The Wider Hampshire Energy Landscape Mapping: Summary and Gap Analysis

Final report to Hampshire County Council's Climate Change Team

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Abstract

This report summarises the results of an MSc Dissertation project to map the current wider Hampshire energy landscape through case studies and data analysis. It synthesises the insights from the dissertation, conducts a wider gap analysis with respect to the energy related activities of Hampshire County Council's Climate change strategic framework of programmes and makes recommendations for future work.

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Executive Summary

This report summarises the results of an MSc Dissertation project to map the current wider Hampshire energy landscape through case studies and data analysis. It synthesises the insights from the dissertation and makes recommendations for future work.

The case study analysis suggested the need to:

- *Consider buildings as an extension of the energy system*
- *Consider the potential for neighbourhood heat networks*
- *Realise and capture the value of local energy systems for the local economy and its environmental context*
- *Understand that demand is dynamic*
- *Understand that markets do not (often) deliver equitably*
- *Focus on the value of measured energy use data*

The data analysis shows that in general overall energy use declined over the 2010-2018 period in the wider Hampshire area with the notable exception of energy for freight transport. However, there is considerable spatial variation in these trends at the district and local area levels, especially when gas and electricity use for domestic and non-domestic activities are considered.

Overall, in the context of the energy related activities of the Hampshire County Council Climate Change Strategic Framework for Programmes, the data analysis suggest the following knowledge gaps:

a) *The need to understand the relationship between domestic fuel poverty, housing quality and energy use at the local area (LSOA, OA or street) level as a basis for prioritising area-based retrofit programmes.*
b) *The need to understand the spatial and temporal distribution of energy-using activities both now and in a potentially 'smart' grid future.*
c) *The need to combine these analyses to understand the potential local distribution network implications of a phased and spatially heterogeneous transition to low-carbon heat in both domestic and non-domestic buildings.*

Finally the gap analysis also recommends:

d) *The need to further explore the local potential for renewable electricity generation in the wider Hampshire area to increase the 3% per annum growth ambition*
e) *An assessment of the relative value of each source in a smart local energy system (ref a-c above)*

The report concludes with a table setting out a series of proposed next steps to fill these gaps.

Contents

1 Introduction

Hampshire County Council declared a Climate Emergency in June 2019 and have since set two targets for the County as a whole:

- To be carbon neutral by 2050
- To be resilient to the impacts of a 2°C temperature rise

It is becoming widely recognised that decarbonising national and local energy systems will be crucial to the successful achievement of targets such as these at both the national and local levels.

While some may be content to rely on national level action to, for example, reduce the carbon intensity of grid electricity to 0, it is becoming clear that local action will be necessary to achieve the rate of transition required (Devine-Wright 2019; Ford et al. 2021). This is particularly the case where local socio-economic conditions require locally-adapted policy and co-ordinated action to ensure local infrastructure resilience (Peacock and Owens 2013) and social inclusivity (Berka, MacArthur, and Gonnelli 2020). Further, it is also clear that this may be best achieved through local open energy systems that enable all 'community' stakeholders to participate in a full range of trading opportunities (Peacock et al. 2017; Parag and Sovacool 2016).

In addition to presenting a significant challenge, this transition also presents opportunities for local post-COVID 'green' investment in renewable energy and fabric-first energy efficiency retrofit. These in turn require skills capacity growth and provide wider socio-economic co-benefits such as improved air quality and associated health outcomes (Chapman et al. 2018).

Ensuring that these opportunities are realised through decarbonising national and local energy systems requires a systemic approach to a future energy strategy.

In order to further flesh out the energy related aspects of their Strategic Framework of Programmes, the Council therefore wished to carry out a review of the current and future energy landscape for the wider Hampshire area to establish:

- The current purpose, pattern and scale of energy supply, generation, distribution and use within the area;
- The extent to which underlying local environmental, social and economic trends have affected and will affect these patterns over time;
- The current and future policy themes and settings which are likely to affect these trends.

Based on this analysis, the Council then wished to develop a gap analysis as a basis for a future-looking energy strategy. This gap analysis would make **recommendations for future work packages** which would seek to understand where the opportunities might be for local action to:

- Reduce and de-carbonise industrial, commercial, public and residential energy use across the wider Hampshire area;
- Co-ordinate, attract and retain inward investment in sustainable, zero-carbon energy related commercial activity;
- Use energy related interventions to achieve outcomes and associated co-benefits defined in local and regional strategic action plans such as the HCC Climate Change Strategy, Green Recovery Roadmap and the Hampshire 2050 initiative.

Given the interconnected nature of the local energy eco-system and the relative arbitrariness of administrative boundaries, the wider Hampshire area is taken to include the County, the Isle of Wight and the cities of Southampton and Portsmouth.

As described below, in discussion with the Climate Change team within Hampshire County Council, the project sought to focus initial work on a selection of the topics described above. This addressed areas of knowledge that were identified as currently missing from the Council's analysis workstreams but were of significant interest.

This report summarises the results of this work, outlines the insights generated and provides a gap analysis describing potential future work to extend the analysis presented here and to widen the scope to the areas not initially included.

1.1 Mapping the wider Hampshire Energy Landscape

The wider Hampshire Energy Landscape comprises all aspects of energy generation, supply and use in the wider Hampshire area and represents an ad-hoc system integrating a wide array of energy sources that has evolved over time to reach its current state. A range of networks provide transport of fuels to intermediate and end users be they households, commercial, industrial or the public sector. Energy usage is therefore spatially distributed across the wider Hampshire area according to the current and, to some extent historical distribution of dwellings, commercial, industrial or public activities and mobility.

An integrated understanding of the scale of the energy flows through these networks and the extent to which elements of the system need to be reconfigured to deliver the Council's county-wide emissions reduction targets is an important baseline. This baseline would need to include at least:

- Import
    - Gas
    - Electricity
    - Vehicle and other liquid fossil fuels
    - Food
- Local energy sources
    - Solar
    - Wind
    - Hydro
    - Tidal/wave
    - Biomass and liquid biofuels
    - Future hydrogen
- Distribution
    - Gas, electricity and other fuel distribution networks
    - District heat networks
    - Transport networks for people and freight
- Use
    - Residential
    - Non-residential – including commercial, industrial, public or agricultural uses
    - Mobility

However, such a 'whole system' mapping is an extremely large undertaking considered beyond the scope of the MSc project dissertation that formed the core of this initial work. In order to avoid replication of work that was already being undertaken the project opted to concentrate in the first instance on two strands:

- Reviewing the energy related actions of the Hampshire Climate Change Strategic Framework of Programmes in the context of case studies of similar activities being undertaken elsewhere
- Describing recent trends in the spatial distribution of domestic and non-domestic energy use with an initial focus on gas and electricity

The remainder of this report summarises the results of this analysis and discusses the key insights that emerged. It then presents an analysis of key knowledge gaps as a guide to future work.

2 Summary of project results

This section summarises the main themes of the MSc dissertation that formed the core of this work[1] and highlights the implications for the energy related actions of the Hampshire Climate Change Strategic Framework.

2.1 Strategic Framework – learning from others

Hampshire County Council's Climate Change Strategic Framework of Programmes[2] includes a range of actions which are directly and indirectly concerned with energy. These focus on:

- Decarbonising the energy used for mobility (via the *Transport* theme);
- Decarbonising the energy used for domestic and non-domestic heat/cool and hot water at the same time as reducing overall demand for energy via fabric-first energy efficiency retrofit and exacting new-build standards (*Residential* and *Buildings/Infrastructure* themes);
- Increasing the level of within-County renewable generation with a stated interest in solar photovoltaics (PV) and on-shore wind; provision via community enterprises and/or an Energy Innovation Zone to deliver novel biomass or hydrogen-based energy sources (*Energy Generation and Distribution* theme);
- Energy efficiency interventions and low-emissions energy economic opportunities (*Business & Green Economy* themes).

In this context two programmes covering similar areas were reviewed: the Bristol 'Smart Energy City[3]' and the Oxfordshire-based Project LEO (Localised Energy Oxford[4]).

2.1.1 Bristol's Smart Energy City

In 2015, Bristol launched a 'Smart Energy City' programme including a 'Bristol Smart Energy City Collaboration' which identified five key objectives:

1. A 'fine-grained' mapping of the city's energy system to enhance planning and operational capabilities.
2. Curbing energy waste and peak demand
3. Enhancing the value of renewable electricity generated in or near the city
4. Smart energy data and interventions to tackle cold homes/fuel poverty

[1] See (Meghan Kingsley-Walsh 2021)
[2] https://documents.hants.gov.uk/climate-change/ClimateChange-Strategic-Framework-of-Programmes.pdf
[3] https://www.cse.org.uk/projects/view/1296
[4] https://project-leo.co.uk/

5. Ensuring the economic & co-benefits of a smarter energy city stay in the city

The first of these maps to the rationale that underpins this report (see Section 1.1 Mapping the wider Hampshire Energy Landscape) but is not explicit in the Hampshire Climate Change Strategic Framework (HCCSF).

Although the second objective maps to the generic HCCSF energy efficiency activities, the HCCSF does not mention the timing of (peak) energy demand either in the context of energy use (demand side) or in the context of distribution or generation (supply side). Although mention is made of potentially constrained local electricity networks, especially under expected growth in electricity demand for heat and transport, the relationship between local generation, energy efficiency and mediation of peak demand could be more fully developed.

The third objective explicitly captures the value of locally generated electricity in locally balancing demand and could be generalised to the local provision of energy per se. This would enhance resilience to future climate disruption and ameliorate capacity problems on all forms of distribution networks whether for electricity, gaseous (e.g. hydrogen) or liquid (e.g. biofuels) fuels. This objective also includes the capture of the economic benefits of localised energy production which maps to the HCCSF Energy Innovation Zone and local/community energy economy activities.

