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Funded by the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement no. 846463

CURRENT PROGRESS ON SMART ISLANDS – H2020 INSULAE PROJECT

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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

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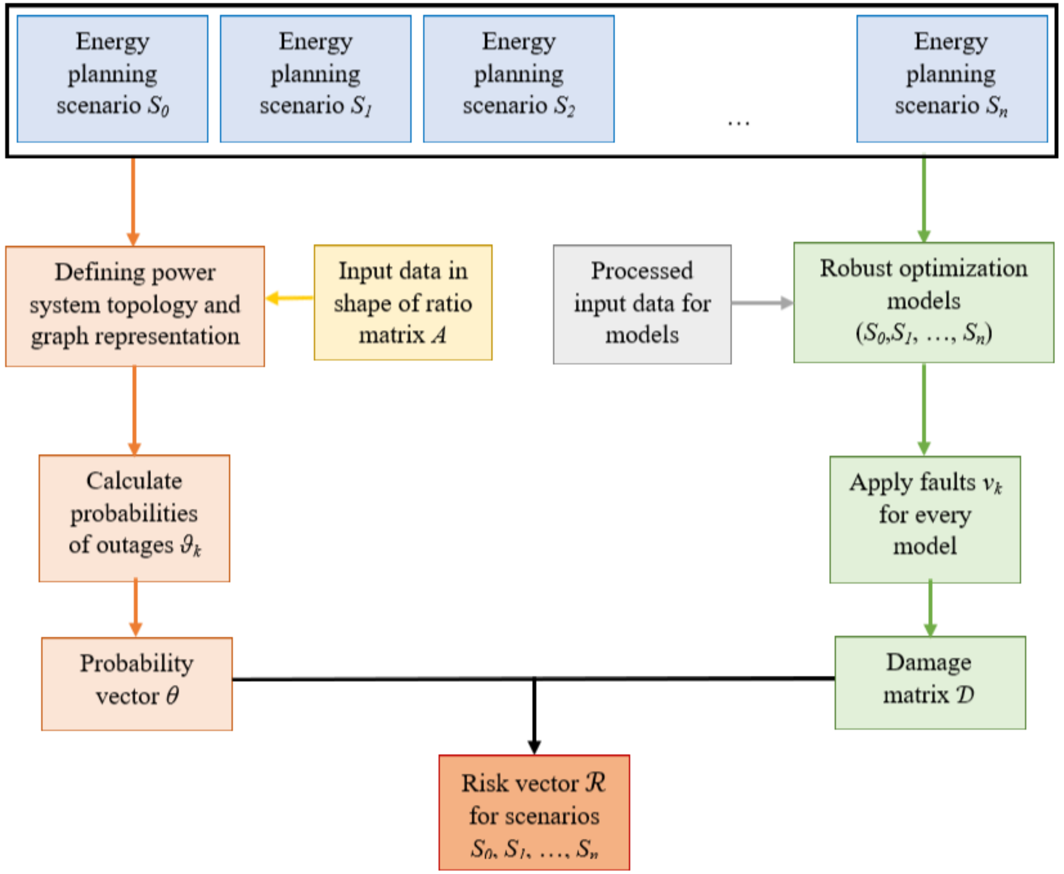
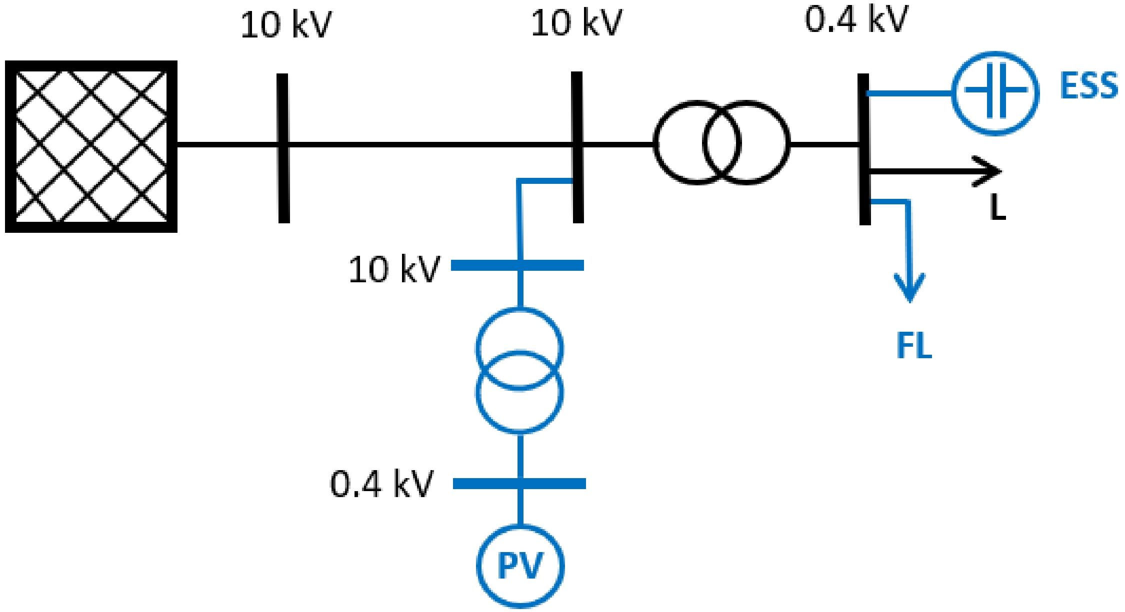
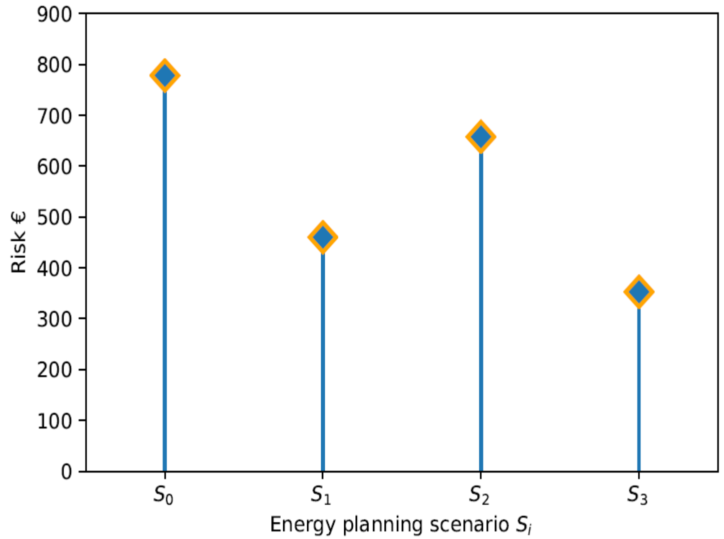
Risk assessment tool

