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THE UK'S NET ZERO INVESTMENT GAPS

A report for E3G and WWF

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FOREWORD

Amid the ongoing global energy crisis, now is the time to accelerate investment into green technologies and climate solutions that will bring down energy bills, foster energy independence, and catalyse economic growth.

The private sector stands ready to invest at scale in the net-zero transition alongside the UK Government and the potential economic benefits are transformational. By 2030, supplying the goods and services to enable the net zero transition could be worth £1 trillion to UK businesses[1] and low-carbon financial services could generate an export opportunity of up to £7.5bn per year.[2] Low-carbon technologies could deliver energy bill savings of over £1,800 a year for some homes.[3]

But the private investment will only be delivered at the speed and scale required if the Government has in place a clear and robust 'Net Zero Investment Plan'. This should include:

- An assessment of public and private financial flows in support of our climate and nature goals.
    - Introducing a Net Zero Delivery Tracker would support Government in assessing public financial flows
- An assessment of the investment needs for decarbonisation in different economic sectors
- An assessment of the low carbon investment gap for sectors and how these will be bridged.

An independent unit, such as the Office for Budget Responsibility, should be given the role to conduct this tracking analysis on an ongoing basis. The unit should have a mandate to make regular advice to the government on the scale and balance of sustainable investments to date, and on how to ensure that investment is mobilised to meet climate goals. This tracking and advice function would enable a rapid and dynamic feedback loop between policymakers and markets.

To maximise its contribution to economic development and the net-zero transition, the private sector needs strong and consistent science-based market signals, the right level of targeted public investment, and transparent policies for supporting new and growing sustainable markets. A Net Zero Investment Plan would reduce policy risk and give the UK business and investment community the market confidence it needs to invest.

This report by Frontier Economics provides high-level analysis of the net-zero financial flows under some of the most important economic sectors. It identifies the investment gap and sets out some policies that can help fill it. It provides proof of concept to show it can be done.

To maximise the leverage of private capital into the economic transition, the private sector needs clarity and certainty. The development of a Net Zero Investment Plan and ongoing analysis of net-zero financial flows would provide a foundation for the UK's economic recovery and the key to future prosperity.

E3G & WWF-UK

1 McKinsey Sustainability (2021), Opportunities for UK business in the net-zero transition

2 Social Market Foundation (2022), Financial services and net zero: Seizing the opportunity

3 Scottish Power, WWF (2022), Better homes, cooler planet - Modelling based on the April 2022 energy price cap and consequent tariffs

EXECUTIVE SUMMARY

There is currently a gap between the Government's ambitions on Net Zero and the flows of public and private investment[4] expected in the 2020s.[5] The Government's own analysis suggests that actions to close this gap could help bring down energy bills and support economic growth.[6]

E3G and WWF have commissioned Frontier Economics to collate research that assesses the gap between existing policies and the investment required in the 2020s to be on a pathway to meeting Net Zero by 2050. The purpose of this report is not to complete a fully comprehensive analysis but to demonstrate the importance of establishing a robust mechanism for tracking investment flows as part of a comprehensive Net Zero investment plan.

Focusing on four key sectors, we have compared the Climate Change Committee's estimates of total public and private investment required[7] with estimates of total public and private investment expected under committed and planned policies that the Government has announced. This comparison shows that Government has made substantial investments in some sectors and established policy mechanisms that are proven capable of leveraging private investment. However, a significant scale-up is likely required in all areas.

We judge that the government has clear policies in place to deliver 16–22% of the needed investment, and we estimate planned investment at £165bn-174bn, half of the required total. Investments in this category are particularly uncertain given the potential for policies to change with a new administration and the unproven outcome of policies yet to be implemented. Overall, considering electricity supply, surface transport, buildings, and manufacturing and construction, our high-level analysis suggests that the gap could be £81 - £111bn in the 2020s (Table 1). This gap could equate to 25-34% of the total investment required in these sectors this decade.

Further action is required across the board, but our research suggests that the largest gap is in buildings. In most cases, scaling up existing and planned policies should be a priority, but there are also requirements for major new policies, particularly in buildings.

We recommend that detailed, transparent and regular assessments of the investment gap are carried out by Government to ensure that policies continue to be developed to fill the gap on the path to Net Zero.

SUMMARY OF INVESTMENTS GAPS

SECTOR		REQUIRED INVESTMENT (2020-30)	ESTIMATED PUBLIC & PRIVATE INVESTMENT			GAP TO 2030
			COMMITTED	PLANNED	TOTAL	
Electricity supply	**Total (£bn)**	**104**	**19 – 23**	**61 – 67**	**80 – 90**	**14 – 24**
	% of required					*(13 – 23%)*
Surface transport	**Total (£bn)**	**92**	**15 – 18**	**70**	**85 - 88**	**4 - 7**
	% of required					*(5 - 8%)*
Buildings (residential and non-residential)	**Total (£bn)**	**118**	**15 – 26**	**29 -32**	**44 – 58**	**60 – 74**
	% of required					*(51 – 63%)*
Manufacturing and construction (inc hydrogen production)	**Total (£bn)**	**15**	**5 – 6**	**5 – 6**	**10 – 12**	**3 – 4**
	% of required					*(20 – 29%)*
	Total (£bn)	**329**	**54 – 73**	**165 – 174**	**218 – 247**	**81 – 111**
	% of required		*(16 – 22%)*	*(50 – 53%)*	*(67 – 75%)*	*(25 – 34%)*

Source: CCC – Sixth Carbon Budget, Frontier research; Note: 1. All figures are £bn, 2020 prices. 2. Numbers may not sum due to rounding. 3. There is significant uncertainty around these figures. Sources and research methodology as set out in the report.

[4] Public investment is from the UK Government and private investment could be from either UK sources or global markets.
[5] House of Lords Economic Affairs Committee (2021) *Investing in energy – price, security and the transition to Net Zero*
[6] HM Government (2021), *Net Zero Strategy: Building Back Greener, p15*
[7] Climate Change Committee (2020) *Sixth Carbon Budget,* Balanced Pathway Scenario

1 INTRODUCTION

The current priority for the UK Government is dealing with the ongoing energy crisis to ensure energy security and support to households. However, the complementary need to focus on delivering investment for Net Zero remains.[8]

The Climate Change Committee (CCC) central estimate for the cost of delivering Net Zero is below 1% of GDP over the next thirty years.[9] However, this is predicated on timely action to tackle climate change. The Office of Budget Responsibility analysis suggests that a delay in action could have significantly higher costs to the UK economy,[10] estimating that acting early could halve the net fiscal cost of getting to Net Zero.[11] In the *Net Zero Strategy,*[12] the UK Government acknowledged that early and ambitious action would help protect lives and livelihoods, while maximising the co-benefits for people, society, the environment, and the economy,[13] alongside which it sets out a roadmap for decarbonising the UK economy to meet Net Zero, with detailed policies and proposals for many sectors. In response to geopolitical events, the British Energy Security Strategy[14] has increased ambition in certain sectors.

Aside from mitigating climate change, there are significant benefits associated with investment to meet Net Zero. The CCC finds that the shift to cleaner, more efficient technologies can deliver major savings in fuel costs.[15] Government analysis estimates that the commitments in its Net Zero strategy could support up to 440,000 jobs by 2030[16] and that by accelerating the deployment of renewable power, and energy efficiency measures, the average consumer energy bill in 2024 will likely be cheaper than it would otherwise have been.[17]

To ensure these benefits and the Net Zero ambition are realised, it will be important for the Government to develop a detailed and comprehensive investment strategy that clearly articulates the investment, both public and private, needs for Net Zero.[18] In this context, it is important to understand if there is a gap between the Government's ambitions on Net Zero and the practical policy needed to provide the necessary market signals to private investors.[19] To comprehensively assess the size of this investment gap requires a framework to track the financial flows toward Net Zero investments that is transparent and reports regularly.

To illustrate the potential value of this type of analysis, E3G and WWF have commissioned Frontier Economics to collate research that assesses the gap between existing policies and investments and the level of investment required in the 2020s to put the UK on track to achieve Net Zero. This research is intended to demonstrate the order of magnitude of the investment gap in key sectors and the importance of establishing a robust mechanism for tracking investment flows and being able to report on that gap.

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[8] We completed our analysis before policy announcements in September 2022 but we would not expect this to substantially change our recommendations.

[9] Climate Change Committee (2020) *Sixth Carbon Budget, p21*

[10] OBR (2021), *Fiscal risks report.* Real GDP ends up 1.4% below the baseline by 2050 in an early action scenario, while in a late action scenario, real GDP settles a further 3.2% below the early action scenario in 2050. In the late action scenario, In this scenario, the UK and the rest of the world do not take decisive steps to cut emissions until the 2030s, but still take action to reach Net Zero by 2050.

[11] OBR (2021) Climate-related measures in the Budget and Spending Review

[12] HM Government (2021), *Net Zero Strategy: Building Back Greener*

[13] HM Government (2021), *Net Zero Strategy: Building Back Greener, p39*

[14] HM Government (2022), *British Energy Security Strategy*

[15] Climate Change Committee (2020) *Sixth Carbon Budget*

[16] HM Government (2021), *Net Zero Strategy: Building Back Greener*

[17] HM Government (2021), *Net Zero Strategy: Building Back Greener, p15*

[18] National Audit Office (2020) *Achieving Net Zero, p15*, The Advisory Group on Finance (2020) *The Road to Net Zero Finance*

[19] House of Lords Economic Affairs Committee (2021) *Investing in energy – price, security and the transition to Net Zero*

The main focus of this report is on the immediate supply-side investments that are needed to be on a Net Zero pathway. Investments in research and development that will take place this decade are in scope, but we do not estimate the R&D needs to scale up investment in future decades.

The report sets out the research as follows:

- In Section 2, we set out the methodology, which is composed of four steps:
  - **Pathway and ambition**
  - **Required investment**
  - **The potential gap**
  - **Policy priorities to fill the gap**
- In Section 3, we apply this methodology to each sector in turn.
- In Section 4, we summarise the findings of the research.