The fourth objective explicitly links the use of smart (meter) data to energy efficient new-build or interventions in retrofit to ensure low-emissions comfort can be achieved. This would ensure that actual energy demand reductions and thus emissions reductions can be traced and the extent of 'rebound' or 'take-back' can be assessed. This will, in turn ensure that the measures taken have real known effects rather than modelled and presumed effects as would be the case with a reliance on Energy Performance Certificates and ratings as key success metrics[5]. This implies that the HCCSF energy efficiency activities may need to address the difficulty of accessing building/dwelling-level smart meter data and ensure that a programme avoids using counts of EPC band upgrades as success criteria.

Finally, the fifth objective frames the Smart Energy city in terms of capturing the social and economic benefits of the transition for the city. In the case of HCCSF this is an explicit reference to ensuring that economic, social, health and other co-benefits are largely captured *within* the Hampshire region. Quite how this would work in practice is unclear but it maps to the HCCSF interest in supporting local community energy enterprises and SMEs in the local low-emissions energy economy. However, the lens also needs to be applied to future Energy Innovation Zone activities and to potential investment in the region by organisations and corporations based outside it. This will be key to avoiding the transfer of significant financial benefits out of the region.

In addition to these relevant objectives, the collaboration also developed a process model of change which captures '*doing'* (things to do for action now), '*preparing'* (things to do now to prepare for action and impact in 1-2 years) and '*exploring'* (creating conditions that make impact possible in the future).

By doing this the City has set measurable targets at each stage with the '*exploring'* and '*preparing'* activities constantly evolving in the background of the current '*doing'* action. Specific activities that emerge through '*exploring'* are then brought through the stages to

[5] See also https://www.passivhaustrust.org.uk/guidance_detail.php?gId=44 for an explanation of why EPC 'Energy Efficiency Ratings' are not (currently) useful as emissions reduction targets.

show a continuous pipeline of delivery actions. Crucial to this is a funnelling process which enables some '*explore'* feasibility studies to 'fail' in the sense that they are filtered out on a range of 'value' dimensions. Although the HCCSF gives some temporality in terms of 'Milestones 2020-2025' and 'Longer term (2015-2050) steps and considerations', the Bristol model suggests that the HCCSF could be usefully recast and communicated in terms of these three stages. This would allow '*doing'* actions and their dependencies to be made clear, the '*preparing'* actions to be explained and the '*explore'* actions to be opened for early discussion and consultation. It would also help to ensure that sufficient resource, whether within the Council or outsourced, is available at each stage to ensure both a constant '*exploring'* activity and a pipeline towards delivery for the activities that move through the stages. It would also enable the communication of which actions under which (current) stage are anticipated to produce the largest impacts, and give gradually strengthening signals to industry of the most likely future policy settings.

2.1.2 Project LEO

In contrast to the Bristol Smart City project, Project LEO is a funded research and development programme intended to run a range of energy infrastructure trials to test the feasibility of a decentralised local energy system. The project's aims are to:

- Test the model: Explore the use of new products and services and look at how these can be used to provide more local economic opportunities and benefit the whole community.
- Improve the capability of the networks to implement new smart, renewable and storage technologies: Identify potential sticking points and developing a strong model of what needs to happen to allow the smooth and successful integration of these new technologies.

These objectives map strongly to the HCCSF interest in developing local energy generation and a local low-emissions energy economy. They also map to the need to mitigate potential distribution network constraints in the face of increased energy demand. This is a recognised risk in an 'all electric' future and local energy systems, which attempt to locally balance demand and supply 'behind the grid access point' are a proposed solution (Ford et al. 2021). This may avoid capital intensive distribution network upgrades and also reduce the need for capital intensive grid scale generation capacity.

While Project LEO trials are ongoing, specific insights from the programme to date include:

- **The need to keep local energy plans under constant review given potentially rapid socio-technical (and policy landscape) change** – this maps to the Bristol model of activity planning;
- **The need to consider energy demand as dynamic and co-produced by an interaction between users and infrastructures** – current levels of 'demand' are not given and future trends are not easily predicted. This means that designing in flexibility and co-designing any local energy system with infrastructure providers and end users is crucial;
- **The need (as with Bristol) to realise and capture the value of local energy systems for the local economy and its environmental context** - mapping to the HCCSF interest in a local and potentially community-driven and co-instantiated energy economy;

- **The 'market' may not adequately provide services in a socially equitable manner**. There will be winners and losers under 'smart systems' and some of the losers may well be those who are least able to adapt, are marginalised or lack the economic, social or knowledge capitals to participate. Systems need to be designed to ensure a Just Transition and this may mean less focus on financial incentives and more on social or normative incentives as well as providing services that provide 'layers' between the 'smart system' and the daily habits of end users[6].

With Project LEO trials that explore or test these insights in 'real' settings about to commence, the results of the project are likely to offer both 'recipes for success' and 'cautions' that the HCCSF can build into future '*preparing'* activities. This is particularly true of the 'Smart and Fair Neighbourhood (SFN)' trials which will be used to explore the impact of decentralised energy systems on individuals and communities to understand how they can be equitable and fair for everyone. This maps to the HCCSF's key principle of 'Proportionate, Affordable, Equitable'.

2.2 Overall energy use in the wider Hampshire area

This section summarises the analysis of non-spatial district energy use data.

2.2.1 All energy use

Overall energy use in the wider Hampshire area is shown in Table 1. The data summarises all energy used for domestic and non-domestic place-based purposes as well as energy used for personal and freight transport. The table shows an overall 7% decrease in energy use with larger decreases in some districts (New Forest, -11%) and 0% change in Hart.

Table 1: Overall energy use 2010-2018 (Source: BEIS)

Local Authority	*Total energy usage (GWh) 2010*	*Total energy usage (GWh) 2018*	*The difference in total energy usage (GWh) from 2010 to 2018*	*Percentage difference in total energy usage from 2010 to 2018*
Basingstoke and Deane	4670.2	4409.3	-260.9	-6%
East Hampshire	3009	2811.6	-197.4	-7%
Eastleigh	2670.9	2562	-108.9	-4%
Fareham	2247.8	2210.8	-37	-2%
Gosport	1106.9	1027.7	-79.2	-7%
Hart	2166.3	2167.1	0.8	0%
Havant	2024.8	1924.4	-100.4	-5%
Isle of Wight	2588.2	2425.5	-162.7	-6%
New Forest	18100.6	16142	-1958.6	-11%
Portsmouth	3790.4	3505.9	-284.5	-8%
Rushmoor	1795.2	1654	-141.2	-8%
Southampton	3757.5	3432.6	-324.9	-9%
Test Valley	3489.9	3565.5	75.6	2%

[6] This is explored further at https://www.creds.ac.uk/who-needs-flexibility-anyway/

Winchester	3600.8	3522.4	-78.4	-2%
Total	***55,018.5***	***51,360.8***	***-3,657.7***	***-7%***

2.2.2 Gas and electricity use

At a more detailed level, Table 2 shows overall gas and electricity use in 2010 and 2019 for the wider Hampshire area. Domestic gas use is substantially higher than non-domestic gas use but the reverse is true for electricity. All measures have reduced over the period but non-domestic use has seen larger percentage reductions. The rates of change mean that the proportional difference between non-domestic and domestic gas use has increased slightly while the difference between domestic and non-domestic electricity use has decreased slightly. Over time as more energy uses become electrified we would expect gas use to fall to close to zero while electricity use will increase if energy efficiency measures are outweighed by increasing demands.

Table 2: Overall gas and electricity use (Source: BEIS, summed district level data)

		2010 (GWh)	*2019 (GWh)*	*% reduction*
Gas	Domestic	9,710	9,139	-6%
	Non-Domestic	3,955	3,547	-10%
	Non-domestic as % of domestic	41%	39%	
Electricity	Domestic	3,546	3,290	-7%
	Non-Domestic	5,029	4,555	-9%
	Non-domestic as % of domestic	142%	138%	

Notable district level changes over the period include:

- *Non-domestic gas use:*
  - Increases in Test Valley (29%) and Fareham (37%)
  - Decreases in Havant (-37%) and East Hampshire (-41%)
- *Domestic gas use:*
  - Decreases in Gosport (-11%) and Southampton (-11%)
- *Non-domestic electricity use:*
  - Decreases in Fareham (-24%) and Rushmoor (-22%)
  - Increase in Hart (52%)
- *Domestic electricity use:*
  - Decreases in Gosport (-11%) and Portsmouth (-11%)

To put these values into perspective, according to Carbon Trust calculations, total renewable ‘generation’ in Hampshire is currently 597 GWh. This represents just 8% of total electricity use in 2018 (7,845 GWh) implying that 92% of the wider Hampshire area’s electricity is therefore ‘imported’.

