Maximizing the impact of innovative energy approaches in the EU islands

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INSULAE PROJECT DETAILS

- Name: Maximizing the impact of innovative energy approaches in the EU islands
- Duration: 48 months
- Start: 01/04/2019
- Call: H2020-LC-SC3-2018-ES-SCC
- Theme: LC-SC3-ES-4-2018-2020 Decarbonising energy systems of geographical Islands

Unije demonstration

1. Joint management of hybridized RES and energy storage

2. Smart integration and control of water and energy system

3. Empowerment of islands' energy communities through 5G and IoT technologies for flexibility services

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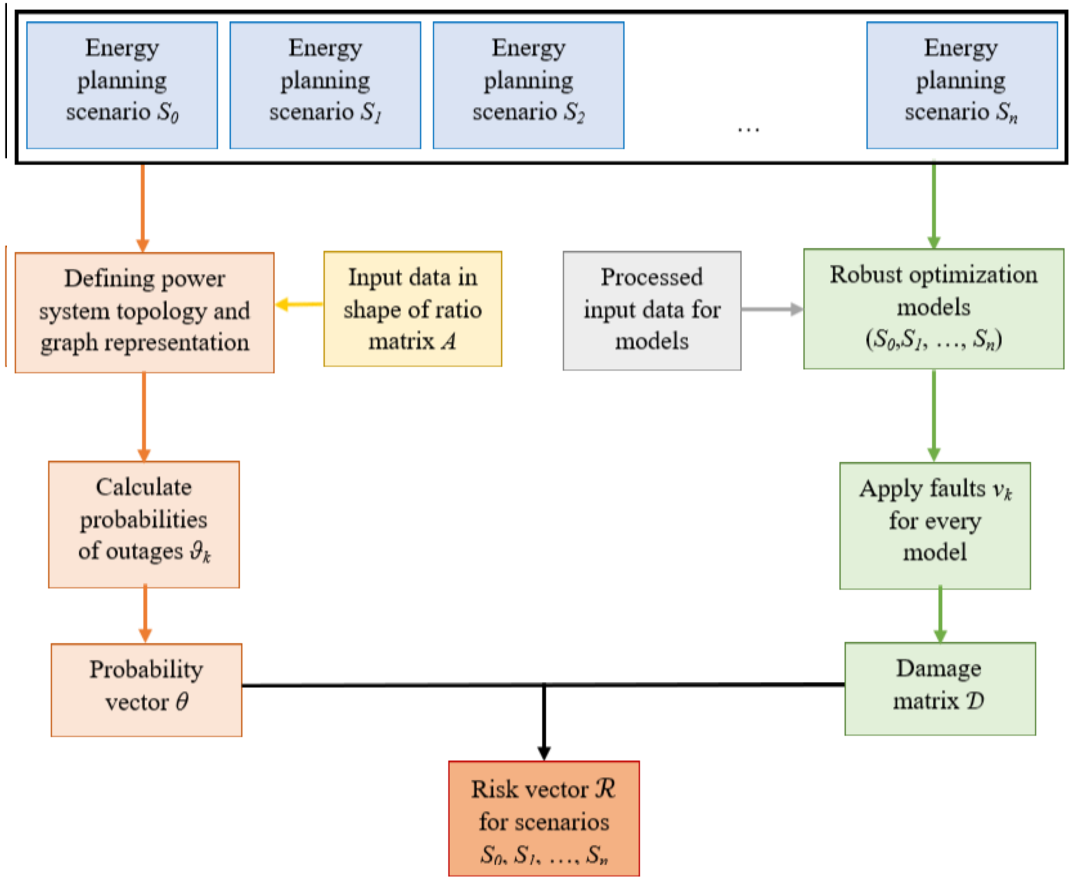
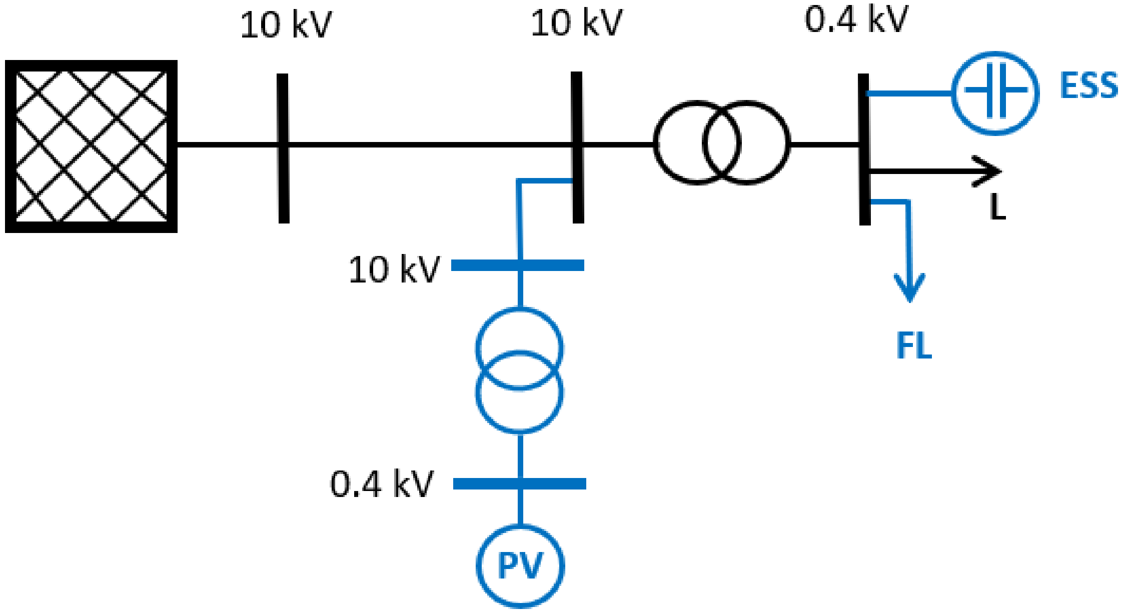
https://www.sciencedirect.com/science/article/abs/pii/S0378779621006970

