Essex Baseline and Pathway to Net Zero

Final report

for

Essex County Council

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Contents

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Acronyms

ASHP ATA	Air Source Heat Pump Air-to-Air
ASHP ATW	Air Source Heat Pump Air-to-Water
BEIS	Departments of Business, Energy and Industrial
CCC	Climate Change Committee
CHP	Combined Heat and Power
DFES	Distribution Future Energy Scenarios
DH	District Heating
ECAC	Essex Climate Action Commission
ECC	Essex County Council
FBS	Future Buildings Standard
FHS	Future Homes Standard
GSHP	Ground Source Heat Pump
HGV	Heavy Goods Vehicle
I&C	Industrial & Commercial
LA	Local Authority
LTN	Low Traffic Neighbourhood
PHV	Private Hired Vehicle
PV	Photovoltaics
UKPN	UK Power Networks

1 Introduction

The focus of this report is to present the baseline of emissions in Essex and a future emissions pathway which has been developed by modelling the impact of the recommended actions of the Essex Climate Action Commission (ECAC). The report is supplemented by the work performed for Essex County Council by Element Energy in 2020 in producing Essex Future Energy Scenarios and Pathways to Net Zero[1].

The baseline of emissions considered the following sectors and has been developed by drawing on the most recently available public datasets:

- Domestic buildings
- Industrial & Commercial (I&C) buildings
- Industrial processes
- Road transport
- Land use and agriculture
- Household waste

Following a review of the Essex Future Energy Scenarios and Pathways to Net Zero work, the ECAC expressed a desire to follow a more ambitious timeline and potentially achieve Net Zero earlier than 2050. To reflect their ambition, the ECAC constructed a range of preliminary recommendations for the decarbonisation of energy and waste in Essex. The recommendations impacted working groups in the areas of Transport, Built Environment, Energy & Waste, and Land use and Green Infrastructure, and are presented as a combination of accelerated net zero target dates, enabling policy measures and key messages of ambition for Essex. This worked involved generating a new scenario world, termed ECAC scenario, that modelled the impact of these recommendations on the future emissions pathway.

The modelling approach follows on closely from our work for UK Power Networks in creating their Distribution Future Energy Scenarios[2] (DFES). That work created scenarios for the key drivers of electricity demand and generation across the region that UK Power Networks serves, including Essex. For certain technologies, such as large, distributed generation, we updated the forecasts in this work to reflect the latest thinking on a

[1] Element Energy for Essex County Council (2020), "Essex Future Energy Scenarios and Pathways to Net Zero (Phase 1)", Available on request from Essex County Council
[2] Element Energy for UK Power Networks (2020), Distribution Future Energy Scenarios, Available from: http://www.element-energy.co.uk/wordpress/wp-content/uploads/2020/03/UKPN_Distribution_Future_Energy_Scenarios_10_March_2020.pdf

decarbonised electricity system. We also produced forecasts for additional technologies, not included in the earlier work such as hydrogen vehicles. Finally, we worked to align the outputs of the Buildings Baseline Study conducted by Element Energy for Essex County Council[3]. Across all of these projects we took a bottom-up approach to modelling that aims to understand the types of homes and businesses across the region to reflect any regional differences that may arise as part of the transition to a low carbon society. The scenarios created reflect the characteristics of Essex and the energy consumers within it.

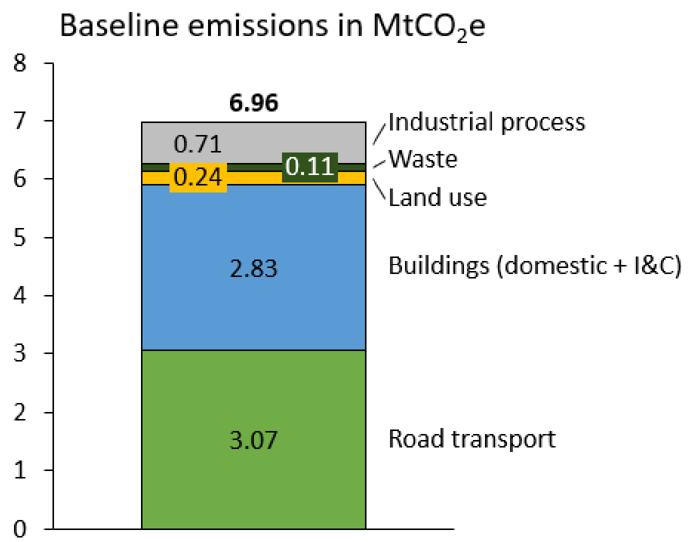
[3] Element Energy for Essex County Council (2020), Built Environment Emissions Baseline and Pathways Review, Available on request from Essex County Council

2 Baseline of emissions

In this section, a baseline view of present-day energy consumption in Essex is shown for the year 2019, based on the most recent publicly available datasets.

Essex currently emits 6,960,000 tonnes of carbon and other greenhouse gas emissions each year. This is made up of 44% from road transport, 32% percent from homes, 9% from places of work, and 10% from industrial process, as shown in Figure 1. We have included 2% from household waste though this analysis excludes commercial waste so understates overall waste contributions; and 3% from land use and agriculture though this is an outline analysis only and further work is required (see section 2.5 below) The detailed scope of the analysis, in terms of the coverage of emissions from these sectors, is presented in Table 1 below. Please note that in this analysis the sectoral emissions are defined by where the end-user activity occurred, rather than the source of the emissions. On this basis, emissions from the energy supply sector, including electricity generation and other production activities such as refining and manufacturing fuels, are attributed to the end-use sector where the electricity or fuel is finally consumed[4].

Figure 1: Baseline carbon emissions in $MtCO_2e$.



Emissions can be broken down into three categories; Scope 1, 2 and 3, defined as follows:

[4] Note that this is a point of difference with some national level emissions reporting, which include energy supply (electricity generation and production of fuels) as a separate source of emissions.

- Scope 1: Direct emissions from fuel combustion and fugitive emissions
- Scope 2: Indirect emissions from the consumption of electricity
- Scope 3: All other indirect emissions, e.g. those associated with business travel, procurement, waste and water.

Scope 1 and 2 emissions are included in the baseline and in the emissions reduction pathways work. Scope 3 has been excluded in addition to emissions from the aviation and shipping sectors. The sources of emissions considered in this analysis for each sector are identified in Table 1 alongside any exclusions.

Table 1: Emission sources included and excluded for each sector

Sector	Included in analysis	Not included in analysis
Domestic buildings	Emissions from space heating, water heating, cooking and electricity use	Household waste (assessed separately – see Household waste sector)
Industrial and commercial (I&C) buildings	Emissions from space heating, water heating, cooking and electricity use	Industrial process emissions (assessed separately – see Industrial processes sector) and waste treatment
Industrial processes	Emissions from high and low temperature processing	Loss of containment
Road transport	Emissions from road transport for journeys within Essex	Aviation and shipping
Household waste	Emissions from the treatment of household waste	Non-domestic waste treatment

For the emissions modelling in this work, we have used national level electricity grid carbon intensity based upon National Grid's 2020 Future Energy Scenarios[5]. The National Grid Consumer Transformation scenario forecasts grid carbon intensity reaching -72kgCO_2e/kWh in 2050. For the

[5] National Grid (2020), Future Energy Scenarios, Available from: https://www.nationalgrideso.com/document/173821/download

purpose of this study, we have rebased the emission trajectory to an endpoint of 0 $kgCO_2e/kWh$. This more conservative assumption was chosen as negative emissions rely heavily on bioenergy with carbon capture and storage (BECCS) which is not guaranteed and could suggest overly favourable future emissions trajectories without any real action being taken at an Essex regional level. See Appendix 8.1 for the modelled carbon intensity trajectory of the electricity grid.

2.1 Buildings sector

In the buildings sector, an archetype stock model was developed for both the domestic and I&C sectors – this work is presented in the Built Environment Baseline study[6]. This was used to provide a bottom-up understanding of building-level fuel consumption in Essex, considering heating and hot water, cooking/catering, lighting and electric appliances. Emissions were then calculated using the carbon equivalent emissions intensity of each fuel[7]. The sources used to develop this baseline fuel consumption model and the building attributes captured in the model are described in Table 2.

Table 2: Data sources used for the buildings emissions baseline.

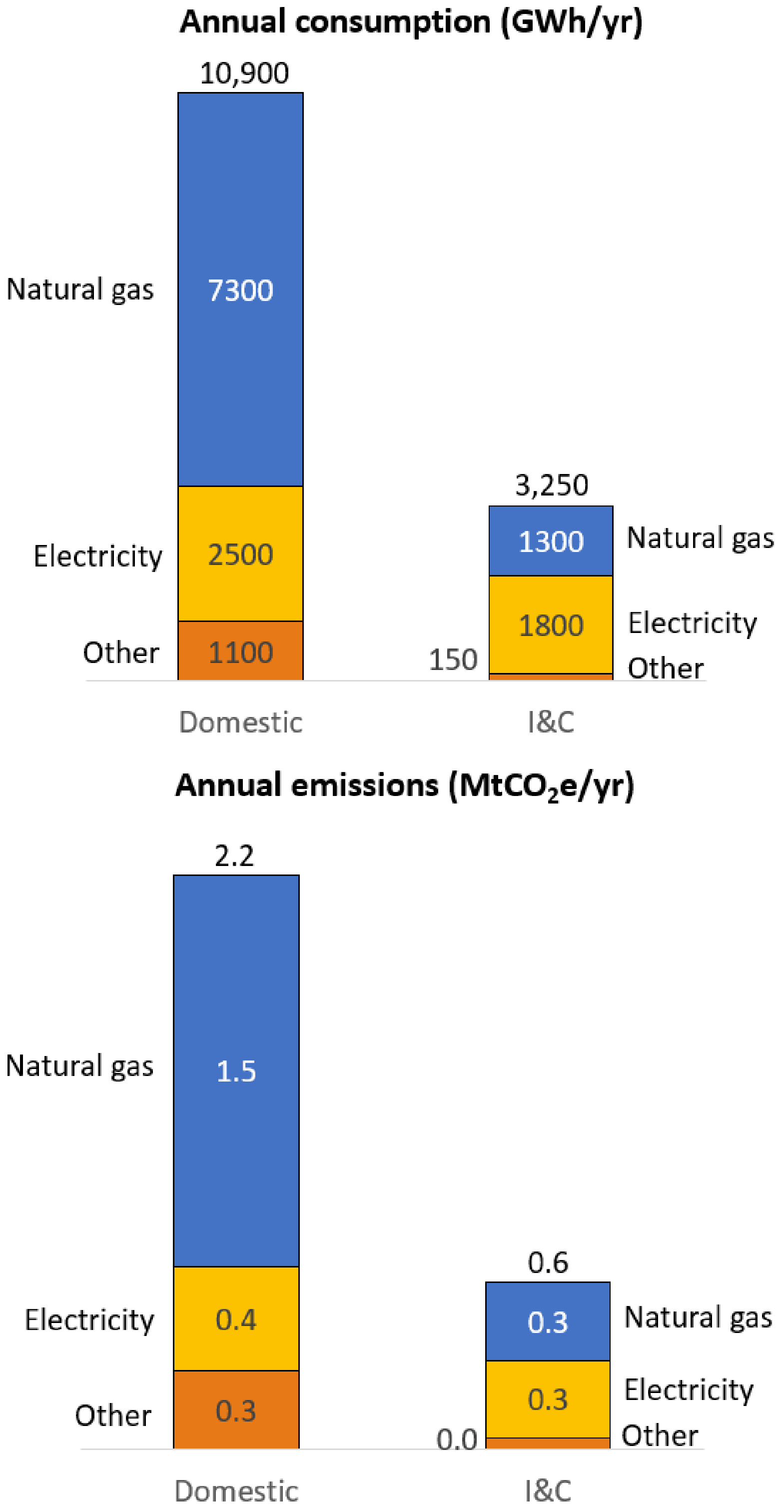
Sector	Source	Information extracted
Domestic	Database for Energy Performance Certificates[8] (EPC)	Age, tenure, fuel type, house type and number of bedrooms
	National Energy Efficiency Data-Framework[9] (NEED)	Electricity and gas demand for different building archetypes
	Department of Business, Energy and Industrial Strategy (BEIS): Sub-	Local Authority (LA) level data used to calibrate stock model

[6] Element Energy for Essex County Council (2020), Built Environment Emissions Baseline and Pathways Review, Available on request.
[7] BEIS (2019), Greenhouse has reporting: conversion factors, Available from: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019
[8] Ministry of Housing, Communities & Local Government, Energy Performance of Buildings Data: England and Wales, Available from: https://epc.opendatacommunities.org/
[9] BEIS (2017), National Energy Efficiency Data-Framework (NEED), Available from: https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework

Sector	Source	Information extracted
	national gas and electricity consumption statistics[10]	
I&C	Database for Energy Performance Certificates[8] (EPC)	Building type, fuel type and floor area
	Building Energy Efficiency Survey[11] (BEES)	Energy intensity of buildings by end-use in each I&C sector
	Department of Business, Energy and Industrial Strategy (BEIS): Sub-national gas and electricity consumption statistics[10]	LA level data used to calibrate stock model
	Energy Consumption in the UK (ECUK)[12]	Provides information on the share of energy used for industrial processes for each fuel type

[10] BEIS (2018), Sub-national Gas and Electricity Consumption Data, Available from: https://www.gov.uk/government/statistics/sub-national-electricity-and-gas-consumption-summary-report-2018
[11] BEIS (2015), Building Energy Efficiency Survey (BEES), Available from: https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees
[12] BEIS (2017), Energy Consumption in the UK: End uses data tables, Available from: https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

Figure 2: Energy consumption and emissions in the buildings sector in CO_2 equivalents, by fuel type.



The buildings sector emitted an estimated 2.8 $MtCO_2e$/yr in 2019. In the domestic sector natural gas is the biggest contributor accounting for approximately 68% of domestic emissions. The contribution in the I&C sector is more closely split between natural gas and electricity with both fuel types accounting for 0.3 $MtCO_2e$/yr. Other fuel types include oil and solid-state fuels like coal.

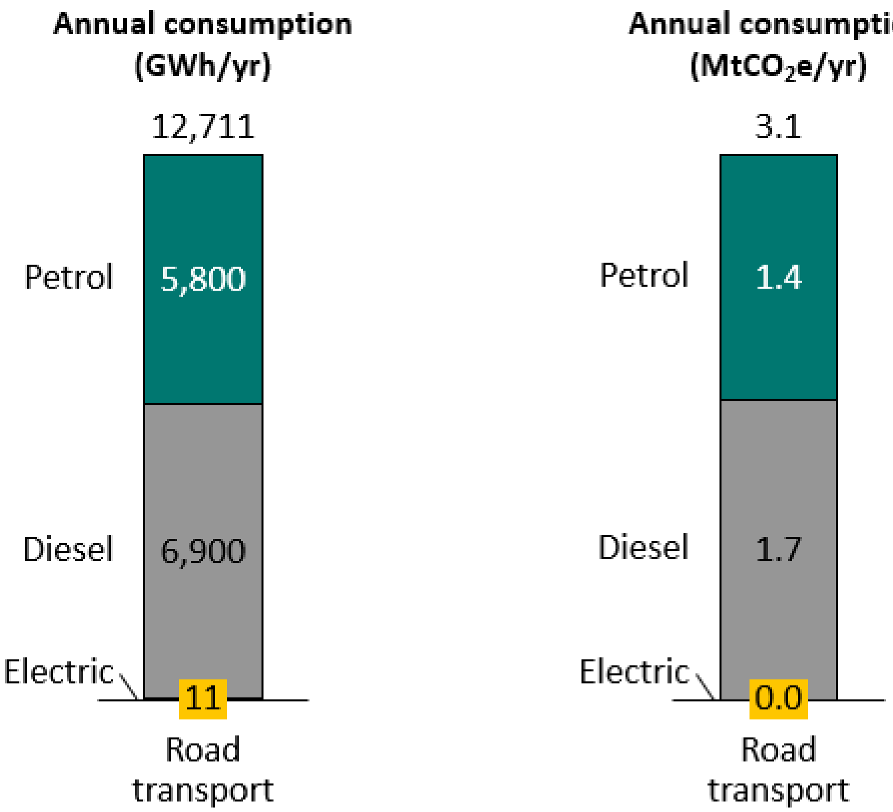
2.2 Transport

The analysis of transport sector emissions includes consideration of road transport for the following vehicle types – cars, vans, private hired vehicles (PHVs) and taxi's, Heavy Goods Vehicles (HGVs), buses, minibuses and coaches, and two-wheeled vehicles. LSOA level data was used to estimate the number of vehicles, by vehicle type, in the 12 LA's. This was combined with data from the Department for Transport[13], which provides the traffic volume in miles by vehicle type, and gives an estimate for the number of total traffic miles covered for each vehicle type in 2019. Emissions relating to aviation and shipping have been excluded from this analysis.

