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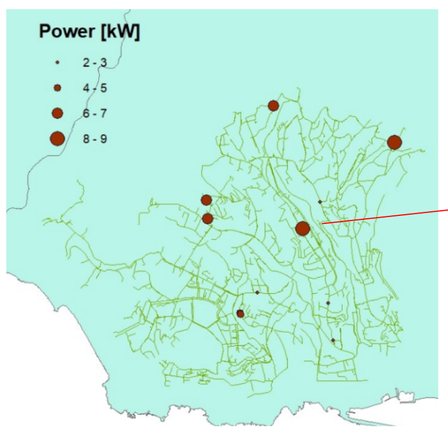
Hydropower energy recovery potential of water distribution networks: Assessing the correlation between the potential and geographical data

Introduction

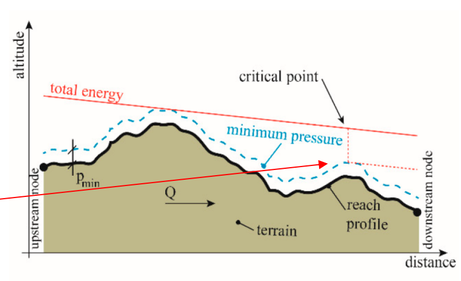
The inefficient consumption of energy in water distribution networks is a well-known problem and one that has been addressed by numerous researchers to date. There are known locations in water distribution networks (WDNs) with excess pressures, where energy is purposely dissipated by using special infrastructure such as break pressure tanks (BPTs) or pressure reducing valves (PRVs), in order to prevent pipes bursting and reduce water leakage losses. One of the solutions to reducing the energy dependency of WDNs is by recovering a portion of this dissipated energy wasted at locations of excess pressure, through the implementation of micro hydropower technology (MHP).

Concept

Water distribution network



Reach with excess pressure

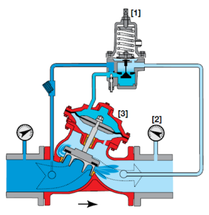


Reducing excess of pressure

Possible alternative: recovering energy using micro-hydropower technology

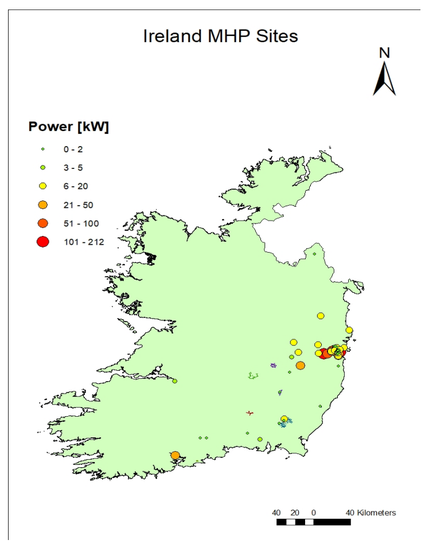
Current solution: dissipating energy using PRV

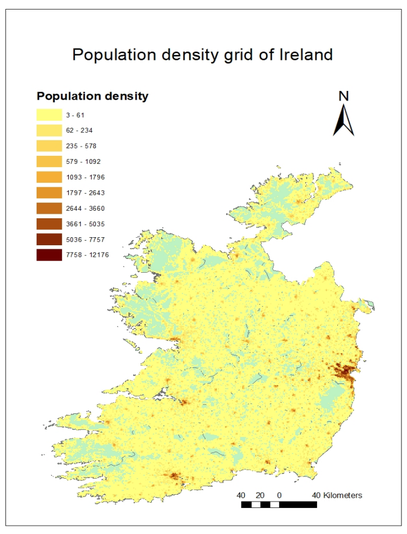
$$Power = \rho g Q H \eta$$

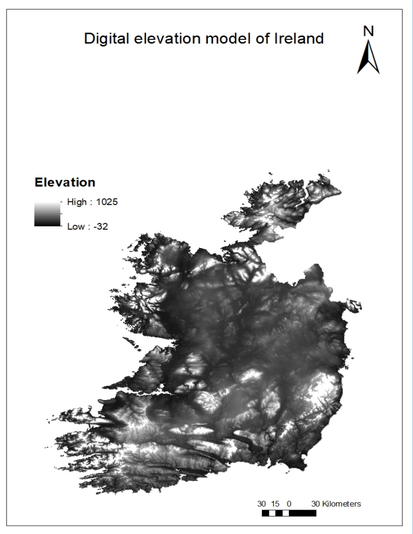


- Recovering a part of wasted energy
- MHP turbine or PAT can be implemented in a WDN without affecting the quality of service
- The best locations are for installation are already known → locations of PRVs, BPTs and inlets or outlets of SRs
- The potential is bigger in networks situated on terrain with big slopes

