WWW.FRONTIER-ECONOMICS.COM

UK LANDSCAPE OF CLIMATE FINANCE

Summary report

SEPTEMBER 2023

Contents

frontier economics

1 Executive summary

Significant investment will be required over the coming decades to achieve the UK's emissions reduction targets. The Government's *Net Zero Strategy* estimates that to achieve net zero, additional capital investment must grow to an average of £50-60bn per year throughout the late 2020s and 2030s.[1] Mobilising private investment will be critical to achieving this. However, there is currently limited consolidated evidence on the level of investment in net zero activities, including how private investment is being mobilised in terms of the sources of finance and the types of instruments being used.

Frontier Economics has been commissioned by the Department for Energy Security and Net Zero (DESNZ) to develop a methodology, and build a model, for a UK Landscape of Climate Finance (UK LCF). The UK LCF aims to test how flows of direct private and public sector investment could be tracked for climate-related activities.

Over time, the UK LCF model could generate timeseries data that could be used to assess trends in net zero investment in the UK economy, and enable the monitoring of progress against 'financing green'[2]. Some of the potential benefits the UK LCF offers could include:[3]

- **Priority sectors:** Evaluation of investment gaps through the comparison of historical aggregate flows with the forecast level of investment needed to achieve net zero could help identify major gaps. For example, if there are sectors that are critical to the delivery of net zero but do not appear to be attracting sufficient capital.
- **Policy effectiveness and investment efficiency:** Comparing investment flows to investment required may help to inform investment decision-making and provide information on the effectiveness of policy. Granular monitoring may facilitate policy adjustments that could enhance the economic benefits of timely action.[4]
- **Leverage private finance:** Understanding financial flows to net zero investments could help identify barriers that finance providers face in specific sectors, and facilitate future policy development, solutions and innovations to overcome these barriers.

1 BEIS (2021) Net Zero Strategy: Build Back Greener, link

2 HM Government (2021) Net Zero Strategy: Build Back Greener, link; HM Government (2023) Mobilising Green Investment, chapter 3, link. Costs reported in the Net Zero Strategy are the additional capital investment costs relative to a baseline of existing policies. This differs from the UK LCF which reports total capital investment in net zero sectors.

3 Potential benefits were identified through desktop research and a series of stakeholder interviews conducted in January-February 2023.

4 OBR analysis has found that there are major economic benefits to timely action on climate change mitigation. OBR (2021) Fiscal Risks Report, link

Scope of the UK LCF

The conceptual structure of the UK LCF is set out in Figure 1 below. The initial version of the model produces estimates for the period 2018-2021,[5] and is designed to be updated annually.[6]

The UK LCF focuses on direct private and public capital investment in net zero sectors and subsectors. Operational, research and development, policy or financing costs are not included.[7] The initial focus on capital investment is in part due to feasibility – there is better data available to comprehensively track financing of capital investment across a range of subsectors. However it is also due to the link between capital investment and net zero outcomes and investment requirements. There is a direct, tangible relationship between capital investment in, for example, offshore wind generation or rail electrification and emissions reductions. Further, work to date to evaluate net zero investment needs has focused on capital investment.[8] The UK LCF could be expanded to other types of investment in future – we discuss this further in Section 5.

The UK LCF estimates total private and public investment observed in net zero activities rather than incremental investment relative to a baseline. For example, the model calculates the total investment in heat pumps rather than the cost difference between a heat pump and a higher carbon alternative such as a gas boiler. Energy efficiency, rather than buildings, is classified as a net zero activity/subsector – therefore total investment in energy efficiency measures is calculated, rather than total investment in constructing or renovating a building.

Some subsectors included within the UK LCF framework currently have had relatively low level of investment but are expected to grow over time. This includes hydrogen and CCUS transport and storage where the UK Government is developing business models to bring forward private investment. Similarly investment will occur under the Hydrogen Production

5 The UK LCF timeseries begins in 2018 primarily due to data and methodology constraints. For some subsectors volume (of capacity or unit) data is not available prior to 2018. Even where volume data is available prior to 2018, unit cost estimates for most subsectors are only available from around 2018. Applying current unit cost estimates retrospectively would likely underestimate historical investment, due to declining technology costs over time in net zero sectors. Developing robust historic financing assumptions would also be challenging given the lack of data, particularly in nascent net zero sectors. Consequently, 2018 represents a relatively robust point to begin the UK LCF timeseries.

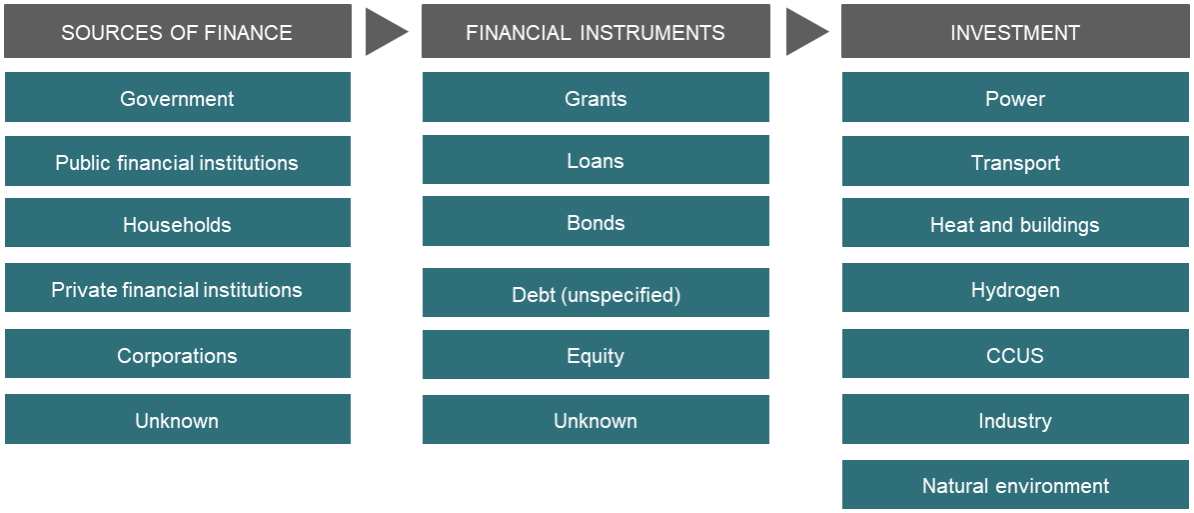
6 It is expected that the model can be updated for 2022 in early-mid 2024, when the full set of data inputs will be available. One of the data inputs – government grants statistics 2022 to 2023 – is expected to be published in the first half of 2024. It is possible that over time data may become available more rapidly, or may be able to be sourced from within government.

7 This is consistent with LCFs in other jurisdictions which have tended to focus on capital investment.

8 Estimates of additional net zero capital investment requirements (against a baseline of existing policies) were set out in the UK Government Net Zero Strategy, and we understand that DESNZ is undertaking further work to develop estimates of total (gross) investment requirements for select sectors/subsectors. The CCC's Sixth Carbon Budget provided estimates of total (gross) net zero capital investment requirements and additional (against a high carbon baseline) net zero capital investment requirements.

Business Model (HPBM). The Net Zero Strategy confirmed that up to £100m would be provided to award HPBM contracts to up to 250MW of electrolytic projects in 2023.[9]

Figure 1 Conceptual structure of the UK LCF



Source: *Frontier Economics*

Note: *1. While CCUS, Industry and Natural environment sectors are within the scope of the UK LCF, they are not structurally included in this initial version of the UK LCF model due to data limitations or due to the current level of investment being close to zero.*
2. While capital investment from Public financial institutions is within the scope of the UK LCF, it is not reported in this initial version of the UK LCF model due to data limitations. This may change in future if data becomes available, for example on green financing undertaken by the UK Infrastructure Bank.
3. 'Debt (unspecified)' is included to capture debt financing where the precise instrument (loan or bond) is unknown
4. 'Unknown' is included as a source of finance and a financial instrument so that investment can be included in the UK LCF even when the means of financing is unclear.

Overview of findings

The initial version of the UK LCF model estimates flows of finance to net zero subsectors from 2018 to 2021. Results are based on the available data, but there are known gaps in some sectors and subsectors, such as energy efficiency.[10]

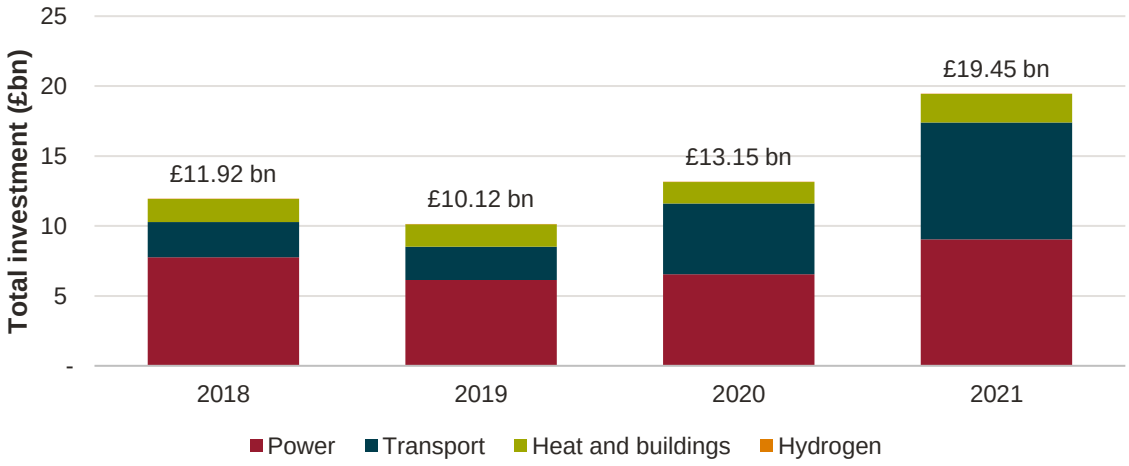
As shown in Figure 2, tracked investment[11] in net zero activities in the UK economy has increased from £11.9bn in 2018 to £19.5bn in 2021. This increase has been mainly driven by investment in the transport sector.

9 Department for Business, Energy & Industrial Strategy (2022) Hydrogen Business Model and Net Zero Hydrogen Fund: Market Engagement on Electrolytic Allocation, link

10 Discussed further in Section 4.4.

11 By 'tracked investment' we refer to investment that is within the scope of this initial version of the UK LCF. As outlined in Section 3, some net zero sectors and subsectors are not currently included in the UK LCF due to data and methodology limitations. Therefore tracked investment does not equate to total investment in net zero activities in the UK economy.

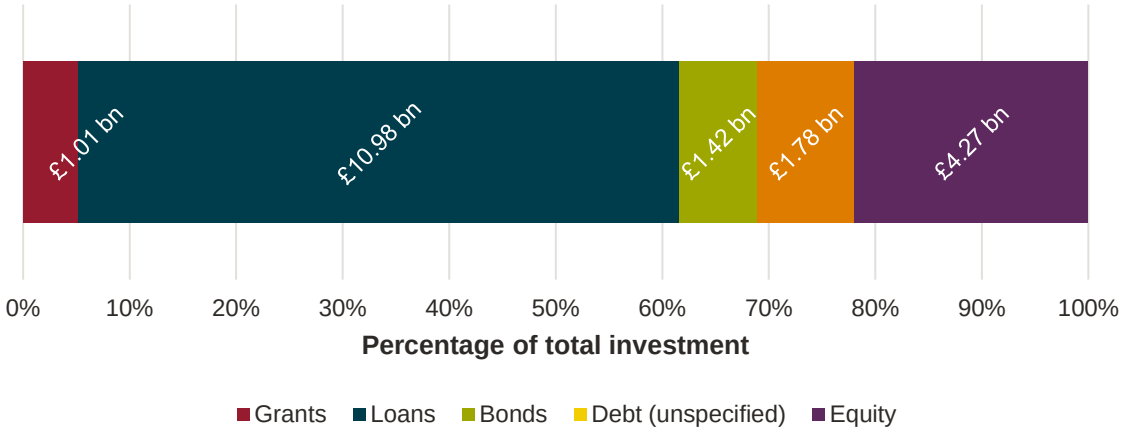
Figure 2 Estimated investment in net zero sectors, 2018-2021



Source: *Frontier Economics*
Note: *2022 prices*

As shown in Figure 3, the debt instruments shown here such as private loans and bonds are the primary instruments used to fund investment in net zero, comprising over 70% of total investment in net zero. Grants currently fund around 5% of investment in net zero, and equity around 20%. Equity includes companies financing investment through equity as well as households financing purchases through savings.

