National Audit Office

REPORT

Support for innovation to deliver net zero

Department for Energy Security & Net Zero

SESSION 2022-23
19 MAY 2023
HC 1321

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Department for Energy Security & Net Zero

Report by the Comptroller and Auditor General

Ordered by the House of Commons
to be printed on 17 May 2023

This report has been prepared under Section 6 of the National Audit Act 1983 for presentation to the House of Commons in accordance with Section 9 of the Act

Gareth Davies
Comptroller and Auditor General
National Audit Office

11 May 2023

HC 1321 | £10.00

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011760 05/23 NAO

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Key facts

£4.2bn

the government's estimated planned spending in its Delivery Plan for net zero research and innovation provided through the Spending Review from 2022 to 2025

£23bn

Department for Energy Security & Net Zero's (DESNZ) estimate, in its updated Green Finance Strategy, of the new low-carbon investment in 2022 in the UK

£60bn – £170bn

Climate Change Committee's estimate for potential total UK export sales in sectors such as the electrification of transport, green finance, precision agriculture, renewables, sustainable construction and sustainable infrastructure by 2030

Seven	number of categories included in the *Net Zero Research and Innovation Framework*: power; industry and low-carbon hydrogen supply; carbon capture and storage and greenhouse gas removals; heat and buildings; transport; natural resources, waste and fluorinated gases; and 'whole systems approach'
115	number of government programmes providing funds for net zero research and innovation, delivered across eight public bodies
£0.35 million to £685 million	the range in size of funding programmes included in the government's net zero research and innovation Delivery Plan

Summary

Background

1 In June 2019, Parliament passed an amendment to the Climate Change Act 2008, committing the UK to achieving 'net zero' greenhouse gas emissions (emissions) by 2050. This means reducing emissions (also known as 'decarbonisation') substantially from current levels, with residual emissions the UK still emits in 2050 being equal to or less than what is removed from the atmosphere by either the natural environment or carbon capture technologies. Since 2009, in support of the government's decarbonisation commitments, the UK has set legally binding carbon budgets, which restrict the total amount of greenhouse gases the UK can emit over five-year periods. To date the UK has set a series of budgets extending out to 2033–2037.

2 The government expects research and innovation to play a crucial part in the UK achieving net zero. The Department for Business, Energy & Industrial Strategy (BEIS) had responsibility for net zero policy until responsibility was transferred to the new Department for Energy Security & Net Zero (DESNZ) on 7 February 2023. BEIS identified that net zero will require "a step change" in the rate of new technologies and processes being developed and deployed into the market and being adopted by businesses and consumers. The Climate Change Committee, an independent emissions advisory body, has also noted innovation is a fundamental component in the transition to net zero. The International Energy Agency has estimated that nearly half of carbon emission reductions required from the global energy sector for the world to reach net zero will need to come from technologies that are still under development.

3 The government believes that the development of net zero technologies will give UK businesses a competitive edge in world markets. A government review highlighted analysis by consultants in 2020 that estimated that renewable and low-carbon technologies could support 1.38 million low-carbon jobs by 2050, with as many as 804,000 direct jobs in the low-carbon and renewable energy economy by 2030 in the UK. In 2017, research commissioned by the Climate Change Committee estimated a potential for total UK export sales of between £60 billion and £170 billion by 2030 for low-carbon goods and services in areas such as the electrification of transport, green finance, precision agriculture, renewables, sustainable construction, and sustainable infrastructure.

4 The government has defined innovation as the creation and application of new knowledge to improve the world. Successful innovation involves multiple stages that can broadly be understood as:

- research and development: creating and advancing ideas or concepts, typically in science and technology;
- commercial prototype: developing an idea into a material form so it can be validated. This stage typically includes testing the technical aspects of the idea, for example, its performance and safety;
- build and scale: building an idea to full size to allow for more testing;
- proven commercial proposition: once an idea meets the requirements and it can be rolled out profitably, from this point, it can go into large-scale production; and
- capital markets ready: when an innovation is fully developed, and it can establish a new market, or gain a share of an existing market.

In practice, innovation often does not follow a neat stage-by-stage process and will take a less predictable path to market, and many ideas do not succeed.

5 In October 2021, BEIS published the government's *Net Zero Research and Innovation Framework* (the Framework). The Framework is intended to provide the private sector and the academic and research communities an indication of the UK's likely areas of focus over the years ahead. BEIS also outlined in the Framework an intention to follow it up with a detailed Delivery Plan setting out how the government investment will be prioritised. The Delivery Plan was published in March 2023.

