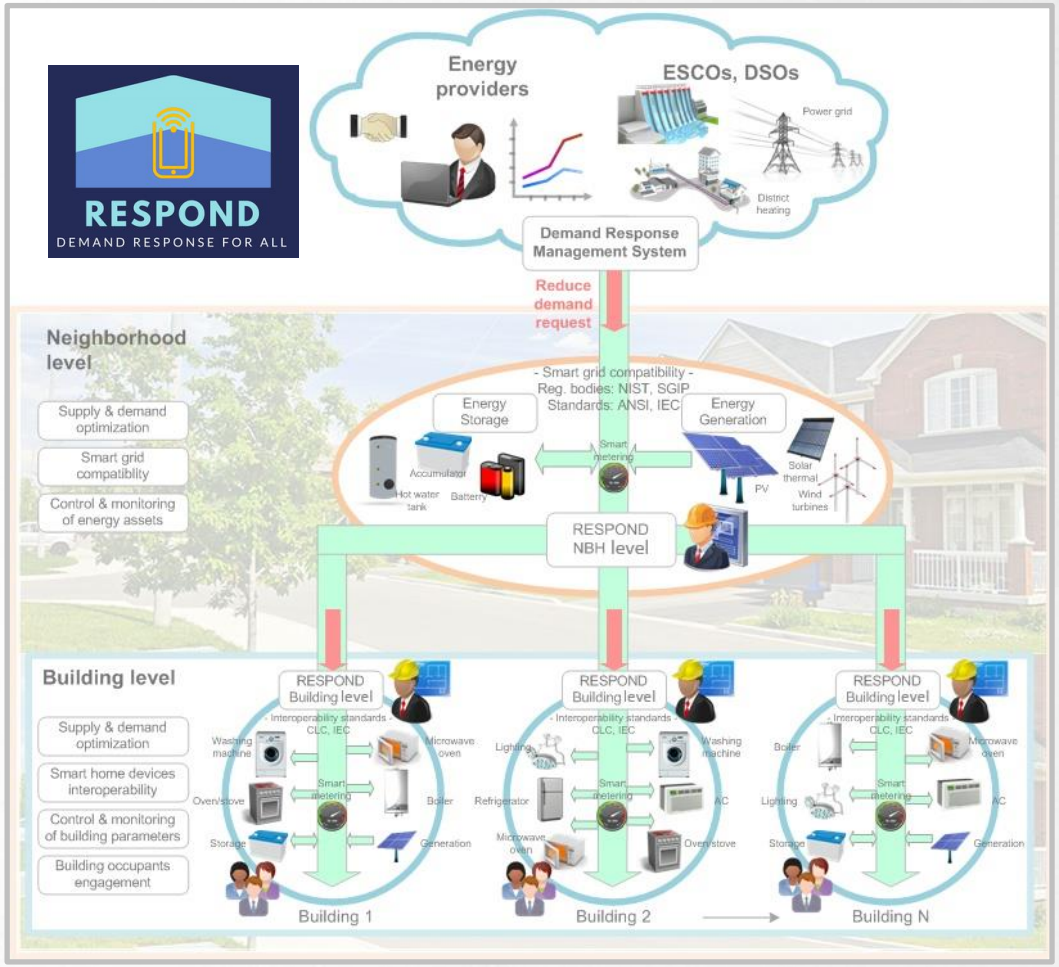
- 11 H2020 (**IDEAS**, **REACT**, **LAMBDA**, **RESPOND**, **InBETWEEN**, SlideWIKI, FeelAGAIN, FLIRT, EEN INNO, FS4SMIH, EENSerbia)
- 22 FP7 (REFLECT, AgroSENSE, META-NET, PERFECTION, WBC-INCO-NET, HydroWEEE, ICT-WEB-PROMS, HELENA, EMILI, ENERGY WARDEN, PROCEED, LOD2, **CASCADE**, HydroWEEE-DEMO, **EPIC-HUB**, SPARTACUS, GenderTIME, ResearchersNight, GeoKNOW, Danube INCO.NET, No-SQL.NET, Trafoon)
- 7 CIP/EIP (CESAR, EIIRC, GREEN, WEEEN, ICIP, IMAGEEN, Share PSI 2.0)
- 3 EC Interreg/DANUBE (MOVECO, NewGenerationSkills, EDU-LAB)
- 1 Adriatic IPA (PACCINO),
- 4 SEE (Intervalue, FORSEE, WBINNO, TV-Web)
- 3 TEMPUS (CARE, HUTON, INCOMING)
- 3 COST Actions (IC1004, IC1304, CA16116)
- 1 RSEDP2 (EMC)
- 1 ERASMUS+ (BEST)
- 4 IPA (Tax, Justice, Agro, EPS)
- 3 FP6 (SARIB, PROMETEA, Web4WeB)
- 2 EC Interreg/CADSES projects (I2E, STRIM)
- 17 bilateral (SUI 2, FRA 2, GER 5, CYP 1, GRE 1, NOR 1, POR 1, CHI 3, SLO 1)

H2020 RESPOND

http://project-respond.eu/

Integrated demand **RE**sponse **S**olution towards energy **PO**sitive **N**eighbourhoo**D**s

- Deploy and demonstrate **cost effective**, **user centred solution**, entailing energy automation, control and monitoring tools, for a **seamless integration of cooperative DR programs** into the legacy energy management systems.
- Owing to its flexibility and scalability, RESPOND solution will be capable of delivering a cooperative demand response **at both building and district level**.