2 METHODOLOGY

2.1 PATHWAY AND AMBITION

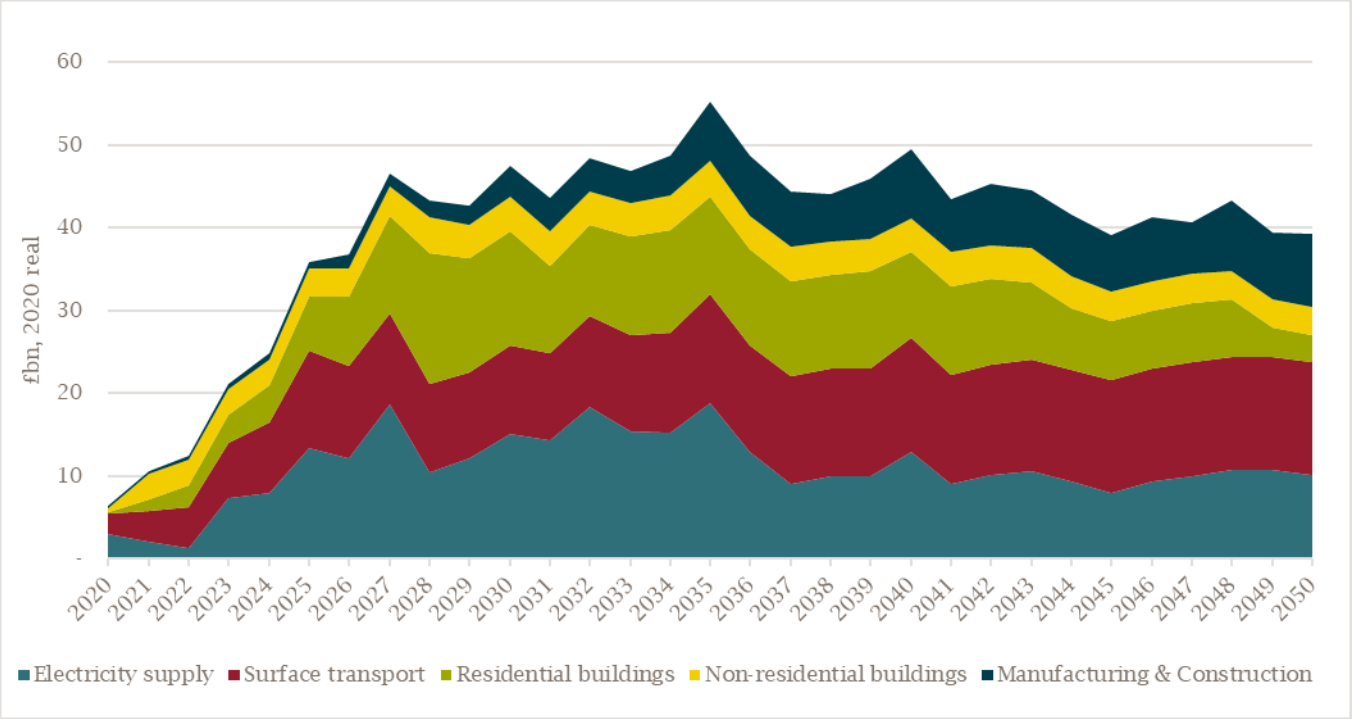
The first step in our analysis is to set out the key policies and low carbon technologies underpinning the CCC's Net Zero Balanced Pathway,[2021] which we then compare to the current level of Government ambition in the respective areas.

2.2 REQUIRED INVESTMENT

The second step in our analysis is to assess the investment requirements during the 2020s underpinning the CCC's Balanced Pathway Scenario. To do this, we draw on analysis undertaken by the CCC for the Sixth Carbon Budget.[22]

Figure 1 illustrates that annual additional capital investment required to meet Net Zero ramps up significantly during the 2020s and early 2030s from around £10 billion in 2020 to around £50 billion by 2030. Additional capital investment is defined in Box 1.

FIGURE 1 REQUIRED ADDITIONAL CAPITAL INVESTMENT (BALANCED PATHWAY SCENARIO)



Source: CCC (2020) Sixth Carbon Budget, Additional Capital Investment, Balanced Pathway Scenario

[20] Climate Change Committee (2020) *Sixth Carbon Budget*

[21] The CCC used scenarios to demonstrate that there are multiple routes to their recommended Sixth Carbon budget and there is no single optimal pathway to Net Zero. We have chosen to focus this research on the Balanced Pathway as it is according to the CCC 'illustrative of what a broadly sensible path based on moderate assumptions would look like.' However, we do note that the level of additional investment required varies between scenarios.

[22] Climate Change Committee (2020) *Sixth Carbon Budget*

BOX 1: WHAT DO WE COUNT AS INVESTMENT NEEDS?

The CCC publishes cost data in relation to the Sixth Carbon Budget[23] across a range of categories. In our analysis and in Figure 1 above, we consider **Additional Capital Investment** for all sectors. For some sectors this data is provided a sub-sector level, e.g. surface transport data is provided for passenger cars and light vehicles, HGVs and public transport. For other sectors such as electricity supply the data is only available at a sector level.

Cost categories included in the CCC data

Cost metric definition	For example	Data
The **baseline** investment in a counterfactual world with no further climate action	Upfront cost of purchasing a fossil fuelled vehicle	Not provided
The **additional capital investment** numbers are in-year gross capital investment costs of building a low-carbon economy, compared to the investment in the baseline.	Additional upfront cost of purchasing an Electric Vehicle + costs of charging infrastructure	Sub-sector level
The **total capital investment** numbers are the sum of the baseline investment costs, and additional capex.	Cost of a fossil fuelled vehicle + additional cost of purchasing an EV and the associated infrastructure.	Sector level
The **additional operating costs** are annual costs of running a low-carbon system as compared to a high-carbon one.	Fuel and maintenance cost savings from an EV relative to the fossil fuelled vehicle.	Sub-sector level
The **financing costs** are any additional costs of financing the investment/purchase.	Borrowing costs to finance the purchase of the vehicle	Not provided
The **resource cost** is the direct cost of building and installing low-carbon technologies, and operating them over the course of their lifetimes (including financing costs) and externalities .	The purchase cost of an electric vehicle, borrowing costs to finance that purchase, the costs of maintenance for the EV, and costs associated with refuelling the vehicle	Sector level

The CCC Sixth Carbon budget investment requirements for this decade (Figure 1) are primarily focused on mitigation measures. There are also important investments to be made this decade with regards to climate change adaptation, given changes to the climate that will occur based on historical and projected emissions, even with global mitigation strategies in place. However, data is not available to assess the required investment and the gap in the same way (see Box 2 for an overview of key published developments).

Because of the lack of data, in the remainder of this report, we focus on estimating the investment relating to climate mitigation. However, where there is a clear policy gap with regards to adaptation (e.g. in buildings), we have also noted this.

BOX 2: REQUIRED INVESTMENTS FOR ADAPTATION

In January 2022 the Government published their latest Climate Change Risk Assessment[24] in response to the CCC's Independent Assessment of UK Climate Risk.[25] The Government's assessment has been well received by the CCC but the updated National Action Plan[26] due in 2023 will be the key milestone against which to assess the commitment to delivering the required level of investment in climate change adaptation.

[23] Climate Change Committee (2020) *Sixth Carbon Budget*
[24] HM Government (2022) *UK Climate Change Risk Assessment*
[25] Climate Change Committee (2021) *Independent Assessment of UK Climate Risk*
[26] Department for Environment, Food and Rural Affairs (2018) *Climate change second national adaptation programme 2018 to 2023*

2.3 CURRENT POLICY AND INVESTMENT AND THE POTENTIAL GAP

In assessing the level of current spend we need to take a judgement in two areas:

- to what degree is the funding or policy committed; and
- what is the potential for the policy or funding to leverage private financing flows.

2.3.1 HOW COMMITTED IS THE FUNDING OR POLICY?

We have defined three categories to describe the degree to which the investment is committed.

(a) **Committed:** Where there is a clear Government policy in place that either provides direct funding or a return on investment that is contracted and underpinned by a consumer levy, we have categorised this as committed investment.

(b) **Planned**: Where there is well developed Government policy in place, but there is no direct funding committed and/or the details of the policy are still being established, we have categorised this as planned investment. The level of estimated investment here is particularly uncertain given the potential for policies to change with new administration, and the unproven nature of policies yet to be implemented.

(c) **Gap:** Where there is no clear policy mechanism and/or finding in place, we have identified an investment gap.

2.3.2 WHAT IS THE POTENTIAL FOR THE POLICY OR FUNDING TO LEVERAGE PRIVATE FINANCING FLOWS?

We then consider the private funding that may flow in response to the policy or public investment. The most suitable methodology to estimate the level of private investment[27] leveraged depends on the policy mechanism and availability of data. We have used five broad categories.

- **Auctioned capacity**: Where the capital investment is private, but compensated by a consumer levy under a contract (e.g. Contract for Differences in the electricity sector), the investment is estimated based on the level of capacity awarded contracts and the capital cost of deploying a given technology.
- **Capital funding**: For direct funding of new technologies or innovation (e.g. the Net Zero Hydrogen Fund), where there is no published level of matched funding, the range of private investment is based on illustrative leverage ratios. In reality, leverage ratios will vary, according to the characteristics of the investment and the investment environment. Detailed research into leverage ratios was beyond the scope of this work. To illustrate the potential magnitude of the effect, we have drawn estimates from the World Economic Forum's *Green Investment Report*[28]. However, the results of this analysis are subject to a high degree of uncertainty and are illustrative only.
- **Grant funding to individuals / business**: For smaller funds that provide direct funding to individuals or business' to make investments, e.g. the Green Homes Grant, the minimum level of matched funding is estimated based on the parameters of the scheme. The upper

[27] Public investment is from the UK Government and private investment could be from either UK sources or global markets.
[28] World Economic Forum (2013) *The Green Investment Report*

end is estimated using illustrative leverage ratios, and again, this upper range is subject to a high degree of uncertainty.

