Energy efficiency demand reduction factors for the Southern England licence area

Results and methodology report

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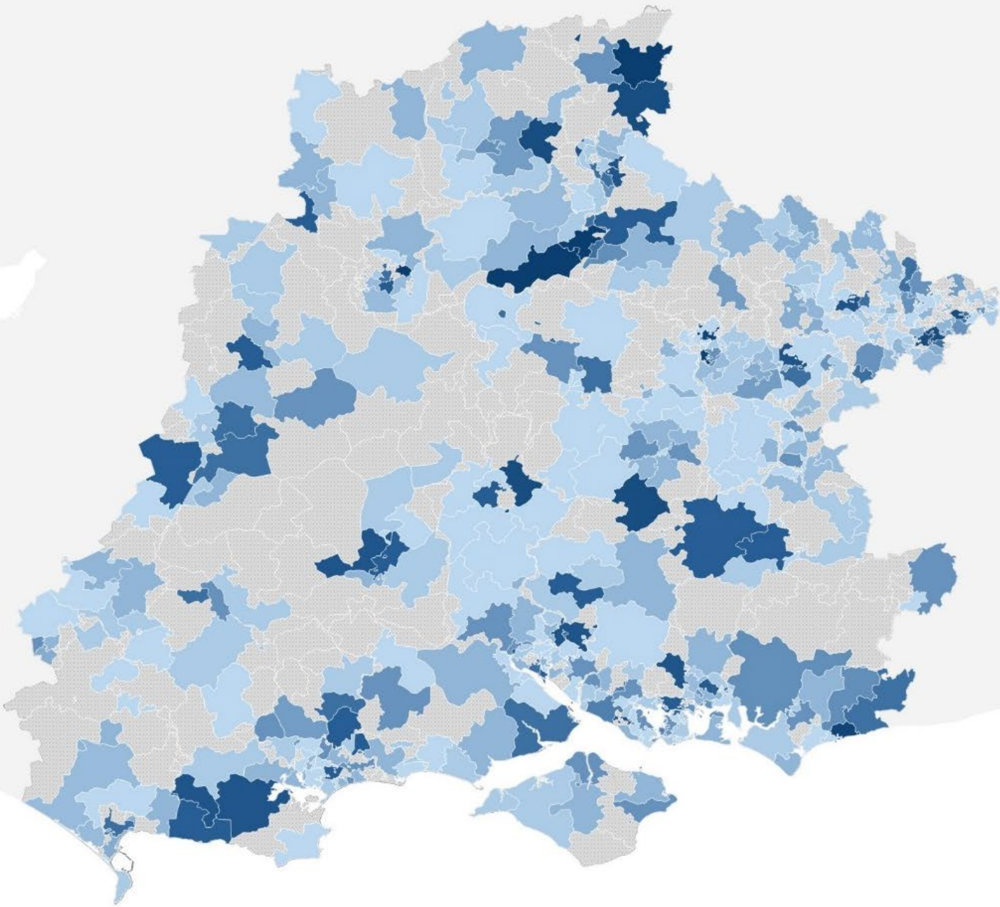

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Scottish & Southern Electricity Networks

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Analysis and report by:	Jonty Haynes, Mark Howard, Sophie Whinney
Approved by:	
	Johnny Gowdy, Project Director
	Regen, Bradninch Court, Castle St, Exeter EX4 3PL Regen is a trading name of the company Regen SW registered number: 04554636

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Introduction

This report details the methodology and results of a study undertaken to provide a more detailed analysis of the projected impacts of the uptake of energy efficiency measures by domestic and non-domestic consumers in Scottish and Southern Electricity Networks (SSEN) Southern England licence area.

This analysis is an extension to the 2020 edition[1] of SSEN's Distribution Future Energy Scenarios (DFES). The main DFES study produces granular scenario projections for the increase (or decrease) of the distribution network connected capacity of electricity generation, storage and low carbon demand technologies, as well as the increase in domestic housing and commercial new developments.

National scenarios, such as those produced by National Grid ESO and the Committee on Climate Change, have a strong narrative around energy efficiency and its impact across all forms of energy consumption. There is a need to understand how these potential outcomes may look at a regional and local level, which this study aims to address.

The energy efficiency impact analysis is presented as a percentage **demand reduction factor** in the underlying demand for heat and electricity in domestic and non-domestic properties, relative to current baseline demand. The intention is that these factors can then be applied by SSEN network planners, as an additional sensitivity, when modelling the expected electricity demand changes using the main DFES datasets.

The analysis has produced a dataset that provides an energy efficiency reduction factors for each year between 2020 and 2050, for each primary substation electricity supply area (ESA) within the SSEN Southern England licence area for five main baseload demand sources:

- Domestic heat
- Domestic appliances and lighting
- Non-domestic building heat
- Non-domestic appliances and lighting
- Industrial processes

[1] https://www.regen.co.uk/publications/scottish-and-southern-electricity-networks-dfes-2020-reports/

Methodology

The energy efficiency analysis uses many of the same methodology elements as the main DFES study, including use of the National Grid FES 2020 scenario, and the definition of electricity supply areas. These are detailed in the main DFES study.

Energy efficiency demand sources

Reductions in energy demand as a result of energy efficiency measures have been modelled across five main demand sources, which have also been combined to produce an overall reduction factor based on the current baseload demand:

Table 1 Energy efficiency demand sources included in the analysis.

Demand source	Includes
Domestic heat	The thermal energy required for space heating in domestic households.
Domestic appliances and lighting	Electricity required for lighting, appliances such as fridges, washing machines etc., and consumer electronics like televisions and computers in domestic households.
Non-domestic building heat	The thermal energy required for space heating and hot water in non-domestic buildings such as offices, schools and shops.
Non-domestic appliances and lighting	Electricity required to lighting, appliances, ventilation, cooled storage, building services etc. in non-domestic buildings such as offices, schools and shops.
Industrial processes	Electricity required for industrial processes, such as higher temperature heating, motors, pumps etc.
Overall baseload	Blended reduction factor for the current baseload electricity demand, based on the proportional contribution of the above five demand sources in the baseline year.

Due to the potential for wide scale electrification of heat over the coming decades, the domestic and non-domestic building heat scenario projections encompass all buildings, not just those currently using electricity for heating and hot water.

For each of these demand sources, ‘reduction factors’ have been projected for each scenario reflecting the potential reduction in demand by demand source as a result of improvements to energy efficiency, relative to the current baseline demand.

These reduction factors can be applied to the existing baseload, as per the ‘Overall baseload’ projection, but are also important when considering the impact of future low carbon technologies on the electricity network, such as currently gas-heated buildings potentially switching to an electric heat pump over the coming decades, to which the energy efficiency projections are equally relevant.

The National Grid FES 2020 framework

The SSEN DFES 2020 has used the National Grid ESO Future Energy Scenarios 2020[2] (FES 2020) as the overarching framework to base the analysis upon. As well as providing a scenario framework the FES 2020 has been used to provide a basis for national level assumptions and growth projections, and for the technology definitions using the industry standard “Building Block” definitions.

The FES 2020 scenario framework is based on two key axes; the speed of decarbonisation and the level of societal change as outlined in Figure 1.

The outcomes for energy efficiency in the FES scenarios are detailed in Table 2. The FES scenarios broadly have a similar range of scenarios to the CCC’s Sixth Carbon Budget[3], with two exceptions:

- The potential for demand reduction in domestic heat demand is significantly smaller in the CCC scenarios, ranging from 11-22% compared to the 10-36% presented in the FES. This is the result of further information regarding the true measured performance of installed measures that were not available earlier in 2020. Due to this new information, the scenarios modelled in this analysis have a similar range to the CCC scenarios for domestic heat.
- The Leading the Way scenario does not have a clear counterpart in the CCC scenarios, as it is based on extremely high levels of societal change, green ambition and technological advancement that allows the UK to reach net zero **before** its legally binding 2050 commitment. This has been reflected in this analysis using ‘maximum technical potential’ in most cases, which in cases such as domestic appliances and lighting leads to highly ambitious outcomes compared to the other three scenarios.

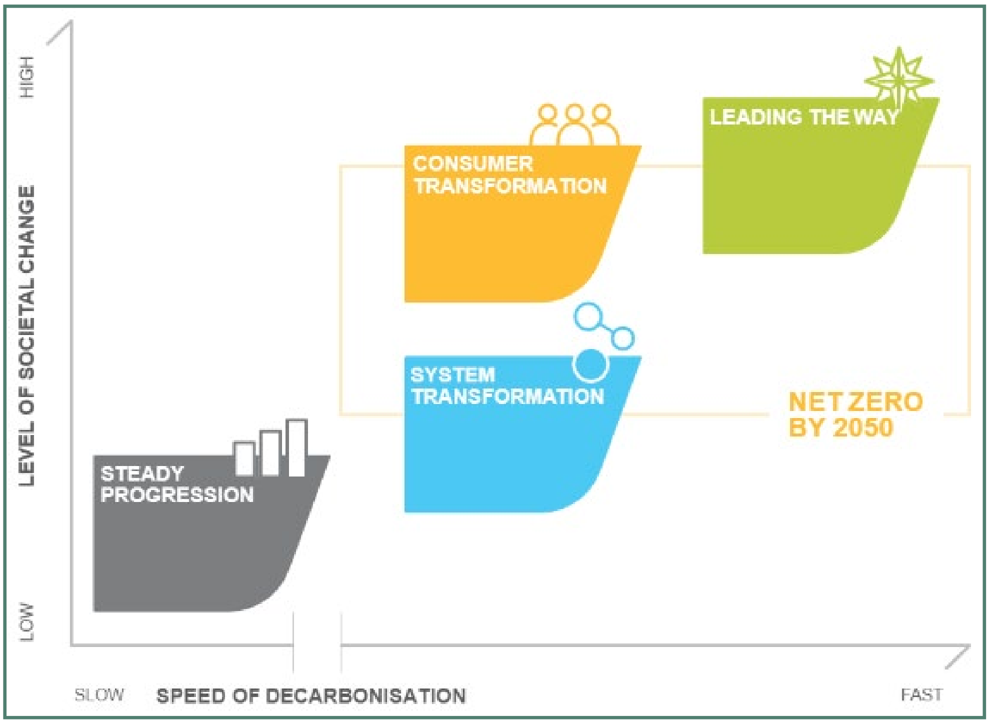

Figure 1 National Grid ESO Future Energy Scenarios 2020 scenario framework

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[2] FES 2020 https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

[3] CCC Sixth Carbon Budget https://www.theccc.org.uk/publication/sixth-carbon-budget/

Table 2 National Grid ESO FES 2020 scenario descriptions for energy efficiency

Scenario	Energy efficiency description by scenario
Steady Progression	Energy efficiency improves incrementally at business-as-usual rates, resulting in a very low level of energy efficiency uptake throughout the scenario timeframe. Building fabric and behavioural change reduce heat demand per household by around 10% by 2050. Domestic appliance and lighting efficiency sees a similar level of improvement. The UK does not meet its 2050 net zero target in this scenario.
System Transformation	Low levels of societal change results in fairly low energy efficiency uptake, especially in terms of more intrusive retrofit measures and behaviour change. Building fabric and behavioural change reduce heat demand per household by around 15-20% by 2050. Domestic appliance and lighting efficiency sees a similar level of improvement. In this scenario, energy efficiency targets such as those set in the UK Clean Growth Strategy are not met, with around 10% energy efficiency improvement in the non-domestic sector by 2030, but the UK meets its net zero target through more centralised, government-driven technological solutions such as hydrogen heating.
Consumer Transformation	Consumer transformation features high levels of societal change and consumer engagement, resulting in high levels of energy efficiency across domestic, commercial and industrials sectors. This includes the rollout of more intrusive retrofit solutions in existing buildings, supporting the wide scale electrification of heat, and high levels of behaviour change as people look to reduce their energy consumption. Building fabric and behavioural change reduce heat demand per household by around 25-30% by 2050. Domestic appliance and lighting efficiency sees a similar level of improvement. In this scenario, energy efficiency targets such as those set in the UK Clean Growth Strategy are met, with over 20% energy efficiency improvement in the non-domestic sector by 2030, and the UK meets its net zero target through high levels of electrified heat and transport combined with renewable energy generation.
Leading the Way	The Leading the Way scenario sees extremely high levels of consumer ambition, societal change and technological development, resulting in very high levels of energy efficiency. Building fabric and behavioural change reduce heat demand per household by around 36% by 2050. Domestic appliance and lighting efficiency sees a slightly higher level of improvement, driven by very ambitious changes to consumer behaviour and engagement in this scenario. In this scenario, energy efficiency targets such as those set in the UK Clean Growth Strategy and carbon budgets are exceeded, with well over 20% energy efficiency improvement in the non-domestic sector by 2030, and the UK meets its net zero target marginally ahead of its 2050 target.

Reduction factor methodology

A high-level summary methodology for each demand source reduction factor has been described in the table below. The summary sheets for each demand source, located at the end of this report, provide further detail.

Table 3 Summary methodology by demand source reduction factor

Domestic heat	• EPC benchmarks were used to model the heat demand of domestic properties as each EPC banding. • Analysis of existing and potential future policies, which primarily use EPC bands as criteria and checkpoints, were used to produce scenario projections based on the level of success and speed of implementation for each measure. • Behavioural change has been modelled to reduce heat demand in each EPC banding over time. The impact of behaviour change depends predominantly on the level of societal change in the scenario. • Appendix 1 gives further detail on how policies were assessed.
Domestic appliances and lighting	• Trends based on historic electricity demand for domestic appliances and lighting were assessed and projected into the near and medium term where appropriate. • Clear existing policies, such as the impact of the 2018 halogen light bulb sales ban and increasing appliance energy efficiency standards were applied in every scenario. • Consumer attitudes towards electricity consumption, including the number of appliances owned and the level of preference towards energy efficient appliances and electronics, were modelled based on the level of societal change in the scenario. This leads to a very high reduction factor in Leading the Way, which assumes a very high level of societal change, technological advancement and consumer 'green' buy-in.
Non-domestic building heat	• Non-domestic building heat reduction factors were modelled through the Building Energy Efficiency Survey (BEES), which identifies heat demand abatement options in terms of potential abatement, associated based on payback rates and carbon reduction value. • Each non-domestic subsector, such as retail, offices and industry, was modelled individually due to their different abatement potential and measures payback rates. The energy demand for each subsector was modelled by ESA, based on employment and energy consumption data by subsector. • Scenario projections were based on payback rates, with low payback measures implemented quicker and in more scenarios. • National business energy efficiency targets and minimum energy performance standards were used to benchmark scenario trajectories.
Non-domestic appliances and lighting	• Non-domestic appliances and lighting reduction factors were modelled as per domestic building heat, based on measures by non-domestic sector identified in the BEES and benchmarked against national targets.

Industrial processes	• Potential for energy efficiency by industrial sector has been modelled using BEIS' Industrial Decarbonisation and Energy Efficiency Roadmaps and Action Plans, combined with data on the electrical energy efficiency potential for different types of industrial components. • The energy demand for each industrial subsector was modelled by ESA based on employment and energy consumption data. • National business energy efficiency targets and minimum energy performance standards were used to benchmark scenario trajectories.

Stakeholder engagement

Although based on national energy scenarios, this is intended to be a locally driven and evidence-based analysis of the future energy scenario outcomes for a specific region, and the ESAs within that region. Stakeholder engagement and consultation is therefore critically important to inform the scenario modelling and test the future assumptions that have been made for the various building block technologies.

