Critical point: securing the raw materials needed for the UK's green transition

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Methodology

This report focuses on a group of critical raw materials needed for the net zero transition: lithium and cobalt for electric vehicle batteries; silver for solar panels; and the rare earth elements (REEs) dysprosium, neodymium and praseodymium, used in permanent magnets for the motors in wind turbines and electric vehicles. Cumulative demand for these materials is calculated for the UK under high and low energy demand pathways (see below for further details). Both scenarios are compatible with net zero emissions by 2050.

The UK's future critical raw material demand under these scenarios is then compared to a per capita fair share of total known and economically recoverable reserves, to assess whether the UK is on track to meet or exceed its fair share during its net zero transition.

The time horizons considered are 2025, 2030 and 2035 and 2050. The 2050 projections are heavily caveated as technology change, resource efficiency and the definition of what reserves are economically recoverable are harder to predict at that timescale. Nonetheless, they serve to illustrate the risks that can be avoided through policy and technology choices.

Projecting cumulative demand for critical raw materials

Cumulative demand is calculated based on: the critical raw material content of each technology, assumptions on material intensity improvement over time, market share projections for different types of wind turbine and vehicle engine, and installed capacity under each of the energy demand scenarios. Cumulative demand is calculated from a starting point of 2021, allowing a comparison to total known global reserves in the same year.

Critical raw material content of electric vehicle batteries is taken from D Blagoeva, P Alves Dias, A Marmier and C Pavel (2016).[1]

Critical raw material content of batteries for electric buses and HGVs was adjusted to take account of larger battery size, but assuming the same chemical composition as batteries for electric cars. Battery size assumptions are taken from A Månberger and B Stenqvist (2018).[2]

Critical raw material content of wind turbines and solar panels are taken from S Carrara, P Alves Dias, B Plazzotta and C Pavel (2020).[3]

Material intensity improvement is assumed to be two per cent a year for lithium and five per cent a year for other metals, based on A Månberger and B Stenqvist (2018).[4]

No material substitution is assumed.

Market share of wind turbine and solar technologies are taken from the 'medium demand scenario' from S Carrara, P Alves Dias, B Plazzotta and C Pavel (2020).[5]

Market share of electric vehicles is calculated as part of Green Alliance analysis on traffic reduction, based on the Committee on Climate Change (CCC)'s sixth carbon budget 'balanced net zero' pathway.

High and low energy demand scenarios

The high energy demand scenario aligns with the current UK government ambition to meet net zero emissions by 2050 without significant energy demand reduction. Power deployment is based on installed capacity of wind and solar from the 'consumer transformation' scenario in the National Grid's Future energy scenario (FES) 2021, as this is the highest energy demand scenario and the only one to meet the government target of 40GW of offshore wind by 2030. The number of vehicles sold is based on the CCC's sixth carbon budget 'balanced net zero' pathway.

The low energy demand scenario was chosen to demonstrate the potential for demand reduction and increased resource and energy efficiency to reduce critical raw material demand while still meeting the 2050 net zero target. This scenario makes the transition to net zero easier and cheaper, as it requires less additional infrastructure. The low energy demand scenario was based on the 'shift' scenario developed by the Centre for Research into Energy Demand Solutions (CREDS), in their 2021 analysis of energy demand pathways for the UK's net zero transition.[6]

The 'shift' scenario represents a "significant shift in the attention given to energy demand strategies providing an ambitious programme of interventions across the whole economy describing what could possibly be achieved with existing technologies and current social and political framings". It, therefore, involves an ambitious but not radical set of interventions.

In our analysis, the reduction in power capacity required is calculated by comparing the 'shift' scenario to a baseline which maintains energy demand while meeting net zero emissions by 2050. These percentage reductions in deployment of wind turbines and solar are then applied to create a new low energy demand deployment scenario. For vehicles, data on new vehicle sales in the low energy demand 'shift' scenario are used to calculate demand.

The low energy demand scenario uses the same assumptions on material intensity improvements and market share as the high energy demand scenario.