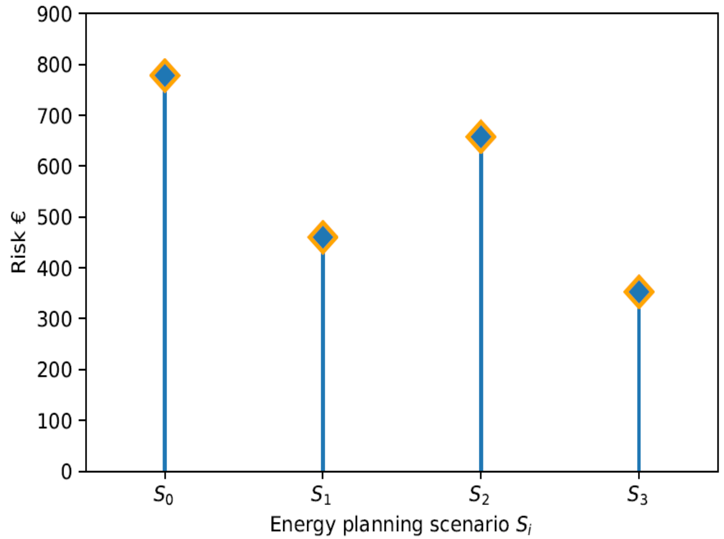
Risk assessment tool

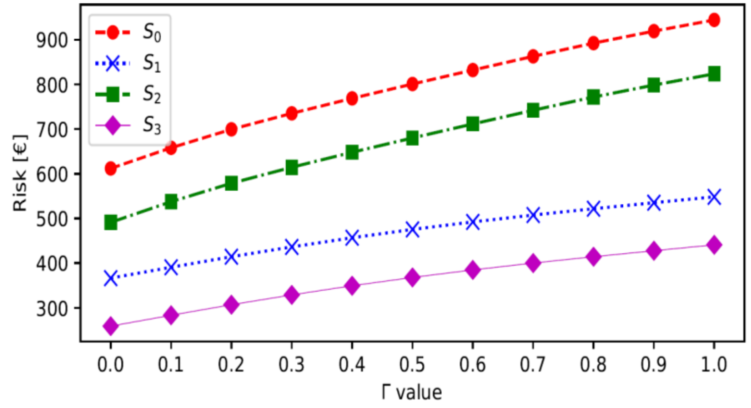
- Risk level of different scenarios – often loss of supply
- Tool for risk assessment of energy scenarios for islands
- Case study on Unije island – 4 analysed scenarios (different capacities of solar and battery plant)



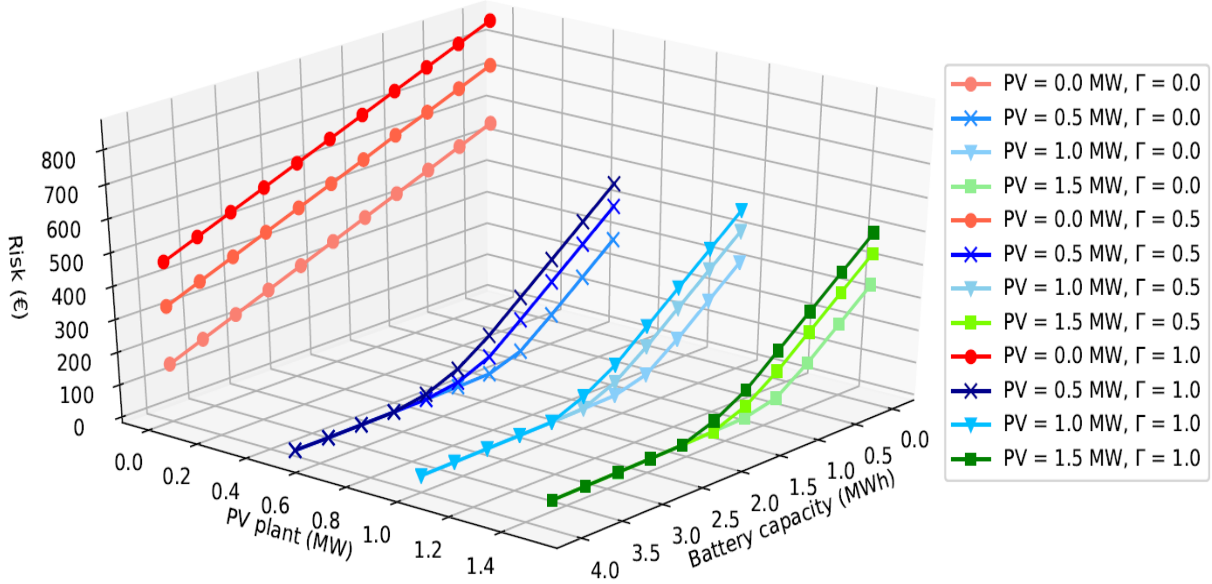


- Tool is developed in GAMS
- Scenario that safely enables the operation in the island regime is achieved for 0.5 MW PV plant and 3.55 MWh battery (with grid forming inverter)



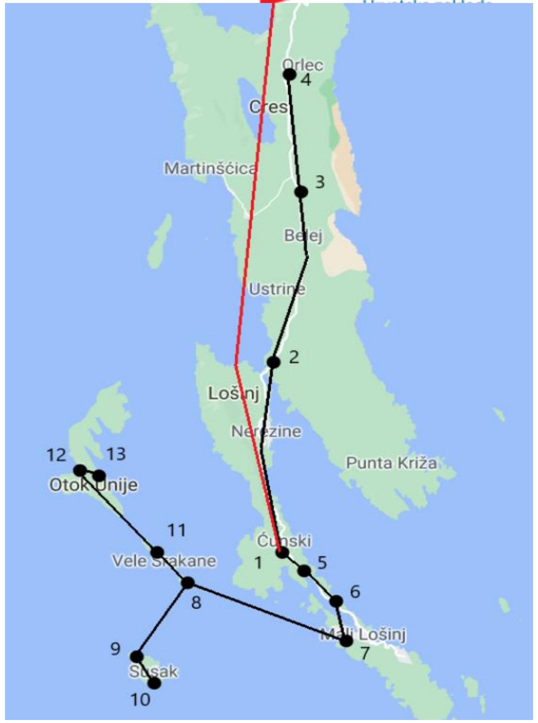


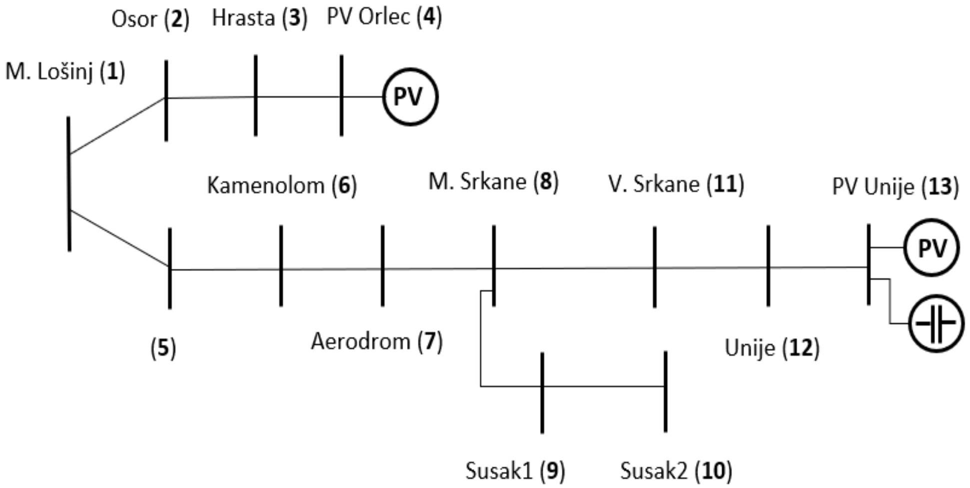
Scenario	PV [MW]	ESS [MWh]	DR
S_0	0	0	No
S_1	1	0	Yes
S_2	0	1	Yes
S_3	1	0.5	Yes
"Zero-import risk"	TBD	TBD	Yes



