

Design, development & evaluation of Positive Energy Districts (PED)

Dr. Francesco Reda, Principal Scientist VTT
SPARCS coordinator





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Content

- Design
 - What is a PED? And how many PEDs exists?
 - National and local conditions
- Development of PED
- Evaluation / KPIs

Design of a PED





What is a PED? And how many PEDs exists?

- Consist of **several buildings** that actively manage their energy consumption as well as the **energy flow** between them and the wider energy system
- **Annual positive energy balance**
- They make optimal use of advanced materials, local RES, storage, smart energy grids, & cutting edge energy management
- **Users interaction**/involvement and ICT

https://setis.ec.europa.eu/system/files/setplan_smartcities_implementationplan.pdf

<https://jpi-urbaneurope.eu/ped/>



What is a PED? And how many PEDs exists?

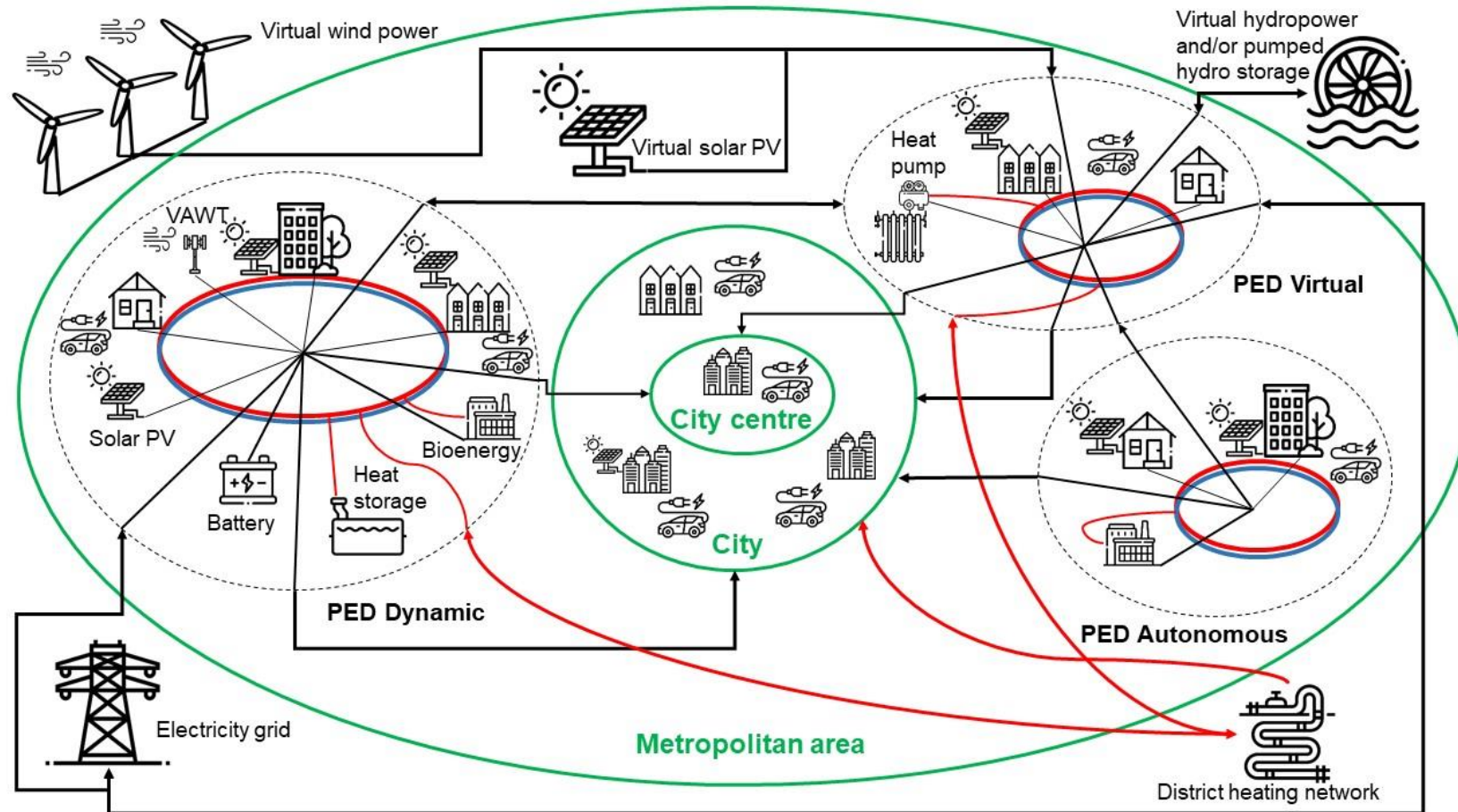
- 3 most important **functions of PEDs in the context of their energy system:**
 - **Rely on renewable energy only**
 - **Energy efficiency**
 - **Energy flexibility**
- **Imperative is to optimize the different functions against one another** to best represent the available renewable energy resources in their respective climate zone
- Considering also **country/local government** specific ambitions and needs.