- **Obligations and mandates**: For market mechanisms that set an obligation for the sale of technologies, e.g. heat pumps or electric vehicles, the range of private investment leveraged is set by the terms of the obligation or mandate itself.
- **Large, unique projects:** For large, unique projects such as Sizewell C, the capital costs are published periodically by the developers.

2.3.3 GAP

We estimate the potential investment gap at a sector level and undertake a qualitative assessment of the policy gap at a sub-sector level. Policy gaps are based on analysis of the CCC's Sixth Carbon Budget work,[29] supplemented by a review of Government policies that have been introduced since. When describing the resulting gap, we differentiate between areas where significant policies are in place, but at insufficient scale, and where there are major policy gaps.

2.4 KEY CONSIDERATIONS FOR FILLING THE POLICY GAP

Having estimated the scale of the gap, we then set out the key areas where additional Government intervention may be required to fill it. These interventions do not necessarily entail direct Government spending, but policy commitments designed to leverage the necessary private investment, including important investments in research and development.

Our assessment of the priorities focuses primarily on policies to drive investments required to be on a Net Zero pathway. We note other measures (e.g. behavioural measures focussed on modal shift) could also be important. The policy and technologies included in the analysis reflect those included in Government and CCC policy documents, rather than necessarily reflecting the views of WWF and E3G on what the correct technologies or policy mix should be.

The aim of this approach is to provide a high level overview of the major policy priorities that may be required to fill the investment gaps identified. Developing detailed policy proposals is beyond the scope of this work and the focus here is on identifying the key areas, and the general principles for policy instruments.

When considering which policies could fill the gap, we have taken the following points into consideration.

- Policy-makers will wish to balance aims across multiple goals, including efficiency, fairness and practicality , and there may be trade-offs between these goals.
- Efficient policies will focus on overcoming market failures and other barriers that are preventing the required investment from occurring. However, in designing efficient policies, it is important to take account of the fact that many investments involve new technologies, and complex system wide impacts. This means that in the near term, the focus may be on initially incentivising private investment, as the first step towards achieving the long term aim of developing efficient and well-functioning markets.
- As well as efficiency, policy design also needs to take into account practicality and fairness. One key consideration in relation to practicality is stability. It takes time to design, consult on and introduce new policies, and for the supply chain to mobilise to

[29] Climate Change Committee (2020) *Sixth Carbon Budget*

deliver them. Where there are existing policies with a track record of delivering cost-effective investment, scaling these up should be a priority, rather than seeking to replace them with 'optimal' policies.

Given these considerations, for each key sector, we summarise major areas where policy needs to be scaled up or introduced to meet Net Zero.

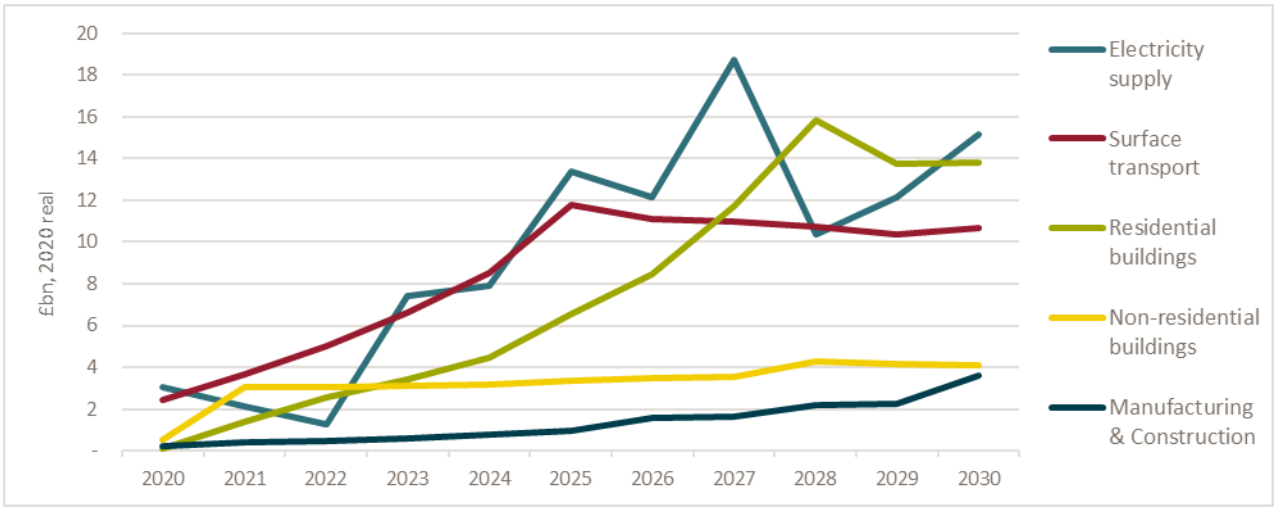
3 SECTORAL ANALYSIS

We focus on the five sectors where Net Zero-related investment requirements are largest:

- Electricity supply;
- Surface transport;
- Residential buildings;
- Non-residential buildings; and
- Manufacturing and construction.[30]

Investment requirements in these five sectors are illustrated in Figure 2, which shows the CCC's estimates of additional investment required in the 2020s to put the UK on track for Net Zero. This is based on the CCC Balanced Pathway Scenario which estimates total additional investment across the five sectors at £334bn this decade.

FIGURE 2 REQUIRED ADDITIONAL CAPITAL INVESTMENT – UK – NET ZERO BALANCED PATHWAY



Source: CCC (2020) Sixth Carbon Budget, Additional Capital Investment, Balanced Pathway Scenario.

We now consider each sector in turn.

[30] We have included investment in hydrogen production and the CO2 T&S network in the Manufacturing and Construction sector. The CCC does not publish data on the additional investment in hydrogen production on a sector basis and BEIS also only publishes investment figures for hydrogen production based on a capacity level, e.g. 5GW. Given that the largest amount of hydrogen use this decade is projected to occur in industry (based on BEIS (2021) *UK Hydrogen Strategy*), we have included associated investment requirements in the Manufacturing and Construction sector. Investment in the CO2 T&S network is included here for the same reasons – the key users of the network will be CCUS enabled hydrogen production and industrial CCS facilities.

3.1 ELECTRICITY SUPPLY

3.1.1 CCC PATHWAY AND GOVERNMENT AMBITION

In 2019 15% of UK emissions were from electricity supply.[31] In the *Net Zero Strategy* the UK Government committed to a power sector in which all electricity will come from low carbon sources by 2035.[32] Table 1 below sets out the Government's ambition in the key sub-sectors of electricity supply alongside the CCC's Sixth Carbon Budget recommendations. This illustrates that the Government's stated ambition matches or goes beyond the CCC's stated requirements with regard to offshore wind and nuclear power but is currently less ambitious for CCS.

TABLE 1 ELECTRICITY SUPPLY RECOMMENDATIONS AND GOVERNMENT AMBITION

	CCC SIXTH CARBON BUDGET	GOVERNMENT AMBITION
Variable renewables	■ 40GW of offshore wind by 2030 ■ Diversity of technology including onshore wind and solar PV	■ 50 GW offshore wind by 2030 including 5GW of floating offshore wind[33]
Firm power	■ One new nuclear plant operational by 2030, and a further plant by 2035	■ Final Investment Decision in at least one new nuclear power plant by the end of this Parliament and up to 24GW by 2050[33]
Dispatchable low-carbon power	■ Multiple power CCS projects including BECCS	■ At least 1 power CCS project in the mid-2020s[34] ■ 5Mt Greenhouse Gas Removal in 2030[35]
Flexibility and security of supply	■ Up to 20% of demand is flexible by 2035, significantly increased long duration storage	■ To deliver a smart and flexible system that will underpin energy security and the transition to net zero[36] ■ To explore the system need and case for further market intervention for long duration storage and hydrogen in power.[37]

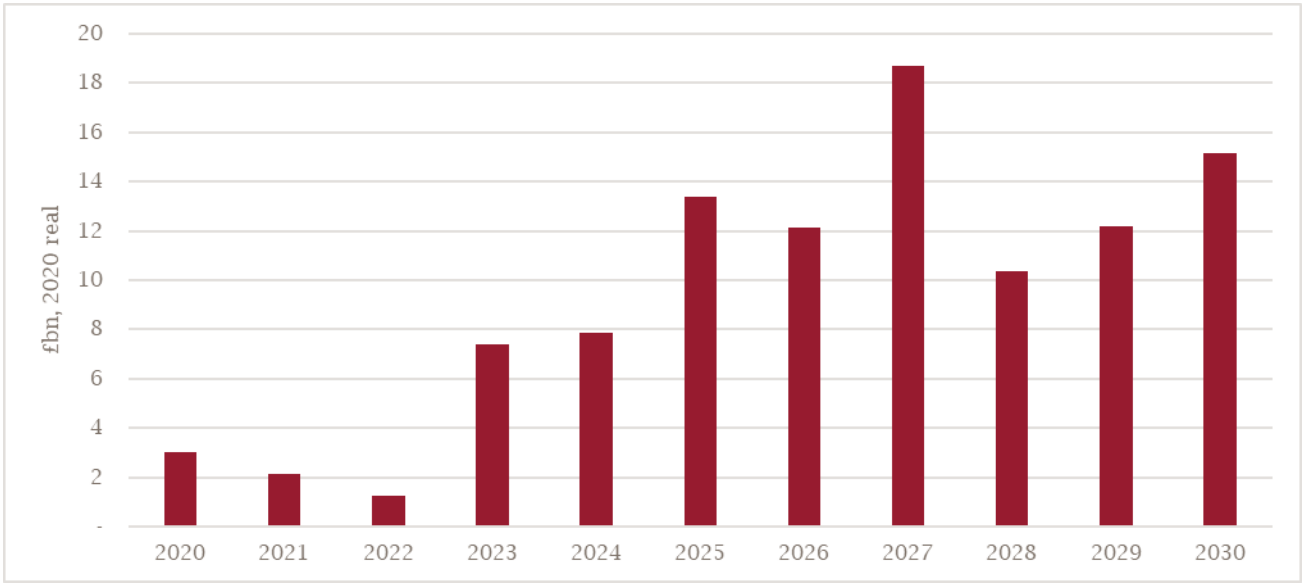
Source: See footnotes

[31] Climate Change Committee (2020) *Sixth Carbon Budget*
[32] HM Government (2021) *Net Zero Strategy*
[33] HM Government (2022), *British Energy Security Strategy*
[34] HM Government (2021) *Net Zero Strategy*
[35] Power BECCS is only one technology that could deliver this CO2 capture. The greenhouse gas removal (GGR) ambition is not specific as to which sector will deliver the 5Mt of capture.
[36] HM Government (2021) *Net Zero Strategy*
[37] HM Government (2021) *Net Zero Strategy*

3.1.2 INVESTMENT REQUIREMENTS

The CCC estimate the cumulative required capital investment in electricity supply from 2020-2030 at £148bn.[38] Of this, the CCC estimate that approximately 30% relates to network investment. We exclude network investment from our analysis in this report.[39] Therefore we use a figure of £104bn, or an annual average of around £10bn per year over the 2020s.

