A COST-BENEFIT ANALYSIS OF NET ZERO

Andrew Montford

With a foreword by Lord Mackinlay

NETZERO WATCH

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About the author

Andrew Montford is director of Net Zero Watch.

Lord Mackinlay was MP for South Thanet from 2015–2024. During that time he was the leader of the Conservative Net Zero Scrutiny Group.

Foreword

By Lord Mackinlay

The question of just how much Net Zero will cost has beguiled MPs for some time. When the legislation first came through Parliament in 2019, the Climate Change Committee (CCC) assured us that the bill would be about £50 billion per year in 2050, equivalent to 1–2 per cent of GDP. This was described as 'modest'. For comparison, the entire spend of the Ministry of Defence in 2019–20 was £40 billion. However, the CCC were silent on the presumably higher costs of delivering Net Zero in 2020–2049.

Then, thanks to a leaked letter from Philip Hammond, we were made aware of internal Government modelling showing that, instead of costing £50 billion a year in 2050, Net Zero was likely to set us back £70 billion. That letter was only revealed after a lengthy freedom of information campaign, and ministers were instructed not to refer to it in answers to Parliamentary questions.

A subsequent analysis of the CCC's numbers by the Office for Budget Responsibility would reveal a gross cost of £1.4 trillion to meet Net Zero. Whatever the precise total given, it was clear that we were looking at spending on a massive scale.

But what MPs could not have been aware of was of the flawed assumptions underpinning these numbers. While they already showed that Net Zero would be enormously costly, those figures were resting on hugely optimistic estimates for key decarbonisation technologies.

In this enlightening cost-benefit analysis, Andrew Montford reveals how wrong some of those flawed assumptions were, and the extremely disturbing implications for the cost of Net Zero. He also compares these costs to realistic estimates of the 'Social Cost of Carbon' – the prospective damage caused by emitting a tonne of carbon dioxide. Britain's political consensus, it seems, is to tax CO_2 emissions at a higher rate than the damage they do and then spend trillions more subsidising technologies that the public would not choose without compulsion. This cannot be sustainable.

Executive summary

Even under the most favourable assumptions, the costs of Net Zero to the UK far outweigh its potential benefits.

- Reaching the target would require an additional £2.7 trillion in spending* (equivalent to £70,000 per household), but this would deliver a reduction in global warming harms of only £1.3 trillion. The costs are therefore at least double the expected benefits.
- Under more realistic, but still optimistic, assumptions, the cost gap would increase to nearly £3 trillion, equivalent to around £100,000 per household. The cost-benefit ratio increases to eight to one (because of much lower benefits).
- With current costs and efficiencies, the cost gap would be higher still. In this scenario, consumers would have to spend around £10 trillion in nominal terms to deliver Net Zero – over £1 trillion on wind energy alone. The costs would exceed the benefits by a factor of over ten.

The analysis reveals the significant risk the UK Government is taking in committing the country to Net Zero. The cost could reach up to £78,000 per household to decarbonise power generation and up to £58,000 per household to decarbonise road transport, between now and 2050.

As Ed Miliband rushes to try and meet his 2030 ambition to decarbonise the power grid, there is a real danger that he cripples the economy long before reaching his hoped-for destination. The UK's trajectory is clearly unsustainable, and we are in considerable danger.

* In discounted terms, over and above the cost of an alternative scenario in which the UK returns to fossil fuels..

Introduction

There are already strong indications that the costs of Net Zero outweigh the benefits. Net Zero is a problem of pollution, or, in economics jargon, of 'externalities'. The latter term simply means that the costs of global warming are not paid by the people who use fossil fuels. However, this problem can be easily remedied through a carbon tax, equal to the harm caused, added onto the prices of those fuels. Once that has happened, no further steps should be necessary. Only activities that remain cost effective – where the costs, including harms caused by global warming, exceed the benefits – should continue to take place.

However, through the UK Emissions Trading Scheme and various forms of taxation, we already add costs to fossil fuels at a rate that is *above* a reasonable estimate of the harm done by global warming.[1] This, together with the array of subsidy schemes that have been deemed necessary to deliver the policy objective, shows that we are incentivising an array of activities that are not cost-effective and, therefore that claims that the benefits of Net Zero outweigh the costs are probably false.