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What is a PED? And how many PEDs exists?





What is a PED? And how many PEDs exists?

- **PED autonomous**
 - Total self-sufficiency
 - More energy storage capacity to cover for demand peaks
 - Problematic for climate zones with high seasonal variation in intermittent energy generation
- **PED dynamic**
 - More flexibility regarding system control
 - Do not require as much energy storage capacity as PED autonomous
 - Dependent on external electricity generation
- **PED virtual**
 - Possible to look for “regional or national” RES alternatives
 - Advanced Energy distribution solutions needed

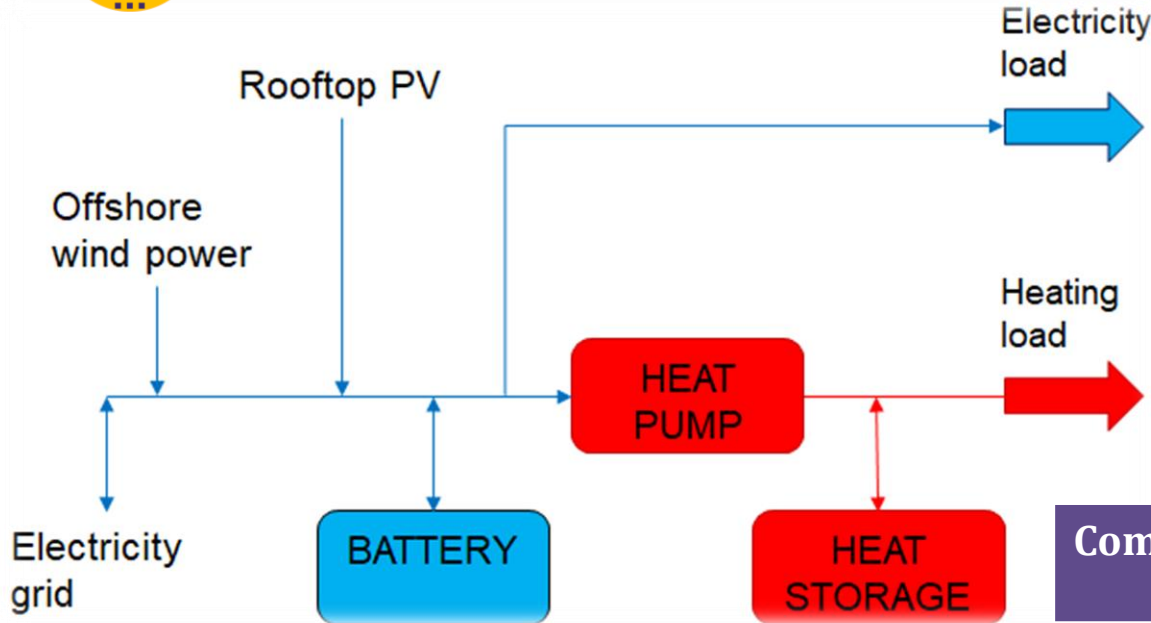
National and local conditions

| Zones and areas in EU | Climatic condition | Population density (people/sq. km) | GDP per capita (\$) | Electricity price (€/kWh) | Electricity consumption per capita |
|------------------------------|-------------------------------------|--|--|---|---|
| Northern European | Cold winters and mild humid summers | Low density (less than 22 people /sq. Km) https://www.indexmundi.com/map/?t=0&v=21000&r=eu&l=en | Greater than \$45000/capita https://brilliantmaps.com/european-gdp-per-capita-1990-2016/ | Average 0.16 €/kWh https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_price_statistics | Average 4 MWh/capita https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Households_consumption_of_electricity_per_capita_2017_(MWh_per_capita).png |
| Central and Eastern European | Cold winters and hot, dry summers | Medium density (less than 106 people /sq. Km) | Lower than \$20000/capita | Average 0.10 €/kWh | Average 0.8 MWh/capita |
| Western European | Mild winters and humid summer | Highly dense (around 250 people /sq. Km) | Between \$40000/capita-\$44000/capita | Average 0.3 €/kWh | 2 MWh/capita |
| Southern European | Mediterranean condition | High density (around 206 people /sq. Km) | Between or lower than \$32000/capita | Average 0.24 €/kWh | 1.2 MWh/capita |