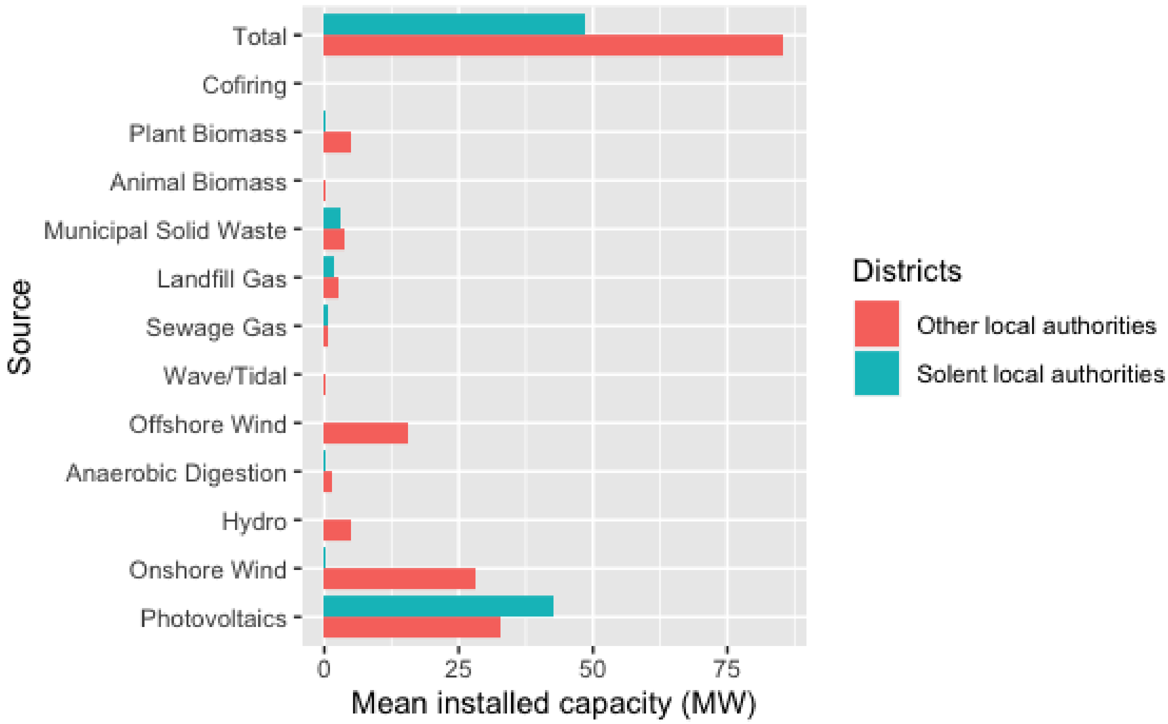

Figure 1:Installed capacity (mean MW per local authority district, 2020)

Local authority level data for 2020 estimates the total installed renewable electricity generation capacity of the wider Hampshire area to be 679 MW. Of this 75% is photovoltaics with 183 MW in Test Valley, 94 MW in Winchester and 92 MW in Isle of Wight districts[7]. Figure 1 shows the mean installed capacity of renewable electricity generation across the wider Hampshire districts compared to all other UK districts. Overall, the wider Hampshire districts have a lower mean installed renewable electricity generation capacity than others in the UK and this is particularly noticeable for both offshore and onshore wind. In contrast, photovoltaic capacity is slightly higher at 42 MW compared to 33 MW more widely.

2.2.3 Transport energy use

Data on energy used for transport is available at the local authority district level and is summed to the wider Hampshire area in Table 3. Overall, energy use by the transport sector has decreased by 7% from 2010 to 2018. However, the energy usage for freight transport increased by 53 TWh (15%) from 2010 to 2018 while energy use by the domestic transport sector decreased by a similar 51 TWh (6% reduction).

At the local authority level (not shown), freight transport energy use has increased by more than 10% in all districts except Eastleigh (4%) and Fareham (4%) with Gosport increasing by 24% (from a low base) followed by Test Valley and East Hampshire at 22%.

Table 3: The change in energy usage for the transport sector from 2010 to 2018

	Total energy usage across the region (GWh) 2010	Total energy usage across the region (GWh) 2018	The difference in total energy usage (GWh) from 2010 to 2018	Percentage difference in total energy usage from 2010 to 2018

[7] https://www.gov.uk/government/statistics/regional-renewable-statistics - data includes large scale and micro generation

Total Transport	55,018.5	51,360.8	-3,657.7	-7%
Freight	350,258	402,881	52,623	15%
Domestic	901,655	850,862	-50,793	-6%

2.2.4 'Residual' energy use

Non-gas, non-electricity and non-transport energy use is also available at district level and Table 4 shows the change in these sources from 2010 to 2019 for the wider Hampshire area. Overall residual energy use has fallen by 9% with notable reductions in coal use as well as some (but not all) forms of petroleum. In the case of domestic petroleum this appears to represent the use of heating oil. There have also been notable increases in the use of energy from bioenergy and wastes.

Table 4: Residual fuels summed across all districts (1000 T oil equivalent)

Energy source	*2010*	*2019*	*% change*
Industrial petroleum[8]	1108.19	936.75	-18%
Domestic petroleum	73.86	55.91	-32%
Rail petroleum	15.16	12.98	-17%
Public administration petroleum	1.34	2.37	43%
Commercial petroleum	2.64	3.16	17%
Agricultural petroleum	22.06	25.12	12%
Industrial coal	30.86	6.51	-374%
Domestic coal	15.00	10.37	-45%
Rail coal	0.42	0.33	-26%
Public administration coal	2.91	0.4	-627%
Commercial coal	0.25	0.28	10%
Agricultural coal	0.02	0	-
Industrial manufactured solid fuels	207.95	218.09	5%
Domestic manufactured solid fuels	11.25	13.9	19%
Industrial bioenergy & wastes	0.13	22.08	99%
Domestic bioenergy & wastes	73.71	124.04	41%
All Fuels	1565.75	1432.22	-9%

2.3 Spatial distribution of non-domestic electricity and gas use

This section summarises the results of mapping levels and trends of non-domestic electricity and gas use at Middle Layer Super Output Area level[9] using data from BEIS[10]. It should be noted that energy use from single large sources is not allocated to an MSOA to ensure non-disclosure but are allocated only to the district level record. These sources are therefore missing from the following maps although they will have been included in the totals described above.

2.3.1 Non-domestic gas

Figure 2 shows non-domestic gas use for the area in 2019 at MSOA level excluding two MSOAs with substantially higher per meter use – E02003558 (Shirley Warren area) in Southampton (5,500 MWh) and E02003525 (Wymering area) in Portsmouth (2,700 MWh). Areas with no reported gas use (no gas network) appear as grey shading. Remaining areas

[8] This value is dominated by its use in the 'New Forest' district as is '*Industrial manufactured solid fuels*'.
[9] Areas containing ~ 4,000 households – see https://www.ons.gov.uk/methodology/geography/ukgeographies/censusgeography#super-output-area-soa
[10] See https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-electricity-consumption and https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-gas-consumption

with high usage are in Rushmoor, Basingstoke & Dean and Gosport (all over 1,100 MWh per meter).

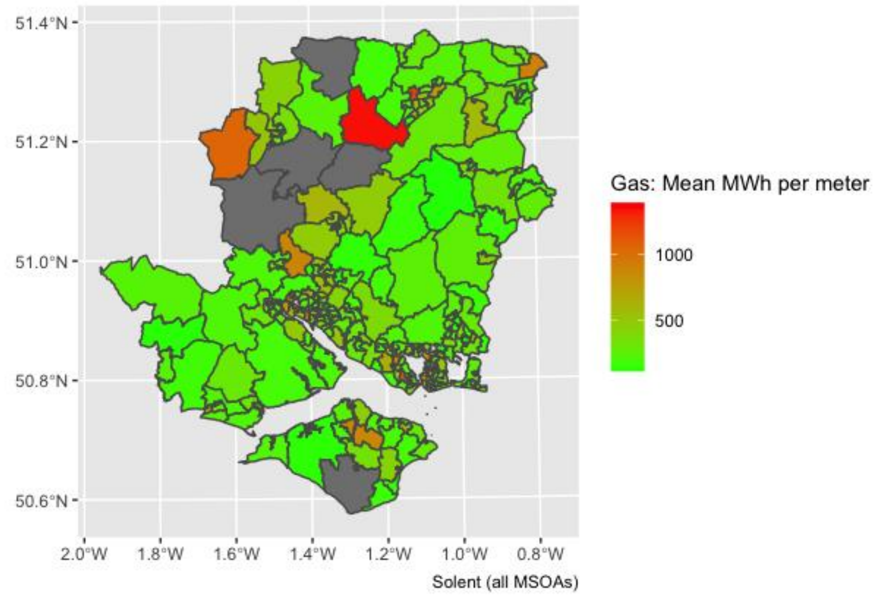

Figure 2: Non-domestic gas (mean MWh per meter, 2019)

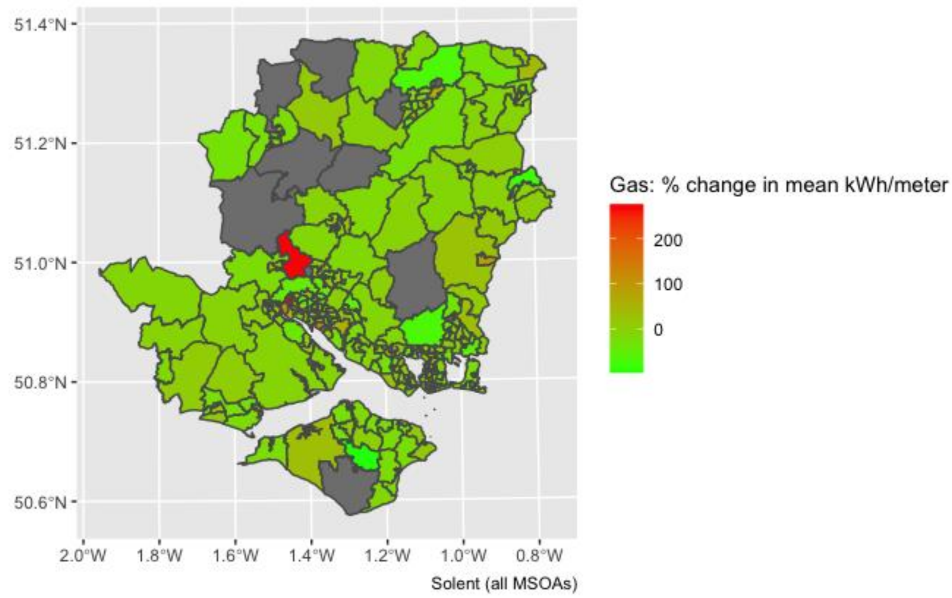

Figure 3: Percentage change in non-domestic gas use (mean kWh per meter)

Figure 3 shows the percentage change in non-domestic gas use from 2010-2019 at MSOA level. The median was -8% as the predominantly green colouring of the map indicates. However, there were areas which showed notable increases with three areas (E02003555 – Maybush area in Southampton, E02004825 - North Baddesley & Braishfield area in Test Valley and E02004807 - Farnborough Town area in Rushmoor) increasing by over 200%.

