Possible Impact of Electrification of Heat and Transport on a Scottish Commuter Town: a Case Study

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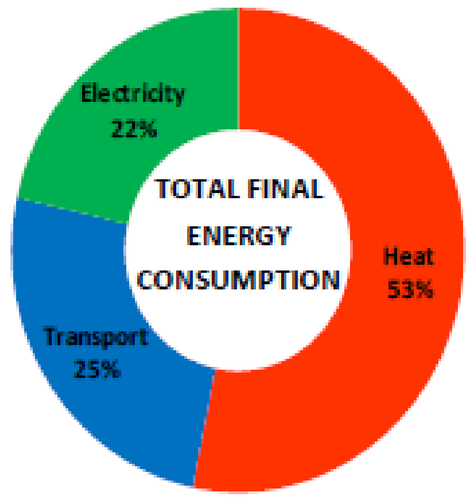
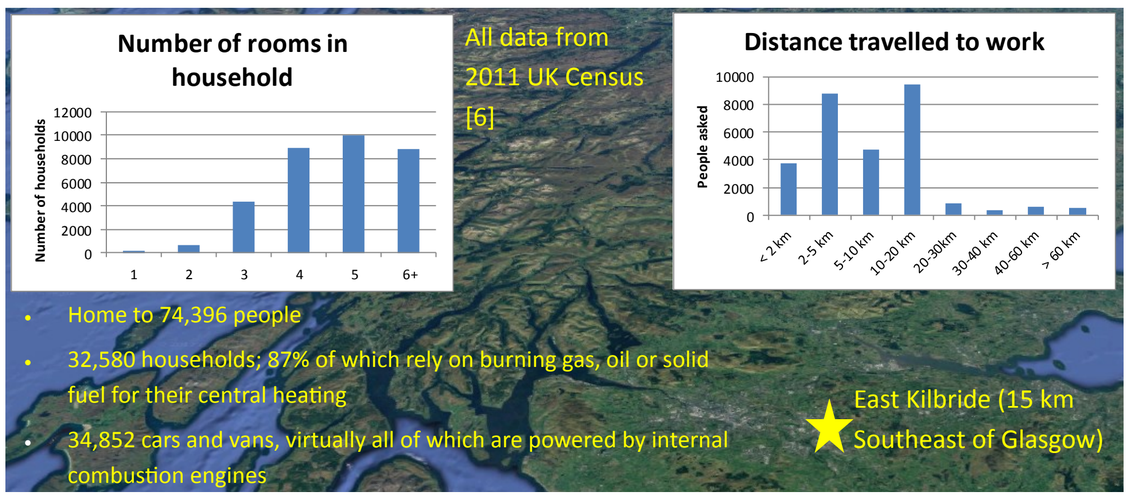
Motivation

- Heating and transport contribute 78% of Scotland's total final energy consumption [1].
- Out of a total 2.4 million Scottish homes, 1.9 million use gas or oil as their primary heating source [2].
- Two-thirds of those employed in Scotland at a place of work away from their homes use private cars to get to work [3], with petrol and diesel powered vehicles comprising over 98% of new registered vehicles in the UK [4].
- 54% of total electricity consumed in Scotland was generated renewably in 2016 [5] and the Scottish Government has targets to produce 100% of electricity consumed by renewable means by 2020 [1].
- The electrification of heating and transport via significant uptake of Electric Vehicles (EVs) and Heat Pumps (HPs) coupled with the continuing decarbonisation of the electricity sector is potentially the most cost-effective way of meeting emissions targets, but what is the impact of this on the electricity network?
- This study aims to quantify the likely additional load due to the electrification of heat and transport in East Kilbride, South Lanarkshire. To investigate the 'worst case', It is assumed that there is no restriction on the time of use of EVs and HPs for this study (i.e. no 'smart' controlled charging of EVs or aggregated demand management for heating).



Total Final Energy Consumption by sector in Scotland, 2014 [1]

