Heat Map Construction for Storage integration in the Distribution Network of the Isle-of-Wight

Vahid Vahidinasab[1,✉], Adib Allahham[1], Damian Giaouris[1], Haris Patsios[1], Phil Taylor[1], Jim Fawcett[2]

[1]School of Engineering, Newcastle University, UK

[2]Department of Energy, Isle of Wight Council, Newport, UK

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Summary

The integration of renewable energy resources (RESs) is attractive worldwide, however their intermittent nature limits their expansion. Because of this intermittency, a number of RD and industrial activities have been carried, and the inteGRIDy is one of them.

The Integrated smart GRID cross- functional solutions for optimized synergetic energy distribution, utilization storage technologies (inteGRIDy) project, a H2020 project funded by European commission, aims to integrate cutting-edge technologies, solutions and mechanisms in a scalable Cross-Functional modular platform (CMP).

The major challenges Europe faces in the coming decades are to smarten the distribution grid with improved control and automation systems. Some key elements to achieve smart networks are: demand response (DR) (including energy efficiency, demand shifting and shaving), energy storage systems (ESSs), Renewable energy resources (RERs) integration, and energy management.

The aim of this work is to present the methodology used to construct the heat map of the distribution network in the Isle of Wight (IoW). The main usage of the resulted heat map is to assess the voltage and power flow constraints of the renewable integrated distribution network in IoW and accordingly decide on the integration of ESSs to solve the technical issues of that grid.

Overview of the Isle of Wight Network

Isle of Wight is supplied from the mainland by three subsea interconnectors and distribute power through 132/33kV primary substations.

Primary power distribution on the Isle of Wight is affected at 33kV, via nine primary substations and an associated distribution network comprising predominantly overhead lines in rural areas and on the outskirts of built-up areas, with a small extent of underground cabling to terminal connections located within built-up areas. Additionally, there are three further substations under Network Rail ownership, supplying the island railway electrical traction system from the 33kV network.
The island 33kV network is supplied from Wootton Common 132kV / 33kV substation and from East Cowes 132kV / 33kV substation, with an additional contribution from the Arreton combined heat and power plant.

The 33kV distribution network is normally operated with all circuits in service and with all elements interconnected, with the exception of the bus section switch at Sandown substation busbar, which is normally kept open, and would only be closed during abnormal network operating conditions.

Results

Power flow limits in January 2017

The analysis of the heat map reflecting the measurement in January 2017 shows that:
Newport substation was loaded by 45-50% of its rated capacity in winter.
One of the transformers in the primary substation in East Cowes was loaded by 87% of its rated capacity in winter. The other transformers in the substation were loaded less than 40% of their rated capacity in winter.
All the branches and substations in the distribution network at 33 kV and 11 kV are loaded less than 45% of their rated capacity in winter. Only two exceptions were found: Sandown village showed the highest demand in January 2017, which was around 60% of the rated capacity of the substation supplying Sandown. Furthermore, Cowes village showed the second highest demand which was around 50% of the rated capacity of the (33/11 kV) substation supplying Cowes.
The demand of the West Wight area, served by Freshwater and Shalfleet substations, was respectively 35% and 25% of the rated capacity of the substations.

Buses' voltage Limits

The buses' voltage is calculated using the model of the distribution network. The simulation was done using IPSA power software. From the heat map of buses' voltage, it can be seen that:
The range of the buses' voltage in January 2017 was 0.956 - 1.04 p.u. This means that minimum voltage at some buses was less than their nominal voltage by 4.4%. The maximum voltage at some buses was more than the nominal voltage by 4%.
The range of the buses' voltage in August 2017 was 0.961 - 1.04 p.u. This means that minimum voltage at some buses was less than their nominal voltage by 3.9 %. The maximum voltage at some buses was more than the nominal voltage by 4%.