Demand response model in the smart archipelago

- Exploitation of fluctuations in day-ahead electricity market prices
- Detailed distribution system model around Lošinj
- Algorithm for providing incentive to the consumers adjusting their consumption – cooperation between UNIZAG FSB, DTU and FER





$$\min f \triangleq \min\left[\sum_{t\in\Omega_T}\left(\lambda_t \cdot E_{slack,t} + \mu \cdot \varphi_{i,t}^{-} \cdot L_{i,t}^{P} + CPV \cdot E_{CPV,t}\right)\right]$$

$$\varphi_{i,t}^{-}\begin{cases} \leq \tanh\dfrac{2(\lambda_t - \lambda_{t-1})}{k(\lambda_t + \lambda_{t-1})}, & \lambda_t - \lambda_{t-1} > 0 \\ = 0, & else \end{cases}$$

$$\varphi_{i,t}^{+}\begin{cases} \leq \tanh\dfrac{2(\lambda_{t-1} - \lambda_t)}{k(\lambda_t + \lambda_{t-1})}, & \lambda_t - \lambda_{t-1} \leq 0 \\ = 0, & else \end{cases}$$

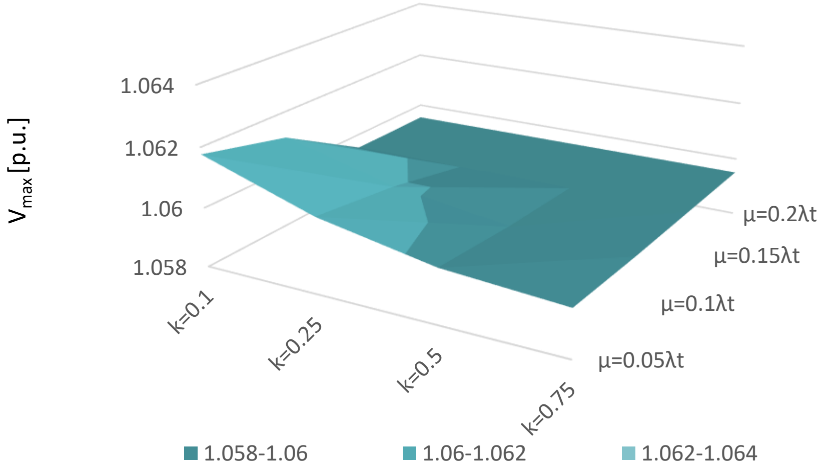
$$\sum_t^T \varphi_{i,t}^{+} \cdot L_{i,t}^{P} = \vartheta \sum_t^T \varphi_{i,t}^{-} \cdot L_{i,t}^{P}$$

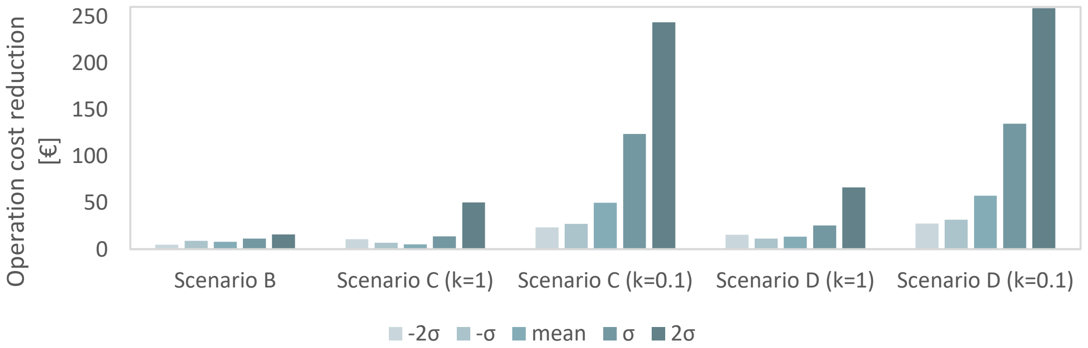
$$P_{ij,t} = \frac{V_{i,t}}{Z_{ij}}\cos(\theta_{ij}) - \frac{V_{i,t}V_{j,t}}{Z_{ij}}\cos(\delta_{i,t} - \delta_{j,t} + \theta_{ij})$$

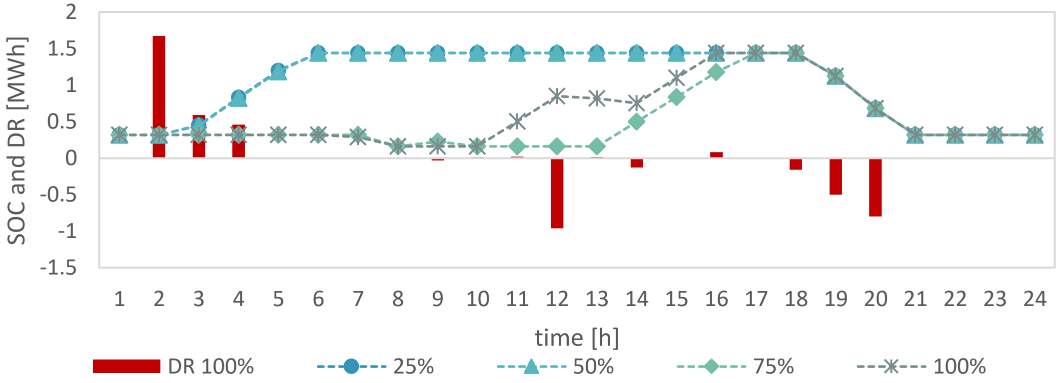
$$Q_{ij,t} = \frac{V_{i,t}}{Z_{ij}}\sin(\theta_{ij}) - \frac{V_{i,t}V_{j,t}}{Z_{ij}}\sin(\delta_{i,t} - \delta_{j,t} + \theta_{ij}) - \frac{bV_{i,t}}{2}$$

$$I_{ij,t} = \frac{V_{i,t}\angle\delta_{i,t} - V_{j,t}\angle\delta_{j,t}}{Z_{ij}\angle\theta_{ij}} + \frac{bV_{i,t}}{2}\angle\left(\delta_{i,t} + \frac{\pi}{2}\right)$$

- All stakeholder benefit from the usage of the demand response model
  - Consumers make revenue
  - Reduced system operation cost
  - No violation of grid code
- Incentive can reach up to 23% of the day-ahead electricity market prices when the model stops using the demand response