Figure 3 Instruments used to finance net zero investment, 2021



Source: *Frontier Economics*
Note: *2022 prices*

Figure 4 provides a snapshot of flows of finance to net zero sectors in 2021, from the source of finance (on the left) to how that finance is used (on the right). The thickness of the

connecting lines correlates to the amount of finance flowing (in £ terms). Figure 5 also provides a snapshot of flows of finance in 2021, but to subsectors.

In 2021, almost half (46%) of tracked net zero finance went to the power sector, while 43% went to transport, 10% to heat and buildings, and less than 1% to hydrogen.[12]

The public sector accounted for 5% (or £1bn) of tracked net zero finance via government grants. This includes government grants that were funded via government bonds. While government bonds generally do not directly fund capital investment in net zero activities (and are therefore not separately included in the UK LCF) green gilt proceeds are allocated to grant programmes that directly finance capital investment (and are captured in the UK LCF).[13] All government grant financing captured in the LCF in 2021 comes from programmes that are linked to green gilts. This includes grants for rail electrification, electric vehicles, chargepoints, heat networks, heat pumps and energy efficiency. This illustrates how bonds are a key way the government raises funds for net zero programmes.[14]

However, it is important to recognise that government support for net zero investment extends beyond direct financing. Government business models, such as Contracts for Difference (CfD) and Regulated Asset Base (RAB) models, incentivise private sector investment in net zero and should be considered when interpreting the results of the LCF.

The private sector accounted for the remaining £18.5bn, with private financial institutions and corporations contributing 93% of tracked private sector financing (via loans, bonds and equity). Private financial institutions include banks and funds, such as pension and investment funds. Corporations include companies and SMEs.[15] Households contribute the remaining 7% of tracked private sector financing, which represents household equity financing (investment of household savings). If a household funds a purchase (e.g. an electric vehicle) with a bank loan, the source of finance is the bank (private financial institution) and the instrument is a loan. While electric vehicles are a major net zero subsector, household EV purchases are typically financed mainly through debt (provided by banks or car companies). For example, although households only provide 5% of total finance for electric cars via equity (£340m), they drive a total of £3.3bn (45%) of investment in electric cars once we include loans taken out by households but provided by private financial institutions and corporations. Currently the UK LCF only includes financing from private, rather than public, financial institutions. However,

12 While the UK Government is developing business models for hydrogen production, transport and storage, funding has not yet been allocated under these.

13 The UK LCF draws on data from the Government Grants Register and other grant programme reporting. Data on green gilts is not separately included in the UK LCF, as this would lead to double counting.

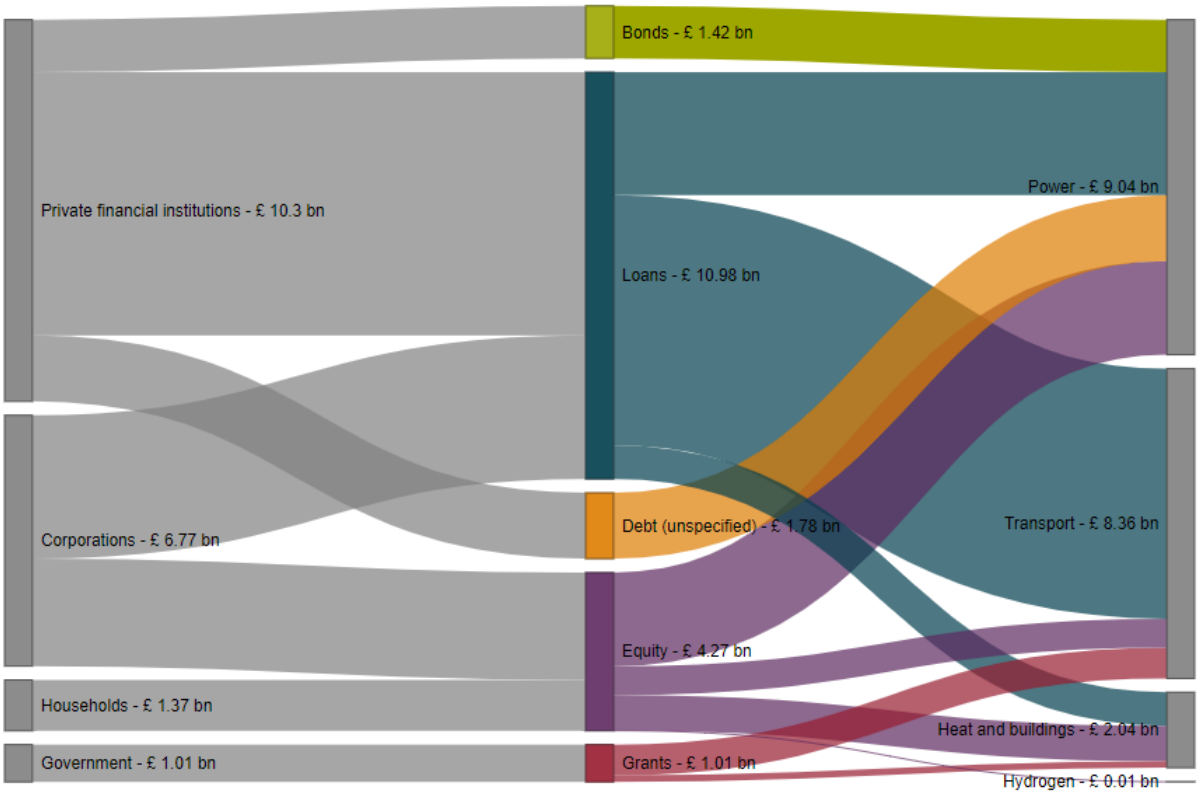
14 Over 2021-2022 the UK Government allocated over £12bn of green proceeds to sectors of Clean Transport, Energy Efficiency and Renewable Energy. Green gilt proceeds do not correspond with funding reported in the UK LCF for a range of reasons including: only the 2021 calendar year is captured in the UK LCF; some green gilt allocations go to expenditures which are not within the scope of the UK LCF (e.g. expenditure which is not upfront capital expenditure such as R&D or international aid); green gilt proceeds can be allocated to *"government expenditures that occurred no earlier than 12 months prior to issuance, the financial year of issuance, and the two financial years following issuance"* HMT (2021) UK Green Financing: Allocation Report, p. 11, link, p. 8.

15 We describe the classifications of sources and instruments in more detail in Section 3.3.

this is expected to change in future as data becomes available on green financing undertaken by the UK Infrastructure Bank, which was established in 2021.[16] Public investment is also made through government grants, as described above.

Overall, these results represent a lower bound estimate of total investment in net zero activity in the UK. As outlined in Section 3, a number of sectors and sub-sectors are not included in the UK LCF due to data limitations, including industry and natural environment. For some subsectors that are included, the results represent a lower bound estimate. This is particularly the case for energy efficiency. This is because, due to data limitations, investment in energy efficiency does not capture measures in non-domestic properties and does not capture energy efficiency measures other than wall or loft insulation, such as window glazing.

Figure 4 Flows of finance to net zero sectors, 2021

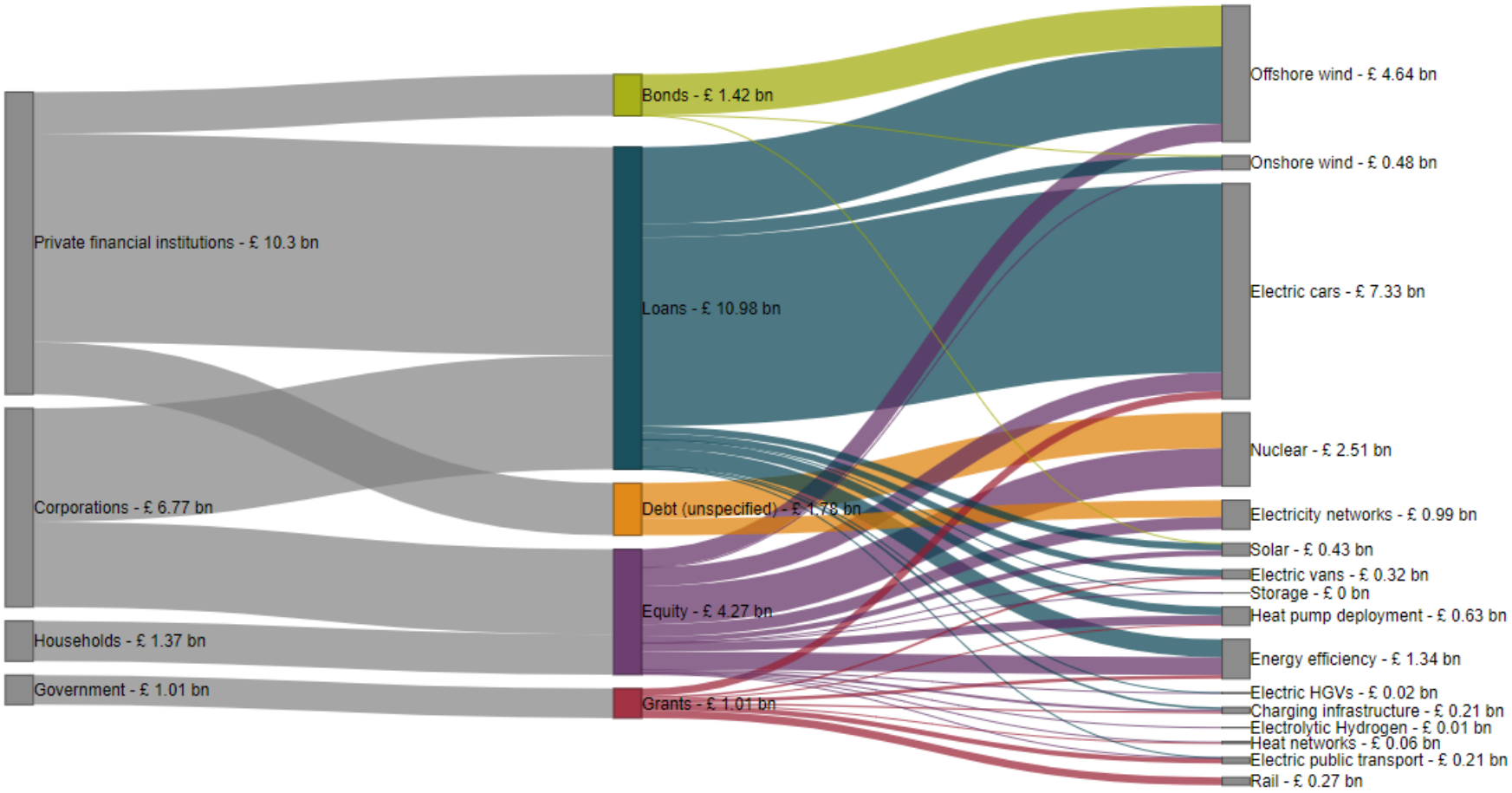


Source: *Frontier Economics*

Note: *2022 prices*
Diagram illustrates the amount of finance flowing from a particular source via a particular instrument (e.g. corporate financing through equity), or the amount being invested in a particular sector via a particular instrument (e.g. equity investment in hydrogen). It does not fully illustrate the amount of finance flowing from a particular source to a particular sector – e.g. that hydrogen investment is financed through equity from corporations. A more detailed breakdown of financial flows is provided in Section 4.