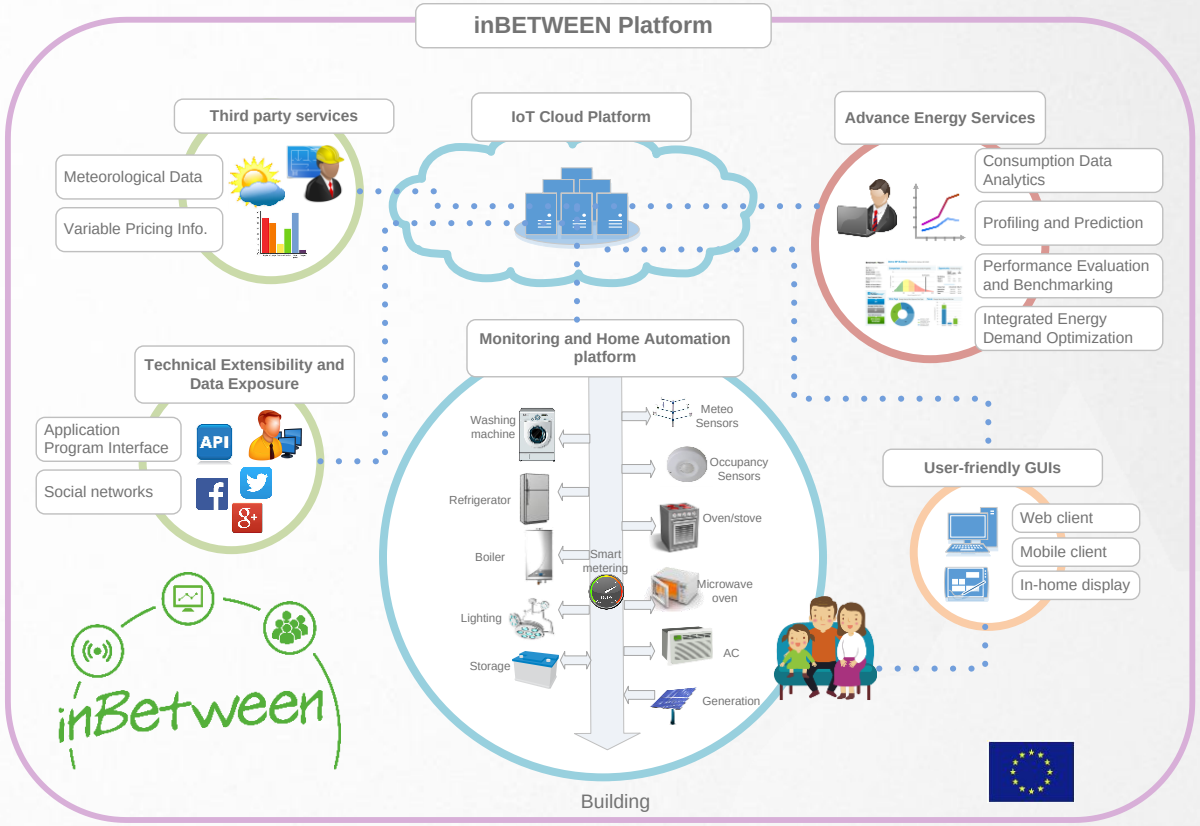


H2020 InBETWEEN

http://www.inbetween-project.eu/

ICT enabled **BE**havioral change **To**W**a**rds **E**nergy **E**fficie**N**t lifestyles

- Engages Users to **IDENTIFY** energy wastes, learn **HOW** to conserve energy, **MOTIVATE** them to act and help them to actually **CARRY OUT** energy efficient practices by…
- …delivering **affordable** cloud-based ICT solution that brings **added value** with **no disruption** of everyday activities and comfort.