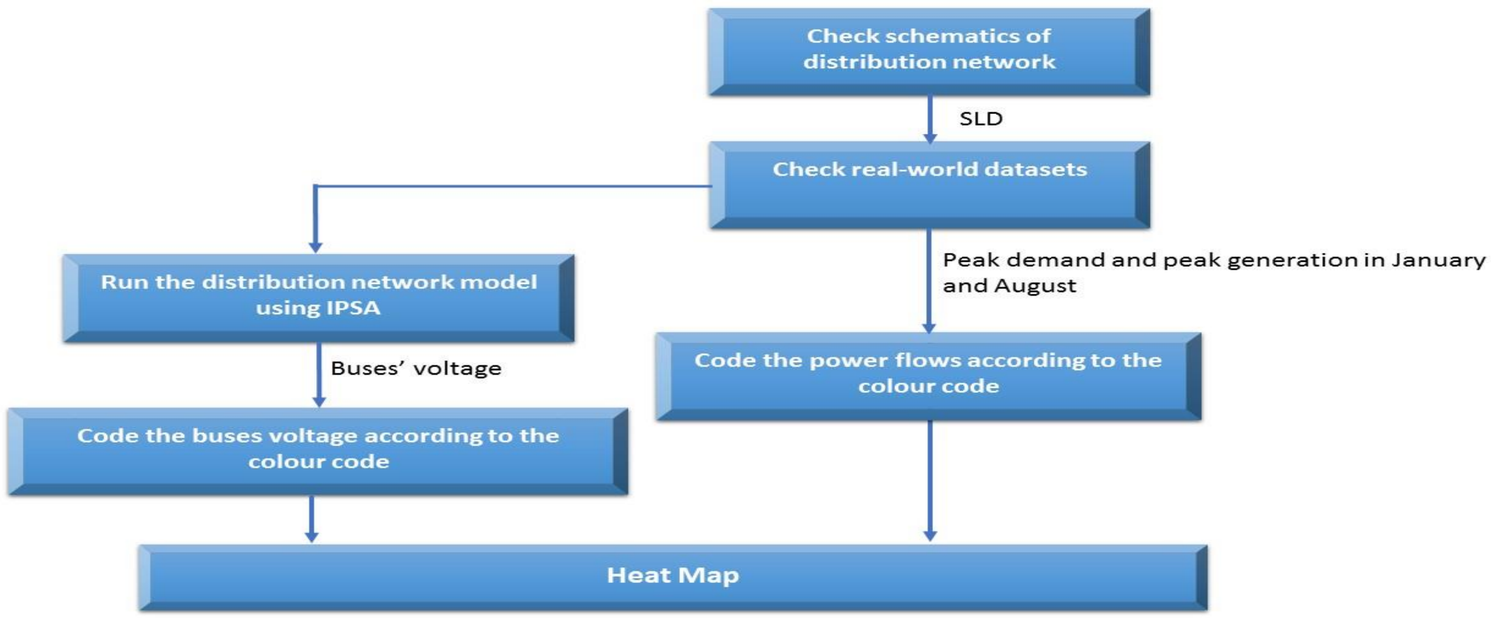
Power flow limits in August 2017

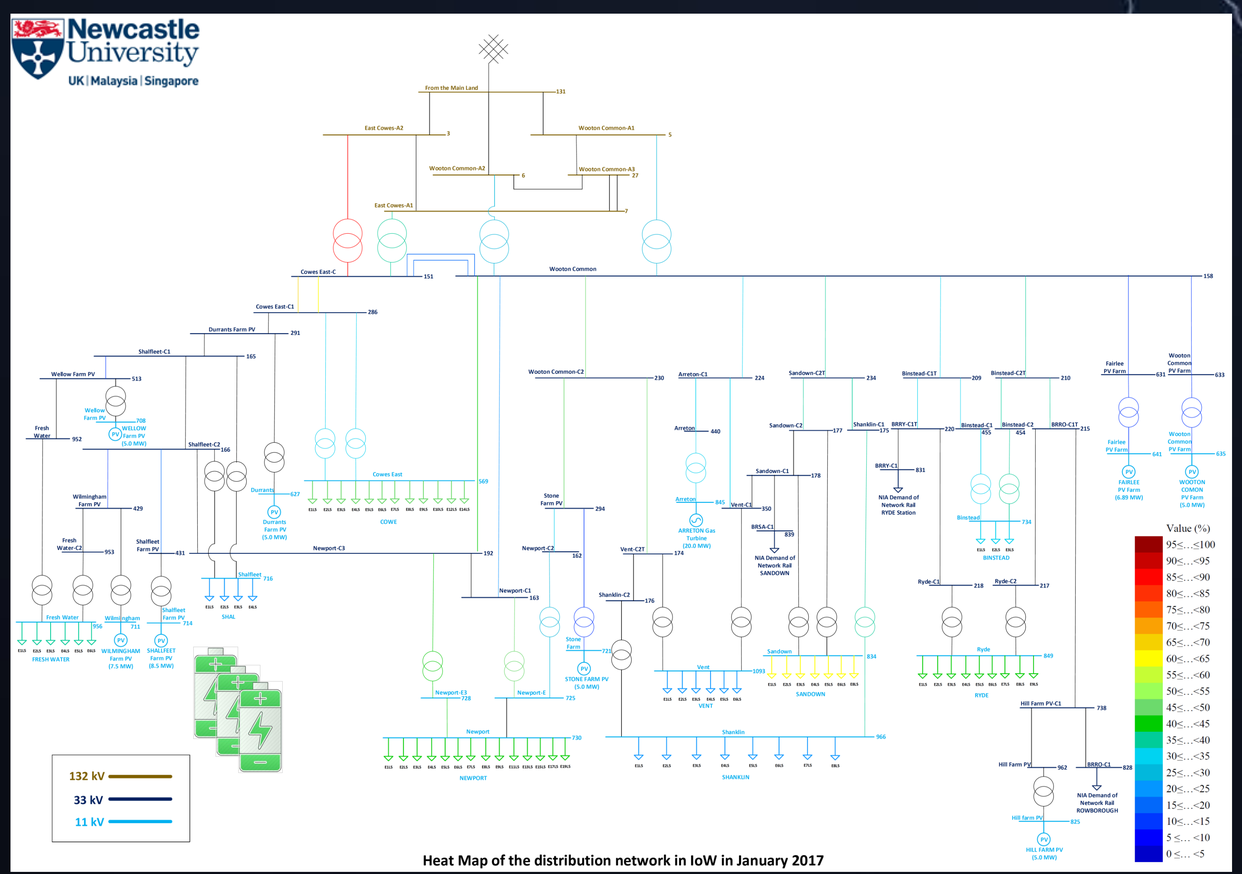
The analysis of the heat map reflecting the measurement in August 2017 shows that:
The transformers in Newport substation were loaded differently. The first, second and third transformers were loaded by 45-50%, 40-45%, and 20% respectively, of their rated capacity.
The transformers in Wootton Common substation were loaded in the range 75% - 90% of their capacity in summer, which is less than their rated capacity. The transformers of East Cowes substation were loaded around 50% of their capacity in summer.
All the branches are loaded less than 50% of their rated capacity in summer, with the exception of the interconnectors linking the secondary bus of Wotton Commons substation and the distribution buses "Wooton Common-C2" and "Arreton-C1". These two interconnectors were loaded by 76% and 64% respectively.
The demand on Freshwater and Shalfleet substations (serving the West Wight villages) was respectively 25% and 17% of the substation rated capacity.