So we know that much – or even most – decarbonisation activity is uneconomic. Nevertheless, the political establishment is still adamant that it should happen anyway. It is therefore useful to try to set out the full costs and benefits of the project, to try to get an indication of just how much money will be wasted.

Existing estimates

The main 'official' estimates of the cost of Net Zero by 2050 are:

- The Climate Change Committee (CCC) 2019 estimate of £50 billion per year from 2050 onwards;[2]
- National Grid ESO's (NGESO) 2020 estimate: £3 trillion.[3]

Neither is credible (see Box 1). This paper presents a more realistic estimate.

Box 1: Spurious offical estimates of the cost of Net Zero

- The CCC only estimates costs for 2050, assuming these will be far below the costs prevalent today. It therefore draws a veil over the necessarily higher costs in 2020–2049.
- NGESO assumes that costs of renewables and other technologies required are already far below their actual costs.
- Neither has modelled temperature-dependent electricity demand (e.g. from heat pumps), thus reducing the quantity of generation and storage equipment apparently required and thus understating the costs.[9]
- The CCC has only modelled a single average year of electricity supply, thus avoiding low wind years, the existence of which necessitates extra generation and electricity storage equipment, and therefore cost.
- The CCC estimate included further serious understatements of costs, by assuming that the cost of an EV had already fallen far below the cost of its petrol equivalent,[10] and by assuming that there would be very few windless days in 2050, thus greatly reducing the amount of electricity storage apparently required.[11]

Modelling

This paper first sets out the spending required to deliver Net Zero in key parts of the economy. Like NGESO, no attempt has been made to be comprehensive; in some areas – for example aviation – we have little idea of how decarbonisation might be achieved at scale and therefore what costs might apply. This paper therefore describes an estimate of the cost of picking the 'low-hanging fruit'. A fully comprehensive estimate, covering the hard-to-decarbonise sectors of the economy, would necessarily be much more costly.

The paper then continues to a full cost-benefit analysis, discounting the costs and adding on an estimate the costs of any global warming each scenario.

Key inputs

The model presented here differs from the CCC and National Grid estimates, being rooted in empirical reality. Key costs and efficiencies in the first year of the simulation can be traced back to audited financial accounts of, for example, windfarms and solar generators, and other sources of empirical data.

Four scenarios are presented, three representing different routes to Net Zero and one base scenario ('Base FF') representing an alternative future in which we return to a fully fossil-fuelled economy. All scenarios begin in 2020 with current costs levels, but, for the Net Zero scenarios, the 2050 endpoints are:

- CurrTech scenario: costs remain unchanged to 2050.
- Net Zero Favourable (NZF): costs decline rapidly.
- Net Zero Unfavourable (NZU): costs decline by half the amount in NZF.

The cost reductions assumed in the NZF scenario are *extremely* optimistic. Interested readers can judge for themselves by referring to the technical sections of this paper, which set out full details of current and projected costs.

In addition, the other assumptions in the NZW are very optimistic. For example, windfarm capacity factors are assumed to be 25% higher than today.

The NZF scenario uses an electricity demand figure of 570TWh, as used in a recent Royal Society report, which in turn appears to have been derived from a National Grid estimate. However, neither of these bodies consider the effect of weather conditions, and particularly temperature, on demand, and will thus have underestimated the capacity of generation and storage equipment required. Nevertheless, we treat this as a best-case scenario for electricity demand.

The NZU and CurrTech scenarios correct the temperature-dependent demand issue, as well as adopting a more cautious approach to improvements in efficiencies of generation and storage equipment.

Summary of results

Spend

Figures 1 and 2 represent two different breakdowns of the spending to 2050 (in undiscounted terms). In all of the Net Zero scenarios, the bill to be paid is much higher than if we abandoned the decarbonisation plan entirely. With current technology, the difference exceeds £4 trillion. Even on the most optimistic assumptions about future costs, the difference is more than £2 trillion.

Figure 1a shows that the increased spend is concentrated in the power generation and road transport sectors. Figure 1b shows that capital spend (capex) is more significant than operating spend (opex) or fuel costs.

