# Rural Intelligent GRID

# RIGRID - from Vision to Realization


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**Fraunhofer IFF**


**ERA-NET SMART GRIDS PLUS | FROM LOCAL TRIALS TOWARDS A EUROPEAN KNOWLEDGE COMMUNITY**


This project has received funding in the framework of the joint programming initiative ERA-Net Smart Grids Plus, with support from the European Union's Horizon 2020 research and innovation programme.

# Rural Intelligent Grid – Motivation

- <u>The dominant role of Renewable Energy Sources (RES)</u>

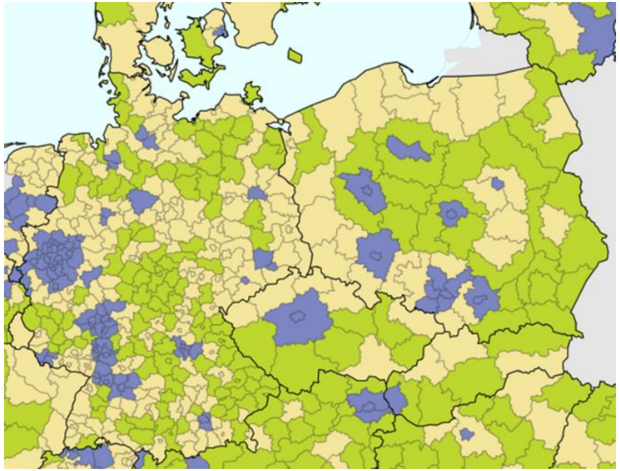
  Aim of European Union: up to 80 % of the total electric demand by RES by 2050

- <u>Opposition from the local population regarding installing new power plants</u>

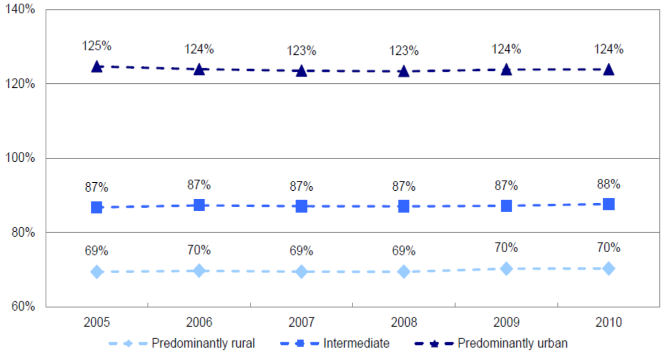
  Non-engagement in the planning and decision-making processes

- <u>Most of the European areas are rural</u>

  The development of smart grid rural areas represents a good test field to realize and test new energy projects

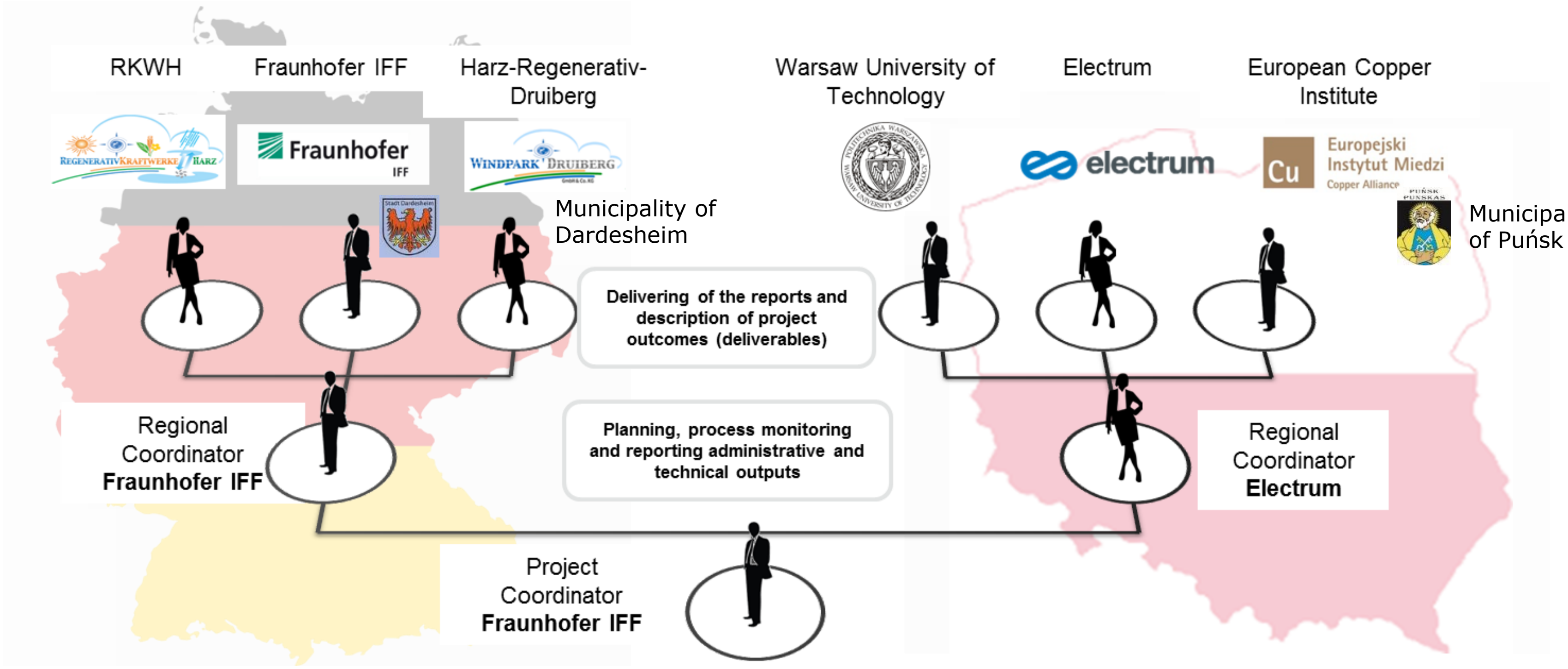


Predominantly urban regions (rural population: <20 % of the total population)
Intermediate regions (rural population: 20–50 % of the total population)
Predominantly rural regions(rural population: >50 % of the total population)
Data not available




GDP per capita in different types of region in relation to the EU average, 2005-2010

# Project Consortium

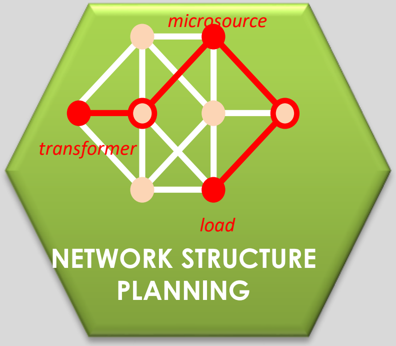


# Three Layers of ERA-Net Smart Grid Plus

## Technical layer

**Local generation from RES**

- to improve reliability and security of supply
- to reduce $CO_2$ emission




## Social layer

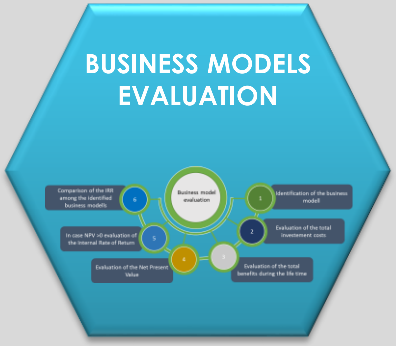
**Active participation of inhabitants**

- acceptance of new investments
- new jobs, contract for local companies
- attract new residents