6 Prior to February 2023, in addition to overall responsibility for achieving net zero, BEIS had lead responsibility for supporting research and innovation. In February 2023 responsibility for supporting research and innovation was given to the newly created Department for Science, Innovation & Technology (DSIT). A number of departments and other bodies play a key role in supporting the government's net zero research and innovation challenge areas.

7 This report examines whether the government is set up to deliver value for money from its approach to investment in research and innovation to deliver net zero in the UK. In doing so, and in keeping with our statutory remit, the report does not question the merits of the government's policy objectives or challenge areas set out in the Framework. The report examines:

- the effectiveness of mechanisms in place for providing leadership and coordination of net zero research and innovation activities (paragraphs 2.2 to 2.8);
- arrangements for delivering net zero research and innovation support and whether this is aligned with the challenge areas set out in the Framework (paragraphs 2.9 to 2.27); and
- plans for reviewing progress and evaluating impact against the desired outputs and outcomes (paragraphs 2.28 to 2.32).

Key findings

Determining net zero research and innovation challenge areas

8 The Framework set out the UK's net zero research and innovation challenge areas for the first time, providing stakeholders with a clear steer on the main innovation priorities and timescales. The Framework put existing research and innovation work for net zero into a wider context. It identified 31 research and innovation challenge areas across seven categories (**Figure 1** overleaf). It also identified the timeframe within which solutions will be needed in each of the challenge areas. The 31 challenge areas operate over different timescales, ranging from building retrofit and energy efficiency solutions where the government hopes to see significant progress over the next decade, to challenge areas such as decarbonising aviation, which are likely to require a much longer-term focus up to 2050 (paragraphs 1.8, 2.3, 2.7 and Figure 3).

9 The cross-government Net Zero Innovation Board (the Board) oversaw the development of the Framework. The Board is chaired by the government chief scientific adviser and brings together public bodies that fund net zero research and innovation activities together with independent members drawn from industry and academics. Successful support for net zero research and innovation will require the host of departments and public bodies involved to work effectively with their private sector partners, the research community, and investors. Since July 2022, the Board has been supported by an Innovation Delivery Board, comprising of senior officials, which has responsibility for reviewing programme delivery, improving collaboration, and capturing and communicating successful outcomes across the research and innovation process (paragraphs 1.14, 1.15, 2.11 and 2.12).

Figure 1

Categories and challenge areas identified in the government's *Net Zero Research and Innovation Framework*

In October 2021, the Department for Business, Energy & Industrial Strategy (BEIS) published the government's *Net Zero Research and Innovation Framework* which set out 31 challenge areas across seven categories

Categories for research and innovation to 2050	Challenge areas identified in the *Net Zero Research and Innovation Framework*
Power	Improving system integration, flexible demand and energy storage
	Continual development of offshore wind (including floating) and earlier stage renewables
	Developing nuclear Small Modular Reactors (SMR) and Advanced Modular Reactors (AMR)
	Utilising bioenergy and Bioenergy with Carbon Capture and Storage (BECCS)
Industry and low-carbon hydrogen supply	Improving resource and energy efficiency in industrial applications
	Switching to low- and zero-carbon fuels and feedstocks
	Capturing and storing industrial emissions
	Efficient production of low-carbon hydrogen at scale
	Bulk hydrogen transportation and storage
Carbon Capture Utilisation and Storage (CCUS) and Greenhouse Gas Removals (GGR)	Capturing emissions efficiently and at low cost
	Supply chain innovation for CCUS
	Developing and improving transportation and storage of carbon dioxide
	Developing and demonstrating GGR technologies
Heat and buildings	Building retrofit and energy efficiency solutions
	Understanding feasibility and safety of hydrogen for heating
	Further innovation of heat pumps, including installation and use
	Researching and trialling heat networks and non-traditional heat sources
Transport	Transport and mobility as a system
	Decarbonising roads
	Decarbonising railways
	Decarbonising aviation
	Decarbonising maritime sectors
Natural resources, waste and fluorinated gases	Integrated and dynamic approach to land use
	Sustainably managing forests, peatlands and the marine environment
	Sustainable food and biomass production
	Reducing and minimising waste and fluorinated gases
Whole systems approach	Understanding optimal net zero pathways
	Creating an integrated energy system
	Enabling integrated, multi-modal transport systems
	Developing digital solutions and unlocking resource and energy efficiency
	Researching, understanding, and unlocking sustainable behaviours, business and financial models