National and local conditions

| Zones and areas in EU | Energy demand | Building efficiency level & policies | Renewable energy policies | Resources available |
|------------------------------|---|--|---|--|
| Northern European | High heating and low cooling demand <small>(https://ec.europa.eu/energy/sites/ener/files/documents/mapping-hc-final_report-wp3-wp4.pdf)</small> | Tight insulation level and passive building regulation (Walls U-values 0.17) <small>(https://www.iea.org/beep/finland/)</small> | Above 50% of share of energy generated from renewable sources in gross final energy consumption <small>(https://www.iea.org/policiesandmeasures/renewableenergy/)</small> | Hydro, Biomass, Wind <small>(https://www.nordicenergy.org/wp-content/uploads/2012/02/Ten-Opportunities-and-Challenges-for-Nordic-Energy-Short.pdf) (http://resourceirena.irena.org/gateway/countrySearch/?countryCode=SWE)</small> |
| Central and Eastern European | Moderate heating and cooling demand | Less strict regulation (Walls U-value= 0.4-0.9W/m ² .K) <small>(https://www.iea.org/beep/poland/codes/technical-regulations-energy-savings-and-thermal-insulation-2002.html)</small> | Around 20-17% of RES share | Wind, Bioenergy, Solar |
| Western European | High heating and Moderate cooling demand | Strict regulations (Walls U-value = 0.36W/m ² .K) <small>(https://www.iea.org/beep/france/codes/reglementation-thermique-rt-2012.html)</small> | Around 20-25% of RES share | Wind, Solar, Hydro <small>(https://globalwindatlas.info/)</small> |
| Southern European | Low heating and high cooling demand | Less strict regulation (Walls U-value= 0.5W/m ² .K) <small>(https://www.iea.org/beep/portugal/)</small> | Around 20-17% of RES share | Solar, Wind, Hydro <small>(https://irena.masdar.ac.ae/GIS/?map=529)</small> |