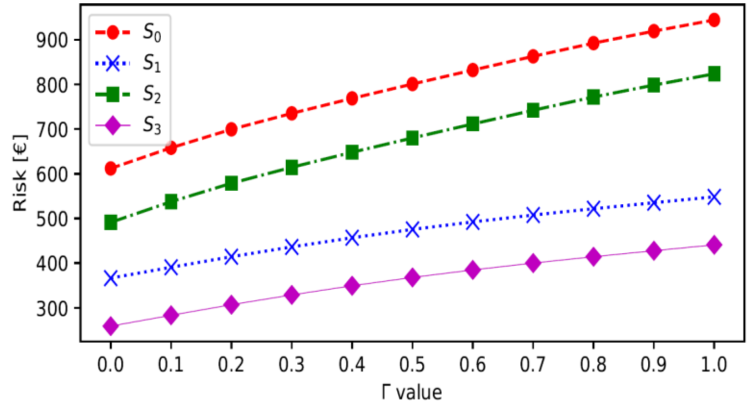
- Risk level of different scenarios – often loss of supply
- Tool for risk assessment of energy scenarios for islands
- Case study on Unije island – 4 analysed scenarios (different capacities of solar and battery plant)



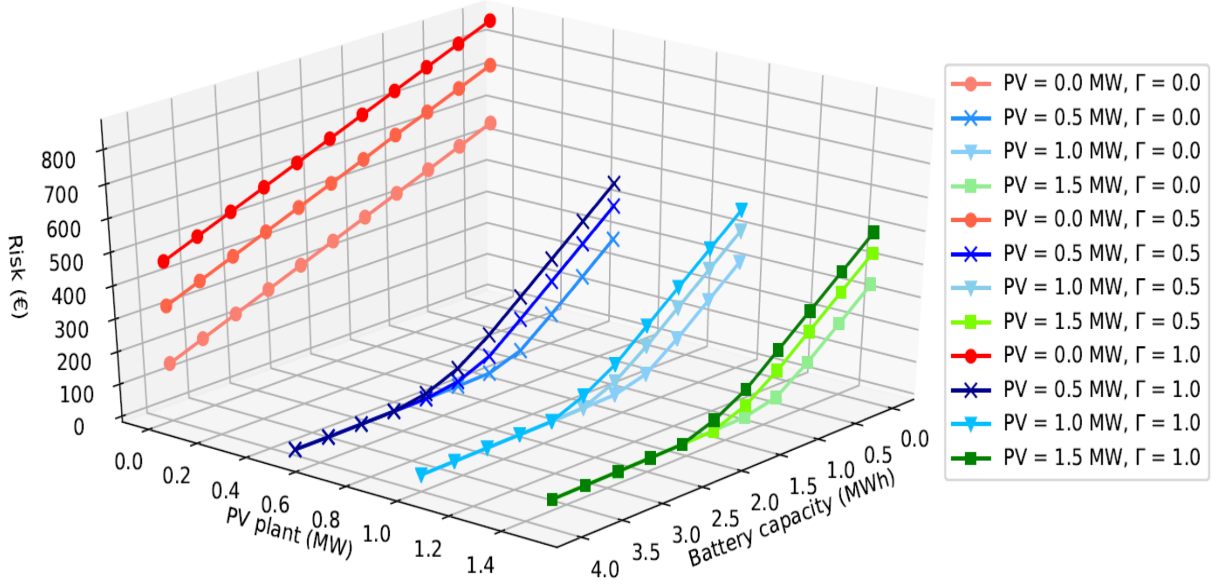


- Tool is developed in GAMS
- Scenario that safely enables the operation in the island regime is achieved for 0.5 MW PV plant and 3.55 MWh battery (with grid forming inverter)





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



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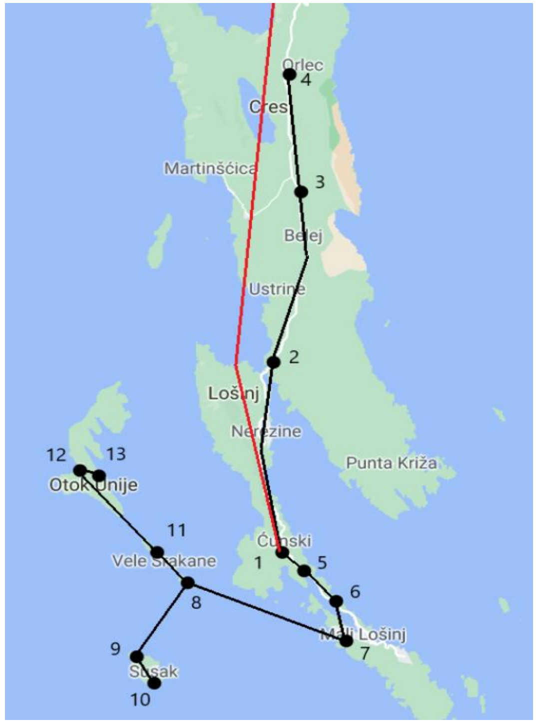
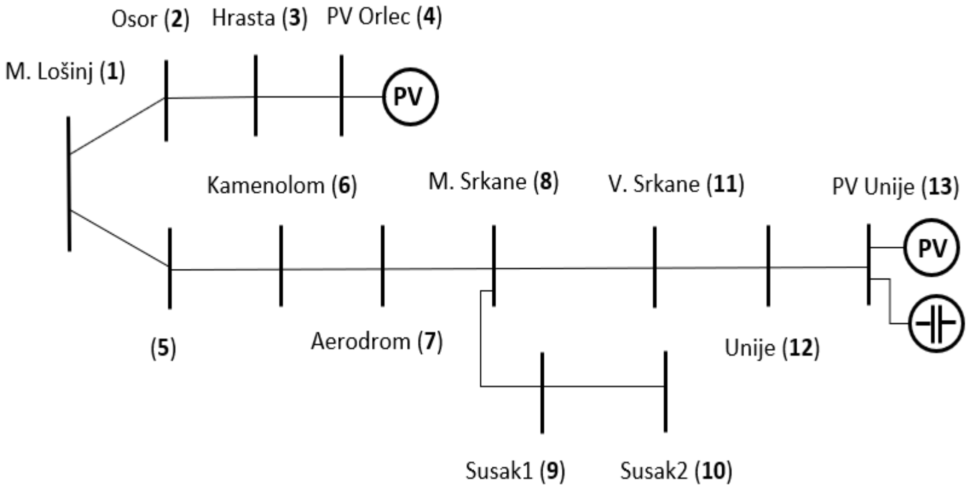
Demand response model in the smart archipelago