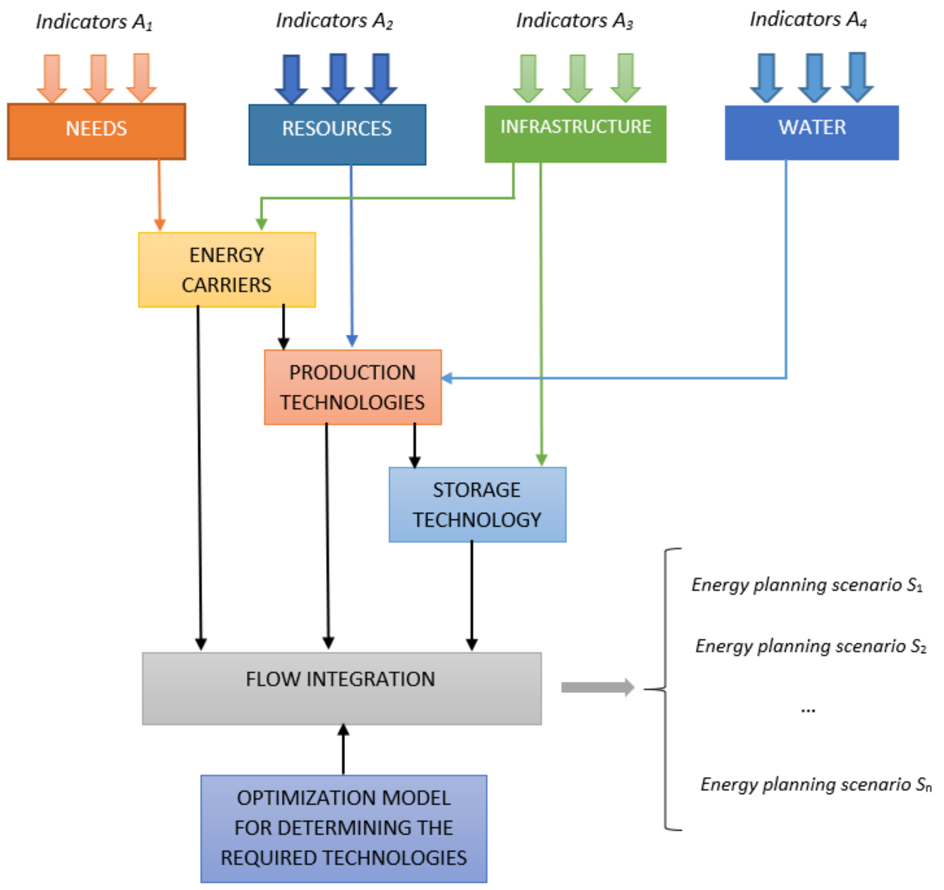




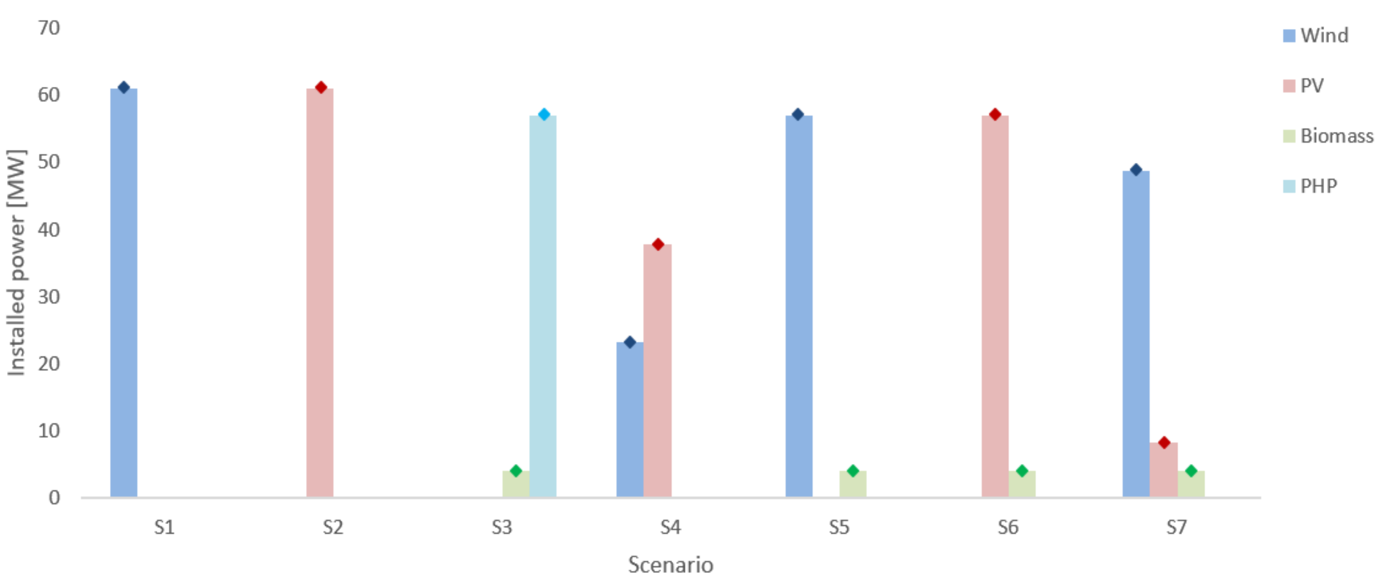


Smart Islands method

- Islands advantage – excellent overview of local needs and resources
- New energy planning scenarios that include cross-integration of 7 sectors
- Investment optimization method that calculates scenarios that meet islands needs with resources developed in Python programming language
- 40 indicators as input data