## Economic layer

**Involvement of the inhabitants into the clean energy idea**

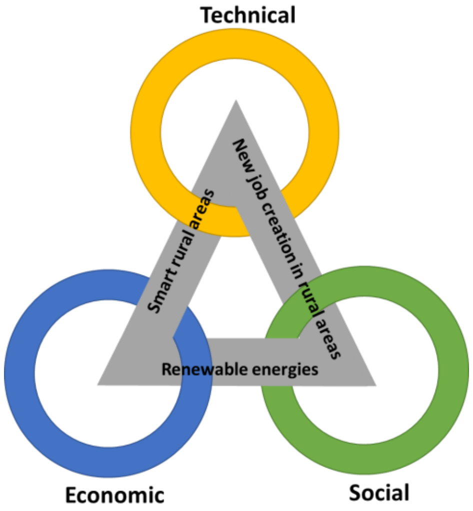
- income from the energy sale
- new career opportunities
- increased visibility of the region
- „energy" tourism development



# Rural Intelligent Grid – aims and innovation

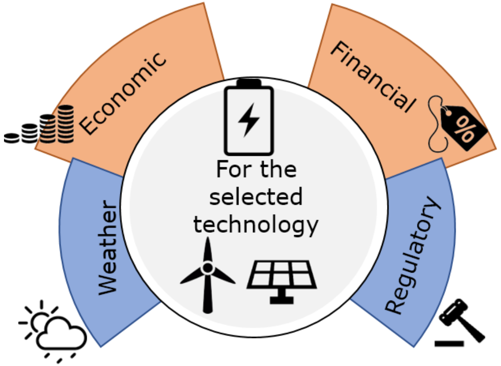
Areas of implementation

## Aims



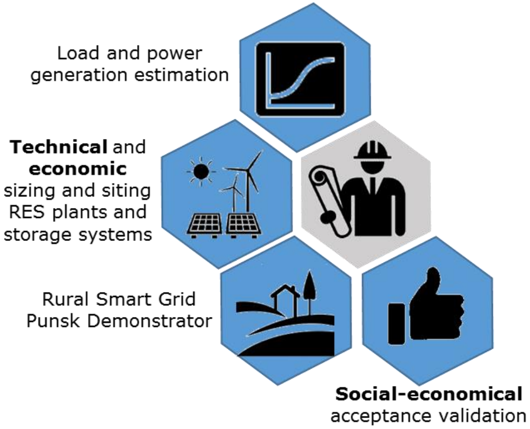

- Design tool for the planning and operation of smart grids in rural infrastructures
- Multiple-criteria approach that considers technical, economic and social aspects

## Methodology




- **Technical**: realization of smart rural area based on the use of RES
- **Social**: acceptance analysis for installation new infrastructures
- **Economic**: developing new business models and attractiveness analysis

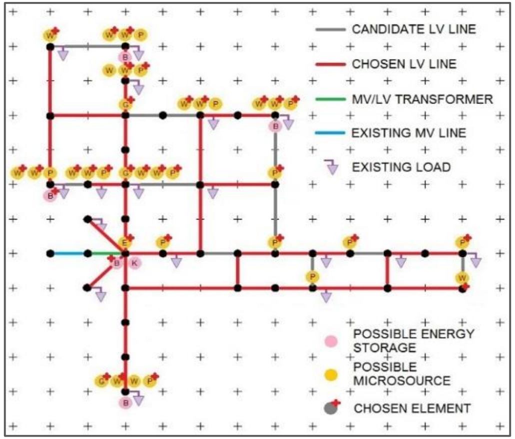
## Results

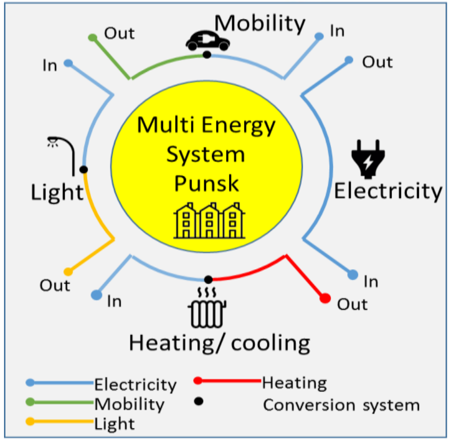


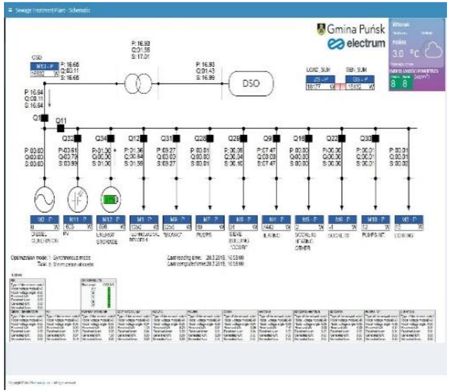

- Software tool based on VRS Platform® and on Microsoft Office®
- 3D visualization of scenarios
- Business model analysis

# **Technical layer** – selected results

- Concepts, models and algorithms for optimal planning and operation of microgrids in rural areas
  - Software for planning optimal structures of LV microgrid
  - Softwar for optimal microgrid operation
  - Multi-energy model of Punsk
- Demontrator in Punsk
  - wastewater treatment plant (30 kW), PV (40 kWp), diesel generator (25 kW), battery storage (18 kW/ 25 kWh), controllable load, metering, control, protection and communication
- EMACS for monitoting and controling microgrid
- Laboratory stand for protection system testing