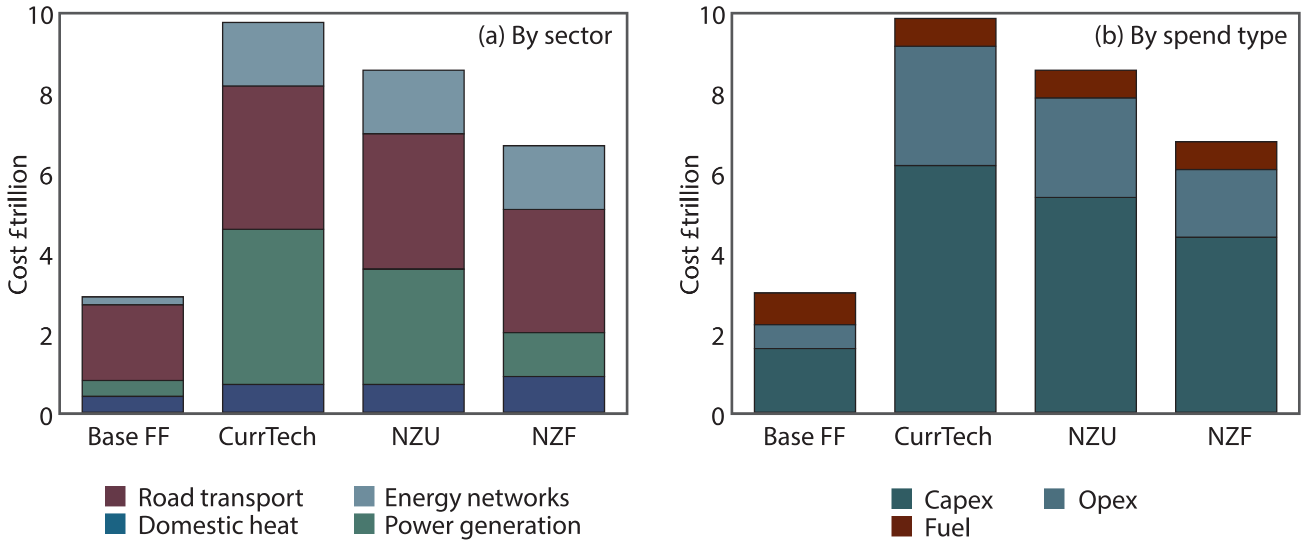


Figure 1: Total spend to 2050 in the four scenarios

(a) By sector and (b) by spend type. Undiscounted terms.

Figure 2 breaks down the capex items for the CurrTech scenario, again in undiscounted terms. The biggest spends are on offshore windfarms and battery electric vehicles.

Analysis of these figures shows that, with Net Zero delivered through the latest green technology compared to a return to fossil fuels, consumers will have to pay an extra £2.1 trillion for power generation (perhaps £78,000 per household), and an extra £1.6 trillion for road transport (perhaps £58,000 per household).

In all these scenarios, fossil fuel prices are assumed to decline slightly from today's prices.[4] Since fuel cost is a relatively small percentage of overall spend in the Base FF scenario, an assumption of rising prices only reduces the spend surplus by £0.5 trillion.