16 The UK LCF model is structurally built to accommodate debt or equity financing from public financial institutions.

Figure 5 Flows of finance to net zero subsectors, 2021



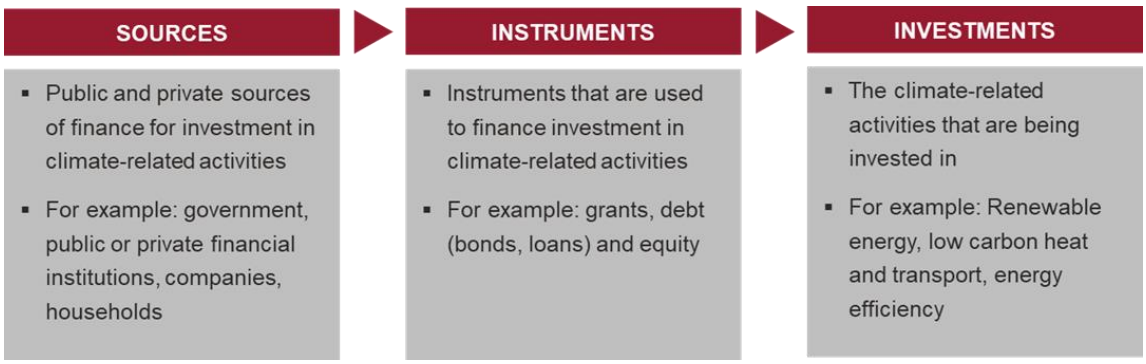
Source: *Frontier Economics*
Note: *2022 prices*

2 Introduction

2.1 Context

Frontier Economics has been commissioned by the Department for Energy Security and Net Zero (DESNZ) to develop a methodology, and build a model, for a UK Landscape of Climate Finance (UK LCF). The UK LCF aims to test how flows of direct private and public sector investment could be tracked for climate-related activities and the means used to finance this investment (sources of finance and financial instruments). A high level illustration of this flow is set out in Figure 6 below.

Figure 6 High level illustration of an LCF



Source: *Frontier Economics*

Note: *Private financial institutions include banks and funds. Corporations include non-financial institutions in any sector of the economy which are investing in net zero activities. Public financial institutions include public banks. Equity includes company equity (e.g. companies' retained earnings) or household equity (e.g. households' savings).*

2.2 Approach to developing a UK LCF

Our approach to developing a UK LCF consisted of two stages:

- Stage 1 drew on stakeholder engagement and desktop review to develop an investment tracking methodology that is tailored to the specific characteristics of the UK, is reliable and robust, and can be easily refined and replicated in future.
- Stage 2 involved further refinement of the methodology and inputs (data and assumptions), and the building and population of the UK LCF model.

2.3 Structure of this report

This document provides an overview of the methodology and the results of the initial version of the UK LCF model. The UK LCF is designed to be updated in future, and we also set out potential next steps to filling data gaps and refining the methodology.

- Section 3 provides an overview of the UK LCF scope and methodology.
- Section 4 describes the results of the initial version of the UK LCF model.
- Section 5 sets out potential next steps for developing the UK LCF in future.

3 Overview of UK LCF

3.1 Purpose and structure

The key purpose of the UK LCF is to track recent investment in net zero activities in the UK economy. Specifically, the model estimates the annual level of investment in various net zero sectors and subsectors[17] and the means used to finance this investment (sources of finance and financial instruments). The conceptual structure of the UK LCF is set out in Figure 7.

Over time, the UK LCF model could generate timeseries data that could be used to assess trends in net zero investment in the UK economy, and enable the monitoring of progress against 'financing green'[18]. Some of the potential benefits the UK LCF offers could include:[19]

- **Priority sectors:** Evaluation of investment gaps through the comparison of historical aggregate flows with the forecast level of investment needed to achieve net zero could help identify major gaps. For example, if there are sectors that are critical to the delivery of net zero but do not appear to be attracting sufficient capital.
- **Policy effectiveness and investment efficiency:** Comparing investment flows to investment required may help to inform investment decision-making and provide information on the effectiveness of policy. Granular monitoring may facilitate policy adjustments that could enhance the economic benefits of timely action.[20]
- **Leverage private finance:** Understanding financial flows to net zero investments could help identify barriers that finance providers face in specific sectors, and facilitate future policy development, solutions and innovations to overcome these barriers.

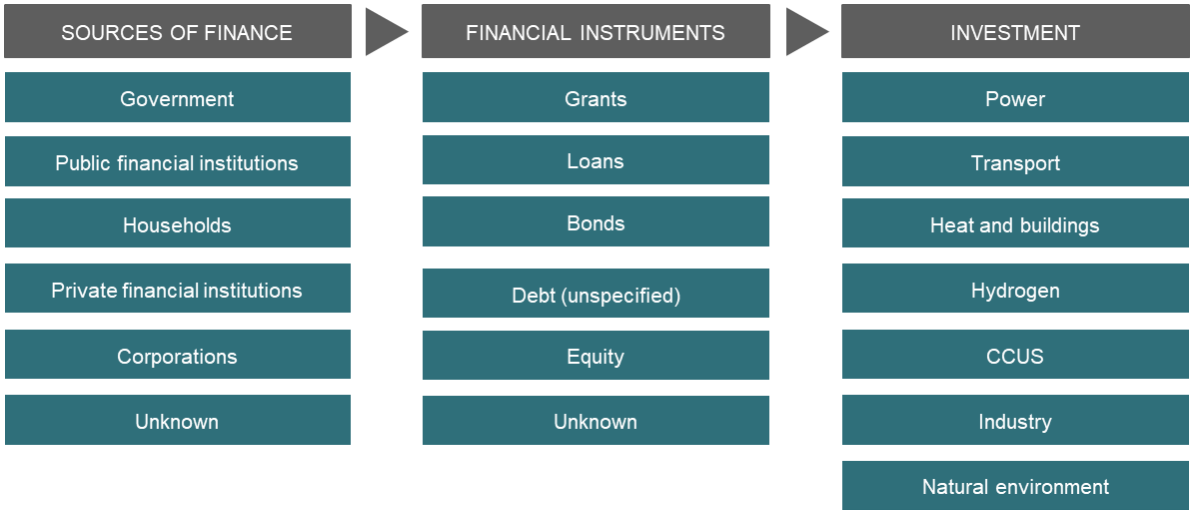
17 Based on the net zero sector and subsector classifications used in UK Government net zero pathways and provided by DESNZ in December 2022.

18 HM Government (2021) Net Zero Strategy: Build Back Greener, link; HM Government (2023) Mobilising Green Investment, chapter 3, link. Costs reported in the Net Zero Strategy are the additional capital investment costs relative to a baseline of existing policies. This differs from the UK LCF which reports total capital investment in net zero sectors.

19 Potential benefits were identified through desktop research and a series of stakeholder interviews conducted in January-February 2023.

20 OBR analysis has found that there are major economic benefits to timely action on climate change mitigation. OBR (2021) Fiscal Risks Report, link

Figure 7 Conceptual structure of the UK LCF



Source: *Frontier Economics*

Note: *1. While CCUS, Industry and Natural environment sectors are conceptually included within the UK LCF, they are not structurally included in this initial version of the UK LCF model due to data and methodology limitations or due to the current level of investment being close to zero.*
2. 'Debt (unspecified)' is included to capture debt financing where the precise instrument (loan or bond) is unknown
3. 'Unknown' is included as a source of finance and a financial instrument so that investment can be included in the UK LCF even when the means of financing is unclear.

3.2 Scope

Below we describe key elements of the UK LCF scope.

Timeseries and frequency of updating

The initial version of the UK LCF model produces estimates for the period 2018-2021.[21] The model is designed to be updated annually when data inputs for that year become available.[22]

[21] The UK LCF timeseries begins in 2018 primarily due to data and methodology constraints. For some subsectors (heat pumps, heat networks) volume (of capacity or unit) data is not available prior to 2018. Even where volume data is available prior to 2018, unit cost estimates for most subsectors are only available from around 2018. Applying current unit cost estimates retrospectively would likely underestimate historical investment, due to declining technology costs over time in net zero sectors. Developing robust historic financing assumptions would also be challenging given the lack of data, particularly in nascent net zero sectors. Consequently, 2018 represents a relatively robust point to begin the UK LCF timeseries.

[22] It is expected that the model can be updated for 2022 in early-mid 2024, when the full set of data inputs will be available. One of the data inputs – government grants statistics 2022 to 2023 – is expected to be published in the first half of 2024. It is possible that over time data may become available more rapidly, or may be able to be sourced from within government.

Scope of investment included

The model focuses on estimating recent capital investment in net zero sectors and subsectors and does not cover operational, research and development (R&D), policy or financing costs.[23]

The model focuses on estimating 'final' capital investment that directly reduces emissions in net zero sectors and subsectors (e.g. an electric vehicle generating lower emissions than an internal combustion engine vehicle, power generation from renewables rather than fossil fuels).[24]

The model focuses on estimating total (gross) investment in net zero activities rather than incremental (net) investment relative to a baseline such as a high carbon counterfactual.[25] At the same time, investment in net zero activities is isolated from broader investment, where possible. For example, the model calculates investment in energy efficiency measures installed in a property rather than the total cost of building or renovating a property.

Scope of sectors and subsectors

The net zero sector/subsector classification used in the model are selected from the sectors used in UK Government net zero pathways.[26] The initial version of the model covers the net zero subsectors shown in red in Figure 8 below. Some subsectors are within the scope of the UK LCF framework but are not populated with data in this initial version of the UK LCF model either due to data limitations (e.g. industry and natural environment). For some sectors the level of investment is currently low (e.g. hydrogen and CCUS transport and storage, although investment is expected to increase in future due to business models being developed by the UK Government).

Treatment of government support schemes

The UK LCF seeks to identify (and estimate the level of financing from) sources and instruments that directly finance investment in various subsectors. Government grants that directly finance capital investment are included in the UK LCF as a financial instrument (see Figure 7 above).

In some subsectors, government-backed schemes incentivise investment but do not provide financing from government sources. This includes renewable generation Contracts for

---

23 This will support tracking progress against the level of investment needed to achieve net zero, which typically focuses on capital investment requirements. For example, both the UK Government's Net Zero Strategy and the Climate Change Committee's Sixth Carbon Budget provide estimates of net zero capital investment requirements.

24 Focusing on expenditure on the end product is also consistent with the 'territorial emissions' approach used in the UK's targets. That is, the targets focus on GHGs emitted within the UK, rather than on emissions that occur as a result of the (potentially global) manufacture of goods and services that are consumed in the UK.

25 For example, the model calculates the total investment in heat pumps rather than the cost difference between a heat pump and a higher carbon alternative such as a gas boiler.

26 Net zero sector and subsector classifications provided by DESNZ in December 2022.

Difference (CfD) and Capacity Market auctions which support investment in battery storage. Capex financing under these schemes is captured in the LCF as financing from private sources (e.g. by companies through equity financing, and by financial institutions through debt financing). Capex financing is incentivised by revenue support that is ultimately provided by a consumer subsidy.

A variation to this is the (now closed) Renewable Heat Incentive (RHI) where capex financing comes from private sources (e.g. by households through investment of savings, and by financial institution through loans which are taken out by households). Capex financing is incentivised by a taxpayer subsidy for heat generation, meaning that government provides indirect financial support. However the RHI is not captured in the UK LCF as 'grants', because upfront capex financing is provided by the private sector, and support payments are received over time to pay back this investment.