Source: National Audit Office analysis of the government's *Net Zero Research and Innovation Framework*, October 2021

10 The Board, supported by BEIS, used an evidence-based approach to advise the government on the 31 challenge areas set out in the Framework. BEIS drew on existing evidence sources to inform the 31 challenge areas for the Framework. This included work it undertook in 2019 to identify innovation needs in the UK's future energy system, and a cost optimisation model of the whole UK energy system. This work identified the technologies that will deliver the greatest emissions and cost reductions to the energy system as a whole. BEIS also drew on another model that produced an estimate of all greenhouse gases, including land use emissions, under different technology options. It also provided extensive scenario and sensitivity analysis. The Board engaged with a wide range of expert stakeholders to obtain views on the main challenge areas. This included holding sector workshops with industry stakeholders and academics to brief them on the draft Framework, receive their challenge and validation of the key innovation challenge areas, and discuss priorities. Of the stakeholders we spoke to who were familiar with the Framework, many were broadly supportive of the Framework, with some suggesting it provided a good level of ambition (paragraphs 2.4 to 2.6).

11 BEIS did not consider in its analysis what level of longer-term public sector investment might be required up to 2050 to support delivery of the innovation challenge areas. BEIS did not include any assessment of the expected costs against the 31 challenge areas in the Framework. Some stakeholders we interviewed, while positive about the clarification of the government priorities contained in the Framework were nevertheless concerned at the absence of any financial allocation beyond the current Spending Review period. Some commentators suggest that many of the technologies would require longer-term financial investment from both the public and private sectors (paragraph 2.8).

12 The Board has sought to influence the allocation of resources across departments and UK Research and Innovation programmes. Based on an assessment of the estimated distribution of spend across the stages of innovation, the Board recommended to government departments that there should be a more equal distribution of funding between the research, development and demonstration stages. The Board does not take decisions on how money is used. Individual public bodies continue to decide how to use their resources based on the budgets provided by HM Treasury via the Spending Review process (paragraphs 1.15, 2.11, 2.12 and 2.18).

Overseeing the delivery of support for net zero research and innovation

13 In March 2023, DESNZ published the government's Delivery Plan which sets out for the first time the complex landscape of public sector support for net zero research and innovation. The Delivery Plan maps the government's current portfolio of research and innovation programmes for the Spending Review period 2022 to 2025 against the categories in the Framework. The mapping exercise identified 115 funding programmes supporting net zero research and innovation activities across eight public bodies. Many of these funding programmes pre-dated the development of the Delivery Plan, with some also pre-dating the 2021 Framework. The programmes ranged in size from £0.35 million to £685 million. In total, the programmes in the Delivery Plan amount to approximately £4.5 billion of support for net zero research and innovation from 2022 to 2025. Of this, £4.2 billion was provided through the Spending Review and £0.26 billion was provided by Ofgem.[1] Individual departments and public bodies oversee and manage the cost of delivering the individual programmes they are responsible for as part of their normal business case approval processes. DESNZ has at present no central information on the costs of administering the 115 funding programmes and, therefore, whether support is being delivered in the most efficient way (paragraphs 2.13, 2.16 and 2.19).

14 The complexity of public sector funding will make it hard for DESNZ and the Innovation Delivery Board to track spending. The next spending round will provide an opportunity to review the overall level of public spend on net zero research and innovation, and the balance of activity across government, including the need for longer-term commitments to key technologies. DESNZ collated the data it set out in the Delivery Plan through submissions from government departments and UKRI. For coordinating portfolio-level information, including the tracking of spending, it will continue to rely on departmental and UKRI data submissions and the underlying programme management of individual government departments and public bodies to ensure programmes are appropriately managed. This will make it difficult to assess how resources are actually being deployed across the innovation process (paragraph 2.17).

1 Ofgem is funded through annual licence fees paid by the licensed companies that Ofgem regulates. Ofgem's Strategic Innovation Fund, which provides innovation funding for the future of gas and electricity networks, is funded through network charges to bill payers that are set by Ofgem.