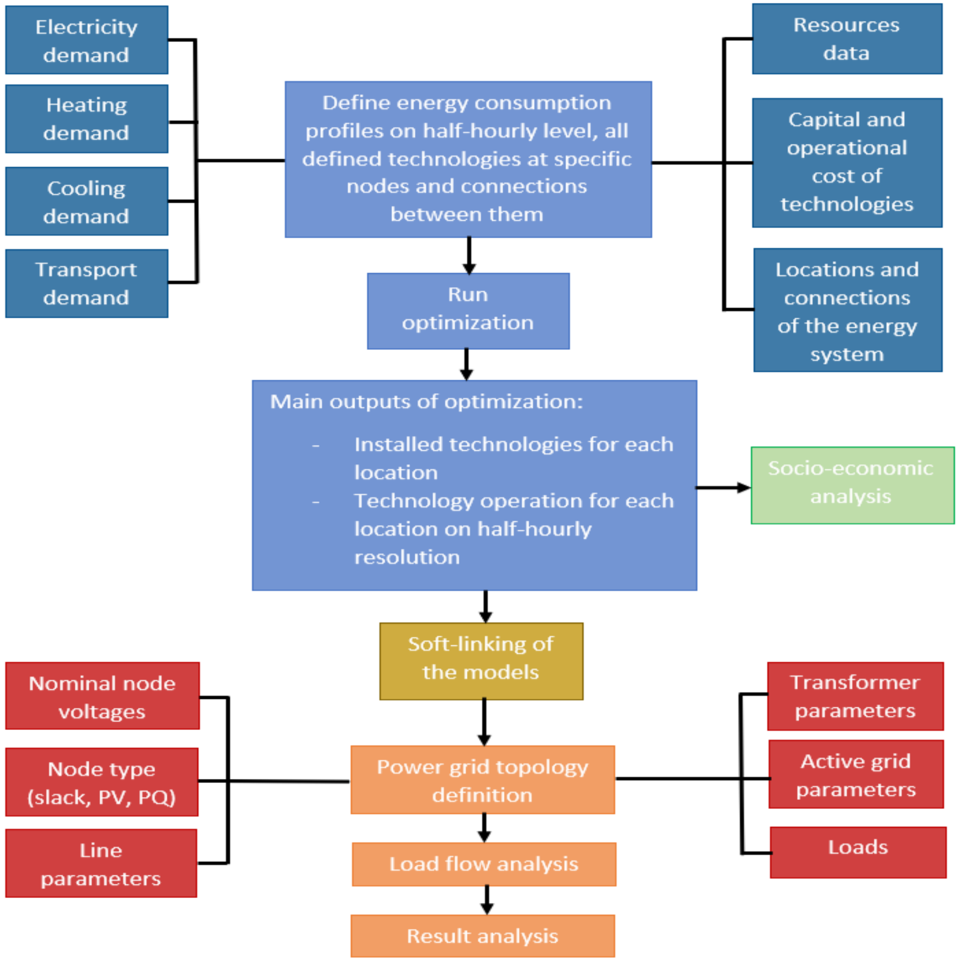
- Case study on Krk – 7 different energy planning scenarios
- Case study on Vis – with and without the interconnection
- Wide range of possible applications of the tool



Interconnection [MW]	16	0
PV [MW]	5.92	5.92
Battery storage [MWh]	0	**5.42**
HP [MW]	6.85	6.85
EV chargers [MW]	1.96	1.96
Desalination [m³]	1.13	1.13
Waste fill [tonne]	232	232
Wastewater tanks [m³]	21.4	21.4

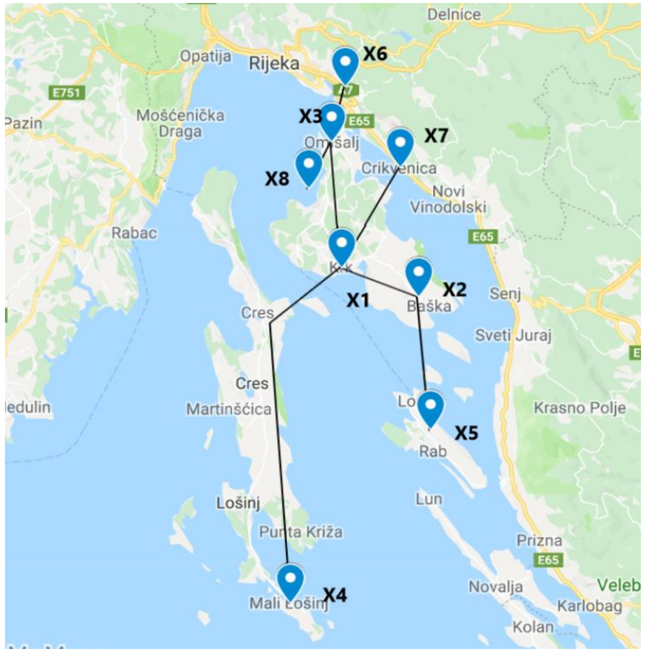
Soft-linking of energy planning and power flow models

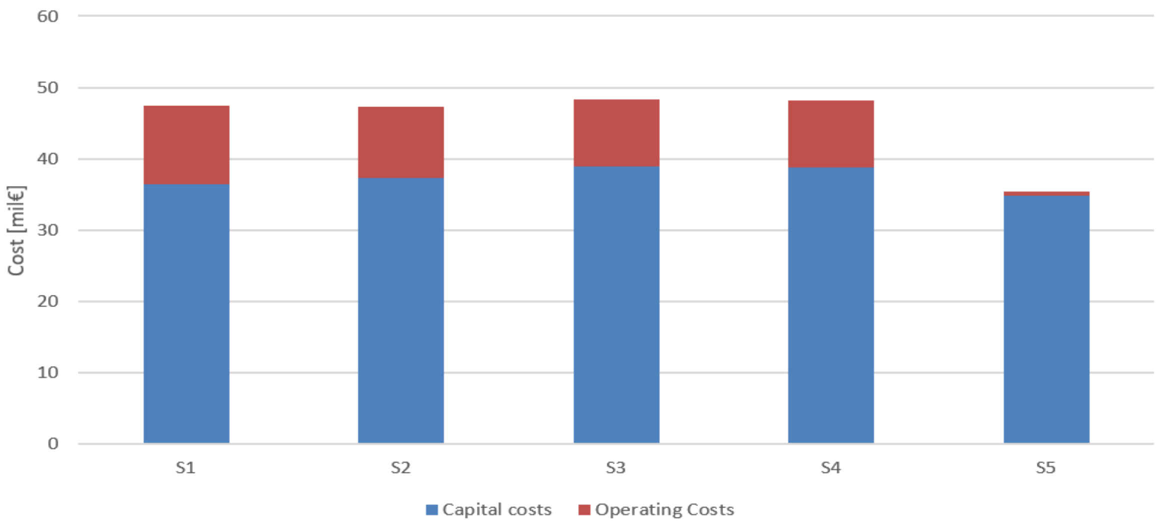
- Soft-linking between energy planning and power flow tools (Newton Raphson algorithm)
- Detailed spatio-temporal energy planning models
- Energy planning scenarios validated with the power flow tool
- 20 different technologies modelled