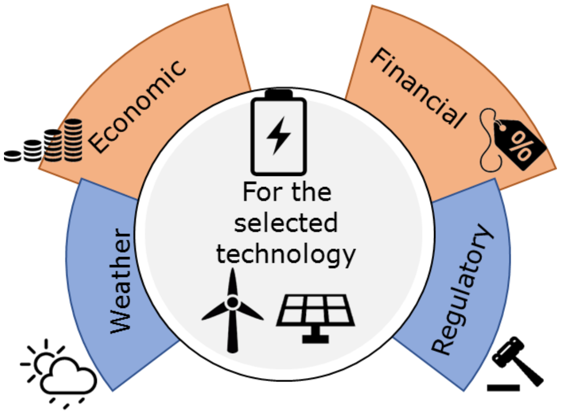


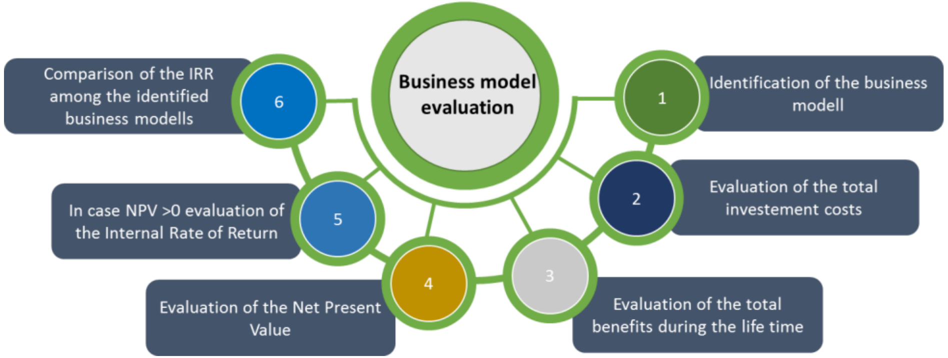



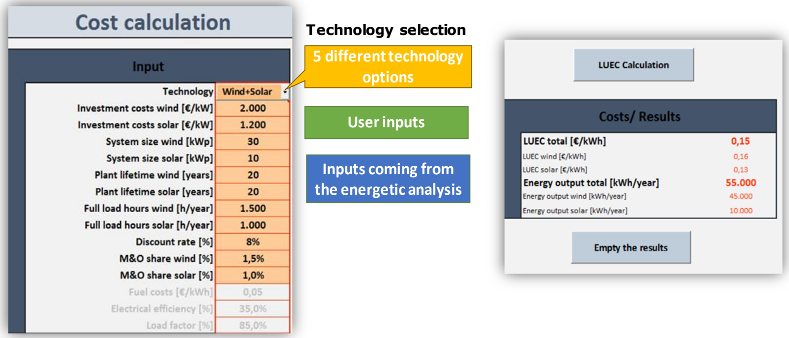



# **Economic layer** – selected results

- Investment and operation cost calculation tool for electrical infrastructure planning and operation
  - Economic sizing of power plants and energy storage systems
  - Under condition: economic, finacial, regulatory, weather
  - Total Investment
  - Electricity Generation Costs
  - Business Model
  - Environmental impact/ Avoided CO2 emissions
  - Potential job creation

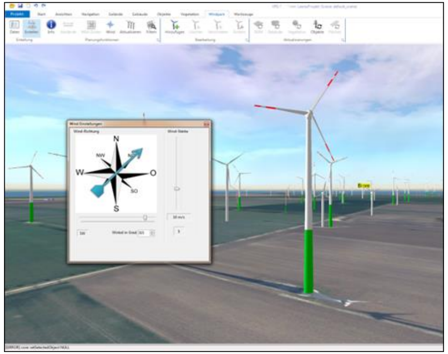


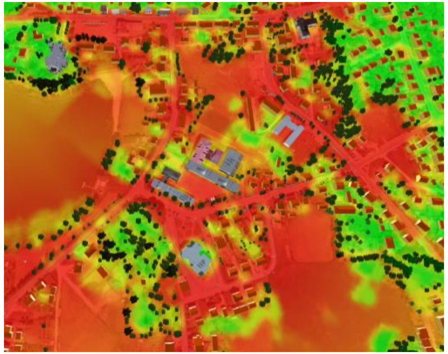



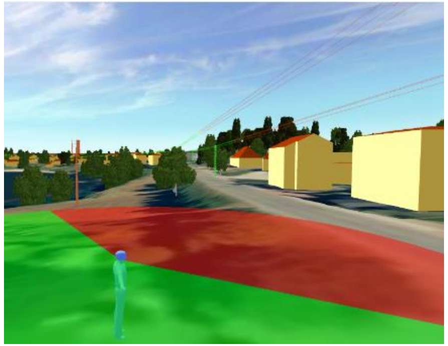



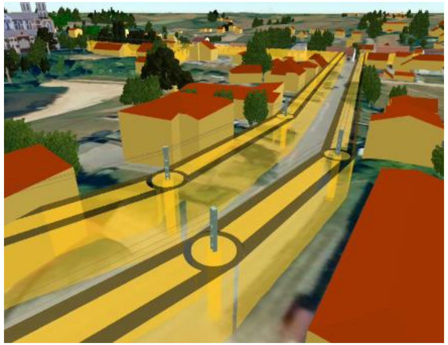
# **Social layer** – selected results

- Virtual Reality tool for spatial planning and acceptance analysis of electrical infrastructure
  - Simulation and communication of planning with decision makers, planners and residents
  - Creation of acceptance among the population
  - Presentation of actual situations and planning alternatives
  - Customized object catalog
  - Interactive functionalities for planning and presentation

