Initiative Title: Net Zero Terrace

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Executive Summary

1. Northern Powergrid (NPg) have been asked to contribute to the discovery phase of the Net Zero Terrace innovation project. This is a Strategic Innovation Fund (SIF) project led by Electricity North West Limited (ENWL) and supported by other partners including Buro Happold and Rossendale Borough Council. The aim of the project is to decarbonise a row of terrace properties by installing a Smart Local Energy System (SLES).
2. NPg will benchmark the project and provide technical feedback from the perspective of another Distribution Network Operator (DNO). This feedback will support the project by ensuring any technical solution can be replicated across the UK. Findings from the project may also be used to develop technical policy around Low Carbon Technologies (LCTs) which will support the decarbonisation of heat.

Initiative overview

3. The scheme will seek to install an individual Ground Source Heat Pump (GSHP)[1] at each property on a row of terraced properties which are all connected via a shared ambient loop (5th generation) heating system.

4. A shared Solar Photovoltaic (PV) array will be installed across the rooftops. This community owned energy can either be used to supply the homes at a discounted rate via a Power Purchase Agreement (PPA) or to export into the distribution system via wholesale and flexibility markets.

5. The counterfactual to the proposed GSHP installation would be Electric Boilers installed in each property. Electric boilers can have a significant impact on the distribution system as the peak electrical demand can be higher than that of a GSHP. For a cluster of properties this could result in additional distribution system reinforcement in comparison to a cluster of GSHPs.

Technical overview

6. The proposed SLES will replace the existing gas heating system in a row of existing terraced properties which are supplied from the Low Voltage (LV) distribution system. Having reviewed the ENWL Discovery Phase report, this document will highlight the similarities and any differences in ENWL and NPg design approach to this type of

[1] 6kW Kensa shoebox GSHPs will be installed at each property.

connection. This will provide a view as to whether the proposed SLES can be replicated in another DNO licence area.

7. As neighbouring DNOs there are many similarities between the ENWL and NPg distribution systems. The distribution systems use similarly rated substations, cables, and other distribution equipment. The ENWL busbar voltage is set at 415V/240V compared to 400V/230V for Northern Powergrid, however both systems are designed to the limits 400V/230V plus 10% and minus 6%.

8. NPg and ENWL are guided by the same Engineering Recommendations (ERs) therefore the summary within the Discovery Phase Report for generation under ERG98 and ERG99 also applies to Northern Powergrid.

9. NPg and ENWL use similar design tools[2] to assess electricity distribution systems and correctly size electrical infrastructure such as cables and transformers in order to support customer demand and generation. Using existing technical policy a NPg designer would follow the same methodology as an ENWL designer and install a new substation to support the additional GSHP demand.

Variations in Technical Policy

10. As NPg are benchmarking the ENWL proposal it is important that differences in design policy are considered, and any variations that may impact the successful replication of the proposal highlighted. In some instances, this may result in modification to existing design policy to allow the proposal to be installed in its current form. The differences are highlighted below.

11. **After Diversity Maximum Demand (ADMD)** – Northern Powergrid and ENWL use alternative methods to assess the diversified demand for a residential property or a cluster of residential properties. These demands are used as part of the technical assessment to correctly size the distribution system to support the requested demand or generation. Table 1 shows the values that ENWL and NPg use to determine the ADMD of residential properties.[3]

12. For the Counterfactual – Table 2 shows a total electric boiler demand of 424.2kW for ENWL and a total electric boiler demand of 1130kW for NPg. This difference would result in significantly more reinforcement by NPg to support the electric boiler demand.

13. For the GSHP proposal – Table 3 shows a total GSHP demand of 515.66kW for ENWL and a total GSHP demand of 341.7kW for NPg. NPg estimated demand is lower in this instance. This difference could result in ENWL carrying out additional distribution system reinforcement compared to a scheme in the NPg licence area.

[2] An excel based spreadsheet method for assessing LV distribution systems and the DINIS application for assessing HV and EHV distribution systems.

[3] Typically these values are historic and can be based on innovation projects unique to the host DNO.

	ADMD Per Customer (kW)			
Property Type	ENWL Day	NPg Day[4]	ENWL Night	ENWL Day
Small Non-Electric Non-Detatched	1.0	$4.6n^{-0.22}$	0.4	$4.6n^{-0.22}$
Non-Electric Detatched	1.4	$4.6n^{-0.22}$	0.6	$4.6n^{-0.22}$
Electric Heating	3.4	1kW + 100% of installed load	2.4	1kW + 100% of installed load
Heat Pump (HP	Values as Per ENA EREC P5	$6.093n^{-0.25}$	Values as Per ENA EREC P5	$6.093n^{-0.25}$

Table 1 – ADMD comparison for ENWL and NPg

	ENWL				NPg	
LV Feeder	No. of Houses	ADMD per house (kW)	Loss of Diversity (kW)	Group Demand (kW)	ADMD per house (kW)	Group Demand (kW)
Bankside Ln Way 3	10	3.4	8.00	42.0	10.0	100.0
Underbank Cl Way 6	84	3.4	8.00	293.6	10.0	840.0
Underbank Cl Way 5	4	3.4	8.00	21.6	10.0	40.0
Boston Rd Way 6	14	3.4	8.00	55.6	10.0	140.0
Boston Rd Way 4	1	3.4	8.00	11.4	10.0	10.0
				424.2		**1130.0**

Table 2 – ADMD comparison for ENWL and NPg for Counterfactual Proposal

[4] Where n is the nth customer being considered.

