Limiting fossil fuel extraction to keep global warming below 1.5° C target

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Nearly 60% of both oil and fossil methane gas and almost 90% of coal must remain in the ground by 2050 in order to keep global warming below 1.5° C, finds a study by UCL researchers.

Global oil and gas production must decline by 3% annually until 2050 in order to reach this target. Many fossil fuel extraction projects, both planned and operational, are not conducive to meeting internationally agreed target limits on global warming, as set out by the Paris Climate Agreement in 2015. A significant number of regions have therefore already reached peak fossil fuel production, and any increase in production from one region must be offset by a greater production decline elsewhere.

The findings, published in *Nature*, are based on a 50% probability of limiting warming to 1.5° C this century, meaning that increasing the likelihood of reaching this target would require an even more rapid decline in production and more fossil fuels left in the ground.

The researchers used a global energy system model to assess the amount of fossil fuels that would need to be left unextracted regionally and globally.

The required unextracted reserves are estimated as the percentage of the 2018 reserve base. This needs to be 58% for oil, 59% for fossil methane gas and 89% for coal by 2050.

Lead author Dan Welsby (UCL Institute for Sustainable Resources) says that "in 2015, 196 parties signed the Paris Climate Agreement, aiming to keep average global temperature rise to well-below 2° C, with 1.5° C the desired target. Since then, the IPCC Special Report on 1.5° C, successive Production Gap Reports and the IEA Net Zero Report have indicated beyond doubt that dramatic cuts in fossil fuel production are required immediately in order to move towards net zero emissions, and that current and indicated fossil fuel production trajectories are moving us in the wrong direction.

"Our new paper adds further weight to recent research, indicating that

global oil and fossil methane gas production has already peaked. From a regional perspective, our results suggest significant transition risk for large fossil fuel producers. Oil production in the Middle East for example roughly halves between 2020 and 2050, suggesting the diversification of economies away from a dependence on hydrocarbon revenues is absolutely critical."

The work builds on previous research in 2015, which found that in order to limit warming to 2° C, a third of oil reserves, nearly half of fossil methane gas (49%) reserves and over 80% of coal reserves should remain in the ground.

The researchers used the TIMES Integrated Assessment Model at UCL (TIAM-UCL). The model captures primary energy sources—oil, fossil methane gas, coal, nuclear, biomass and renewables—from production through to conversion (e.g. electricity, hydrogen and biofuel production or oil refining), and distribution to meet a set of demands in each end-use sector.

Countries of the world are represented as 16 regions, which allows for a detailed characterization of regional energy sectors. The model assessed different scenarios including lower demands in key carbon intensive sectors (aviation and chemicals) and uncertainty around the availability and deployment of key carbon capture, utilization and storage (CCUS) and negative emissions technologies (NETs).

In terms of the regional distribution of unextractable fossil fuel reserves, the researchers found that the Middle East must leave around 60% of oil and gas reserves in the ground, which given the large size of its reserve base also results in huge absolute volumes. Additionally, regions with high concentrations of relatively high cost and high carbon intensive deposits of oil within the reserve base show high proportions of unextractable reserves including the oil sands in Canada (83%) and ultra-

heavy oil in Central and South America (73%). The regional differences in the proportion of fossil fuels which must remain unextracted is down to a combination of factors including extraction costs, the carbon intensity of production and the costs of alternative technologies to fossil fuels.

Mr. Welsby continued, "We stress that our estimates of unextractable reserves and production decline rates are likely underestimates, given we use a carbon budget consistent with only a 50% chance of meeting 1.5° C and the huge uncertainty around the deployment of negative emission technologies. However, assuming the political will is present to fulfill the commitments made in Paris, the reductions in fossil fuels suggested in our work are entirely feasible."

More information: Dan Welsby et al, Unextractable fossil fuels in a 1.5° C world, *Nature* (2021). DOI: 10.1038/s41586-021-03821-8

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