Using fuel consumption factors (estimated energy consumption per km travelled) for the different fuel and vehicle types, total energy consumption from road traffic in Essex could be estimated. Emission factors[14] were then used to calculate total emissions in the transport sector.

[13] Department for Transport (2021), Road Traffic Statistics, Available from: https://www.gov.uk/government/collections/road-traffic-statistics
[14] BEIS (2019), Greenhouse has reporting: conversion factors, Available from: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

Figure 3: Energy consumption and emissions in the transport sector, by fuel type.



As shown in Figure 3, total energy consumption in 2019 in the road transport sector is estimated at 12,711 GWh/yr. Consumption of diesel outstrips petrol at 6,900 and 5,800 GWh/yr, respectively. This contributes to around 3.1 $MtCO_2e$/yr in carbon equivalent emissions, 41% more than the total emissions from the domestic and I&C buildings sectors combined.

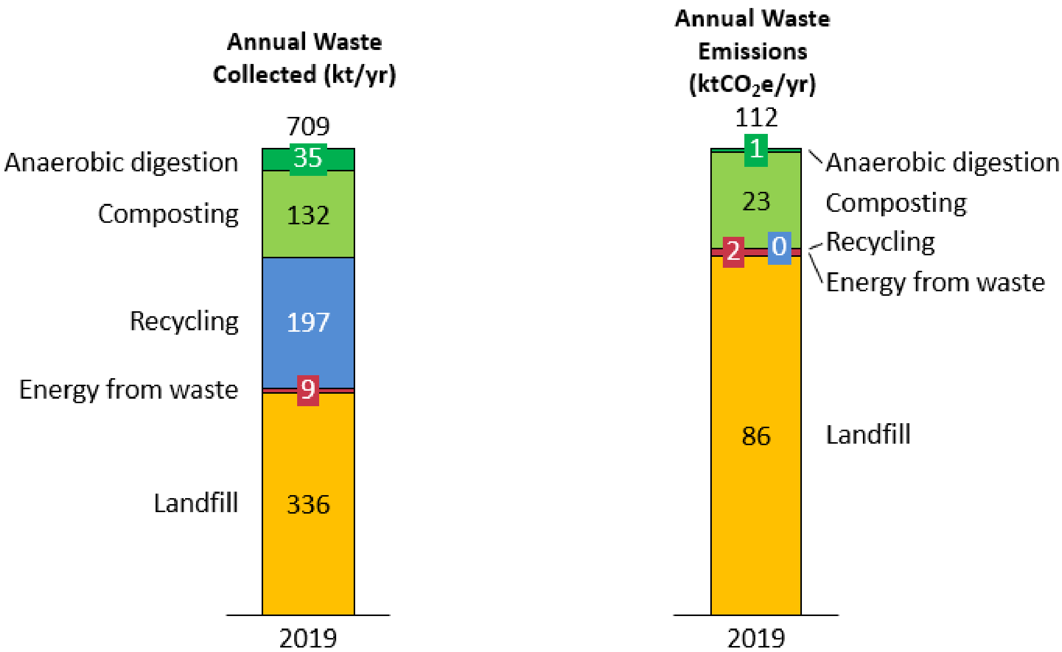
2.3 Waste

For the waste sector, recent data on the amount of domestic waste collected by the local authority was provided by Essex County Council. This identified the mass of waste disposed of through five different treatment routes: landfill, energy from waste, recycling, composting and anaerobic digestion. Domestic waste accounts for around 50% of all waste produced in Essex. Non-domestic waste has not been considered in this analysis, and further work is needed to account for emissions from non-domestic waste.

Emission factors were used to convert mass of waste to emissions for each treatment option. For landfill and energy from waste, emission factors from

Zero Waste Scotland[15] were utilised, and for composting and anaerobic digestion the emission factors were taken from the IPCC.[16] For recycling, process emissions should be accounted for alongside emissions relating to material usage.

Figure 4 Waste mass and emissions by treatment



As shown in Figure 4, total waste collected in 2019 was 709 kt. Of this waste, the most common treatment option is landfill, making up 47% of all waste collected. Waste accounts for emissions of 0.1 $MtCO_2e$/yr, which corresponds to less than 2% of total emissions in Essex. Landfill accounts for 77% of total waste emissions, a higher proportion than it accounts for by mass due to the high carbon intensity of the landfill process (landfill is the waste treatment type with the highest emissions intensity per tonne of waste produced).

Emissions from household waste treatment in Essex are slightly higher than the average in England, at 0.075 tCO2e versus 0.065 tCO2e[17] respectively per capita per annum. The difference is driven by two factors:

[15] Zero Waste Scotland (2020), The Climate Change Impacts of Burning Municipal Waste in Scotland. Available from: https://www.zerowastescotland.org.uk/sites/default/files/ZWS%20%282020%29%20CC%20impacts%20of%20incineration%20TECHNICAL%20REPORT.pdf
[16] IPCC (2006, refined 2019), Guidelines for National Greenhouse Gas Inventories. Available from: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_4_Ch4_Bio_Treat.pdf
[17] DEFRA (2021), Statistics on waste managed by local authorities in in England in 2019/2020. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/966114/Statistics_on_waste_managed_by_local_authorities_in_England_in_2019v3_accessible.pdf

Essex produces slightly more waste than the English average, and a higher proportion of Essex's waste is sent to landfill.

2.4 Industrial Process

Industrial process emissions are calculated using three sources:

1. The UK local authority and regional carbon dioxide emissions national statistics: 2005-2018[18] – This dataset provides estimates of the total emissions (in $kgCO_2$) in the I&C sectors for Electricity, Gas, "Other fuels" and "Large Industrial Installations".
2. Energy Consumption in the UK (ECUK): End Use Tables[19] – This dataset is used to estimate the share of energy consumption in the industrial sector that can be attributed to industrial process for electricity and gas fuel types.
3. National Atmospheric Emissions Inventory (NAEI): Sub-national Residual Fuels[20] – This dataset is used to estimate the share of energy consumption in the industrial sector that can be attributed to industrial process, for "other" fuel types.

BEIS estimates total I&C emissions to be 1,520 $ktCO_2$ in 2018. Using ECUK data, which estimates that 39% of electricity consumption and 40% of gas consumption is attributable to industrial process in the industry sector, and the sub-national residual fuels data, which estimates that 85% of other fuel consumption is attributable to industrial process in the industry sector, we can estimate the emissions from industrial process only. In 2018, this is estimated to be 754 $ktCO_2$, which is equivalent to 704 $ktCO_2$ in 2019, accounting for a reduction in the grid's electricity carbon intensity.

2.5 Land use

Land use emissions contribute 0.24 $MtCO_2e$ in the baseline. Note that analysis of emissions related to land use has not been undertaken as part of this study, but has been assessed as part of a separate study undertaken by JBA Consulting. Further work on the impact of land use change on the county's emissions is expected to be undertake by ECC in the future.

[18] BEIS (2018), UK local authority and regional carbon dioxide emissions national statistics, Available from: https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2018

[19] BEIS (2019), ECUK: End uses data tables, Available from: https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

[20] NAEI (2018), UK sub-national residual fuel consumption for 2005-2018, Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/920752/uk-sub-national-residual-fuels-2005-2018.pdf

3 Essex Future Energy scenarios

The ECAC scenario developed in this work is based on the Future Energy Scenarios (FES) presented in the Essex Future Energy Scenarios and Pathways to Net Zero study.[21] Three different scenario worlds were constructed for the future evolution of the energy system within Essex:

- Steady Progression: General progress towards decarbonisation continues; however, the rate of change is not sufficient to meet net zero carbon emissions in 2050.
- Green Transformation: Meets net zero driven primarily by centralised initiatives and transformation of existing infrastructure, including the production of low carbon hydrogen, requiring less change for individuals.
- Engaged Society: Meets net zero emissions in 2050 with significant engagement at an individual level and a high degree of electrification.

In creating these scenarios consideration of the absence of clear policy direction, particularly in sectors such as heating, was necessary. The three scenario worlds developed, therefore, reflect the broad range of outcomes that could constitute a net zero compliant energy stem in 2050.

To build up the three over-arching scenario worlds in the Essex FES, we created individual scenario describing the evolution of drivers of energy demand and generation across Essex. These drivers include; domestic housing stock, distributed generation, electric vehicles, energy efficiency measures, industrial and commercial floor space, decarbonised heating, battery storage, and flexibility. Once the future scenarios for each key driver were modelled, specific scenarios were aggregated into the three over-arching scenario worlds that represent a single cohesive view of a potential future world. See Figure 5 for the breakdown of the three scenario worlds.

Where possible, during the development of the Essex FES, we made use of the scenarios produced in our work for UK Power Networks (UKPN) creating their Distribution Future Energy Scenarios[22]. As part of that work, we disaggregated the future energy scenarios for all key drivers of electricity demand and generation to high geospatial resolution. This was informed by geospatial information such as the existing uptake of low carbon technologies, planned developments and therefore reflects the

[21] Element Energy for Essex County Council (2020), "Essex Future Energy Scenarios and Pathways to Net Zero (Phase 1)", Available on request

[22] Element Energy for UK Power Networks (2020), Distribution Future Energy Scenarios, Available from: http://www.element-energy.co.uk/wordpress/wp-content/uploads/2020/03/UKPN_Distribution_Future_Energy_Scenarios_10_March_2020.pdf

socio-economics characteristics of the different regions. This granularity allowed us to filter the data for the areas relevant to the 12 Local Authorities that fall within Essex County Council.

Figure 5 Breakdown of the drivers of energy demand and generation in the three scenario worlds

	Scenario world	Steady Progression	Engaged Society	Green Transformation
Core	Net-zero by 2050?	No	Yes	Yes
	Energy efficiency	Low	High	Medium
	Building stock growth	Medium	Medium	Medium
Transport	Electric vehicles (cars and vans)	Low	Medium	Medium
	Electric vehicles (other)	Baseline	High electrification	Green transformation
Heat	Heating technologies	Medium electrification	High electrification	Low electrification with decarbonised gas
	District Heat uptake	Low	High	High
	District Heat supply	Decentralised scenario	Electrification scenario	Decarbonised gas scenario
Generation	Small scale solar PV	Low	High	Medium
	Large solar PV	Low	Medium	High
	Gas reciprocating engine	High	Low	Low
	Onshore wind	Low	High	Low
	Hydrogen generation	Low	Low	High
	Other renewable generation	Low	High	Medium
Storage	Domestic battery storage	Medium	High	Low
	I&C behind-the-meter battery storage	Low	Medium	Low
	Co-located battery storage	Medium	High	Low
Flexibility	Grid-scale battery uptake	Medium	Medium	High
	Flexibility	Medium	High	Low
	EV smart charging	Medium	High	Low

The outputs from the Essex Future Energy Scenarios and Pathways to Net Zero study are shown in Figure 6 and Figure 7, which present the annual energy consumption and annual emissions for the three scenario worlds, respectively.

Figure 6 Annual energy consumption in the three scenario worlds

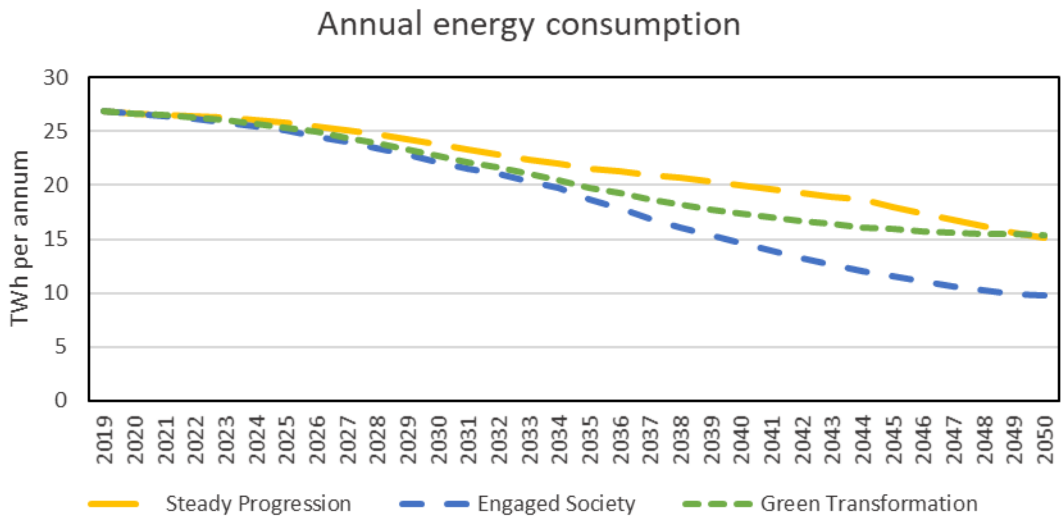
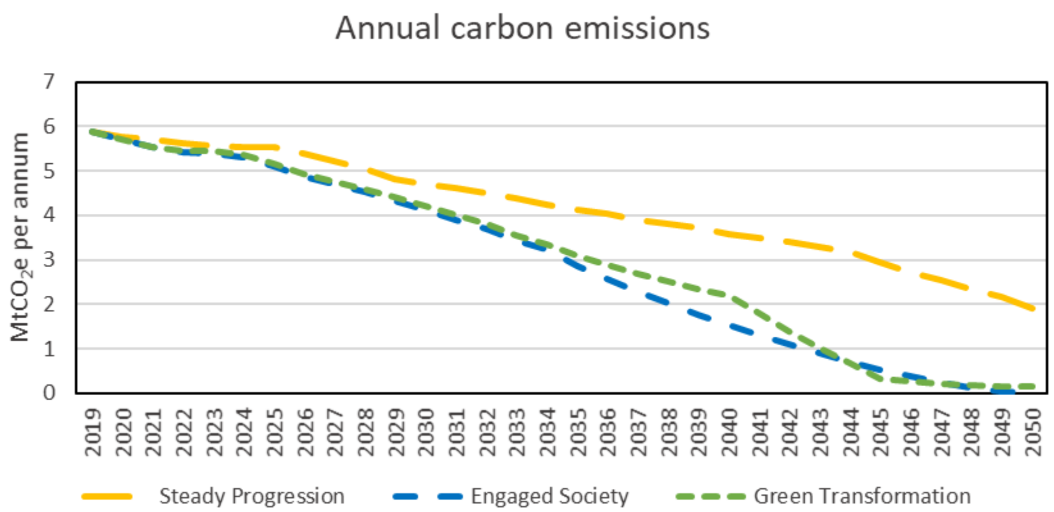


Figure 7 Annual emissions from the three scenario worlds



The ECAC recommendations expresses a desire to follow a more ambitious timeline then what is presented in the previous work and potentially achieve Net Zero earlier than 2050. A new scenario, termed ECAC scenario, is created to show the impact of these recommendations. The Engaged Society scenario was chosen as the starting point for the new ECAC scenario. This is because the ECAC recommendations look to set an ambitious target of reaching net zero compliance before 2050 and thus requires immediate action and engagement in the uptake of low carbon heating technologies in Essex. The technology required to achieve this and which is readily available now would see a high degree of electrification of heat as seen in an Engaged Society world.

4 Buildings

This section considers how the ECAC recommendations translate into an energy and emissions pathway for the buildings and power sectors. It also includes a gap analysis to identify areas to strengthen the ECAC recommendations.

4.1 ECAC Scenario Modelling

In order to assess the impact of the ECAC recommendations in the buildings sector we undertook analysis to calculate how the ECAC recommendations translate into heating technology and energy efficiency deployment and subsequently modelled the impact on emissions. The approach drew on the 2050 net zero compliant scenarios developed in our previous work for ECC[23] and looked to accelerate these scenarios to meet the ECAC targets. Three scenarios; Steady Progression, Engaged Society and Green Transformation were developed in the previous work (see Section 3 for a more detailed description of these scenarios).

The Engaged Society scenario was chosen as the starting point for the new ECAC scenario. This is because the ECAC recommendations look to set an ambitious target of reaching net zero compliance before 2050 and thus requires immediate action and engagement in the uptake of low carbon heating technologies in Essex. The technology required to achieve this and which is readily available now would see a high degree of electrification of heat as seen in an Engaged Society world.

