COP30 Presidency Roadmap — *Input Submission*

Which countries should phase out fossil fuels first?

New methodology for a roadmap based on common but differentiated responsibility

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This submission provides a new tool (the differentiated phase-out index) that helps answer two questions posed by the COP30 presidency:

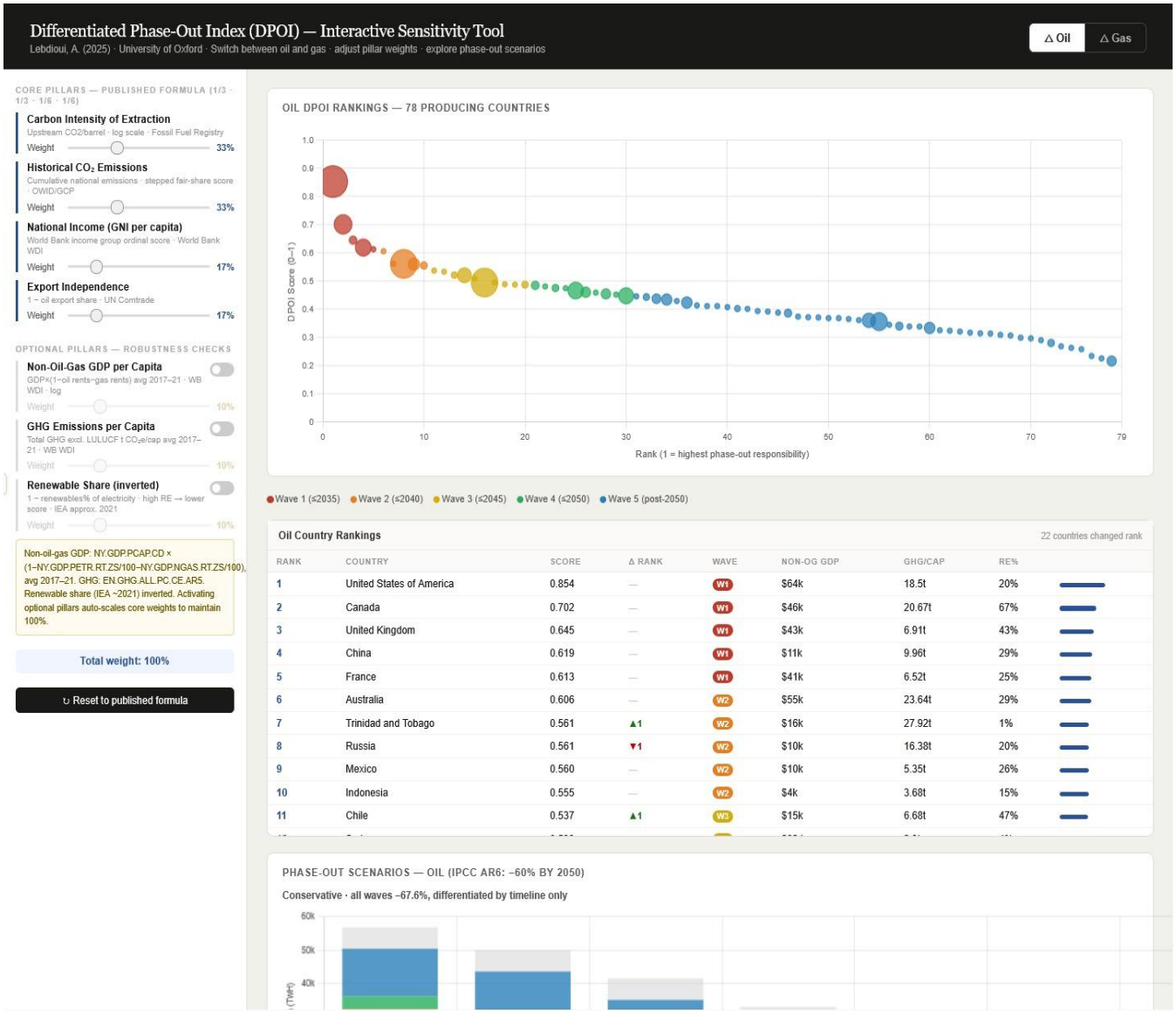
- *Question (a): What are the most critical barriers preventing a transition away from fossil fuels?*
- *Question (d): How can a just, orderly and equitable transition best reflect the diverse realities of countries at different stages of development and with different degrees of dependence on fossil fuels?*

This submission explains that the supply-side governance gap is a critical barrier to phase out plans, which suffer from a paralysis from the absence of any agreed metrics of fairness, responsibility and capacity for phase-out. The lack of a rigorous, transparent and comprehensive methodology for the question of which countries should stop extracting which fuels, and in what sequence, leads to a collection action challenge that is extremely environmentally costly, especially given large upstream emissions differences for oil and gas extraction across countries. This means that the ecological effectiveness of a phase-out strategy also depends on country differentiation, rather than uniform imposition on all producers. As witnessed in recent years, any phase-out risks being met with substitution by richer nations that produce more carbon intensive fossil fuels, threatening both the climate and global development agenda.