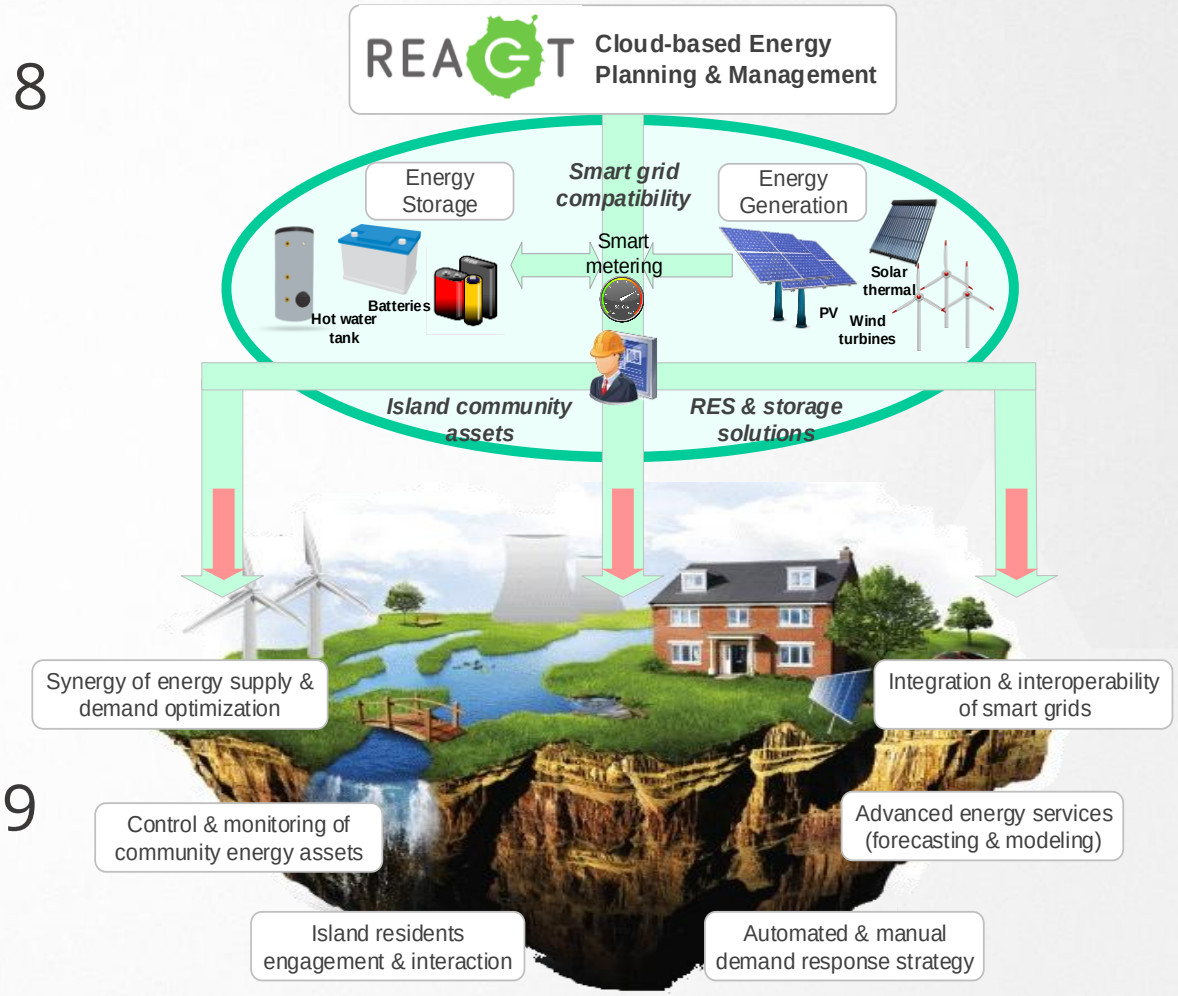


H2020 LAMBDA - Learning, Applying, Multiplying Big Data Analytics

- **Strategic Partnership** (with **FHG, UBO and UOXF**) - establishment and development of productive and fruitful long-term cooperation that continues after project completion
  - Strategy and Action Plan for 2021-2025
- **Boosting scientific excellence** of the linked institutions and capacity building of the widening country and the region in Big Data Analytics and semantics
  - Train the Trainer sessions, mentoring activities
  - Big Data Analytics Summer School 2019, 2020
- **Spreading excellence and disseminating knowledge** throughout the West Balkan and South-East European countries
  - 5 WS at International conferences, 2 Research-Industry Forums
- **Sustainability of research related to key societal challenges** (sustainable transport, sustainable energy, security, societal wellbeing) **and financial autonomy in the long run**

REACT - Renewable Energy for self-sustAinable island CommuniTies

- **Work programme topic:** LC-SC3-ES-4-2018 (Decarbonising energy systems of geographical Islands)
- **Type of action:** IA Innovation action
- **Consortium:** 23 partners from 11 countries (industry, research, SME…)
- **Total budget:** EUR 10.764.405,00 (EC contribution EUR 8.974.327,88)
- **Project lifetime:** 4 years (from 01/01/2019 until 31/12/2022)