We categorise the ECAC recommendations relating to the buildings and power sector into four main areas: domestic new builds, existing domestic buildings, I&C new builds and existing I&C buildings. These categories are discussed in more detail below.

4.1.1 Domestic new builds

Table 3 lists the ECAC recommendations relevant to the domestic new build sector and describes the approach taken to develop the ECAC scenario based on them. The ECAC recommendations refer to 'zero carbon' homes which we have defined based on the Future Homes Standard.

Future Homes Standard[24] (FHS)

[23] Element Energy (2020), Essex County Council Future Energy Scenarios and Pathways to Net Zero

[24] Ministry of Housing, Communities & Local Government (2021), The Future Homes Standard: changes to Part L and Part F of the Building Regulations for new dwellings, Available from: https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings

The FHS sets out the Government's plans for changes to Part L and Part F of the Building Regulations in England to improve energy efficiency and cut carbon emissions in new build homes. From 2025, homes built under the FHS should produce 75-80% less carbon emissions compared with current new build regulations. The government has also committed to ensuring that once a new house has been built, no retrofitting will be necessary to reach zero carbon as the electricity grid continues to decarbonize.

The FHS is set in performance terms, setting minimum levels of CO_2 emissions and primary energy with backstop limits on fabric standards and building services standards, but without prescribing the technologies to be used. This allows housebuilders flexibility to innovate and select the most practical and cost-effective solutions. Although the FHS is mainly a carbon standard, rather than an energy standard, there are proposed backstop U-values (i.e. minimum standards for the thermal performance of the building fabric, defined as the heat loss rate through building elements) to ensure a reasonably high level of fabric efficiency. The carbon standards ensure that new homes will not be built with fossil fuel heating, e.g. natural gas boilers, and it is expected that heat pumps will become the main source of heating – direct electric will only be allowed in some cases. The FHS is intended to be consistent with the Net Zero legislation, it has therefore been used as a basis for a "zero carbon home" in this work.

Table 3: Recommendations for domestic new builds.

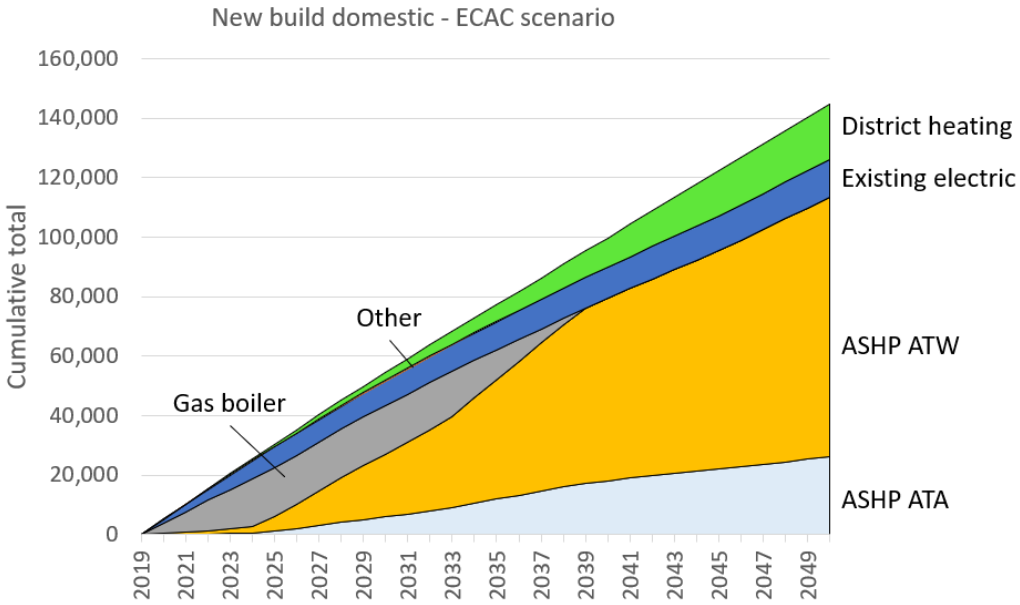
ECAC recommendations	Breakdown of recommendation into constituent parts	Approach to scenario development
1. All new homes consented to be carbon zero by 2025	Increase uptake in low/zero carbon technology	Allowed heating systems: heat pumps (HPs) and district heating (DH). Direct electric allowed but not encouraged (due to higher running costs / fuel bills) unless there is a good reason not to do DH or HPs (e.g. very low heat demand, HPs and DH not technically feasible). Disallowed heating systems: gas boilers and bioenergy boilers.

	Higher Energy Efficiency standards in housing	The Future Homes Standard (FHS) sets out draft notional building fabric and services specifications. The indicative U-values are more stringent than those previously set out in Part L and Part F of the Building Regulations for new homes. To model the FHS, we have estimated space heating demand that corresponds to the U-values. To do this, we have leveraged analysis by Currie & Brown[25] for the CCC, drawing on different combinations of efficiency measures for various house types.

We have adapted the heating technology uptake projections from the Engaged Society scenario to achieve the targets set out in the ECAC recommendations. New builds have been modelled such that, from 2025, gas and oil boilers are not used and only 5% of the new build stock each year is put on direct electric (e.g. are heated using electric resistive or electric storage heaters). We also assume a high level of uptake of district heat (DH), so that by 2050, 13% of the new build domestic stock will be served by DH. Additionally, the low carbon heating technology assumed in the notional building in the FHS is an Air Source Heat Pump Air-to-Water (ASHP ATW), to keep in line with this narrative, 80% of ASHPs in new builds are air-to-water, the remainder are air-to-air (ATA). The impact of the above ECAC recommendations on the technology mix in the new build housing stock is shown in Figure 8.

[25] Currie & Brown and AECOM (2019), The costs and benefits of tighter standards for new buildings, Available from: https://www.theccc.org.uk/publication/the-costs-and-benefits-of-tighter-standards-for-new-buildings-currie-brown-and-aecom/

Figure 8 Heating technology mix in the new build domestic stock.



In the emissions model, new builds are classified as those built post 2019. Using an average boiler lifetime of 15 years, those boilers added in 2024 (before the 2025 ban) will reach the end of their life in 2039 - this is the reason for the grey wedge in the graph above extending beyond 2025.

4.1.2 Existing domestic buildings

Table 4 lists the ECAC recommendations relating to existing domestic buildings and describes the approach to model their impact.

Table 4: ECAC recommendations for existing home retrofits.

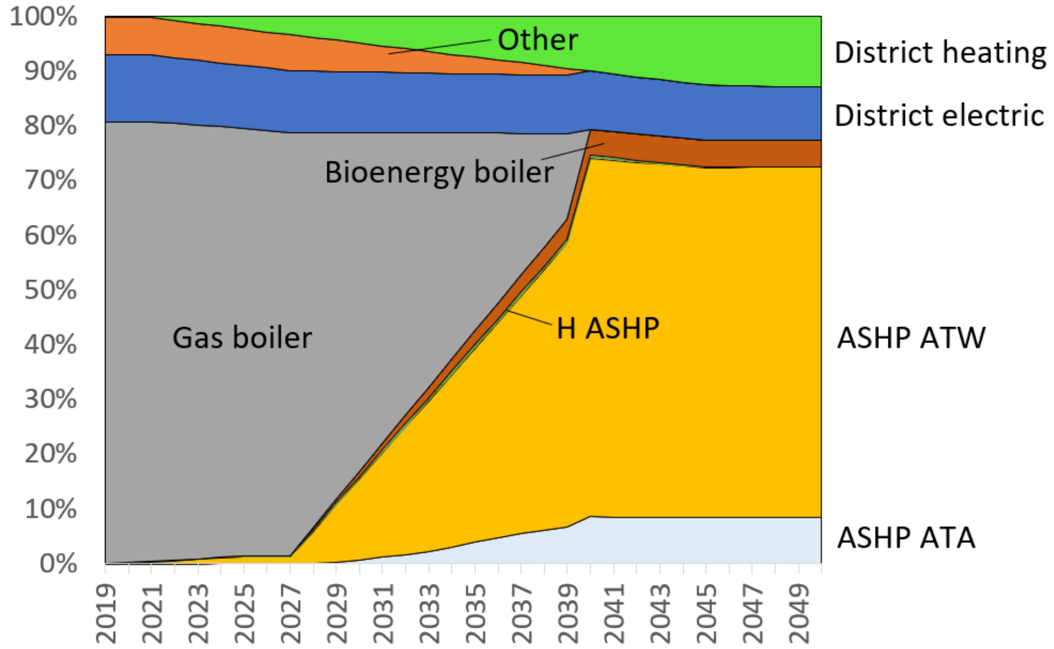
ECAC recommendations	Breakdown of recommendation into constituent parts	Approach to scenario development
1. Two thirds of all dwellings to be retrofitted as far as possible to net zero carbon standards by 2030 2. Retrofit across the whole housing stock by 2040,	Retrofitting dwellings with low/zero carbon heating technology	Allowed heating systems: heat pumps, direct electric and biomass boilers (used for hard-to-decarbonise off-gas homes). Disallowed heating systems: gas boilers, oil boilers and all other fossil fuels e.g. solid fuel. The year 2030 (& possibly 2040) is in advance of a possible widespread hydrogen transition for the gas network in

introduce an incentive to accelerate the shift to low carbon heating solutions 3. Existing residential buildings- carbon emissions reduction of 50 per cent by 2030. Carbon Zero by 2040 4. Use bioenergy for all rural homes that are hard to decarbonise through electrification by 2030 5. 100% of fuel poor households retrofitted and supplied with affordable renewable energy by 2030		Essex therefore we propose to disallow gas boilers in zero carbon homes. To achieve zero carbon homes in advance of hydrogen rollout would require a ban on the replacement of existing gas boilers. We have modelled this policy effect from 2028 with some boiler scrappage of 10-12 years old.
	Retrofit housing with improved energy efficiency measures	We have revisited the energy efficiency measures in Phase 1 and rolled them out at a faster rate – two-thirds of the efficiency deployed by 2050 in Engaged Scenario is now deployed by 2030 in the ECAC scenario.

The recommendations in Table 4 impact two main areas of the emissions model for the existing domestic stock; the heating technology uptake and energy efficiency.

For the heating technologies, we have used the Engaged Society scenario from Phase 1 as a starting point for the heating technology mix and adapted it to align with the ECAC recommendations. The resultant uptake is shown in Figure 9.

Figure 9 Heating technology mix in existing domestic buildings.



From 2028, there is a ban on the replacement of gas & oil boilers which results in 1/15th of the domestic stock[26] on gas and oil converting to low carbon heating systems annually until 2039. In 2039, there is a sharp increase in uptake of low carbon heating to achieve the 2040 ECAC target, which involves replacing systems ahead of their normal lifetime, i.e. a gas/oil boiler scrappage scheme.

Applying the ban on replacement earlier, e.g. 2025, is highly ambitious and especially challenging to do ahead of implementation at a wider / national level. The CCC Sixth Carbon Budget[27] suggests that the heat pump supply chain would need more time to ramp up supply to meet the demand if this policy were introduced before 2028. There is also the regulatory issue of introducing such policy locally i.e. how to stop homeowners from purchasing boilers in neighbouring counties where they are still allowed.

Using internal Element Energy analysis based on our work for the UKPN[28], we find that there are approximately 30,000 off-gas homes that can be classified as hard-to-decarbonise and are unsuitable for HPs. We assume these homes take bioenergy boilers as specified in the ECAC recommendations. Features of hard-to-decarbonise homes are those that

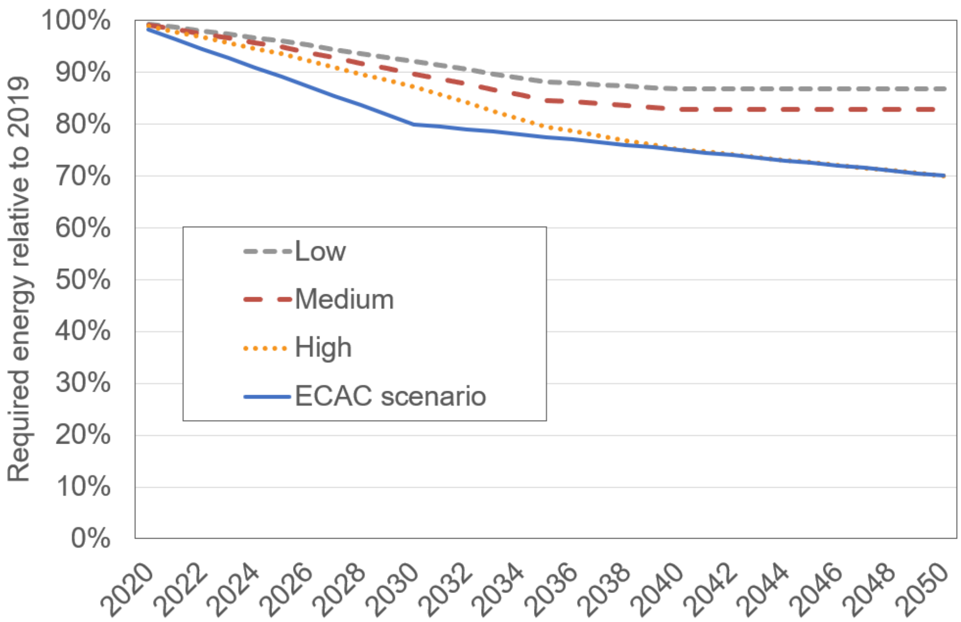
[26] 1/15th based on Element Energy analysis of boiler statistics to determine their average lifetime of 15 years.
[27] Climate Change Committee (2020), The Sixth Carbon Budget, Available from: https://www.theccc.org.uk/publication/sixth-carbon-budget/
[28] Element Energy (2021), Heat Street; Scenarios to assess the impact of decarbonisation of heat on the electricity network in UPN areas to 2030, Available from: https://innovation.ukpowernetworks.co.uk/projects/heat-street-local-system-planning/

have space constraints and are therefore not suitable for heat pumps, or those which are listed buildings making retrofitting difficult and more costly.

Additionally, the level of uptake of district heating and direct electric heaters follows that of the Phase 1 Engaged Society scenario, which assumes a high level of district heat uptake.

For thermal efficiency, the ECAC scenario is consistent with the Commission's recommendation that two thirds of all dwellings are retrofitted as far as possible to net zero carbon standards by 2030. This is represented by an accelerated version of the High scenario used in Engaged Society as shown in Figure 10. The level of retrofit achieved by the ECAC scenario is not deeper than the High scenario, but it is achieved faster.

Figure 10 Energy efficiency of the existing domestic building stock.



4.1.3 I&C new builds

Table 5 lists the ECAC recommendations relevant to the I&C new build sector and describes the approach taken to develop the ECAC scenario based on them. The ECAC recommendations refer to 'zero carbon' buildings which we have defined based on the Future Building Standard.

Future Buildings Standard[29] (FBS)

The FBS is a government proposal analogous to the FHS, setting out proposed changes to Part L and Part F of the Building Regulations for non-

[29] Ministry of Housing, Communities & Local Government (2021) The Future Buildings Standard, Available from: https://www.gov.uk/government/consultations/the-future-buildings-standard

domestic buildings. It sets out proposals which provide a pathway to highly efficient non-domestic buildings which are zero carbon ready, better for the environment and fit for the future. The FBS is less developed than the FHS in terms of detailing 2025 targets. However, like the FHS, the government has set out an interim uplift in energy efficiency from 2021. Two options for improvements in energy efficiency are presented in the FBS which reflect different approaches and levels of ambition. The option preferred by the government is one which delivers a 27% reduction in carbon emissions on average per building compared to the existing Part L standard. In this work, the FBS is used to help define a "zero-carbon non-domestic building" and guide the energy efficiency requirements in new builds.

Table 5: Recommendations for I&C new builds.