15 To achieve its net zero objectives the government depends on innovations gaining commercial viability, but the Delivery Plan only covers government support up to the end of the commercial prototype stage. The government intends the Framework to cover the full innovation process. The Delivery Plan details the major programmes for each net zero category, providing support up to the end of the commercial prototype stage and the government's key deliverables. It does not extend, for example, to how the innovation support will work alongside the work of policy teams and industry, and the action that may be needed to de-risk technology deployment and mobilise private sector investment. In March 2023, the government published its updated Green Finance Strategy, providing a high-level overview of how it expects to work with public financing bodies to commercialise and finance green technologies needed for the transition to net zero.[2,3] The government also published in March and April 2023 several net zero investment roadmaps setting out the government support for investing into some sectors including offshore wind, heat pumps, hydrogen, and carbon capture, use and storage; and it committed to publishing a series of further net zero investment roadmaps throughout 2023 (paragraphs 2.14 and 2.15).

16 It is not clear who is responsible for overseeing end-to-end progress on the individual innovation challenge areas. The Board has commissioned from its DESNZ secretariat a series of 'deep dives' looking at the progress made on some of the seven categories identified in the Framework. Individual organisations are responsible for how they spend their own resources, however, no single person or organisation has responsibility for overseeing the performance of the end-to-end innovation system and the delivery of the desired outcomes for the individual innovation challenge areas. Without such oversight, there is a risk that support is not targeted effectively at the right innovation stages, potential blocks to progress are not addressed quickly, and the businesses and the research community lack a clear focal point for providing feedback (paragraph 2.12).

2 HM Government, *Mobilising Green Investment: 2023 Green Finance Strategy,* March 2023. Available at: https://www.gov.uk/government/publications/green-finance-strategy/mobilising-green-investment-2023-green-finance-strategy

3 Public financing bodies include the UK Infrastructure Bank, the British Business Bank, Innovate UK and UK Export Finance.

17 BEIS recognised that organisations were finding it difficult to access support because of the number and complexity of innovation funding schemes. Some stakeholders we interviewed told us that businesses have found it difficult to navigate all the net zero research and innovation sources of public sector funding. The government's 2021 *UK Innovation Strategy* recognised a need to simplify innovation support. Innovate UK is responsible for helping industry navigate public sector funding. It introduced the first version of an online search tool, a key commitment in the *UK Innovation Strategy*, via Innovate UK's online Innovation Hub in December 2022, and it plans a full launch later in 2023. The aim is to help businesses find all innovation funding and support in one place. At the time of our fieldwork, it was too early to assess whether the search tool had made it easier for businesses to find government support for net zero research and innovation (paragraph 2.20).

18 DESNZ estimates that private capital investment in net zero in the UK will need to increase substantially by the late 2020s. DESNZ estimated in its updated Green Finance Strategy that new low-carbon investment in 2022 in the UK was £23 billion.[4] It told us it expects this will need to increase to around two to three times that level per year through the late 2020s and 2030s.[5] It expects most of this increase will need to come from the private sector. The government is currently not able to estimate what the present level of private capital investment in net zero is, but it has commissioned an external project to develop its approach to tracking flows of net zero investment. Since 2021, the government expects the British Business Bank and UK Infrastructure Bank to work with the private sector to support net zero investments and help build the investment market, to support pushing technologies to the market. Both are still in the early stages of building up their expertise on emerging net zero technologies and where to target investment. Our work suggested that they were yet to be integrated into the end-to-end process for supporting net zero research and innovation. Both the UK Infrastructure Bank and the British Business Bank presented their work on green finance to the Board in February 2023. However, neither organisation has representatives on the Board or sector-specific forums, such as the Hydrogen Advisory Council. On 30 March 2023, UK Infrastructure Bank, British Business Bank, UKRI, and UK Export Finance announced they were establishing a joint forum to encourage collaboration (paragraphs 2.21 to 2.25).

4 DESNZ analysis of BloombergNEF data. We have not audited this estimate.
5 DESNZ internal government estimate. DESNZ was unable to provide supporting evidence for this estimate and we have not audited it.

Measuring and evaluating progress

19 DESNZ, with other departments, has started to establish a process for monitoring progress systematically across the Framework but is still to define what outcomes it is seeking to deliver and what level of risk it will tolerate. The uncertain and longer-term nature of innovation makes some level of failure inevitable. At the time of our fieldwork in early 2023, DESNZ was developing an Innovation Delivery Dashboard, including a set of indicators for measuring progress. Many of the proposed programme indicators were output-focused rather than outcome-focused, such as the number of projects and organisations supported, rather than the number of business opportunities created or the potential for reductions in carbon emissions. This reflects the output-focused commitments in the Delivery Plan. The Innovation Delivery Board, with DESNZ, had yet to specify what interim measures of success might look like. It had also yet to define what level of failure it could tolerate across the Framework, instead placing reliance on risk management by departments at the individual programme level. Without clearly defined outcomes, and a clear assessment of its risk tolerance, it will be difficult for DESNZ and the Innovation Delivery Board to assess whether individual innovation challenge areas are making sufficient progress to contribute to the UK achieving net zero within the expected timescales (paragraphs 2.28 and 2.29).