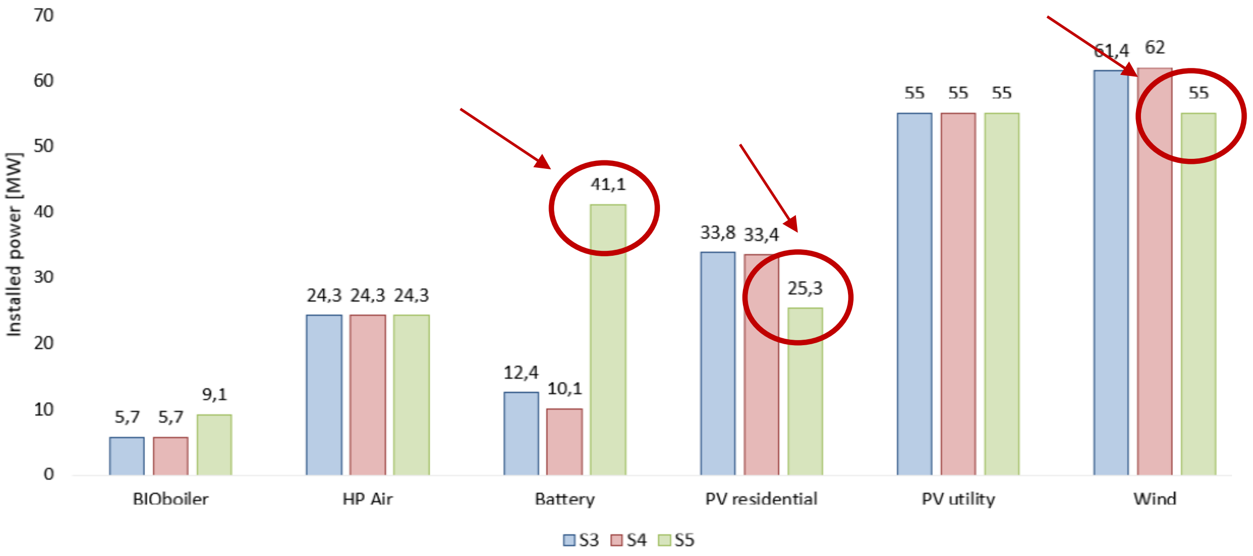


Case study on Krk island

- Significant difference between coarser (S3) spatio modelling versus distributed spatial (S5) modelling
- Less expressed difference between hourly (S3) and half hourly modelling (S4)