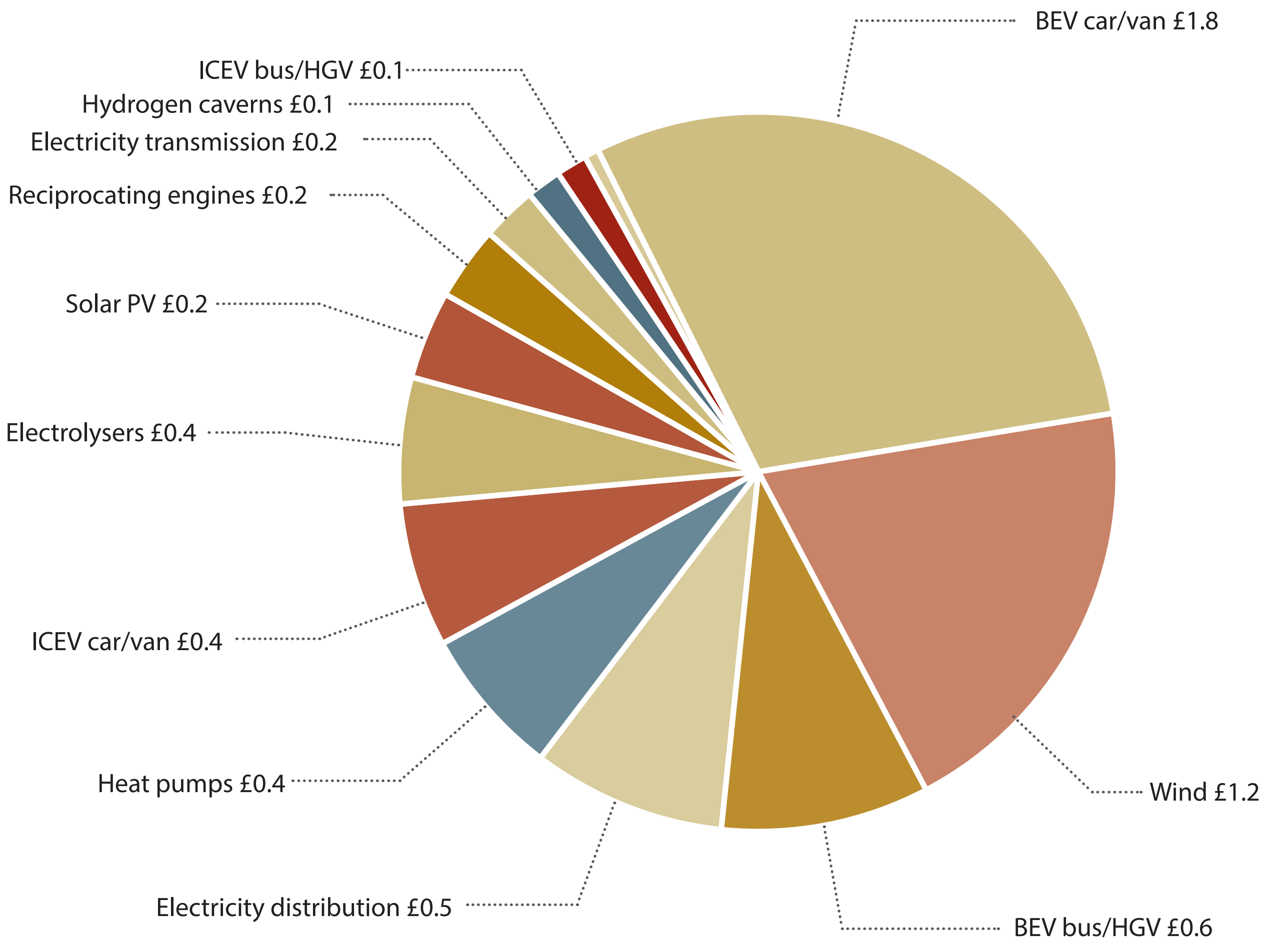


Figure 2: Breakdown of capex in CurrTech scenario

All values in undiscounted £trillion. BEV, battery electric vehicle; ICEV, internal combustion engine vehicle

Cost-benefit analysis

To prepare a cost-benefit analysis, the carbon emissions have to be estimated for each scenario, and costed at a chosen value for the social cost of carbon. Then the direct costs, as described in the last section, have to be discounted at a chosen interest rate, which should be the same as the rate used for the social cost of carbon calculation. Lower values of the social cost of carbon, typically less than $50 per tonne, tend to use 'real-world' interest rates of perhaps 4%.[5] Larger values, of up to $200 per tonne, get their results by using much lower rates, perhaps of just 2%. Since this paper tries to remain rooted in the real world, the primary results are presented with a social cost of carbon of $50/tonne and the costs are discounted at 4%.

Figure 3 shows that in every Net Zero scenario, the costs are higher than in the Base FF scenario. In other words, the costs of Net Zero exceed the benefits

It might be objected that a higher social cost of carbon should be used, or perhaps that increasing fossil fuel prices would make a difference. Figure 4 adjusts the NZF and Base FF scenarios to use a $200 carbon price, an interest rate of 2% and fossil fuel prices that rise by 20% to 2050.

It is clear that even when the assumptions are made unrealistically favourable to Net Zero, the costs of pursuing the policy are higher than returning to fossil fuels. Net Zero is therefore an irrational policy.

It is perhaps worth reminding the reader that these figures exclude the hard-to-decarbonise sectors of the economy.

Figure 3: Cost–benefit analysis: 4% discount

Costs discounted at 4%, plus carbon cost at $50/t.