20 The government does not plan to complete a cross-departmental evaluation of activity across the Framework. There are features we regard as good practice in DESNZ's plans for the evaluation of its own Net Zero Innovation Portfolio, a fund directly administered by DESNZ. This includes reviewing progress by theme and an assessment of the feasibility of measuring its impact compared with a scenario without the intervention. DESNZ believes, however, it would be challenging to implement a Framework-wide evaluation approach because of the diverse mix of innovation challenges in the Framework. It would also require collaboration with many funders. However, without a Framework-wide strategy for evaluation, the government may miss opportunities for learning across organisational boundaries (paragraphs 2.29 to 2.32).

Conclusion on value for money

21 BEIS' creation and publication of the *Net Zero Research and Innovation Framework* clarified the government's priorities in pursuit of net zero and helped communicate those priorities to stakeholders outside government. Its development of the Framework brought together departments and funding bodies from across government and has begun to prompt the right questions within government of how to support the innovation that will be needed. There remains, however, a lack of clarity over who is responsible for overseeing end-to-end progress across the innovation system in the priority areas, what success will look like at key milestones, and what government's risk appetite is in supporting the different priorities within the innovation portfolio.

22 The recent Delivery Plan, published by DESNZ, has mapped out the estimated £4.2 billion of net zero research and innovation public sector funding to 2025 for the first time. This is a significant achievement and a vital step, but there is more to do. The complexity of the funding routes, many of them pre-dating the creation of the Delivery Plan, will make it harder for DESNZ and the Innovation Delivery Board to track spend, identify gaps or duplication in funding, and assess whether funding is being delivered through the most efficient mechanisms. The government intends the Framework to cover the full innovation process. Its updated Green Finance Strategy and investment roadmaps provide a high-level overview of how government expects to work with public finance bodies. However, activities aimed at supporting the latter stages of the innovation process, including the take-up of new innovations in the marketplace, have yet to be brought together in the underlying Delivery Plan. DESNZ should take prompt action to further strengthen its governance and delivery mechanisms, building on the good work done to develop the Framework. Without such action there is a risk that the government will not achieve its carbon and economic objectives, or secure value for money from its £4.2 billion investment.

Recommendations

23 We make the following recommendations to the Department for Energy Security & Net Zero and the Department for Science, Innovation & Technology:

a DESNZ should, by October 2023, set out who is responsible for providing stewardship and overseeing cross-government delivery in each of the seven categories within the Framework, and how it will encourage action if progress is not on track against intended outcomes. In doing so, we recognise that it will be important that individual funding bodies continue to have discretion to take decisions based on the merits of individual research and innovation opportunities and the quality of applications for funding.

b DSIT, working with DESNZ, should by October 2023 identify the lessons learned from the development of the cross-government *Net Zero Research and Innovation Framework*. These lessons should be documented and actively considered in future to aid consistent and effective support across government for innovation objectives, while recognising that there cannot be a one-size-fits-all approach. The aim should be to share thinking across government on how best to support innovation systems, comprising public, private and third sector bodies, to deliver against government innovation objectives.

24 We make the following recommendations to the Net Zero Innovation Board:

c The Board with DESNZ should, by March 2024, coordinate a review of net zero research and innovation programme funds to determine their strategic fit with the Framework, the efficiency of delivery (for example whether fewer larger funds would be more efficient to administer), and what consequent changes are needed.

d The Board should build on its work to develop the Framework to estimate, where possible, by March 2024, what level of public investment might be needed to deliver the required net zero research and innovation activity up to 2050.

e The Board should specify desired outcomes and what level of failure is tolerable for each of the challenge areas by December 2023. From then on, it should monitor and publish regular update reports against the output and outcome targets it has set for each of the challenge areas. This could include, for example, the potential for reductions in carbon emissions and creating business opportunities, such as the amount of private investment. Its reporting on outputs should show public spending broken down by stage of the innovation process.