However, these government-backed schemes are key drivers of private investment, and should be considered when interpreting the results of the LCF. For example, most large-scale renewable generation projects are supported by CfDs, and electricity network investment is supported by a RAB model.

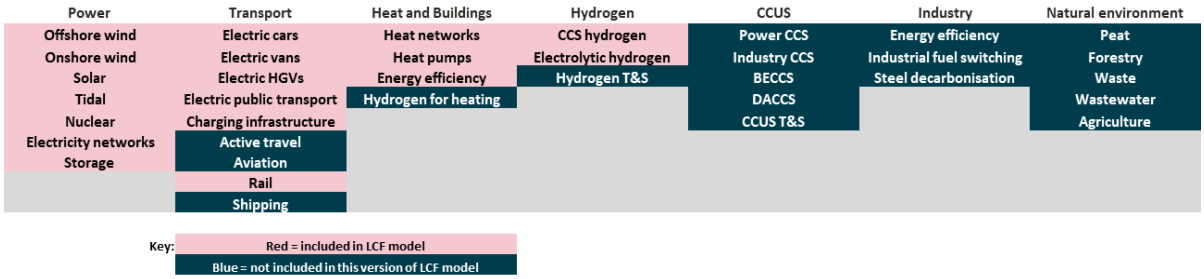
Similarly, government bonds (green gilts) are not captured in the UK LCF as government financing, as green gilts are typically used to finance government grants, rather than as a direct means of financing capital investment in net zero activities.[27] To avoid double counting (that would arise from including both government grants and green gilts financing government grants) we do not separately include financing through government bonds. However, the model is structurally built to accommodate government bonds if direct financing were to arise in future.

3.3 Methodology

The UK LCF tracks investment in the UK economy that contributes to emissions reductions and helps the UK achieve its net zero targets. Investment is categorised and estimated by net zero sector and subsector, with a bespoke methodology applied for each subsector. The net zero sectors included in this initial version of the UK LCF model are outlined in Figure 8.

[27] For example, green gilt proceeds have been allocated to electric vehicle grant schemes for cars, vans and buses which are captured within the LCF as government grant financing. HM Treasury and UK Debt Management Office (2022) UK Green Financing: Allocation report, p. 11, link

Figure 8 Net zero sectors included in the UK LCF model



Source: Frontier Economics

The UK LCF model tracks investment into net zero subsectors (described above) from the source of finance via the instrument used the finance the investment. This is conceptually set out in Figure 7 above.

Sources are the parties representing the most immediate sources of finance for investment in a particular net zero activity. Instruments are the mechanisms used to finance the investment. Definitions of sources of finance and financial instruments are set out in Table 1 and Table 2 below.

Table 1 Sources of finance

Source	
Government	Finance from governments within the UK
Public financial institutions	Finance from UK public institutions such as banks or funds
Foreign public institutions	Finance from foreign governments or public institutions, such as the EU
Households	Finance from households
Private financial institutions	Finance from private institutions such as banks and funds
Corporations	Finance from companies
Unknown	Balancing category where any unknown financing can be allocated

Source: Frontier Economics

Table 2 Financial instruments

Instrument	
Grants	Finance given with no obligation for repayment or a return
Loans	Finance given with obligation for repayment
Bonds	Bonds issued to provide direct financing for investment in a net zero activity
Debt (unspecified)	Debt where nature of financing instrument (whether loans or bonds) is unknown
Equity	Finance through company retained earnings or household savings
Unknown	Balancing category where any unknown financing can be allocated

Source: Frontier Economics

The UK LCF is structurally set up so that any combination of the above sources of finance, financial instrument and net zero subsector can be populated. However, in practice, particular combinations are common and other combinations are not observed. For example, governments are typically the source of finance for grants. Households are not generally recorded as a source of debt finance (although a household could be a source of an informal loan to another household this is not captured in the LCF).

A summary of the methodology and data sources used to estimate the level of investment, instruments and sources of finance for each net zero subsector is provided in Table 3 below.

Table 3 Methodology by sector

Sector	Subsector	Level of investment	Instruments and sources of finance
Power	Wind, tidal, solar	Calculate annual net incremental generation capacity from DESNZ renewable electricity capacity and generation data.[28]	Apply UK-specific gearing ratios to estimate the level of financing through debt and equity.[31]

[28] DESNZ (2023) Energy trends: UK renewables, renewable electricity capacity and generation (ET 6.1), link

[31] For onshore and offshore wind and large scale solar, we apply assumptions of the % of investment that is financed by loans, bonds and equity derived from Refinitiv project finance data. For tidal, we assume all private finance is from corporate equity. For small-scale solar, we apply household and company specific gearing ratio.

Sector	Subsector	Level of investment	Instruments and sources of finance
		Adjust for the assumed construction period from DESNZ generation cost projections[29] to estimate capacity *under construction* each year. Apply pre-construction and construction cost estimates provided by DESNZ.[30]	
Power	Nuclear	Calculate annual investment based on expected capex cost and construction period for individual nuclear projects.[32]	Apply a gearing ratio set out in the European Commission's decision on state aid for Hinkley Point C.[33]
Power	Electricity transmission and distribution networks (onshore)[34]	Calculate annual investment in reinforcement expenditure from Ofgem and the Utility Regulator of Northern Ireland data.[35]	Apply gearing ratios as reported by Ofgem to estimate the level of financing through debt and equity.[36]
Power	Storage (batteries)[37]	Calculate annual cumulative battery storage capacity from Modo monthly battery energy storage data.[38]	Apply UK-specific gearing ratios to estimate the level of financing through debt and equity.[40]

29 DESNZ (2020) Energy generation costs (2020), link

30 Provided by DESNZ 17 July 2020. Estimates are an output from the modelling for DESNZ (2020) Energy generation costs (2020), link

32 See EDF (2022) Hinkley Point C Update, link

33 European Commission (2015) Commission decision (EU) 2015/658, table 1, link

34 Due to data limitations, we do not include offshore electricity network investment. In the UK to date windfarm developers have invested in offshore transmission infrastructure, the operation of which is later competitively tendered through Ofgem's OFTO regime. Information on the initial investment in offshore transmission infrastructure is not readily available.

35 Ofgem (2023), RIIO-ED1 annual report 2021-22 supplementary data file, ch 4 expenditure drivers, link; Ofgem (2022) RIIO-ET1 supplementary data file 2021-21, 8-year data, link; Utility Regulator (2017) Annex O – Assessment of RP6 network investment direct allowances, tables 4.9 and 4.10, link

36 Ofgem (2023) Supporting data file to regulatory financial performance annex to RIIO-1 annual reports – 2021-22, RAV-Gearing, link

37 This approach does not capture investment in residential batteries and therefore represents an underestimate of the level of investment in battery storage. We also only include investment in short-duration battery storage in the UK LCF, as there is currently no new investment in large-scale, long-duration electricity storage (LDES) technologies in the UK. This can be expanded to other technologies in future as the LDES market develops, subject to data availability.

38 Received from Modo via email request, link

40 Prior to 2021, we use Lazard (2021) debt-equity ratio, link. In 2021, we use a 50-50 blend of the Lazard debt-equity ratio and assumptions derived from the Refinitiv data.

Sector	Subsector	Level of investment	Instruments and sources of finance
		Adjust for the assumed construction period of 1 year. Apply DESNZ storage cost and technical assumptions.[39]	
Transport	Electric vehicles	Calculate annual new vehicle registrations for plug-in vehicles from DfT data.[41] Apply cost estimates for different vehicle types from various sources (CCC, internal DfT data provided by DESNZ and Electric Car Guide).	Isolate government grant funding. For cars and vans, apply UK-specific ratios of proportion of new vehicle sales financed through lending.[42] For HGVs and buses, apply estimated gearing ratio for UK companies[43] to estimate the level of financing through debt and equity.
Transport	Charging infrastructure	Calculate annual net incremental charging devices from DfT data on publicly available charging devices and grant scheme installations.[44] Apply cost estimates for different charging device types (slow, fast, rapid, ultra rapid) from a study by Ricardo for the CCC.[45]	Isolate government grant funding. Apply household and company specific gearing ratios, depending on type of charging device, to estimate the level of financing through debt and equity.
Transport	Rail	Calculate annual investment from expenditure on rail electrification projects from Network Rail regulatory financial statements.[46]	Network Rail electrification expenditure funded wholly through investment through government grants.

39 We use the cost of lithium-ion batteries. This mature technology is likely to represent the majority of battery storage deployed to date. Mott MacDonald (2018) Storage costs and technical assumptions for BEIS: Summary document, p. 33, link

41 Department for Transport (2023) Vehicle licensing statistics data tables, VEH0181: Plug-in vehicles (PiVs) registered for the first time by body type and fuel type, including breakdown of generic models: Great Britain and United Kingdom, link

42 The Car Expert (2023) Car finance debt continued growing in 2022, link

43 Estimated general leverage ratio calculated from UK national balance sheet for private non-financial corporations. ONS (2022) The UK national balance sheet estimates (Table 5), link

44 Department for Transport (2023) Electric vehicle charging device statistics: April 2023, link; Department for Transport (2023) Electric vehicle charging device grant scheme statistics: April 2023, link

45 Ricardo (2022) Understanding the costs and impacts of potential approaches to providing electric vehicle charging for households without private off-street parking, table 6-1, link

46 Network Rail (various) Regulatory financial statements, link

Sector	Subsector	Level of investment	Instruments and sources of finance
Heat and buildings	Heat networks	Calculate annual investment based on expected capex cost and construction period from projects reported in the DESNZ heat networks pipeline database.[47]	Apply estimate of the proportion of investment financed by government. Apply assumption that early heat network investment is financed through equity.[48]
Heat and buildings	Heat pumps	Calculate annual number of heat pump installations for residential and non-residential buildings from CCC data.[49] Apply cost estimates from CCC data on the average cost per heat pump.	Isolate government grant funding. Apply household and company specific gearing ratios, to estimate the level of financing through debt and equity.
Heat and buildings	Energy efficiency	Calculate the net incremental number of households with insulation measures each year from DESNZ household energy efficiency statistics.[50] Apply average cost of retrofitting from government scheme data.[51]	Isolate government grant funding. Apply household specific gearing ratios, to estimate the level of financing through debt and equity.
Hydrogen	Hydrogen	Calculate annual net incremental production capacity from the IEA hydrogen projects database[52]. Adjust for the assumed construction period from DESNZ hydrogen production cost estimates[53] to estimate capacity *under construction* each year.	Apply assumption that early hydrogen production projects are financed through equity.[54]

47 DESNZ (2023) Heat networks pipelines: Project pipeline summary: January March (Q1) 2023, link

48 Debt financing would be expected to be used in the future as the subsector develops.

49 CCC (2023) Progress in reducing emissions – 2023 Report to Parliament – Supplementary indicator data, All indicator data, link

50 DESNZ (2023) Household Energy Efficiency Statistics, detailed report 2022, Detailed report 2022 HEE tables, T8.1, link

51 DESNZ (2023) Green Homes Grant Local Authority Delivery (LAD) and Home Upgrade Grant (HUG) release, link. Data is not reported on the cost of installation under the Green Homes Grant Voucher

52 IEA (2022) Hydrogen projects database, link

53 DESNZ (2021) Hydrogen production costs, link

54 Review of UK hydrogen projects has not identified any use of debt instruments, which is not unexpected given the UK hydrogen market is in its nascency. We, therefore, assume that aside from government grants, hydrogen production projects are financed through equity. However, this assumption should be reviewed and updated in future as this subsector develops, potentially drawing on Refinitiv data on financing of hydrogen projects.