ECAC recommendations	Breakdown of recommendation into constituent parts	Approach to scenario development
1. All new commercial buildings to be carbon zero by 2025 2. All new schools commissioned to be carbon zero by 2022	Selecting archetypes	We have defined the following archetypes from our building stock model as 'commercial buildings': • Retail, Offices, Storage, Hospitality, and Community, arts & leisure. The number of new schools in Essex has been estimated using the School Organisation 10 year plan[30]
	Increase uptake in low/zero carbon technology	Allowed heating systems: heat pumps (HPs) and district heating (DH). Direct electric is allowed but not encouraged unless there is a good reason not to do DH or HPs. This is in

[30] Essex School Organisation Service (2021), 10 Year Plan Meeting the demand for school places in Essex 2021-2030, Available from: https://assets.ctfassets.net/knkzaf64jx5x/1sTwHeX9pKGI7ebfWZQ8yS/64c4aca7768117ae8a77fb0ba51fd260/ECC_10_year_plan_school_places_2021_2030.pdf

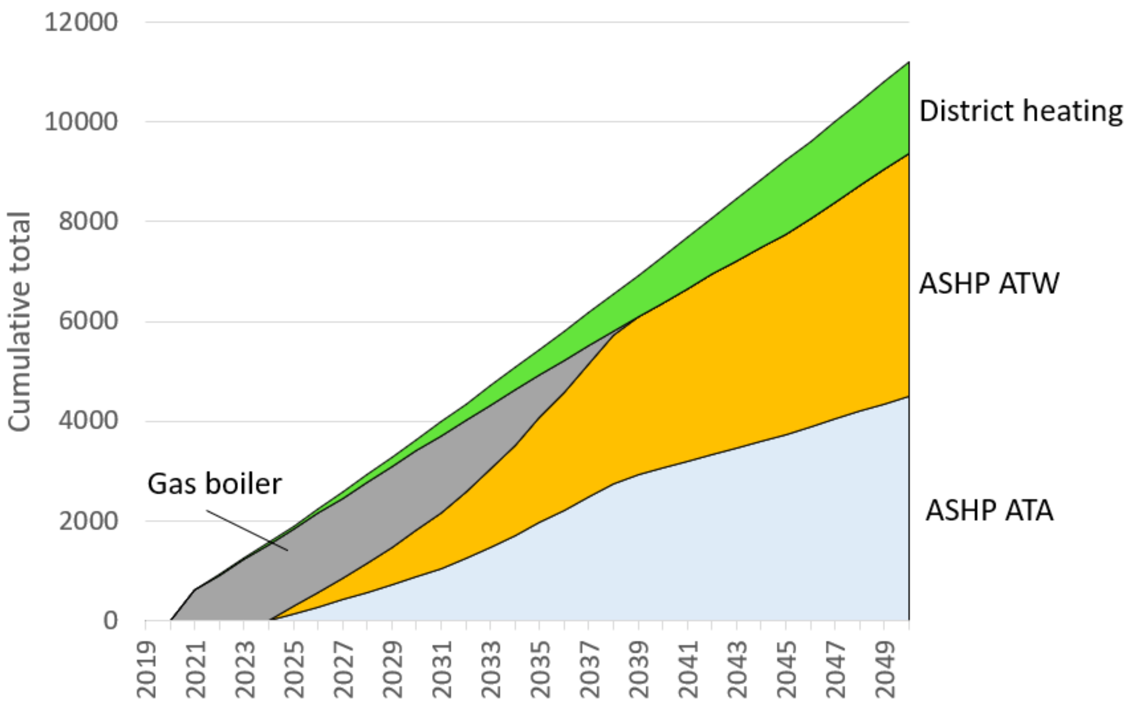
		line with the Future Buildings Standard. There is little guidance on disallowed heating systems in the FBS so we have followed the same logic as is applied to the domestic sector.
	Energy efficiency	We have drawn on the FBS which sets out energy efficiency specifications for non-domestic new builds for 2021. For the ECAC scenario we have used the specifications listed in Option 2 – these are more stringent specifications and is the government's preferred option. Using analysis from the Ministry of Housing, Communities and Local Government[31], we have identified thermal demands for different building types that correspond to the proposed energy efficiency specifications set out in the FBS.

The Essex 10-year plan indicates that there will be 19 new schools constructed by 2031 (not including school extension projects). We have assumed that this level of growth continues out to 2050 and that, from 2022, all new schools have heat pumps installed. To further align with the recommendations, we have assumed that from 2025, all new I&C buildings have a heat pump or are supplied by district heating. The level of district heating uptake is the same for Engaged Society, which estimates around

[31] Ministry of Housing Communities & Local Government (2019), Energy Performance of Buildings Directive: Second Cost Optimal Assessment for the UK, Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770783/2nd_UK_Cost_Optimal_Report.pdf

16% of the new build I&C stock will be on district heating by 2050. The technology uptake projections can be seen in Figure 11.

Figure 11 Heating technology mix for I&C new builds.



4.1.4 Existing I&C buildings

Table 6 lists the ECAC recommendations relevant to existing I&C buildings and describes the approach taken to develop the ECAC scenario based on them. To assess the impact of the recommendations, we have calculated the share of buildings in each existing I&C archetype that is relevant to the recommendation. For example, where a recommendation refers to 'schools', the ECC site list has been used to estimate the number of schools in Essex and thus the relevant share of buildings in our 'Education' building stock model archetype; Table 6 shows this breakdown, and the breakdown for the other archetypes in the emissions model. The table shows that that the proportion of the non-domestic building stock affected by the ECAC recommendations is small – this is because the ECAC recommendations only really influence the public estate, including anchor institutions.

Table 6 Existing I&C breakdown showing the share of buildings attributed to Anchor Institutions or the ECC estate

I&C archetype	Share of buildings attributed to Anchor Institutions or the ECC Estate
Retail	<1%
Offices	<1%
Industrial	<1%
Storage	6%
Hospitality	0%
Education	37%
Health	<1%
Community, arts & leisure	12%
Other	2%

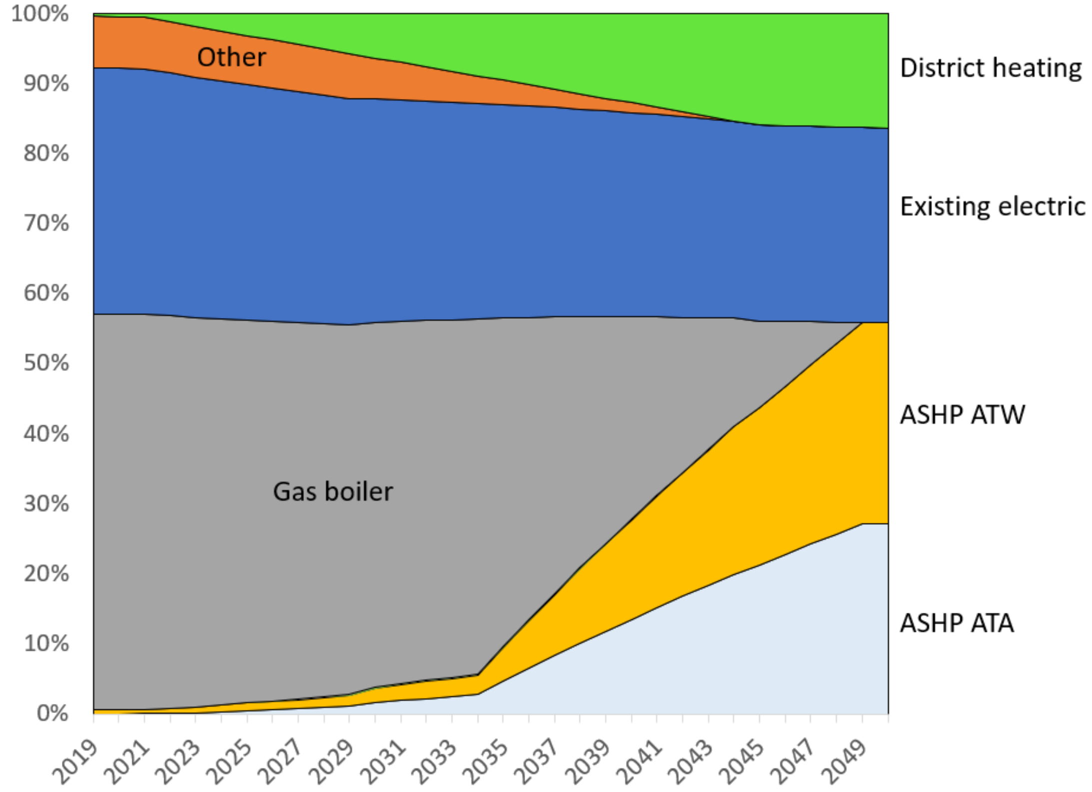
Table 7: Recommendations for existing I&C buildings.

ECAC recommendations	Breakdown of recommendation into constituent parts	Approach to scenario development
1. All Anchor Institutions and ECC estate assets to be retrofitted to net zero carbon standards by 2030	Determine share of schools, Anchor Institutions and ECC estate assets in the existing I&C archetypes	We have used the ECC site list and additional information on Anchor Institutions provided by ECC, to estimate the share of buildings in the existing archetypes that will be affected by the relevant ECAC recommendations.
2. 50 per cent of Essex schools to be retrofitted to net zero standards by	Retrofit buildings with low/zero carbon heating technology	We have assumed that the share of buildings affected by the ECAC recommendations will switch to a low carbon

2025. 100 per cent by 2030		heating system. From 2022, 1/15th of the stock on gas or oil boilers is switched to an ASHP, followed by an increase before 2030 to align with the recommendation.
	Retrofit buildings with improved energy efficiency measures	We have revisited the energy efficiency measures in Phase 1 and, for the share of buildings that fall under Anchor Institutions, ECC Estate and schools, have rolled them out at a faster rate (100% deployment by 2030). This has a small effect on the overall heating demand of the I&C sector due to the low proportion of buildings captured by the ECAC recommendations.

We have used the Engaged Society scenario from Phase 1 as a starting point for the heating technology mix and adapted it to align with the ECAC recommendations. This is done by accelerating the uptake of low carbon heating technologies to ensure the net zero target dates set out in the ECAC recommendations are achieved – the projections can be seen in Figure 12.

Figure 12 Heating technology mix for existing I&C buildings



The proportion of existing buildings in each archetype considered part of the ECC estate is determined by the ECC site list and Anchor institutions list. To align with the ECAC recommendations, this share of the stock is switched to low carbon heating technologies by 2030. As with the domestic sector, this is achieved by switching 1/15th of the ECC gas and boiler stock annually, followed by a certain level of gas and oil boiler scrappage in 2029 to achieve the 2030 target. The number of buildings on electric and district heating are kept the same as for Engaged Society, this scenario already assumes a high level of uptake of district heating.

The overall impact of the ECAC recommendations on uptake of low carbon heating technologies is marginal because, as demonstrated in Table 6, the ECAC recommendations are only relevant to a small share of the I&C building stock.

4.1.5 Modelling outputs

The impact of the ECAC recommendations on the overall emissions trajectories in Essex is shown in Figure 13 and Figure 14 for the domestic buildings sector and the I&C buildings sector, respectively.

Figure 13 Emissions trajectories in the domestic buildings sector

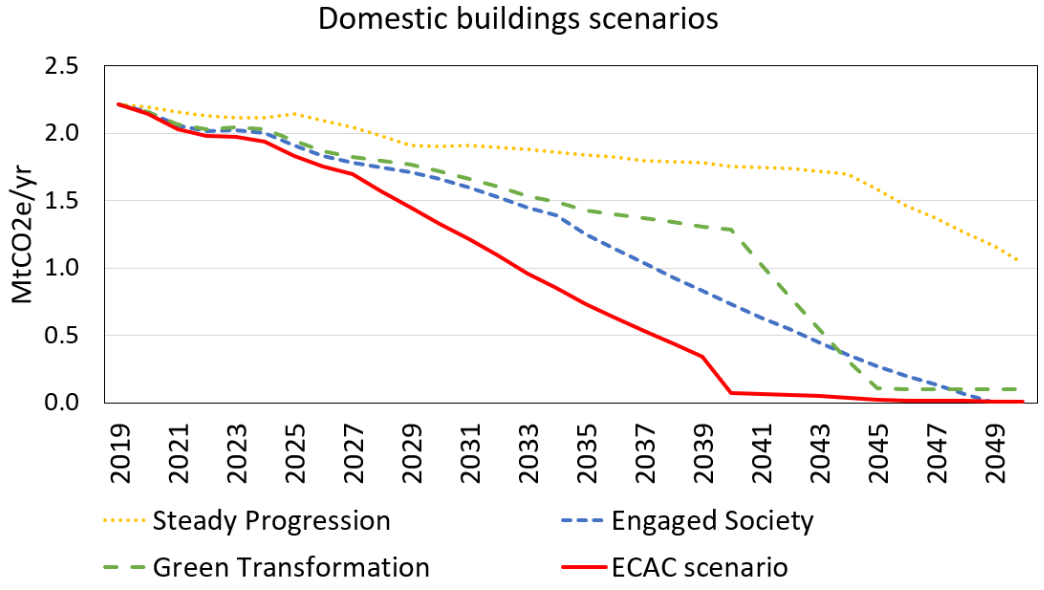
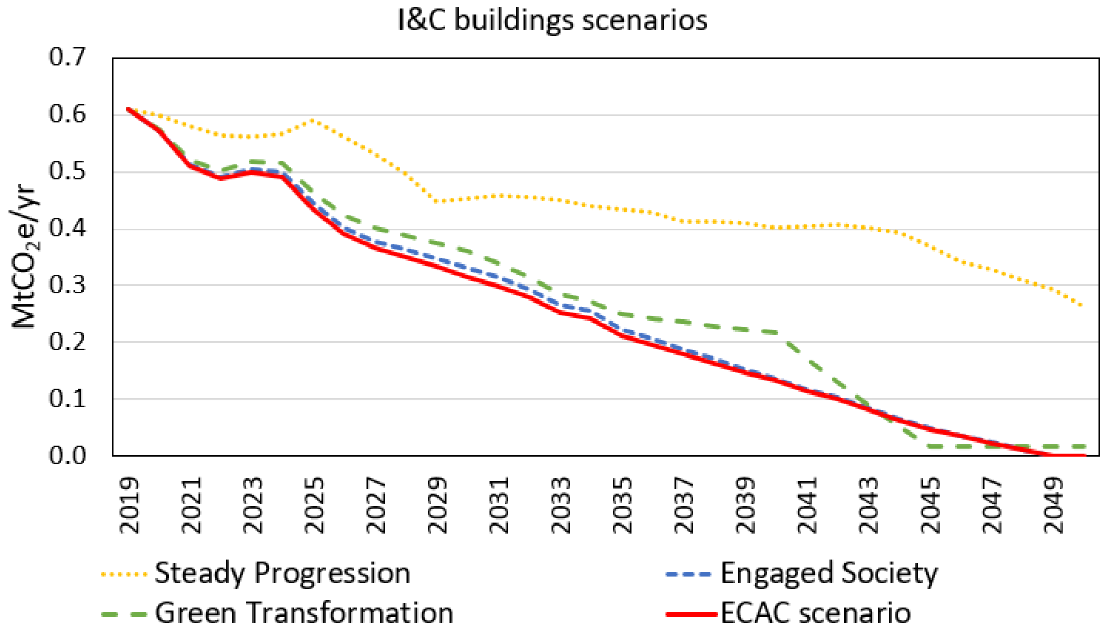


Figure 14 Emissions trajectories in the I&C buildings sector



In the domestic sector, the ECAC recommendations accelerate the reduction in CO_2e emissions, reaching very low levels by 2040. The ECAC scenario will become net zero at the same point in time as in the Engaged Society scenario due to the remaining carbon intensity of the electricity grid.

The ECAC scenario in the I&C sector shows a very similar emissions trajectory as the Engaged Society scenario. This is because the ECAC recommendations are relevant to only a small share of the I&C building stock, as discussed in Section 3.1.4, and therefore have only a small impact on emissions.

See Appendix 8.1 for more graphs detailing the impact of the ECAC recommendations on energy and emissions by fuel type and technology in the domestic and I&C buildings sector.

4.2 Gap analysis

This section considers gap between the ECAC recommendations and Essex's ambition to achieve net zero emission as soon as possible in the buildings sector. We assess what implicit assumptions have been made in our modelling to achieve the target which are not explicitly detailed in the ECAC recommendations.

In our modelling of the ECAC scenarios, we assume the High district heating uptake scenario from our Phase 1 work. This level of uptake assumes that 13% (~100,000 homes) of the domestic stock and 16% (~9,000 buildings) of the I&C stock is served by zero carbon district heat in 2050. District heating is key to providing substantial cost-effective heat decarbonisation, especially for homes with space constraints that may be unsuitable for heat pumps. Deployment of heat networks requires engagement and influence at local government level; however, there is no mention of district heating in the ECAC recommendations.

In Table 8 we highlight policy interventions that ECC could use to encourage district heat in Essex. The recommendations are split into those in which ECC has direct control and those in which ECC has a high level of influence.

Table 8: DH policy recommendations.