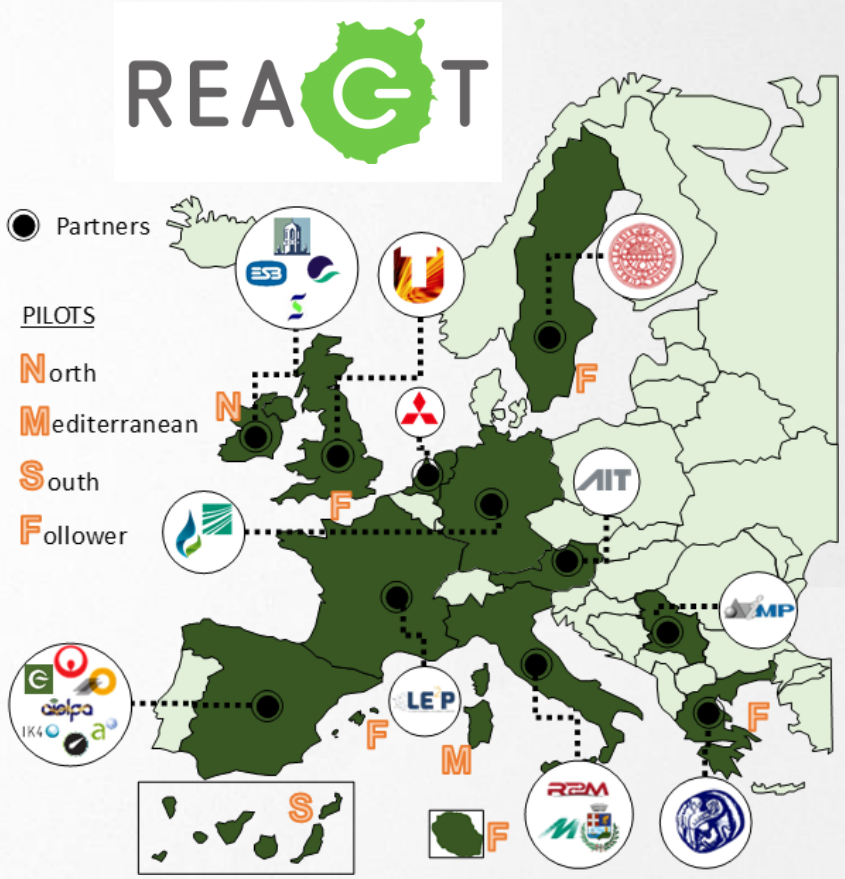
Project objectives

- **Integrating existing and emerging technologies to create the REACT cloud-based solution enabling an integrated and digitalised smart grid**
  - Potential to support 100% energy autonomy of geographical islands.
- **Piloting the REACT solution on 3 islands in 3 market contexts in 3 different climates**
  - Potential to reduce GHG emission and energy costs both by > 60%, achieve at least 10% of energy savings.
- **Develop partner-backed viable plans for the large-scale replication of the implementations of the REACT solution on 5 follower islands**
  - Measure the socio-economic benefits of enhancing islands' energy autonomy to the extent that existing fossil fuel generators shall be used only as security back-up in the long term.