Given future trends in energy efficiency and the electrification of space heating and process heat we would expect both total and mean gas usage per meter to reduce over time. The increases noted above are likely to be caused by changes in commercial or industrial activity but without a more detailed local analysis of what has changed where, and whether the non-MSOA allocated gas use has also changed it is impossible to offer further insights.

2.3.2 Non-domestic electricity

Figure 4 shows the distribution of non-domestic electricity use in 2019 at MSOA level. As with gas, urban areas are difficult to see due to the scaling but higher use around the urban areas bordering the Solent as well as around Basingstoke are clearly visible. The area with the highest use as mapped is E02004713 (Eastleigh North) at 29 MWh per meter followed by E02003552 (Coxford & Lords Hill in Southampton) at 28 MWh.

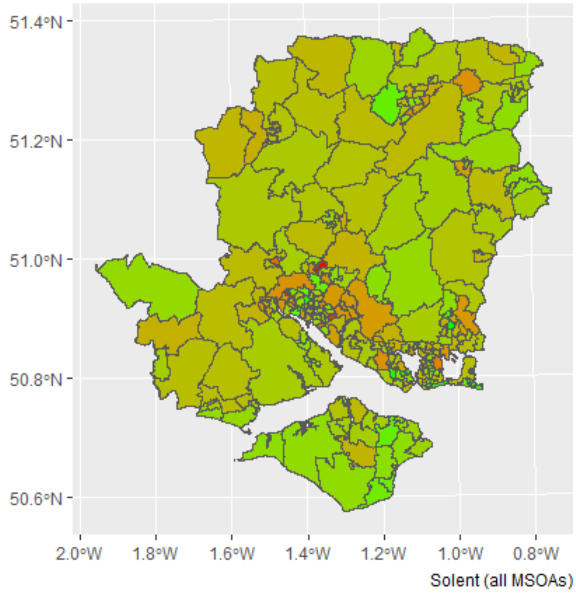

Figure 4: Non-domestic electricity consumption 2019 MSOA level

Figure 5 shows the percentage change in non-domestic electricity use from 2010 to 2019. Overall the median decrease in mean kWh per meter was 34% but there were notable increases in Hightown (Southampton, 31%) and Coxford & Lords Hill (Southampton, 29%). In contrast several areas in Havant, Basingstoke & Deane and Portsmouth showed a decrease of over 60%.

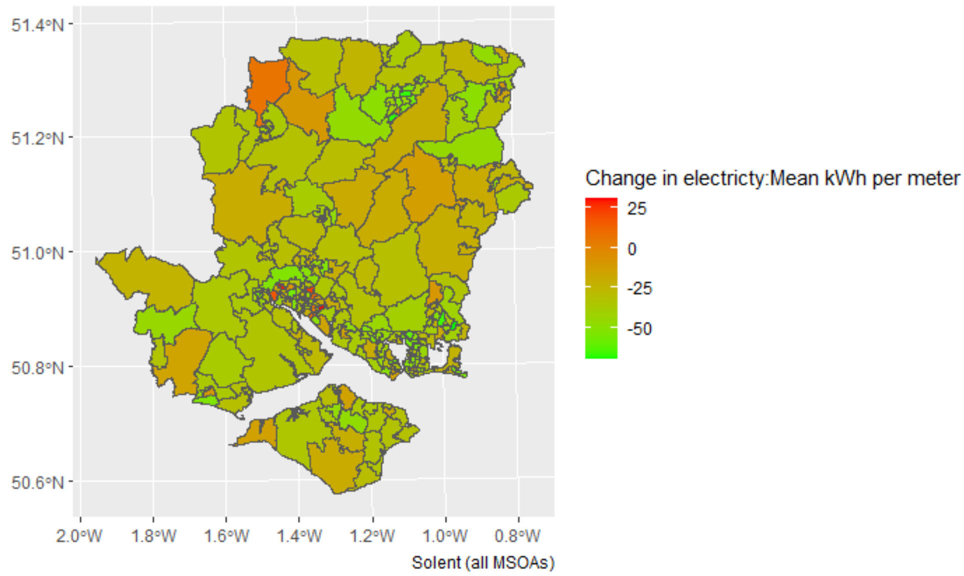

Figure 5: Percentage change in non-domestic electricity from 2010 to 2029 at MSOA level

As with gas, without more detailed spatial analysis of changing commercial and industrial uses at specific sites it is not possible to provide additional insights into the reasons for these trends. Some of the decrease may be due to energy efficiency interventions in non-domestic activities and also to a possible reduction in energy intensive industry in the area.

In future it is likely that the electrification of both space heating and process heat may lead to increases in electricity use in specific areas, especially for those commercial or industrial activities which can easily switch to electricity as an energy source.

The extent to which the local distribution network will be able to accommodate this growth is currently unclear but it is likely that, as now, future major electricity users will require dedicated high capacity connections and/or network reinforcement. Clearly these considerations are crucial to several aspects of a smart local energy plan and the potential to supply local electricity needs from local renewable generation (see Section 2.1 (Strategic Framework – learning from others)).

2.4 Spatial distribution of domestic electricity and gas use

This section summarises the analysis of domestic energy use in the wider Hampshire area which can be analysed at Census Lower Layer Super Output Area[11] levels and above using BEIS' sub-national energy use datasets.

2.4.1 Domestic gas

Figure 6 shows domestic gas use for the area in 2019 at LSOA level. As before, the grey areas correspond to off-gas neighbourhoods and are visually dominated by the relatively large rural areas of central Hampshire and the Isle of Wight. This map also illustrates the difficulty of mapping areas of similar populations but different land area sizes but does provide some

[11] Areas containing ~ 1,000 households – see https://www.ons.gov.uk/methodology/geography/ukgeographies/censusgeography#super-output-area-soa

insight into the spatial distribution of domestic gas use in 2019 with particularly high values visible in Hart, some parts of New Forest and Test Valley (see also Figure 8).

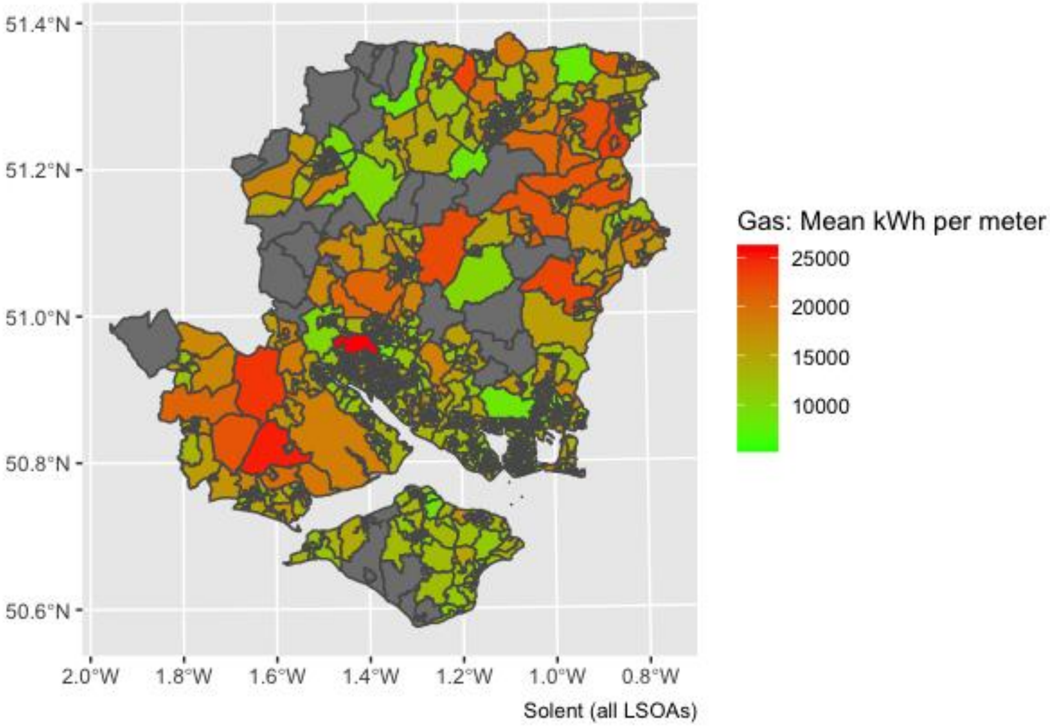

Figure 6: Mean domestic gas use per meter (LSOAs, kWh, 2019)

Figure 7 shows the distribution of gas use in Southampton and shows a clear ribbon of high gas-using areas in the central belt along the A33/Avenue. As discussed below, these tend to be less deprived areas with larger homes.