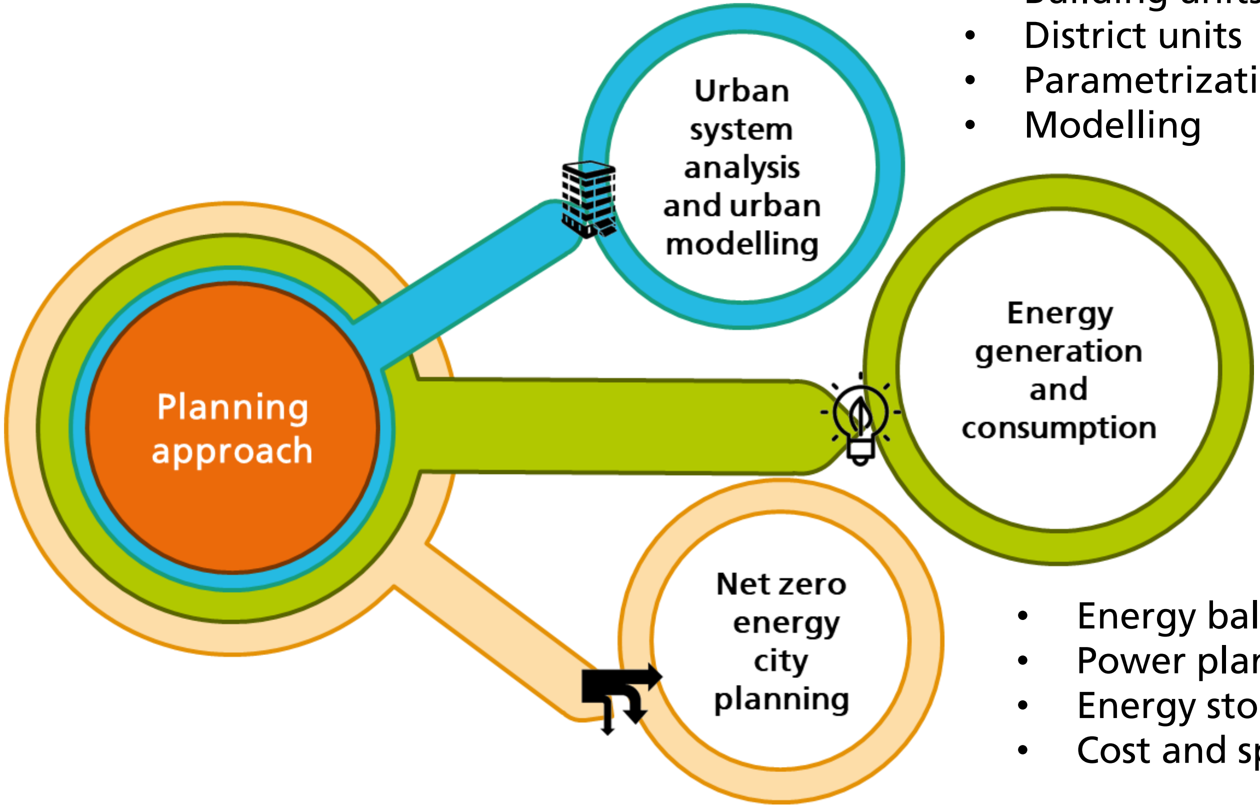








# RIGRID Tool: Planning Net Zero Energy Cities

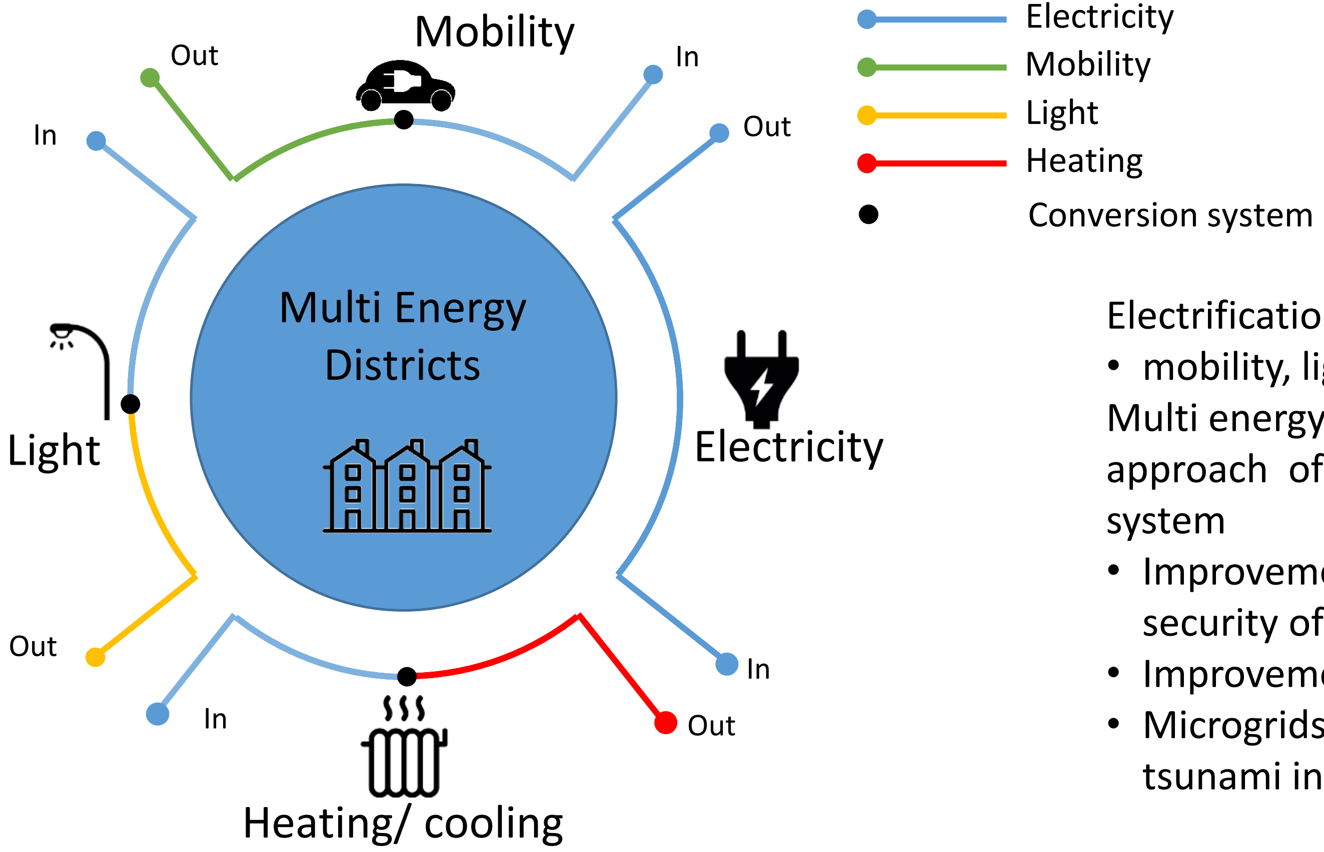



- Building units
- District units
- Parametrization of units (buildings, districts etc)
- Modelling

- Spatial room analysis
- Energy generation potential
- Energy consumption analyis (for electricity, heating and tranport)

- Energy balancing
- Power plant sizing
- Energy storage plant sizing
- Cost and spatial optimization

# RIGRID Tool: Planning Net Zero Energy Cities- Holistic approach



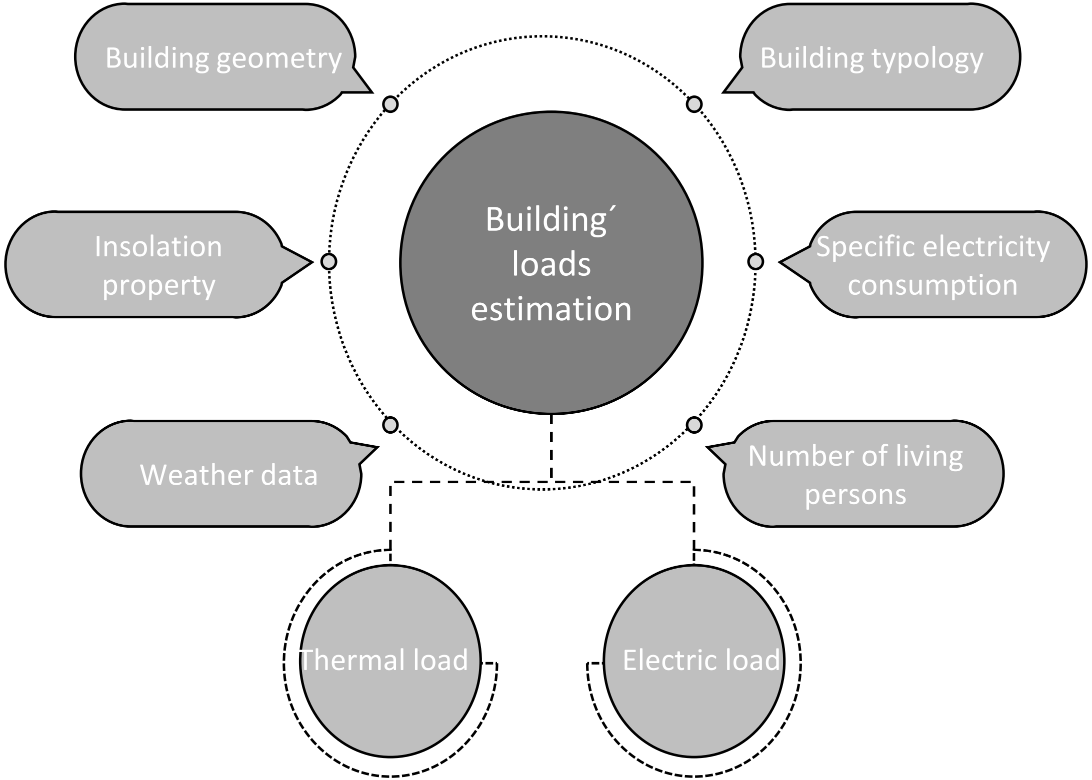

Electrification of all energy uses:

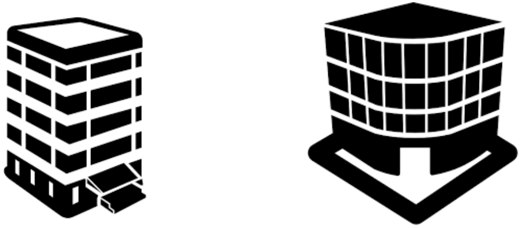
- mobility, light and heating-cooling

Multi energy systems: holistic approach of the whole energy system

- Improvement of relisience and security of the urban energy system
- Improvement of reliability
- Microgrids as solutions (i.e. 2011 tsunami in Japan)

# RIGRID Tool: Planning Net Zero Energy Cities- Modelling tools for energy use in buildings

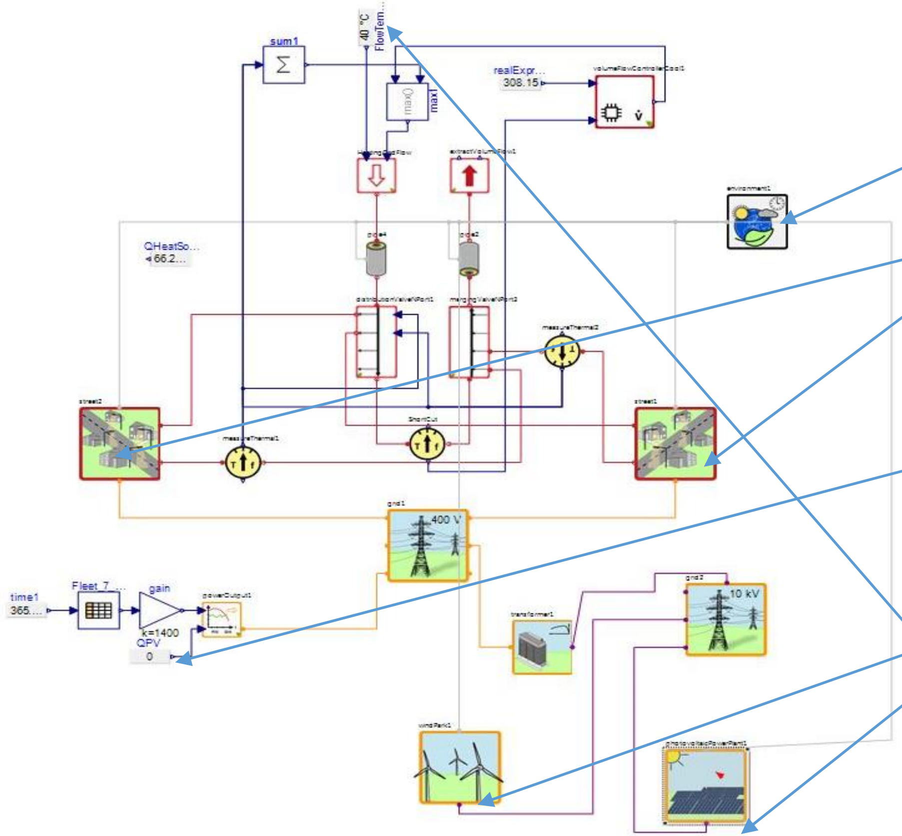


**Insolation property and building geometry: Thermal load**
**Building typology and number of living persons : Electric load**

# RIGRID Tool: Planning Net Zero Energy Cities- Evaluation of consumption and generation potential

Source: GreenCity Library-SimulationX




Weather data

Electric-thermal loads for districts

Load profile for the mobility

Electricity generation by RES

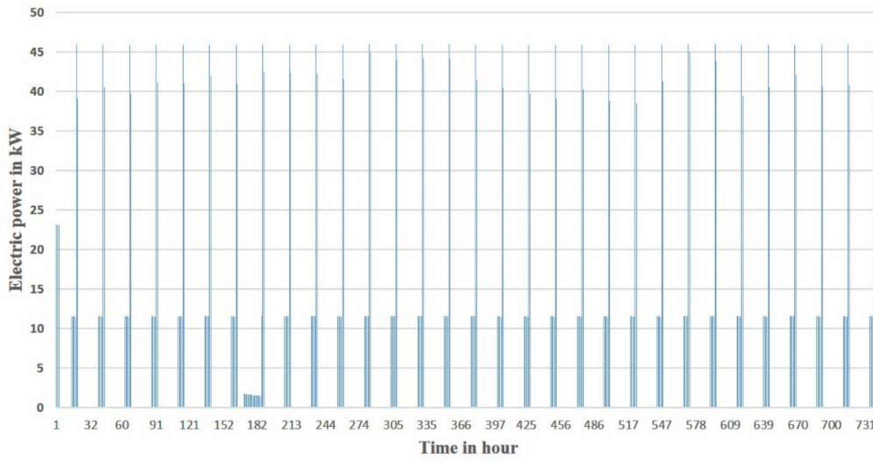
Heat supply

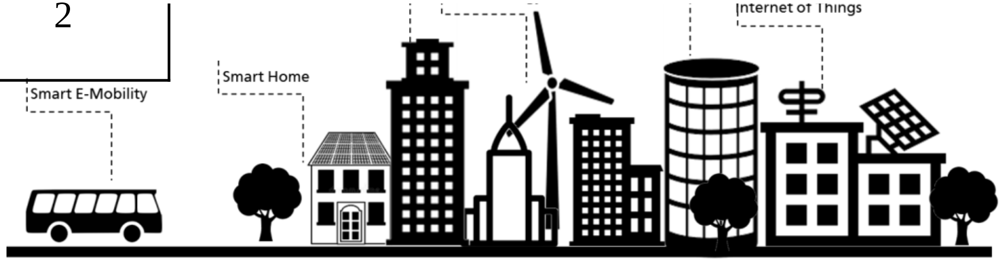
# Study case: Punks 2050- Net Zero Energy System
# Buildings and E-mobility assumptions