FIGURE 3 REQUIRED ADDITIONAL CAPITAL INVESTMENT IN UK ELECTRICITY SUPPLY SECTOR (2020-2030)



Source: CCC (2020) Sixth Carbon Budget, Additional Capital Investment, Balanced Pathway Scenario

3.1.3 THE ESTIMATED GAP

We have estimated the potential investment gap in electricity supply investment by comparing committed and planned investment[40] to the CCC's estimate of investment required to be on a path to Net Zero in the 2020s, under the Balanced Pathway Scenario.

Table 2 shows that the investment gap in electricity supply (excluding networks) could be between 13-23% of required investment. This range is primarily driven by:

- the timing of investment in Sizewell C (whether it proceeds as planned); and
- the uncertainty of the level of private investment leveraged by infrastructure and innovation funding;
  - in the case of R&D, we assume the low end of the range is 2.3x leverage, informed by a BEIS report on the relationship between public and private funding in R&D,[41]
  - in the case of funding and infrastructure, we assume matched (1:1) funding,[42]

[38] Climate Change Committee (2020) *Sixth Carbon Budget - Electricity generation sector summary*

[39] This is because differentiating between business as usual and Net Zero related investment is complex in this part of the sector, and a full review of network business plans was not possible within the scope of this analysis.

[40] These categories of investment are defined in Section [2].

[41] Department for Business, Energy & Industrial Strategy (2020) *Research and development: relationship between public and private funding*

[42] This is the case with the UK's funding to support SMR development with Rolls Royce

- in both cases, we assume the high end of the range is 8x leverage, informed by chapter two of the World Economic Forum's *Green Investment Report*, on unlocking private finance.[43]

It is also important to note that we have categorised a significant proportion of funding as 'planned' which is dependent on continued support and policy stability, e.g. Contracts for Difference (CfD). Removal of existing policies, or a change in policy direction could increase this gap.

TABLE 2 COMMITTED AND PLANNED INVESTMENT IN THE ELECTRICITY SUPPLY SECTOR

	POLICY / FUND	COMMITTED	PLANNED
Variable renewables	■ Contracts for difference ■ Offshore wind infrastructure ■ Floating offshore wind R&D	£14 – 16bn	£49bn
Firm power	■ Hinkley Point C online by 2030 ■ Sizewell C ■ New nuclear innovation funding	£3 – 5bn	£10 - 14bn
Dispatchable low-carbon power	■ Dispatchable power agreement	0	£2-4bn
Flexibility and security of supply	■ Capacity market ■ Review of Electricity Market arrangements	£2bn	0
	Total **UK Public investment**[44] **Investment as a % of total required investment**	**£19 – 23bn** *£18bn* *(18 – 22%)*	**£61 – 67bn** *£51 - 53bn* *(59 – 64%)*
	Investment required **Total committed & planned investment**	**£104bn** **£80 – 90bn**	
	Investment gap **Investment gap as a % of total required investment**	**£14 – 24bn** *(13 – 23%)*	

Source: Frontier research

3.1.3 POLICY PRIORITIES TO FILL THE NET ZERO GAP

Good progress has already been made in the electricity supply sector using the existing instruments. Therefore, we recommend that the emphasis should be on scaling up existing major programmes. This will need to be complemented by incentives to deliver the technologies to provide the system flexibility

[43] World Economic Forum (2013) The Green Investment Report
[44] We have categorised CfD, CM and DPA backed investment as public investment.

necessary to accommodate high level of renewable generation. Central to this will be the Review of Electricity Market Arrangements (REMA) ensuring that incentives are aligned across the sector to deliver the significant level of investment that is required over the coming decade. These priorities are summarised in Table 3 and 4.

TABLE 3 ESTIMATING THE GAP

POTENTIAL SIZE OF INVESTMENT GAP	CHARACTERISATION OF THE GAP	REQUIREMENT TO SCALE UP EXISTING OR PLANNED POLICIES IN MAJOR AREAS	REQUIREMENTS FOR NEW MAJOR POLICIES
£14 – 24bn (13 – 23%)	■ Primarily a gap of future policy commitment to leverage private investment.	■ Support for low carbon renewables ■ Support for CCUS	■ Action to ensure end to unabated fossil fuel generation by 2035 ■ Incentives to procure required system flexibility., such as long duration storage.

Source: Frontier analysis

TABLE 4 PRIORITIES TO FILL THE GAP

SUBSECTOR	PRIORITIES
Variable renewables	■ Policy stability is key to deliver the pipeline of projects and to meet Government substantial offshore wind ambition. However, consideration is also needed over how the existing mechanisms will need to develop as deployment scales. ■ For technologies other than offshore wind, policy clarity will be key to delivering the diversity of renewable technologies. ■ Additional clarity of the approach to future, more regular, auctions will allow the supply chain to develop.
Firm power	■ Policy stability with regard to the Government's commitment to the level of firm power required.
Dispatchable low-carbon power	■ Provide funding for the existing commitments to power CCS and scaling up the support to further CCS projects via the DPA. ■ Policy design to provide the necessary incentives for other low carbon flexible generation.
Flexibility and security of supply	■ Incentives for investment in large scale storage. ■ Consider regulation to limit investment in unabated fossil fuel generation by 2035.

3.2 SURFACE TRANSPORT

3.2.1 CCC PATHWAY AND GOVERNMENT AMBITION

The surface transport sector was responsible for 22% of UK emissions in 2019, primarily tailpipe emissions from fossil-fuelled road vehicles.[45] In 2021 the UK Government set out comprehensive plans to reduce emissions in the sector in the Department for Transport's *Decarbonising Transport: a Better, Greener Britain*.[46] Some of these ambitions have since been updated and Table 5 below sets out the latest Government position alongside the CCC's recommendations. Again, the Government ambitions here broadly match or exceed the CCC's recommendations in all areas, other than the number of rapid chargers installed by 2030.

TABLE 5 SURFACE TRANSPORT POLICY RECOMMENDATIONS AND GOVERNMENT AMBITION

	CCC SIXTH CARBON BUDGET	GOVERNMENT AMBITION
Passenger cars and light goods vehicles	■ Phase-out of all new fossil-fuelled car and van sales by 2032 with only a very small proportion of hybrids allowed alongside until 2035. ■ 300,000 charge points across the UK by 2030, including 10,000 rapid.	■ Phase-out of new fossil-fuelled car and van sales by 2030, with allowance for hybrids that offer significant zero-emission capability until 2035[47] ■ 300,000 charge points across the UK by 2030, including 6,000 rapid[48]
Heavy Goods Vehicles	■ Zero-emission HGVs reach nearly 100% of sales by 2040	■ 100% of new HGV sold are zero emission by 2040[49]
Buses	■ 100% of new buses are zero-carbon by 2035.	■ 100% of new buses/coaches sold – target date under consultation[50]. ■ Deliver 4,000 zero emission buses and the infrastructure needed to support them[51]
Rail	■ Net Zero rail network by 2050 – optimal technology mix uncertain	■ Net zero railway network by 2050[52] ■ Remove all diesel-only trains from the network by 2040

[45] Climate Change Committee (2020) *Sixth Carbon Budget*
[46] Department for Transport (2021) *Transport Decarbonisation Plan*
[47] HM Government (2021) *Net Zero Strategy*
[48] Department for Transport (2022) *Taking charge: the electric vehicle infrastructure strategy*
[49] Department for Transport (2021) *Zero-emission HGVs by 2040*
[50] Department for Transport (2021) *Ending UK sales of new, non-zero emission buses consultation*
[51] Department for Transport (2021) *Transport Decarbonisation Plan*
[52] Department for Transport (2021) *Transport Decarbonisation Plan*