Policy	Level of influence
Develop an Essex-wide district heating strategy including identifying areas of high demand, opportunities for using waste heat, river sources etc, and sources of funding (e.g. HDNU)	Direct control
Explore opportunities for Council buildings to act as an anchor load for a new heat network.	Direct control
Use influence in local plans to set targets for district heating connection based on strategy	High

Work with Councils to transition from CHP to low carbon sources in heat networks, including no new gas CHP (e.g. at Langdon Hills)	High
Develop and implement a heat zoning policy, that mandates that new and existing buildings connect to heat networks to drive high connection rates.	High
Use of planning policy to require connection of existing homes to heat networks at suitable trigger points, where appropriate. Approaches based on local heat zoning should be considered, combining planning instruments with financial incentives where required.	High

We have also identified the hard to decarbonise homes sector as another area where the ECAC recommendations could be strengthened. Using internal Element Energy analysis based on work for UKPN[32], we find that there are approximately 30,000 off-gas homes that can be classified as hard to decarbonise (i.e. unsuitable for heat pumps). Constraints to heat pump deployment in these homes include fuse limits, space constraints and high peak thermal demands.

The hard to decarbonise homes sector is an area that requires strong influence at local government level. Currently, only one ECAC recommendation addresses hard to decarbonise homes: "Use bioenergy for all rural homes that are hard to decarbonise through electrification by 2030". We suggest that supporting policies and measures would be required to supplement this recommendation. We also recommend further focus on homes which are hard to decarbonise but not classed as 'rural' or which may be unsuitable for bioenergy boilers:

- Hard to decarbonise homes where bioenergy boilers are be unsuitable, e.g. densely populated areas with air quality concerns over bioenergy boilers.
- Hard to decarbonise homes that are space constrained and therefore not suitable for heat pumps.

[32] Element Energy (2021), Heat Street; Scenarios to assess the impact of decarbonisation of heat on the electricity network in UPN areas to 2030, Available from: https://innovation.ukpowernetworks.co.uk/projects/heat-street-local-system-planning/

- Hard to decarbonise heritage homes that have more onerous planning restrictions and/or more costly approaches to retrofit.

At a local government level, the following recommendations can be used to help address the gap in policy:

- Undertake further research to better understand the additional challenges and costs of energy efficiency retrofitting and uptake of low carbon heating systems in heritage and space constrained homes, and the number and type of homes which these issues are likely to apply.
- Develop the skills base required to deliver low carbon retrofit solutions to this segment, such as through training programmes and other initiatives.

5 Power

This section considers how the ECAC recommendations impact the uptake of renewable energy generation in Essex. It also includes a gap analysis to identify areas to strengthen the ECAC recommendations.

5.1 ECAC scenario modelling

This section considers the following ECAC recommendations:

1. Install solar panels on every available rooftop on both domestic and industrial and commercial buildings by 2050, and on 25% of available rooftops by 2030.
2. All new build houses to have solar panels installed immediately.
3. All new build I&C units to have solar panels installed immediately.
4. One third of commercial buildings to be retrofitted as far as possible with renewable energy systems by 2030.
5. All new homes and non-domestic buildings consented to be carbon positive by 2030.
6. All new schools commissioned to be carbon positive by 2030.
7. Build 1.43 GW of large scale solar on available land without unduly compromising agricultural land by 2030.

5.1.1 Domestic Sector

In the domestic sector, recommendations 1, 2 and 5 apply. For recommendation 2, we assume all new build homes have solar PV installed. To address recommendation 1, we have modelled the additional solar PV capacity that this target would drive by considering typical domestic solar PV installations in the range 3-4 kW[33] and assigning them to our building stock model archetypes. Larger building archetypes take a larger capacity. In this projection we have assumed that newbuilds take up part of the 'available' rooftops.

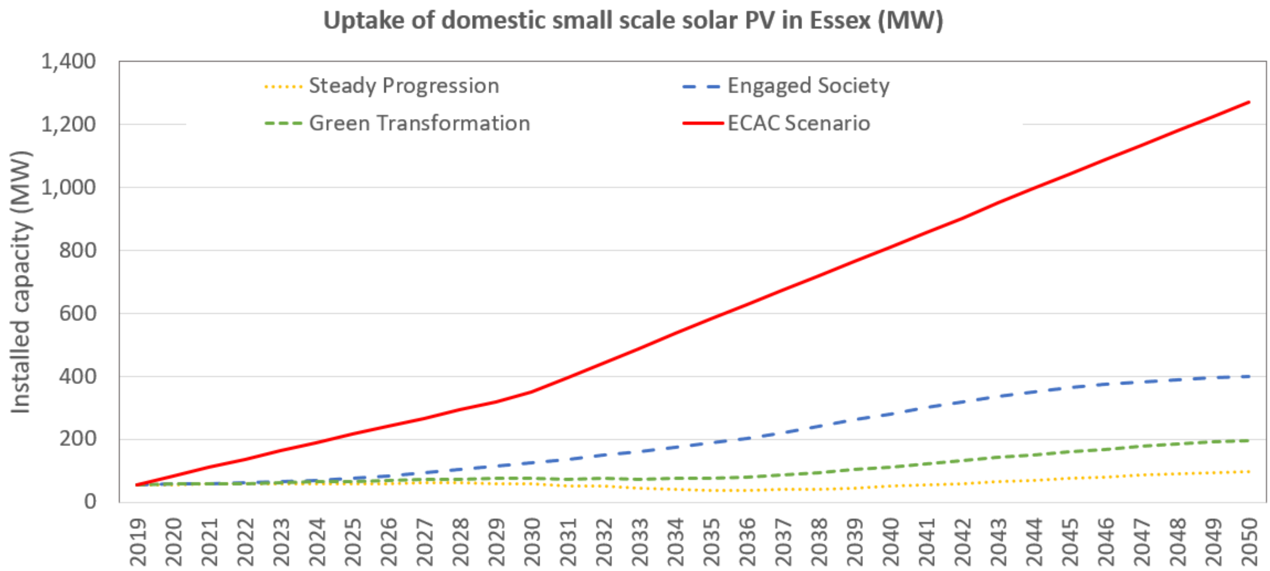
We rely on literature estimates to determine the proportion of roofs available to take solar PV. As an upper-bound, approximately 50% of domestic buildings (new + existing) can be considered viable for solar PV[34]. Solar PV is unsuitable on a large proportion of houses which have no / limited roof space, unfavourable orientation/inclination of roof parts, and shaded roofs from obstacles like chimneys or from neighbouring properties.

Together with Essex County Council, we agreed that the recommendation that all new homes and non-domestic buildings should be carbon positive

[33] https://www.self-build.co.uk/30-ways-to-save-money-on-your-home-extension-project/
[34] K Bodis et al (2019), A high-resolution geospatial assessment of the rooftop solar photovoltaic potential in the European Union, Available from: https://www.sciencedirect.com/science/article/pii/S1364032119305179

by 2030 would be defined around offsetting electricity emissions of a proportion of the existing building stock. This proportion was defined as the proportion of hard-to-decarbonise homes in the domestic building stock. As described earlier, our analysis suggests there are around 30,000 off-gas homes in Essex that are hard-to-decarbonise. The non-heating electricity demand from these homes in 2050 is around 124 GWh. Assuming a solar panel with an average yield of 800 kWh/kWp (typical of current solar panel technology under UK conditions and therefore potentially conservative given technology improvements over the period to 2050) we estimate that an additional 154 MW of solar PV capacity is required to satisfy the above recommendation. We assume the additional 154 MW is installed across all new build developments at the point of construction from 2030 onwards in both the domestic and I&C sectors. The overall uptake of domestic small scale solar PV for the ECAC scenario is shown in Figure 15, against the Phase 1 solar PV uptake scenarios.

Figure 15 Uptake of domestic small scale solar PV.



5.1.2 Industrial and Commercial Sector

In the I&C sector, the following recommendations apply:

1. Install solar panels on every available rooftop by 2050, 25% of available rooftops by 2030.
2. All new build I&C units to have solar panel installed immediately.
3. One third of commercial buildings to be retrofitted as far as possible with renewable energy systems by 2030
4. All new homes and non-domestic buildings consented to be carbon positive by 2030.
5. All new schools commissioned to be carbon positive by 2030.

Literature estimates of the technical potential of solar PV in the I&C building stock (new + existing) is 80% for industrial buildings and 40% for all other commercial buildings[35]. Assuming all new builds have solar panels installed (satisfying recommendation 2, above), the estimated technical potential for existing industrial buildings is 74%, and 25% for all other archetypes - this has been set as the limit of the uptake in 2050 i.e. the proportion of available roofs.

The archetypes identified as commercial archetypes (Retail, Offices, Storage, Hospitality, and Community, arts & leisure) have solar panels installed on every available roof by 2030 (this is 25% of all rooftops in that archetype i.e. the full technical potential described above)– note this is less than the one third target in ECAC recommendation 3, listed above. To align with recommendation 1, all other archetypes achieve 25% of their technical potential by 2030 i.e. 6.25% of all rooftops of that archetype).

By analysing historic solar PV installations in GB, we find that the average capacity of non-domestic installations is 16 kWp[36]. We use this value to define the average non-domestic system size in our model but we allocate larger systems to larger non-domestic archetypes.

Addressing recommendation 4 and, by proxy, recommendation 5, follows the same approach as for the domestic PV – the steps are repeated below for clarity. Together with Essex County Council, we agreed that the recommendation that all new homes and non-domestic buildings should be carbon positive by 2030 would be defined around offsetting electricity emissions of a proportion of the existing building stock. This proportion was defined as the proportion hard-to-decarbonise homes in the domestic building stock. As described earlier, our analysis suggests there are around 30,000 off-gas homes in Essex that are hard-to-decarbonise. The non-heating electricity demand from these homes in 2050 is around 124 GWh. Assuming a solar panel with an average yield of 800 kWh/kWp, we estimate that an additional 154 MW of solar PV capacity is required to satisfy the above recommendation. We assume the additional 154 MW is installed across all new build developments at the point of construction from 2030 onwards in both the domestic and I&C sectors. The overall uptake of I&C small scale solar PV for the ECAC scenario is shown in Figure 16, against the Phase 1 solar PV uptake scenarios.

[35] SQW (2010), Northwest renewable and low carbon energy capacity and deployment, Available from: http://www.sqw.co.uk/files/6813/8694/8765/40.pdf

[36] BEIS (2021), Solar photovoltaics deployment, Available from: https://www.gov.uk/government/statistics/solar-photovoltaics-deployment

Figure 16 Uptake of I&C small scale solar PV.

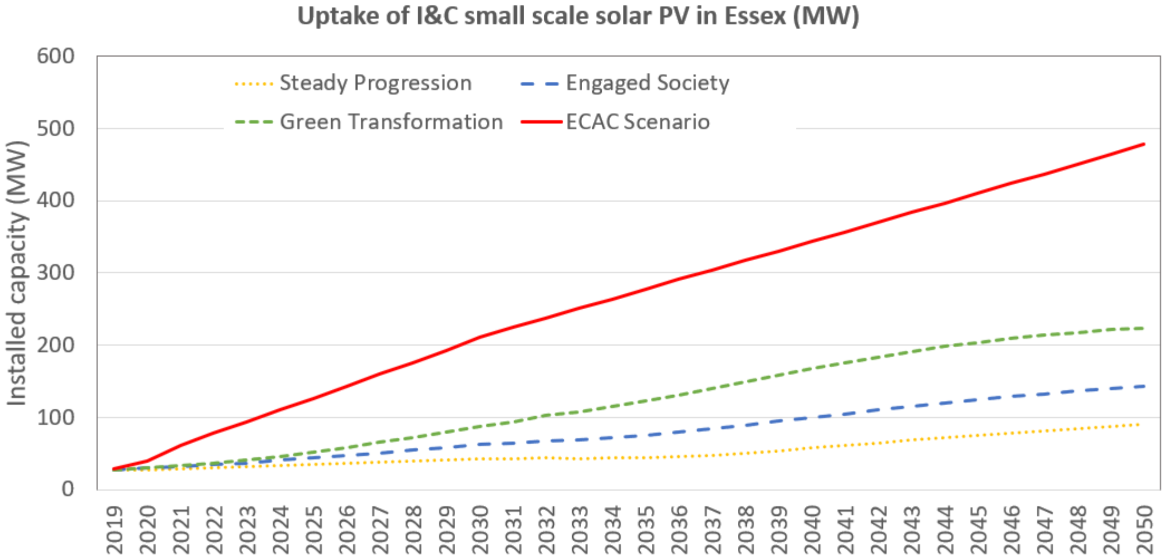
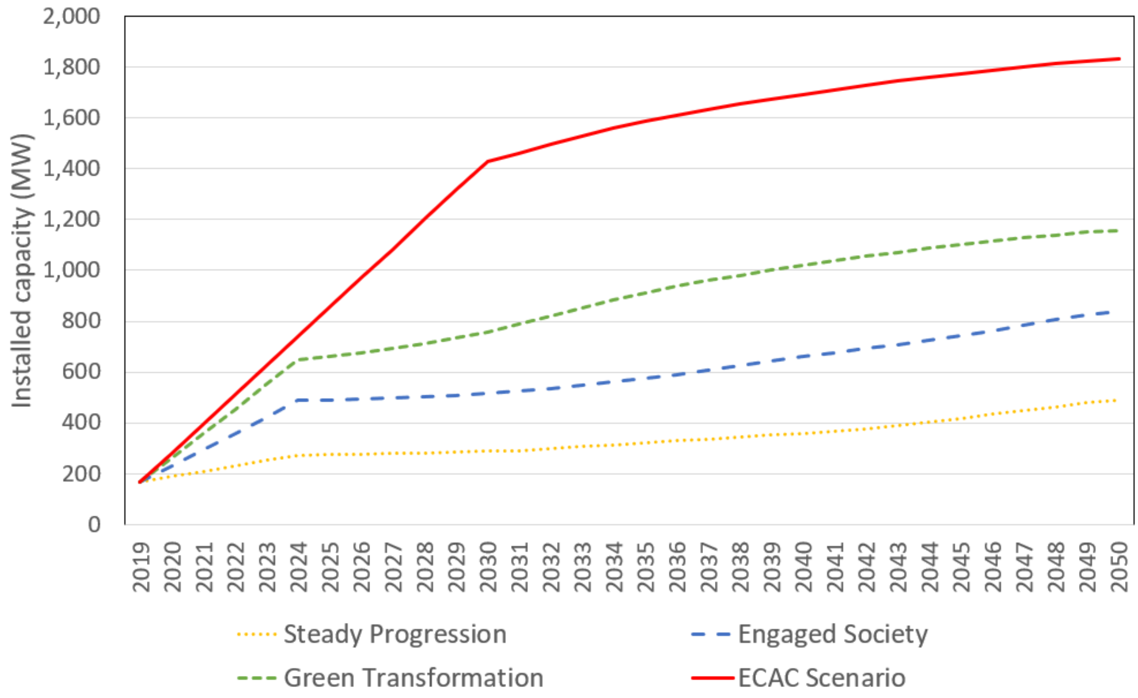


Figure 16 shows the uptake of I&C solar PV for the ECAC scenario compared with the three scenarios in Phase 1. The ECAC scenario is much more ambitious than the others, achieving twice the level of uptake than the most ambitious Phase 1 scenario.

The ECAC recommendations also show increased ambition in the development of large scale solar PV which includes ground-mounted installations. The ECAC target is to install 1.4 GW of capacity by 2030. Figure 17 shows the projections if this target is met compared to the projections from the three scenario worlds in Phase 1. Beyond 2030, we apply the same incremental increase as the Phase 1 Green Transformation scenario. Note that in the Green Transformation scenario, generation is met by large, centralised generation which is why it takes the highest uptake of the three Phase 1 scenarios in Figure 17. For small-scale rooftop solar PV discussed earlier, the Engaged Society scenario, which relies more on decentralised generation, has the highest level of uptake.

Figure 17 Large scale solar PV uptake.



The ECAC recommendation to construct 1.4 GW of large-scale solar PV capacity by 2030 stipulates that agricultural land should not be unduly compromised in meeting this recommendation. We have undertaken geographical land analysis at MSOA-level[37] to calculate the technical potential of large scale solar PV. We assume that 5% of low grade agricultural land[38] – defined as agricultural grades 3 to 5 – would be suitable for solar PV. Agricultural land located in Areas of Outstanding Natural Beauty (AONBs) and National Parks has been excluded. By considering this amount of available land as well as solar PV efficiency, typical load factor and irradiance in the UK, we estimate that 12,054 MW of large-scale solar PV capacity could be installed in Essex as an upper limit. This is well in excess of the values shown in the graph above, giving confidence that agricultural land would not be unduly compromised.