- 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



$$\min f \triangleq \min\left[\sum_{t\in\Omega_T}\left(\lambda_t \cdot E_{slack,t} + \mu \cdot \varphi^{-}_{i,t} \cdot\right.\right.$$



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

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

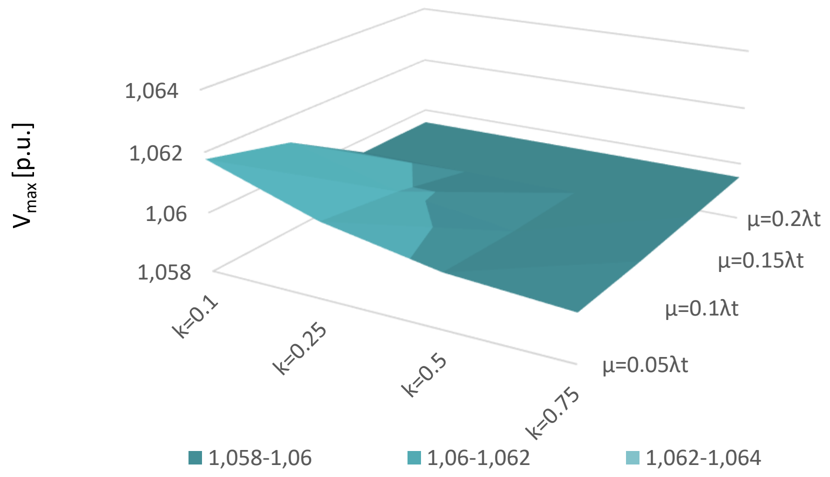
$$\sum_t^T \varphi^{+}_{i,t}\cdot L^P_{i,t} = \vartheta \sum_t^T \varphi^{-}_{i,t}\cdot L^P_{i,t}$$

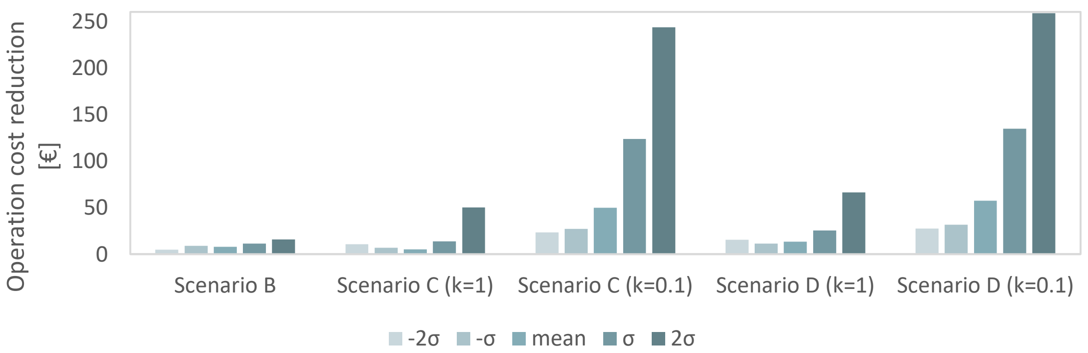
$$P_{ij,t} = \frac{V_{i,t}}{Z_{ij}}\cos(\theta_{ij}) - \frac{V_{i,t}V_{j,t}}{Z_{ij}}\cos(\delta_{i,t}-\delta_{j,t}+\theta_{ij})$$

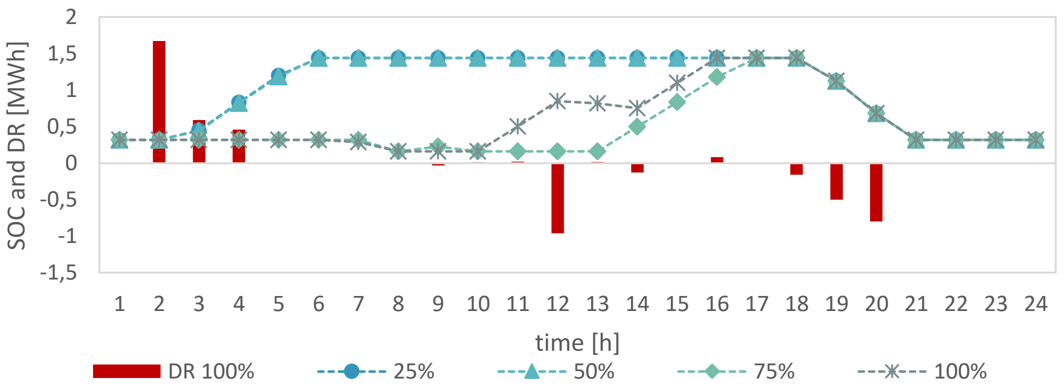
$$Q_{ij,t} = \frac{V_{i,t}}{Z_{ij}}\sin(\theta_{ij}) - \frac{V_{i,t}V_{j,t}}{Z_{ij}}\sin(\delta_{i,t}-\delta_{j,t}+\theta_{ij}) - \frac{bV_{i,t}}{2}$$