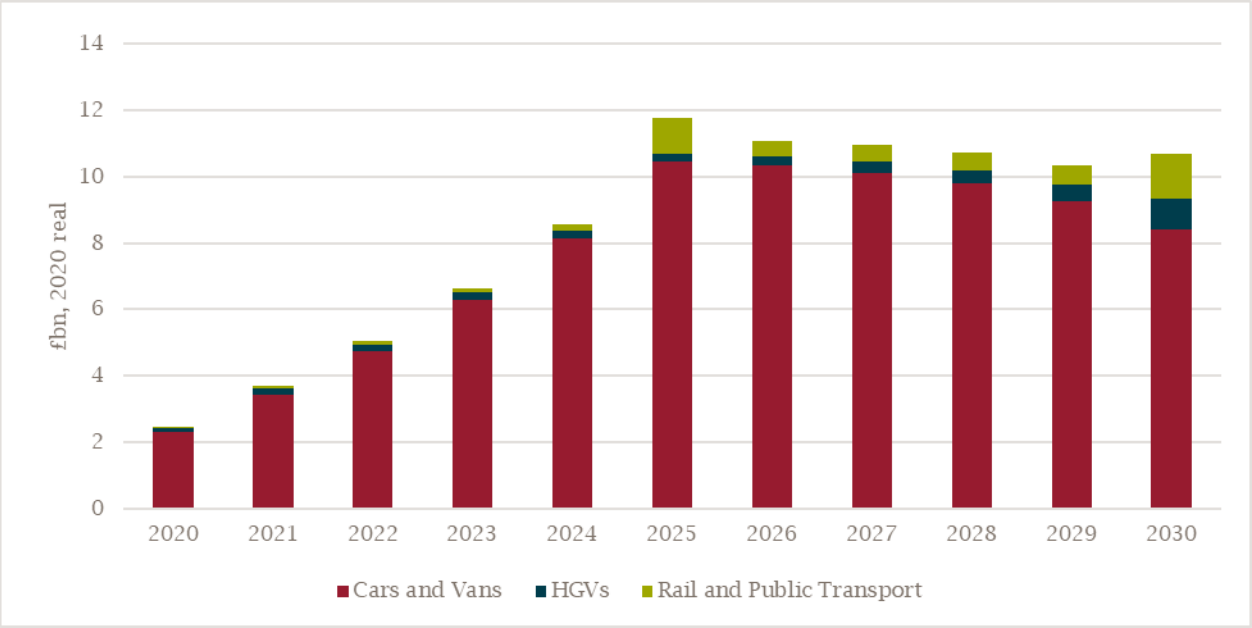
	CCC SIXTH CARBON BUDGET	GOVERNMENT AMBITION
Cycling and walking	■ 5-7% of car journeys could be shifted to walking and cycling (including e-bikes) by 2030	■ Double cycling 2013 to 2025. Increase walking activity by 2025[53]

Source: CCC (2020) Sixth Carbon Budget, DfT (2021) Transport décarbonisation plan

3.2.2 INVESTMENT REQUIREMENTS

The CCC estimate the cumulative required additional capital investment in surface transport from 2020-2030 at £92bn. The vast majority of investment, £83bn (£7.6bn annually) is needed in the sub-sector of cars and vans.[54]

FIGURE 4 REQUIRED ADDITIONAL CAPITAL INVESTMENT IN SURFACE TRANSPORT SECTOR (2020-2030)



Source: CCC (2020) Sixth Carbon Budget, Additional Capital Investment, Balanced Pathway Scenario.

3.2.3 THE POTENTIAL GAP

Again, we have estimated the potential gap in transport by comparing committed and planned investment[55] to the CCC's estimate of investment required in the 2020s, under the Balanced Pathway Scenario. This analysis is shown in Table 6.

Electric vehicles (EVs) are projected to reach upfront-price parity with petrol and diesel vehicles in this decade and already have significantly lower running costs.[56]

[53] Department for Transport (2021) *Gear Change: a bold vision for cycling and walking*

[54] We expect the required investment in EVs to be lower than this in practice due to higher than anticipated uptake and cost reductions happening at a higher pace than expected when the Sixth Carbon Budget analysis was completed.

[55] These categories of investment are defined in Section [2].

[56] Bloomberg NEF (2021), *Hitting the EV price inflection point*

- **Electric cars.** More than 90% of electric vehicles purchased this decade are expected to be cars.[57] Assuming projected cost reductions occur, consumers and businesses may adopt electric cars without the need for significant policy targeted at their purchase (though policy support for charging infrastructure may still be required).
- **Electric vans.** Electric vans are currently being adopted at slower rates than electric cars,[58] and ongoing policy support may be required. Assuming the continuation of existing support for electric van purchases, and that the Zero Emission Vehicle Mandate trajectory for vans is set appropriately,[59] private investors may also adopt electric vans.

EV cost reductions, and the policies in place for electric vans means that there may only be a very small investment gap, relating to charging infrastructure. There is uncertainty over how much investment in charging infrastructure existing schemes will leverage and how much of the required investment will need to be leveraged from less developed 'planned' policies. The range around charging infrastructure investment is driven by the level or private capital that committed grant funding can leverage for EV charging infrastructure.

- As in the power sector, our high range is informed by the World Economic Forum's Green Investment Report, on unlocking private finance.[60]
- The low range is informed either by levels of government co-funding specified in the policy, or match funding by the private sector, as in the power sector.

The majority of investment in other sub-sectors is required from 2030 onwards. However, although any gap in this decade is expected to be small, there will need to be policy development and innovation funding to lay the foundations for future investment.

TABLE 6 COMMITTED AND PLANNED INVESTMENT IN THE SURFACE TRANSPORT SECTOR

	POLICY / FUND	COMMITTED	PLANNED
Passenger cars and light goods vehicles	■ Plug-in / Zero Emission Vehicle Grants[61] ■ Zero Emission Vehicle Mandate (ZEV)[62] ■ Automotive Transformation Fund (ATF)[63] ■ Funding local charging infrastructure (LEVI)[64]	£12bn	£70bn

[57] National Grid (2022) *Future Energy Scenarios*
[58] SMMT (2022), https://www.smmt.co.uk/2022/05/three-quarters-of-a-million-evs-now-on-uk-roads-but-car-ownership-falls-for-second-year/
[59] Department for Transport (2021) *Technical consultation on zero emission vehicle mandate policy design*
[60] World Economic Forum (2013): *The Green Investment Report*
[61] Grant funding to cars has now ended but this figure includes an estimate of investment since 2020.
[62] Department for Transport (2022) *Technical consultation on zero emission vehicle mandate policy design*
[63] UKRI (2022) *Expression of interest: Automotive Transformation Fund*
[64] Department for Transport (2022) *Local EV Infrastructure*

	POLICY / FUND	COMMITTED	PLANNED
	■ Rapid charging fund[65]		
Heavy Goods Vehicles	■ Zero emission road freight trials[66]	£0.4 – 2bn	-
Buses	■ Ultra-low emission bus scheme	£0.5 – 2bn	-
Rail	■ Rail innovation: First of a Kind competitions[67]	£0.01 – 0.03bn	-
Cycling and walking	■ Gear change strategy[68]	£2bn	-
	Total	**£15 – 18bn**	**£70bn**
	UK Public investment	**£6bn**	**-**
	Investment as a % of total required investment	*(16 – 20%)*	(76%)
	Investment required		**£92bn**
	Total committed & planned investment		**£85 – 88bn**
	Investment gap		**£4 - 7bn**
	Investment gap as a % of total investment		*(5 - 8%)*

Source: Frontier research

3.2.4 POLICY PRIORITIES TO FILL THE NET ZERO GAP

There is a need to scale up activity in several areas for low carbon transport:

- For EVs, it will be important to continue to monitor the ongoing progress towards price parity. Continued grant support may be required for vans and will be required to provide charging infrastructure at scale.
- For other areas where the timeline for decarbonisation is later, the level of innovation funding will need to be increased and in some cases, e.g. rail, diversified to maintain optionality.

TABLE 7 ESTIMATING THE GAP

POTENTIAL SIZE OF INVESTMENT GAP	CHARACTERISATION OF THE GAP	REQUIREMENT TO SCALE UP EXISTING OR PLANNED POLICIES IN MAJOR AREAS	REQUIREMENTS FOR NEW MAJOR POLICIES
£4 - 7bn *(5 - 8%)*	Policy certainty to leverage private investment but additional public investment	■ Support shift to walking, cycling and public transport	

[65] Department for Transport (2022) *Rapid Charging Fund*
[66] Department for Transport (2022) *Zero-emission HGVs*
[67] Department for Transport (2022) *Small Business Research Initiative (SBRI)*
[68] Department for Transport (2021) *Gear Change: a bold vision for cycling and walking*

POTENTIAL SIZE OF INVESTMENT GAP	CHARACTERISATION OF THE GAP	REQUIREMENT TO SCALE UP EXISTING OR PLANNED POLICIES IN MAJOR AREAS	REQUIREMENTS FOR NEW MAJOR POLICIES
	will be required to support infrastructure investment.	■ Support for EV infrastructure ■ Support for Net Zero public transport ■ Action on HGVs	

Source: Frontier research

TABLE 8 PRIORITIES TO FILL THE GAP

	PRIORITY POLICIES
Passenger cars and light goods vehicles	■ Coordination of policy to incentivise EV adoption and provide the necessary charging infrastructure should be priority. ■ Continued grant funding may be needed to support the growth of the electric van market. ■ The design of the Zero Emission Vehicle mandate will be key to providing clear and stable signals to the market and supply chain. ■ Funding for EV charging infrastructure will need to be ramped up to stimulate the market to deliver the substantial investment required in a way that is convenient and affordable. ■ There will also remain an important role for Government in directing investment to ensure the coverage of infrastructure enables equality of access.
Heavy Goods Vehicles	■ Current plans reflect the timing of the required investment in this sector. ■ The optimal technology is still not clear and scaling up and diversifying innovation funding is needed to find the necessary solutions to decarbonise at scale.
Rail and public transport	■ Current plans reflect timing of ambition but there are significant decisions to be made this decade which will require Government policy to be clear and consistent. ■ The level of innovation funding will need to increase to leverage private investment.

Source: Frontier research

3.3 BUILDINGS

3.3.1 CCC PATHWAY AND GOVERNMENT AMBITION

The buildings sector was responsible for 17% of UK emissions in 2019, primarily emissions from using fossil fuels for heating.[69] In 2021 alongside the *Net Zero Strategy,* the UK Government set out comprehensive plans to reduce emissions in the sector in the BEIS *Heat and Buildings Strategy*.[70] Some of these ambitions have since been updated and Table 10 below sets out the latest Government position alongside the CCC's recommendations. Government ambitions here broadly match the CCC's recommendations, with the exception of the target for annual heat pump installations by 2028 where Government ambition is 50% lower.