REACT - Renewable Energy for self-sustAinable island CommuniTies

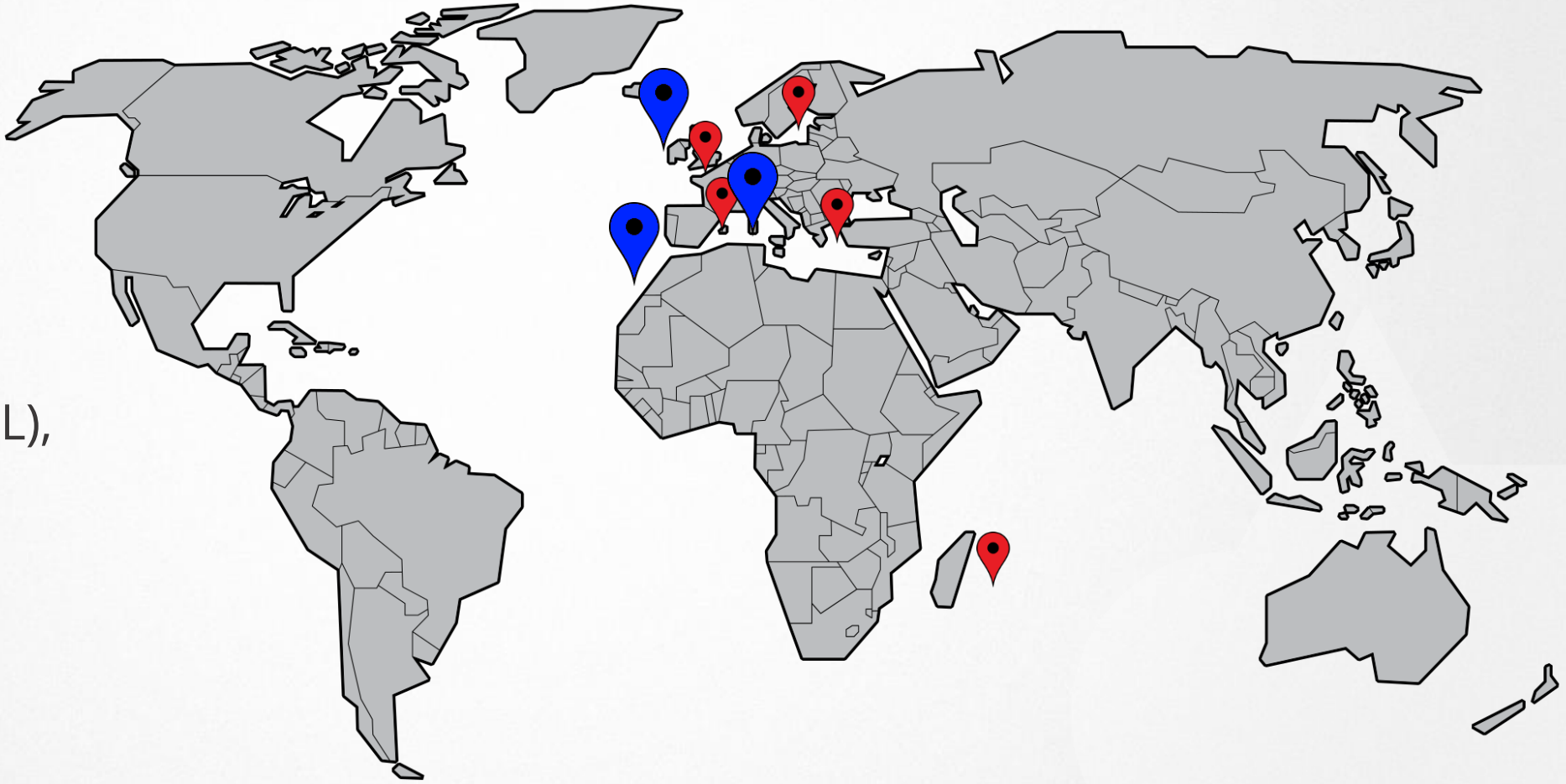
REACT Consortium

- 23 partners from 11 countries



Pilot sites

- **Demo islands**
  La Graciosa (ES),
  San Pietro (IT),
  Aran Islands (IE)
- **Follower islands**
  Gotland Island (SE),
  Lesbos Prefecture (EL),
  Isle of Wight (UK),
  Majorca Island (ES),
  Reunion Island (FR)



ENERGY PRODUCTION & DEMAND FORECASTING

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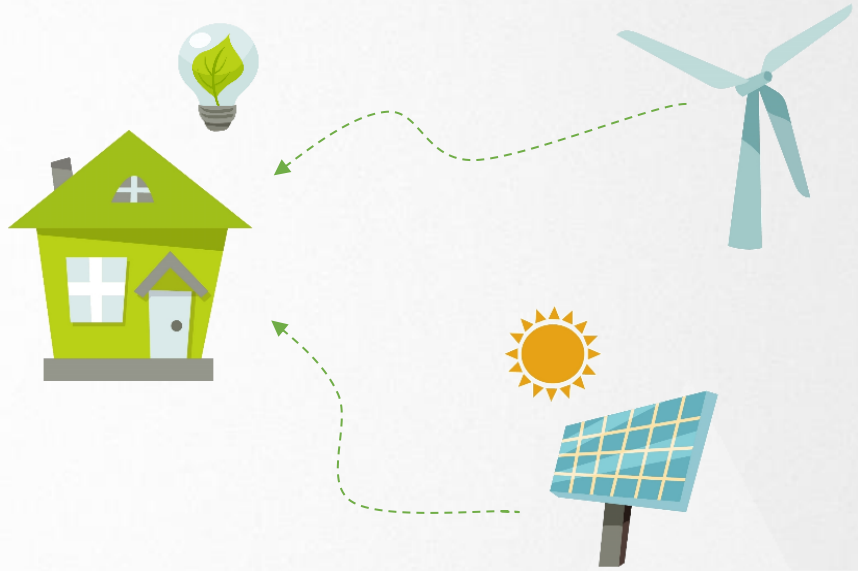
- **Motivation:**
  - Ecological interest
  - Stability of the grid
  - Planning and optimization
  - Economic benefits