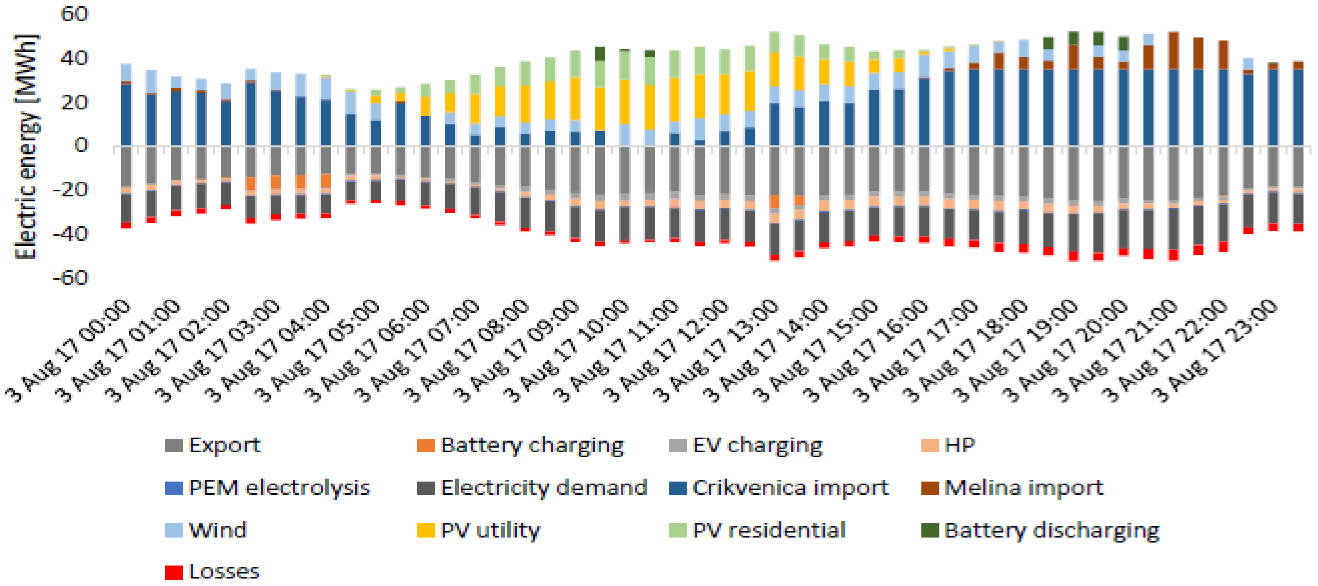


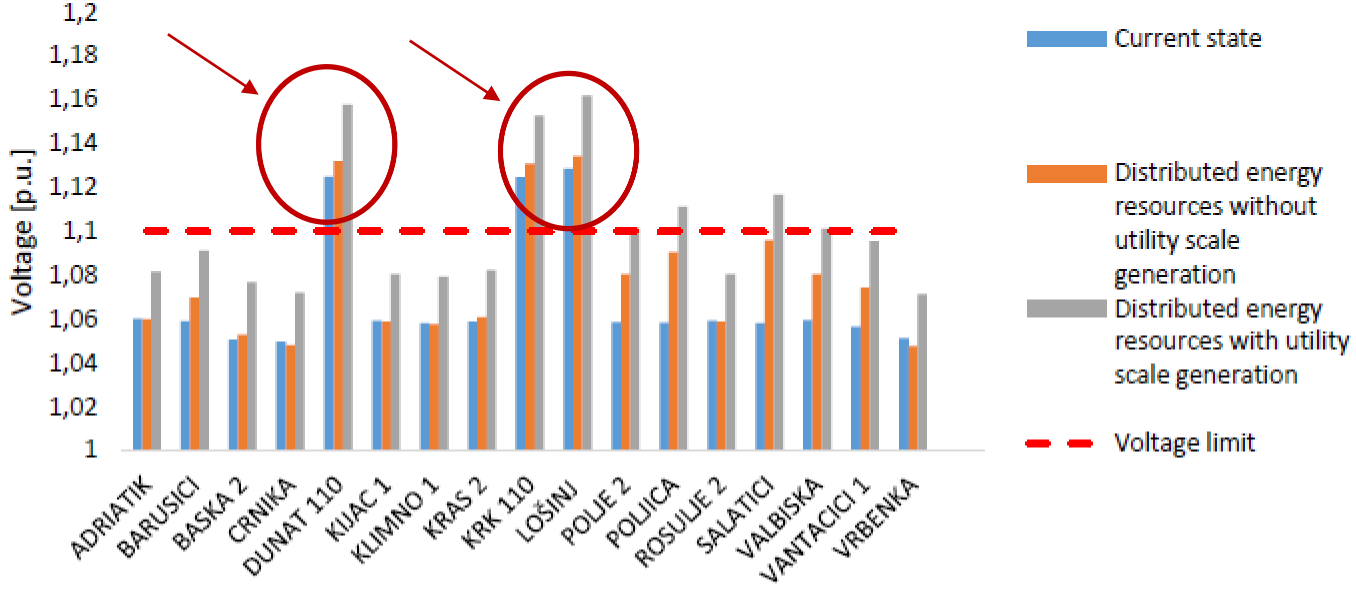




Power flow analysis

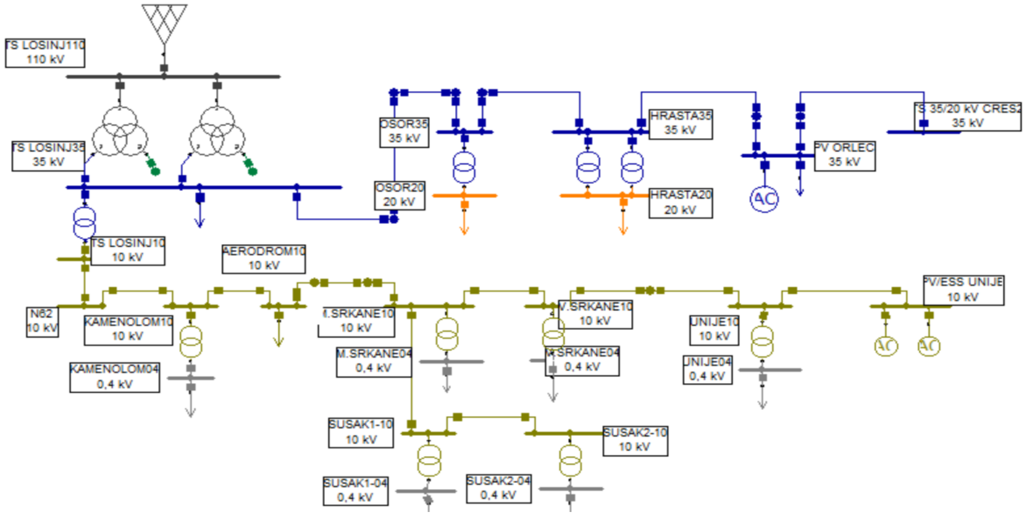
- Detailed representation of energy system operation
- **How does the power grid react to two extreme cases?**
- No problem for maximum demand, but there is a grid code violation for minimum demand and maximum production -> **we need to analyse the power grid in order to see the application possibilities of the energy planning scenarios**

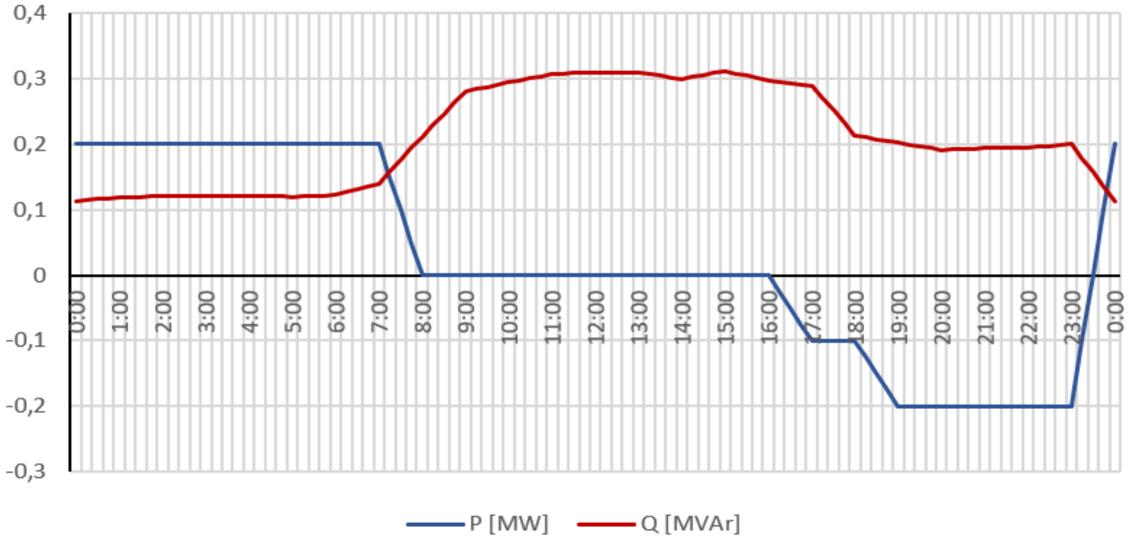




Implementation and testing in the scope of INSULAE project on Unije

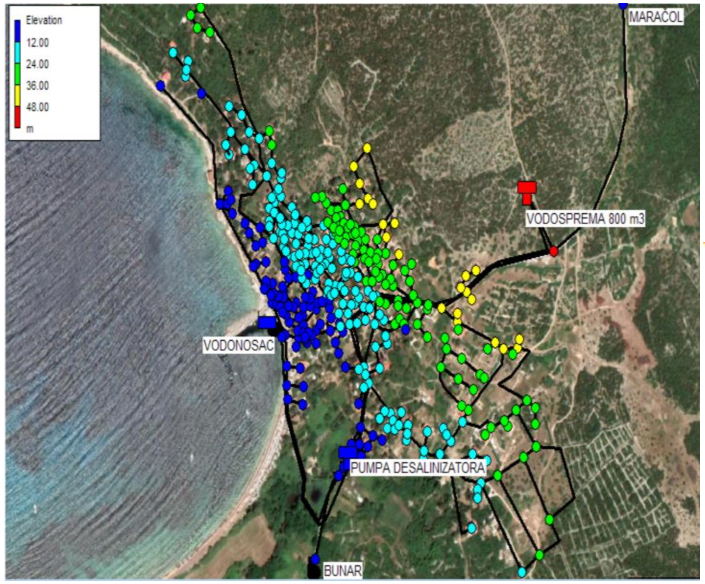
- Use case 1 – Joint operation of solar plant and battery system
- Island operation
- Using battery for the maximization of solar power plant profit
- Ancilliary services