As an extension to the main SSEN DFES study, this analysis built on the existing consultation with local authorities and Local Enterprise Partnerships (LEPs) within the licence area, including analysis of stated climate ambitions and heat and buildings strategies to understand how the uptake of energy efficiency measures may differ at a sub-regional level.

Similarly, stakeholder engagement and market insight developed during the modelling of electrified heating technologies as part of the main SSEN DFES has been used where relevant.

Summary of results

Energy efficiency demand reduction factors

The impact of energy efficiency measures in each modelled demand source, by scenario, is shown on the figure below (Figure 3). The analysis is presented as a **% reduction factor** in energy demand against the current baseline due to energy efficiency measures.

Details on each individual demand source can be found in the 'Summary Sheets' section of the report.

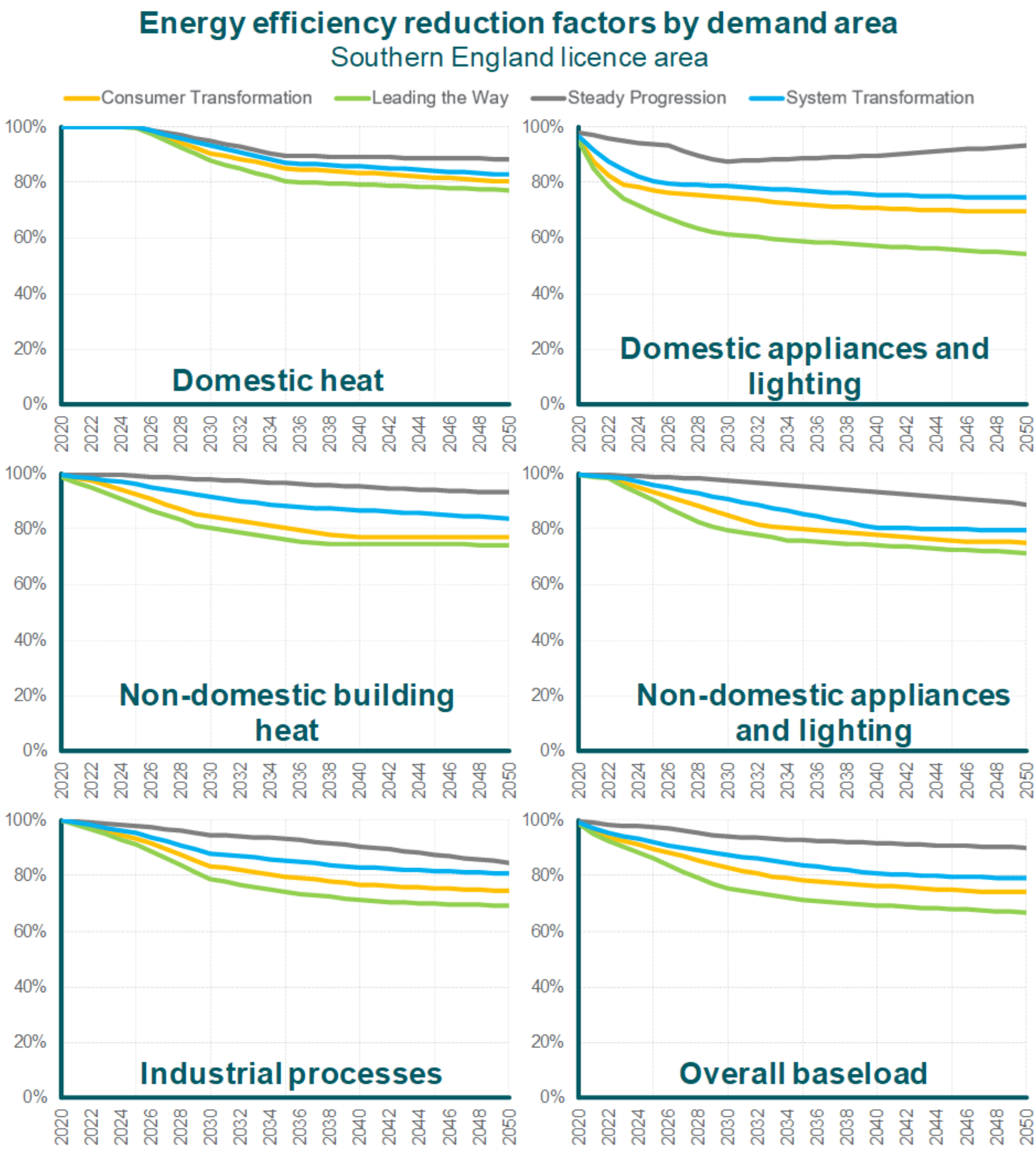

Figure 2 Results by demand source for the Southern England licence area

Applying the reduction factors to the existing baseload demand

To illustrate the impact of energy efficiency on the existing demand, reduction factors have been applied the current baseload for each ESA based on the estimated proportion of each demand area in the baseload electricity demand. These ESA-level figures are then aggregated to licence area level.

Note: This is not a projection of future demand, which will be determined by a number of growth factors, it is a projection of the impact of energy efficiency on the existing baseload demand.

The 'Overall baseload' projection has been constructed using SSEN and BEIS electricity consumption data to disaggregate the current electricity baseload into each of the five demand sources, allowing an overall set of scenario projections for how energy efficiency may impact current baseload electricity demand. In the Southern England licence area this broadly reflects the overall UK trajectory, with reduction at its fastest in the near and medium term to 2035, due to ambitious reductions in the non-domestic sector and 'easy win' energy efficiency in the domestic sector, particularly in domestic appliances and lighting where product standards and behaviour change have historically had a substantial impact.

While the trajectory of the licence area as a whole broadly mirrors the national picture, there is a wide range of trajectories for the hundreds of ESAs located within the Southern England licence area.

This reflects the diversity of the licence area, from urban areas of Southampton, Swindon and Oxford to the several, highly rural Areas of Outstanding Natural Beauty present in the licence area. These trajectories are have been modelled using a set of local attributes, including but not limited to: the current condition of domestic and non-domestic buildings stock; the types of businesses and industries present; the level of heat electrification in the area; levels of fuel poverty; the tenure of housing, such as social renters and owner-occupiers; specific local authority plans and ambitions; behaviour changes associated with socio-economic demographics, such as pensioners; and the proportion of each demand source that makes up the overall consumption of electricity in each ESA, ranging from almost entirely domestic ESAs to ESAs dominated by offices and retail premises in city and town centres.

The overall range of outcomes are illustrated and detailed in the maps and tables below. For the mapping, a checkpoint of 2035 under the Consumer Transformation has been chosen, as this broadly reflects the achievement and timeframe of existing and proposed policy.

Domestic heat	• Current measures such as ECO and the Green Homes Grant drive domestic heat energy efficiency in the near term, focussing on improving comfort and reducing fuel poverty in poorly insulated homes. When combined with further measures, the impact of energy efficiency on heat demand accelerates quickly in the mid-2020s. • The majority of impact is projected to occur between 2025 and 2035, where UK government heat ambitions are achieved in the Consumer Transformation and Leading the Way scenarios. • Domestic heat has a narrower range of reduction factors than other demand sources, guided by recent work by the CCC around the actual measured impact of energy efficiency measures compared to modelled impact.

Domestic appliances and lighting	• The wide array of components that factor into domestic appliances and lighting results in a wide range of scenario outcomes. • Increasing product standards have a major impact in all scenarios. • A key difference between scenarios is consumer choice and behaviour; choosing low energy appliances and electronics strongly influences the net zero scenarios, particularly Leading the Way. Similarly, consumer behaviour and efforts to reduce electricity demand are a major driver behind the wide range of scenario projections.
Non-domestic building heat	• Energy efficiency improvements in the non-domestic sector are achieved more quickly than domestic measures, and broadly completed by the early 2030s in the net zero scenarios. • Leading the Way and Consumer Transformation see particularly high levels of energy efficiency uptake, helping to facilitate the electrification of heat. • System Transformation still sees a significant uptake of energy efficiency for this demand source, to reduce fuel costs as on-gas buildings transition from natural gas to hydrogen in this scenario.
Non-domestic appliances and lighting	• As per non-domestic building heat, much of the energy efficiency improvements in appliances and lighting occur within the next decade under the net zero scenarios. • Well over 50% of potential demand reduction due to energy efficiency improvements was identified to have estimated payback periods of less than five years, meaning this is feasibly achieved to meet standards and targets set to achieve the UK's business efficiency goals.
Industrial processes	• Industrial processes have high energy demands, and therefore have historically had strong financial impetus to reduce energy consumption per unit of output. Historically, electricity consumption per unit of output has reduced slower than fossil fuel consumption. These aspects continue in the near and medium term in all scenarios.

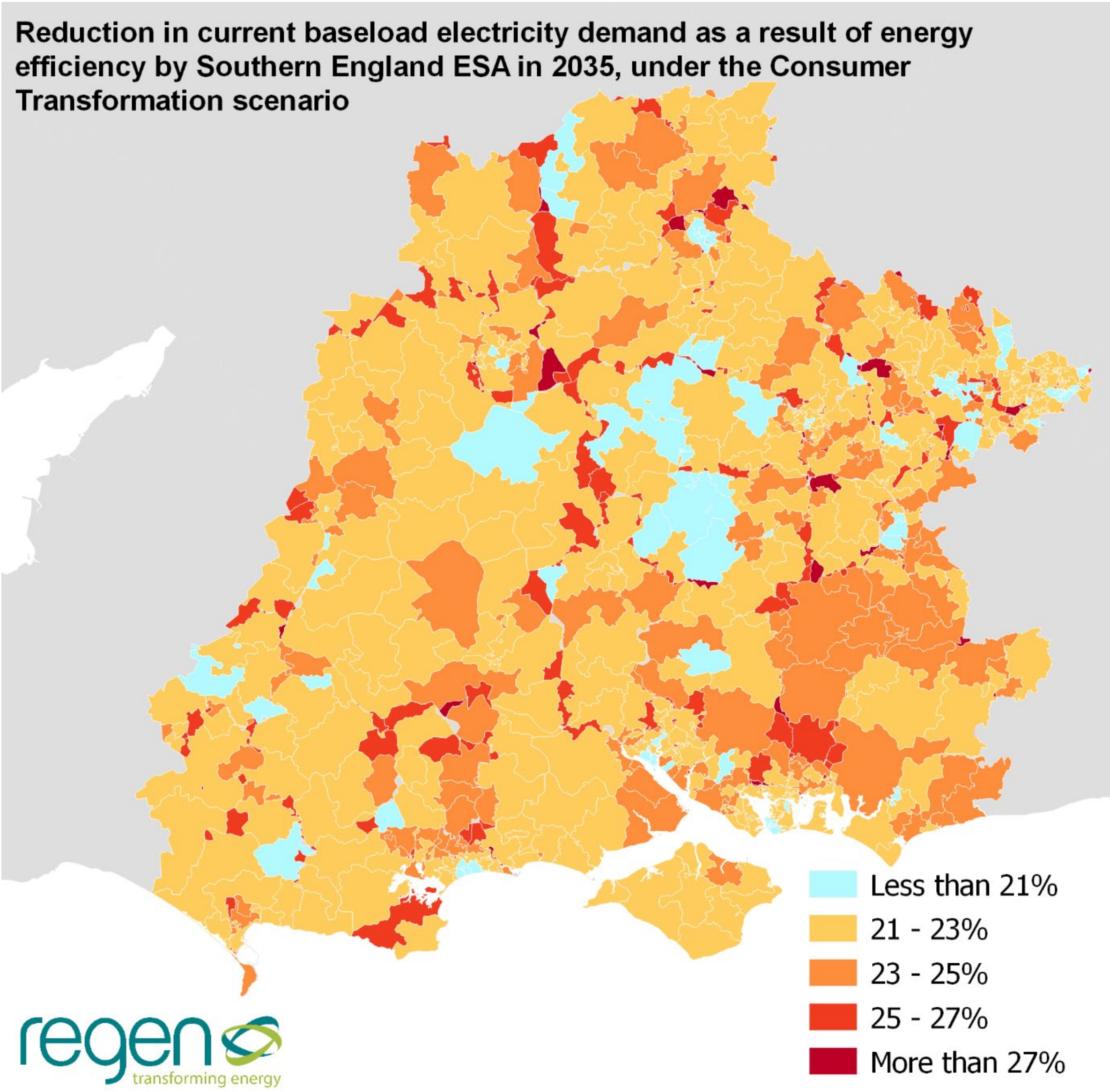

Figure 3 Projected impact of energy efficiency on the current electricity baseload by ESA, under Consumer Transformation in 2035

On the map in Figure 4, ESAs where the overall energy efficiency reduction factor is lower are highlighted in cyan. These clearly depict two archetypal areas: city centres, such as Southampton, Portsmouth, Oxford, Bournemouth and parts of west London, which are dominated by lower-potential office and retail premises and flats, and large rural ESAs that have a higher-than-average proportion of baseload attributed to domestic electric heating, which is the slowest demand source to reduce in demand through implementation of energy efficiency.

Areas of high percentage of demand reduction are typified by domestic homes not heated through electricity, where domestic electricity consumption is predominantly from appliances and lighting and therefore decreases relatively quickly, coupled with higher potential non-domestic premises such as industrial units.

A lower reduction factor does not necessarily mean a lower potential for energy efficiency measures. For example, city centres may typically see lower reduction factors, but their current electricity consumption is much higher than domestic-only rural areas. Similarly, some more rural areas have high reduction factors, but these factors may impact a relatively small absolute electricity demand.

The map in Figure 4 represents the impact of energy efficiency measures on the current baseload electricity demand in the licence area. For the domestic and non-domestic heat reduction factors, the factors are designed to be applied not only to currently electrically heated properties, but also potential future electrically heated properties that are currently heated through fossil fuels. This is particularly pertinent in on-gas areas around the major population centres in the licence area.

Domestic heat	• The scenario modelling suggests that there could be a wide range of outcomes in the near term between ESAs, owing primarily to the current condition of housing. In 2035 under Consumer Transformation, domestic heat demand reduction by ESA ranges from 6% to 25%, and is 3%-23% in Steady Progression. • The least heat demand reduction occurs in the COVE_Hart ESA. This is due to almost 90% of houses in the baseline already rated and EPC A or B, all of which are owner-occupied. As a result, there is very limited potential for further domestic heat demand reduction in this ESA. • Conversely, the LAMBOURN_Vale of White Horse ESA sees one of the highest levels of heat demand reduction. 96% of homes in this ESA that have an ESA record have an EPC rating of E or below, and so the vast majority are projected to see a significant amount of retrofit energy efficiency measures in the net zero scenarios. 70% of homes in this ESA are private rented, and therefore Minimum Energy Efficiency Standards (MEES) regulations would dictate that a high proportion of these homes must be upgraded to a C or above by 2028.
Domestic appliances and lighting	• There is considerably less variation in domestic appliances and lighting, as previous studies show that socio-economic factors have little correlation with appliance and lighting product standards in homes. • Saturation of low energy lighting recorded in EPC data ranged from 22% to over 90% between ESAs, causing some variation between ESAs in the near term as LED bulbs completely replace halogen bulbs in all scenarios.
Non-domestic building heat	• There is a wide range of outcomes in the near term between ESAs, resulting from the varying types of non-domestic premises present. In 2035 under Consumer Transformation, non-domestic heat demand reduction by ESA ranges from 11% to 28%. In contrast, the range is 2% to 6% under Steady Progression. • One of the biggest impacts of energy efficiency for this demand source is seen in the MAYBUSH_Southampton ESA, containing Southampton General Hospital. Health buildings such as hospitals are identified by the Building Energy Efficiency Survey (BEES) as having high potential to reduce heat demand with measures with relatively low payback periods. • In contrast, the BRIDGE ROAD_Hounslow ESA sees much less reduction in non-domestic building heat demand. This is due to the ESA containing a very high proportion of storage premises, and a significant amount of office and retail premises. All of these sectors, but especially the storage sector, are identified as having much fewer cost-effective thermal energy efficiency measures available to them.