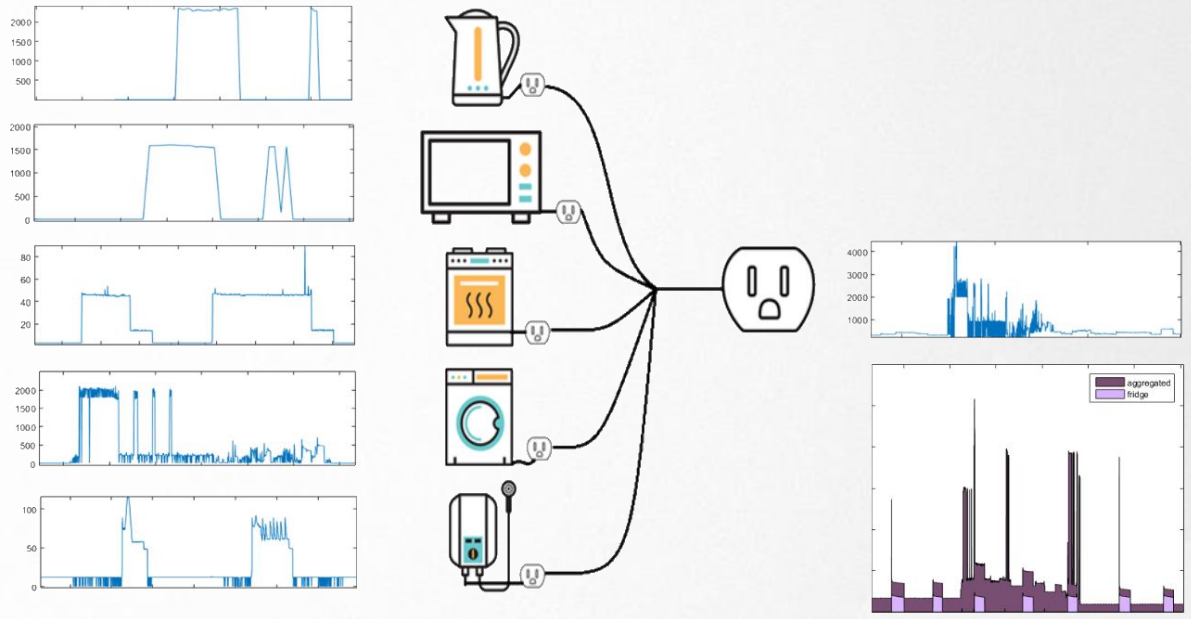


- **Production forecaster** – estimation of the the renewable sources' energy production depending on the forecasted weather conditions (temperature, wind speed, irradiation, cloud coverage etc.)
- **Demand forecasters** - providing information about the energy consumption in consistence with previous consumptions, temperature, occupancy etc.
- **Current SoA** for the **data-driven** forecasters are several machine learning approaches such as support vector regression, **random forest**, linear regression, **neural networks** etc.

* Illustrations by macrovector / Freepik

NON-INTRUSIVE LOAD MONITORING (NILM)

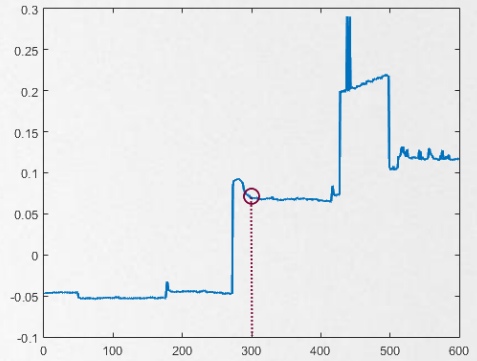
- Residential and commercial buildings consume **approx. 60% of the world's electricity**[1]
- Feedback to costumers on how they spend energy can influence them to **reduce up to 12%** of their energy consumption[2]
- **ILM** – expensive, impractical, non-appealing to customers
- Estimation of appliance activation/consumption using **aggregated power measurements**
- **NILM** systems can be used for analysis of the costumers energy demand's habits, regardless on their age, country, profession etc.



[1] The United Nations Environment Programmes Sustainable Building and Climate Initiative (UNEP-SBCI)

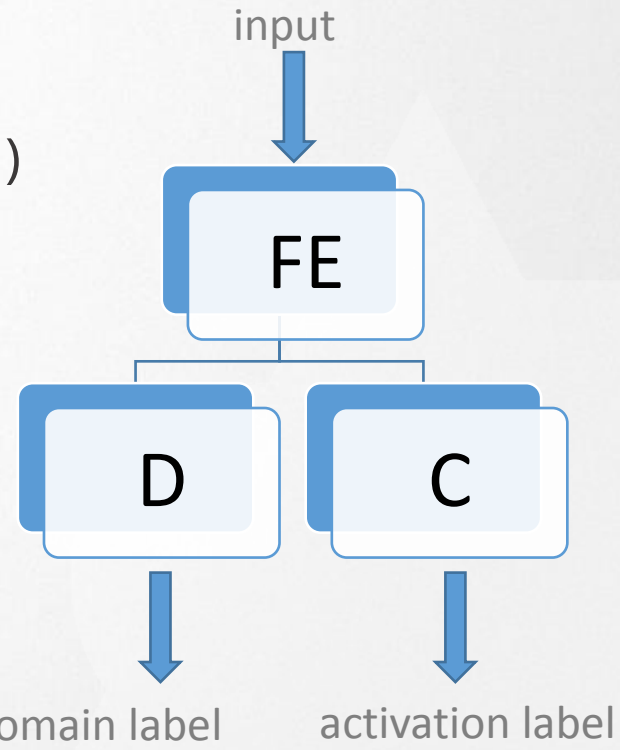
[2] K. C. Armel, A. Gupta, G. Shrimali, and A. Albert, "Is disaggregation the holy grail of energy efficiency? The case of electricity," Energy Policy, vol. 52, no. 0, pp. 213 – 234, 2013.

