Who needs Stratigraphers, Sedimentologists & Paleontologists? Evolving roles through the Energy Transition

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It seems that geoscience is facing something of an existential crisis. At the heart of the concerns are a drop in student numbers, with total 2019 undergraduate student enrolments down by 35% in UK universities from a high in 2014 (Boatright et al. 2019). There is evidence of similar trends in many other western countries, including the USA (Saucier 2020). Numbers for some vocational courses are down by even greater percentages.

The consequences could be dramatic. Fewer students equals reduced income, leading to university departments facing budget cuts and possibly even closure. In turn, this leads to a reduction in research activity and the development of the science. At the same time, employers could find themselves facing a talent shortage, especially if the brightest young people choose other subjects instead of geoscience.

Why are young people apparently less interested in studying geoscience? We desperately need hard data to get to the answer of this question, but there are a number of factors, probably acting in concert. Perhaps it's because the subject has yet to fully embrace societal diversity. Perhaps it's because the subject appears rather old-fashioned in an age of rapidly advancing technology. And perhaps it's because of negative environmental perceptions associated with the extractive industries that geology supports, and even that these industries are rapidly coming to the end of their days (i.e. even you wanted to work in industry, there aren't any jobs). We are in a time of energy transition, with renewable energy sources forming an increasing proportion of the energy mix. What does that mean for the employment of geologists, not least stratigraphers, sedimentologists and palaeontologists, very many of whom have historically found gainful employment in the oil and gas industry?

In order to begin this analysis, we need an assessment of society's appetite for energy and how this will be supplied. Access to affordable energy is essential for economic growth and social development (Lloyd 2017) and the meeting of UN sustainable development goals. Put simply, people with access to greater amounts of energy live longer and more prosperous lives (Figure 1). The current global population is 7.8 billion, with UN projections suggesting that this will most likely rise to 9.8 billion by 2050 and 11 billion by 2100 (United Nations 2019). Without very substantial changes in the efficiency of energy usage, a growing global population inevitably consumes more energy, especially as every nation seeks economic growth to ensure the prosperity and well-being of their citizens. As elegantly argued by Scott Tinker (e.g. Millam 2019), energy poverty is a very real issue. Currently, 940 million people (13% of the world population) do not have access to electricity. 3 billion (40% of the world population) have only intermittent access, at supply levels a fraction of that enjoyed in developed nations, and do not have access to clean fuels for cooking. This comes at a high health cost for indoor air pollution (https://ourworldindata.org/energy-access), leading to 3 million deaths per year. Therefore, because of population growth and economic growth, global annual energy demand is set to rise from current levels by around 50% by 2050 (www.eia.gov/ieo) (Figure 2).

How will this rising demand for energy be sourced if we are not otherwise simply to deny energy to large numbers of people, most likely those from developing nations? Doubtlessly renewable sources will form an increasing proportion of the energy mix, as electrification of heating and transportation promotes their greater use, especially as the price of their supply falls. The Energy Information Administration (EIA) project predicts that by 2050, renewables will be the single most important source of energy (Figure 3). However, because of rising energy demand, almost all energy sources see rises in demand, such that by 2050 global energy will be supplied by almost equal proportions of oil, gas and renewables, and a smaller proportion of coal, plus nuclear. The EIA projections can be compared with those of other organisations (e.g. BP Energy Outlook 2020; McKinsey 2019), but although there are differences in detail, none predict a significant collapse in the demand for gas and oil, with these forming part of a balanced energy supply alongside renewables.