Resource







- Locations of networks with excess of pressure, with flow and pressure data → in general these are locations of existing water network infrastructure such as PRVs, BPTs and inlets and outlets of SRs
- Population density grid with cell size of 1x1 km^2
- Digital elevation models with cells size of 30x30 km^2

Results

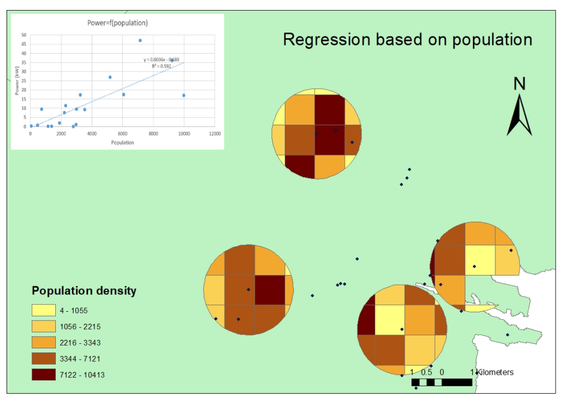
Ireland

- 51 potential sites
- 33 sites with Power > 2kW
- Total potential 1043 kW

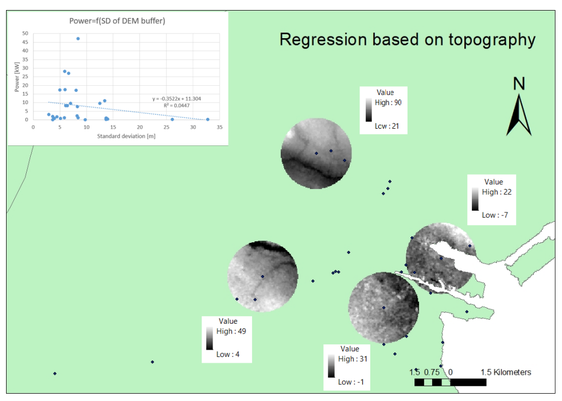
Wales

- 187 potential sites
- 95 sites with Power > 2kW
- Total potential 1167 kW

Spatial analysis using GIS



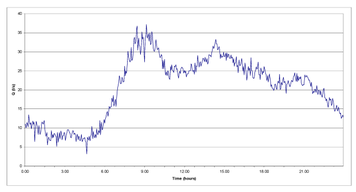
Ireland → R^2=59.2% subset of 18 PRVs
Wales → R^2<5%



Ireland → no meaningful correlation
Wales → no meaningful correlation

Challenges

- Flow control → turbines or PATs work with the best efficiency (η) when the flow is constant. WDNs are characterized with the big flow variability
- How to use generated electricity? On site or to sell to the grid
- Exploitation of sites with small potential → PAT technology, less efficient than the conventional turbine but much cheaper, makes these site economically viable
- Estimating the potential of a wider geographical coverage e.g. Europe→ network data is not available for a big part of the coverage → the need for an extrapolation methodology



Conclusion

Topography of the network usually dictates its excess of pressure and consequently the potential for this type of technology. The same magnitude of importance for this type of potential has the size of the network i.e. number of people for whom the network is designed.
Using the spatial analysis the correlation between the population density in proximity to the sites and the power potential of sites is found with R^2=59.2% for a subset of PRVs in Ireland. On the other hand the same analysis in Wales did not show almost any correlation with the population density. Also the spatial analysis of the topography in proximity to sites did not show any meaningful correlation with the power potential of sites neither in Ireland nor in Wales.

The REDAWN project is aimed at improving the energy efficiency in the pipe networks across irrigation, public water supply, process industry and waste-water networks setting in the Atlantic Area. The present research has been supported by the ERDF Interreg Atlantic Area Programme 2014-2020.

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REDAWN
Reducing Energy Dependency in Atlantic area Water Networks