5.2 Gap analysis

This section considers the ECAC recommendation:

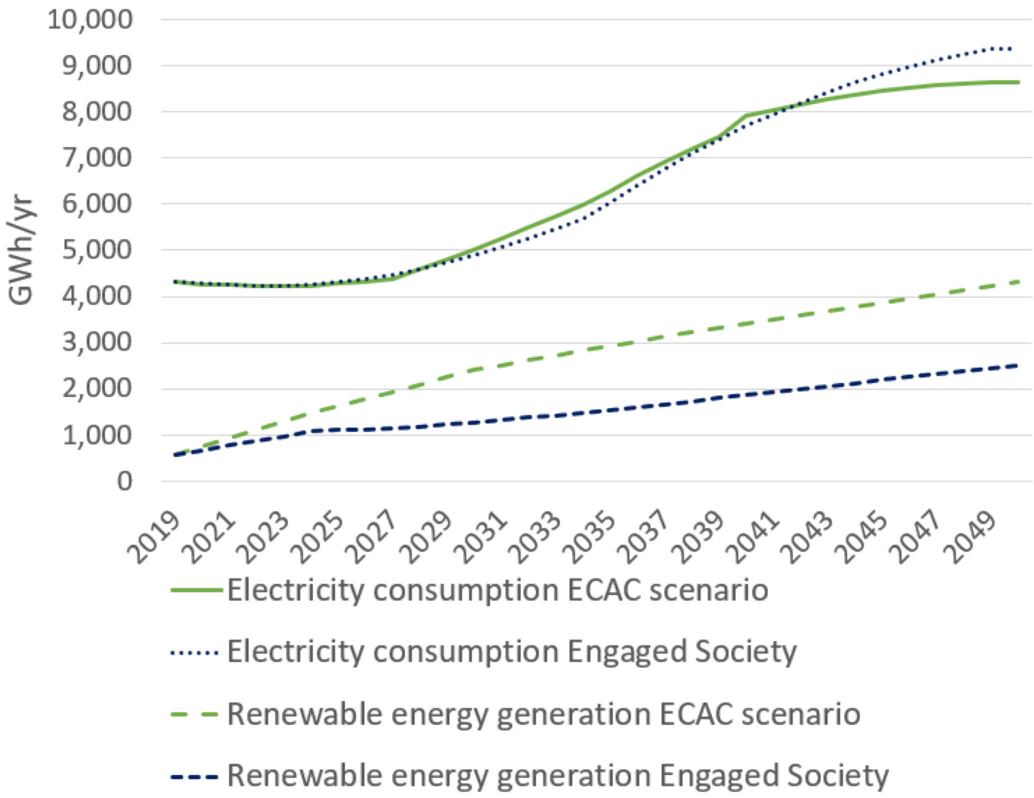
[37] Middle Layer Super Output Areas (MSOA) are a geographic hierarchy designed to improve the reporting of small area statistics in England and Wales. Each MSOA has between 5,000 and 7,200 inhabitants.

[38] We use this same proportion in our work to estimate solar PV technical potential with several electricity network operators across the UK. The assumption has been tested with several players in the UK solar PV market.

- Essex produces enough renewable energy within the county to meet its own needs by 2040.

Our analysis has identified a gap between the ECAC's renewable generation deployment targets and its aim to be self-sufficient by 2040. We find that the renewable energy generation targets set out by ECAC do not provide sufficient electricity to meet the County's needs by 2040, as shown in Figure 18. In 2040, Essex consumes an estimated 7,900 GWh/yr but produces only 3,400 GWh/yr from renewable sources under the ECAC scenario. The purpose of this gap analysis is to understand what the gap is and what options are available for Essex to increase renewable generation.

Figure 18 Electricity consumption vs generation



As described in section 5.1, by considering the availability of low grade agricultural land for the deployment of large scale solar PV, we have estimated the technical potential of large-scale solar PV at 12,054 MW.

Our literature review has identified the East of England Renewable and Low Carbon Energy Capacity Study[39] to estimate the technical potential of onshore wind in Essex. In this report, analysis of onshore wind potential is

[39] AECOM (2011), East of England Renewable and Low Carbon Energy Capacity Study, Available from: https://www.eastsuffolk.gov.uk/assets/Planning/Suffolk-Coastal-Local-Plan/Document-Library/Infrastructure/east-of-england-renewable-energy-capacity-study.pdf

undertaken considering three levels of constraints. To be conservative, the analysis with the highest level of constraints has been assumed. This takes into account physical constraints such as roads, railways, inland waters and the buffer zones applied to these constraints where turbines cannot be physically installed; Ancient Woodlands; and other considerations such as National Parks, AONBs, biodiversity designations and bridleways. Beyond these constraints, the estimated technical potential for onshore wind in Essex is estimated at 12,942 MW or enough to generate 34,000 GWh on an annual basis.

From a technical standpoint, we can conclude that Essex has the capacity to generate sufficient electricity to meet its own consumption requirements by 2040 through the deployment of large-scale solar PV and onshore wind.

Whilst our assessment demonstrates the viability in technical potential terms, we caution that no assessment of the economic feasibility has been included. The economics of large-scale renewables projects will depend on numerous factors, including capital costs, the available resource (wind speed or solar irradiation), land costs, grid connection costs, extent of curtailment due to electricity network constraints (if any) and so on. These factors can vary significantly between sites and there is therefore significant uncertainty regarding the fraction of the technical potentially that will be economically viable to develop. High levels of renewable energy integration may result in constraints on the local electricity network, potentially leading to curtailment, which could undermine the economics of new projects seeking to connect. Technologies such as local energy storage or demand management could be deployed to manage constraints and improve grid stability at high levels of renewable generation penetration.

Note that the decarbonization of the electricity grid over the period to 2050 is assumed to occur in the baseline, requiring large-scale deployment of transmission connected renewable generation, such as offshore wind, as well as smaller scale, distributed renewable generation projects. The ECAC recommendation for Essex to generate enough renewable energy to meet its own needs within the county by 2040 is well-aligned with this national effort and can be considered as Essex contributing more than its ‘fair share’ to delivering a decarbonized electricity grid.

6 Transport

6.1 ECAC scenario modelling

This section considers how the ECAC recommendations translate into an energy and emissions pathway for the transport sector. It also includes a gap analysis to identify areas to strengthen the ECAC recommendations.

6.1.1 Approach

The approach taken for the transport sector is to consider the potential for modal shift of journeys within the boundaries of Essex. Particular journeys considered are those currently completed by car, to active and public transport modes. We then consider the extent of modal shift delivered by the ECAC recommendations – the impact of this modal shift was used to derive the new ECAC scenario.

The modelling approach starts by grouping the ECAC recommendations into the following categories; active travel, low traffic neighbourhoods (LTNs), e-scooters, bus travel, park and ride, local delivery, and disincentivising unnecessary car use. We then determined which journey type each category relates to. Journey types differ by journey length, road types and vehicle types e.g., short urban, medium rural, etc. Each individual recommendation has been considered to have a supporting role on its category, but direct impact of each recommendation cannot be measured. It is worth noting that some ECAC recommendations related to behaviour change and expanding the charging network are not explicitly modelled. These recommendations can enable the success of other recommendations, but have no direct impact on modal shift.

East of England National Travel Survey (NTS) data has been used to estimate the potential maximum shift of each category of ECAC recommendations, and has helped identify the proportion of miles travelled in the short, medium and long distance journeys, and the proportion of miles travelled in the urban, rural and motorway road types – Table 9. Short distances are considered to be less than 5 miles, medium considered to be 5 to 25 miles and long considered to be more than 50 miles.

Table 9 Share of miles per person by trip length and road type

Distance	Short	Medium	Long
Share of miles per person	16%	39%	45%

Road type	Urban	Rural	Motorway
Share of miles per person	39%	43%	18%

Table 10 shows the current split of travel in Essex, for all vehicle types, by trips and by km travelled, and the corresponding maximum potential in modal shift for the different categories. It shows that active and public transport is suitable for 75% of travel km in Essex if the correct infrastructure is in place.

Table 10 Split of travel in Essex by trips and km travelled (for all vehicle types).

Vehicle type	Current split by trips	Maximum potential split by trips	Current split by km	Maximum potential split by km
Car driver	53%	1%	55%	7%
Car passenger	27%	1%	29%	4%
Shared car	1%	2%	1%	12%
Walk	10%	20%	1%	2%
Bike	3%	23%	1%	8%
eBike	0%	13%	0%	9%
eScooter	0%	0%	0%	0%
On-demand bus	0%	22%	0%	15%
Route bus	4%	5%	3%	3%
Coach	0%	5%	0%	12%
Train	2%	8%	9%	28%

In Table 10 we focus on the trips completed by car. The current split of journeys by type and km, show only the car journey segments (accounting for 81% of total trips and 85% of total km). The maximum potential for modal shift of these car journeys is then shown in the maximum potential splits columns of the table. We find that a large fraction of car trips of short, medium and long distance are suitable for completion by active or public modes of transport (up to 72% of car km could be shifted to other modes).

Table 11 Split of car travel in Essex by trips and km travelled.

Vehicle type	Current split by trips (car trips only)	Maximum potential split by trips (car trips only)	Current split by km (car trips only)	Maximum potential split by km (car trips only)
Car driver	53%	2%	55%	9%
Car passenger	27%	1%	29%	5%
Shared car	1%	2%	1%	14%
Walk	-	10%	-	1%
Bike	-	24%	-	7%
eBike	-	15%	-	10%
eScooter	-	0%	-	0%
On-demand bus	-	25%	-	14%
Route bus	-	7%	-	3%
Coach	-	6%	-	12%
Train	-	9%	-	25%

Table 12 shows the predicted trip and km breakdown on all travel in Essex as a result of the impact of the ECAC recommendations. The number of trips completed by car as a fraction of total trips is down to 47%, compared to the current share of 81%. However, most of the trips impacted are short, meaning that car driver km and therefore car km only drop from 55% (as shown in Table 12) to 45%. The biggest driver of this change is buses which jump from 3% of km to 9% of km. Active travel in total jumps from 2% of km to 7%, with 50% of this jump delivered by e-bikes being used on longer trips between urban centres.

Table 12 Impact of ECAC recommendations on travel in Essex.

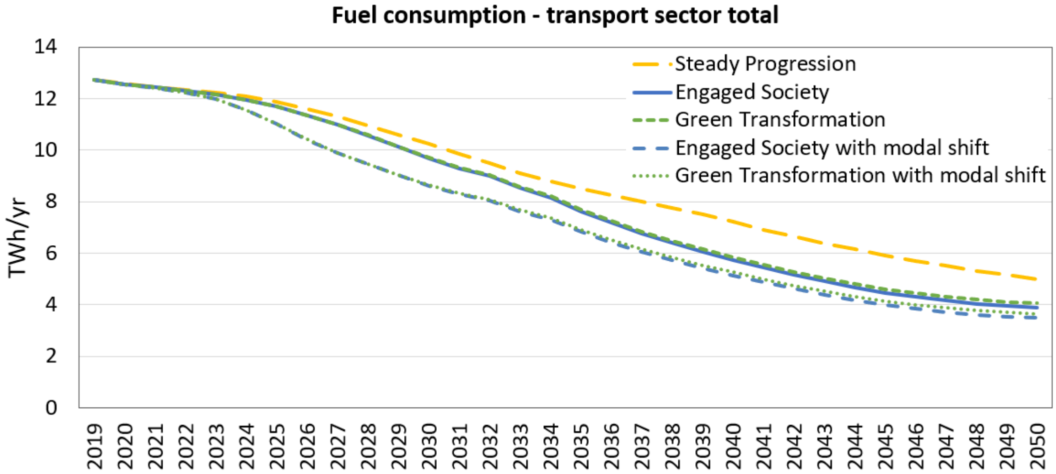
Vehicle type	Predicted trip breakdown	Predicted km breakdown
Car driver	30%	45%
Car passenger	15%	24%
Shared car	2%	3%
Walk	21%	2%
Bike	7%	2%
eBike	6%	3%
eScooter	0%	0%

On-demand bus	0%	0%
Route bus	15%	9%
Coach	0%	0%
Train	4%	11%

6.1.2 Modelling outputs

In this section we consider the impact of the ECAC recommendations on the overall fuel consumption and emissions in the transport sector, with comparisons to the three scenario worlds developed in the Phase 1 study.

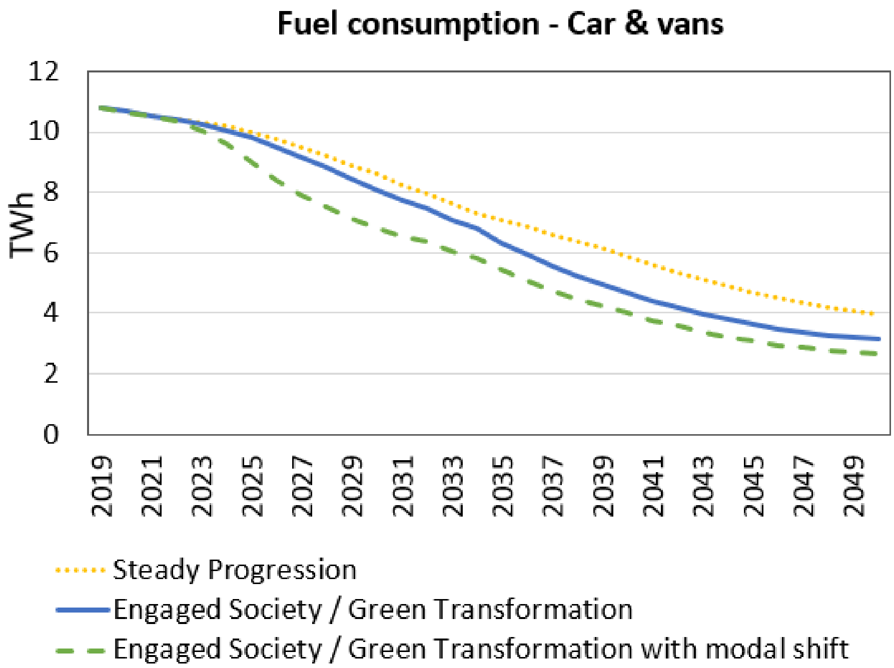
Figure 19 Total fuel consumption in the transport sector

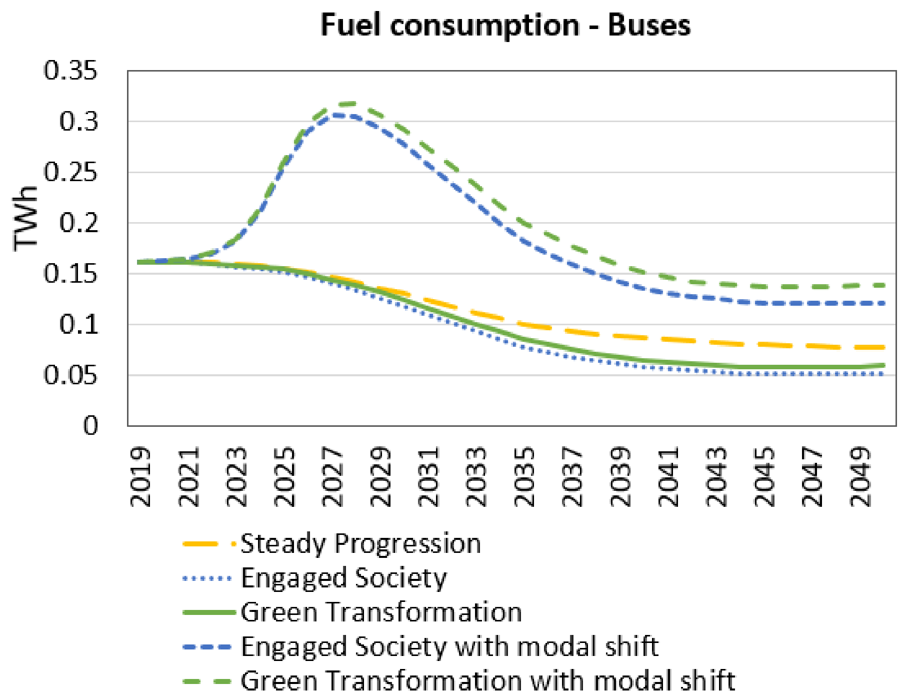


The general trend across all scenarios is a decrease in overall fuel consumption. This is driven mostly by transition towards more efficient electric powertrains. Modal shift provides an additional 8% reduction (relative to 2019) in fuel consumption by 2030 for the Engaged Society and Green Transformation scenarios.