East Kilbride, South Lanarkshire

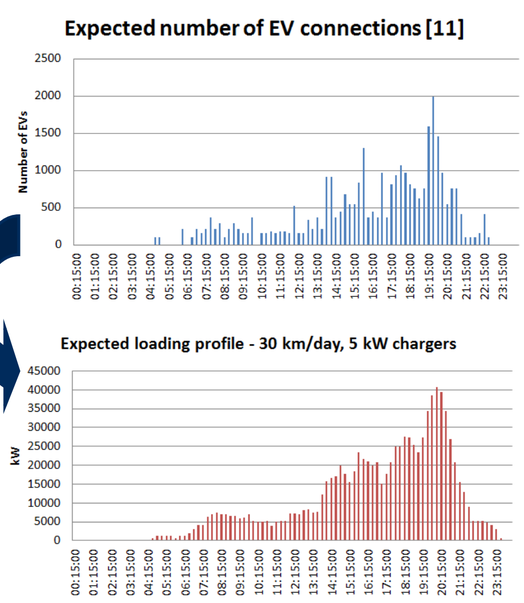


Heating: Parameters & Assumptions

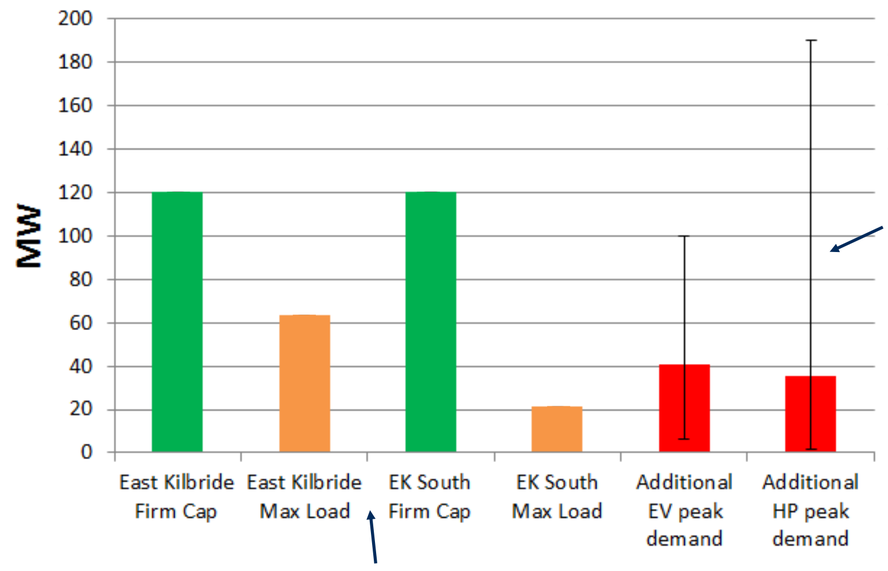
Parameter	Nominal	Lightly Loaded	Heavily Loaded	Reasoning
% Electrification	90%	20%	100%	National Grid's Two Degrees scenario assumes that Heat Pumps make up over 90% of heating by 2050 [7].
Avg. heating capacity	12 kW	5 kW	15 kW	Based on a typical 1 kW/10 m^2 heating requirement, 5 kW would be required for the average 1 bedroom flat and 15 kW would be required for the average 5 bedroom house using [8]
Avg. Coefficient of Performance	2.5	4	1.5	Heat pumps benefit from a COP of 3-4, but this can in practice fall to 2.5 in cold weather. Some electrified heating may be electric resistance heaters, which would have a COP of 1—however, the emphasis in [7] is on very high uptake of heat pumps.
Avg. diversity factor	3.5	4	1.5	[9] found the maximum demand after diversity of a 3 kW (electrical) heat pump to be 0.86 kW, giving a diversity factor ~3.5

Transport: Parameters & Assumptions

Parameter	Nominal	Lightly Loaded	Heavily Loaded	Reasoning
% Electrification	90%	20%	100%	National Grid's Two Degrees scenario assumes that EVs make up over 90% of cars by 2050 [7].
Distance travelled per day	30 km	20 km	60 km	Most people in East Kilbride travel less than 20 km to work (each way) according to Census data. The average distance travelled by car per day in England & Wales was 30 km in 2016 [10].
Avg. charger capacity	6 kW	3.5 kW	15 kW	Current chargers available in the UK are either 'slow' (3.5 kW) or 'fast' (7 kW). Based on a 80 A household fuse and smarter device usage, it is plausible that future chargers could reach 15 kW.
Charging frequency	Once per day	N/A	N/A	It is assumed that every EV user charges once per day, regardless of the battery's state of charge on return.
Charging probability distribution	*	N/A	N/A	*Taken from [11], which was based on real trial results from an Irish network operator.



Results: Additional Peak Demand



The expected additional peak demand for EVs and HPs is shown for the nominal case with error bars representing the 'lightly loaded' and 'heavily loaded' cases

For comparison, the firm capacity and current maximum load of the two Grid Supply Points (GSPs) serving East Kilbride – East Kilbride and East Kilbride South—are shown [12].

References

[1] Scottish Government, Energy in Scotland 2017, p26. https://goo.gl/kmp6Pe

[2] Scottish House Conditions Survey 2013. https://goo.gl/nBxkZe

[3] Transport and Travel in Scotland 2015. https://goo.gl/P9qdjJ

[4] Society of Motor Manufacturers and Traders, August 2017—EV Registrations. https://goo.gl/9skvL3

[5] Scottish Renewables (2017). Renewables in Numbers. https://goo.gl/NHv27H

[6] Infuse—UK 2011 Census Data. https://goo.gl/7RXBKD

[7] National Grid Future Energy Scenarios 2017. https://goo.gl/Rn8TE8

[8] Housing Standards (2008). Dwelling Size Survey. https://goo.gl/rrbvpT

[9] Energy Networks Association (2016). Distribution System 2030 Report Stages 4&5 p71. https://goo.gl/wT53Aa

[10] Great Britain Road Use Statistics 2016. https://goo.gl/UXeGse

[11] University of Manchester (2015). Modelling & Analysis of Representative Low Voltage Feeders for the My Electric Avenue Project. https://goo.gl/eKkwJ8

[12] SPEN DG Heatmap. https://goo.gl/Ss8AN3

Conclusion & Future Work

- For the nominal case, which is thought to represent the most likely, the capacity headroom on both GSPs can accommodate the additional peak demand brought about by the electrification of heat and transport in East Kilbride, so long as that loading is at least partially spread between the two GSPs.
- If the 'heavily loaded' case were to become reality, the additional peak demand would significantly outstrip the available thermal capacity of the GSPs.
- The impact of the electrification of heat and transport lower down the voltage levels (primary, secondary and LV circuits) should be examined, including the effect of 'clustering' of EVs and HPs on local grid infrastructure.

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