Non-domestic appliances and lighting	• The impact of energy efficiency on non-domestic appliances and lighting energy efficiency ranges slightly less than non-domestic heat demand, but still considerably. In 2035 under Consumer Transformation, the reduction in demand by ESA ranges from 15% to 26%. • The distribution of outcomes is similar to non-domestic heat, with areas with high proportions of industrial premises, such as the PADWORTH_West Berkshire ESA, see high levels of quick-payback demand reduction for lighting in particular.
Industrial processes	• All industrial processes have potential to reduce energy demand, with outcomes by ESA ranging from 13% to 23% reduction by 2035 under Consumer Transformation. • ESAs with high proportions of chemicals manufacture, water treatment and waste treatment saw the highest levels of energy efficiency.

Uncertainty in the energy efficiency reduction analysis

As the first iteration of energy efficiency analysis in the DFES, there are a number of areas of uncertainty associated with the modelling. These have been detailed below, including any mitigation measures that have been used in this analysis, and how future improvements to the process could further reduce uncertainty.

Range of outcomes

The roll out of energy efficiency on the path to net zero carbon has seen significant levels of uncertainty over the past few years, in terms of both the level of upgrades that could be reasonably achieved, and the impact those upgrades have on reducing energy consumption. To take domestic heat demand as an example, the four scenarios in the NGESO FES 2020 ha a range of 10-36% reduction in demand, while the CCC's 6th Carbon Budget, also published in 2020, had a more conservative 12-22% envelope based on evidence of how measures are currently performing in existing homes. To reflect this level of uncertainty, the scenarios presented within this study have a similarly wide range of outcomes.

National policy uncertainty

The analysis in this study is based on existing programmes and targets from the UK government, which help build the near-term and medium-term trajectories under each scenario. However, these are subject to change quickly and significantly, as the recent Green Homes Grant has shown. The upcoming Heat and Buildings Strategy is expected to shed light on the intended role of energy efficiency in the UK government's plan to achieve net zero emissions by 2050.

When released, analysis of the Heat and Buildings Strategy will reveal whether current pathways remain relevant or whether new scenario modelling is required. This will depend on the level of ambition the strategy details, and proposed trajectory towards that ambition. This would be the natural period to improve and enhance this DFES energy efficiency analysis.

On a regional and local level, completing the analysis as part of the full DFES process would allow a much more expanded programme of consumer engagement, helping to provide a greater bottom-up evidence base to the analysis. This could focus on local and regional government, installers of energy efficiency in the area, consumers etc.

EPC targets and modelling

For this study, introducing energy efficiency to the DFES for the first time, the domestic sector modelling has been based heavily on EPC data and targets. EPCs provide high levels of granularity, with record data down to postcode level, and align well with published government targets and CCC recommendations, which typically frame their ambitions in terms of moving domestic consumers into higher EPC bands through rollout of energy efficiency measures.

However, using EPC data in this way does introduce another element of uncertainty. EPC ratings are fundamentally a measure of fuel cost rather than energy demand, and rating improvements can be achieved not only through installing energy efficiency, but alternatively through enabling consumers to move to a cheaper heating fuel or install rooftop solar panels. This has been mitigated in the analysis through primarily looking at actual gas consumption benchmarks when calculating typical heat demand for each EPC band, thereby removing the fuel element of EPC benchmarking.

Finally, EPC ratings reflect a modelled energy demand rather than an actual measured consumption. Our analysis of NEED data suggests that, particularly in the lower EPC bands, there is not a purely linear relationship between modelled energy demand and measured consumption. This is likely due to the 'rebound effect', where improved efficiency allows the consumer to use more energy for the same cost as before, rather than reduce consumption. This is especially true in lower EPC bands, where fuel consumption is more driven by how much can be afforded rather than how much is required for a high level of comfort.

Future development of this process would look to move away from EPC-driven scenarios towards more detailed building models, especially as more detailed data on domestic and non-domestic energy consumption becomes available. However, while high-level government policies remain focussed on EPC-based metrics and targets, any development of the analysis will continue to use these targets as key modelling inputs, and as such will also mirror the inherent uncertainties that using EPC data for energy efficiency modelling contains.

Geographic granularity of data

For DFES analysis, it is important that any modelling could be replicated at an ESA level, which in some cases can encompass a relatively small number of homes and businesses, especially in rural areas. Some data, especially related to commercial and industrial consumption where data anonymity is paramount, is only publicly available aggregated to fairly large areas such as Middle Layer Super Output Areas (MSOAs). Where possible this has been modelled at a lower level using Ordnance Survey Addressbase data.

In a limited number of particularly small ESAs, typically on boundaries with local authority borders, there has not been the granularity of data required to form individual projections. In some cases, the ESA does not host even an Output Area centroid, which represents only around 100 homes. In these cases, the ESA has been assigned the same reduction factors as its most closely related neighbouring ESA.

Data is increasingly becoming available at smaller scales, and any future iterations of the analysis will make use of whatever data is available. Building stock models, where each building is modelled individually, is the natural end point for this type of modelling.

Impact on peak demand

Energy efficiency measures will impact peak demand as well as reducing annual consumption. The impact on peak demand can be by a direct reduction of peak energy required to heat and power buildings, and also by allowing greater demand flexibility and shifting of demand away from peak (high cost) periods.

However, the relationship between reducing annual consumption and reducing peak demand is complex, particularly with regards to heat demand, which is highly seasonal and impacted by a multitude of behavioural and non-behavioural factors.

For current domestic electricity consumption, space heating only makes up around 20% of annual consumption which is mainly in the form of Economy 7/10 tariff electric heating, the rest being used for appliances and lighting. Appliance and lighting efficiencies translate directly to reduced peak demand, and there is therefore a strong correlation between energy efficiency and peak demand reduction.

However, in the future, under scenarios where heat is increasingly electrified, the correlation between energy demand reduction and peak demand reduction will vary, and will depend greatly on the ability of consumers to use smart heating technologies, and potentially energy storage, to shift demand away from more expensive peak time periods.

Most research on the effect of energy efficiency measures is focused on changes to annual consumption. While past energy efficiency programs have shown significant reductions to peak demand[4], the academic understanding of the effect on the peak is comparatively in its infancy. The benefits of energy efficiency have so far typically been considered in terms of reducing annual energy costs and associated carbon emissions, not impacts on the energy networks, and hence are more concerned with annual consumption than peak load.

This is exacerbated by a lack of appropriate data, as historic metering data does not have the granularity to show the impact of energy efficiency on peak demand; this will hopefully improve with the roll out of smart meters and further studies such as SSEN's SAVE project[5]. It would also be preferable to identify UK studies, due to the significant effect of climate and behavioural factors on heat demand during peak periods.

There are a handful of data studies from energy efficiency programs for which the data provides evidence of the relationship between reductions in annual consumption and peak demand; some of these studies show peak heat demand flattening to a 'tabletop' after measures have been implemented, suggesting a significant reduction in winter peak as well as consumption[6]. However, a review of global data from 2007 concluded that "energy efficiency programs clearly have achieved significant peak demand reductions…but most program evaluations have not used direct, on-site measurement of the demand impacts"[4].

More data-based studies[7] as well as models, particularly UK-based, are needed to better model singular and aggregated users. As more smart meter data becomes available, it may be possible to compare the consumption patterns of homes with varying energy efficiency standards in order to make statistical predictions of the aggregated peak, particularly if daily profile data from energy efficiency programs were available.

Alongside this study, Regen are working with SSEN to produce high level conversion factors to translate annual energy efficiency demand reduction factors into projected impact on peak electricity demand.

In addition to the available literature, analysis of historic electricity system peak and annual demand at a national level using ESO FES 2020 data can provide an indicative measure of the relationship between annual efficiency and the expected peak demand reduction. For example, since 2005, the overall GB electricity system peak electricity demand has fallen by around half as much as annual consumption. However, it is not possible to ascertain the direct impact of energy efficiency in this relationship, especially in the industrial sector where increased Triad (TNuoS peak charge) avoidance has also reduced peak winter demand.

Further analysis of FES projections for specific technologies, especially electric heat pumps, is being undertaken to derive approximate annual to peak conversion factors. The relationship varies by demand source and whether flexibility provided by thermal storage, demand shifting and Time of Use Tariffs is included in the analysis. Early analysis suggests that the impact of energy efficiency on peak domestic heat electricity demand may be less than half of the impact on annual demand (i.e. a 10% annual energy efficiency demand reduction factor may lead to a 4-5% reduction in peak electricity demand).

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[4] York, Dan; Kushler, Martin; Witte, Patti. 2007 "Examining the Peak Demand Impacts of Energy Efficiency: A Review of Program Experience and Industry Practices", American Council for an Energy-Efficient Economy

[5] http://news.ssen.co.uk/news/all-articles/2019/june/ssens-save-project-findings-show-significant-reduction-in-carbon-emissions-and-household-energy-costs/

[6] Ridley, Ian et al. 2013 "The monitored performance of the first new London dwelling certified to the Passive House standard" *Energy and Buildings* 63: 67-78, https://doi.org/10.1016/j.enbuild.2013.03.052.

[7] The current BEIS Heat Pump trial should provide a new valuable source of data. The Energy System Catapult is also working on a number of "Living Lab" models.

Summary sheets for the Southern England licence area

The remaining section of this document is a compendium of the individual summary sheets covering all of the demand sources that form the energy efficiency analysis.

These summary sheets provide:

- A definition and scope of the demand source.
- An overview of the key assumptions, methodology and logic that has been applied to determine the scenario projections.
- A summary of scenario projection results at each projection stage (near, medium and long term).
- An overview of the local and stakeholder evidence obtained and fed into the analysis for that demand source.
- A reconciliation between the DFES projections and the National Grid ESO FES 2020, and other appropriate sources such as the CCC's 6th Carbon Budget, where possible.
- A list of the references and data sources used.

This report contains into five demand sources, as listed below:

Category	Demand source
Energy efficiency	1. Domestic heat
	2. Domestic appliances and lighting
	3. Non-domestic building heat
	4. Non-domestic appliances and lighting
	5. Industrial processes

1. Demand reduction factors for domestic building heat

Summary of modelling assumptions and results.

Demand source specification:

The analysis covers the change in energy efficiency levels of domestic properties, which is reflected as a reduction in space heating demand. This demand source relates to **DFES technology building block Dem_BB001b.**

Data summary for domestic building heat in the Southern England licence area:

Energy efficiency reduction factors		Baseline	2020	2025	2030	2035	2040	2045	2050
Domestic building heat	**Steady Progression**	100%	100%	99.9%	95%	90%	89%	89%	88%
	System Transformation		100%	99.8%	93%	87%	86%	84%	83%
	Consumer Transformation		100%	99.8%	91%	85%	83%	82%	80%
	Leading the Way		100%	99.7%	88%	80%	79%	78%	77%

Overview of demand source projections in the licence area:

- Electricity demand for space heat currently accounts for around 19% of domestic building electricity demand in the Southern England licence area, but this proportion could increase significantly in scenarios where heat is decarbonised through electrification. At the same time, the overall demand for heat will be reduced, due to the impact of energy efficiency measures. Modelling of domestic heat demand for this study has been conducted for buildings irrespective of the heating technology or energy vector used to meet the demand.
- There are a range of existing national policies, such as the Energy Companies Obligation[8] (ECO) and the Green Homes Grant[9] (GHG), seeking to improve domestic energy efficiency in the short term. There is significant further ambition for the longer term that goes beyond the projected impact of these policies. This ambition is outlined in key government documents such as the UK Clean Growth Strategy (CGS)[10] and more recently the CCC Sixth Carbon Budget[11].

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[8] Energy Companies Obligation programme, OFGEM, retrieved March 2021, https://www.ofgem.gov.uk/environmental-programmes/eco
[9] Green Homes Grant guidance, BEIS, retrieved March 2021, https://www.gov.uk/guidance/apply-for-the-green-homes-grant-scheme
[10] UK Clean Growth Strategy, BEIS, 2017, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf
[11] Sixth Carbon Budget, CCC, 2020, https://www.theccc.org.uk/publication/sixth-carbon-budget/

- Scenario projections have been modelled by evaluating the likely shift in Energy Performance Certificate (EPC) bandings that policies would drive. This has been carried out by tenure, to account for differing behaviours and policy approaches. Revised EPC banding distributions are combined with typical heat demand by band, to produce a revised heat demand.
- The impact of behaviour change on space heat demand has been modelled by incorporating a reduction in the typical heat demand of each EPC band, varied by tenure and scenario.
- Changes in heat demand to 2030 have been driven by the relative success of policies that are in place or currently under consultation, those to 2035 have been driven by assumptions made about what the success of the Clean Growth Strategy would look like. Beyond this, to 2050, speculative assumptions have been made about further policy achievements that would be in line with the relevant scenario.
- 'Consumer Transformation' has been used as to represent current policy objectives and ambitions being met, with 'Leading the Way' going above and beyond, whilst 'System Transformation' and 'Steady Progression' fall behind.

Scenario projection results:

Baseline (up to end of 2019)

- Baseline domestic heat demand has been modelled by combining the average annual heat demand of a dwelling by property tenure by EPC band, with the numbers of dwellings from each tenure representing each EPC band[12].

Near term (2020 – 2025)

- The key near term policies that drive change in domestic energy efficiency are the Energy Companies Obligation (ECO) and the Green Homes Grant (GHG) scheme.
- As a well-established scheme with clearly defined objectives[13], the impact of ECO is assumed to apply equally across all scenarios. The policy is modelled to drive between 6% and 12% (dependent on tenure) of baseline EPC band F and G properties up by one band. Whilst measures will also be delivered in D and E band properties, the single measures delivered by ECO are not sufficient to shift the 'typical' D or E property up a band.

[12] Refer to the accompanying Regen results and methodology' report for detail.
[13] ECO 3 Final stage impact assessment, BEIS, 2018, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/749638/ECO_3_Final_Stage_IA__Final.pdf

- At the time of writing, the GHG scheme is budgeted to target up to 200,000 properties nationally with energy efficiency and low carbon heating measures[14]. The impact on EPC bands has been modelled based on Regen analysis of the impact of meeting CGS objective (See below) and the GHG scheme budget (£2 bn) relative to the estimated cost of meeting the CGS objective[15]. Regen analysis suggests that the GHG scheme would drive between 0.2 % and 1.6 % of baseline properties rated D or below to the C rating.
- Whilst these policies doubtless deliver positive impacts at the household level, the relative shift in the EPC banding, and resultant reduction in heat demand is relatively modest. Across the scenarios EPC C ratings increase by <1% (variable by tenure and scenario), as a consequence, a modest <1% reduction in heat demand is seen in the near term across all scenarios.
- No behavioural change that would reduce the typical heat demand by EPC band has been applied in the near term.