## Building typology and charactheristics

| Building Typology | Building age | Nr. of floors | Annual specific elec. consume [kWh/m²] | Nr. of persons living in 100 m² | Amount of buildings |
|---|---|---|---|---|---|
| Educational | 1995-2002 | 3 | 15 | 12 | 2 |
| Residential | 1995-2002 | 2 | 11 | 4.8 | 250 |
| Farm | 1995-2002 | 2 | 10.2 | 1.5 | 9 |
| Office | 1995-2002 | 2 | 36 | 2.5 | 2 |

## Electric power consumption for e-mobility



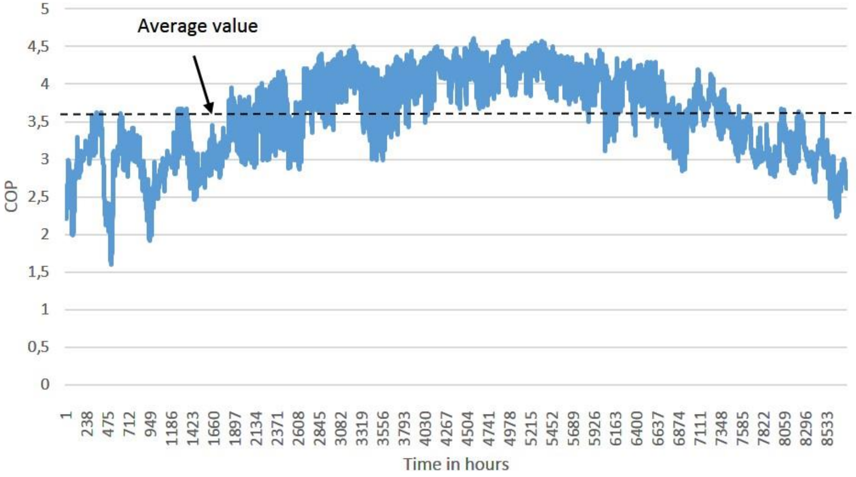



# Study case: Punks 2050- Net Zero Energy System- Heat Pump performance evaluation

RURAL INTELLIGENT RIgrid

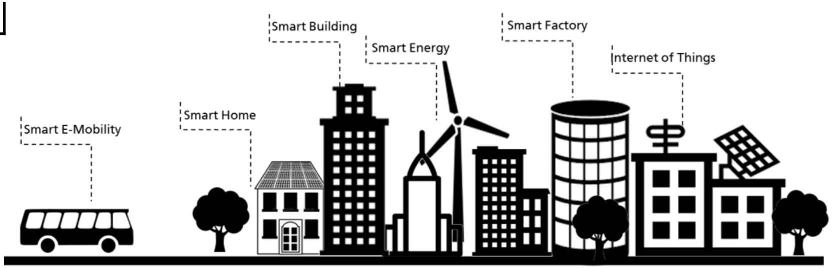
## Air-to-Water Heat Pump

| Heat source temperature (K) | Sink side temperature (K) | | | | |
|---|---|---|---|---|---|
| | 288.15 | 308.15 | 318.15 | 328.15 | 333.15 |
| 253.15 | 3.2 | 1.9 | 1.4 | 1.2 | 1.1 |
| 258.15 | 3.6 | 2.3 | 1.8 | 1.4 | 1.2 |
| 266.15 | 4.0 | 2.9 | 2.5 | 2.1 | 1.9 |
| 275.15 | 4.7 | 3.4 | 2.9 | 2.5 | 2.4 |
| 280.15 | 5.6 | 4.0 | 3.3 | 2.8 | 2.7 |
| 283.15 | 5.5 | 4.1 | 3.5 | 2.9 | 2.7 |
| 288.15 | 6.3 | 4.6 | 3.7 | 3.1 | 2.9 |
| 293.15 | 6.5 | 4.8 | 3.8 | 3.2 | 3.0 |

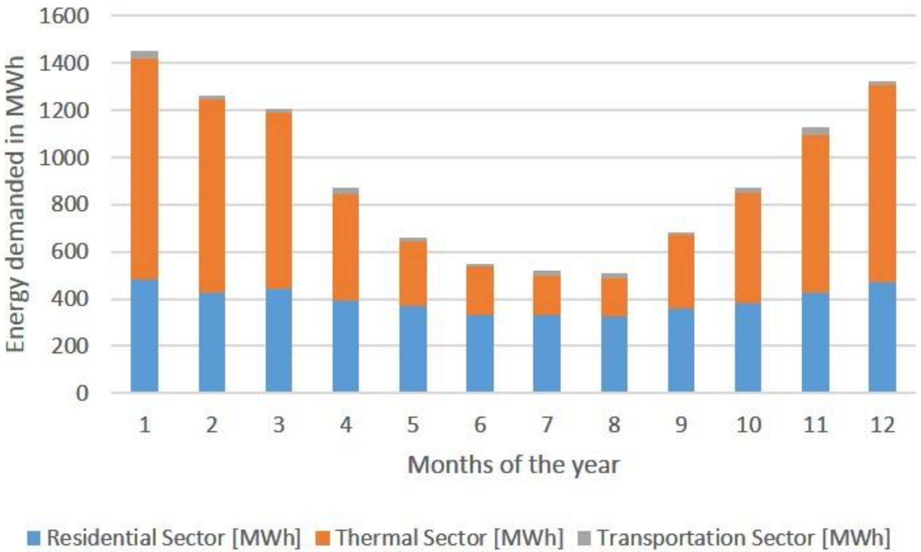



## Air Temperature 2010

| Min (°C) | Max (°C) | Average (°C) |
|---|---|---|
| -20.8 | 29.9 | 7.26 |



# Study case: Punks 2050- Net Zero Energy System- Energy consumption




| | Residential sector | Thermal sector | Transportation sector |
|---|---|---|---|
| Max demanded electric power [kW] | 1221 | 2874 | 460 |
| Yearly demanded electricity [MWh] | 4718 | 6029 | 240 |

# Study case: Punks 2050- Net Zero Energy System- Energy and economi indexes

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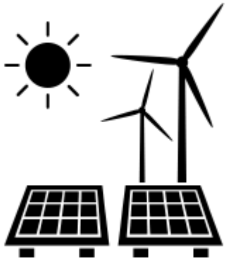
$$SSCI = \frac{\int_{t=t_1}^{t_2} \min\left\{Load(t), RES_{gen}(t)\right\}}{\int_{t=t_1}^{t_2} RES_{gen}(t)}$$