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

- 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

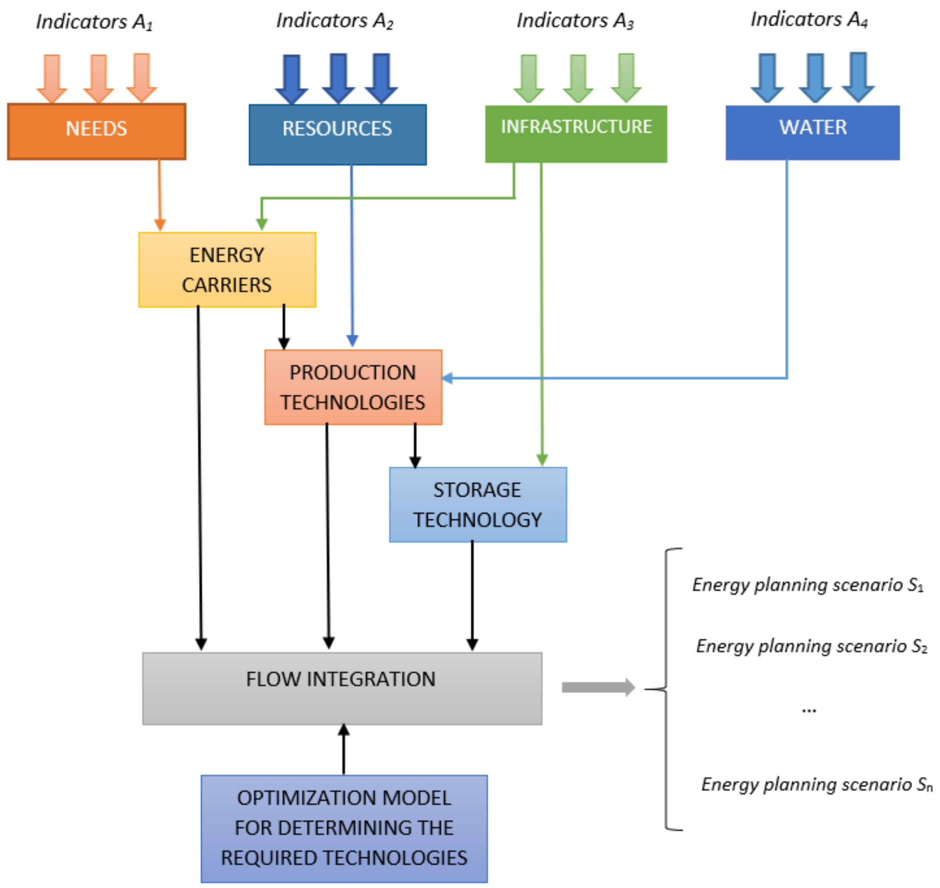




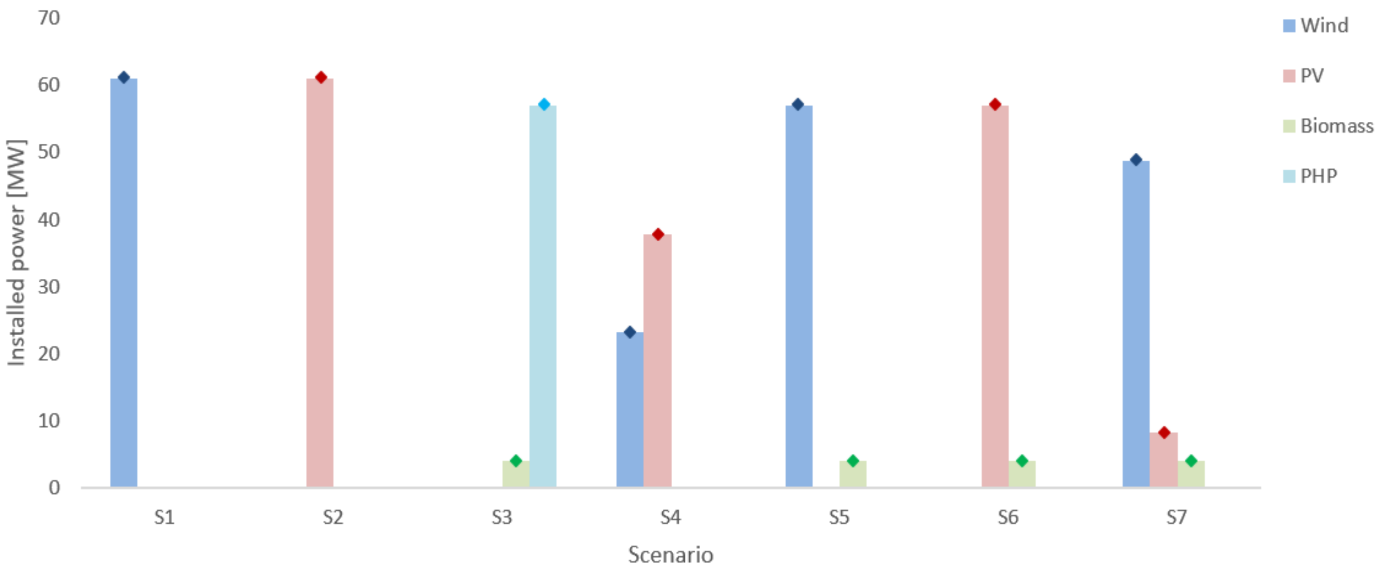


Smart Islands method

- 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



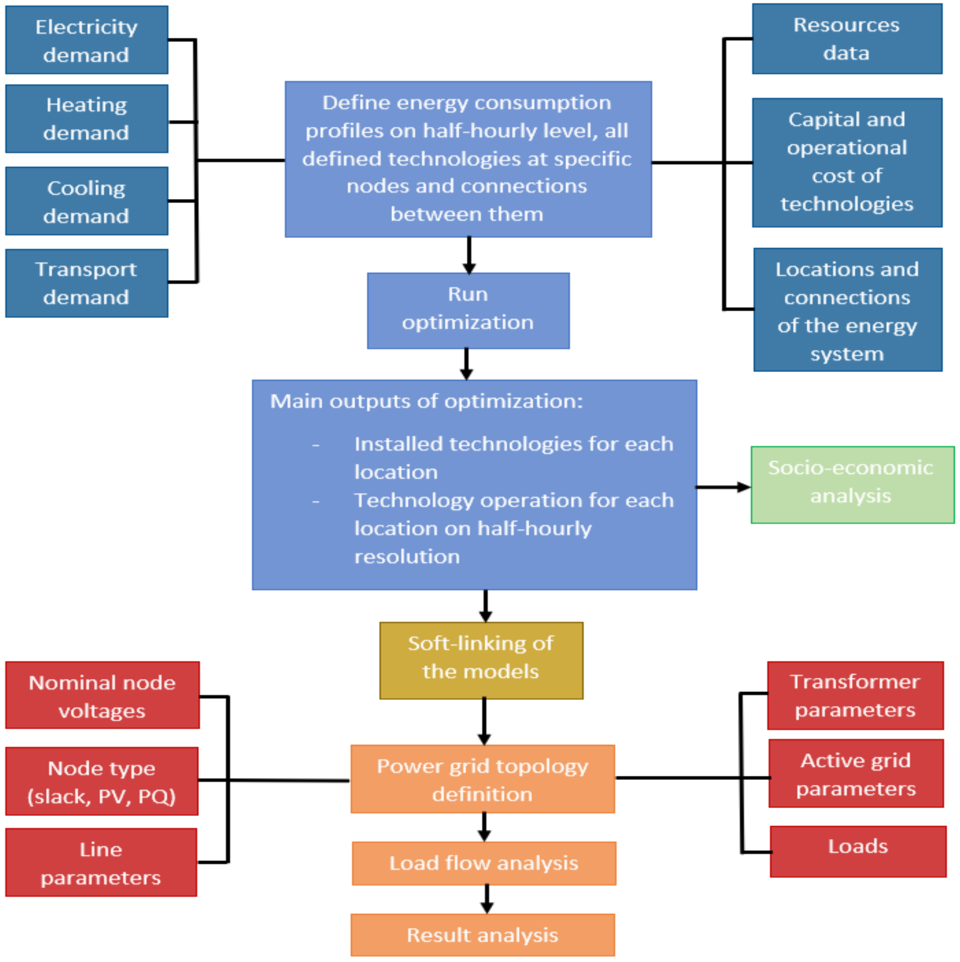
- Case study on Krk – 7 different energy planning scenarios
- Case study on Vis – with and without the interconnection
- Wide range of possible applications of the tool