Medium term (2025 – 2035)

- The key policies modelled to drive change in domestic energy efficiency in the medium term are the Minimum Energy Efficiency Standards[16] (MEES) for the private rental sector, and the (at the time of writing undetailed) Social Housing Decarbonisation Fund (SHDF). For the purposes of modelling, the SHDF has been assumed to mirror the MEES.
- In addition, it is assumed that progress is made towards the ambition outlined in the Government's 2017 Clean Growth Strategy[10] that "as many homes as possible are improved to EPC Band C by 2035, where practical, cost-effective and affordable."
- It is further assumed that additional policies and trends begin to stimulate a shift in C banded properties to be more efficient and move up to a B banding.
- In all scenarios it is assumed that most properties rated E or below are shifted to higher bands, driven by policies and consumer trends towards greater levels of comfort, it is assumed that a small proportion of homes remain in these lower bands due to heritage constraints as identified in recent analysis for the CCC[17].
- All of these key policy drivers vary across the scenarios, with greater change achieved in Leading the Way and Consumer Transformation, where, by 2035, properties rated D or lower are reduced from 65% to 15% and 35% respectively.
- Least change is seen in socially rented housing, which is already typically more efficient than other tenures both in terms of EPC banding and the typical heat demand by band. Clarity over the SHDF may reveal higher policy ambition for this tenure.
- The greatest change is seen in owner occupied housing, where over 70% of baseline properties are rated D or lower, with the shift in EPC bands driven by alignment with the CGS ambition. An absence of defined policy goals for this tenure, combined with it representing 66% of the stock in the license area, and typically having higher heat demand, means that this tenure represents the greatest area of uncertainty in the scenarios.

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[14] GHG press release, BEIS, 2020, https://www.gov.uk/government/news/quality-assurance-at-heart-of-new-2-billion-green-homes-grants

[15] Government response to BEIS Select Committee's recommendations, 2019, https://publications.parliament.uk/pa/cm201919/cmselect/cmbeis/124/12403.htm

- A reduction in typical heat demand by EPC band due to behavioural change has been assumed to take place to 2035. This is in line with recent modelling conducted for the CCC 6th Carbon Budget, and represents the majority of achievable behavioural change to 2050 happening in this timeframe, with minimal further reduction out to 2050. Depending on the scenario and tenure this reduction ranges from 1.6 % - 8 %.
- Overall, the changes to 2035 produce up to 20% reduction in heat demand. This represents a significant redistribution of EPC bandings, in turn representing deployment of efficiency measures in most buildings in the license area.

Long term (2035 – 2050)

- Energy efficiency uptake slows in the long-term in the net zero scenarios, as the best value measures have already been implemented in the preceding years.
- It has been assumed that to 2050 there is a continued consumer trend driving a shift from C bands to B bands, in addition it has been assumed that there will be policy focus to reduce the number of D banded properties, with success commensurate with the scenario ambition.

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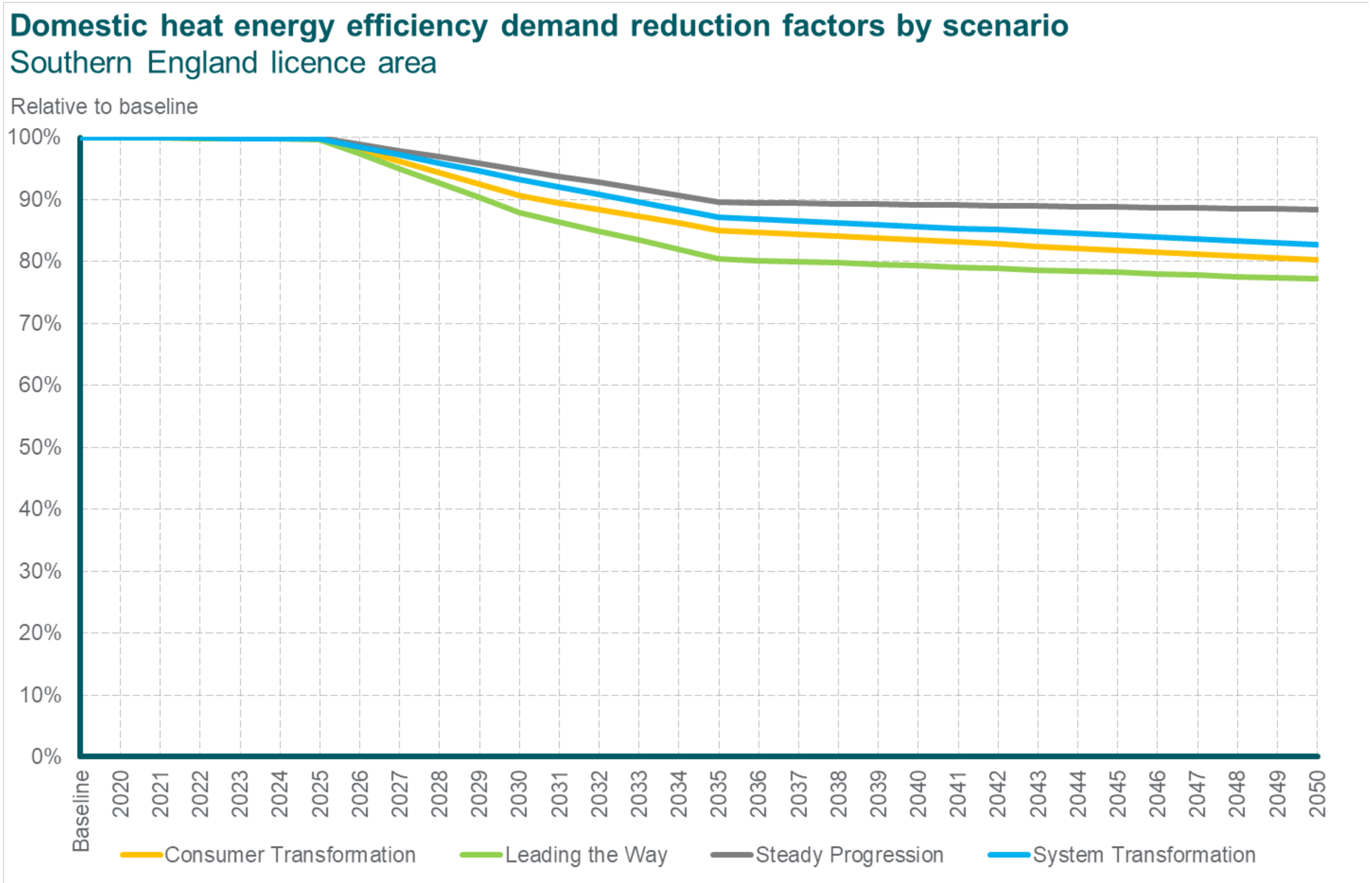
[16] MEES consultation, BEIS, 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/932403/prs-epc-c-consultation-stage-ia.pdf

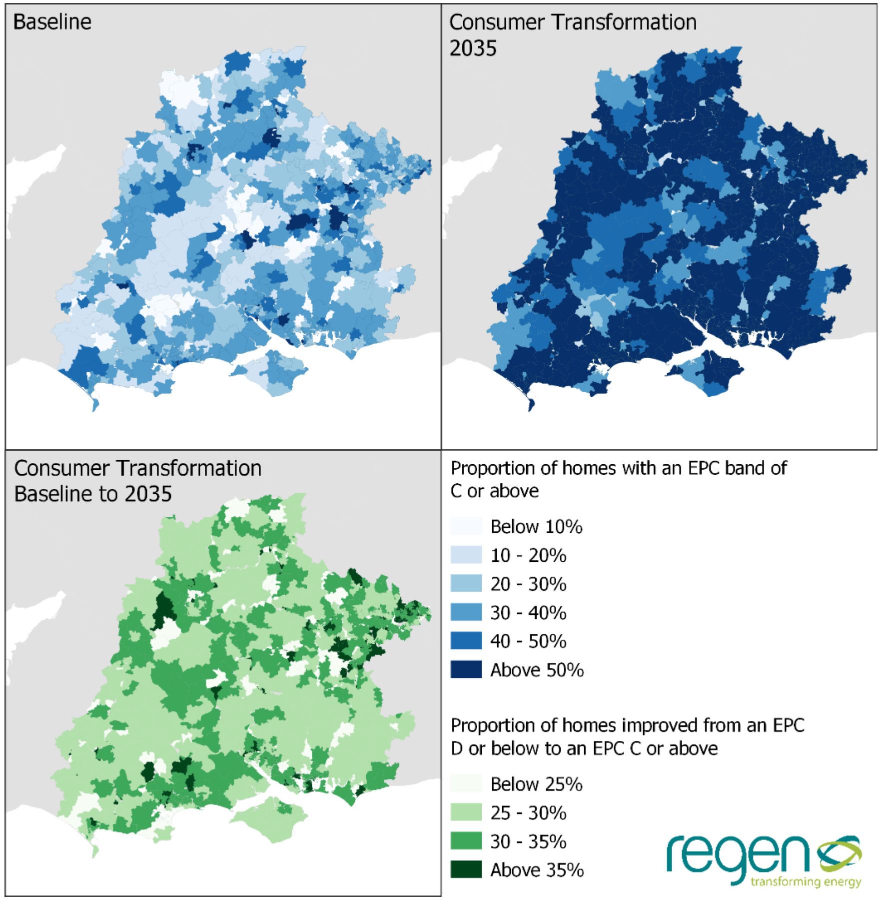
[17] Development of trajectories for residential heat decarbonisation, Element Energy for the CCC, 2020, https://www.theccc.org.uk/publication/development-of-trajectories-for-residential-heat-decarbonisation-to-inform-the-sixth-carbon-budget-element-energy/



Domestic heat energy efficiency demand reduction factors by scenario
Southern England licence area
Relative to baseline
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Baseline
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
Consumer Transformation
Leading the Way
Steady Progression
System Transformation

Reconciliation with National Grid FES 2020:

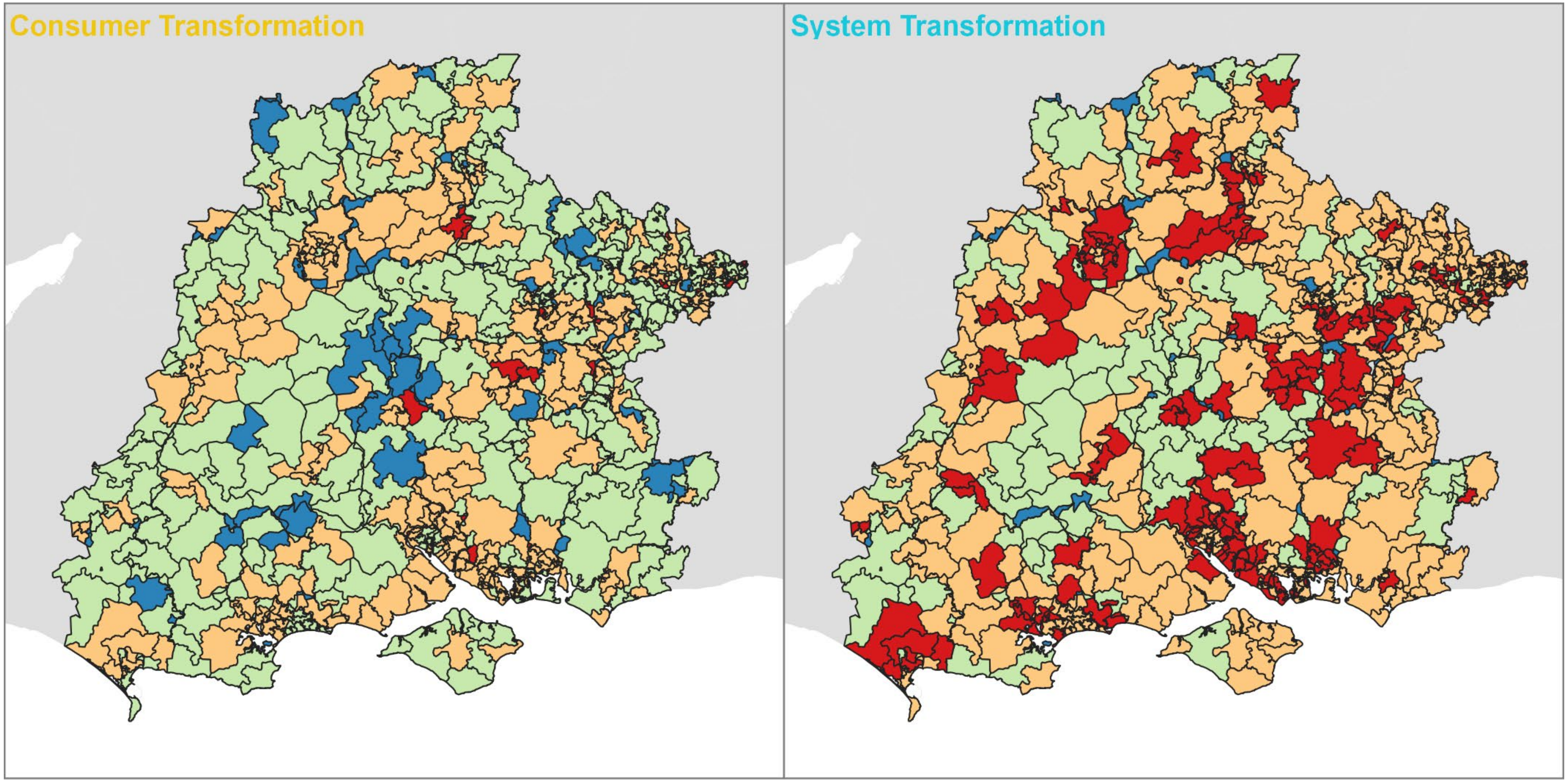
- It is difficult to directly compare outputs with the FES, as improvements in domestic space heat demand are not explicitly documented, however the FES FAQ document does provide an indication of the bandwidth of change as 'between 10% and 36%' reduction[18].
- Modelling has aligned with the lower end of this envelope, but using the current methodological approach of shifting EPC bandings would struggle to align with the upper end. The analysis does however align with the upper bounds of reduction identified in more recently published work carried out for the CCC for the 6th Carbon Budget. It was highlighted in the CCC report that estimates of the potential for reduction in heat demand had been downgraded, based on stakeholder feedback and revised technical assessment[9]. As such, Regen anticipates that the upper bounds of heat demand reduction will be reduced in the next publication of FES in closer alignment with the analysis produced here.



Factors that will affect deployment at a local level:

- The modelling was based on the current EPC bands and tenures of the housing stock, which directly captures the local attributes of each ESA. For example, ESAs with a high proportion of socially rented homes in EPC bands of E and below would see greater levels of demand reduction due to energy efficiency in the near and medium term. This is illustrated on the figure to the right. Note the high levels of variation in the baseline, with over 50% of homes rated an EPC C or above in some ESAs, and less than 10% in others.
- In addition to EPC bands and tenure, the distribution considers:
    - Areas with higher levels of fuel poverty and low income are targeted by measures such as ECO and the Warm Home Discount in the near term.
    - Local authority strategies and ambitions around fuel poverty, climate emergencies and energy consumption targets.
    - Listed buildings and conservation areas, which are expected to host many of the poorly insulated homes that remain in the latter years of every scenario.