This submission therefore proposes a differentiated, criterion-based supply-side framework that operationalises the principle of common but differentiated responsibilities. The index integrates four evidence-based variables: the carbon intensity of extraction, historical cumulative emissions, national income, and economic dependence on fossil fuel revenues. Applying the DPOI to 91 producing countries, it shows that the United States, Canada, Australia, the United Kingdom, and China carry the greatest responsibility to lead the transition away from oil and gas in a first wave. I then model two differentiated phase-out scenarios showing that both can meet IPCC Sixth Assessment Report requirements of a 60% reduction in oil and a 45% reduction in gas production by 2050 while embedding equity in time and equity in volume. Our results suggest that this wave-based phase-out framework could anchor supply-side negotiations and provide a benchmark for evaluating national responsibilities as part of the COP30 roadmap.

An online interactive version of the DPOI allow users to adjust pillar weights and observe the effects on rankings (with has little effect on the country composition of the first wave). This feature that would facilitate legitimate disagreement about normative priorities rather than concealing it.

The interactive tool (soon to be available at https://oxford-tide.org/dpoi)



Question (a): What are the most critical barriers — whether physical, economic, financial, institutional, technological or social — preventing a transition away from fossil fuels?

The supply-side governance gap as a foundational barrier

The most foundational and underappreciated barrier to a transition away from fossil fuels is institutional and methodological: the near-total absence of any agreed framework for allocating differentiated supply-side phase-out responsibility among producing nations. Existing climate governance (national emissions inventories, carbon pricing, efficiency standards, renewable energy deployment) overwhelmingly focuses on the consumption side. The supply side (who extracts, and how much, and in what sequence) has been largely excluded from formal climate negotiations. Without an explicit framework for supply-side differentiation, producer nations face collective-action failures, accusations of burden-shifting, and the paralysis that comes from having no agreed metric of fairness.

This gap has concrete consequences. The Production Gap Report documents that governments worldwide continue to plan for fossil fuel production far in excess of what a Paris-compatible pathway allows, not because they are unaware of the science, but because there is no operationalised principle governing who should reduce first and by how much. The COP28 commitment to "transitioning away from fossil fuels in energy systems in a just, orderly and equitable manner" (paragraph 28d/GST1) cannot be translated into implementation without such a framework.

The carbon intensity heterogeneity barrier

A second critical barrier, technical in nature but with profound equity implications, is the enormous variation in the upstream carbon intensity of fossil fuel extraction across countries. A barrel of Canadian oil sands emits approximately 102 kgCO_2e — the highest of any large producer — while Colombian crude emits roughly half that, Norwegian oil roughly a third, and Saudi light crude nearly a quarter. A tonne of natural gas extracted in Australia carries a significantly higher methane leak rate than the same tonne extracted in the Netherlands. These upstream emission differences, which can span an order of magnitude, mean that a uniform phase-out obligation applied to all producers would be both ecologically suboptimal and normatively unjust: it would reduce emissions less efficiently and would treat highly intensive producers the same as low-intensity ones. Any operational roadmap must therefore differentiate not only by capacity and development status, but by the intrinsic ecological cost of each country's extraction activities.

Fiscal dependence and structural economic lock-in

The third major cluster of barriers is economic and financial. Many producing countries, particularly in the Global South, face acute development transition challenges: limited fiscal buffers, high exposure to stranded asset risk, and economies structurally dependent on hydrocarbon export revenues. For several Sub-Saharan African producers, hydrocarbon revenues are the primary source of public investment in health, education, and infrastructure. For these countries, the economic adjustment cost of rapid phase-out is qualitatively different from that faced by diversified high-income economies, even when absolute production volumes are comparable.