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

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



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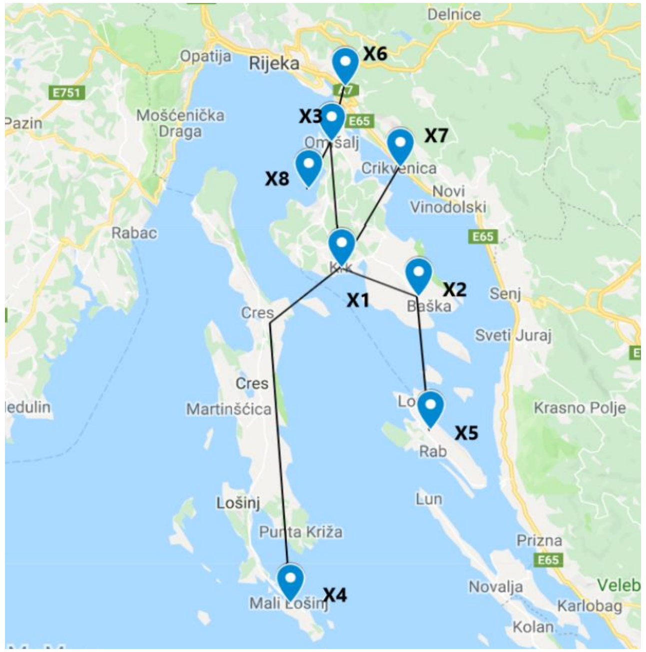
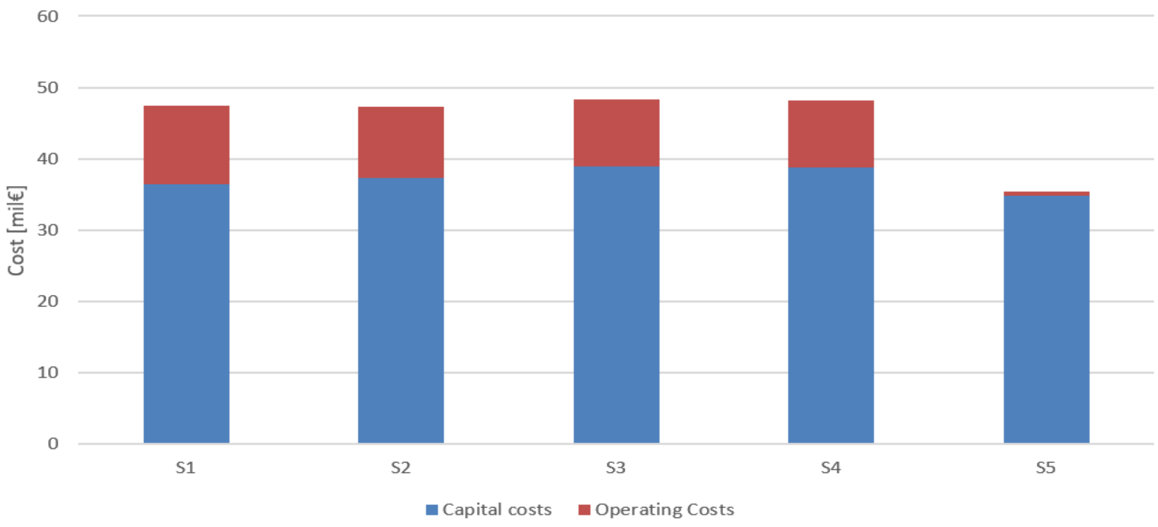
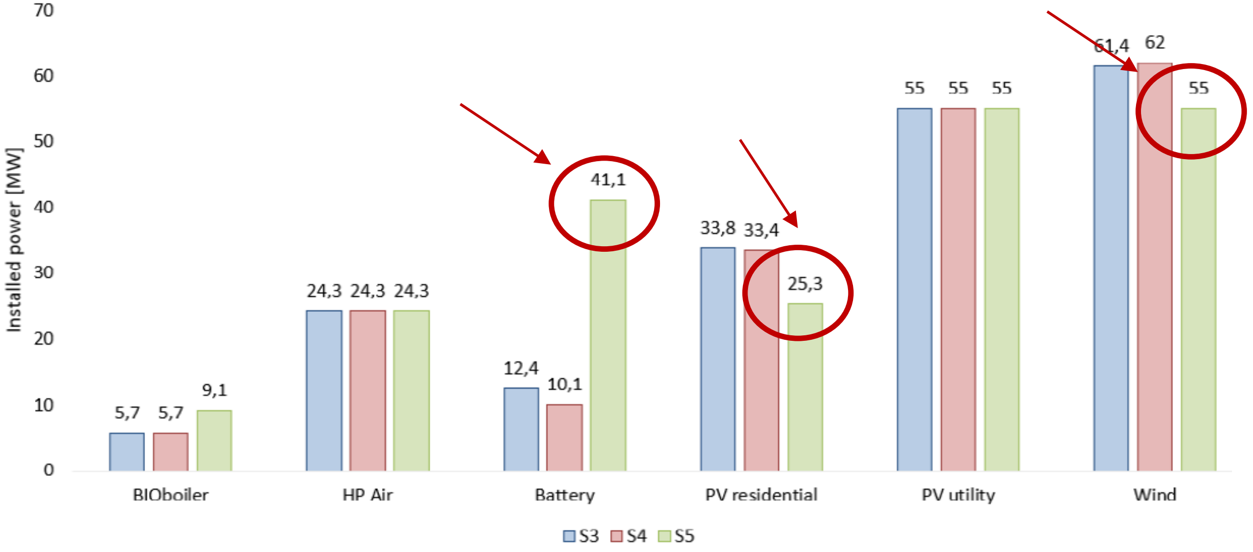
Case study on Krk island