NILM & DATA SCIENCE



- **Huge amount of data used and processed:**
  - Conclusion are driven out according to the available data
  - Predictions are made in consistence with the previous system behavior

- **Possible approaches:**
  - Hidden Markov Models and its modifications (FHMM & Semi HMM)
  - Neural Networks
    - **Convolutional Neural Networks** (sequence 2 point)
    - LSTM (long short-term memory)
    - Auto-encoders
  - **Generative adversarial networks** (GAN)



ENERGY EFFICIENCY BENCHMARKING

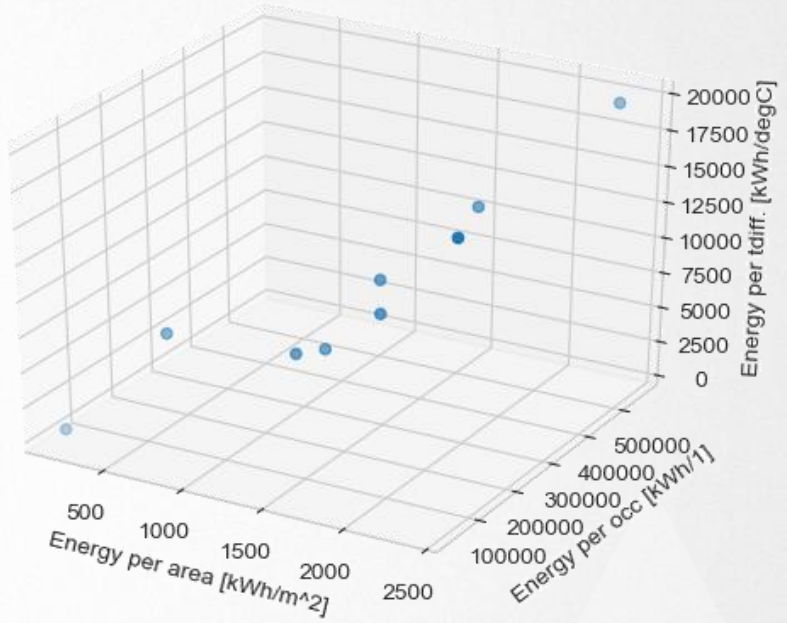
General idea (user benchmarking)

- To spark a **“competition“ between users** in order to drive them to reduce consumption and increase energy use efficiency
- **IoT-driven concept**: smart home network created by interconnecting smart sensors, gateways and cloud-based analytics
- Various measurements provide **key intel about user habits** and facilitate the derivation of benchmarking parameters

* Illustrations by Develco, macrovector & iconicbestiary / Freepik

ENERGY EFFICIENCY BENCHMARKING

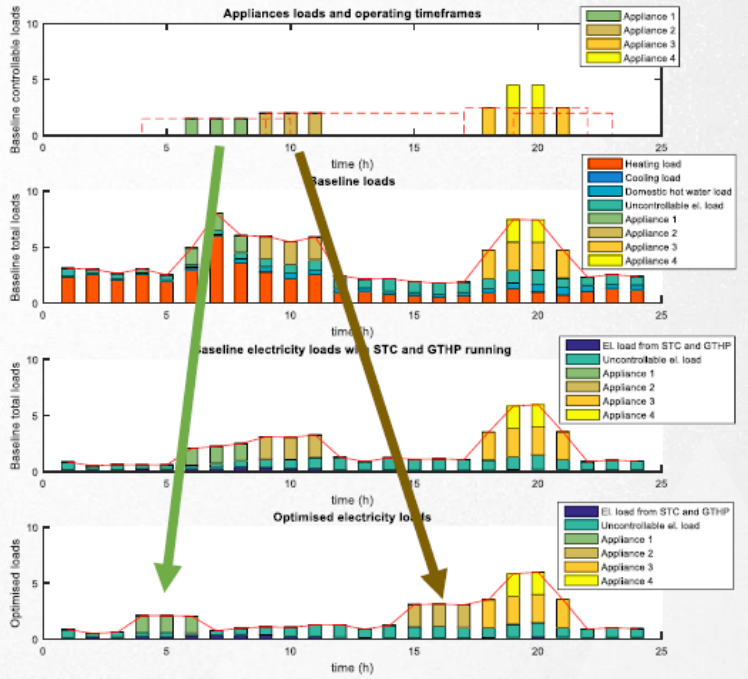
- **Static parameters** taken into account:
  - Gross/Net/Heated area of apartment
  - Window/Wall area exposed to external conditions
  - Thermal conductivity and insulation type
- **Dynamic parameters** taken into account:
  - Average occupancy
  - Average absolute difference between indoor and outdoor temperature
  - Heating/Cooling degree days
- **Data envelopment analysis** (DEA) allows for benchmarking of data sets and relatively dictates the relevance of each parameter in the final ranking

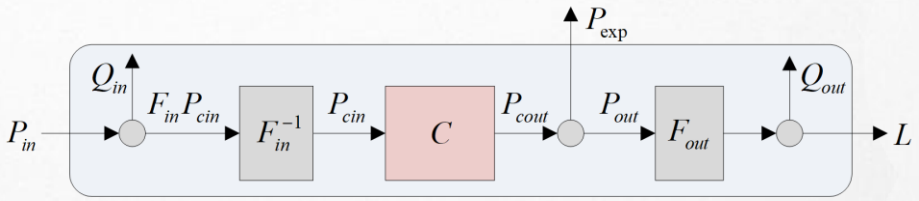


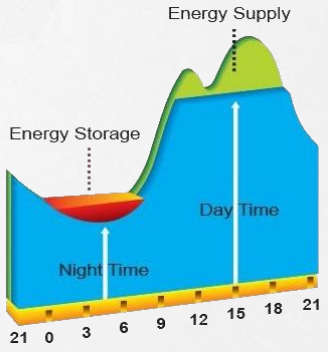
- Close to frontier => low relative efficiency => bad score
- Away from frontier => high relative efficiency => good score
- (In)efficiency ranking is proportional to the distance from the frontier (convex hull of the data)