Sector	Subsector	Level of investment	Instruments and sources of finance
		Apply construction cost estimates from DESNZ hydrogen production cost estimates.	

Source: Frontier Economics

4 Overview of findings

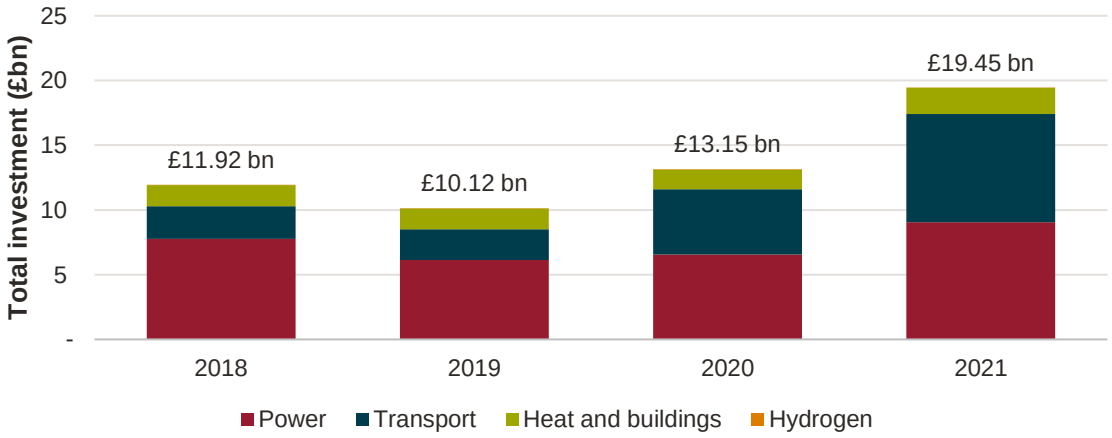
In this section we provide an overview of the findings of the initial version of the UK LCF model, which estimates flows of finance to net zero subsectors from 2018 to 2021.

4.1 UK LCF overview

The initial version of the UK LCF model estimates flows of finance to net zero subsectors from 2018 to 2021. Results are based on the available data, but there are known gaps in some sectors and subsectors, such as energy efficiency.[55]

As shown in Figure 9, tracked investment[56] in net zero activities in the UK economy has increased from £11.9bn in 2018 to £19.5bn in 2021. This increase has been driven by investment in the transport sector.

Figure 9 Estimated investment in net zero sectors, 2018-2021



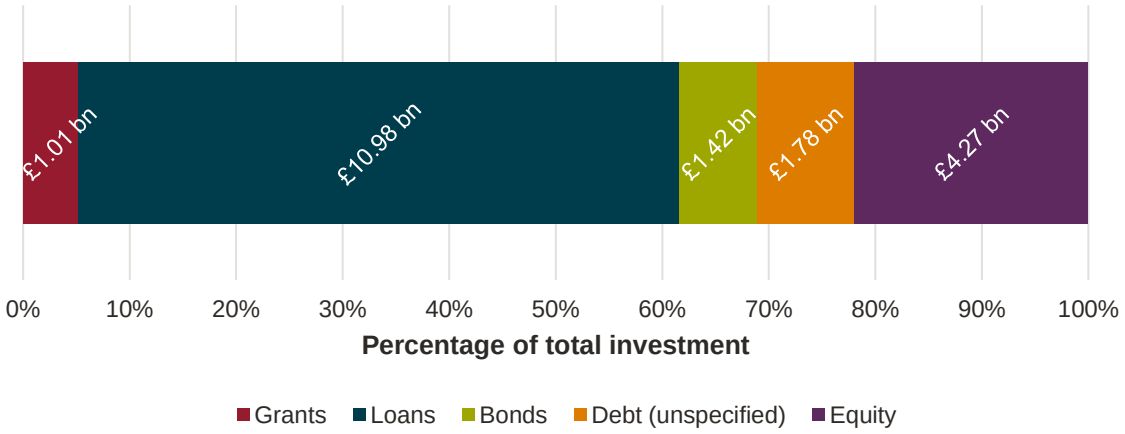
Source: *Frontier Economics*
Note: *2022 prices*

As shown in Figure 10, the debt instruments such as loans and bonds are the primary instruments used to fund investment in net zero, comprising over 70% of total investment in net zero. Grants currently fund around 5% of investment in net zero, and equity around 20%. Equity includes companies financing investment through equity as well as households financing purchases through savings.

55 Discussed further in Section 4.4.

56 By 'tracked investment' we refer to investment that is within the scope of this initial version of the UK LCF. As outlined in Section 3, some net zero sectors and subsectors are not currently included in the UK LCF due to data and methodology limitations. Therefore tracked investment does not equate to total investment in net zero activities in the UK economy.

Figure 10 Instruments used to finance net zero investment, 2021



Source: *Frontier Economics*
Note: *2022 prices*

Figure 11 provides a snapshot of flows of finance to net zero sectors in 2021, from the source of finance (on the left) to how that finance is used (on the right). The thickness of the connecting lines correlates to the amount of finance flowing (in £ terms). Figure 12 provides the same snapshot, split into net zero subsectors.

In 2021, almost half (46%) of tracked net zero finance went to the power sector, while 43% went to transport, 10% to heat and buildings, and less than 1% to hydrogen.

The public sector accounted for 5% (or £1bn) of tracked net zero finance via government grants. This includes government grants that were funded via government bonds. While government bonds generally do not directly fund capital investment in net zero activities (and are therefore not separately included in the UK LCF) green gilt proceeds are allocated to grant programmes that directly finance capital investment (and are captured in the UK LCF).[57] All government grant financing captured in the LCF in 2021 comes from programmes that are linked to green gilts. This includes grants for rail electrification, electric vehicles, chargepoints, heat networks, heat pumps and energy efficiency. This illustrates how bonds are a key way the government raises funds for net zero programmes.[58]

[57] The UK LCF draws on data from the Government Grants Register and other grant programme reporting. Data on green gilts is not separately included in the UK LCF, as this would lead to double counting.

[58] Over 2021-2022 the UK Government allocated over £12bn of green proceeds to sectors of Clean Transport, Energy Efficiency and Renewable Energy. Green gilt proceeds do not correspond with funding reported in the UK LCF for a range of reasons including: only the 2021 calendar year is captured in the UK LCF; some green gilt allocations go to expenditures which are not within the scope of the UK LCF (e.g. expenditure which is not upfront capital expenditure such as R&D or international aid); green gilt proceeds can be allocated to *"government expenditures that occurred no earlier than 12 months prior to issuance, the financial year of issuance, and the two financial years following issuance"* HMT (2021) UK Green Financing: Allocation Report, p. 11, link, p. 8.

However, it is important to recognise that government support for net zero investment extends beyond direct financing. Government business models such as Contracts for Difference (CfD) and Regulated Asset Base (RAB) models, and mechanisms such as the Capacity Market,[59] incentivise private sector investment in net zero and should be considered when interpreting the results of the LCF.

The private sector accounted for the remaining £18.5bn, with private financial institutions and corporations contributing 93% of tracked private sector financing (via loans, bonds and equity). Private financial institutions include banks and funds, such as pension and investment funds. Corporations include companies and SMEs.[60] Households contribute the remaining 7% of tracked private sector financing, which represents household equity financing (investment of household savings). If a household funds a purchase (e.g. an electric vehicle) with a bank loan, the source of finance is the bank (private financial institution) and the instrument is a loan. While electric vehicles are a major net zero subsector, household EV purchases are typically financed mainly through debt (provided by banks or car companies). For example, although households only provide 5% of total finance for electric cars via equity (£340m), they drive a total of £3.3bn (45%) of investment in electric cars once we include loans taken out by households but provided by private financial institutions and corporations. Currently the UK LCF only includes financing from private, rather than public, financial institutions. However, this is expected to change in future as data becomes available on green financing undertaken by the UK Infrastructure Bank, which was established in 2021.[61] Public investment is also made through government grants, as described above.

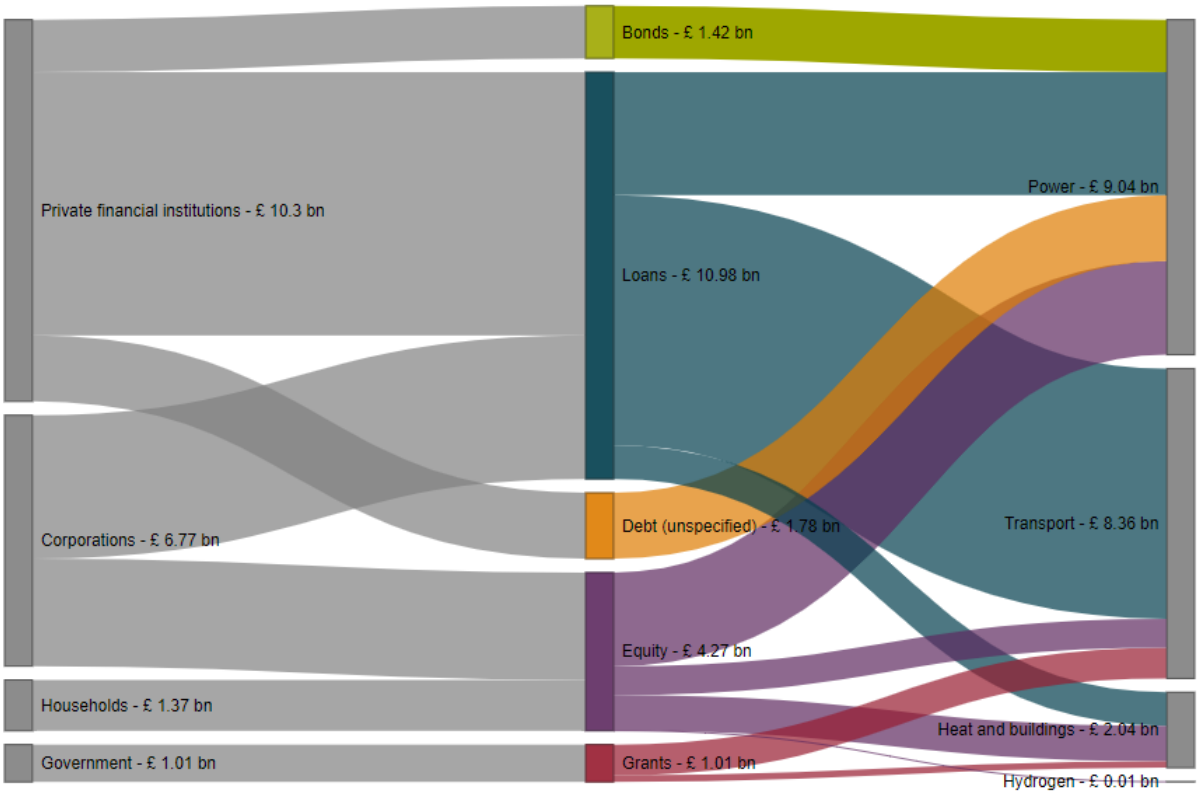
Overall, these results represent a lower bound estimate of total investment in net zero activity in the UK. As outlined in Section 3, a number of sectors and sub-sectors are not included in the UK LCF due to data limitations, including industry and natural environment. For some subsectors that are included, the results represent a lower bound estimate. This is particularly the case for energy efficiency. This is because, due to data limitations, investment in energy efficiency does not capture measures in non-domestic properties and does not capture energy efficiency measures other than wall or loft insulation, such as window glazing.