By 2050, the gap in total fuel consumption between scenarios with and without modal shift decreases to 3%. This is because the fleet transitions to more fuel-efficient vehicles. For example, in 2030, the fleet is still largely made up of ICEs so reducing how much people travel has a significant impact on fuel consumption. However, by 2050 when the fleet is largely zero emission vehicles, the impact is smaller.

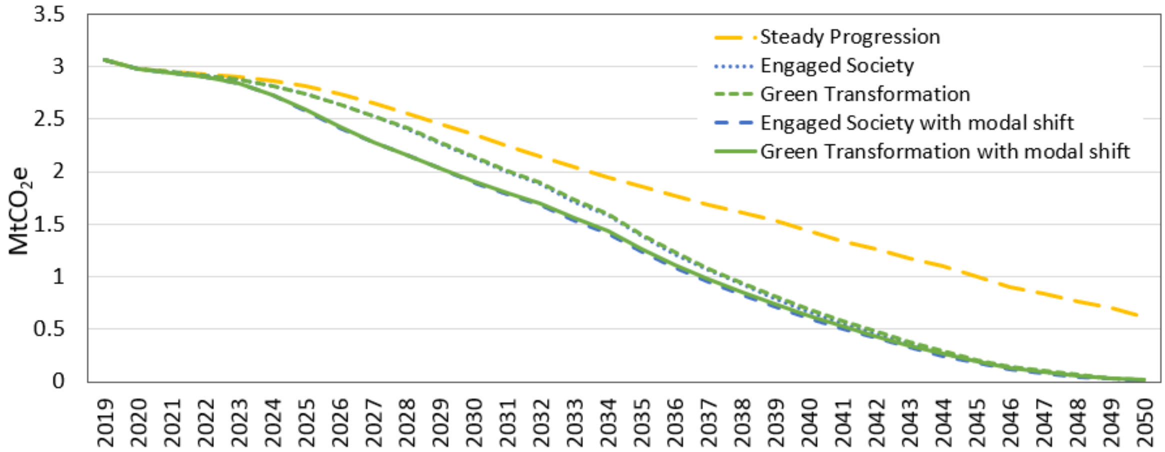
Figure 20 Fuel consumption for cars, vans and buses.





By 2030, modal shift provides an additional 9% decrease in fuel consumption by cars and vans relative to Phase 1 net zero scenario, this gap reduces to 4% by 2050. Modal shift increases bus travel until 2028, which results in a net increase in fuel consumption. From 2028, net fuel consumption decreases due to further electrification of bus fleets. Fuel consumption in minibuses and HGVs is unaffected relative to the Phase 1 scenarios so is not shown in this work here.

Figure 21 Total emissions in the road transport sector.



The modal shift driven by the ECAC recommendations does not change when net zero is achieved but does affect the emissions pathway. By 2028, modal shift provides an additional 8% decrease in emissions (relative to 2019) compared to the equivalent scenarios without modal shift. By 2050, emissions for scenarios with and without modal shift are the same, because by this date, all forms of road transport have already switched to very low carbon electricity or gas.

6.2 Gap analysis

For the transport sector, we have provided a list of additional recommendations that have not been captured by the ECAC scenario but can be adopted to support the desired modal shifts in the transport sector. The additional recommendations apply to the following categories: active travel, low traffic neighbourhoods (LTNs), disincentivising unnecessary car use, e-scooters and e-bikes, land and planning, long distance travel and infrastructure.

Category	Additional recommendations
Increase active travel	• Provide segregated infrastructure to improve user safety, in line with current Government advice[40] • Improve easy access to key destinations with access through routes blocked to cars, contra-flow bike lanes on one-way street, active travel only bridges or underpasses etc.

[40] Department for Transport (2020), Gear Change: A bold vision for cycling and walking, Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904146/gear-change-a-bold-vision-for-cycling-and-walking.pdf

	• Active travel promotion in schools and workplaces, including starting with Council staff • Support members of the community to switch to active travel through supporting cycle training and maintenance initiatives
e-scooters and e-bikes	• Ensure cycling infrastructure connects satellite towns and villages to urban hubs in a way that is safe (cycling along 60mph rural roads is very dangerous) and direct (often rural roads connect villages making for indirect routes from satellite villages to town centres, new cycle routes can be more direct with feeders connecting to local villages along route) • Increase awareness and experience of e-bikes to help educate residents of their suitability for longer routes and for less able riders
Low Traffic Neighbourhoods/school streets	• Provide goods and services within the LTN areas following the 15 minute city agenda to reduce the need to drive into/out of the LTN areas. Instead encouraging residents to enjoy the benefits of LTN as they use active travel regularly in their local area.
Disincentivising unnecessary car use	• Tackle pavement parking • Reduce on street parking • Convert parking space into community space to provide services local people are keen to have • Financially support modal shift e.g. Birmingham CAZ provides financial support (can be public transport credits) to people scrapping their car
Rebuild passenger transport	• Improve bus reliability through contactless payments, bus lanes and bus priority • Make buses more affordable by increasing car parking and driving costs, and using income to support bus fares • Improve bus passenger experience by ensuring buses are modern, clean, have power sockets and wifi • Ensuring bus journeys are easy to plan with digital route information available in route planning services and at bus stops (avoid timetables in small print pdf in a non-central location on bus operators websites) • Integration of public transport timetables, ticketing, and information across modes to make multi-modal journeys seamless

	• Ensure taxi licensing transitions the fleet to zero-emission vehicles by 2030 • Provide demand responsible public transport to rural communities
Land and Planning	• Ensure new developments have access to public and active travel options • Ensure new developments are focused in accessible central locations • Ensure unused building stock including retail and office space unused after the pandemic is utilised to provide local goods and services to cut travel demand for local citizens • Return goods and services to rural communities to allow access by active travel. Develop local community hubs which could include space for office space, nursery, parcel collection (to avoid last mile deliveries), convenience store etc. • Redesign road space to prioritise active and public travel modes (more space for these modes, priority at crossings and junctions, faster more direct access from homes to services)
Long Distance Travel	• Support local business in targeting a replacement of a certain proportion of business travel with teleconferencing • Improve connectivity to train stations and timetabling between buses and trains • Prioritise and support bids to reinstate train lines where they would offer the biggest benefit to reduce long distance car trips
Infrastructure	• Support the rollout of digital infrastructure to increase access to home working and teleconferencing business calls • Support rollout of flexible working hubs which allow people to work in the office but avoid most of their commuting emissions and additional home emissions/costs from heating • Prioritise investment on active and public infrastructure rather than roads

7 Waste

For the waste sector, recommendations were set in close consultation with the county council and their waste expert. This section considers how the recommendations translate into a waste and emissions pathway for the waste sector. It also includes a gap analysis to identify areas to strengthen the recommendations.

Note that the scope of the waste sector analysis presented in this report is limited to ECC’s domestic waste, which accounts for around 50% of total waste arisings in Essex. Further work will be undertaken in future to assess the emissions pathway for non-domestic waste in Essex.

7.1 ECAC scenario modelling

7.1.1 Approach

The approach taken for the waste sector is to model reductions in municipal waste produced and changes in how this waste is treated. Recommendations are defined by the following parameters: waste produced per household, percentage of waste recycled or composted, and percentage of residual waste sent to landfill. Some recommendations apply only to specific types of waste, so the recommendations are defined further by the following waste types: total municipal solid waste, food waste and garden waste. The factors defining the future waste and emissions scenarios are shown in Figure 22.

Figure 22 Factors defining future waste and emissions scenarios

Municipal solid waste per household
- Define amount
- Define % recycled and composted
- Define % residual waste sent to landfill

Food waste per household
- Define amount
- Define % food waste sent to residual waste streams

Garden waste per household
- Define amount

Initial data on domestic waste production by treatment route has been provided by ECC. Treatment routes are landfill, energy from waste, recycling, composting and anaerobic digestion.

The waste production data is then scaled with the household stock projections from the Phase 1 work to produce a baseline scenario for waste production and emissions. The recommendations are applied to this baseline to produce future scenarios for emissions from waste.

For the ECAC scenario, the recommendations are:

- A reduction in total municipal solid waste per household of 10% by 2030
- The percentage of waste recycled or composted to reach 60% by 2026, and 70% by 2030
- The percentage of residual waste to landfill to reduce to 50% in 2023 and then to 0% in 2030
- A decrease in food waste per household by 20% by 2025, and by 50% by 2035, in line with the CCC Net Zero Report[41]

All recommendations were set with respect to 2020 as a base year, for which waste data was provided. No targets were set relating to garden waste produced per household.

For the target relating to a reduction in food waste, food waste existing in the residual waste stream was considered. This results in reductions in residual waste due to these food waste reductions. The WRAP 2020 Food Waste Report[42] was used to identify the amount of food waste produced per household. The amount of food waste in the segregated food waste stream and the mixed food and garden waste stream can then be subtracted from the total food waste per household to produce the amount of food waste in the residual stream.

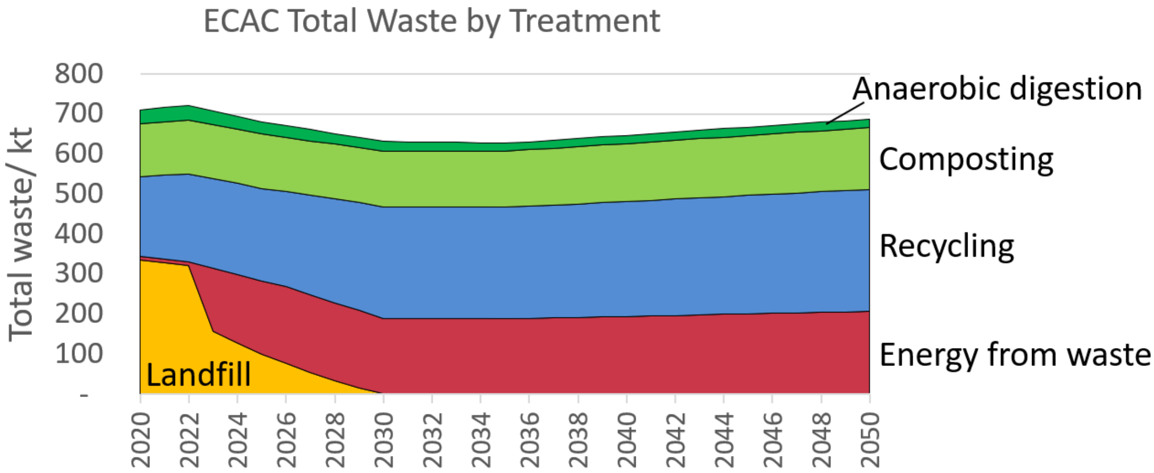
7.1.2 Results

The resulting ECAC future waste scenario is shown in Figure 23. Overall, total waste decreases from 710 kt in 2020 to 687 kt in 2050. The increase in waste with household projections is outweighed by the decrease in municipal solid waste per household alongside a decrease in food waste.

[41] Committee on Climate Change (2019), Net Zero technical report. Available from: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf

[42] WRAP (2020), Food Surplus and Waste in the UK. Available from: https://wrap.org.uk/sites/default/files/2020-11/Food-surplus-and-waste-in-the-UK-key-facts-Jan-2020.pdf

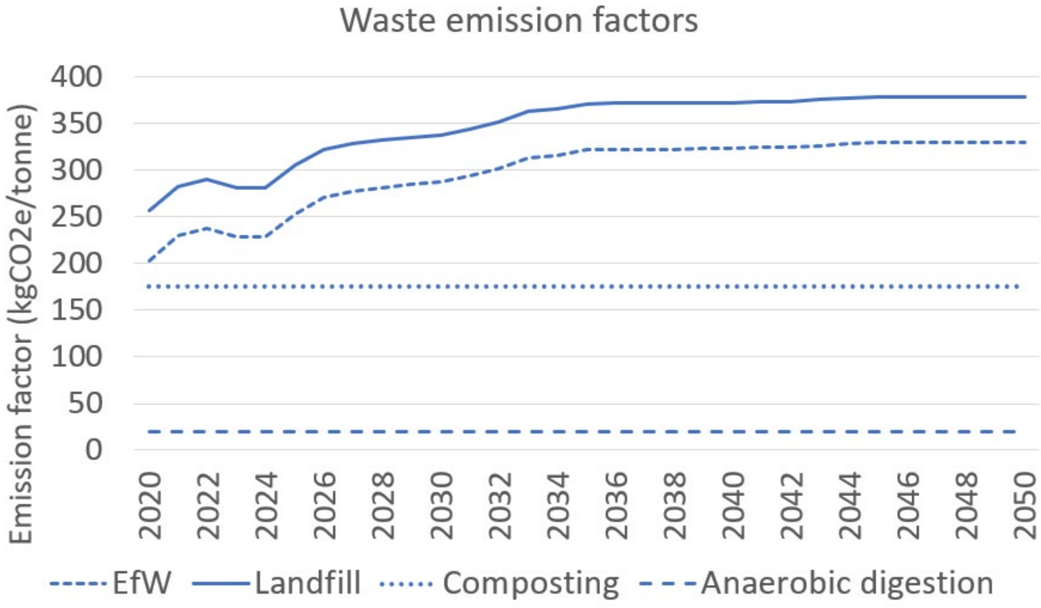
Figure 23 ECAC future waste scenario



Emission factors[43,44] to convert from waste mass to emissions for each treatment were used. As both processes can be utilised to generate electricity, the emission factors for landfill and energy from waste include a contribution for displaced electricity production. This contribution varies by year as the emissions intensity of the electric grid changes. As the electric grid decarbonises, the displaced electricity contribution to the emission factors shrinks, causing the emission factors to increase over time. This is shown in Figure 24.

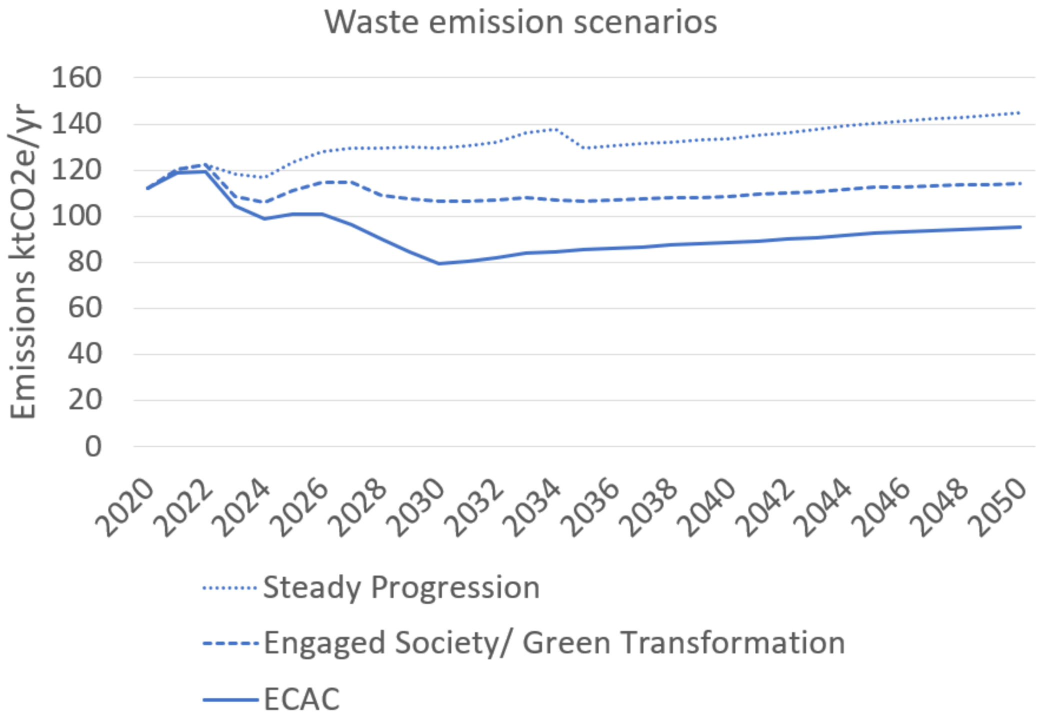
[43] Zero Waste Scotland (2020), The climate change impacts of burning municipal waste in Scotland. Available from: https://www.zerowastescotland.org.uk/sites/default/files/ZWS%20%282020%29%20CC%20impacts%20of%20incineration%20TECHNICAL%20REPORT.pdf
[44] IPCC (2006, refined 2019), Biological treatment of solid waste. Available from: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_4_Ch4_Bio_Treat.pdf

Figure 24 Emission factors by treatment 2020-50



Application of the emissions factors to the ECAC future waste scenario results in a future emissions scenario, as shown in Figure 25. For the ECAC scenario, there is a decrease in total waste emissions from 112 ktCO_2e in 2020 to 95 ktCO_2e in 2050. This is a decrease in emissions per household of 28% from 0.18 tCO_2e to 0.13 tCO_2e.