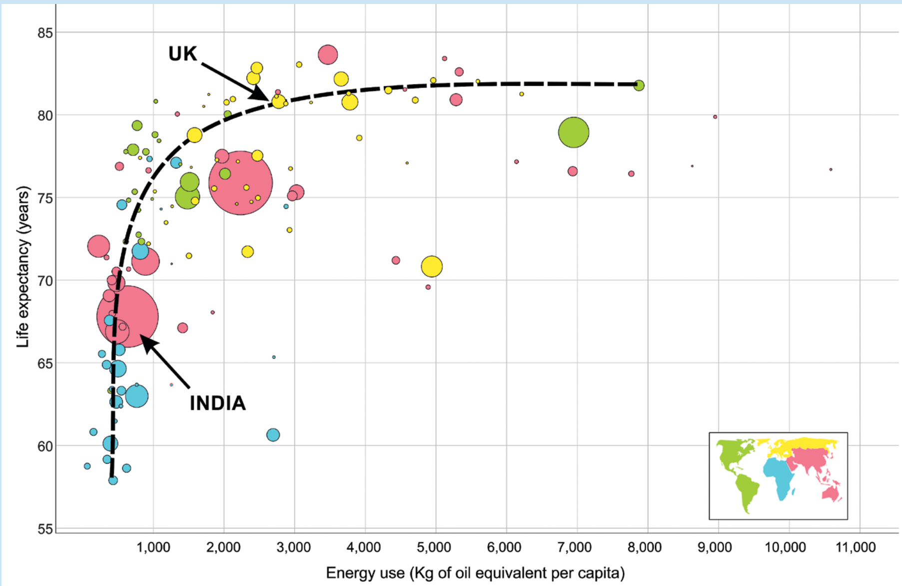

Figure 1: Graph displaying life expectancy vs. energy consumption (data for 2014). Each colored bubble represents a country, size proportionate to population. A clear trend indicates that greater energy consumption relates to greater life expectancy. Based on free material from www.gapminder.org

Even in scenarios which see a rapid transition towards renewables in order to meet the aims of the Paris Agreement on Climate Change, ~900 billion barrels of oil and ~4,700 Tcf of gas are required to meet demand between now and 2050 (Figure 4). To put that in context, that's almost two thirds of all the oil we have ever used and more than all the gas we have ever used. Some of that resource will come from existing discoveries, but a large part of it remains to be found.

Why does the energy mix continue to be diverse over coming decades? Discussion of all technological reasons why renewables cannot quickly and totally replace hydrocarbons as an energy source are beyond the scope of this brief note (see Mackay 2009 for a comprehensive discussion, and Smil 2020 for a condensed version). However, key issues relate to energy density (e.g. to power an aircraft engine, or industrial machinery), geopolitics, costs, intermittent supply and storage, supply uncertainties of raw materials for renewables, and the capital intensity of the energy system. Moreover, 85% of current global energy supply comes from hydrocarbons. With fossil fuels accounting for 11,865 mtoe of energy supply, it would take more than 1 mtoe a day, to bring hydrocarbon usage down to zero by 2050. 1 mtoe is equivalent to the energy supplied by a nuclear power station or 1500 wind turbines. The challenge is indeed enormous.

Therefore, and acknowledging that there will be those who will wish otherwise, oil and gas will be part of the energy mix for several decades to come. But this doesn't mean business as usual. The industry will focus on reserves with the lowest carbon intensity to find and produce – "advantaged hydrocarbons". Geoscientists, need to contribute to increasing the efficiency, and hence reduced carbon footprint, in obtaining these resources. In other words, getting the geology right and central to this are stratigraphy, sedimentology and palaeontology. Practitioners of these subjects have key roles to play in everything from regional geology studies high-grading areas for exploration, to building accurate reservoir models (Figure 5), through to rigsite work, and steering well trajectories so that production is optimized. Fewer dry wells and fewer poorly producing wells lead to a reduced carbon footprint.

Given the apparent inevitability of fossils fuels continuing to form a significant part of the energy mix in coming decades, carbon capture and