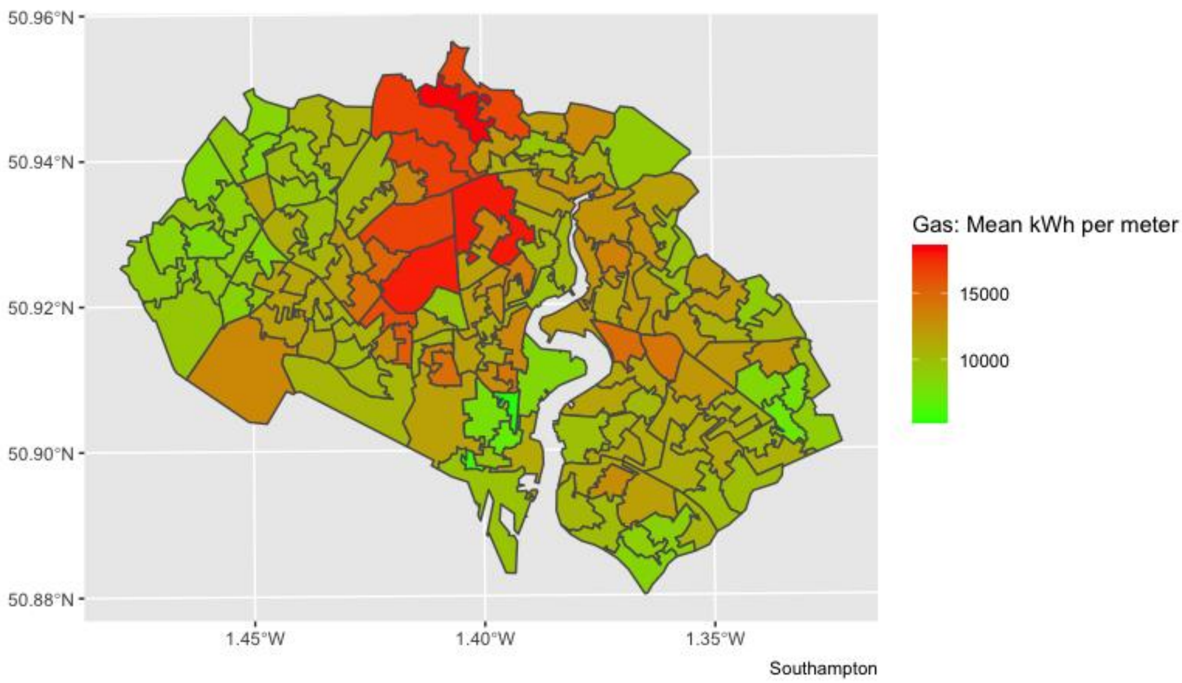

Figure 7: Mean gas use per meter (Southampton LSOAs, kWh, 2019)

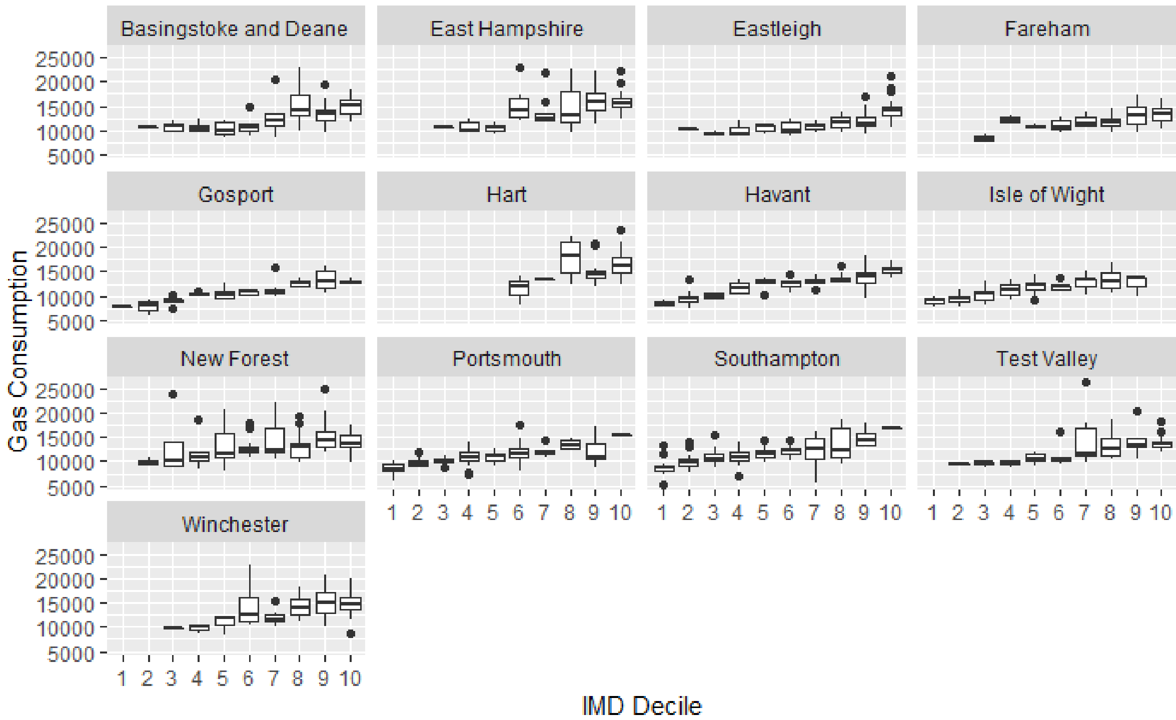

Figure 8: Mean gas use per meter (LSOAs, mean kWh per meter, 2019 by local authority, IMD decile 1 = most deprived, IMD decile 10 = least deprived)

Figure 8 shows the distribution of LSOAs by index of multiple deprivation deciles and mean gas use per meter. The plot show that gas use tends to increase as deprivation decreases (IMD decile 10 are least deprived). This is true of all districts although the relationship is clearest in Havant, Southampton and Portsmouth.

Despite a 6% rise in the number of domestic gas meters, presumed to reflect an increase in domestic dwellings, total domestic gas use decreased by 6% over the period 2010 to 2019. Mean gas use per meter decreased by 1,676 kWh per meter (median ~ -10%) over the 2010-2019 period with less deprived areas seeing larger decreases in mean gas consumption but from a higher baseline. As a result, percentage reductions in mean per meter gas use are roughly similar across deprivation levels potentially reflecting under-heating in more deprived areas with little resulting scope for further decrease with the heating infrastructure currently in place. There were however some notable exceptions to these reduction trends with a 53% reduction in Southampton 029F (Bargate area) and a 97% increase in Southampton 032D (Weston area). The latter is an extreme outlier – the next highest increase was 15% in the St Mary's area of Southampton.

Reductions in domestic gas use at the LSOA level are likely to be a result of energy efficiency interventions such as insulation and boiler upgrades as well as more recent switches to electric heating, hot water and cooking. Localised increases are likely to be the result of additional small-scale development or in the case of extreme outliers, new-build developments using gas rather than electricity as a main source of space heating. Over time we would expect both total and mean per meter domestic gas use to decline in all areas as wider scale energy efficiency and low-carbon heat interventions take effect.

2.4.2 Domestic electricity

Domestic electricity usage can also be analysed at Census Lower Layer Super Output Area levels and above using BEIS' sub-national energy use datasets.

In contrast to gas, electricity is available in all areas of the wider Hampshire region and higher mean per meter use can be seen in the more rural areas that visually dominate Figure 9. Clearly we would expect electricity use to be higher in off-gas areas where cooking, heating and hot water are likely to use electricity and/or oil. This is largely supported by the map.

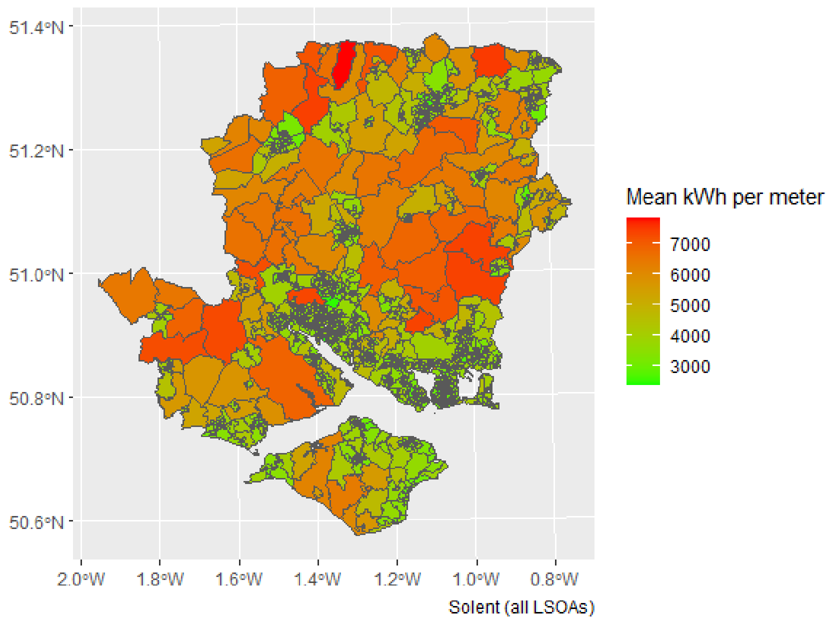

Figure 9: Map of domestic electricity consumption at an LSOA level

As before distributions in urban areas is difficult to see and so Figure 10 shows the pattern for Southampton. Unlike gas use, there is a much less well marked ribbon down the A33. This suggests that electricity use is currently much less closely correlated to levels of deprivation than gas. In addition, a number of areas near the southern tip of the City show relatively high usage. These are generally new-build flats in relatively low deprivation areas which use electricity as a primary heat source. These are in direct contrast to the areas across the river Itchen in Woolston which are both much more deprived and have much lower electricity use.