Figure 25 Waste future emission scenarios



The waste sector has only a small contribution to total emissions, 2%. For the ECAC scenario, waste emissions do not reach net zero by 2050. The emissions of the waste sector must be offset with absorption of emissions in other sectors.

7.2 Gap analysis

For the waste sector, the recommendations for the ECAC scenario generate a 28% reduction in emissions compared to the baseline. All waste treatment options have associated emissions, including emissions from the carbon in the waste itself, and therefore the waste sector is unable to achieve absolute net zero. Therefore, a net zero compliant scenario for waste is one with a low level of residual emissions that can be offset.

In the ECAC scenario, some of the recommendations are less ambitious than other national targets. In order to reduce the residual emissions of the ECAC waste scenario, the targets should be brought into line with more ambitious national targets.

The target to reduce total municipal solid waste per household by 10% by 2030 in the ECAC scenario is less ambitious than the Balanced Net Zero scenario in the CCC Sixth Carbon Budget which aims to reduce total waste per household by 33% by 2037.

The CCC Sixth Carbon Budget provides scenarios in which the emissions from waste decrease by up to 80% by 2050. To achieve this, the CCC suggests the following policies:

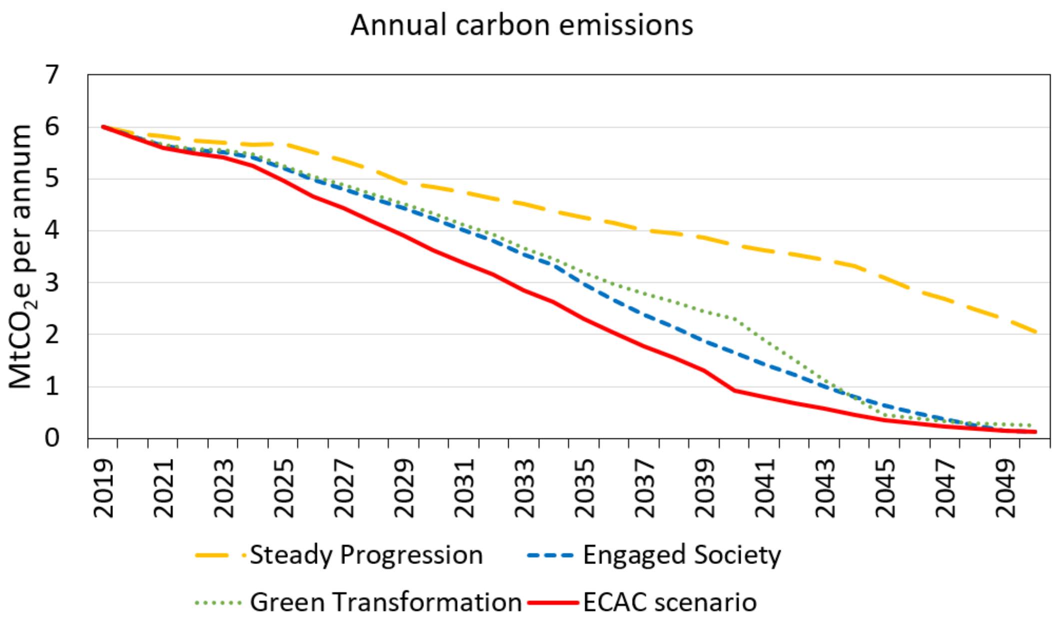
- A ban on certain biodegradable waste in landfill in 2025
- CCS fitted in all energy from waste plants by 2050
- Increased landfill methane capture via a network of pipes in the landfill itself
- Increased landfill methane oxidation using biocovers and biowindows as filters
- Composting forced aeration to reduce anaerobic processes that produce methane

If these policies are adopted alongside current recommendations the residual emissions due to waste can be significantly reduced.

8 ECAC scenario overall results

The ECAC recommendations set out to achieve a more ambitious timeline in Essex's energy consumption and emissions pathway compared to the scenarios developed in the Phase 1 work. A new scenario, termed the ECAC scenario, was developed to measure the impact of these recommendations. Figure 26 shows the emissions pathway for all four scenarios considered in the analysis and presents the total estimated CO_2e emissions projections from domestic and I&C buildings, transport, and emissions from waste. Emissions from land use and industrial process are not included in these projections, and further work to model these areas is needed.

Figure 26 Total annual CO_2e emissions



The ECAC scenario will reach net zero at the same time as the Engaged Society and Green transformation scenario (2050) due to the remaining carbon intensity of the electricity grid (see Appendix 9.1), however, between the baseline and 2050, the ECAC scenario will see a significant reduction in overall emissions, producing 12 $MtCO_2e$ and 16 $MtCO_2e$ less than the Engaged Society and Green Transformation scenarios, respectively.

The ECAC recommendations are achieving the greatest influence in emissions reduction in the domestic building sector; accounting for over 70% of the total emissions reductions from the baseline to 2050. In 2040 alone, the ECAC scenario reduces annual emissions by 659 $ktCO_2e$ per year from domestic buildings. The recommendations for the waste and transport sectors also see a reduction in annual emissions, producing 20 $ktCO_2e$ and 40 $ktCO_2e$ less than in Engaged Society in 2040, in the waste and transport sectors respectively. The ECAC recommendations have shown to have a marginal impact in the I&C buildings sector due to the small share of the existing I&C building stock that are influenced by the recommendations.

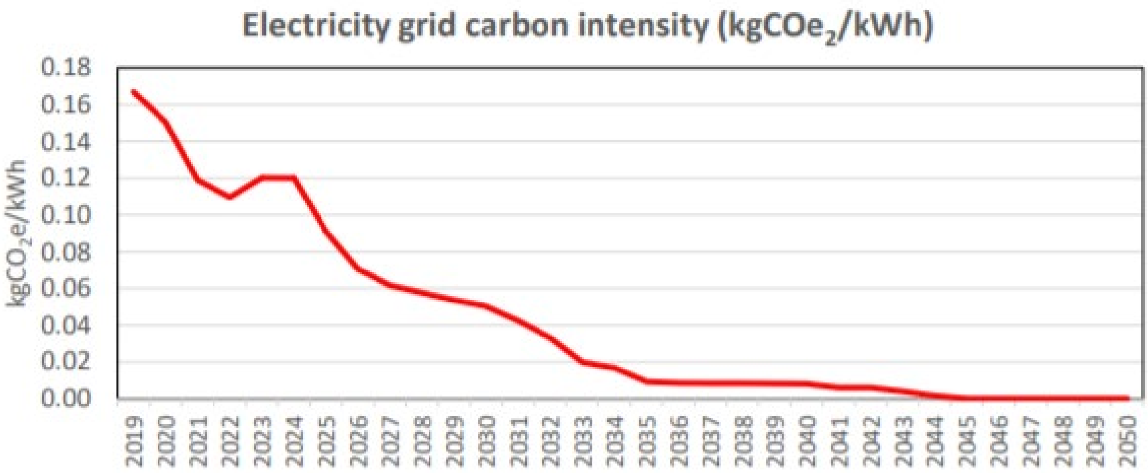
9 Appendix

9.1 Electricity grid carbon intensity

The modelled carbon intensity of the electricity grid carbon intensity based upon National Grid's 2020 Future Energy Scenarios[45]. The National Grid Consumer Transformation scenario forecasts grid carbon intensity reaching -72kgCO_2e/kWh in 2050. For the purpose of this study, we have rebased the emission trajectory to an endpoint of 0 kgCO_2e/kWh. This more conservative assumption was chosen as negative emissions rely heavily on bioenergy with carbon capture and storage (BECCS) which is not guaranteed and could suggest overly favourable future emissions trajectories without any real action being taken at an Essex regional level.

National Grid do not specify what modelling assumptions cause the slight increase in carbon intensity in 2024 but as our generation scenarios align to their generation mix, we have maintained that trajectory.

Figure 27 Modelled carbon intensity of the electricity grid



45 National Grid (2020), Future Energy Scenarios, Available from: https://www.nationalgrideso.com/document/173821/download

9.2 Energy consumption and emissions comparison between the ECAC scenario and Engaged Society scenario

Figure 28 Engaged Society and ECAC scenario comparison in domestic buildings energy consumption and emissions

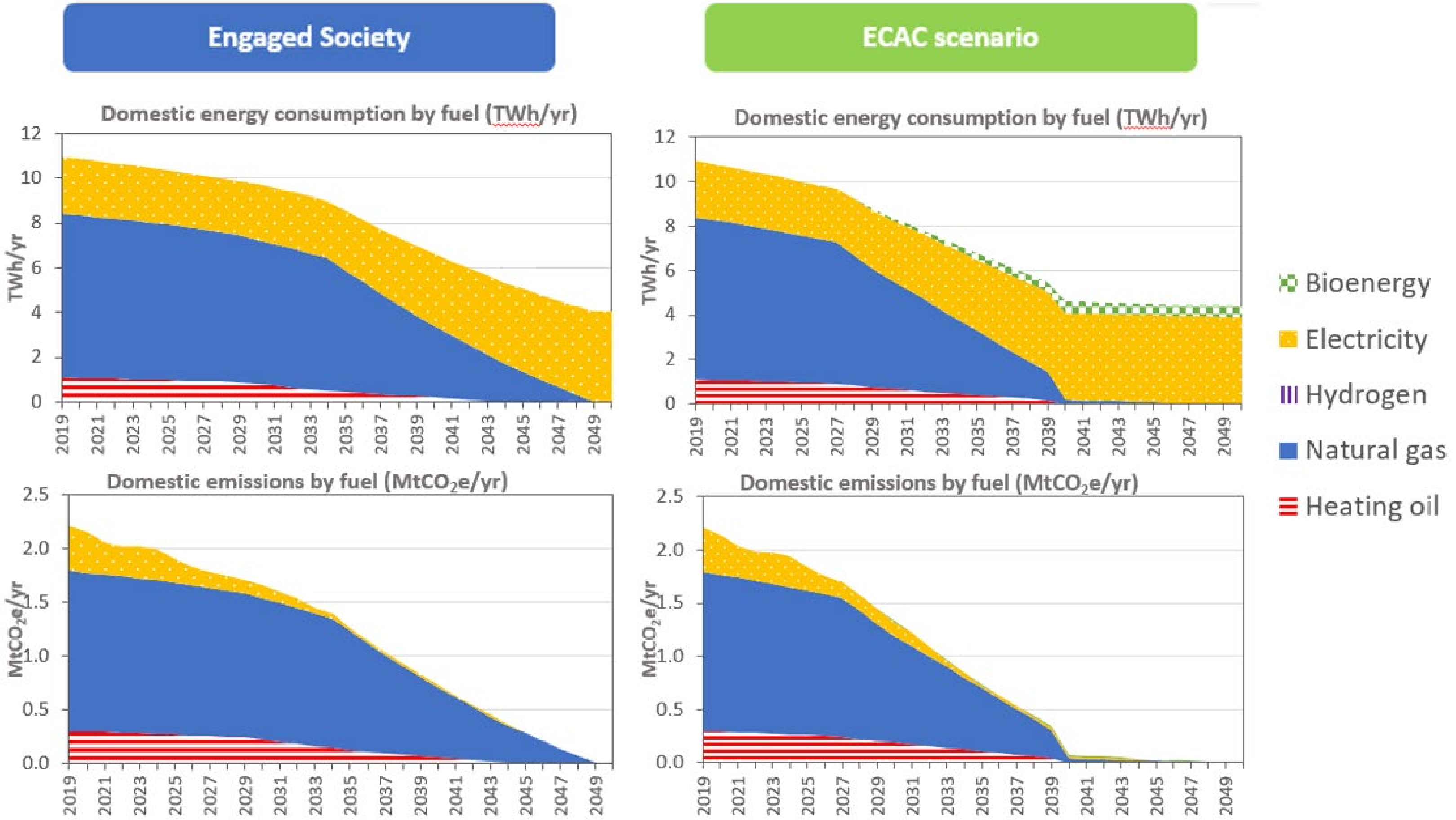


Figure 29 Engaged Society and ECAC scenario comparison in I&C buildings energy consumption and emissions

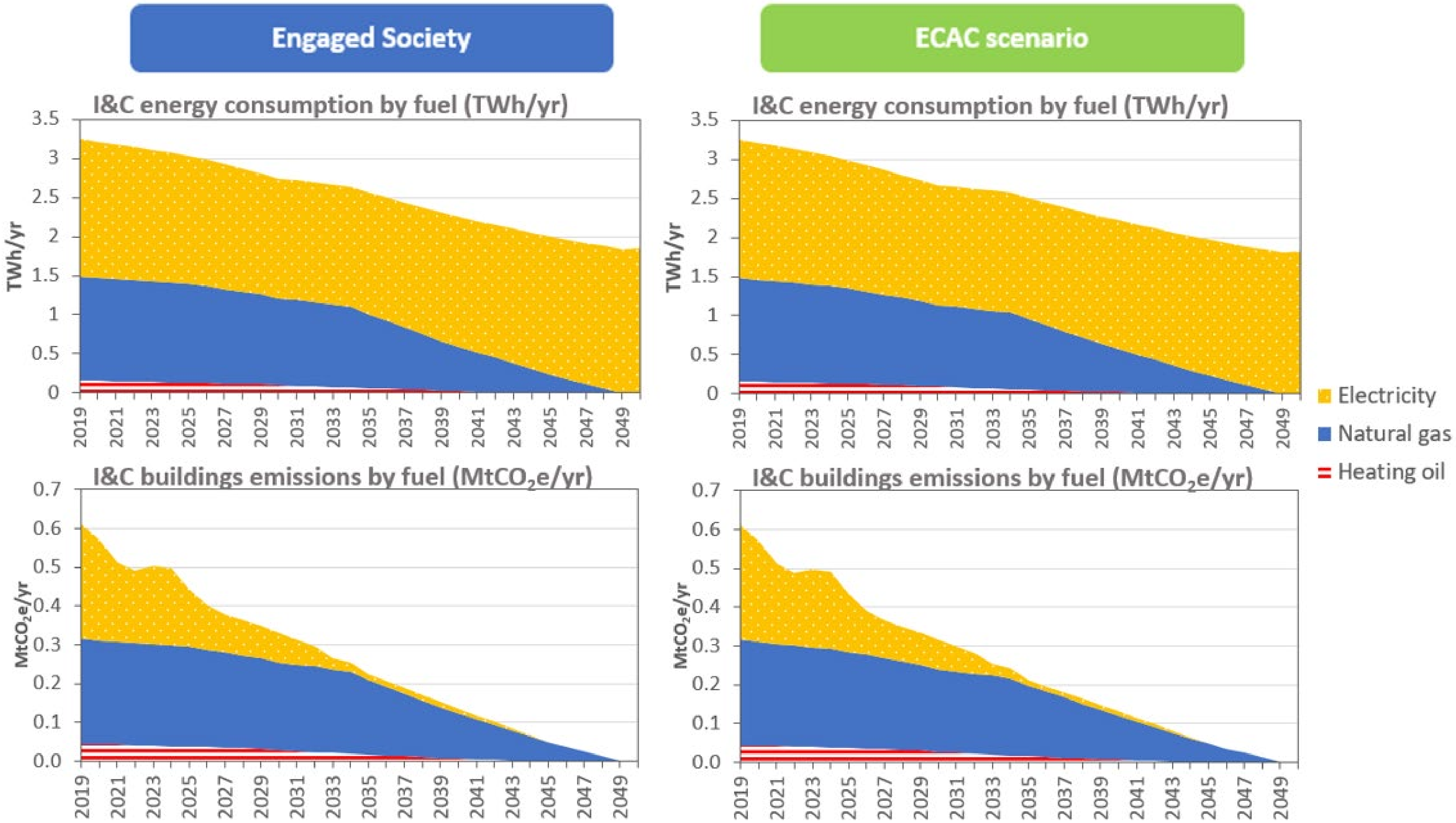


Figure 30 Engaged Society and ECAC scenario comparison in heat generation and emissions by technology