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

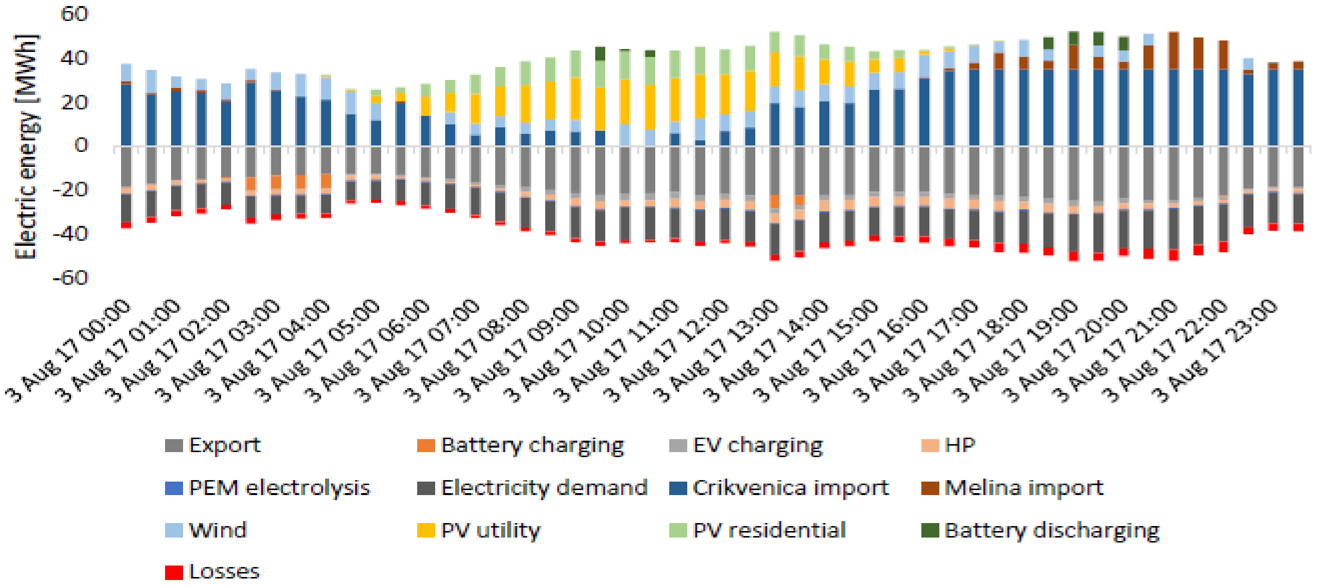


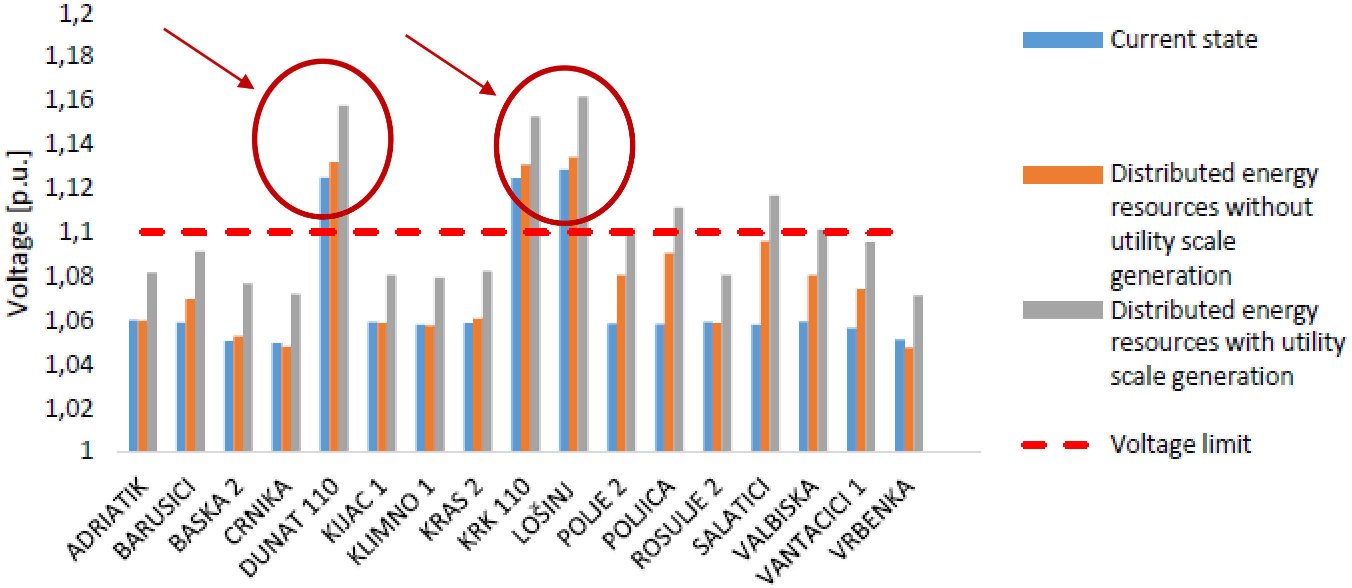




Power flow analysis

- 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**





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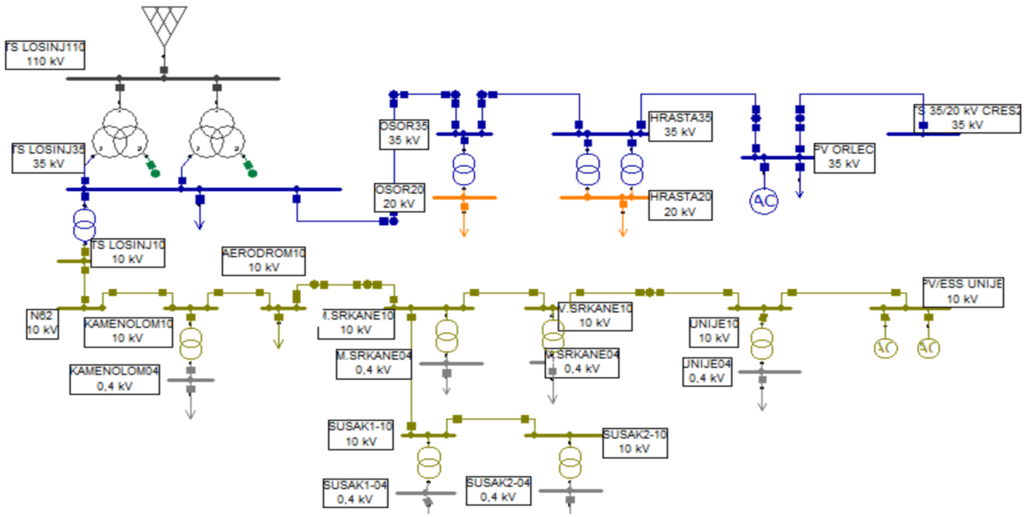