**System Self Consumption Index**

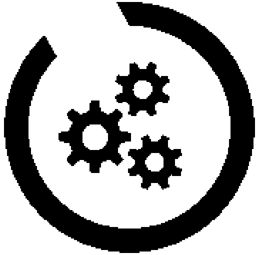


$$NPV = \sum_{t=0}^{N} \frac{CF_t}{(1+i)^t}$$

$$IRR = \sum_{t=0}^{N} \frac{CF_i}{(1+r)^t} = 0$$

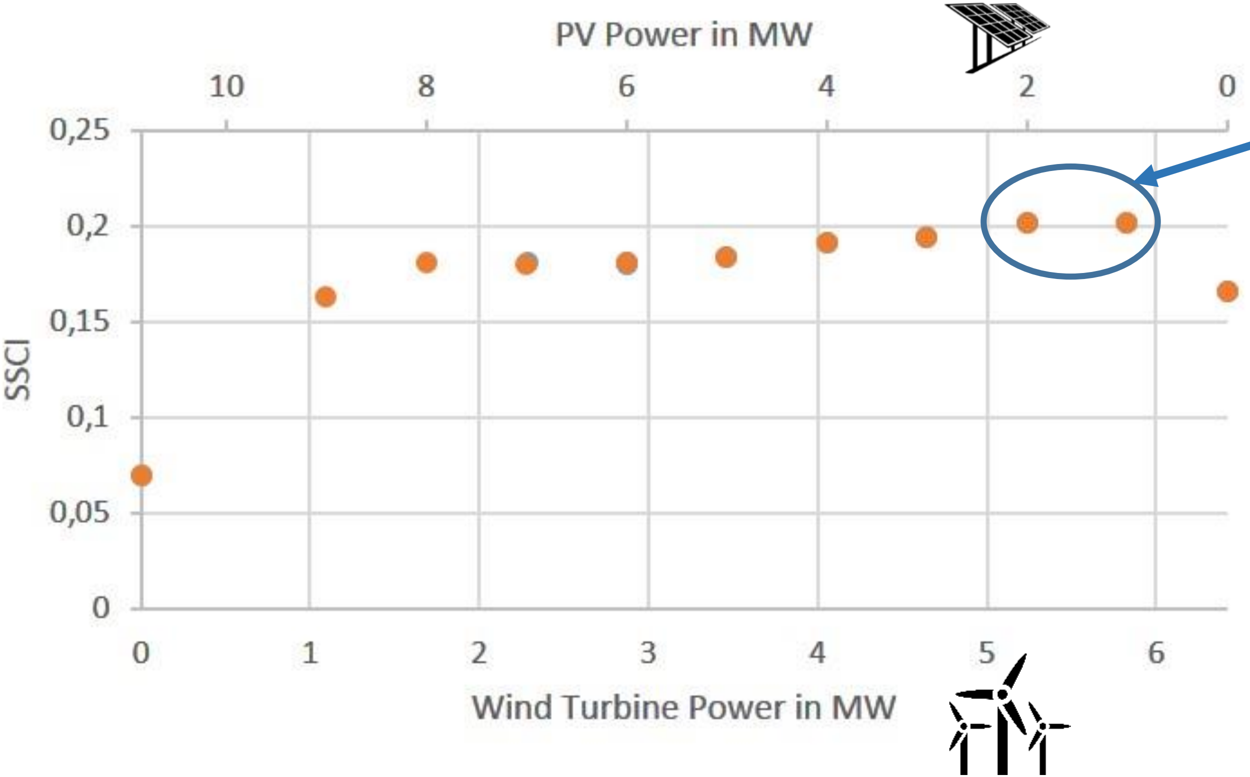
$$SSSI = \frac{\int_{t=t_1}^{t_2} \min\left\{Load(t), RES_{gen}(t)\right\}}{\int_{t=t_1}^{t_2} Load(t)}$$

**System Self Sufficiency Index**



$$LUEC = \frac{\gamma \cdot i}{h \cdot \left[1-(1+i)^{-y}\right]} + \frac{M\,\&\,O}{E_{el}}$$

# Study case: Punks 2050- Net Zero Energy System- Technical evaluation




Optimal solution: maximal integration of RES

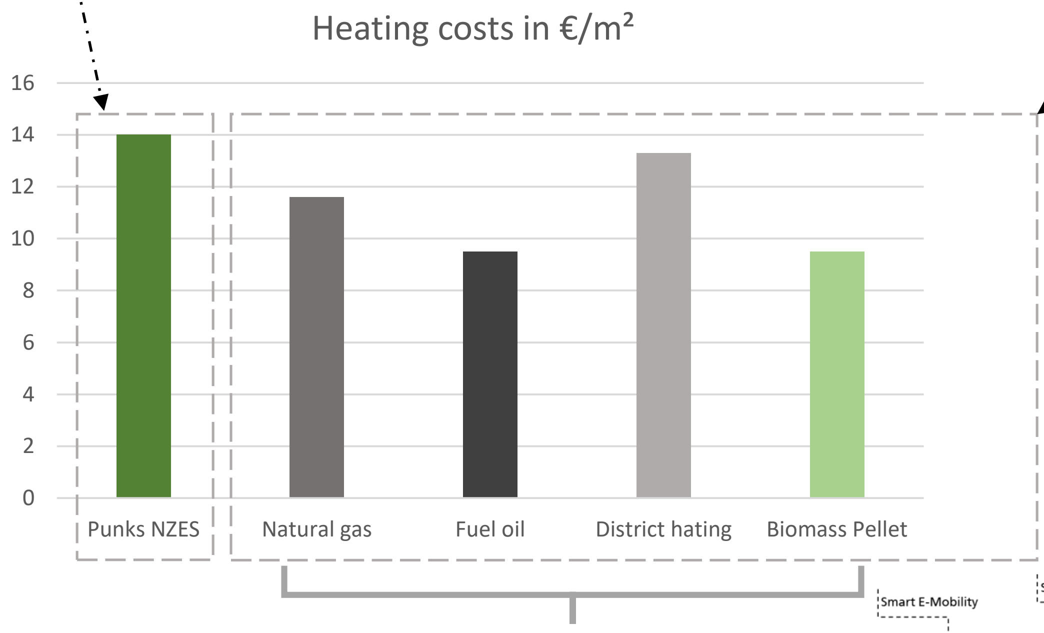
Energy storages (thermal and electric) are necessary for increasing the SSC index

# Study case: Punks 2050- Net Zero Energy System-Economic evaluation-Electricity generation costs

| PV (kW) | Wind (kW) | $LUEC_{NZES}$ (€/MWh) | NPV (k€) | IRR (%) |
|---|---|---|---|---|
| 10850 | 0 | 128 | 640 | 5,34 |
| 9000 | 1100 | 127 | 3056 | 6,7 |
| 8000 | 1621 | 118 | 2850 | 6,7 |
| 7000 | 2282 | 108 | 2663 | 6,78 |
| 6000 | 2873 | 98 | 2839 | 7,06 |
| 5000 | 3464 | 89 | 2643 | 7,1 |
| 4000 | 4055 | 79 | 2572 | 7,25 |
| 3000 | 4646 | 70 | 2625 | 7,55 |
| 2000 | 5237 | 61 | 2678 | 7,93 |
| 1000 | 5828 | 51 | 2607 | 8,28 |
| 0 | 6420 | 46 | 2591 | 8,50 |