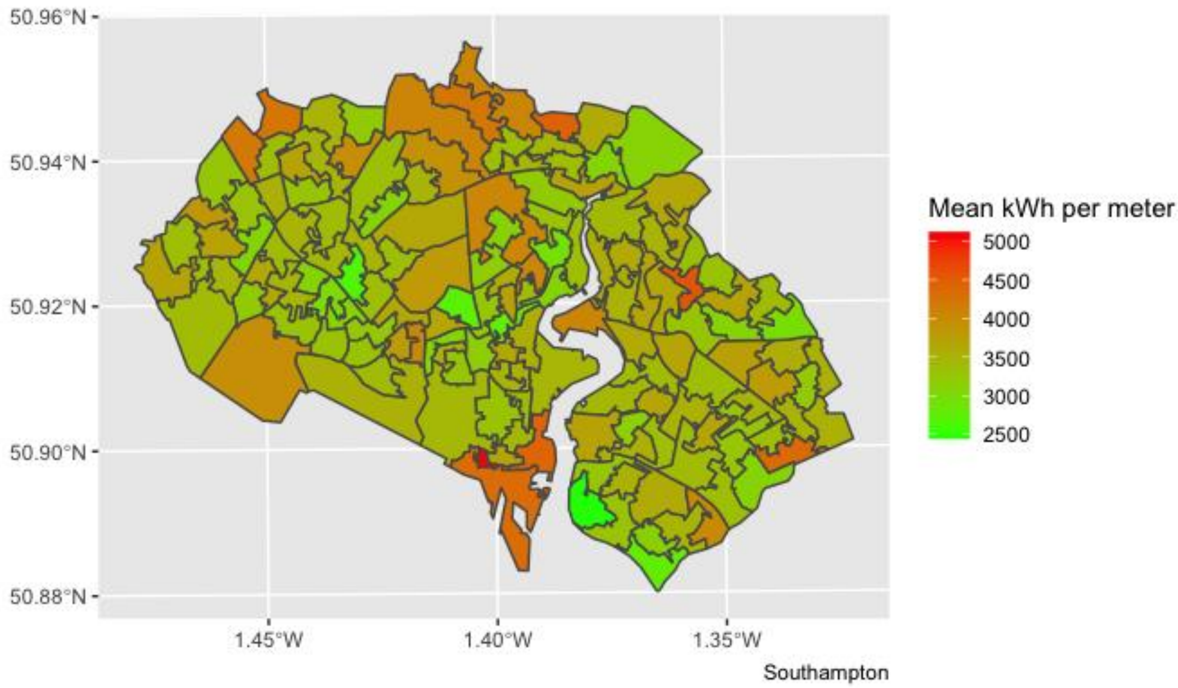

Figure 10: Mean electricity use per meter (Southampton LSOAs, kWh, 2019)

As expected, domestic electricity use shows a much less consistent relationship with deprivation as Figure 11 shows. While more deprived areas (decile 1-3) generally show lower median electricity use, and least deprived areas (deciles 9 & 10) show higher median use, there is considerable variation as the dotted outliers show. This is particularly the case for areas with increasingly electrified heat which may be spread across all deprivation deciles.

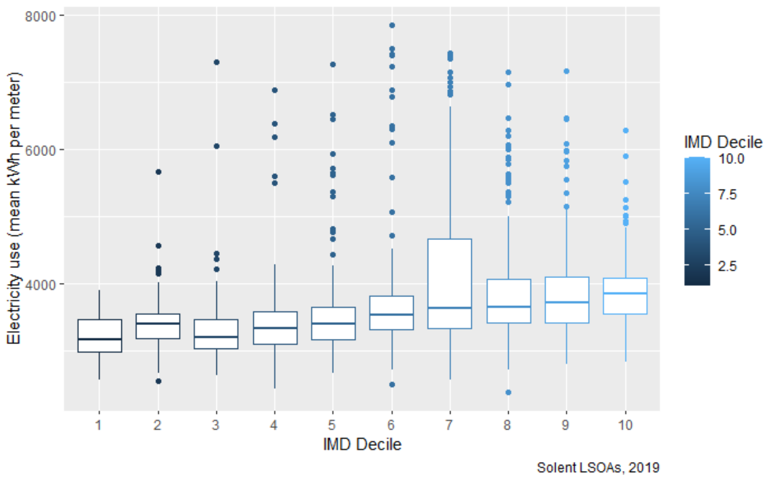

Figure 11: Relationship between electricity consumption (kWh per meter, 2019) and deprivation (IMD decile, 2019). Horizontal bars represent medians

Overall, total electricity use decreased by 7% between 2010 and 2019 even though, as for gas meters, there was a 6% increase in the number of electricity meters. This decrease is likely to be due to increased uptake of more energy efficient appliances and lighting as well as a contribution from residential PV installations[12]. LSOA level electricity use declined in nearly all areas with the largest decrease (-2,325 kWh per meter) in the Romsey area. The mean decrease was -526 kWh with a reduction of mean per meter electricity use of -12%. In general, both absolute and relative change showed little relationship with levels of deprivation with the exception of the Isle of Wight where higher percentage and absolute reductions in domestic electricity use per meter were found in more deprived areas with smaller or no reductions in less deprived areas. In contrast larger absolute reductions in electricity use were generally found in less deprived areas of Havant and, to some extent, Portsmouth.

The change observed in the Isle of Wight could potentially be a side effect of the recently increased high energy efficiency social housing provision in more deprived areas. With potential Isle of Wight developments in non-electric off-gas heat networks and increased energy efficiency of electrically heated homes, this decrease is likely to continue but is may be outweighed by increasing use for electric mobility.

Overall, as most aspects of energy use are increasingly electrified we would expect mean per meter electricity use to increase if energy efficiency savings are out-weighed by increases in use for heat, cooling, cooking and EV charging. Given the already high electricity usage in rural areas, we would expect these increases to add additional load to potentially constrained rural distribution networks. This underlines the potential need to particularly consider local electricity generation in a rural context in order to balance demand within the local network and avoid significant and costly network reinforcement. However, it should be noted that the most likely generation source (PV) provides little resource in winter evening peaks when current demand is highest. Although localised storage via batteries can be used to meet within-day demand peaks this is not usually considered part of an inter-seasonal energy storage system which would be likely to require other storable energy vectors.

Further, the socio-economic and structural factors that drive increased gas use in less deprived areas are also then likely to apply to electricity use so that over time we would expect to see an increasingly strong negative correlation between electricity use and deprivation.

It is important that the temporality of these electricity usage patterns is clearly understood. We do not yet know if low-emissions heat sources such as heat pumps will exacerbate 16:00 – 20:00 peak demand although this seems likely (Eggimann, Hall, and Eyre 2019). Nor do we know if EV owners will preferentially charge vehicles during off-peak periods. We also don't yet know if highly efficient new-build and retrofits can offer thermal load deferral ('demand flexibility') to the grid although the recently published BEIS Smart Systems and Flexibility Plan assumes that they do, while 'appliance load shifting' provides a relatively insignificant contribution[13].

The local spatial geography of these patterns matters to the local distribution network which may have particular spatial constraints that will prove vulnerable to 'energy source substitution/reconfiguration' in particular areas. As noted in Section 2.1 (Strategic Framework – learning from others), understanding the potential future temporal and spatial pattern of localised energy use will therefore be crucial to any local energy plan.

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[12] We are not aware of any data on the district or county level net contribution of residential PV installations to the electricity grid.

[13] See https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021

2.5 Spatial distributions of domestic energy (fuel) poverty

Resolving domestic fuel poverty is often considered to be a significant co-benefit of reducing energy required for thermal comfort via fabric-first retrofit. Understanding the distribution of fuel poverty in the context of energy use is therefore important.

Data on residential fuel poverty in the wider Hampshire region is available from BEIS at the Lower Layer Super Output Area level[14]. Figure 12 shows the fuel poverty rates for the wider Hampshire area. At first sight fuel poverty appears to be relatively low across the area but if we focus on urban areas in particular (e.g. Figure 13) pockets of fuel poverty in particular areas are clearly visible.

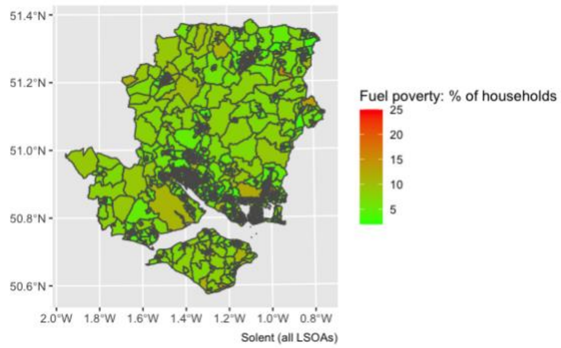

Figure 12: LSOA level fuel poverty rates, 2019 (BEIS, 2021)

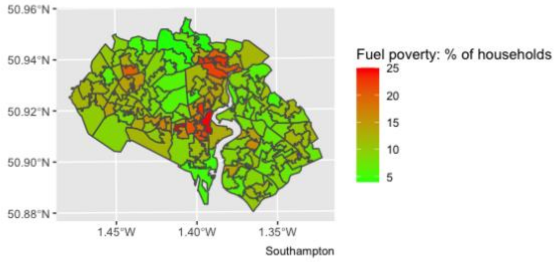

Figure 13: LSOA level fuel poverty rates, Southampton 2019 (BEIS, 2021)

Figure 14: Relationship between fuel poverty and multiple deprivation by district (Higher IMD score = more deprived area)

[14] https://www.gov.uk/government/statistics/sub-regional-fuel-poverty-data-2021

As we would expect, levels of deprivation and fuel poverty correlate (r = 0.71) and