The absence of supply-side equity metrics

A further institutional barrier is that the principle of Common But Differentiated Responsibilities (CBDR), enshrined in the UNFCCC and reaffirmed in the Paris Agreement, has been extensively applied on the demand side but has almost never been operationalised on the production side. Countries have no agreed basis for assessing their

relative supply-side obligations. This normative vacuum makes it politically impossible for any individual producing nation to lead a unilateral reduction without appearing to accept an asymmetric burden, and makes it equally impossible for international negotiations to converge on a fair allocation of phase-out obligations.

Question (d): How can a just, orderly and equitable transition best reflect the diverse realities of countries at different stages of development and with different degrees of dependence on fossil fuels?

The need for a differentiated, criterion-based supply-side framework

A just, orderly and equitable transition requires an explicit and verifiable framework for differentiating supply-side phase-out obligations across producing nations. The Differentiated Phase-Out Index (DPOI) that I propose is one such framework. It operationalises the CBDR principle on the production side by integrating four evidence-based pillars into a single composite score for each of 91 oil- and gas-producing countries:

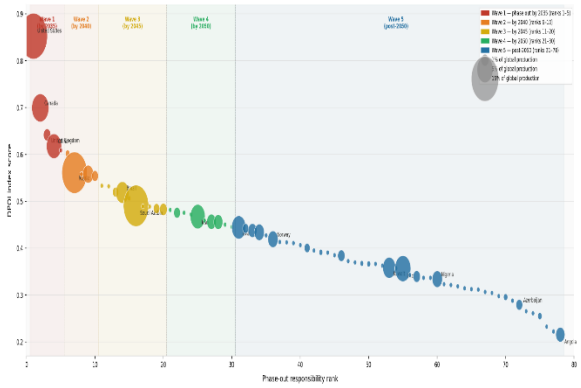
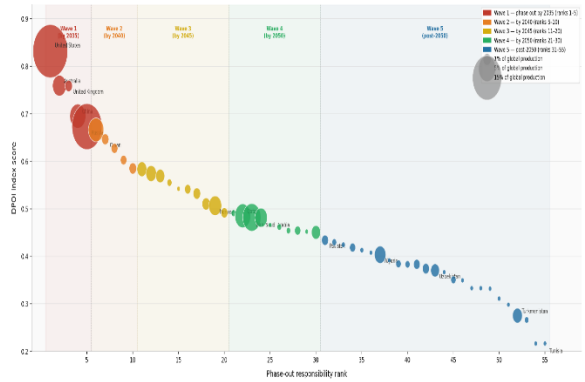
1. *Carbon intensity of extraction* (upstream CO_2e per barrel/boe, sourced from the Fossil Fuel Registry): the intrinsic ecological cost of a country's production, reflecting the climate imperative to prioritise the elimination of the most polluting barrels first.
2. *Historical cumulative CO_2 emissions* (from Our World in Data / Global Carbon Project): the country's contribution to the atmospheric carbon stock that now threatens all nations.
3. *National income* (GNI per capita, World Bank income group): the economic capacity to absorb transition costs.
4. *Export dependence on fossil fuels* (share of fossil fuels in total merchandise exports, UN Comtrade): the degree of structural economic vulnerability to production reductions.

The current set formula is: *DPOI = (1/3) × S_intensity + (1/3) × S_hist + (1/6) × S_income + (1/6) × S_dependence*, where each S is a normalised score on [0, 1] with higher values indicating greater phase-out responsibility. But on the interactive tool, users can adjusted the weighting they want to give to each variable, as well as include additional variables.

Key findings on differentiated responsibility

Applying the DPOI to 91 oil- and gas-producing countries yields results that are both analytically robust and politically tractable. The United States, Canada, Australia, the United Kingdom, and China carry the greatest responsibility to lead the transition under either the oil or gas ranking. These five countries together account for over 45% of global gas production and a comparable share of oil, meaning that differentiated action by a small group of high-ranking countries can generate the bulk of the required global reduction, a finding with significant implications for the design of supply-side agreements.

Interesting, some of the world's largest producers by volume rank lower on the DPOI. Saudi Arabia ranks 16th in oil (score 0.491), Iraq 45th, Kuwait 50th. This is not because these countries face no obligations (they are included in the later waves of the phase-out modelling) but because their comparatively low extraction carbon intensity, modest historical cumulative emission shares, and, in several cases, high fiscal dependence on hydrocarbon revenues justify a more graduated timeline. The index therefore captures the diversity of national circumstances in a structured and transparent way, rather than treating all producers as equivalent. However, the inclusion of dependence of fossil fuel revenues raises some questions as to fairness consideration given that over-reliance on fossil fuel revenues is partly a policy choice in many nations, which is why discounting this variable for high income status nations could be a valuable improvement in the current metrics in the interactive tool.