59 Which can provide revenues to storage assets.

60 We describe the classifications of sources and instruments in more detail in Section 3.3.

61 The UK LCF model is structurally built to accommodate debt or equity financing from public financial institutions.

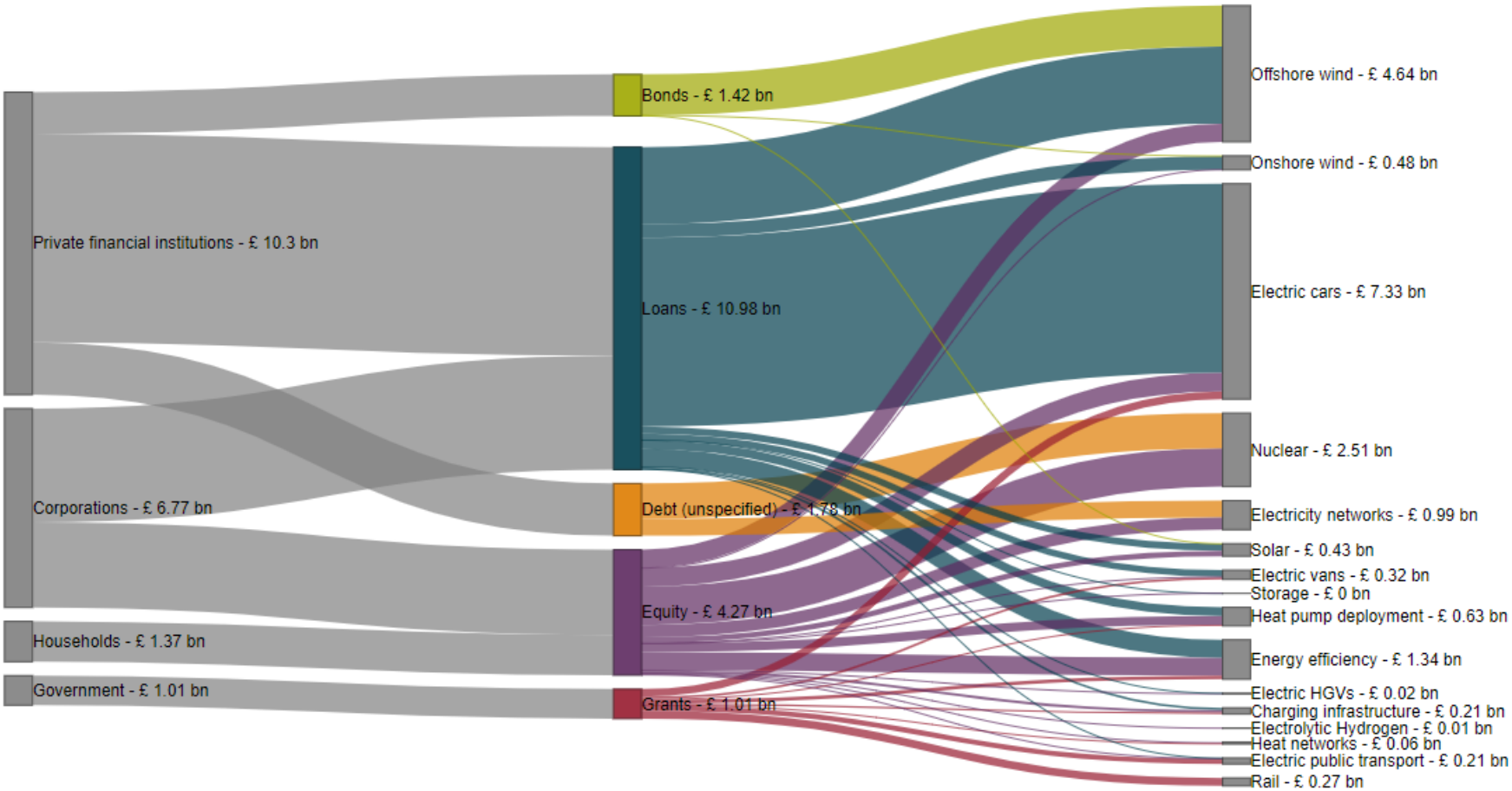
Figure 11 Flows of finance to net zero sectors, 2021



Source: *Frontier Economics*

Note: *2022 prices*
Diagram illustrates the amount of finance flowing from a particular source via a particular instrument (e.g. corporate financing through equity), or the amount being invested in a particular sector via a particular instrument (e.g. equity investment in hydrogen). It does not fully illustrate the amount of finance flowing from a particular source to a particular sector – e.g. that hydrogen investment is financed through equity from corporations. A more detailed breakdown of financial flows is provided in Section 4

Figure 12 Flows of finance to net zero subsectors, 2021

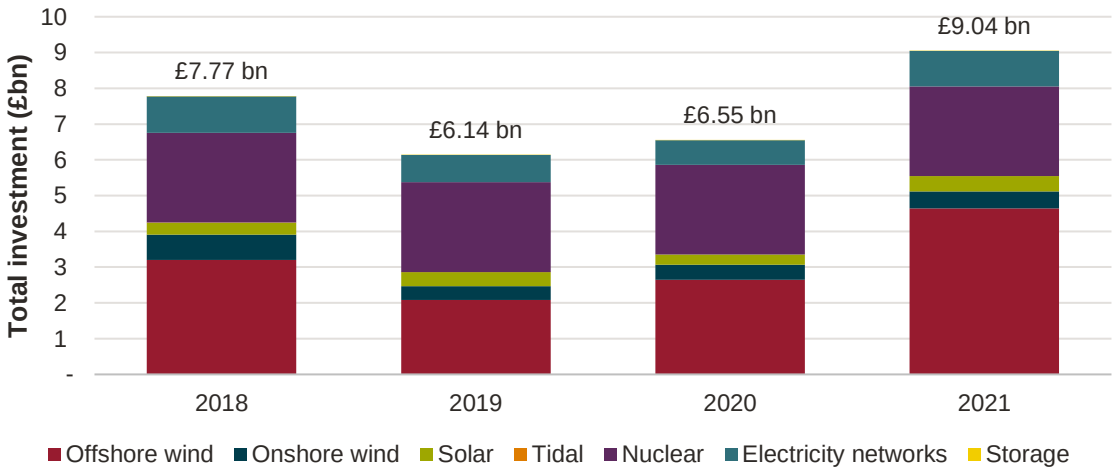


Source: *Frontier Economics*
Note: *2022 prices*

4.2 Power sector

As shown in Figure 13, tracked investment in the power sector has increased from £7.8bn in 2018 to £9bn in 2021. Increased investment is driven by deployment of low carbon technologies rather than increased costs, as costs of low carbon technologies are generally decreasing over time. The fall in investment from 2018 to 2019 is predominately driven by falls in offshore wind capacity under construction. Investment in energy networks (transmission and distribution), onshore wind, tidal and battery storage also fall from 2018 to 2019.

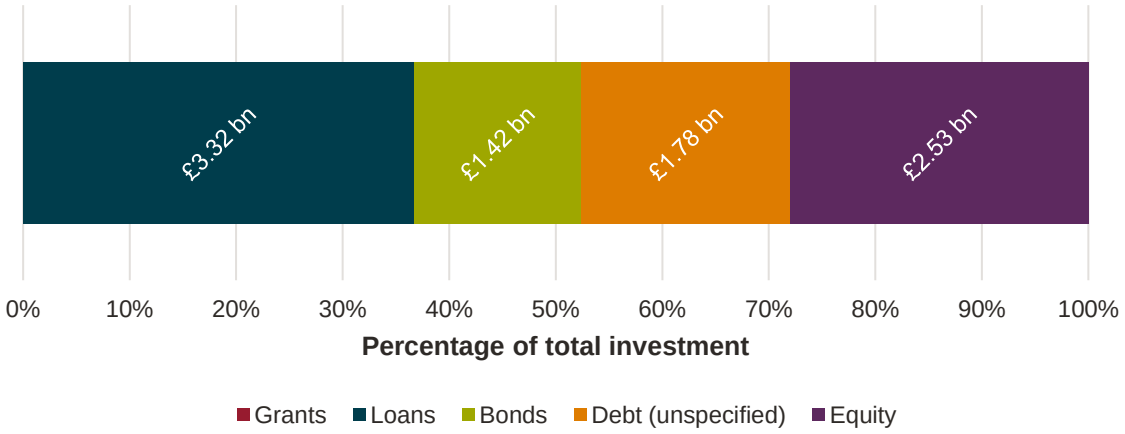
Figure 13 Investment in power by net zero subsector, 2018-2021



Source: *Frontier Economics*
Note: *2022 prices*

As shown in Figure 14, the majority of finance in the power sector comes from debt (72%), with the rest (28%) coming from equity. No grant financing is included in the LCF for the power sector.

Figure 14 Instruments used to finance power net zero investment, 2021



Source: *Frontier Economics*
Note: *2022 prices*

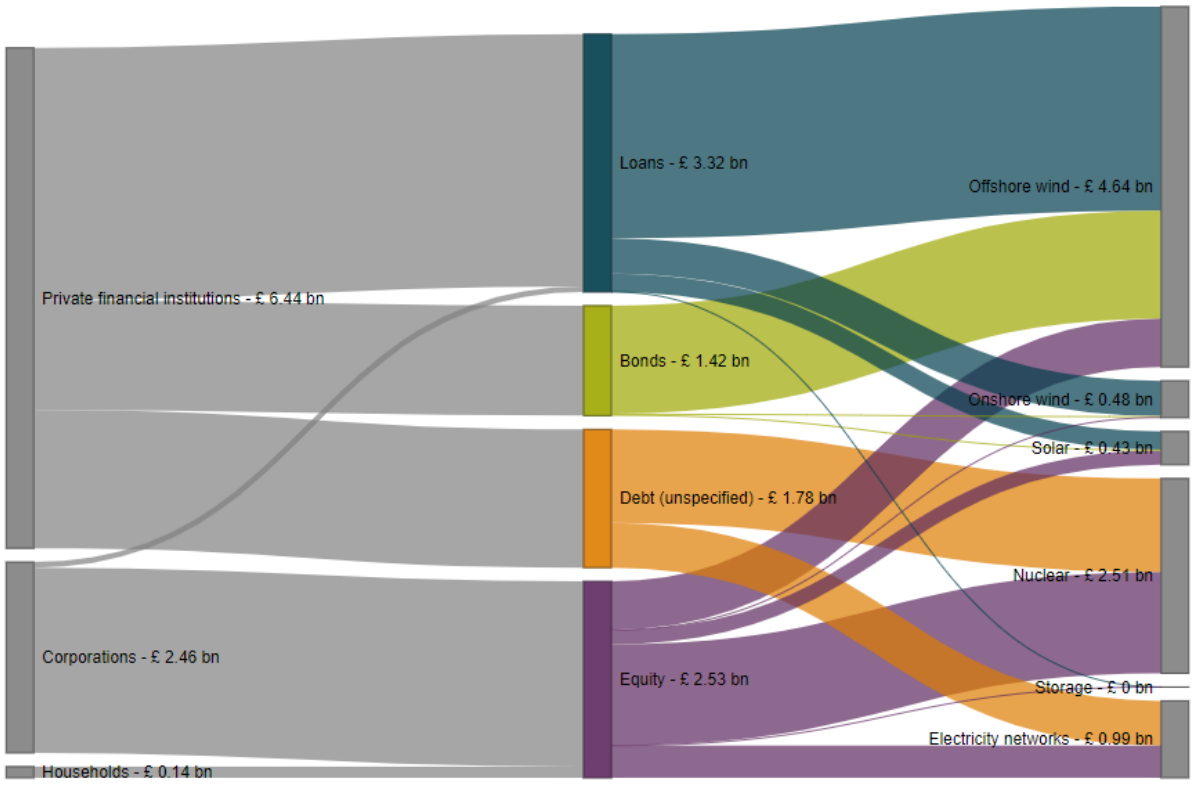
Figure 15 provides a snapshot of flows of finance to power subsectors in 2021.