[18] FES 2020 FAQ document, National Grid ESO, 2020, https://www.nationalgrideso.com/document/174911/download



Domestic heat reduction factors by ESA under the Consumer Transformation and System Transformation scenarios

Relevant assumptions from National Grid FES 2020:

Assumption:	Heat: comfort level (3.1.8)	Home thermal efficiency levels (4.1.22)
Steady Progression	Low willingness to change lifestyle and accustomed comfort level as energy prices remain low	Low level of energy efficiency improvements as based on solely on enthusiastic consumers and new build homes
System Transformation	Some consumer willingness to explore alternative ways of maintaining comfort at lower internal temperatures. High energy prices and high awareness of personal impact on environment make consumers reduce consumption	Least disruptive energy efficiency measures (e.g. insulation) are incentivised to customers
Consumer Transformation	High consumer willingness to explore alternative ways of maintaining comfort at lower internal temperatures. High energy prices and high awareness of personal impact on environment make consumers reduce consumption	With greater electrification of heating, homes need to be greatly improved to function well with a heat pump and improvements delivered at same time as heat pumps are installed
Leading the Way	High consumer willingness to explore alternative ways of maintaining comfort at lower internal temperatures. High energy prices and high awareness of personal impact on environment make consumers reduce consumption	With greater electrification of heating, homes need to be greatly improved to function well with a heat pump and improvements delivered at same time as heat pumps are installed

References:

EPC data, National Grid ESO Future Energy Scenarios, DECC Household Electricity Survey, BEIS, ONS Census 2011 data, SSEN DFES 2020

2. Demand reduction factors for domestic appliances and lighting

Summary of modelling assumptions and results.

Demand source specification:

The analysis covers the electricity required in domestic households for lighting, white goods, and consumer electronics such as televisions and computers. This demand source relates to **DFES technology building block Dem_BB001b.**

Data summary for domestic appliances and lighting in the Southern England licence area:

Energy efficiency reduction factors		Baseline	2020	2025	2030	2035	2040	2045	2050
Domestic appliances and lighting	Steady Progression	100%	98%	93%	87%	88%	88%	90%	91%
	System Transformation		97%	80%	78%	76%	74%	73%	73%
	Consumer Transformation		96%	77%	75%	73%	71%	70%	70%
	Leading the Way		95%	69%	61%	59%	57%	55%	54%

Overview of demand source projections in the licence area:

- Electricity consumption by domestic appliances and lighting has decreased significantly over recent decades. This is due to increasingly stringent product energy efficiency standards and labelling, as well as changes to consumer behaviour and increasingly portable, lower power consumer electronics. This trend continues in the near term, with the impact of efficient LED lightbulbs, televisions and cold appliances, coupled with a shift towards lower power computing, resulting in strong decreases in per-household electricity demand by 2030.
- However, a competing underlying trend in the increasing number of appliances, electronics and lighting in each household, which is projected to continue. This tempers the energy savings made by more efficient products, particularly under the 'business-as-usual' Steady Progression.
- Beyond 2030, diminishing returns on product standards and consumer behaviour change means that energy efficiency gains in domestic appliances and lighting are limited. In the three net zero scenarios, over 80% of energy efficiency improvement occurs between 2020 and 2030. In the longer-term, the focus is likely to be on increasing the 'smart and flexible' ability of appliances, especially in scenarios where Time of Use Tariffs, domestic storage and DSR etc. are widely adopted.
- For technologies broadly impacted by national or international markets, such as televisions, fridges/freezers and consumer electronics, we have followed the FES assumptions and projections. The focus of this analysis has been identifying and modelling technologies with regional variation, such as lighting, cooking and behaviour change.

Scenario projection results:

Baseline (up to end of 2019)

- BEIS' ECUK[19] statistics show that energy consumption has greatly reduced for almost all types of appliances over the last decade:

Appliance type	2010 UK consumption (GWh)	2019 UK consumption (GWh)	2010-2019 change	Reasons for change
Lighting	14,072	10,508	-25%	Ban on incandescent (2009) and halogen (2018) bulb sales
Cold appliances	16,104	10,754	-33%	EU minimum energy performance and energy labelling standards
Wet appliances	14,495	14,189	-2%	EU standards matched by increasing uptake of wet appliances in new and existing homes
Televisions	3,954	1,582	-60%	Shift to more efficient LCD and LED televisions
Consumer electronics	8,861	5,043	-43%	Move away from DVD/VCR and set top boxes towards more efficient smart TVs and laptops for content viewing
Computing	4,913	2,878	-41%	Shift from desktop computers and monitors to lower wattage laptops
Cooking	11,544	12,743	10%	Increasing number of electric ovens and hobs replacing gas versions
Vacuum cleaners	667	518	-22%	EU minimum energy performance and energy labelling standards
Total	**74,610**	**58,216**	**-22%**	**-**

- In the baseline year, domestic appliances and lighting accounts for an average annual consumption of 2.1 MWh per household. The 2014 Household Electricity Survey by the Department of Energy & Climate Change[20] found that single person households and retired households used significantly less electricity on average, while non-working households and affluent households had much higher-than-average electricity consumption.

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[19] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk
[20] https://www.gov.uk/government/collections/household-electricity-survey

Near term (2020 – 2025)

- Appliances covered by EU energy performance standards continue to incrementally improve efficiency as they are replaced in all scenarios, continuing recent trends. Similarly, the shift to lower power computers, televisions and consumer electronics continues in the near term.
- Lighting is significantly impacted by the 2018 halogen bulb ban, as almost all domestic lighting is replaced by much more efficient LED bulbs. In all scenarios it is assumed that the UK regulations remain similar to the EU, as per the recent lighting Ecodesign consultation[21], and that the UK market would not have access to significant numbers of halogen bulbs in either case[22].
- In the three net zero scenarios the impact of the ban is as intended, with domestic lighting demand reducing by an average of 66% by 2025 in these scenarios. In contrast under Steady Progression, stockpiled halogen bulbs mean that lighting demand decreases more slowly.

Medium term (2025 – 2035)

- With fast replacement rates, LED lightbulb potential is achieved by the mid-2020s in all net zero scenarios, reducing lighting demand 60-70%, after which efficiency gains level out. Under Steady Progression, a slower transition occurs, with demand for lighting dropping 30% over this timeframe.
- Demand from appliances typically replaced at slower rates such as fridges, freezers and washing machines continues to see a steady reduction under the net zero scenarios, continuing the near-term increasing product standards. Under Leading the Way, highly ambitious standards and behaviour change see appliance energy consumption fall even further, by up to 20% for wet appliances.
- Under Leading the Way and Consumer Transformation, public ambition to reduce electricity consumption results in demand from computing and consumer electronics falling by 15-20%, as consideration of the electricity consumption results in consumer choosing less energy intensive electronics, such as laptops and tablets over desktop computers.
- Under Leading the Way and Consumer Transformation, the accelerating shift from gas boilers to electric heat pumps results in an increase in electricity demand for cooking, as gas hobs and ovens are replaced by electric equivalents.

Long term (2035 – 2050)

- In the net zero scenarios, energy consumption by domestic appliances and lighting remains steady, as focus turns from reducing demand to shifting demand through smart appliances. As a result, less than 10% of the overall efficiency gains to 2050 are made during this time period.
- The shift to low carbon heating has a knock-on impact on appliance electricity demand. In Consumer Transformation, where the majority of households currently on-gas shift to electrified heating, electrified cooking appliances similarly see much greater uptake. Conversely, under System Transformation, hydrogen hobs are preferred to induction hobs in the latter years of the scenario. As the Southern licence area is less on-gas than the UK overall, the impact of electrification of cooking is lower than the national trajectory, as a greater number of homes already utilise electricity for cooking in the baseline.

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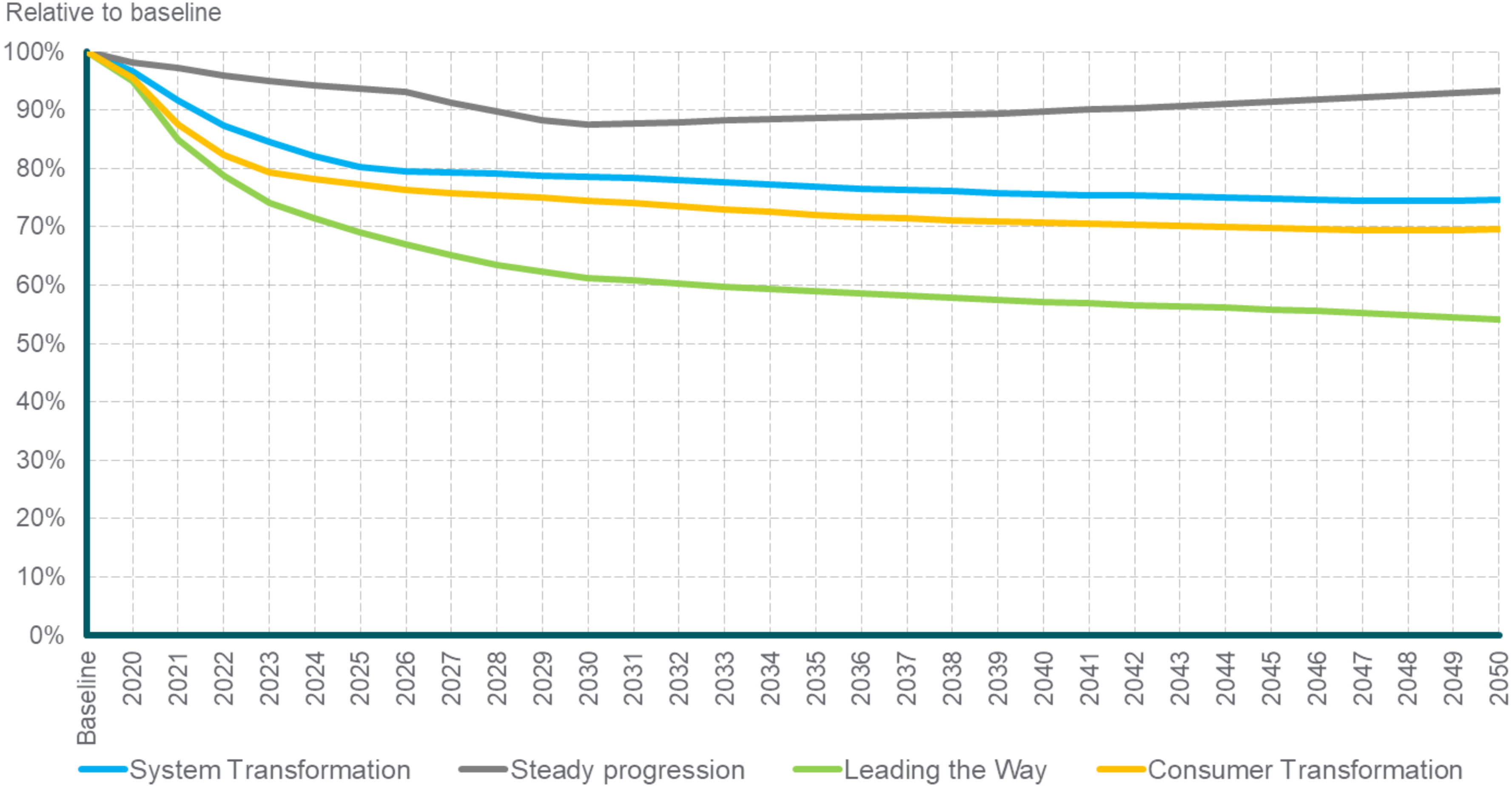
[21] https://www.gov.uk/government/consultations/draft-ecodesign-and-energy-labelling-regulations-lighting-sources-2021
[22] https://www.which.co.uk/news/2018/08/eu-halogen-light-bulb-ban-everything-you-need-to-know/

Domestic appliances and lighting energy efficiency demand reduction factors by scenario

Southern England licence area



Reconciliation with National Grid FES 2020:

- The overall results are similar to National Grid FES due to focus on national and international drivers for this demand source. Regional variation does occur from assessment of current low-energy lighting levels and projected electrification of heating in the Southern licence area, as well as slight differences in demographics. However, this has a greater impact on energy efficiency in individual ESAs, whereas the trajectory for the licence area as a whole is much closer to the national trajectory.

Factors that will affect deployment at a local level:

- Potential for lighting energy efficiency gains has been distributed to ESAs based on analysis of EPC records from 2012 to 2020. Across this time period, the average EPC record in the licence area had low energy lighting in 55% of outlets. However, there was some variability across ESAs, with low energy lighting levels ranging from 14% to 90%.
- Cooking demand, and to a lesser extent the electricity consumption of gas/hydrogen boilers, has been factored into the projections at an ESA level based on Regen's heat technology projections for the main SSEN DFES 2020.
- DECC's Household Electricity Survey found no significant relationship between demographics and efficiency of owned appliances, however, there was a strong link between demographics and behaviour-based electricity consumption. Notably, households with a high NRS Social Grade had greater consumption per household, and thus have greater potential for behaviour change to reduce appliance and lighting demand, particularly in the Consumer Transformation and Leading the Way scenarios. Conversely, pensioners were found to already be using electricity very efficiently, and had less potential to reduce consumption through behaviour change. These demographic aspects were reflected at a local level based on the demographics of each ESA.

Relevant assumptions from National Grid FES 2020:

Assumption number	3.1.5
Steady Progression	Lack of government action, low disposable income and low willingness to change lifestyle means consumers buy similar appliances to today.
System Transformation	Moderate Government action (clear effective targets and bans) and societal change combined with incomes, means consumers adopt low energy appliances in order to decarbonise and achieve targets
Consumer Transformation	Moderate Government action (clear effective targets and bans) and societal change combined with incomes, means consumers adopt low energy appliances in order to decarbonise and achieve targets
Leading the Way	Effective government action (targets, bans scrappage schemes) and societal change combined with incomes, means consumers adopt low energy appliances in order to decarbonise and achieve targets.

References:

EPC data, National Grid ESO Future Energy Scenarios, DECC Household Electricity Survey, BEIS, ONS Census 2011 data, SSEN DFES 2020

3. Demand reduction factors for non-domestic building heat

Summary of modelling assumptions and results.

Demand source specification:

The analysis covers the impact of energy efficiency measures on space heating and hot water demand for non-domestic buildings. This does not include high-grade or low-grade heat for industrial processes. This relates to **DFES technology building block Dem_BB002c.**

Data summary for non-domestic building heat in the Southern England licence area:

Energy efficiency reduction factors		Baseline	2020	2025	2030	2035	2040	2045	2050
Non-domestic building heat	**Steady Progression**	100%	100%	99%	98%	96%	95%	94%	93%
	System Transformation		99%	96%	92%	88%	87%	85%	84%
	Consumer Transformation		99%	92%	85%	80%	77%	77%	77%
	Leading the Way		99%	89%	80%	76%	75%	74%	74%

Overview of demand source projections in the licence area:

- Electricity demand for building heat currently accounts for around 10% of non-domestic building electricity demand, but this proportion could increase significantly in scenarios where heat is decarbonised through electrification.
- The UK Clean Growth Strategy and CCC Sixth Carbon Budget aim for the vast majority of commercial and industrial energy efficiency improvements to be complete by the early 2030s. This is achieved under Leading the Way and Consumer Transformation, where over 70% of demand reduction occurs within the first decade of the projections. Under System Transformation thermal energy demand reduces more slowly and to a lesser extent, due to less behaviour change and a focus on less intrusive decarbonisation measures. Under Steady Progression, only the most cost-effective measures are implemented, and as a result reduction in heat demand in minimal.
- Using the Building Energy Efficiency Survey (BEES)[23], heat demand abatement options have been modelled for each sector and assessed based on payback rates and carbon reduction value. This leads to variation across licence areas and ESAs depending on the make-up of non-domestic building types in that area. For example, industrial and education buildings have almost twice as much potential to reduce heat demand compared to the storage, office, and retail buildings.