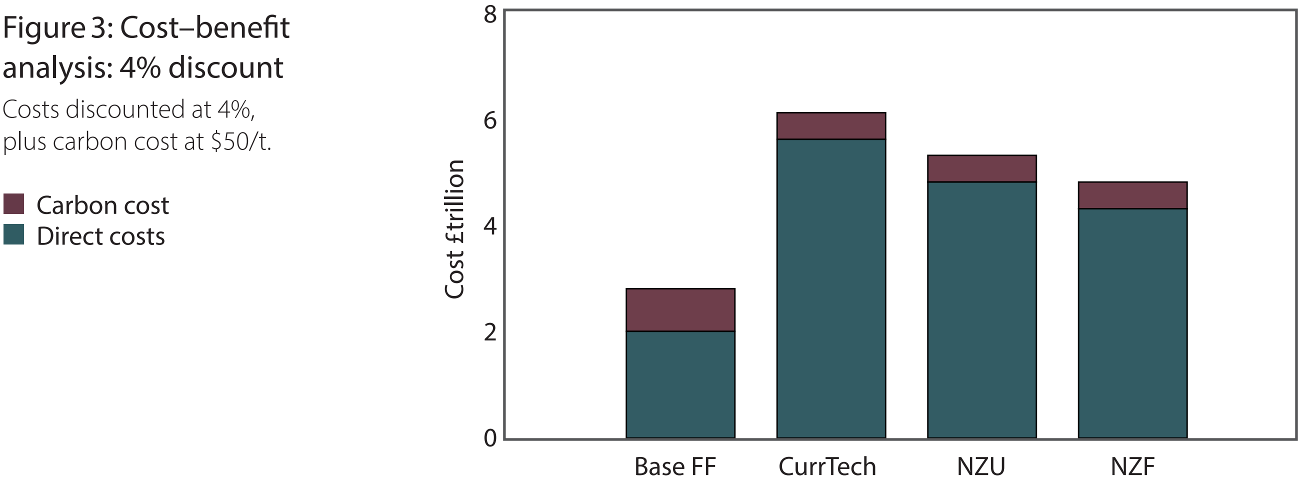
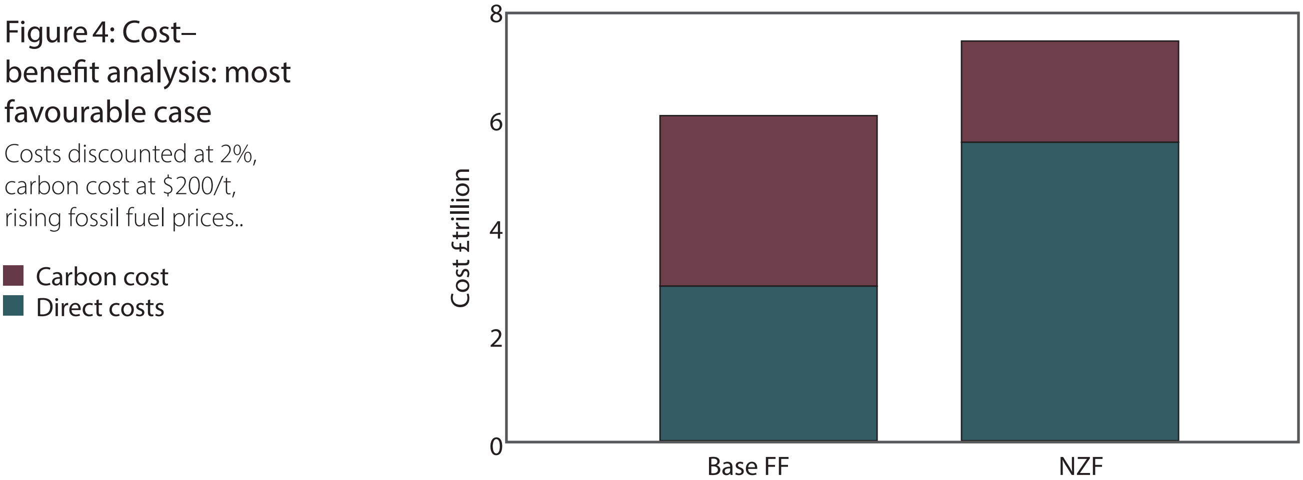


Figure 4: Cost–benefit analysis: most favourable case

Costs discounted at 2%, carbon cost at $200/t, rising fossil fuel prices..