All investment in the power sector is privately financed, with government support being provided through business models (CfDs, RABs) which incentivise private sector investment. Only a very small proportion (2%) comes from households; household financing exclusively goes to small-scale solar projects.

Loan financing makes up the largest proportion of tracked investment (37%). Bond financing makes up 16% of tracked investment; this is predominately in the offshore wind sector, with only very small amounts of bond financing identified for other subsectors. 20% of financing is from unspecified debt.

More than half of all tracked finance in the power sector goes to offshore wind (51%). Nuclear is the next largest subsector (28%), followed by energy networks (11%) and onshore and solar (5% each). There is no tidal investment identified in 2021 and only a small amount of battery storage investment (£400,000).

Figure 15 Flows of finance to power, 2021

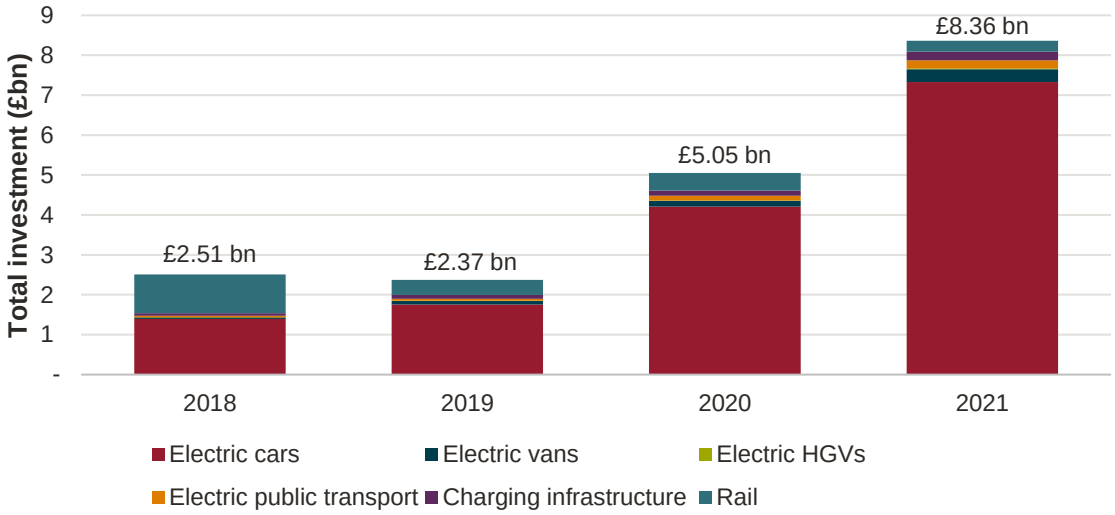


Source: *Frontier Economics*
Note: *2022 prices*

4.3 Transport sector

As shown in Figure 16, tracked investment in the transport sector has increased from £2.5bn in 2018 to £8.4bn in 2021. This increase has been driven by purchases of electric vehicles, particularly cars (with investment in cars increasing from £1.4bn to £7.3bn). Investment in charging infrastructure has tripled (from £67m to over £200m), but remains small in relative terms.

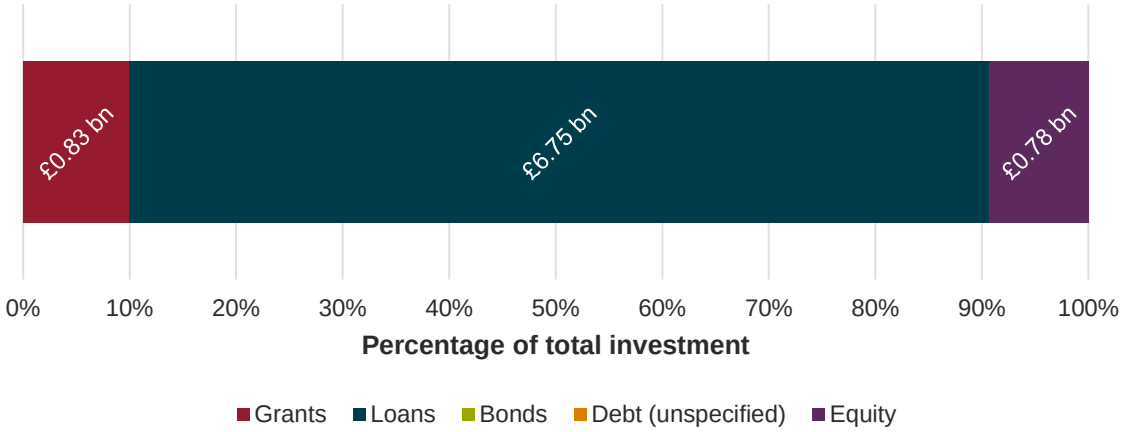
Figure 16 Investment in transport by subsector, 2018-2021



Source: *Frontier Economics*
Note: *2022 prices*

Figure 17 shows the instruments used to fund transport investment in net zero. The majority of investment (81%) comes from loans, with 10% each from equity and grants.

Figure 17 Instruments used to finance transport investment, 2021



Source: *Frontier Economics*
Note: *2022 prices*

Figure 18 provides a snapshot of flows of finance to transport subsectors in 2021.

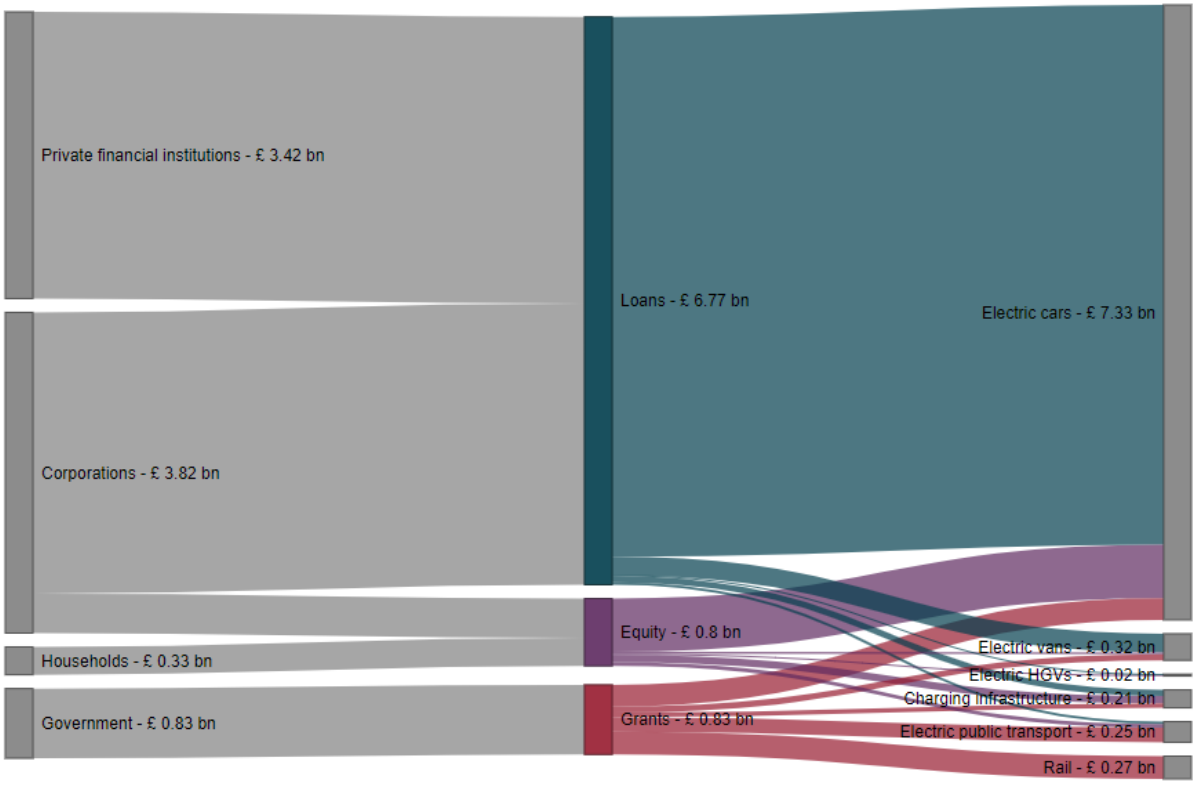
Public sources (in the form of government grants) provide 10% of tracked investment in transport. Grant financing is spread across most of the subsectors. The remaining investment comes from private sources. Of private finance, 95% comes from corporations and private

financial institutions. Although households only provide 5% of total finance via equity (£340m), they drive a total of £3.3bn of investment in electric cars once we include loans taken out by households but provided by private financial institutions and companies.

Loan funding makes up the largest share of finance, driven by the high proportion of loan financing for electric vehicles. In this sector, loan financing is split roughly equally between private financial institutions and corporations, where for example car companies offer loans to customers.

Investment in electric cars is £7.3bn, making up a large majority of tracked investment in the transport sector (88%). Electric HGV investment is small, at only £20m. All other subsectors make up investment between 2-4% of total tracked investment in transport (£0.21-£0.32bn).

Figure 18 Flows of finance to transport, 2021



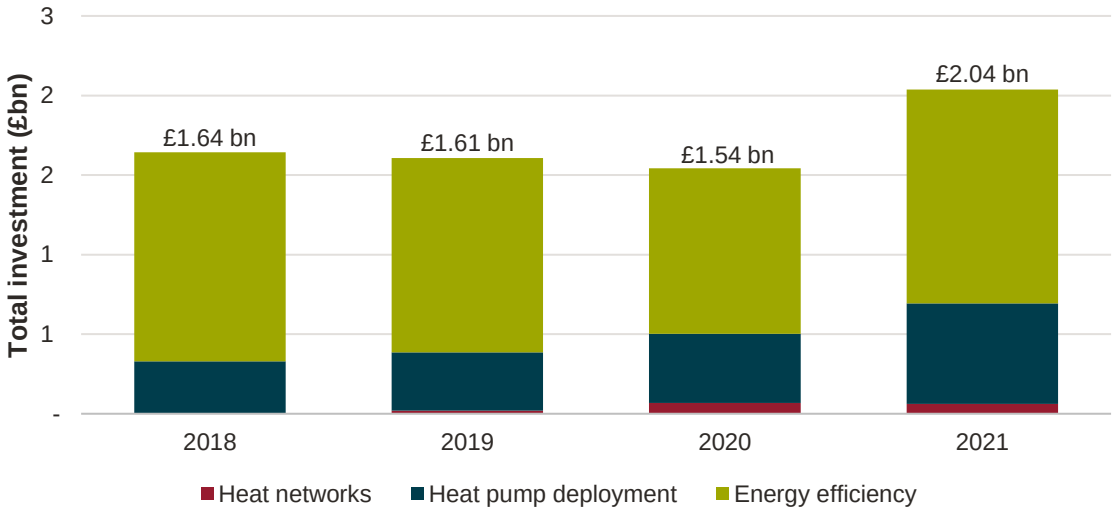
Source: *Frontier Economics*
Note: *2022 prices*

4.4 Heat and buildings sector

As shown in Figure 19, tracked investment in the heat and buildings sector has increased from £1.6bn in 2018 to £2bn in 2021. This increase has been driven by investment in heat pumps.

It should be noted that investment in energy efficiency does not capture measures in non-domestic properties (for which data is not available) and does not capture energy efficiency measures other than insulation. It therefore represents a lower-bound estimate of total investment in energy efficiency.