[23] https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

Scenario projection results:

Baseline (up to end of 2019)

- Electricity consumption for heat in the non-domestic sector has slowly decreased in recent years, by approximately 1% per year according to ECUK data[24]. However, fuel consumption for non-domestic heat across all fuels, predominantly natural gas and oil, has remained steady since 2016.
- The Southern licence area is similar to the UK overall in terms of heat demand by non-domestic subsector, with almost half of electricity demand for non-domestic heat coming from retail premises. Retail premises are notable for being much more commonly heated by electricity than office, health and hospitality buildings.

Near term (2020 – 2025)

- As with non-domestic appliances and lighting, scenario projections have been modelled by sector based on the Building Energy Efficiency Survey, which identifies abatement potential by measure for each non-domestic sector and expected payback periods for each measure. In the near term, measures with optimal payback periods of two years or less begin to be implemented under all scenarios.
- Under the net zero scenarios, this is accelerated by ambitious minimum energy standards imposed by government in order to achieve the UK Clean Growth Strategy targets. This includes the recently consulted minimum energy efficiency standards for the non-domestic private rented sector[25], which could require all relevant buildings to achieve an EPC B by 2030 where cost effective, building on the current Minimum Energy Efficiency Standards (MEES) requirement to be EPC E by 2023 at the latest[26].

Medium term (2025 – 2035)

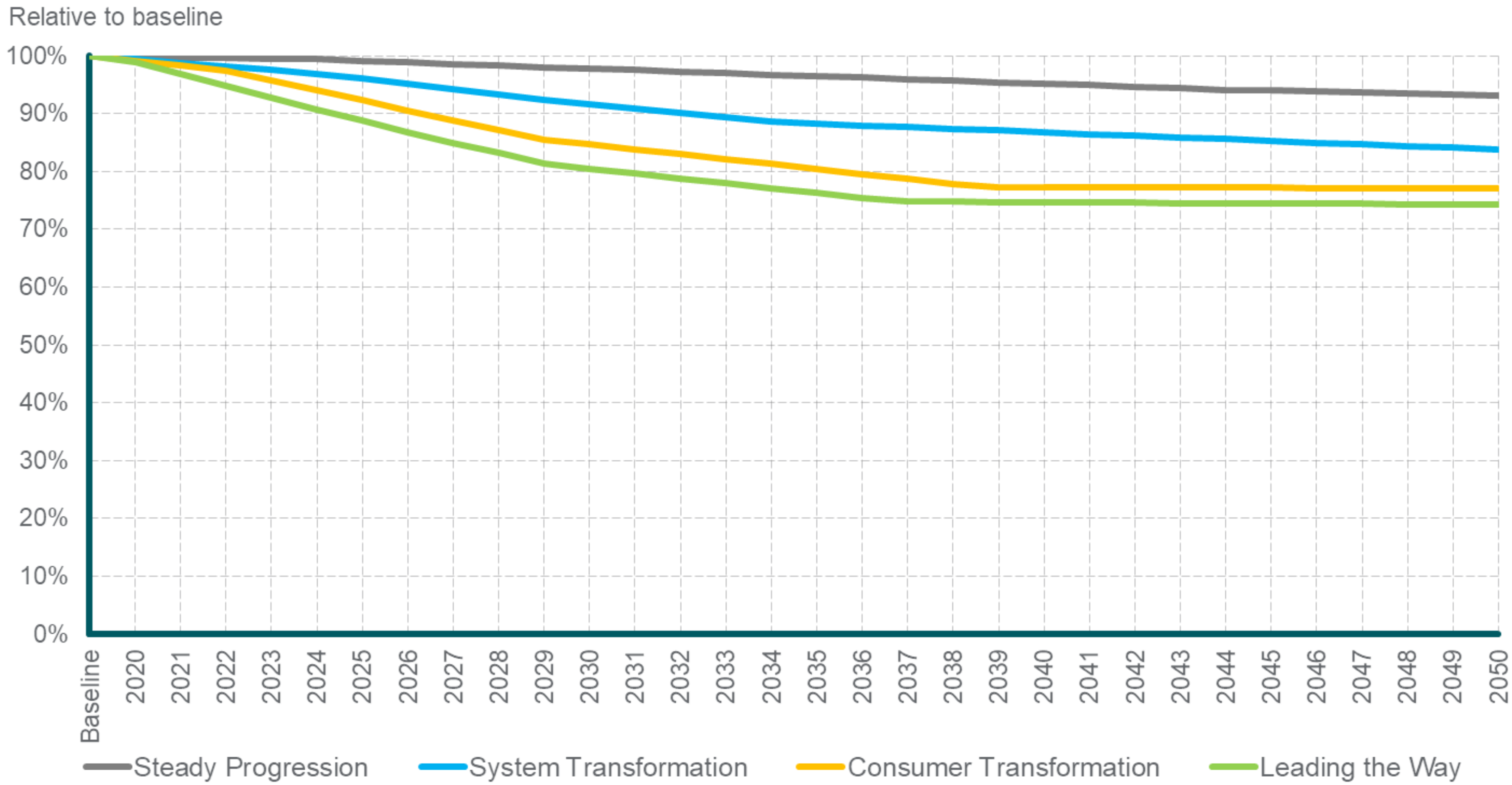
- In alignment with the CCC's Path to Net Zero report[27], commercial and public sector energy efficiency is largely complete by the early 2030s in the Consumer Transformation and Leading the Way scenarios. System Transformation and Steady Progression see much slower progress, with decarbonisation focussed on more centralised solutions.
- By 2030, compared to the 2019 baseline, overall demand for heat in non-domestic buildings reduces by 20% compared to the 2019 baseline under Leading the Way and around 15% under Consumer Transformation. This helps to facilitate the coincident rapid uptake of electric heat pumps in these scenarios.

Long term (2035 – 2050)

- Energy efficiency uptake slows in the long-term in the net zero scenarios, as the best value measures have already been implemented in the preceding years.
- Under Leading the Way and Consumer Transformation all cost effective measures have been implemented by the late 2030s, and decarbonisation efforts focus on electrification in the 2030s and 2040s. Under System Transformation and Steady Progression progress continues to be made throughout the timeframe, but only where most cost effective.

Non-domestic building heat energy efficiency demand reduction factors by scenario

Southern England licence area



[24] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk
[25] https://www.gov.uk/government/consultations/non-domestic-private-rented-sector-minimum-energy-efficiency-standards-future-trajectory-to-2030
[26] https://www.gov.uk/government/publications/non-domestic-private-rented-property-minimum-energy-efficiency-standard-landlord-guidance
[27] https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf

Reconciliation with National Grid FES 2020:

- It is difficult to directly compare outputs with the FES, as non-domestic electricity consumption in the FES includes electrification of additional buildings, appliances, and industrial processes. However, the modelling has aligned with assumptions around achieving the UK's Clean Growth Strategy target, which is met under Consumer Transformation and Leading the Way, and sees similar trajectories for each of the four scenarios in the near and medium term.
- The FES FAQ document[28] details the assumptions for long-term non-domestic energy efficiency, which is that energy efficiency improves at half the rate of the previous decade. In this analysis this is not directly replicated, as evidence from the CCC's net zero pathways suggests that non-domestic energy efficiency must be more or less complete by the early 2030s in order for the UK to achieve net zero and its intermediate carbon budgets.

Factors that will affect deployment at a local level:

- Each non-domestic sector is modelled separately, and local deployment of thermal energy efficiency will hinge on the breakdown of each sector within each ESA. Areas with high proportions of office and retail buildings, such as town and city centres, see less reduction in heat demand compared to areas with high levels of health, industry, and military buildings.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.2.21
Steady Progression	Some policy effort to improve energy efficiency to meet fuel poverty and environmental targets. Policy targets are missed by a significant margin
System Transformation	Strong commitment to decarbonisation backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. Clean Growth Strategy 2030 target could be hit on time, hit early, enhanced or weakened
Consumer Transformation	Behavioural changes and strong commitment to decarbonisation are backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. CGS 2030 target could be hit on time, hit early, or enhanced.
Leading the Way	Behavioural changes and strong commitment to decarbonisation are backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. CGS 2030 target could be hit on time, hit early, or enhanced.

References:

Building Energy Efficiency Survey, National Grid ESO Future Energy Scenarios, ECUK, BEIS, DECC, CCC, ONS Business Register and Employment Survey

[28] https://www.nationalgrideso.com/document/174911/download

4. Demand reduction factors for non-domestic appliances and lighting

Summary of modelling assumptions and results.

Demand source specification:

The analysis covers the impact of energy efficiency measures on electricity consumption for non-domestic appliances and lighting, encompassing all business electricity consumption that is not related to space heating and hot water, or industrial processes. This demand source relates to **DFES technology building block Dem_BB002c.**

Data summary for non-domestic appliances and lighting in the Southern England licence area:

Energy efficiency reduction factors		Baseline	2020	2025	2030	2035	2040	2045	2050
Non-domestic appliances and lighting	Steady Progression	100%	100%	99%	98%	95%	93%	91%	89%
	System Transformation		100%	96%	91%	86%	81%	80%	79%
	Consumer Transformation		100%	93%	85%	80%	78%	76%	75%
	Leading the Way		99%	90%	80%	76%	74%	73%	71%

Overview of demand source projections in the licence area:

- The uptake of energy efficient commercial appliances and lighting depends on suitable payback periods for each measure, combined with increasing product energy standards such as the recent ban on halogen lightbulbs. As a result, there is a broad range of scenario outcomes that depend on electricity prices, carbon taxation, government policy and product standards.
- By 2035, the overall reduction of electricity consumption ranges from just 5% under Steady Progression, representing a continuation of recent historic trends, up to 25% under Leading the Way, where the UK exceeds its Clean Growth Strategy target.
- In addition to scenario variation, there is significant variation in abatement potential for different sectors within the non-domestic sector. For example, energy efficiency improvement by 2030 under the Consumer Transformation scenarios ranges from 9% (in the Education and Community, Arts and Leisure sectors) to over 25% (in the Emergency Services and Military sectors). This results in variation at a regional and ESA level, depending on the non-domestic sectors present in that area.

Scenario projection results:

Baseline (up to end of 2019)

- Electricity consumption for appliances and lighting in the non-domestic sector has slowly decreased in recent years. According to ECUK data[29], appliance and lighting electricity consumption has fallen by just over 1% per year since 2015.
- The Southern England licence area is similar to the UK overall in terms of electricity consumption by non-domestic subsector, with offices and retail accounting for almost half of this consumption between them.

Sector	Proportion of Southern England non-domestic appliances and lighting electricity consumption	Proportion of UK non-domestic appliances and lighting electricity consumption	Southern England relative to UK
Community, arts & leisure	4%	4%	96%
Education	6%	6%	104%
Emergency services	2%	2%	109%
Health	7%	8%	87%
Hospitality	11%	11%	100%
Industrial	12%	14%	91%
Offices	23%	22%	102%
Retail	25%	24%	104%
Storage	11%	9%	118%

[29] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

Near term (2020 – 2025)

- Scenario projections have been modelled by sector, based on the Building Energy Efficiency Survey (BEES)[30], which identifies abatement potential by measure for each non-domestic sector, and includes expected payback periods for each abatement measure. In the near term, measures with payback periods of two years or less begin to be implemented under all scenarios.
- The Education, Hospitality and Health sectors see the greatest improvement to energy efficiency in the near term. In contrast, the Retail, Office, and Industrial sectors, which make up over half of non-domestic appliance and lighting electricity consumption in the baseline, have no measures with payback periods of two years or less in the BEES data.
- Under Leading the Way and Consumer Transformation the shortest payback measures are quickly implemented, and slightly longer payback measures (2-5 years) also begin to be implemented.

Medium term (2025 – 2035)

- In the medium term, measures with reasonable payback periods between two and five years are implemented. These measures represent over half of the potential abatement identified by the BEES study. As a result, the 2020s and early 2030s see the fastest uptake of energy efficiency measures in the non-domestic sector, as the UK looks to achieve its Clean Growth Strategy target of 20% reduction in business energy demand by 2030.
- Under Consumer Transformation and Leading the Way, these measures are fully implemented by 2033 and 2029 respectively, as the UK achieves its Clean Growth Strategy target in these scenarios. Under System Transformation uptake is less rapid, and under Steady Progression these measures do not begin to be implemented until 2030.
- In alignment with the CCC's Path to Net Zero report[31], commercial and public sector energy efficiency is largely complete by the early 2030s in the Consumer Transformation and Leading the Way scenarios. System Transformation sees slower uptake, but reaches a similar level of energy efficiency improvement by the late 2030s.

Long term (2035 – 2050)

- Energy efficiency uptake slows in the long-term in the net zero scenarios, as the best value measures have already been implemented in the preceding years.
- Incremental improvements continue throughout the timeframe, especially measures with low-cost relative to the amount of carbon abated, particularly in the Leading the Way scenario where carbon taxation is particularly high in the long term.