A note on opportunity costs

The analysis presented here does not take into account the opportunity costs of Net Zero. Spending at the scale required, even in the most optimistic scenarios, would crowd out other vital areas, for example, housing, social care, education, roads and healthcare. Politicians must therefore set their priorities accordingly.

Technical details

General approach

It is necessary to estimate the costs of two possible futures:

- Net Zero
- an alternative future representing 'business as usual'.

We should note in passing that the National Grid ESO study only covers the first of these. In this paper, the alternative future is one in which there is a complete return to fossil fuels

In addition, if the results are to represent a full cost-benefit analysis, it is necessary to represent the benefits of decarbonisation in each future, namely global warming harms avoided. This is done by including multiplying the emissions by the social cost of carbon.

The modelling has three parts:

- Estimating 2050 demand
- Designing the 2050 grid
- Modelling the transition of the economy by 2050.

The first two parts are encapsulated in what we will refer to as the NZW model, which was described in an earlier paper, *Costing the Green Grid*.[6] A second model, the Transition Model, simulates the replacement of all our existing infrastructure, including the power generation system, to a new Net Zero system, over a period of 30 years.

The Transition Model

The Transition Model covers:

- Power generation
- Road transport
- Domestic heat
- The electricity network

This is similar to the approach used by National Grid ESO. Some sectors are almost impossible to model. For example, the synthetic fuels required for aviation decarbonisation do not yet exist outside the lab, and so any cost estimate for them is little better than guesswork. Industrial heat is complex, and will involve many different technologies. For this reason, such hard-to-decarbonise sectors have been excluded from the model. Readers should bear in mind that the figures presented represent only the 'low-hanging fruit', and are therefore likely to be considerably understated.

For each item in each sector

- Capex volumes are calculated such that the fleet in 2050 is of the required size.
- Capex and opex costs are then calculated by applying unit costs as necessary.
- Fuel costs and CO_2 emissions are derived from the fleet size for relevant line items.

Scenarios

In the 2050 electricity system model in *Costing the Green Grid*, a number of scenarios were presented. These were based on different sets of assumptions about, on the one hand, demand, and on the other hand the costs and efficiencies, derived either from current levels, or on figures assumed for 2050 by the Royal Society in their 2023 report on the Net Zero electricity grid.[7] The cost-optimal mix of wind and solar and storage was presented for each.

The scenarios in *Costing the Green Grid* used either the Royal Society's 2050 electricity demand figure of 570 TWh, or a figure of around 900 TWh (varying year by year) derived from the NZW model. However, the Royal Society's demand figure is flawed, because it is based on on average weather conditions – in other words the capacity of generation equipment in its results is inadequate to deal with abnormal years, and in particular very cold years, when electricity demand will soar.

Therefore, although the Transition Model can project costs for them, no results based on 570 TWh of demand are presented here. It is worthy of note that the 570 TWh figure relies on completion of an expensive programme of insulation of domestic property, and the costs almost completely counteract any advantage from lower generation and storage capacity.

Thus, of the grids designed in *Costing the Green Grid*, only two are carried forward to this report.

The CurrTech scenario uses a scenario from *Costing the Green Grid* that assumes no improvements to current technology over the next 30 years. While unrealistically pessimistic, *Costing the Green Grid* argued that it is important for policymakers to understand what current technology can deliver, so that they can properly assess the extent to which projected lower costs are hostages to fortune.

The NZF scenario assumes that efficiencies and unit outputs increase to the level in the Royal Society report over 30 years.

The NZU scenario was developed especially for this report, and simply assumes that improvements in efficiencies and outputs delivered between today and 2050 are half the level projected by the Royal Society.

The Transition Model then simulates the build-up of this generation and storage capacity over 30 years, alongside a reduction in unit costs over the same period to:

- The Royal Society's projected costs (which are based on DESNZ figures).
- A more pessimistic assumption, halfway between current levels and the Royal Society's figures.

It also considers the build up of other Net Zero equipment, such as EVs and heat pumps, in identical fashion.