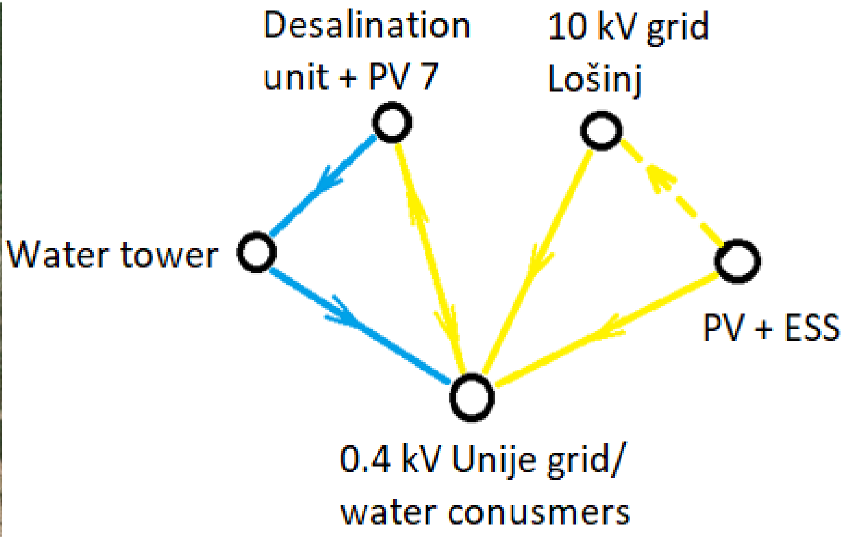


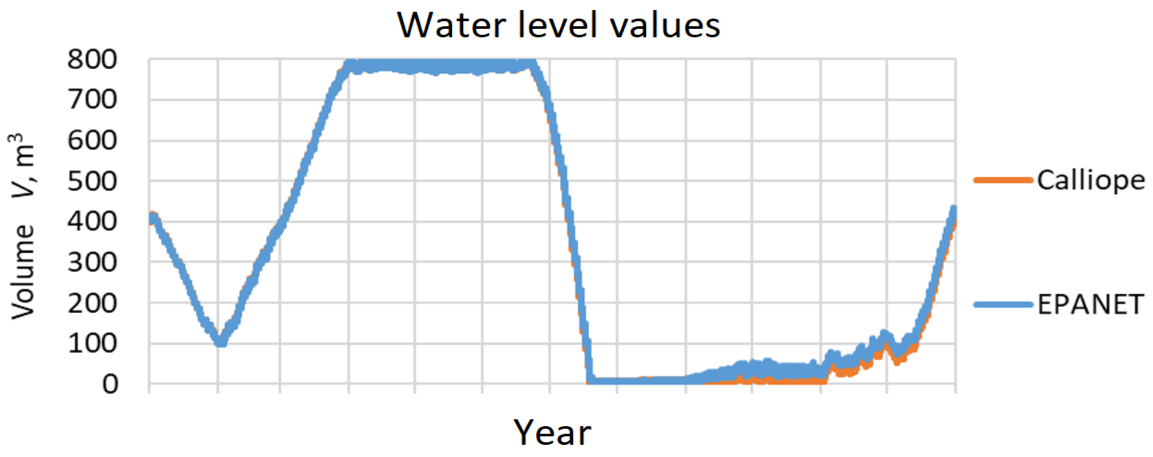


Water-energy nexus

- Demand response with the desalination plant on Unije island
- Connection to the water system and water tanks
- 7 kW solar plant on the desalination

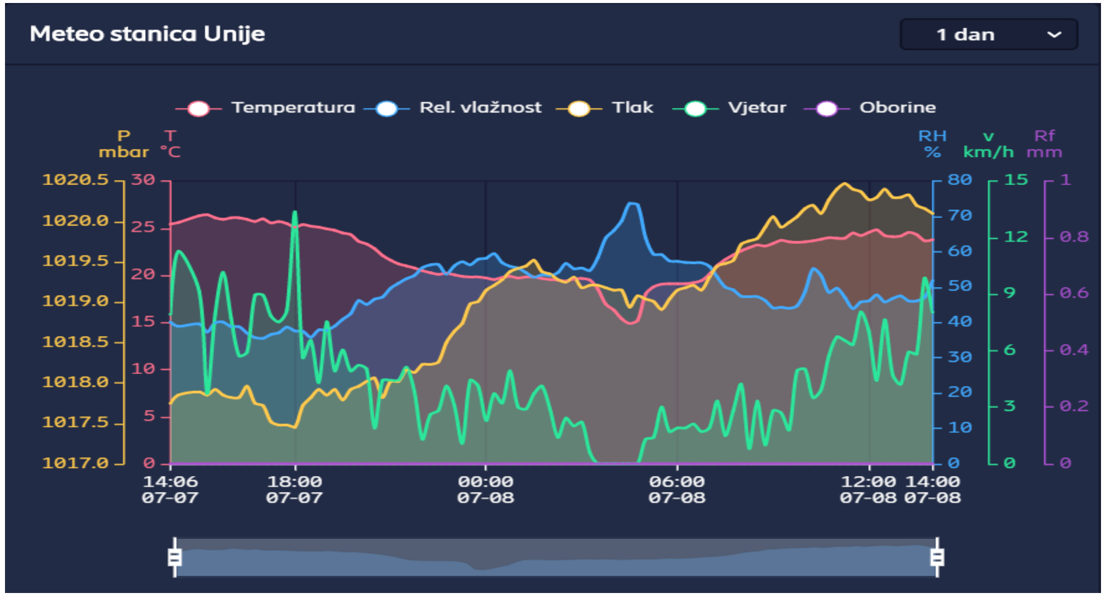


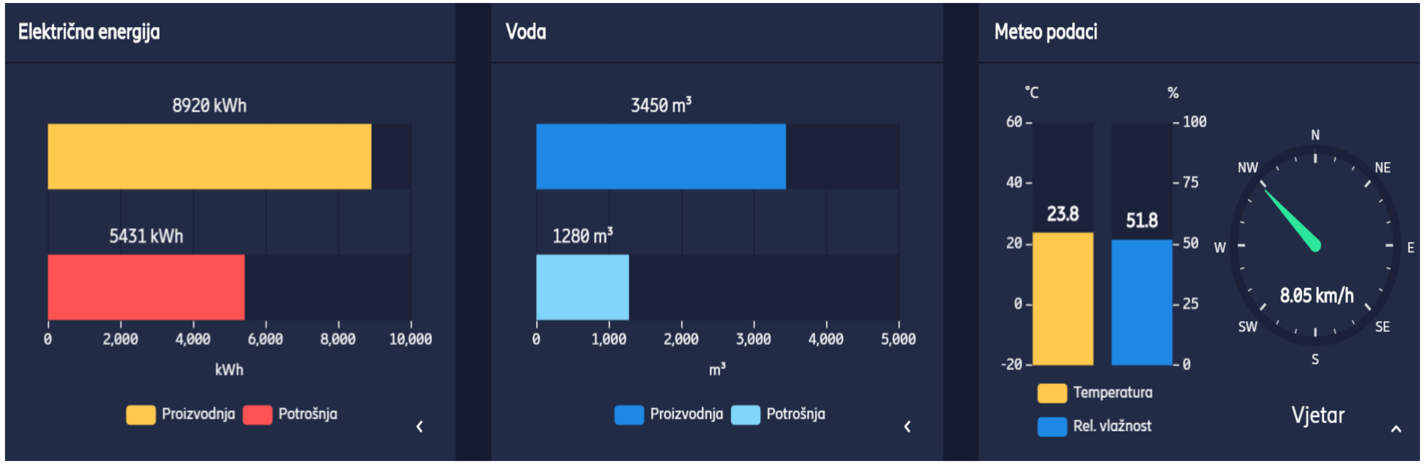




Utilization of IoT, 5G and blockchain

- Sector integration can only be achieved with the utilization of ICT technologies
- Smart sockets, water level sensors, smart meters, control units in households connected to the IoT platform
- Households with batteries will be able to trade on the blockchain platform





Conclusion

- New alternative for securing energy supply on the islands
- The possibility of scaling and tranferring solutions from the islands to the mainland
- Example of cooperation between the academy, local communities and the private sector
- Further investigations, models and algorithms will be necessary to maximize the positive effects of smart energy systems

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