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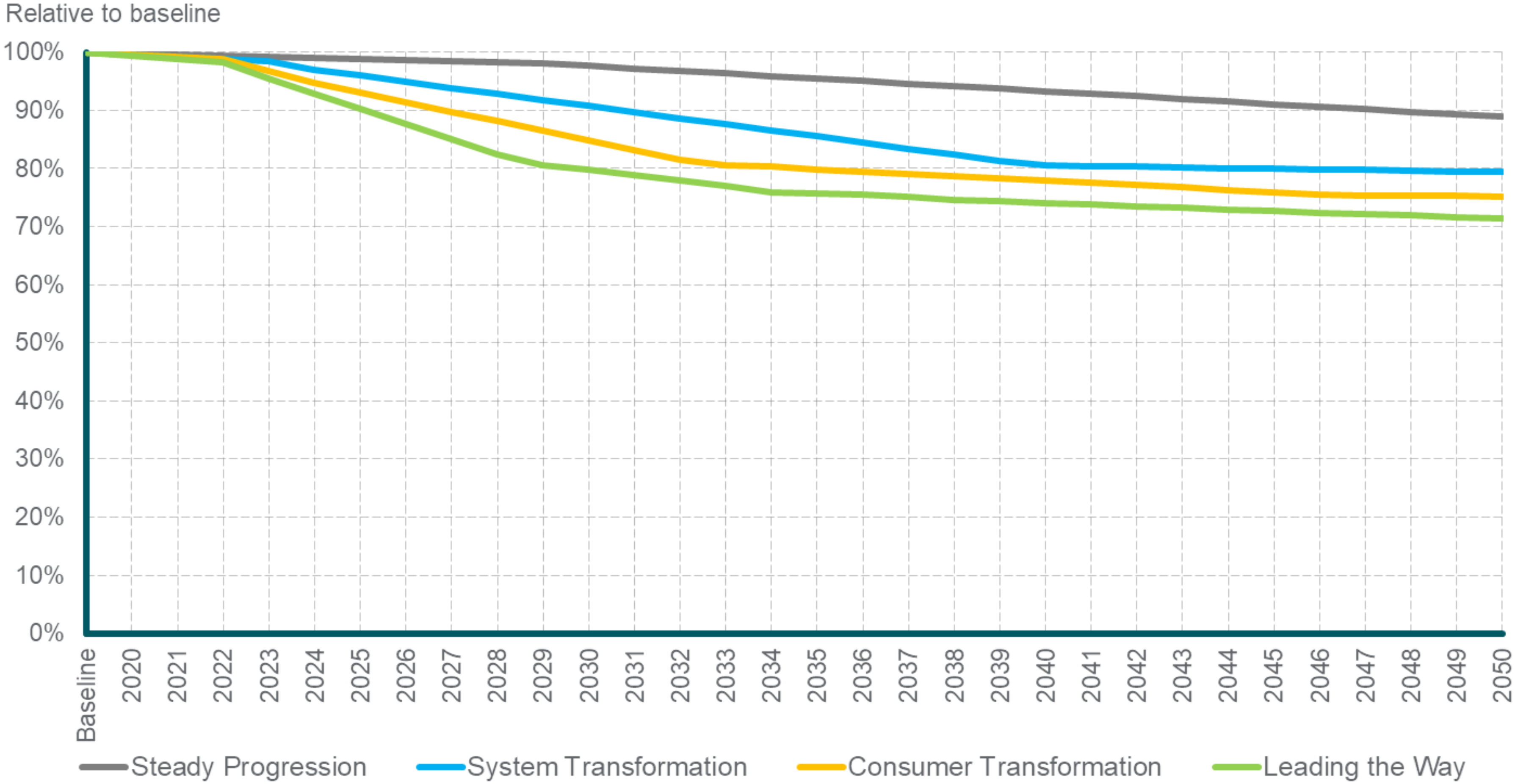
[30] https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees
[31] https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf

Non-domestic appliances and lighting energy efficiency demand reduction factors by scenario

Southern England licence area



Reconciliation with National Grid FES 2020:

- It is difficult to directly compare outputs with the FES, as non-domestic electricity consumption in the FES includes electrification of additional buildings, appliances, and industrial processes. However, the modelling has aligned with assumptions around achieving the UK's Clean Growth Strategy target, which is met under Consumer Transformation and Leading the Way, and sees similar trajectories for each of the four scenarios in the near and medium term.
- The FES FAQ document[32] details the assumptions for long-term non-domestic energy efficiency, which is that energy efficiency improves at half the rate of the previous decade. In this analysis this is not directly replicated, as evidence from the CCC's net zero pathways suggests that non-domestic energy efficiency must be more or less complete by the early 2030s in order for the UK to achieve net zero and its intermediate carbon budgets.

Factors that will affect deployment at a local level:

- Each non-domestic sector is modelled separately, and local deployment of energy efficiency will hinge on the breakdown of each sector within each ESA. Areas dominated by office and retail buildings, such as town and city centres, see less reduction in electricity consumption compared to areas with high levels of health, industry and military buildings.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.2.21
Steady Progression	Some policy effort to improve energy efficiency to meet fuel poverty and environmental targets. Policy targets are missed by a significant margin
System Transformation	Strong commitment to decarbonisation backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. Clean Growth Strategy 2030 target could be hit on time, hit early, enhanced or weakened
Consumer Transformation	Behavioural changes and strong commitment to decarbonisation are backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. CGS 2030 target could be hit on time, hit early, or enhanced.
Leading the Way	Behavioural changes and strong commitment to decarbonisation are backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. CGS 2030 target could be hit on time, hit early, or enhanced.

References:

Building Energy Efficiency Survey, National Grid ESO Future Energy Scenarios, ECUK, BEIS, DECC, CCC, ONS Business Register and Employment Survey

[32] https://www.nationalgrideso.com/document/174911/download

5. Demand reduction factors for industrial processes

Summary of modelling assumptions and results.

Demand source specification:

The analysis covers the impact of energy efficiency measures on electricity consumption for industrial processes, such as high-grade and low-grade grade process heat, motors, drying/separation and refrigeration. This demand source relates to **DFES technology building block Dem_BB002c.**

Data summary for industrial processes in the Southern England licence area:

Energy efficiency reduction factors		Baseline	2020	2025	2030	2035	2040	2045	2050
Industrial processes	Steady Progression	100%	100%	98%	95%	93%	91%	88%	85%
	System Transformation		99%	95%	88%	85%	83%	82%	81%
	Consumer Transformation		99%	93%	83%	80%	77%	75%	75%
	Leading the Way		98%	91%	79%	74%	71%	70%	69%

Overview of demand source projections in the licence area:

- Industrial electricity consumption has decreased significantly in the last two decades, but this trend must be accelerated in order for the UK to achieve its Clean Growth Strategy targets[33].
- Industrial energy efficiency uptake will depend on suitable payback periods for each measure. As a result, there is a broad range of scenario outcomes depending on electricity prices, carbon taxation, government policy etc. that influence the business case for energy efficiency measures. By 2030, reduction of electricity consumption ranges from just 5% under Steady Progression, representing a continuation of recent historic trends, up to over 20% under Leading the Way, where the UK exceeds its Clean Growth Strategy target.
- In the net zero scenarios, the majority of energy efficiency improvements are made in the 2020s, and almost entirely complete by 2040. This aligns with the Committee on Climate Change's Path to Net Zero pathways.[34]

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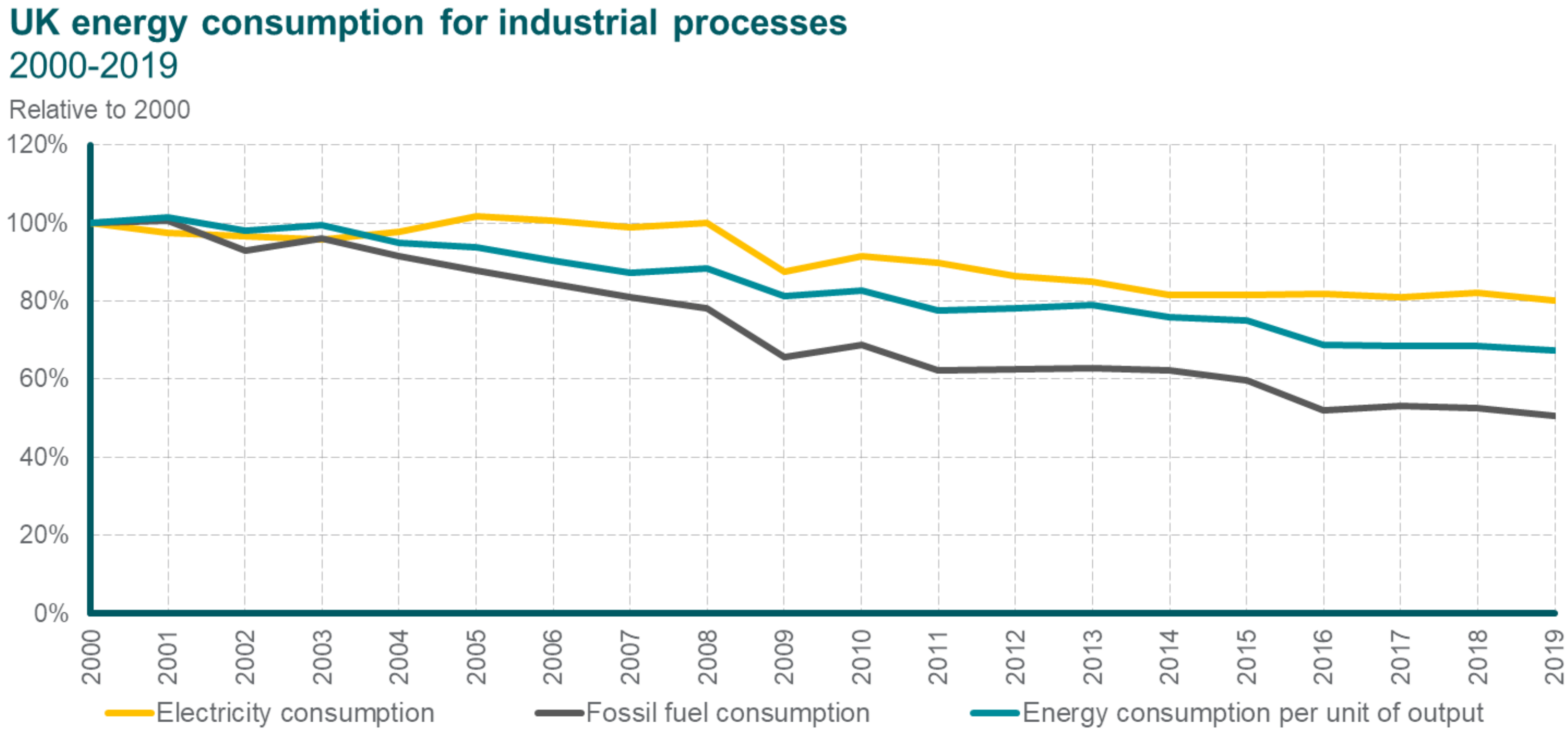
[33] https://www.gov.uk/government/publications/clean-growth-strategy
[34] https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf

Scenario projection results:

Baseline (up to end of 2019)

- Across the UK, energy demand for industrial processes has fallen by 37% since 2000 while output has only reduced 7%, resulting in a reduction of consumption per unit of output (i.e., energy efficiency gains) of 33%[35]. By industry, energy efficiency gains range from 2.5% in mechanical and electrical engineering, to almost 60% in the chemicals and vehicles industries.
- Specifically, electricity consumption for industrial processes has reduced by 20% since 2000. While this follows a similar trend to overall energy consumption, it is only around half the reduction compared to energy use as a whole, showing that the major reductions in energy consumption are due to more efficient use of fossil fuels, of which consumption has reduced by 50% in the same time period.



[35] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

- Industrial process electricity consumption in the Southern England licence area is fairly similar to the UK as a whole, with the exception of less iron and steel, mineral and textiles industry and more chemicals, electrical engineering and vehicle manufacture. This has been modelled using ECUK data on electricity consumption per 2-digit SIC code, and ONS data on employment by SIC code[36]. Note that this initial baselining is based on national metrics for consumption of fuel per unit of output and per employee, due to lack of data at a

Sector	Proportion of Southern England industrial electricity consumption	Proportion of UK industrial electricity consumption	Southern England relative to UK
Iron, steel, non-ferrous metals	2%	8%	**22%**
Mineral products	6%	8%	**73%**
Chemicals	24%	18%	**130%**
Mechanical engineering	6%	5%	**114%**
Electrical engineering	6%	3%	**192%**
Vehicles	4%	3%	**129%**
Food, drink and tobacco	13%	14%	**92%**
Textiles, leather, etc.	2%	3%	**63%**
Printing, publishing	9%	12%	**77%**
Other industries (primarily water and waste)	29%	26%	**112%**

Near term (2020 – 2025)

- While significant efficiency gains have been made over the past two decades, process has slowed since 2015, particularly with regards to electricity consumption per unit of output. In the near term these trends continue, with the upper rate achieved under the Leading the Way and Consumer Transformation scenarios, and only the lower rate achieved under Steady Progression.

Medium term (2025 – 2035)

- Improvement in industrial energy efficiency accelerates in the latter half of the 2020s, as the UK aims to achieve its Clean Growth Strategy ambition of 20% business energy efficiency improvement by 2030[37].

- Potential for energy efficiency by industrial sector has been modelled using BEIS' Industrial Decarbonisation and Energy Efficiency Roadmaps[38] and Action Plans[39], combined with data on the electrical energy efficiency potential of industrial components[40]. The chemicals and 'other' industries, which make up over half of modelled industrial electricity consumption in the Southern England licence area, are identified as having high potential for energy efficiency due to their high usage of pumps and motors. In contrast, the engineering and vehicle manufacture sectors have less energy efficiency potential, owing to the amount of demand used for low temperature process heat in these sectors.
- The Clean Growth Strategy is the key benchmark in this time period. While the overall 20% energy efficiency ambition is achieved under Consumer Transformation and exceeded under Leading the Way, this is not directly reflected in industrial electricity energy efficiency, with reductions of 16% and 21% respectively. This is due to electrical consumption, as illustrated in the 'Baseline' section, having less energy efficiency potential than fossil fuel consumption.

Long term (2035 – 2050)

- Ambition to achieve the Clean Growth Strategy target means that the most cost-effective energy efficiency measures have been undertaken by 2035 in the net zero scenarios. Previously less cost-effective measures are pursued in the Consumer Transformation and Leading the Way scenarios as a result of consumers favouring 'green' products, alongside incremental technological improvements.
- Under Steady Progression, industrial energy efficiency continues the baseline trend of only the most cost-effective measures with short payback periods being considered.

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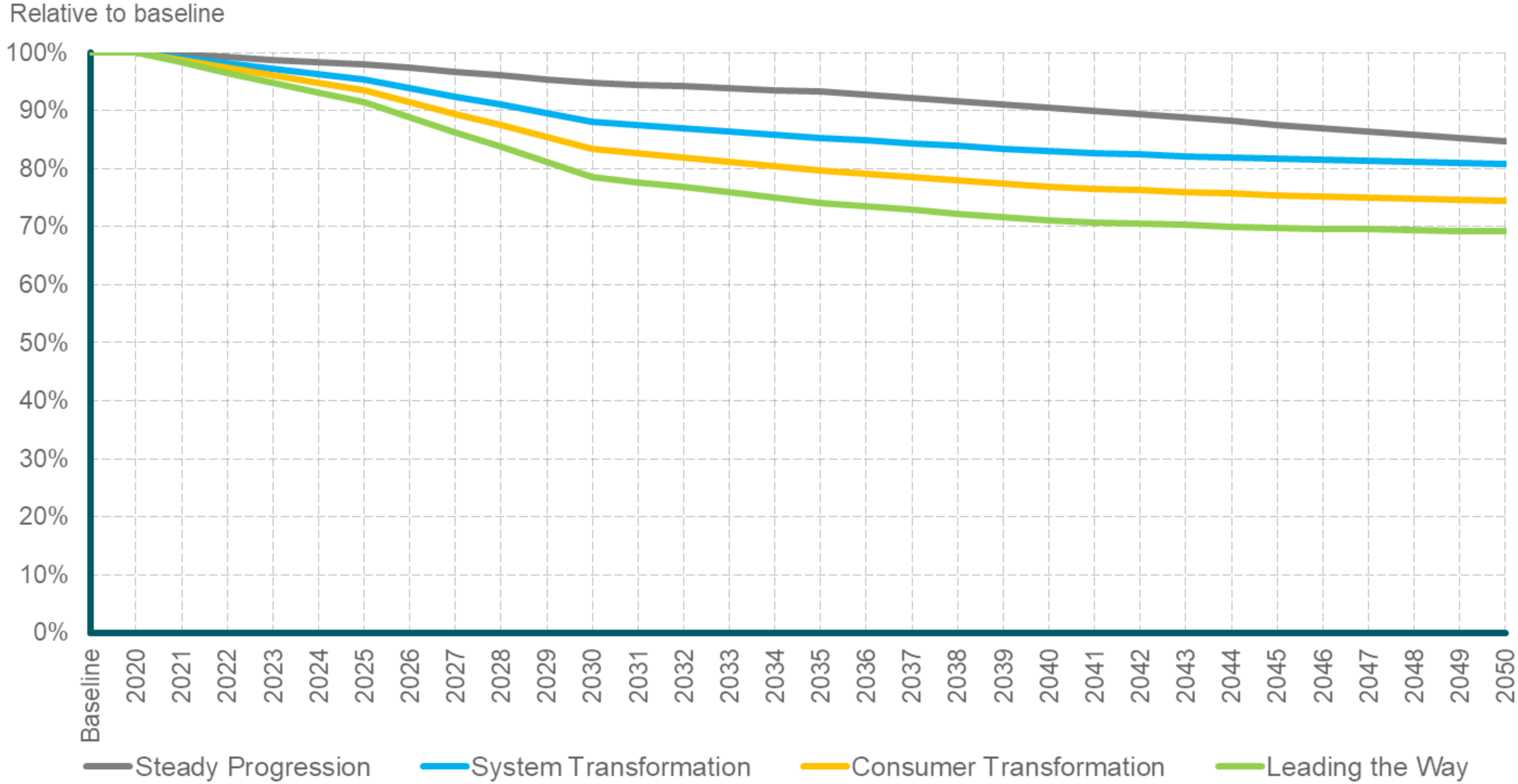
[36] https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/industry235digitsicbusinessregisterandemploymentsurveybrestable2
[37] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf
[38] https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050
[39] https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-action-plans
[40] https://www.gov.uk/government/publications/capturing-the-full-electricity-efficiency-potential-of-the-uk--2

Industrial processes energy efficiency demand reduction factors by scenario

Southern England licence area



Reconciliation with National Grid FES 2020:

- It is difficult to directly compare outputs with the FES, as industrial electricity consumption in the FES includes electrification of additional industry. However, the modelling has aligned with assumptions around achieving the UK's Clean Growth Strategy target[41], which is met under Consumer Transformation and Leading the Way, and sees similar trajectories for each of the four scenarios in the near and medium term.