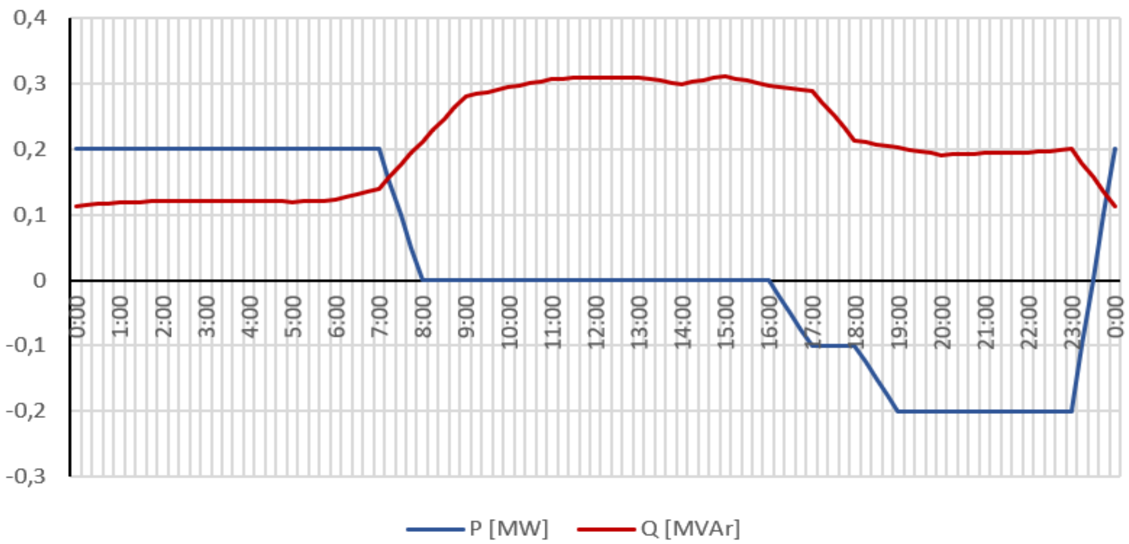
Implementation and testing in the scope of INSULAE project on Unije

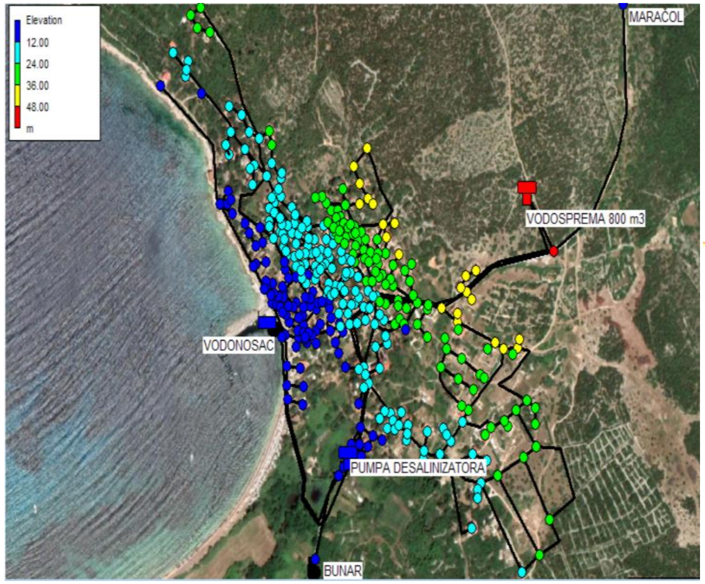
- Use case 1 – Joint operation of solar plant and battery system
- Island operation
- Using battery for the maximization of solar power plant profit
- Ancilliary services

