European Commission

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To meet increasing energy demands, by 2050 the UK and Turkey will need to import metals from other countries

Energy demand is on the rise globally, and this is predicted to continue in coming decades. Increasing energy production to meet this demand requires materials — both metals and non-metal minerals — from a number of countries. As some materials are in short supply, it is important to consider material dependency and availability when developing national energy plans for the future. This study is the first to address material dependency effects on a nation's energy development plans, with the UK and Turkey as case studies.

30 May 2019
Issue 526

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Source: Kucukvar, M., Onat, N. and Haider, M. (2018). Material dependence of national energy development plans: The case for Turkey and United Kingdom. *Journal of Cleaner Production*, 200, pp.490-500.

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The US Energy Information Administration (EIA) predicts an increase in global energy consumption of 48% by 2040. After the USA and China, the European Union (EU) is the largest producer of electricity. The EU has committed to increasing renewable energy and minimising energy demand, but with the global population set to rise to nine billion by 2050, limited mineral resources that are needed to produce future energy are likely to become even scarcer.

The type and ratio of materials required depends on a nation's chosen energy plan. However, in all three of the scenarios examined in this study — business as usual (BAU), official plan (OP), and renewable energy development plan (RED) — there will be some dependency on another nation. The OP scenario[1] is based on the Turkish and UK governments' intended energy mix in the future; whereas the RED plan is based on a World Water Federation (WWF) report in collaboration with the national alternative energy provider for Turkey, and a paper on life-cycle sustainability of UK electricity scenarios until 2070. This dependency on other nations highlights the need to manage the use of material resources as efficiently as possible, in order to meet increasing demand.

At present, the EU (Eurostat) uses Gross Domestic product (GDP) divided by Domestic Material Consumption (DMC) as the main indicator for resource efficiency roadmaps and sustainable development plans (as do the Organisation for Economic Co-operation and Development and the United Nations Environment Program). The researchers suggest that this approach is flawed, as it does not account for raw materials consumed outside of the focal economy. They instead use a global, multi-regional, input–output (MRIO) method to quantify material footprints. This MRIO approach is capable of capturing indirect impacts across industry global supply chains, and considers international material flows to produce a more accurate benchmark for policymaking and assessment.

To investigate material flows across countries, the study analysed 10 metallic and nine non-metallic minerals used during electricity production[2] — including infrastructure and activities in the supply chain — across 11 different sectors. The analysis used an environmentally extended MRIO framework (EE-MRIO), and data were collected from two sources: a high-resolution global MRIO database named EXIOBASE v.2, and the International Energy Agency (IEA) website, which holds historical data on the UK and Turkey's electricity production from 1990 onwards.

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1. The OP for Turkey was derived from the National Renewable Energy Action Plan (NREP); while the OP for the UK was obtained from Stamford, I. and Azapagic, A. (2014). Life cycle sustainability assessment of UK electricity scenarios to 2070. *Energy for Sustainable Development,* Volume 23, pp 194–211.

2. For a list of energy production sectors and minerals, see Table 1 in an earlier study by Kucukvar, M., Onat, N. and Haider, M. (2017). Exploring the material footprints of national electricity production scenarios until 2050: The case for Turkey and UK. *Resources, Conservation and Recycling*, 125,pp 251–163.

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To cite this article/service: "Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.

The analysis first used the EXIOBASE v.2 database, which was built for the 2007 economy — this was updated to 2017 by factoring in inflation, and a statistical calculation, known as the Leontief inverse matrix, was used to generate a unit multiplier for each of the relevant consumed materials for each energy sector. Secondly, the study used IEA data on electricity production for the UK and Turkey from 1990 to 2013, and extended this to 2050 via statistical forecasting. The researchers then combined these results with various energy scenarios to project the energy mix for Turkey and the UK in 2050 in three different cases: BAU, OP, and RED. These projections were then multiplied by the previously obtained unit multipliers to calculate material consumption (in kilograms per euro of economic output). This was multiplied again by the unit cost of electricity (producer price) to yield the material consumption in kilograms. Lastly, MATLAB — mathematical software — was used to analyse the matrix data and draw conclusions on mineral consumption for specific sectors and regions.

For both Turkey and the UK, the critical metallic minerals were iron ores, copper, and aluminium, and the critical non-metallic minerals in all three scenarios were chemical fertilisers and other construction and industrial materials. To meet iron ore demand for electricity production, Turkey will rely 42% on Russia and China in a BAU scenario; 34% on Australia and China in an OP scenario; and 19.2% on Russia in a RED scenario. The UK will rely on fewer countries overall for iron ore: 22% on China for a BAU scenario; 14% on Russia for an OP scenario; and 13% on Brazil in a RED scenario. For non-metallic minerals — such as 'other construction minerals' — these dependencies do not change much between the three scenarios for both the UK and Turkey. However, Turkey will rely on itself for 55% of its other construction material in a BAU case, whilst the UK will only be able to meet 16.5% of its own construction material needed by 2050.

A considerable share of the raw materials needed in European energy production are imported, and are thus vulnerable to global developments that may lead to problems with security of supply. These findings support European policy efforts to identify the critical materials for energy sectors, and relate to the EU Raw Materials Initiative[3]. The approach can be used to develop scenarios and track the source and availability of valuable scarce resources. In addition, the EU currently has the Circular Economy Action Plan in place to address reusing and recycling within Europe[4]. The researchers noted that an extension of this study would include the critical material reserves and the effect of recycling policies on the dependency of the EU on other countries to meet its growing energy demands.

3. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0699.

4. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614.