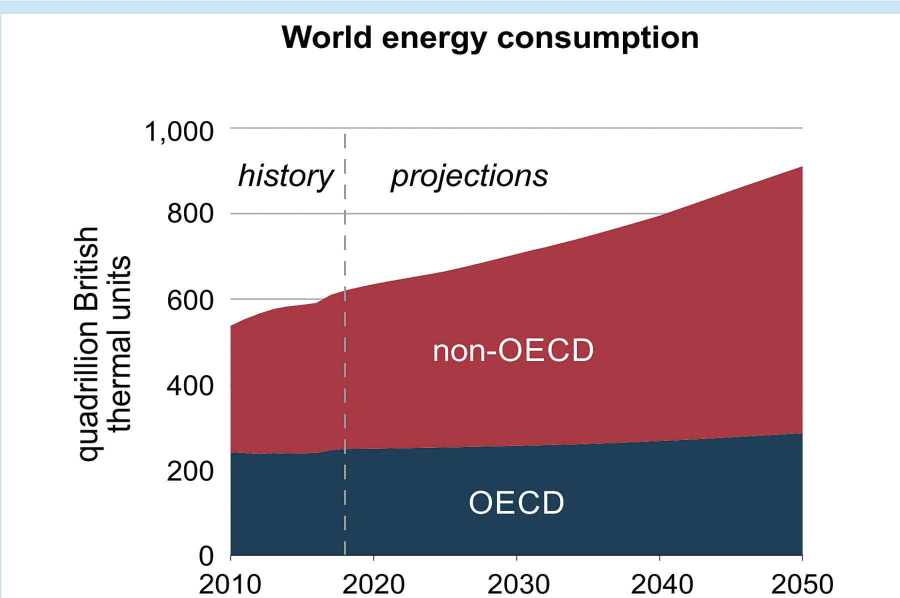

Figure 2: Projection of global energy consumption to 2050 (https://www.eia.gov/outlooks/ieo/). A rise of ~50% is predicted, mostly from developing nations.

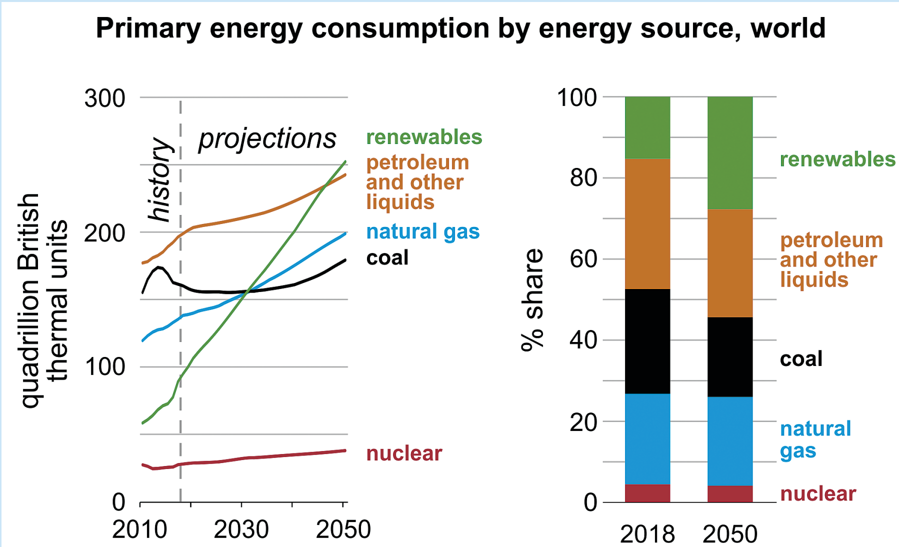

Figure 3: Projected primary supply source to 2050. By 2050, renewables will have become the most important energy source, but other energy sources remain an important and significant part of the energy mix (https://www.eia.gov/outlooks/ieo/)

sequestration (CCS) have become essential (Stephenson 2018; Ringrose 2020) – *"a necessity not an option"* to quote the UK Committee on Climate Change. Secure storage will require geoscientists who can locate and model suitable subsurface repositories for CO_2 and model the behaviour of CO_2 injected into those repositories. Once again, important work for stratigraphers, sedimentologists and palaeontologists. In addition, subsurface models will be needed for hydrogen storage (a key future energy source) and geothermal energy projects.

As oil and gas companies transition into energy companies, many will increase their investment in wind farm technology. Determining the appropriate location for wind farms requires an analysis of numerous factors, but the geotechnical suitability of their installation locations is a key concern. For example, in the North Sea, the considerable variability in the nature of sediments resulting from Quaternary glaciations is a key challenge. Technical challenges associated with a buried landscape of glacial and fluvial channels and thrusted moraine complexes (Cotterill et al. 2017) must be overcome. Detailed sedimentological and stratigraphic understanding support such geotechnical endeavours.

Geoscience is undergoing a paradigm shift. Although geoscience may be seen as rather old-fashioned, we are increasingly using digital technologies and techniques such as machine learning and AI to help make interpretations of outcrops, wireline logs, seismic data, and fossil assemblages. For this to be a success requires the in-depth domain expertise of stratigraphers, sedimentologists and palaeontologists. In turn, the reward is that geoscientists can dedicate more time to exploring different interpretation scenarios allowing more efficient, accurate, consistent, and insightful contributions to solving the challenges posed by the energy transition.