Oil Differentiated Phase-Out Index (DPOI) rankings	*Gas Differentiated Phase-Out Index (DPOI) rankings*
	

Bubble area is proportional to share of global oil or gas production (TwH, 2021).

A wave-based phase-out structure: equity in time and equity in volume

The DPOI supports a wave-based phase-out structure that is directly relevant to the COP30 Roadmap's objective of providing "differentiated options that countries, subnational entities, and economic sectors can adapt according to their circumstances." Countries are grouped into five waves by DPOI rank:

- **Wave 1** (ranks 1–5: US, Canada, UK, China, France for oil; US, Australia, UK, China, Russia for gas): phase-out target by 2035
- **Wave 2** (ranks 6–10): by 2040
- **Wave 3** (ranks 11–20): by 2045
- **Waves 4–5** (ranks 21–53/91): by 2050 or post-2050

Two differentiated phase-out scenarios (both calibrated to meet IPCC AR6 requirements of a 60% reduction in oil and 45% reduction in gas production by 2050) illustrate how this structure can embed equity at multiple levels:

Conservative scenario: All waves reduce by the same percentage (68.6% for oil, 45% for gas), differentiated only by timeline. This provides *equity in time* (earlier phase-out for higher-responsibility producers) while maintaining a uniform volumetric obligation across waves.

Distributed scenario: Reduction obligations are additionally differentiated by volume, using a graduated scheme with a fixed step between waves. For oil, Wave 1 reduces production by 93.9% by 2035, Wave 2 by 78.9%, Wave 3 by 63.9%, and so on. For gas, the corresponding reductions are 65.7%, 52.7%, and 39.7%. This provides both *equity in time* and *equity in volume* as the countries best positioned by virtue of their wealth, diversified economies, and historical responsibility absorb the steepest cuts, while lower-ranked producers (many in the Global South) face no mandatory reduction before 2050, preserving meaningful fiscal space and development opportunities.

Figure 1 presents two wave-based phase-out scenarios for oil, both calibrated to the IPCC requirement of a 60% reduction in global oil production (in TwH) by 2050 relative to 2021.

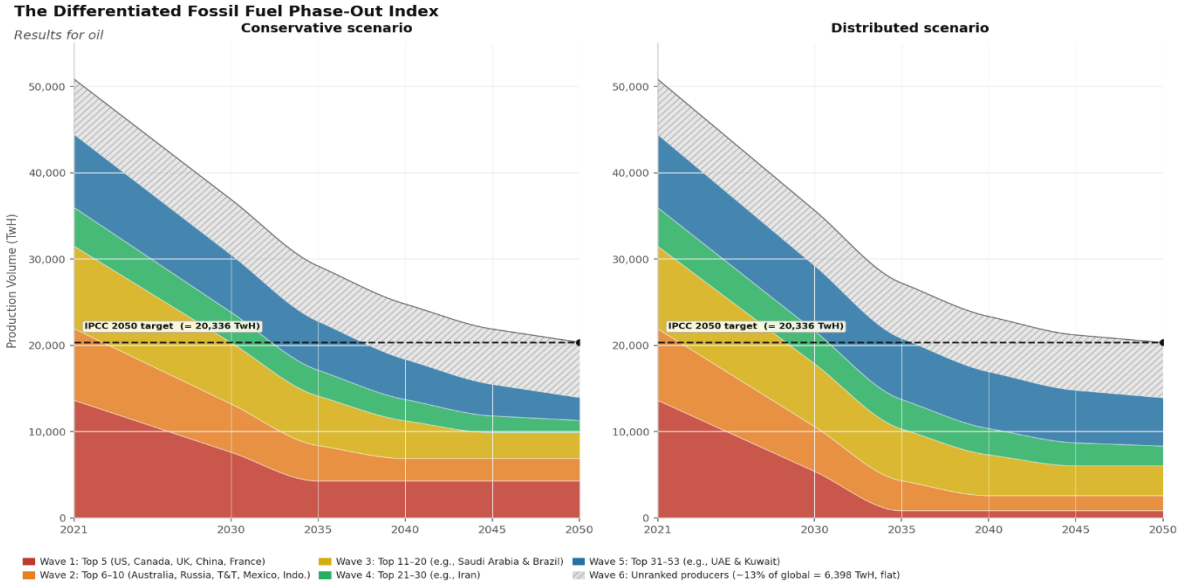


Figure 1 | Differentiated phase-out scenarios for oil consistent with IPCC 1.5 °C pathways. Stacked bar charts show production volumes (TwH) by wave group from 2021 to 2050, under the conservative scenario (left panels, uniform reduction percentage by wave) and distributed scenario (right panels, steeper reductions for earlier waves). Horizontal dashed line indicates the IPCC-compatible production level for 2050 (oil: −60% from 2021 baseline). Country group compositions are given in the legend; further detail in the methods section.