Conclusions

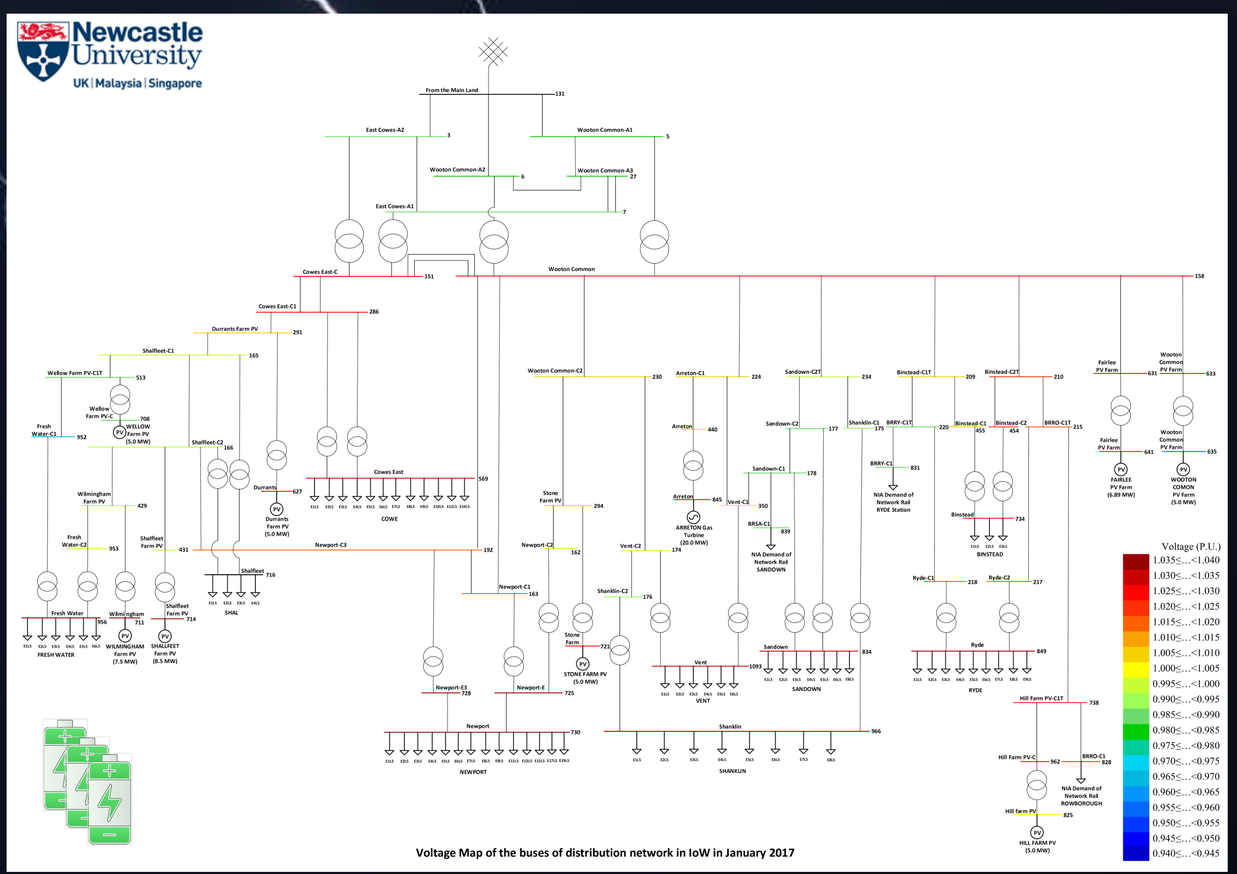
This report presented the model of the distribution network in the Isle of Wight and the analysis results of the heat map of this network. This heat map helps to define the ranges of power flow and buses voltage during the highest demand month (January 2017) and highest generation month (August 2017). It was concluded that the demand of the West Wight area, served by Freshwater and Shalfleet substations, was respectively 35% and 25% of the rated capacity of the substations in January, and 25% and 17% of the substation rated capacity in August. This observation shows that additional loads can be added to the West Wight area for decarbonising this part of Isle of Wight. The details of the decarbonisation scenarios and the potential additional loads to be added to the network will be presented in the deliverable "D9.4 – Demand Response Strategies" of EAC project.

Methodology of Heat Map Construction





Heat Map of the distribution network in IoW in January 2017



Voltage Map of the buses of distribution network in IoW in January 2017