Other key scenario inputs are:

- Fossil fuel prices, which fall by 10% over 30 years in the main scenarios.
- Carbon price

In summary, the key scenarios presented here are as follows:

Net Zero Favourable (NZF)

- Grid design based on Royal Society projections of improvements outputs and efficiencies for 2050
- By 2050, unit costs fall to the levels projected by the Royal Society or, for other sectors, by National Grid ESO

Net Zero Unfavourable (NZU)

- Grid design based on assumption that only half of the output and efficiency improvements imagined by the Royal Society will be achieved by 2050
- by 2050, unit costs fall by only half the amount projected by the Royal Society (or, for other sectors, by National Grid).

CurrTech

- Grid design based on performance of current technology.
- Unit costs remain at current levels to 2050.

Appendix: Cost assumptions

Capex

Outside the power generation sector, the figures used in the Transition Model are largely based on those used in the National Grid ESO model.[8] The key inputs are as follows:

Table 1: Capex assumptions

		2020	2050 costs	
		CurrTech	NZF	NZU
Offshore wind	£m/MW	3	1.6	2.3
Solar	£m/MW	0.6	0.43	0.515
Electrolysers	£/MW	2.5	0.3	1.4
Reciprocating engine	£m/MW	0.73	0.315	0.5225
Caverns	£/MWh	400	400	400
BEV car/van	£m/unit	0.030	0.020	0.025
BEV bus/HGV	£m/unit	0.400	0.300	0.350
ICE car/van	£m/unit	0.025	0.025	0.025
ICE bus/HGV	£m/unit	0.180	0.180	0.180
Gas boiler	£m/unit	0.00381	0.00381	0.00381
ASHP	£m/unit	0.01123	0.009235	0.010233
CCGT	£m/MW	0.5	0.5	0.5