TABLE 9 BUILDINGS POLICY RECOMMENDATIONS AND GOVERNMENT AMBITION

	CCC SIXTH CARBON BUDGET	GOVERNMENT AMBITION
Energy Efficiency	EPC band C: ■ Across housing stock by 2035 ■ Private rented homes by 2028	EPC band C:[71] ■ Across housing stock by 2035 ■ Private rented homes by 2028 Social housing and owner occupied - under consultation[72]
Low carbon heating	Fossil fuel heating phase out: ■ In homes: gas – 2033, oil - 2028 ■ In commercial and public: gas – 2033/30, oil – 2025/26 ■ Heat pump installations per year by 2028: 900k	Fossil fuel heating phase out:[73] ■ In homes: gas – 2035, oil - 2026 ■ In commercial and public: gas – 2035, oil – 2024/26 ■ Heat pump installations per year by 2028: 600k
Heat networks	■ Low –carbon district heating: 25TWh by 2030, 47TWh by 2028	■ Low –carbon district heating: 15TWh by 2030, 29TWh by 2028[74]
Public sector	■ Halve emission reductions from 2017 levels by 2032 and reduce by 60% by 2037	■ Halve emission reductions from 2017 levels by 2032 and reduce by 75% by 2037[75]

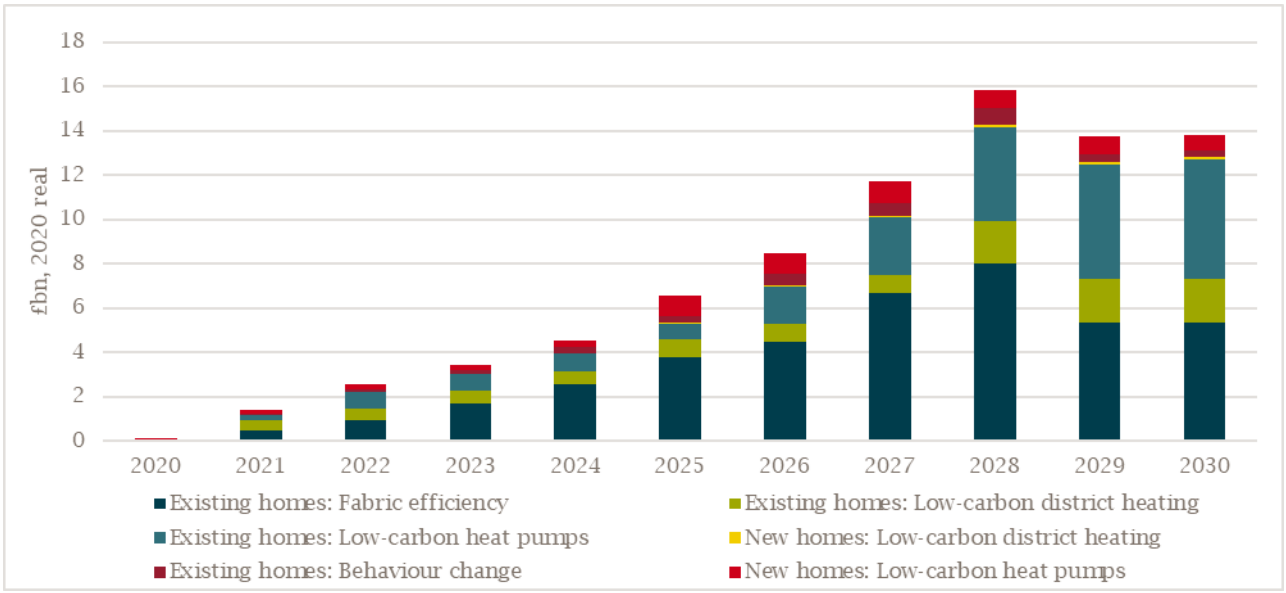
Source: See footnotes

[69] Climate Change Committee (2020) *Sixth Carbon Budget - Buildings sector summary*
[70] Department for Business, Energy and Industrial Strategy (2021) *Heat and buildings strategy*
[71] Department for Business, Energy and Industrial Strategy (2021) *Heat and buildings strategy*
[72] Department for Business, Energy and Industrial Strategy (2021) *Heat and buildings strategy*
[73] HM Government (2021) *Net Zero Strategy*
[74] Department for Business, Energy and Industrial Strategy (2021) *Heat and buildings strategy*
[75] Department for Business, Energy and Industrial Strategy (2021) *Heat and buildings strategy*

3.3.2 INVESTMENT REQUIREMENTS

The CCC estimates that the cumulative required additional capital investment in residential buildings from 2020-2030 is £82bn [Figure 5] . The vast majority of investment, £62bn combined (£5.6bn annually) is needed in energy efficiency and low carbon heat in existing homes.

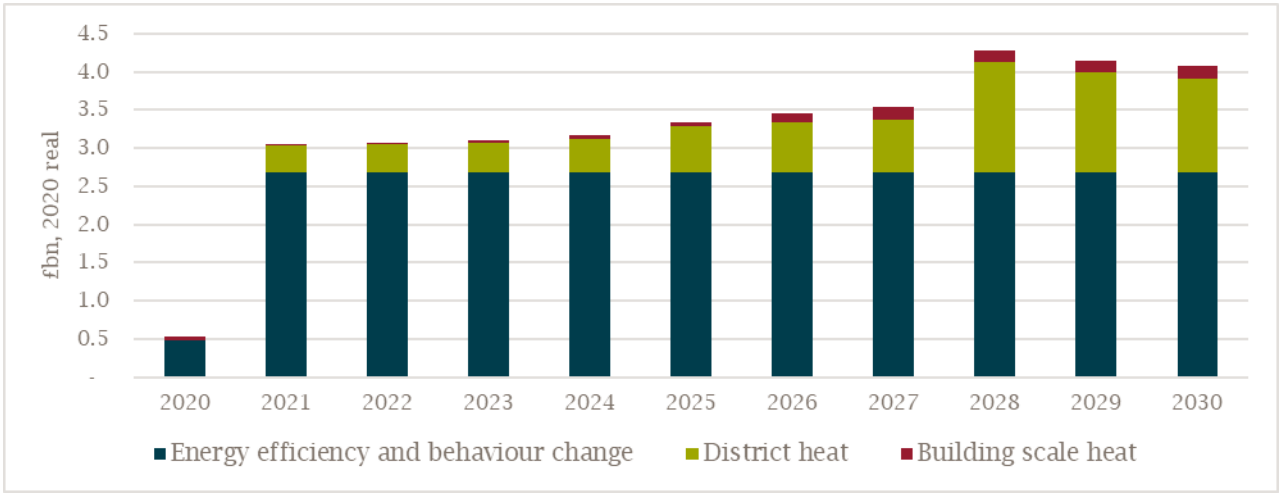
FIGURE 5 REQUIRED CAPITAL INVESTMENT IN RESIDENTIAL BUILDINGS SECTOR (2020-2030)



Source: CCC (2020) Sixth Carbon Budget, Additional Capital Investment, Balanced Pathway Scenario.

According to the CCC's Sixth Carbon Budget, the cumulative required additional capital investment in non-residential buildings from 2020-2030 is £36bn [Figure 6]. The majority of investment, £27bn (£2.5bn annually) is needed in energy efficiency and demand side measures.

FIGURE 6 REQUIRED CAPITAL INVESTMENT IN NON-RESIDENTIAL BUILDINGS SECTOR (2020-2030)



Source: CCC (2020) Sixth Carbon Budget, Additional Capital Investment, Balanced Pathway Scenario

3.3.3 THE POTENTIAL GAP

We estimate that committed and planned investment in the buildings sector could be less than half of the £118bn total required combined investment in residential and non-residential buildings [Table 10] .

The range is driven by the amount of private investment that existing energy efficiency schemes and funding for low carbon district heating will leverage. Where government schemes have specific co-funding limits, we use this to inform the low end of our range, and assume matched funding at the high end. For R&D, we again assume a range informed by the previously cited BEIS[76] (low) and World Economic Forum[77] (high) estimates.

We have assumed that the Market Based Mechanism for Low Carbon Heat[78] is designed and implemented in a way that incentivises the investment needed to meet the Government's ambition of 600 thousand heat pumps installed annually by 2028.[79] We have categorised this as planned investment but[80] the range in investment reflects the pace at which heat pumps are deployed to reach the target. However, there is still uncertainty around the detailed design, and impact of the Market Based Mechanism. Even achieving the ambition of 600 thousand heat pumps would leave a gap in investment to incentivise the additional 300 thousand heat pumps the CCC estimates are required.

TABLE 10 COMMITTED AND PLANNED INVESTMENT IN THE BUILDINGS SECTOR

	POLICY / FUND	COMMITTED	PLANNED
Energy efficiency	■ Green Home Grant[81] ■ Social housing decarbonisation fund[82] ■ Home upgrade grant ■ Energy company obligation[83] ■ Private rented sector minimum standards[84]	£9 – 16bn	£14bn
Low carbon heat	■ Boiler upgrade scheme[85] ■ Low carbon heat market mechanism[86] ■ Heat pump VAT removal[87]	£1.8 - 2.1bn	£15-17bn

[76] Department for Business, Energy & Industrial Strategy (2020), *Research and development: relationship between public and private funding*
[77] World Economic Forum (2013), The Green Investment Report
[78] Department for Business, Energy & Industrial Strategy (2022), *A market-based mechanism for low-carbon heat,*
[79] HM Government (2021), *Net Zero Strategy*
[80] We estimate the investment figure for the 600 thousand heat pumps net of the cost of a high-carbon substitute (e.g. a replacement gas boiler). This is consistent with the CCC approach to additional capital investment.
[81] Department for Business, Energy & Industrial Strategy (2021) Green Homes Grant
[82] Department for Business, Energy & Industrial Strategy (2022) *Social Housing Decarbonisation Fund*
[83] Ofgem (2022) *Energy Company Obligation*
[84] Department for Business, Energy & Industrial Strategy (2022) *Improving the energy performance of privately rented homes*
[85] Department for Business, Energy & Industrial Strategy (2022) *Boiler Scheme Upgrade*
[86] Department for Business, Energy & Industrial Strategy (2021) *Market-based mechanism for low carbon heat*
[87] HM Government (2022) *British Energy Security Strategy*

	POLICY / FUND	COMMITTED	PLANNED
	■ Innovation funding[88]		
Heat networks	■ Green heat network fund[89] ■ Heat network investment project[90]	£2 – 6bn	-
Public sector	■ Public sector decarbonisation fund[91]	£2.4bn	-
	Total	**£15 – 26bn**	**£29 - 32bn**
	UK public investment	**£12bn**	**-**
	Investment as a % of total investment	*(12 - 22%)*	*(25 - 27%)*
	Investment required	**£118bn**	
	Total committed & planned investment	**£44 – 58bn**	
	Investment gap	**£60 – 74bn**	
	Investment gap as a % of total investment	*(51 - 63%)*	

Source: Frontier research

3.3.4 POLICY PRIORITIES TO FILL THE NET ZERO GAP

The above analysis suggests there is a significant investment gap in the buildings sector, which will require major investment in both energy efficiency and low carbon heating. This will need to be supported by policy stability and transparency to maximise the potential for public funding to leverage private investment and to allow the supply chain to mobilise.