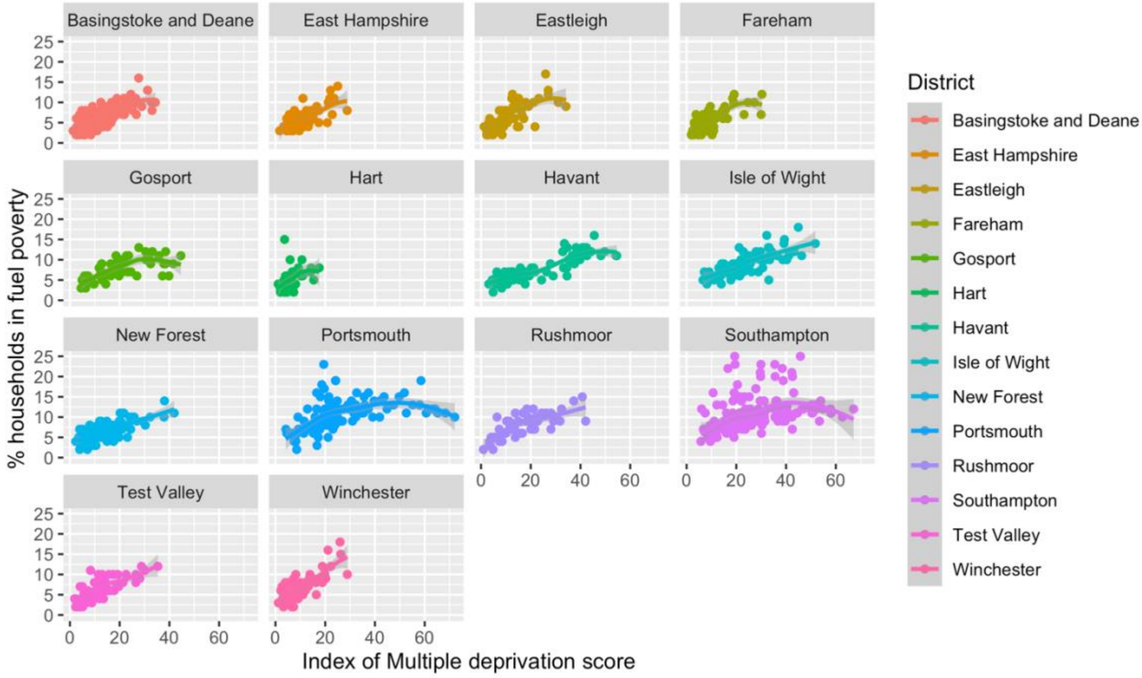

Figure 14 shows the relationship between the two at the LSOA level for each district. While the general relationship between deprivation and fuel poverty is clear there are notably higher levels of fuel poverty than might be expected in some areas of Portsmouth and Southampton. In both cases, some of these are not areas with particularly high deprivation, probably reflecting areas with poorer quality housing.

This work did not analyse the relationship between fuel poverty and mean energy (gas or electricity) use at the LSOA level. This would be instructive to explore, especially given the mediating effects of housing quality, deprivation and recent energy efficiency interventions in social housing which has lead to an increase in heat pump installations.

2.6 Insights and Implications

2.6.1 Summarising the case studies

The analysis of the Bristol Smart Energy City and Project Leo case studies provided a number of insights that are directly applicable to the HCCSF not only in terms of content but also presentation and communication. While specific points were discussed in relevant parts of Section 2.1 above, considering the two projects together highlights that a future Hampshire (smart) local energy system needs to:

- **Consider buildings as an extension of the energy system** – highly energy efficient buildings, whether new-build or retrofit, reduce the demand for heat/cooling energy at the same time as new demands (e.g. electric mobility and process heat) are emerging. This reduces the need for new capital-intensive generation and distribution network reinforcement. In addition, they also provide the ability to defer heat providing flexibility to locally constrained electricity networks so reducing peak period loads especially in winter.
- **Consider the potential for neighbourhood heat networks –** although most likely to be practical in urban or town settings, heat networks provide the ability for

centralised heat production using low-emissions sources (e.g. hydrogen, BECCS if proven) with efficient local distribution**.** BEIS is currently consulting on methods to identify (zone) neighbourhoods with the potential to utilise a heat network approach as part of a local energy system[15]. As BEIS point out, this could provide a way to make use of surplus heat from industrial processes such as energy from waste operations, data centres, industrial operators or sewage utilities. Potentially, area-based fabric-based energy efficiency interventions would be implemented *at the same time* as heat network build-out for maximum effect and minimum local disruption.

- **Understand that demand is dynamic** and emerges from the interaction of energy users with infrastructure – this implies that plans and infrastructures need to be open and flexible to enable new innovative 'energy uses' (and demand reductions) to emerge. We cannot just assume a certain level of demand and 'build' to meet it. We must also understand that as with roads, more capacity induces more demand, not less.
- **Understand that markets do not (often) deliver equitably** – and they frequently act to siphon economic benefits away from a region of innovation or production. Some form of 'local economic value capture' and redistribution is likely to be required to ensure that economic (co-)benefits stay within the region and act to 'level up' communities within Hampshire rather than drive even greater inequality of resources and outcomes.
- **Focus on the value of measured energy use data** – to provide the means to accurately assess the effects of actions and interventions at the building, street, neighbourhood, district and county levels[16]. In the first instance this may mean requesting an annual Hampshire subset of BEIS' NEED data[17] if annual data is sufficient. However to more accurately understand the timing of energy use for energy system planning purposes and to assess impact with respect to intermittent and non-dispatchable local renewable generation, half-hourly (smart) data would be required[18].

2.6.2 Summarising the energy use analysis

The analysis of overall energy use in the wider Hampshire area showed that there has been a small (7%) decrease in total energy use from 2010 to 2018, the last year for which data is available (Section 2.2). Non-domestic gas use fell by 10% while domestic gas use fell by 6%. Non-domestic electricity use fell by 9% and domestic electricity use by 7%.

Transport energy use also fell (by 7%) but the 6% (51 TWh) reduction in energy use for personal/domestic mobility contrasted with and was cancelled out by the 15% (53 TWh) increase in freight energy use (Section 2.2.3).

Beneath these headline figures there was substantial variation at district level with some seeing substantial increases or decreases depending on the energy considered. These

[15] https://www.gov.uk/government/consultations/proposals-for-heat-network-zoning
[16] See also: https://www.cse.org.uk/news/view/2091
[17] See https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework & https://www.gov.uk/government/collections/non-domestic-national-energy-efficiency-data-framework-nd-need
[18] See https://www.smartdcc.co.uk/news-events/unlocking-smart-meter-data-to-accelerate-the-energy-revolution/

differences are potentially due to increased energy efficiency and the reconfiguration of sources of energy for different uses such as space and process heat as well as the dynamic mix of commercial, industrial and domestic uses in the districts.

Other 'residual' energy use fell by 9% over the 2010-2019 period led by significant decreases in the use of petroleum (heating oil) and coal in nearly all sectors (Section 2.2.4). On the other hand, Industrial bioenergy showed a substantial increase, albeit from a very low base. The comparatively high levels of Industrial petroleum and manufactured solid fuel use reflects industrial activity in the New Forest district.

The spatial distribution of non-domestic and domestic gas and electricity use as well as the distribution of change over time suggested that the overall declines in energy use were not uniform across the area. Some areas had increased energy use (against the trend) most likely reflecting growth in specific industrial or commercial activities on the one hand and additional housing on the other. How these distributions will change over time is unclear given the complex dynamic interactions of:

- Increased energy efficiency in appliances, processes and buildings
- Increasing 'electrification' and increased demand for electricity for 'old uses' such as transport
- The changing mix of commercial and industrial activities in the area
- The changing socio -economic profile of the area which is likely to see an increase in older and single-occupancy households and a relative decrease in working age population[19]

However, it *is* clear that understanding these spatial distributions will be a crucial foundation for any wider Hampshire energy framework or smart energy plan since it will need to overlay current and future spatial energy demand on current and future energy generation, supply and storage infrastructures. This is especially the case where non-controllable (e.g. wind) or time-specific (e.g. PV) renewables become an increasing part of the local distributed energy system and when area based retrofit programmes start to be implemented at scale. This implies that the spatial distribution of retrofit programmes and renewable generation investments need to be considered *together*.

In this context the *timing* of energy use is also crucial to the design and operation of such a system. To the best of our knowledge, little or no data on the timing of energy use (or the domestic and non-domestic practices and processes that drive it) exists in the wider Hampshire area, nor does a spatial mapping of the daily or sub-daily flow of gas, electricity and other energy vectors on which supply-side investments may need to build.

Finally, the analysis of fuel poverty established the extent to which area level deprivation and fuel poverty are correlated. It also showed that some areas have higher estimated fuel poverty than their levels of deprivation would predict, especially in the Cities of Portsmouth and Southampton. If proven, these outliers may point to areas of particularly poor housing quality necessitating higher than 'expected' energy inputs to attain acceptable levels of thermal comfort. This may provide an additional dimension to the prioritisation of areas for a wider Hampshire retrofit programme.

[19] See https://solentlep.org.uk/media/2834/solent-lep-new-geography-baseline-forecasts-november-2019-final-report.pdf and https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/householdprojectionsforengland/2018based

3 Gap Analysis and future work

The results summarised in the previous section have sketched the outline of a 'wider Hampshire energy landscape'. They provided high-level data on overall energy use and broke this down by sector at the district level before providing more detailed analysis of small area (MSOA/LSOA) patterns of use and change for gas and electricity.