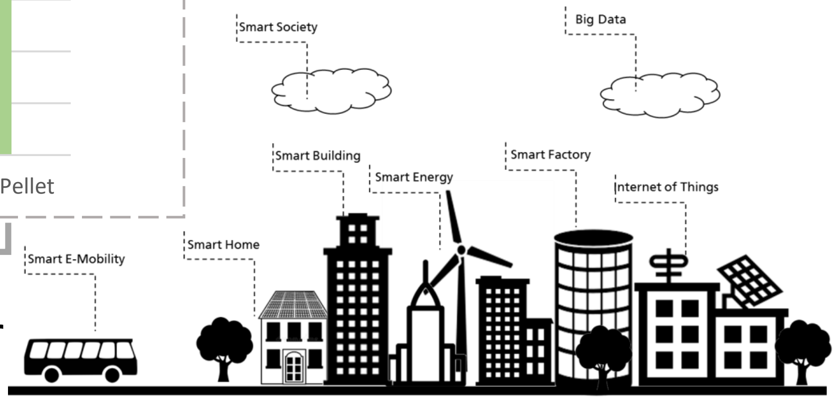
# Study case: Punks 2050- Net Zero Energy System- Economic evaluation- Heating costs

Pollutions free solution



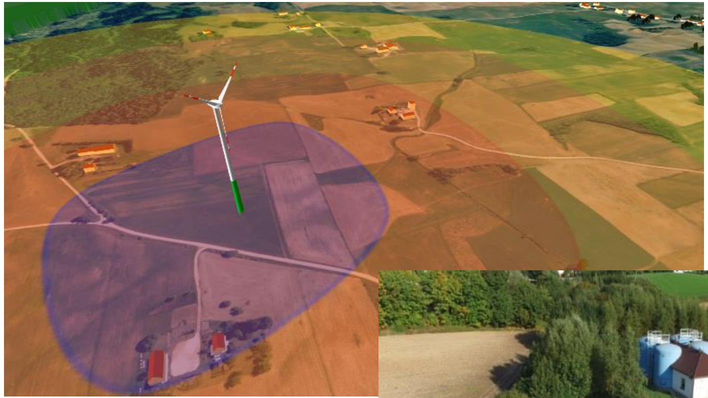

Average value for German houses and German weather

$CO_2$ and Pollutions emitter technologies



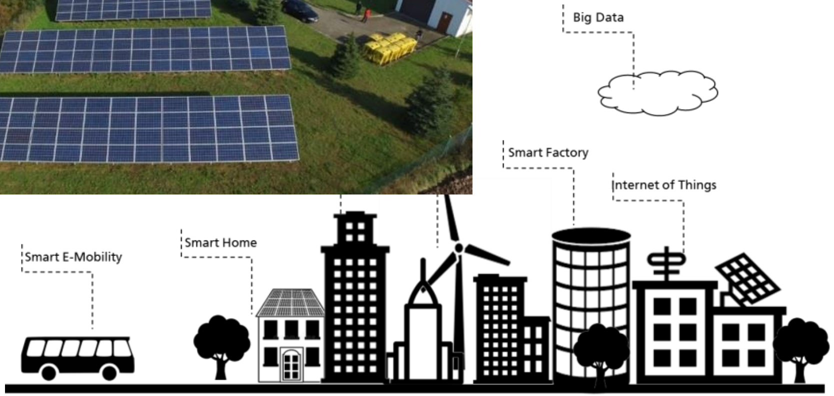
# Study case: Punks 2050- Net Zero Energy System- Spatial Development evaluation

Live DEMO



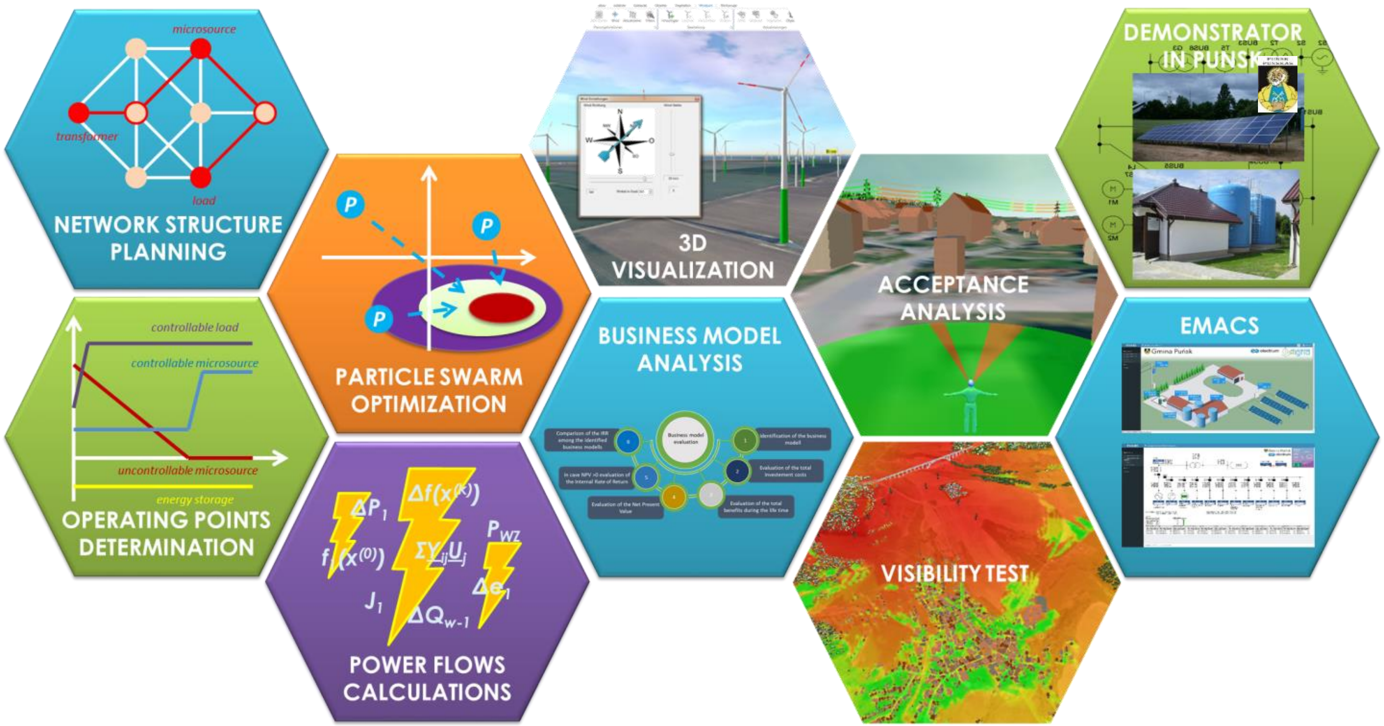
1,25 km^2 ( 2x 2,5 MW Wind Turbines)

28 521 m²



# RIGIRD Realization

RURAL INTELLIGENT Rigrid




ISGAN Award of Excellence 2019

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INTERNATIONAL SMART GRID ACTION NETWORK

# Thank you for your attention!

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Smart Grids Plus ERA-Net

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