TABLE 11 ESTIMATING THE GAP

POTENTIAL SIZE OF INVESTMENT GAP	CHARACTERISATION OF THE GAP	REQUIREMENT TO SCALE UP EXISTING OR PLANNED POLICIES IN MAJOR AREAS	REQUIREMENTS FOR NEW MAJOR POLICIES
	RESIDENTIAL BUILDINGS		
£60 – 74bn *(51 – 63%)*	■ Energy efficiency – Potential public investment gap in some sectors, e.g. able to pay / owner occupied households, plus	■ Support for energy efficiency investments ■ Support for heat networks	■ Action to ensure new fossil fuel systems are not installed post 2035.

[88] Department for Business, Energy & Industrial Strategy (2022) *Heat Pump Ready Programme*
[89] Department for Business, Energy & Industrial Strategy (2022) *Green Heat Network Fund*
[90] Department for Business, Energy & Industrial Strategy (2021) Heat Network Investment Project
[91] Department for Business, Energy & Industrial Strategy (2021) *Public Sector Decarbonisation Scheme*

POTENTIAL SIZE OF INVESTMENT GAP	CHARACTERISATION OF THE GAP	REQUIREMENT TO SCALE UP EXISTING OR PLANNED POLICIES IN MAJOR AREAS	REQUIREMENTS FOR NEW MAJOR POLICIES
	additional support for low income households ■ Low carbon heating – policy certainty and clarity to incentivise private investment post public funding ■ Adaptation – policy commitment and potential public investment	■ Support for low carbon heat	
	NON-RESIDENTIAL BUILDINGS		
	■ Energy efficiency - public investment gap in public and commercial sectors ■ Low carbon heating – public funding alongside policy certainty and clarity to incentivise private investment	■ Support for public sector energy efficiency and low carbon heating ■ Support for heat networks	■ Support for commercial energy efficiency and low carbon heating ■ Action to ensure new fossil fuel systems are not installed post 2035.

Source: Frontier research

TABLE 12 PRIORITIES TO FILL THE GAP

	PRIORITY POLICIES
Residential buildings	■ Policy stability is key to allow the supply chain for low carbon heating and energy efficiency to develop effectively and to incentivise investment in skills. Simplicity and practicality is also key in this sector, given behavioural barriers (such as a general lack of household engagement in the heating market to date). ■ Further grant funding is likely to be required for low- income households. Low carbon heating investments tend to have high upfront costs, and lower running costs. Low income households are likely to need financial help with these upfront costs to allow them to participate in this market. This could involve a scale up of existing schemes such as ECO. Whether such schemes should be funded via the tax system rather than via electricity bills should also be considered. Grants to enable take up of heat pumps for low-income household may also be required.

		PRIORITY POLICIES
	■	For the able to pay market, some additional public funding may be required but the emphasis should be on simple, stable policies. This could include regulation at key trigger points (boiler replacement and home sales, for example) and economic instruments such as the Market Based Mechanism for Low Carbon Heat[92] to encourage uptake of heat pumps.
	■	The same principles are also applicable to adaptation. Regulation is needed to ensure that the UK's future housing stock is resilient to the impacts of the changing climate: for higher average temperatures, flooding and water scarcity[93] and public funding will be required to retrofit existing homes. The design of funding schemes here will be key.
Non-residential buildings	■	Once again, there should be an emphasis on providing stable policy signals so that the supply chain can scale up. Policies should also be designed to be simple, and to avoid transaction costs, taking into account the fact that many businesses may not have significant resources available to devote to managing energy use.
	■	Regulation and market based instruments are likely to be required to support commercial sector energy efficiency and low carbon heat. This should include the implementation of the Energy Efficiency Scheme for Small and Medium Sized Businesses[94]. Market incentives or regulation are also likely to be required for larger businesses for energy efficiency and low carbon heat. Across both small and large businesses, action may be required to ensure that new fossil fuel systems are not installed post 2035.
	■	The Public Sector Decarbonisation Scheme could continue to provide funding for public sector organisations for both mitigation and adaptation.

3.4 MANUFACTURING AND CONSTRUCTION

3.4.1 CCC PATHWAY AND GOVERNMENT AMBITION

Key abatement measures in the manufacturing and construction sector include fuel switching to hydrogen, electrification, and applications of carbon capture and storage (CCS).[95] The CCC Balanced Pathway also sees a significant role for electrification measures.

Installing CCS and switching to hydrogen as a fuel are routes to reduce emissions in multiple sectors and the capital costs of installing these technologies cannot be easily allocated to end use sectors. We have therefore taken the approach to include capital investments in this sector for:

- Hydrogen production costs for 5GW of capacity (as published by BEIS)
- CO2 transport and storage network (as published by BEIS)[96]

[92] Department for Business, Energy & Industrial Strategy (2022), *A market-based mechanism for low-carbon heat,*
[93] Climate Change Committee (2019) *UK housing: Fit for the future?*
[94] Department for Business, Energy & Industrial Strategy (2020), *Energy efficiency scheme for small and medium sized businesses*
[95] Climate Change Committee (2020) *Sixth Carbon Budget*
[96] It is unclear exactly how the CCC have treated CO2 network costs so there may be a mismatch between our estimate in this sub-sector. We have used the estimate of total investment published in the *Net Zero Strategy*

- No specific business model is in place to incentivise electrification, so we estimate that there are not currently any committed or planned investments here.

Table 14 below sets out the latest Government position alongside the CCC's recommendations. This shows that Government ambitions here broadly match or exceed the CCC's recommendations, with the exception of fuel switching, where the Government ambition is lower.[97] With regard to hydrogen production and CO2 capture from industrial facilities, the Government ambition is significantly higher than the CCC recommendation.[98]

TABLE 13 M&C AND FUEL SUPPLY POLICY RECOMMENDATIONS AND GOVERNMENT AMBITION

	CCC SIXTH CARBON BUDGET	GOVERNMENT AMBITION
Fuel switching	■ 60 TWh of fuel-switching per year by 2035	■ Replace 50 TWh/year of fossil fuels by 2035
Hydrogen production	■ 25TWh of low carbon hydrogen demand across all sectors in 2030	■ 10GW of low carbon hydrogen production capacity by 2030[99]
CCUS	By 2030 ■ 22MtCO2 capture ■ 2MtCO2 of industrial emissions, ■ 3MtCO2 from fuel switching	By 2030[100] ■ Four industrial clusters ■ 20-30MtCO2 ■ 6MtCO2 of industrial emissions
Other	■ No specific targets on electrification, resource efficiency and bioenergy[101].	■ Resource and Energy Efficiency (REEE) measures with ambition of achieving the anticipated requirement of 11 MtCO2e worth of savings by 2035.[102] ■ Commitment to publish support for electrification by end of 2021[103]

Source: See footnotes

[97] We could expect Government ambition for fuel switching to increase to reflect the increase in ambition for hydrogen production from 5GW to 10Gw by 2030.

[98] The total CO2 capture figures are similar but the CCC balanced pathway has more CCS deployed in power and Government ambition currently is great in industry.

[99] HM Government (2022), *British Energy Security Strategy* Note: end use sectors for hydrogen production are unspecified

[100] HM Government (2021) *Net Zero Strategy*

[101] Some electrification options are introduced in the early 2020s due to high levels of technology and commercial readiness. Electrification measures include electric boilers, switching from on-site generation to a grid connection, electric arc furnaces, electric mobile machinery, electric dryers and electric infra-red heaters. CCC (2020) Sixth Carbon Budget – Manufacturing and Construction summary

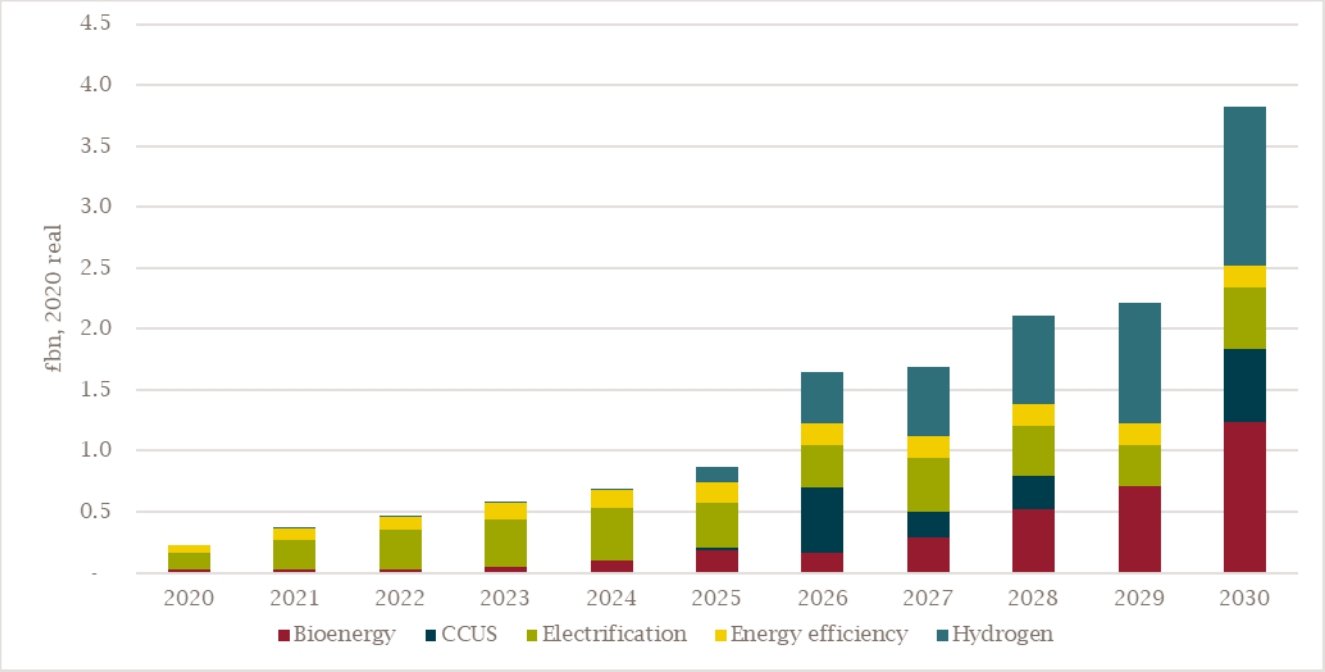
[102] HM Government (2021) *Net Zero Strategy*