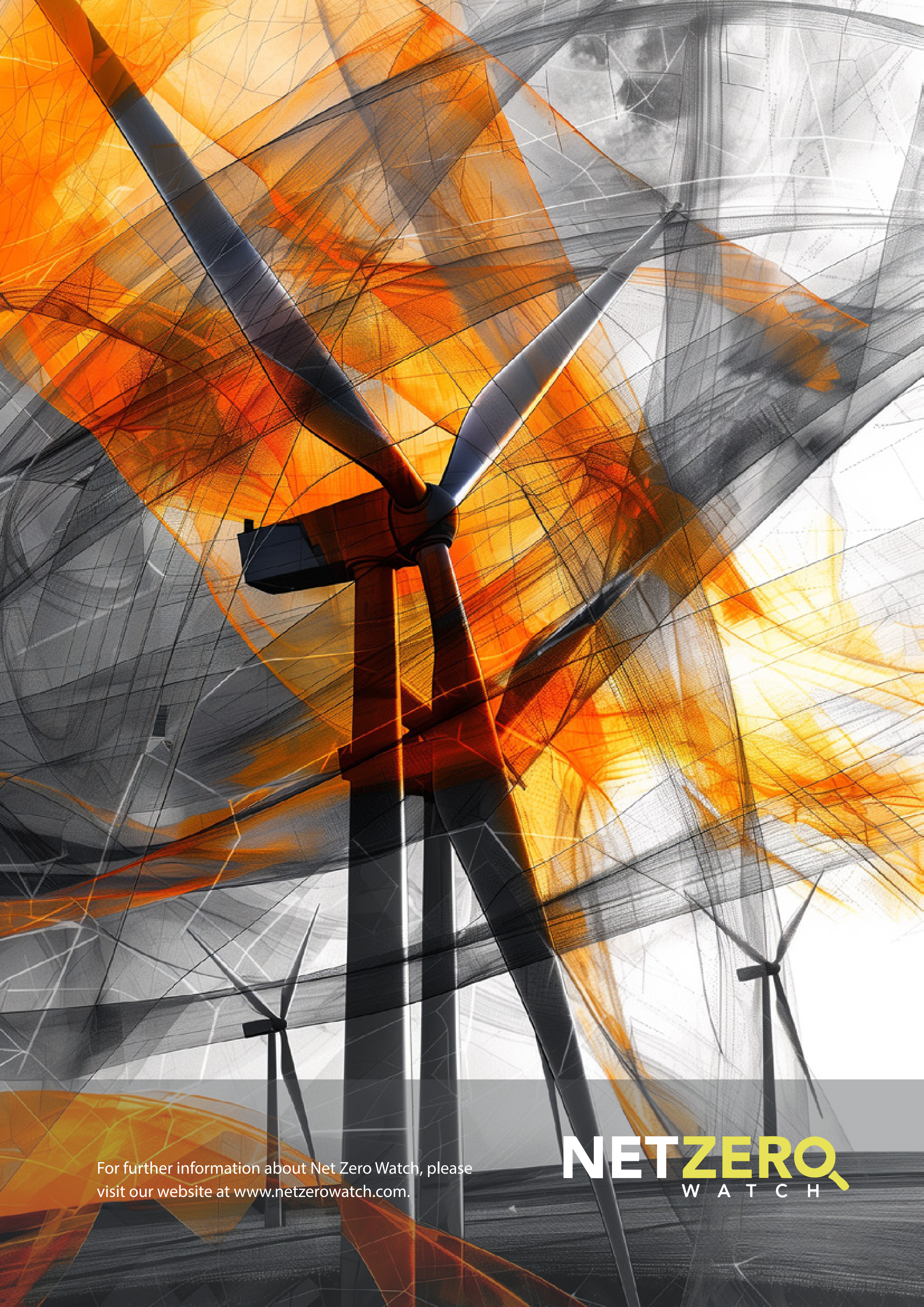
Annual opex

Table 2: Annual opex assumptions

		2020	2050	
		CurrTech	NZF	NZU
Offshore wind	£m/MW	0.18	0.05	0.115
Solar	£m/MW	0.03	0.0089	0.01945
Electrolysers	£m/MW	0.075	0.004995	0.039998
Reciprocating engine	£m/MW	0.018269	0.004725	0.011497
Caverns	£m/MWh	4	4	4
BEV car/van	£m/unit	0.000095	0.000048	0.000071
BEV bus/HGV	£m/unit	0.00170	0.00085	0.001275
ICE car/van	£m/unit	0.000095	0.000095	0.000095
ICE bus/HGV	£m/unit	0.0017	0.0017	0.0017
Gas boiler	£m/unit	0.000244	0.000244	0.000244
ASHP	£m/unit	0.000104	0.000104	0.000104
CCGT	£m/MW	0.021	0.021	0.021

Notes

1. UK ETS prices have typically been at £60–80/tCO_2, whereas the social cost of carbon is below £40/t.
2. The CCC gave a figure of £50 billion for 2050, but was silent on the intervening years. Treasury figures suggest that the CCC is implying a total spend of £1.3 trillion. https://www.netzerowatch.com/all-news/revealed-the-1-3-trillion-net-zero-cost-estimate-called-more-realistic-by-treasury-suppressed-by-government.
3. ESO stands for energy system operator, the subsidiary of National Grid that is responsible for managing the electricity and gas networks. The £3 trillion figure only represents the investment cost. The cost estimate was published as part of the Future Energy Scenarios for 2020.
4. The scale of changes is much smaller than assumed in equivalent government figures. https://assets.publishing.service.gov.uk/media/66f3e1a8080bdf716392e855/2024-Fossil-Fuel-price-Assumptions-Publication.pdf.
5. Apart from the anomalously low interest rates seen between the financial crisis of 2008 and 2023, UK long-term interest rates have generally been 4% or more. At time of writing, they are slightly higher than this. See https://www.ceicdata.com/en/indicator/united-kingdom/long-term-interest-rate.
6. Montford, A. *Costing the Green Grid*. Report, Net Zero Watch. 2024. https://www.netzerowatch.com/all-papers/costing-the-green-grid.
7. Llewellyn-Smith C et al. Large-scale Electricity Storage. Report, The Royal Society, 2023. https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/large-scale-electricity-storage/.
8. The cost of CCGTs is based on the new Keadby power station.
9. https://www.netzerowatch.com/all-news/an-extraordinary-coincidence.
10. https://www.telegraph.co.uk/politics/2021/09/25/parliament-misled-cost-net-zero-target-say-conservative-mps/.
11. https://www.telegraph.co.uk/politics/2021/10/23/net-zero-target-relies-rise-windy-days/.



For further information about Net Zero Watch, please visit our website at www.netzerowatch.com.

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