ENERGY DISPATCHING OPTIMIZATION

- **Optimal energy dispatching**
  - Energy supply mix selection (local/renewable production, grid, etc.)
  - BTM energy routing (from grid to energy storage or local consumption)
  - If the load is flexible, how to organize appliance activations (**appliance scheduling**)
  - Underpinned by **Energy Hub concept (multi-objective optimization)**
- **Potential outcomes**
  - Lowering monetary costs for users (monthly bills)
  - Increasing energy efficiency and positive ecological effects
  - Maintaining grid stability

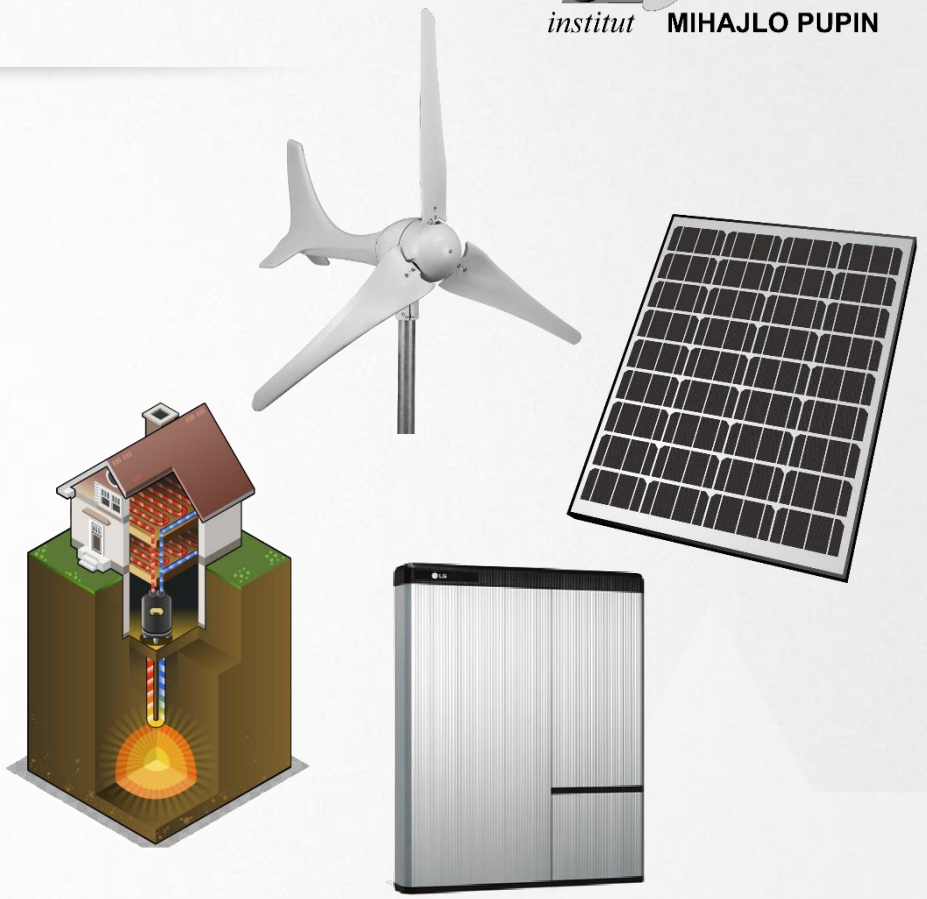


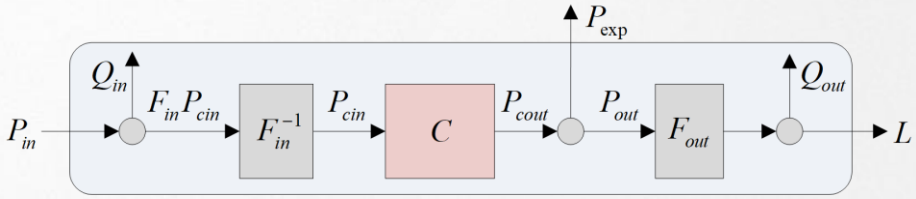




OPTIMAL DESIGN & SIZING

- **Optimal sizing problem (planning)**
  - **First assumption:** the operation aspect (energy dispatching) can be optimized in order to compare the efficiency of different configurations
  - **Determining feasible configurations** (capacities of renewable sources, storage units, etc.)
  - Running multiple **operation optimization** for a set of predefined **Energy Hubs**
  - **Multi-criteria decision making (MCDMA)** to select the optimal configuration
- **Potential outcomes**
  - Optimizing for long-term investment and payoff for users
  - Increasing the energy performance





THANK YOU FOR YOUR ATTENTION!

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