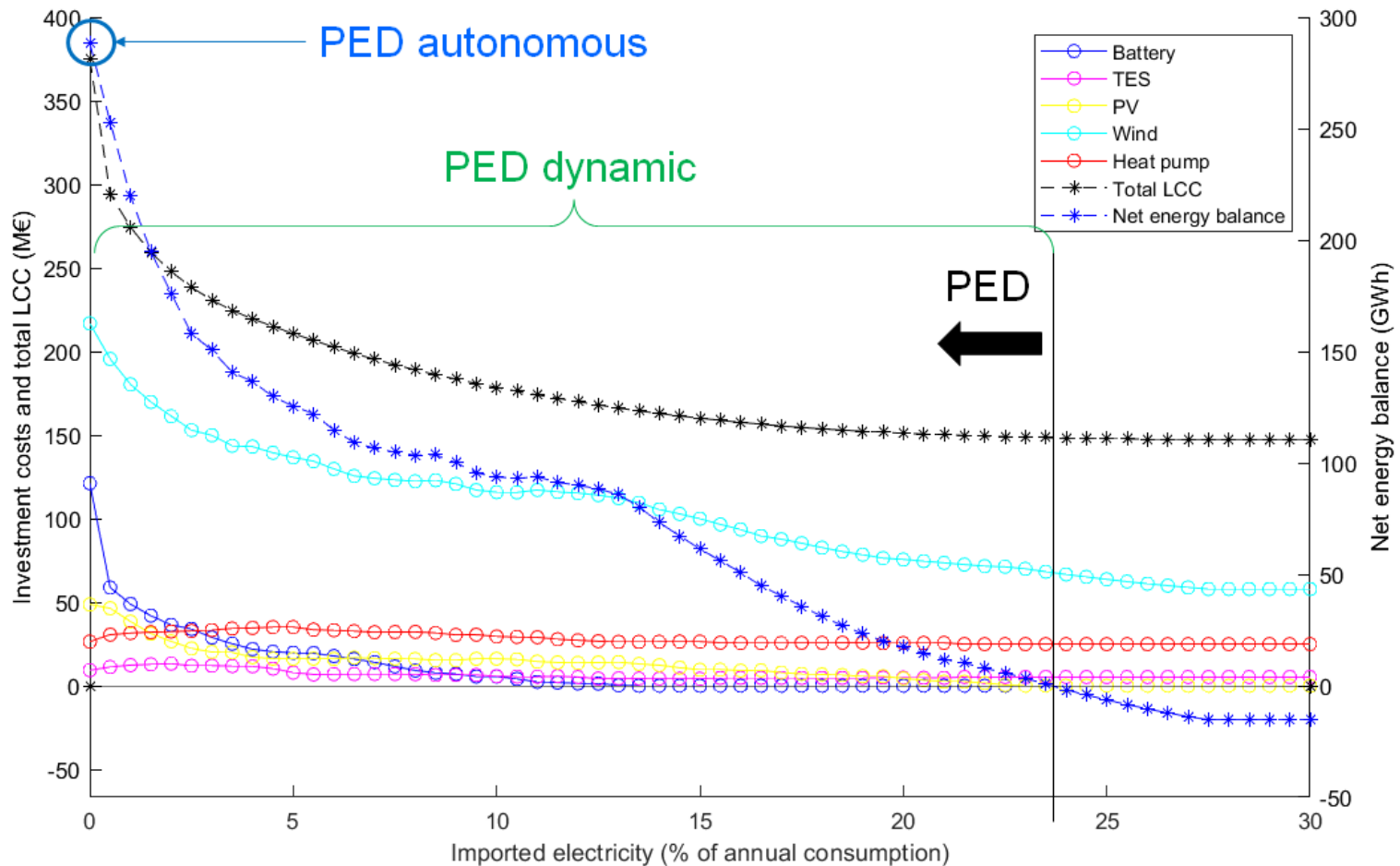
Case study, Kalasatama PED



- Life cycle cost analysis of autonomous and dynamic PEDs
- Investigating the effect of different electricity import rates

| Component | Installation cost | O&M cost (% of installation cost) |
|--------------|-------------------|-----------------------------------|
| Wind power | 3000 €/kW | 1.5% |
| Rooftop PV | 800 €/kW | 2% |
| Battery | 600 €/kWh | 1.5% |
| Heat storage | 5 €/kWh | 1.5% |
| Heat pump | 1000 €/kW | 1% |

Case study, Kalasatama PED





Takeovers

- **The PED concept may vary depending on the location, local regulations, polices, economics, and resources available, that needs to be identified.**
- **Holistic approach is needed to define PED for different regions and also to compare and analyse different PEDs.**

Development...

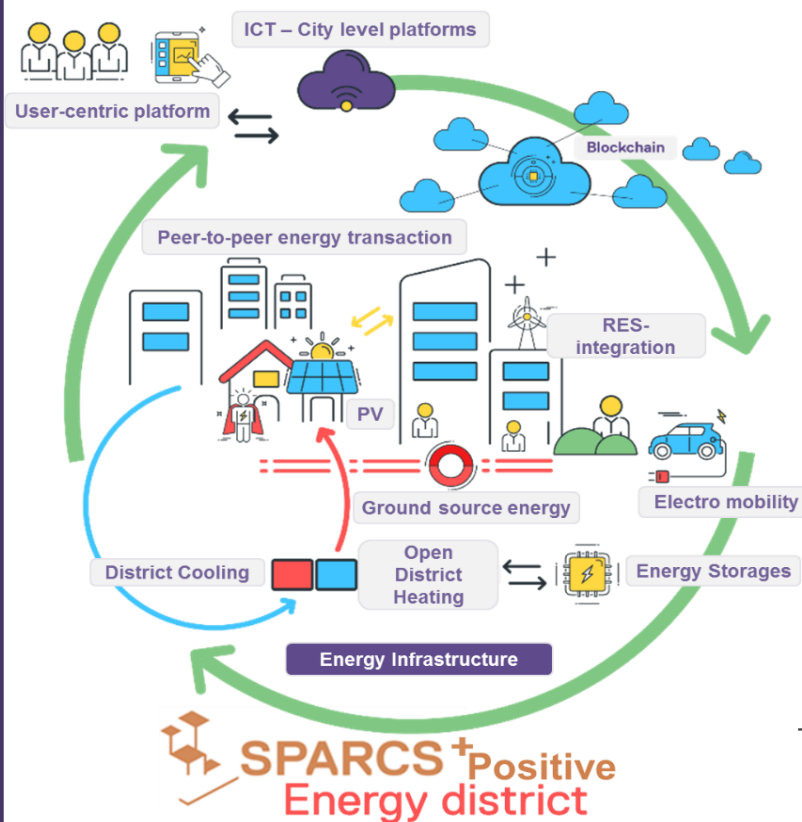


Development...

Services and technical solutions identified
Support the creation of local innovation ecosystem
hackathons and start-up competitions

Inclusive Governance and planning instruments for PED area
City Planning support

Co-creation of citizen- and investment- friendly urban sustainable & carbon free PED solutions
Integrated ICT, technical, financial, regulation & financial-friendly solutions ~ blended package





PED evaluation & KPIs

- **Annual positive energy balance**
 - On-site Energy Ratio comparing the annual balance between local renewable energy supply and energy demand at annual level
- **Mismatch indicators to indicate the short term balance**
 - E.g. Annual Mismatch Ratio, Maximum Hourly Deficit, Monthly Ratio of Peak values...
- Some **economic and social** KPIs under development
 - Holistic evaluation important
- Due to variety of PED definitions, **lack of harmonization** in KPIs
- **Workshop in October 2021 to define common PED KPIs** for the smart city lighthouse projects



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