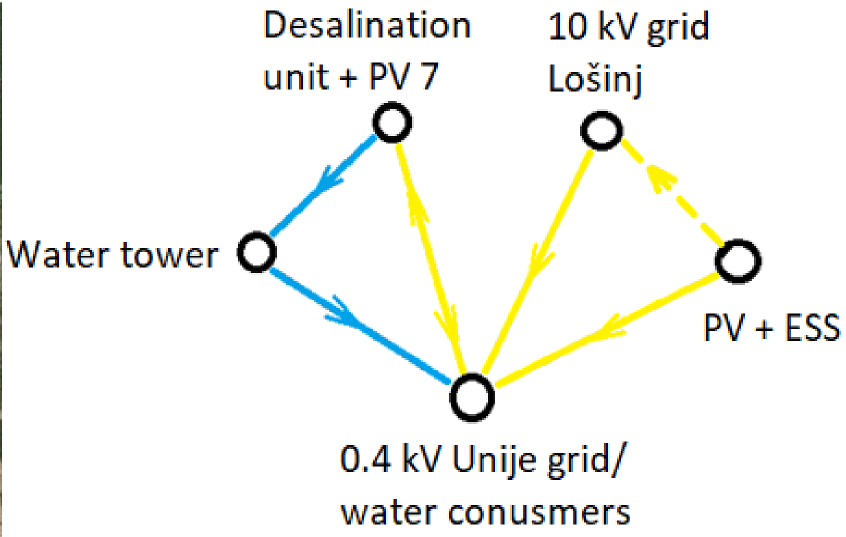


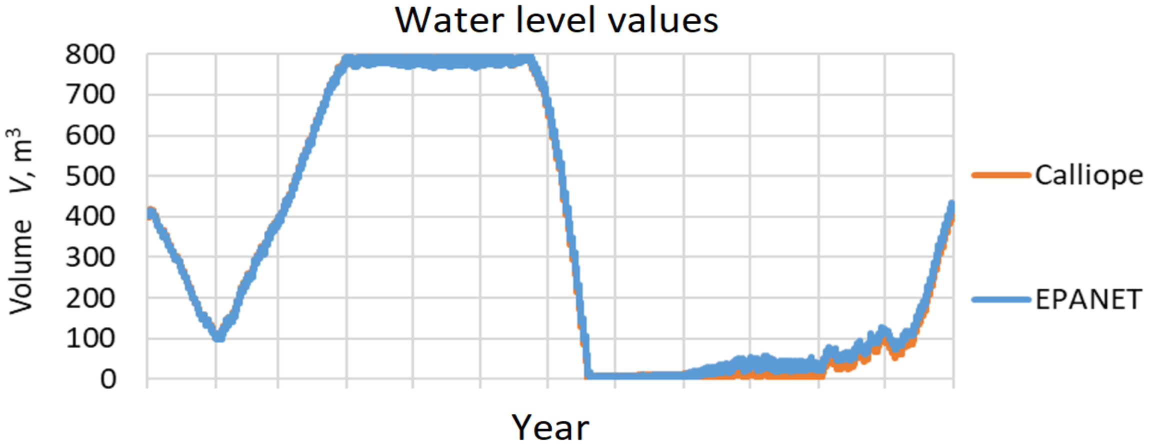


Water-energy nexus

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







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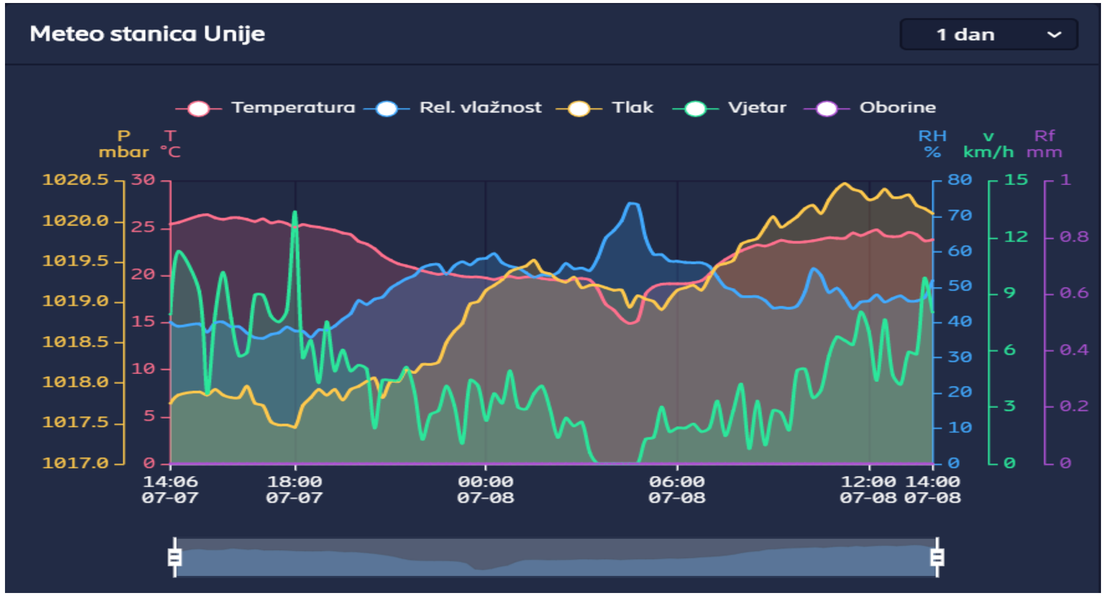
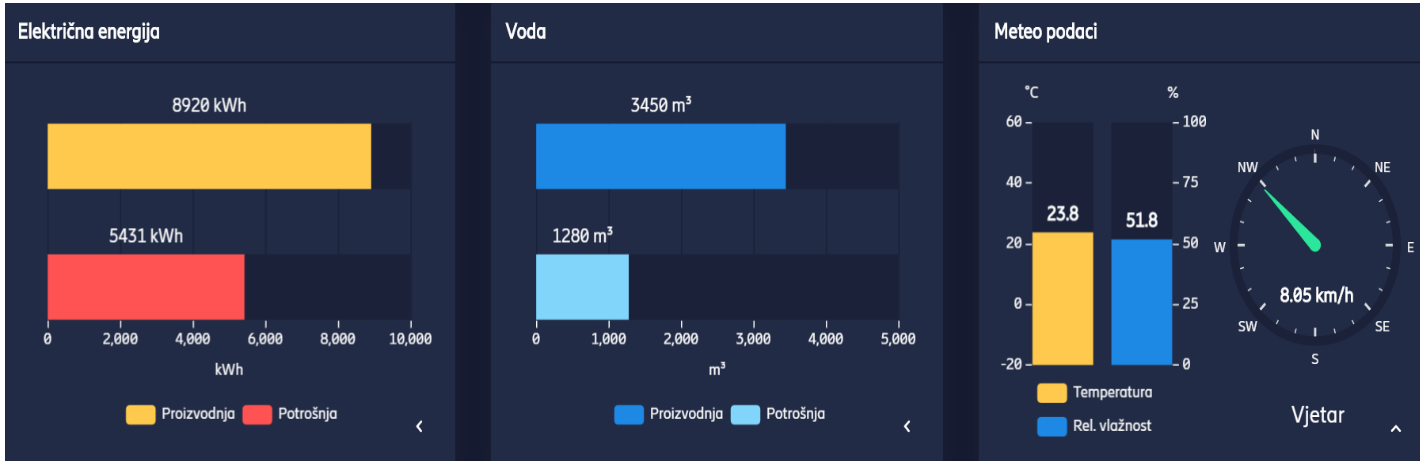
Utilization of IoT, 5G and blockchain

- 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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Acknowledgement

This work has been supported by the Young Researchers' Career Development Programme (DOK-01-2018) of Croatian Science Foundation which is financed by European Union from European Social Fund and Horizon 2020 project INSULAE - Maximizing the impact of innovative energy approaches in the EU islands (Grant number ID: 824433).

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