Factors that will affect deployment at a local level:

- Industrial electricity consumption by sector in each ESA has been modelled using BEIS, ECUK and ONS data. As each sector has been modelled separately, projections differ between ESAs depending on the sectors found within in that area.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.2.21
Steady Progression	Some policy effort to improve energy efficiency to meet fuel poverty and environmental targets. Policy targets are missed by a significant margin
System Transformation	Strong commitment to decarbonisation backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. Clean Growth Strategy 2030 target could be hit on time, hit early, enhanced or weakened
Consumer Transformation	Behavioural changes and strong commitment to decarbonisation are backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. CGS 2030 target could be hit on time, hit early, or enhanced.
Leading the Way	Behavioural changes and strong commitment to decarbonisation are backed up by ambitious policies and effective implementation strategies to improve energy efficiency; energy efficiency seen as pre-requisite to effective decarbonisation. CGS 2030 target could be hit on time, hit early, or enhanced.

References:

National Grid ESO Future Energy Scenarios, ECUK, BEIS, DECC, CCC, ONS Business Register and Employment Survey

[41] https://www.nationalgrideso.com/document/174911/download

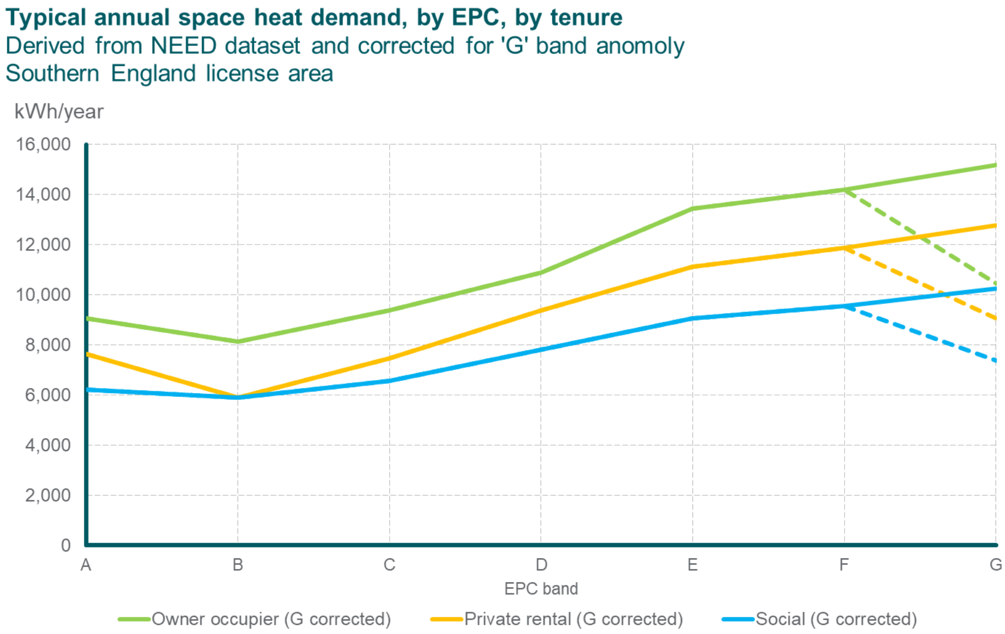
Appendix 1 - Domestic heat detailed modelling assumptions

Summary of modelling assumptions

Baseline domestic heat demand has been modelled by combining the average annual heat demand of a dwelling by property tenure by EPC band, with the numbers of dwellings from each tenure representing each EPC band.

As EPC data does not cover 100% of the stock, to provide a representative model of the building stock the available data was inflated in line with key parameters aligned with the most recent Census data. Analysis of the EPC data showed that sampling bias favoured private rented property, and to a lesser extent social rented property, over owner-occupied property. This is likely to be a result of the requirements for an EPC certificate on every rental or sale of a domestic property, which results in more samples in higher-turnover rented properties. A similar correction was applied based on building type, with flats overrepresented and detached houses and bungalows underrepresented in the EPC data. A weighting factor was determined for each EPC based on tenure and building type, to match the EPC sample with the latest Census data.

Heat demand data was derived from the NEED dataset of average gas demand by EPC band by tenure, the gas demand was adjusted to first remove typical annual consumption for cooking, then to account for typical gas boiler efficiency, delivering a typical annual heat demand[42]. The NEED dataset contains a known anomaly in relation to 'G' banded properties, where despite poorer levels of energy efficiency, gas consumption in G band is typically lower than E, or F[43]. This is thought to be due to a mix of the small sample size (<1.2% of properties are rated a G) along with the use of additional fuels, such as wood, for heating. To account for this the model extrapolated data trends for lower band properties to produce a projected heat demand for G banded properties (see chart).



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[42] National Energy Efficiency Data-Framework (NEED): impact of measures data tables, BEIS, 2020, https://www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-impact-of-measures-data-tables-2020

[43] Domestic energy consumption by energy efficiency and environmental impact, BEIS, 2015, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/669734/Domestic_Energy_Consumption_by_Energy_Efficiency_and_Environmental_Impact.pdf

Projections for changing heat demand due have been made based on two factors that would be driven by policy:

1. Properties shifting from lower (<C) EPC bands to higher (C or above) bands
2. Behavioural changes that would drive a shift in the mean energy consumption of an EPC band

Medium term changes in EPC bands out to 2035 have been modelled driven by the relative success of existing or proposed policies, with changes out to 2050 driven by speculative estimates in line with the relevant scenario.

The key policy drivers and how they have been used in making scenario projections are highlighted in the table below:

Domestic, ignoring new build
Driven by policy
Adjusted to reflect policy impact

			% tenure in EPC band				
Scenario	**Tenure**	**EPC band**	**2020**	**2025**	**2030**	**2035**	**2050**
All	All	A	Baseline data	Baseline data	Interpolated between 2025 and 2035 for OO, PRS and S driven by relative success of PRS MEES, assuming S aligns with this	Baseline data	Baseline data
All	All	B		Baseline data		Assumed % of baseline C bands upgrade to B	Assumed % of baseline C bands upgrade to B
All	All	C		Increased to account for reduction in lower bands		Increased to account for reduction in lower bands	Increased to account for reduction in lower bands
All	All	D		Reduction in bands D - G driven by Green Homes Grant, shifts up a band in F and G from ECO		Reduction driven by relative success of the Clean Growth Strategy target	Estimate of how many D ratings remain, consistent with within the scenario ambition
All	All	E				Assumed E bands eleminated	Assumed E bands eleminated
All	All	F				Assumed up to 1% of F and G bands too challenging to eliminate	Assumed up to 1% of F and G bands too challenging to eliminate
All	All	G					

Driver specific assumptions

Clean Growth Strategy target

The Clean Growth Strategy (CGS) outlined an ambition that "as many homes as possible are improved to EPC Band C by 2035, where practical, cost-effective and affordable."[i] Whilst government has yet to outline what the achievement of this ambition would mean in terms of numbers of homes, they have provided some greater detail to the BEIS select committee as to the definitions of practical, cost effective and affordable, which has guided the modelling used here.[ii] The response highlighted that 'cost effective' could be deemed to mean costing less than £200/tCO2e abated. Modelling for the CCC 5th Carbon Budget identified that approximately 9.1 million homes could be treated with energy efficiency measures for a cost of <£200/tCO2e.[iii] For the purposes of this study it has been assumed that each of these treatments would shift the treated property to an EPC band of C or above and that policies put into place to achieve this ambition would target the poorest performing properties (rated E, F and G) as a priority. If we assume that the existing EPC dataset is representative of all stock (not all dwellings have an EPC) then at a national level the success of this ambition would be equivalent to eliminating all bandings below D and 26% of the 'D' bands as measured in the baseline year. This picture of success has been used for the purposes of scenario modelling and applied across all tenures, the proportion of baseline D bands upgraded varied to reflect the different scenarios, as highlighted in the table below. Note it has been assumed that up to 1% of F and G properties cannot be improved due to practical constraints such as heritage status.

Scenario	% EFG remaining	Proportion of baseline Ds moved to C or above
Steady Progression	<1%	1%
System Transformation	<1%	20%
Consumer Transformation	<1%	26%
Leading the Way	<1%	70%

Green Homes Grant

The Green Homes Grant (GHG) is an existing short-term policy (2020-2022) that will deploy energy efficiency and low carbon heat, making a contribution towards meeting the CGS ambition[iv]. As with the CGS, it has not been made clear how this would directly translate into changes in EPC banding, however the stated ambition is that up to 200,000 properties would be treated by the policy and it could again be assumed that each treatment would equate to moving a <C property into the C banding. This assumption has been checked against the previous assumptions made about the CGS: The government has assessed that meeting the CGS target would cost £35 - £65 billion, the GHG policy has a budget of £2 billion, which is equivalent to 1.5% - 3% of the cost of meeting the CGS ambition. For the purposes of modelling here, it has been assumed that the GHG achieves a pro-rated proportion of the calculated 'success' of the CGS i.e. 1.5% - 3% of 9.1 million properties improved from <C to a C. At a national level, the mid-point of this range is ~200,000 dwellings, (or 1.2% of stock rated <C), in line with the stated ambition of the GHG. In addition to the core GHG policy, the GHG Local Authority Delivery scheme has been taken into account. GHG LAD aims to improve the efficiency of 11,000 homes with ratings of D or below, equivalent to ~0.04% of the stock. This has been applied to the scenarios as outlined in the table below.

Scenario	Average shift from <C bandings	Average shift from <D bandings (GHG LAD)
Steady Progression	0.2%	0.04%
System Transformation	0.8%	0.04%
Consumer Transformation	1.2%	0.04%
Leading the Way	1.6%	0.04%

MEES regulations

The MEES regulations dictate the minimum energy efficiency standards in the private rented sector, with a current minimum requirement that dwellings are rated an EPC E, unless an exemption has been filed on cost or practicality grounds. At the time of writing the government is consulting on tightening these regulations to bring the standard up to an EPC C by 2028, the impact assessment accompanying the consultation identifies the proportion of private rented sector (PRS) properties expected to comply with the regulations, dependent on the cost of works cap at which an exemption could apply (the higher the cap the more properties are within scope).[v] This, in line with a statement that government expects 10% of PRS dwellings to claim an exemption on grounds other than cost (e.g. heritage status), has been used to drive a shift in PRS EPC bands towards C across the scenarios as outlined in the table below.

Scenario	% PRS homes meeting C
Steady Progression	20.0%
System Transformation	37.8%
Consumer Transformation	63.0%
Leading the Way	66.6%

Social Housing Decarbonisation

The government has committed to reviewing the Decent Homes Standard, which effectively dictates a minimum EPC band of F for social housing, to bring it in line with the CGS ambition of EPC C by 2035. In addition, the government made a manifesto pledge to invest in upgrading a ‘significant number’ of socially rented homes to an EPC band C, via the Social Housing Decarbonisation Fund which currently is in a demonstration phase.[vi] At the time of writing there is no detail of the scale of the ambition of the SHDF beyond the demonstrator which will improve 2,200 homes. As such it has been assumed that the policy will put very similar requirements on social landlords to the MEES regulations on private landlords, and so the same drivers have been applied to social tenures as PRS for the period to 2030.

ECO

BEIS projections for uptake of number of insulation measures under ECO3 were used to model the EPC shift as a result of this policy, which has been recently extended out to 2026 under the ‘Sustainable Warmth’ strategy. It was assumed that single insulation measures would be delivered, evenly distributed between properties rating D or below, with the scheme shifting a proportion of each band to a higher band. Modelling in this manner shows greatest change in reducing ‘F’ and ‘G’ rated bandings, as ‘D’ and ‘E’ bands requiring more than a single efficiency measure to reduced heat demand sufficiently to shift to a higher band. There is a chance that this modelling approach slightly underrepresents the impact of the ECO scheme, however a more nuanced approach to fully capture the impact was beyond the scope of the current piece of work.

Behavioural change

In addition to improvements that move properties between bands, there will also be improvements that drive a change in the mean heat demand of each band, these will be a mix of smaller fabric improvements and behavioural change. In the most recent CCC 6th budget report, an assessment was made of the impact of behavioural change on heat demand from which it has been possible to derive a typical annual reduction in heat demand per household[vii]. This reduction has been calculated as a percentage of the baseline mean heat demand by tenure and EPC band, and applied to produce projected heat demand per band by tenure in 2050. It has been assumed that 75% of this reduction is achieved by 2030, in line with increasing public policy around energy efficiency, with the remaining reduction made in a linear fashion out to 2050.

[i] UK Clean Growth Strategy, BEIS, 2017, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

[ii] Government response to BEIS select committee, 2017, https://publications.parliament.uk/pa/cm201919/cmselect/cmbeis/124/12403.htm

[iii] https://www.theccc.org.uk/publication/analysis-on-abating-direct-emissions-from-hard-to-decarbonise-homes-element-energy-ucl/

[iv] GHG press release, BEIS, 2020, https://www.gov.uk/government/news/quality-assurance-at-heart-of-new-2-billion-green-homes-grants

[v] MEES consultation, BEIS, 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/932403/prs-epc-c-consultation-stage-ia.pdf

[vi] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/924260/shdf-demonstrator-supplier-event-presentation-2809202.pptx

[vii] Development of trajectories for residential heat decarbonisation, Element Energy for the CCC, 2020, https://www.theccc.org.uk/publication/development-of-trajectories-for-residential-heat-decarbonisation-to-inform-the-sixth-carbon-budget-element-energy/