For each scenario, cumulative UK demand for critical raw materials at each time horizon is calculated by multiplying material content (considering material intensity improvements) by deployment (taking into account market share of different technologies) for each of solar panels, onshore wind, offshore wind, electric cars, vans, buses and HGVs.

Calculating our fair share of resources

UK critical raw material demand is calculated cumulatively from 2021 and compared to known global reserves (the amount estimated to be economically and technically recoverable), based on United States Geological Survey data. To consider future demand from other uses, such as metal alloys and ceramics, current consumption of the critical raw materials for other uses is projected to increase in line with population growth. Critical raw material demand for other uses was subtracted from the global reserves available for solar panels, wind turbines and electric vehicles.

Global per capita fair share of critical raw materials was calculated by dividing the known global reserve of each material, minus consumption for other uses, by the global population.

Global population projections were taken from United Nations World Population Prospects 2019 medium variant projection. This global per capita fair share was compared to UK demand per capita. UK population projections were taken from the Office for National Statistics population projections 2018.

Recycling assumptions

The calculation of UK critical raw material demand considers the contribution from secondary supply, based on the best available estimates of current recycling rates and the lifetime of technologies.

Current recycling rates for cobalt, lithium and REEs are taken from S Taylor *et al* (2020).[7]

The current recycling rate for cobalt in the EU is 35 per cent. Global average recycling rates for lithium and REEs are one per cent. The global average recycling rate for silver is 80 per cent, based on A Månberger and B Stenqvist (2018).[8]

The average lifetime assumptions are taken from the same study. For wind turbines and solar panels average lifetime is 25 and 30 years respectively. The average lifetime of electric cars and vans is 14 years, HGVs 12 years and buses 15 years. This analysis assumes that once they reach retirement, products enter the waste stream and are available for recycling.

Historic wind turbine and solar installation data, and critical raw material content estimates, going back to 1996 were taken from S Carrara, P Alves Dias, B Plazzotta and C Pavel (2020).[9]

Vehicle sales and critical raw material content data going back to 2015 were taken from D Blagoeva, P Alves Dias, A Marmier and C Pavel (2016).[10]

Prior to 2015, very few battery electric cars were sold, so there would be minimal contribution to secondary supply from recycling.

To estimate the potential contribution of secondary supply to meeting annual demand in the low energy demand scenario in 2050, ambitious recycling rates are assumed, based on maximum feasible rates from A Månberger and B Stenqvist (2018).[11]

These rates are 70 per cent for lithium, 80 per cent for rare earths and 90 per cent for cobalt. The estimate of how much of annual demand in 2050 could be met from secondary supply was based on products expected to be retired in that year, and these ambitious recycling rates.

Endnotes

[1] D Blagoeva, P Alves Dias, A Marmier and C Pavel, 2016, 'Assessment of potential bottlenecks along the materials supply chain for the future deployment of low-carbon energy and transport technologies in the EU: Wind power, photovoltaic and electric vehicles technologies, time frame: 2015-2030,' Publications Office of the European Union

[2] A Månberger and B Stenqvist, 2018, 'Global metal flows in the renewable energy transition: exploring the effects of substitutes, technological mix and development', *Energy Policy*, Volume 119, pp 226-241

[3] S Carrara, P Alves Dias, B Plazzotta and C Pavel, 2020, 'Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system', Publication Office of the European Union

[4] A Månberger and B Stenqvist, 2018, op cit

[5] S Carrara, P Alves Dias, B Plazzotta and C Pavel, 2020, op cit

[6] J Barrett, S Pye, S Betts-Davies, N Eyre, O Broad, 2021, 'The role of energy demand reduction to achieve net-zero in the UK', Centre for Research into Energy Demand Solutions

[7] S Taylor, B Ledingham, S Watson, L Duffield, M Ward, K Rowland, R Mason, G Darwin, 2020, 'Review of the future resource risk faced by the UK economy', report for the Department for Environment, Food and Rural Affairs

[8] A Månberger and B Stenqvist, 2018, op cit
[9] S Carrara, P Alves Dias, B Plazzotta and C Pavel, 2020, op cit
[10] D Blagoeva, P Alves Dias, A Marmier and C Pavel, 2016, op cit
[11] A Månberger and B Stenqvist, 2018, op cit