Overall, in the context of the Hampshire Strategic Framework for programmes the results suggest the following knowledge gaps:

- **The need to understand the relationship between domestic fuel poverty, housing quality and energy use at the local area (LSOA, OA or street) level**. This should include an assessment and mapping of dwelling 'archetypes' which have similar built forms and potentially similar energy efficiency retrofit requirements. This would enable large-scale retrofit programmes to proceed from an understanding of which areas should be priority targets to reduce dwelling-related and especially space/hot water heating derived emissions while helping to resolve fuel poverty. Analysis should focus on the household segments unlikely to be targeted by central government funding such as owner-occupiers, private rental landlords and others who are in theory 'able to pay'. Focusing on clusters of archetypes would support 'whole street' approaches enabling economies of scale and the consideration of heat networks where appropriate in contrast to a piecemeal dwelling by dwelling approach. In addition this assessment should be combined with an estimate of a) the interior air quality and health co-benefits that such interventions would bring and b) the benefits to the electricity system in reducing energy demand for heat as new demands (such as EV charging) emerge. This will provide a view on the wider social and economic value of fabric-first energy efficiency measures and thus who should contribute to funding them.
- **The need to understand the spatial and temporal distribution of energy-using activities both now and in a potentially 'smart' grid future**. This includes the timing of appliance-using activities as well as commercial/industrial processes, but also needs to assess future mobility (e.g. EV charging) and space heating whether 'on demand' or as part of a managed and potentially deferable thermal load. The latter represents one immediate value of large scale energy-efficiency retrofit across the area since in aggregate it could provide a substantial 'flexible demand' resource (BEIS 2021) and could significantly reduce the need for new capital intensive generation and distribution network reinforcement.
- **The need to combine these analyses to understand the potential local distribution network implications of a phased and spatially heterogeneous transition to low-carbon heat in both domestic and non-domestic buildings**. For example, recent work has suggested that heat pumps could lead to network overloading (Eggimann, Hall, and Eyre 2019) while widespread PV installation can cause substantial voltage violations if local storage or usage is not able to 'absorb' local generation (Gupta et al. 2021) on summer sunny days. It is likely that this work would take a scenario-based approach and require the use of sophisticated spatially granular supply/demand and network infrastructure modelling tools.

More generally, as noted in the introductory sections, this work did not attempt to map the scale of current or potential future energy 'generation' in the Hampshire area nor the delivery infrastructures the currently exists or may do so in the future. Analysis by the

Carbon Trust estimates current renewable generation in Hampshire to represent about 8% of total electricity use (see Section 2.2) and Hampshire County Council's Strategic Framework assumes an annual 3% increase in renewable electricity generation over 21 years. While this produces a 186% increase in total renewable generation, this level of ambition provides a mere 6 percentage points uplift (to 14%) in the percentage of wider Hampshire electricity demand that can be met by renewables assuming demand is constant. This suggests:

- **The need to further explore the local potential for renewable electricity generation** to substantially exceed the stated aim of a 3% per annum increase. This should build on recent work by the districts[20] and, given constantly evolving technological innovation and resources understanding, should include updated assessments of the technical and economically achievable potential for:
    - **Photovoltaics** - to grow the installed PV capacity where feasible bearing in mind the potential for 'excess' PV generation to cause local distribution network faults in the absence of sufficient local demand or inter/intra-day storage. This should include analysis linked to the assessment of large scale retrofit options which may include the installation of PV to achieve net-zero operation[21];
    - **Offshore and onshore wind** – although recent research has suggested the potential for onshore wind in the wider Hampshire area is negligible under current wind resource, planning and other structural constraints (Harper et al. 2019a; 2019b);
    - **Wave and tide resources** potentially building on historical work conducted at the University of Southampton (Blunden, Batten, and Bahaj 2009) and similar recent work conducted on sites in the Channel Islands (Coles, Blunden, and Bahaj 2017);
    - **Hydro resources**, including direct electricity generation and also the potential for water-source heat pumps for small-scale heat networks;
    - **Bioenergy and Biomass resources**, assuming carbon capture and storage is proven.
- This work should be extended to include an assessment of the **feasibility of producing other energy sources** – such as low emissions liquid biofuels and hydrogen in the Hampshire area.
- The results of these analyses should then be combined with an **assessment of the relative value of each source in a smart local *energy system*** (Ford et al. 2021) as part of the scenario based analysis described above. For example, significant PV capacity cannot meet winter evening peaks in demand for heat but it could meet a proportion of summer mid-day commercial or industrial demand. Conversely biomass or liquid fuel resources could meet winter peak demand periods but have obvious emissions implications. Green hydrogen may provide a source of energy for specific industrial processes and for local heat networks but appears unlikely to be useful for large scale domestic space heating and the economics are currently

[20] E.g. https://www.easthants.gov.uk/renewable-and-low-carbon-study
[21] See https://cotswold.gov.uk/netzerocarbontoolkit for guidance

unproven[22]. In addition, the role of large-scale EV uptake and charging/dis-charging practices would also need to be considered, especially where longer-distance commutes with workplace charging may effectively 'import' electricity to residential commuter areas via vehicle-to-grid.

Taken together, these knowledge gaps imply a need for some form of scenario-based analysis based on a comprehensive mapping and modelling of Hampshire's current energy system. Potential tools that could be reviewed for this purpose include the Energy Systems Catalyst's Local Area Energy Planning Tool[23]. In particular the effectiveness of the approach as applied to the Greater Manchester Combined Authority[24] should be assessed alongside the recent Centre for Sustainable Energy's guide to Local Energy Planning[25].

Overall, in the context of the Hampshire County Council Framework of Programmes and the NEF work related to a proposed fabric-first energy efficiency programme, the analysis presented here has identified a number of areas for future work. These are summarised in Table 5.

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[22] See https://www.carbonbrief.org/in-depth-qa-does-the-world-need-hydrogen-to-solve-climate-change and also (Sunny, Dowell, and Shah 2020; Climate Change Committee 2020; BEIS 2021)
[23] https://es.catapult.org.uk/tools-and-labs/our-place-based-net-zero-toolkit/
[24] https://es.catapult.org.uk/tools-and-labs/our-place-based-net-zero-toolkit/local-area-energy-planning/ and see also https://carbon.coop/portfolio/greater-manchester-local-energy-market-gmlem/
[25] https://www.cse.org.uk/projects/view/1369

Table 5: Summary of recommended future work

Project	Description	Link to HCC Framework of Programmes	Potential contributors (suggestions)
1.	**Assessment of the relationship between fuel poverty, energy use, deprivation, housing quality and energy infrastructures** at the LSOA level; conduct initial analysis and exploit latest Census 2021 data when available.	*Residential, Buildings & Infrastructure*	University of Southampton (Energy & Climate Change)
2.	**Updated assessment of technical and economic potential for renewable electricity generation** in the wider Hampshire area	*Energy Generation & Distribution*	University of Southampton (Energy & Climate Change, technical assessment), Community Energy South (practical experience?), SSEN (distribution network)
3.	**Assessment of the technical and economic potential for biomass, biofuel and hydrogen production** in the wider Hampshire area	*Energy Generation & Distribution*	?
4.	**Mapping of wider Hampshire domestic dwellings, housing quality, energy efficiency, dwelling & energy archetypes** to provide a 'dwelling stock model' as a tool for prioritising area-based retrofit programmes, recommending intervention 'clusters' and assessing heat deferment 'demand flexibility' options. Intended for use as both an internal and public-facing tool. May also be of value to future heat network zoning. Phase 1: Demonstrator Phase 2: Full implementation	*Residential; Buildings & Infrastructure; Business & green Economy*	University of Southampton (Energy & Climate Change, Geography), Parity Projects, NEF, HCC One Stop Shop/Energy team, Hampshire Energy Co-op?
5.	**Mapping of wider Hampshire non-domestic buildings, energy efficiency & energy archetypes** to provide a 'non-domestic dwelling stock model' as a tool for a) prioritising area-based retrofit programmes of publicly owned non-domestic buildings	*Buildings & Infrastructure; Business & green Economy*	?

	and b) identifying highly emitting privately owned buildings. Intended for use as both an internal and public-facing tool. Phase 1: Demonstrator Phase 2: Full implementation		
6.	**Development of scenarios for the likely future distribution of (decarbonised) energy use for mobility** under proposed HCC policies and projects (including passenger, public & freight and all fuel sources – electricity, liquid fuels etc); explore role of commercial and community/social enterprise in the 'energy for mobility' ecosystem; consider implications for all energy distribution networks.	*Transport; Buildings & Infrastructure; Business & green Economy*	University of Southampton (Transport Research Group, Energy & Climate Change), ?
7.	**Assessment of the wider Hampshire distribution network capacity and potential constraint points**; analysis of the potential need for demand flexibility and demand response at the local and wider Hampshire levels under future demand and local generation/storage scenarios.	*Buildings & Infrastructure; Business & green Economy*	University of Southampton (Energy & Climate Change), SSEN,?
8.	**Assessment of the value of local/regional energy modelling toolkits** (e.g. Energy Systems Catapult) for exploring wider Hampshire 'Future Energy System' scenarios	*Buildings & Infrastructure , Energy Generation & Distribution; Business & green Economy*	?
9.	**Future energy scenarios**: combining the results of the above assessments and the outcome of the toolkit review to explore: a) The potential role of an area-based Hampshire-wide energy efficiency retrofit programme in delivering a local energy system at least cost b) The potential role of commercial and social enterprises in delivering increased renewable generation as part of a future local Hampshire energy system c) The likely shape and spatial distribution of future energy networks in the wider Hampshire area	*As above*	Toolkit service provider, University of Southampton (Energy & Climate Change, research), Community Energy South (practical experience), Centre for Sustainable Energy (research & facilitator), SSEN & other local energy network & energy service operators (as stakeholders)

4 Acknowledgements

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Early versions of these results were presented to the Hampshire County Council Climate Change Expert Stakeholder Forum and we are grateful for their feedback.

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