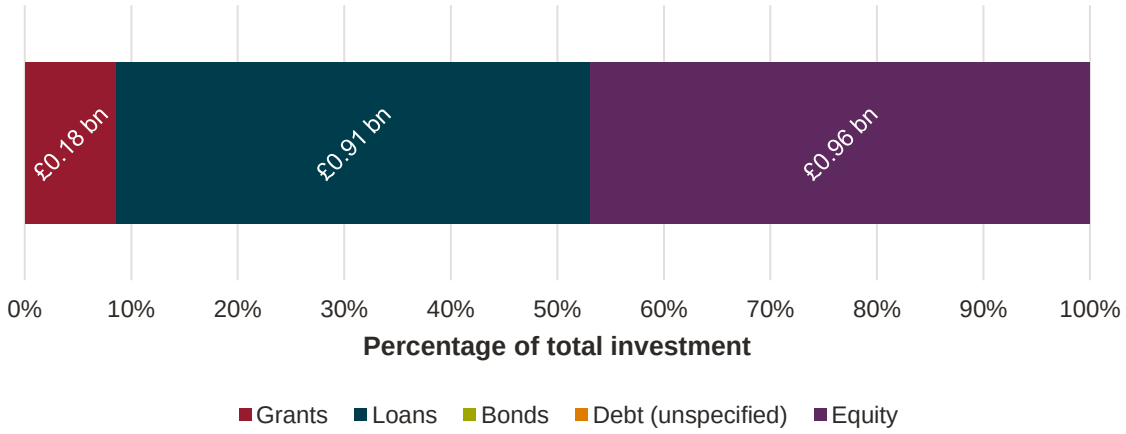
Figure 19 Investment in heat and buildings by net zero subsector, 2018-2021



Source: *Frontier Economics*
Note: *2022 prices*

Figure 20 shows the instruments used to fund heat and buildings investment in net zero. Around 9% of investment comes from grants, with the rest of the investment split roughly equally between loans (45%) and equity (47%).

Figure 20 Instruments used to finance heat and buildings investment, 2021



Source: *Frontier Economics*
Note: *2022 prices*

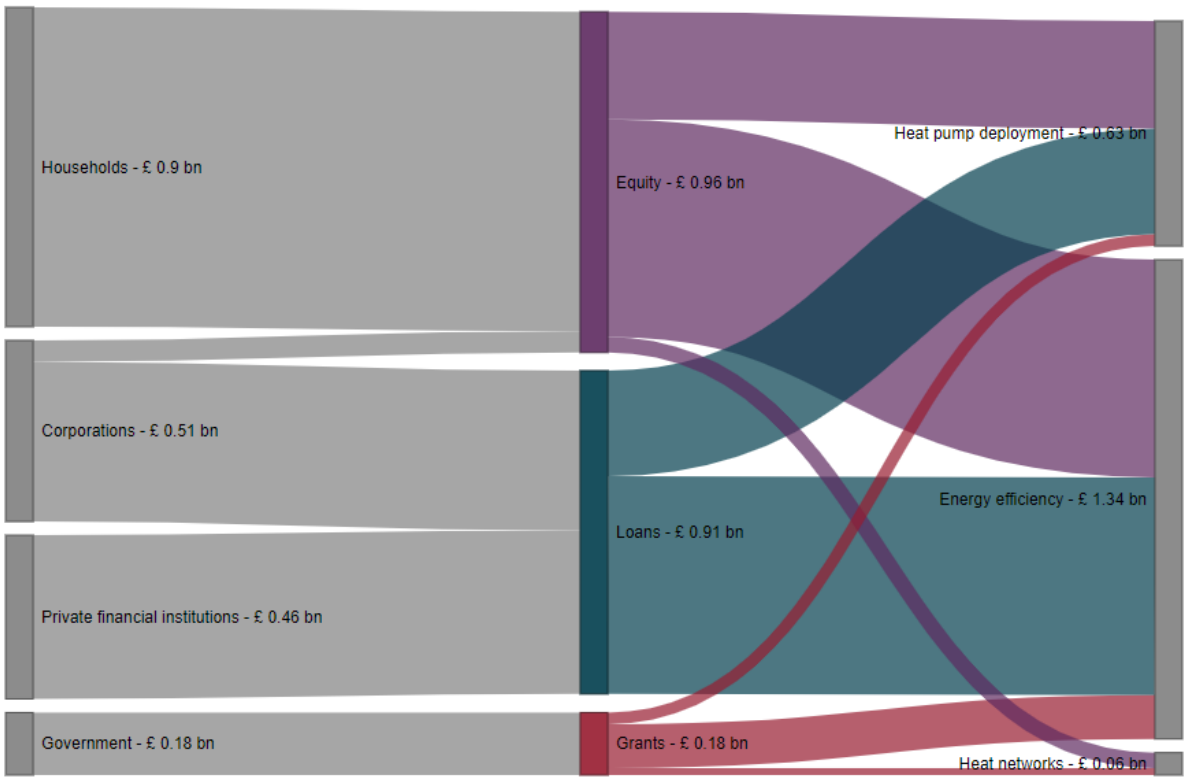
Figure 21 provides a snapshot of flows of finance to heat and buildings subsectors in 2021.

The public sector accounted for 9% of tracked investment in heat and buildings in 2021 (£0.2bn). Households make up nearly half (48%) of tracked private finance. However, this is partly driven by the fact that energy efficiency estimates do not capture energy efficiency investment by corporations. Private financial institutions and corporations each provide around £0.5bn of investment.

Equity makes up 47% of total tracked investment in heat and buildings, with households using their savings to invest in heat pumps and energy efficiency measures and corporations relying on corporate equity for their heat pump instalments. Government grants are distributed across all heat and building subsectors.

Energy efficiency is around two-thirds of tracked investment in heat and buildings (£1.3bn). Heat pump deployment is around a third (£0.6bn), with heat networks less than £0.1bn of investment.

Figure 21 Flows of finance to heat and buildings, 2021



Source: *Frontier Economics*
Note: *2022 prices*

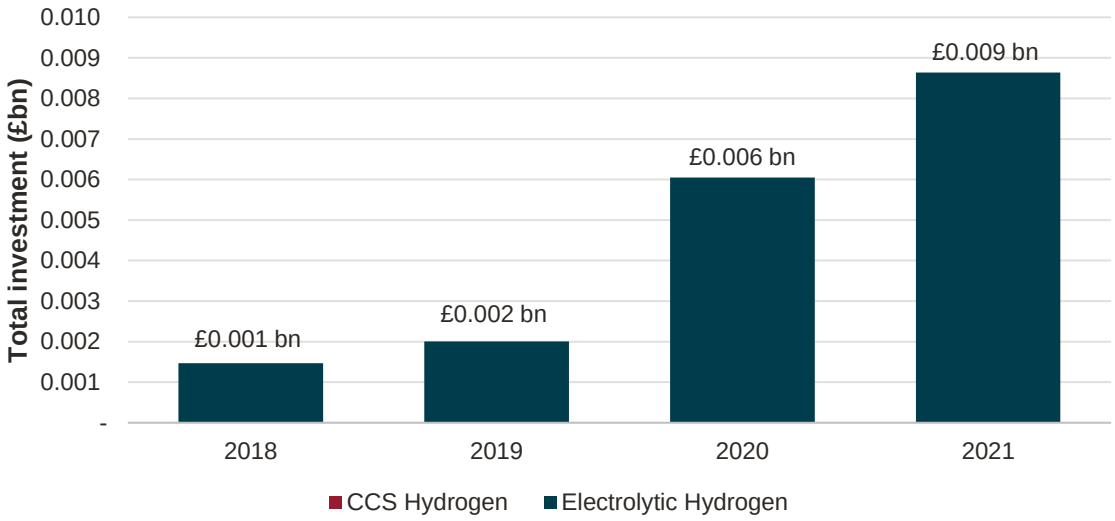
4.5 Hydrogen sector

As shown in Figure 22, tracked investment in the hydrogen sector has increased from £1m in 2018 to £9m in 2021. This is very small compared to overall tracked investment in net zero activities in the UK economy. It is expected that investment in hydrogen production will increase significantly in future years as the UK Government's Hydrogen Production Business Model, which provides revenue support for projects, comes into effect.[62] Investment in hydrogen transport and storage infrastructure is also anticipated in future years, and the UK Government is currently developing business models for these.

All hydrogen investment is tracked as financed via corporate equity so we do not provide a breakdown by source and instrument.

[62] Up to £100m has been proposed for electrolytic projects n 2023, and there will be subsequent allocation rounds beyond this. Department for Business, Energy & Industrial Strategy (2022) Hydrogen Business Model and Net Zero Hydrogen Fund: Market Engagement on Electrolytic Allocation, link

Figure 22 Investment in hydrogen by net zero subsector, 2018-2021



Source: *Frontier Economics*
Note: *2022 prices*

5 Next steps

In the course of this project we have identified areas where the UK LCF can be developed and strengthened in future.

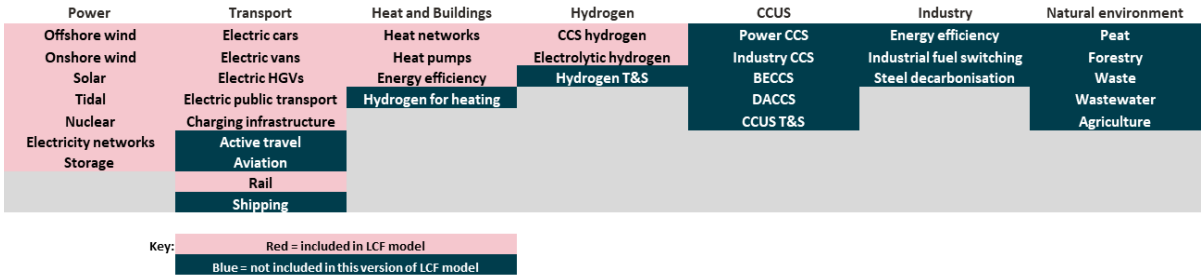
- **Data improvements.** There are a number of areas where data improvements would improve the accuracy or coverage of LCF estimates. This includes: improved data coverage in subsectors with particularly large data challenges (e.g. energy efficiency, heat networks); more consistent, reliable data sources (e.g. inclusion of emerging subsectors such as hydrogen, storage and CCUS in government energy data); improved data to understand the instruments used by households and businesses to finance investment across net zero subsectors, e.g. via surveys of households and businesses.

- **Expansion to other net zero sectors and subsectors.** There is scope to include additional subsectors in the future as investment increases or data availability improves (see subsectors highlighted in blue in Figure 23 below). In particular, investment is expected to increase significantly in areas of hydrogen production, hydrogen transport and storage and CCUS due to the establishment of UK Government business models in these sectors.

- **Expansion to innovation/R&D or supply chain investment.** The UK LCF could potentially be expanded to track R&D investment as an early indicator of investment in different subsectors. However, this should be separately tracked and reported rather than combined with capital investment, to ensure that capital in investment can still be tracked against requirements. Consideration could be given in future to estimating and separately tracking supply chain investment as an early indicator of investment in different sectors. However, isolating this is expected to be challenging because some industries will produce a mix of inputs to net zero and non-net zero. Further, supply chain investment in the UK may directly reduce emissions outside of the UK, and vice versa.

- **Expansion to climate change adaptation activities.** The UK LCF model focuses on estimating investment in activities that contribute to climate change mitigation. In future, the UK LCF could potentially be expanded to track investment in climate change adaptation activities. However, there expected to be significant data challenges in this area. While tracking financial flows into climate change adaptation activities would provide valuable information on actual investment in adaptation, there is not a clear framework for evaluating against adaptation investment need as there is for mitigation where net zero targets and pathways have been clearly established.

Figure 23 Net zero sectors included in the UK LCF model



Source: Frontier Economics

Frontier Economics Ltd is a member of the Frontier Economics network, which consists of two separate companies based in Europe (Frontier Economics Ltd) and Australia (Frontier Economics Pty Ltd). Both companies are independently owned, and legal commitments entered into by one company do not impose any obligations on the other company in the network. All views expressed in this document are the views of Frontier Economics Ltd.