		ENWL						NPg	
LV Feeder	**No. of GSHP's**	**ADMD (kW)**	**Group Demand (kW)**	**ADMD (kW)**	**Group Demand (kW)**	**Loss of Diversity (kW)**	**Total**	**ADMD (kW)**	**Group Demand (kW)**
Bankside Ln Way 3	10	3.09	36.59	4.65	55.04	8.00	63.04	4.22	42.2
Underbank Cl Way 6	84	2.04	209.51	3.04	315.12	8.00	323.12	2.60	218.3
Underbank Cl Way 5	4	3.71	16.81	5.59	25.29	8.00	33.29	5.03	20.1
Boston Rd Way 6	14	2.89	48.43	4.35	72.84	8.00	80.84	3.93	55.0
Boston Rd Way 4	1	4.90	4.90	7.37	7.37	8.00	15.37	6.10	6.1
							515.66		**341.7**

Table 3 – ADMD comparison for ENWL and NPg for GSHP proposal

14. **Minimum demand –** Northern Powergrid use a fixed figure of 0.3kW per property as the minimum demand when assessing distributed generation. This varies from the ENWL calculated minimum demand but the difference is negligible.

15. **Secondary supplies** – the proposal wishes to connect the solar array through either a private wire arrangement into individual properties or through a single array to the communal heat source. Under existing NPg policy both options would not be considered as there would be a risk of interconnection with existing supplies. NPG consider the private wire option at risk of breaching the existing Electricity, Safety and Quality (ESQCR) regulations. This could be done through offering a single point of supply for the whole street through a single connection, however this may complicate the billing arrangement for the existing properties. An additional risk could be full export from the PV array through a single connection due to fault on the customer's side. Controls would be required to mitigate this risk.

16. The single array option may be a viable option however the connection arrangement would need to be considered to ensure any risk related to interconnection and earthing was mitigated. This would require a change to existing NPg technical policy.
17. **Minimum demand –** NPg generation studies base the minimum load on 0.3kW per property. This is a single value as opposed to the calculated ENWL value however the difference is negligible and would not affect the design assessment.
18. **Cold load pickup (CLPU) –** ENWL use a specific methodology to calculate demand and ensure the distribution system is able to support GSHP demand at times of CLPU[5]. Northern Powergrid assets are sized in order to mitigate the effect of CLPU however this approach may need to be revised as the volume of GSHPs on LV feeders increases.

Alpha Phase Proposals

19. There are several areas that could be considered as part of further learning through a real-world field trial of the SLES proposal. This would support efforts to refine DNO technical policy and increase the roll out of low carbon heating solutions through a possible reduction in reinforcement.
20. **Export Limitation –** could export from the solar array be limited and if so this may reduce the volume of reinforcement that is required to the distribution system? If this was a single PV array could battery storage be installed at a single point to import from the PV array and remove the requirement to export to the distribution system?
21. **ADMD –** could monitoring be installed in the distribution substation and at the individual properties to measure demand on the distribution system? This could be used as a guide to revise the existing ADMD figures and improve the accuracy of the figures currently in use by both DNOs. LV monitoring could also be used to assess the maximum and minimum demands on the distribution system pre and post installation of the GSHPs. This would guide future decarbonising schemes when considering clustered PV and GSHP installations.
22. **Multiple points of supply –** a risk assessments could be carried out to identify the main issues arising from multiple points of supply and efforts taken to mitigate any risks.
23. **Cold Load Pickup –** if random timers can be installed in the GSHP by the manufacturer this could remove the requirement for a designer to consider the effect of CLPU when planning a LV distribution system. This could remove the element of reinforcement initiated by the effect of CLPU.
24. **Design considerations –** if the impact of the GSHPs and PV array is lower than that predicted by ADMD assessments it may be that new design methodologies can be employed for future schemes. This may reduce the requirement for reinforcement and allow alternative lower cost, time efficient connection methods to be employed, e.g. the

[5] Cold Load Pickup is the effect of multiple GSHPs starting together following an outage on the distribution system.

splitting of existing LV feeders to accommodate the additional demand and generation rather than installing a new distribution substation.

Conclusions

25. The technical proposal by ENWL is extremely competent and could be replicated in another DNO region. The one key issue that will need to be resolved is around the multiple points of supply, particular for a private wire solution. This can be resolved through open discussion and careful consideration of the SLES to be installed.