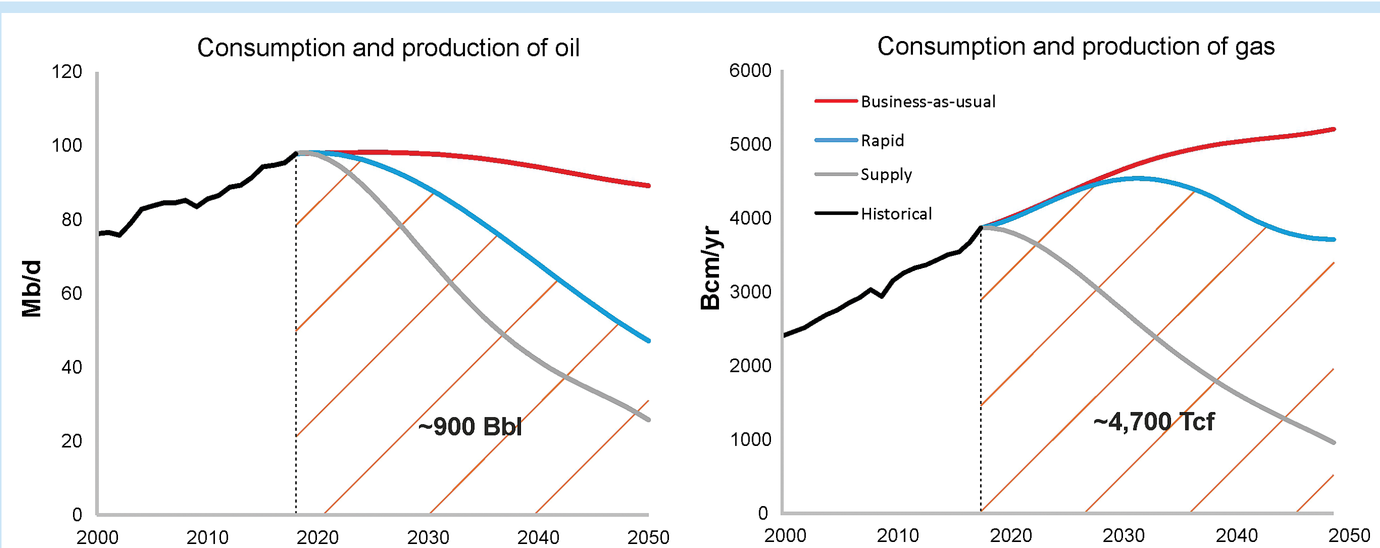

Figure 4: Future oil demand in a rapid energy transition and business as usual scenarios (BP 2020). Even in a rapid transition scenario, oil demand is forecast to be ~50 million barrels per day in 2050 with an annual gas demand of 3,700 Bcm. That translates to a demand for ~900 billion barrels of oil and ~4,700 Tcf of gas between now and 2050.

Figure 5: Outcrop of a key reservoir analogue in South Devon. Studying such helps build better reservoir models that in turn leads to efficiency in hydrocarbon extraction, reducing carbon intensity of operations. Or the models can be used in modelling carbon storage repositories and in green energy projects such as hydrogen storage and geothermal.

Outside of industry, if we are to meet the challenge set by one of the founders of geology, Georges Cuvier, who encouraged us to "burst the limits of time", meaning to envisage the history of the Earth and life upon it, and the mechanisms by which internal and surface Earth processes operate (Simmons 2018), the need for geoscience never ends. That challenge is now being taken to our neighbouring planets. This note has focused on the practical societal needs for stratigraphers, sedimentologists and palaeontologists, but of no less importance is the *wonder* of geoscience, simply (although actually far from simple!) to understand the Earth for its own sake. And this has practical value too, if we wish to model the future impact of humankind on the planet, we need to look to the geological past for analogues. Stratigraphers, sedimentologists and palaeontologists are amongst the custodians and curators of Earth history, perfectly placed to advise on the future of the planet and those who live on it.

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