[103] This commitment was made in the HM Government (2021) *Net Zero Strategy, p128* but nothing has been published to date

3.4.2 INVESTMENT REQUIREMENTS

The CCC estimates that the cumulative required additional capital investment in manufacturing and construction from 2020-2030 is £14.5bn (£1.3bn annually), ramping up in the latter half of the decade (Figure [7]). This is significantly lower than investment required in other sectors, reflecting the fact that much decarbonisation in this sector is expected by the CCC to happen after 2030. [104]

FIGURE 7 REQUIRED ADDITIONAL CAPITAL INVESTMENT IN M&C SECTOR (2020-2030)



Source: CCC (2020) Sixth Carbon Budget, Additional Capital Investment, Balanced Pathway

3.4.3 THE POTENTIAL GAP

We estimate that committed and planned investment in this sector in the 2020s to be around a quarter of the £14.5bn total required investment. In the CCC Balanced Pathway additional capital investment in electrification is £4bn for the decade[105] and although a commitment was made in Net Zero Strategy, BEIS are yet to publish any details of a policy mechanism to deliver this investment.[106]

The range in our estimate is primarily driven by:

[104] CCC (2020) Sixth Carbon Budget – Manufacturing and Construction summary – average annual additional investment in M&C the 2030s is around £3bn.
[105] Climate Change Committee (2020) Sixth Carbon Budget – Manufacturing and Construction summary
[106] We do however note that some investment from existing funds is availability for electrification. For example the *Industrial Energy Transformation Fund (IETF)* which is designed to help businesses with high energy use to cut their energy bills and carbon emissions through investing in energy efficiency and low carbon technologies.

- uncertainty over the capital investment associated with the CO2 transport and storage networks. We have used a range published by BEIS in the Net Zero Strategy.[107]
- leverage ratios for fuel switching and cross-cutting industrial funds. Where government schemes have specific matched funding we have used this. For other innovation funding, we again assume a range informed by the previously cited BEIS[108] (low) and World Economic Forum[109] (high) estimates.

How much of the total investment is committed rather than planned depends on key assumptions over the capacity of hydrogen production that can be delivered via already announced funding.

- In the Net Zero Strategy BEIS estimate that deploying 5GW of hydrogen production could deliver investment of £4bn. We have allocated that investment between committed and planned based on the share of the £4bn that we estimate can be leveraged from public funding already committed [110]

TABLE 14 M&C AND FUEL SUPPLY COMMITTED AND PLANNED INVESTMENT

£BN, 2020	POLICY / FUND	COMMITTED	PLANNED
Fuel switching	■ Industrial fuel switching competition ■ Red diesel replacement	£0.2–0.4bn	-
Hydrogen production	■ Hydrogen production business model[111] ■ Net Zero hydrogen Fund (NZHF) ■ IDHRS Revenue support[112]	£2bn	£3bn
CCUS	■ IDHRS revenue support of ICC projects[113] ■ CCUS Infrastructure Fund (CIF)[114]	£1bn	£2 – 3bn
Other	■ Multiple funds for industrial decarbonisation and energy efficiency	£2bn	-

[107] HM Government (2021) *Net Zero Strategy*

[108] Department for Business, Energy & Industrial Strategy (2020): *Research and development: relationship between public and private funding*

[109] World Economic Forum (2013): *The Green Investment Report*

[110] BEIS state that funding currently allocated to hydrogen could deliver 1.5GW - HMG (2021) *Net Zero Strategy, p116*

[111] Department for Business, Energy & Industrial Strategy (2022) *Hydrogen Business Model and Net Zero Hydrogen Fund: Market Engagement on Electrolytic Allocation*

[112] HM Government (2021) *Net Zero Strategy*

[113] Planned investment for Industrial Carbon Capture is likely to be an underestimate due to the limitations of data and bespoke nature of projects which mean that we have not been able to estimate the capital investment in this sub-sector that the CIF and ICC business model could leverage.

[114] Department for Business, Energy & Industrial Strategy (2021) *The Carbon Capture and Storage Infrastructure Fund (CIF): an update on its design*

£BN, 2020	POLICY / FUND	COMMITTED	PLANNED
	Total	**£5 – 6bn**	**£5 – 6bn**
	UK public investment	**£3bn**	**-**
	Investment as a % of total investment	*(38 – 40%)*	*(33 – 40%)*
	Investment required		**£15bn**
	Total committed & planned investment		**£10 – 12bn**
	Investment gap		**£3 – 4bn**
	Investment gap as a % of total investment		*(20 – 29%)*

Source: Frontier research

3.4.4 POLICY PRIORITIES TO FILL THE NET ZERO GAP

Bridging the investment gap in this sector will require a combination of public and private investment. It will be important to ensure that the commercial frameworks currently being developed across the different CCS and hydrogen business models allocate risk in a way that gives investors the confidence to make significant capital investments.

TABLE 15 ESTIMATING THE GAP

POTENTIAL SIZE OF INVESTMENT GAP	CHARACTERISATION OF THE GAP	REQUIREMENT TO SCALE UP EXISTING OR PLANNED POLICIES IN MAJOR AREAS	REQUIREMENTS FOR NEW MAJOR POLICIES
£3 – 4bn *(20 – 29%)*	Public investment will be required via both capital and revenue support to investors but the majority of the investment will be private funding leveraged from allocating risk appropriately.	▪ Support for CCUS ▪ Support for hydrogen production	▪ Support for fuel switching ▪ Support for electrification

Source: Frontier analysis

TABLE 16 PRIORITIES TO FILL THE GAP

	PRIORITY POLICIES
Fuel switching	▪ Funding for demand side measures to allow consumers to invest in the required kit for the new fuels.
Hydrogen production	▪ The required policies are being developed to incentivise and support hydrogen production and the priority should be to ensure that the pace of delivery and the necessary government funding both match the increased ambition.

	PRIORITY POLICIES
	■ Consideration should also be given to dealing with the uncertainties over the role of different hydrogen production technologies, and whether the incentives for investment will be sufficiently strong and supply chain capacity sufficiently large to deliver hydrogen production at scale and pace of the increased ambition.
CCUS	■ Good progress has been made on CCUS, inducing the development of ICC and CO2 T&S business model. ■ It will be important to maintain momentum on CCS to give confidence to the market and to ensure a pipeline of projects is there to meet Government ambitions. ■ Funding to support ICC projects via the business model will need to be committed to the IDHRS scheme.
Other	■ Support for electrification may be required, including for dispersed sites that face technical barriers or higher costs of connecting to CO2 or hydrogen networks, and for sites where electrification is the most cost-effective option.

Source: Frontier research

4 SUMMARY

Table 17 summarises the investment gaps in the 2020s, on a path to Net Zero, and sets out at a high level key policies that could help address the gap. This shows that:

- Across the five sectors we have considered, the gap is significant, £81 - £111bn (25-34%).
- Government spending amounts to around £38bn of committed and £53bn of planned investment, together making up 37-41% of total potential investment.[115]
- Further action is required across the board, but the largest gaps are potentially in buildings.
- In most cases, scaling up existing and planned policies should be a priority, but there are also requirements for major new policies, particularly in buildings.

There are a number of key considerations that will impact whether the committed or planned policy or investment will deliver private funding to produce an outcome at the lower end of the gap range:

- There are key policies at an early stage of development and will rely on the market to deliver a significant level of private investment, e.g. the low carbon heat market-mechanism. The design of these will impact outcomes substantially.

[115] These figures are highly sensitive to how we have considered investment underpinned by levy back contracts (e.g. CfD, CM) which we have categorised as public rather than private investment.

- Where grant-funding is required to enable business and individuals to make investments stability, transparency and accessibility is crucial to deliver and leveraging investment.

TABLE 17 SUMMARY OF INVESTMENTS AND RECOMMENDATIONS TO FILL THEM

	POTENTIAL SIZE OF INVESTMENT GAP	REQUIREMENT TO SCALE UP EXISTING OR PLANNED POLICIES IN MAJOR AREAS	REQUIREMENTS FOR NEW MAJOR POLICIES
Electricity supply	**£14 – 24bn** *(13 - 23%)*	■ Support for low carbon renewables and nuclear ■ Support for CCUS	■ Action to ensure end to unabated fossil fuel generation by 2035
Residential buildings	**£60 – 74bn** *(51 – 63%)*	■ Support for energy efficiency investments ■ Support for heat networks ■ Support for low carbon heat	■ Action to ensure new fossil fuel systems are not installed post 2035.
Non-residential buildings		■ Support for public sector energy efficiency and low carbon heating ■ Support for heat networks	■ Support for commercial energy efficiency and low carbon heating ■ Action to ensure new fossil fuel systems are not installed post 2035.
Surface transport	**£4 - 7bn** *(5 - 8%)*	■ Support shift to walking, cycling and public transport ■ Support for EV infrastructure ■ Support for Net Zero public transport ■ Action on HGVs	
Manufacturing and construction	**£3 – 4bn** *(20 – 29%)*	■ Support for CCUS ■ Support for hydrogen production	■ Support for fuel switching ■ Support for electrification

Source: Frontier research

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