Figure 2 presents the equivalent scenarios for natural gas, calibrated to a 45% reduction in global gas production by 2050.

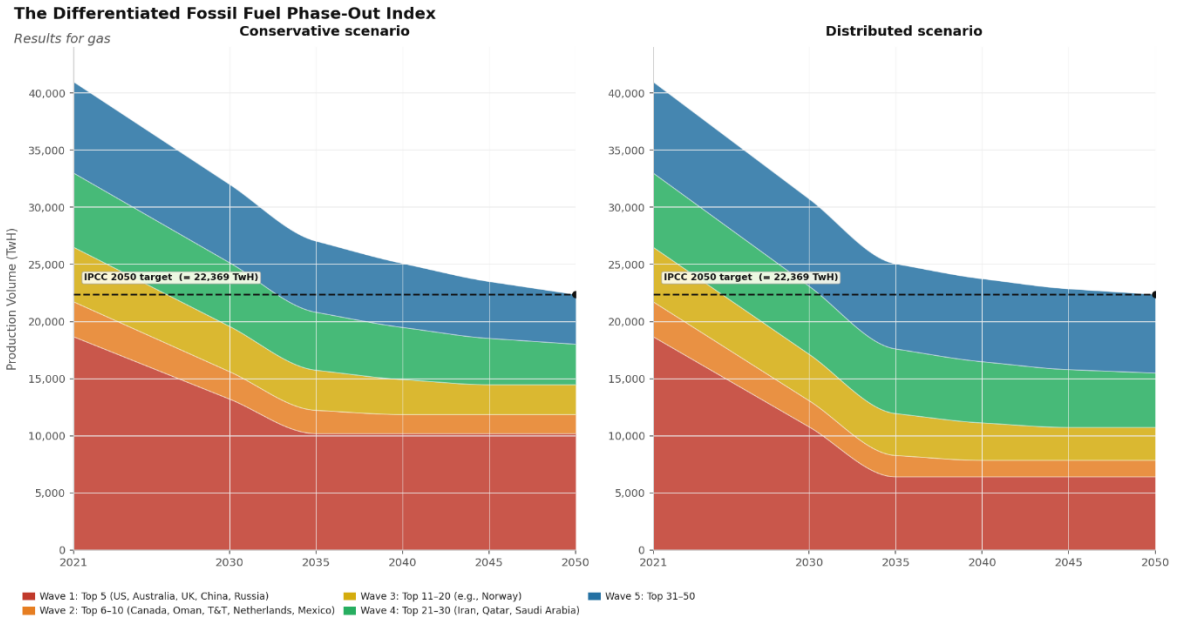


Figure 2 | Differentiated phase-out scenarios for natural gas consistent with IPCC 1.5 °C pathways. Stacked bar charts show production volumes (TwH) by wave group from 2021 to 2050, under the conservative scenario (left panels, uniform reduction percentage by wave) and distributed scenario (right panels, steeper reductions for earlier waves). Horizontal dashed line indicates the IPCC-compatible production level for 2050 (gas: −45% from 2021 baseline). Country group compositions are given in the legend; further detail in Methods.

Implications for the Global South and climate finance

The DPOI findings have direct implications for the just transition debate as it applies to developing-country producers. Sub-Saharan Africa accounts for roughly 3% of global cumulative emissions, and many African nations have only recently begun developing their hydrocarbon resources. Several rank in the lower tiers of the DPOI, indicating they bear less immediate responsibility to reduce production. A just, differentiated phase-out framework allows these countries time to extract a portion of their resources for domestic development while the largest historical emitters lead the reduction — what the paper terms *in-kind climate justice*.

This redistribution of time and economic opportunity does not replace direct financial transfers, but it complements them. The countries at the top of the DPOI ranking have generated extraordinary fiscal revenues from fossil fuel extraction over the past century while contributing disproportionately to the atmospheric carbon stock. This constitutes a form of ecological debt that should inform both the scale and direction of climate finance flows. The distributed scenario quantifies one dimension of this debt: by requiring the highest-ranked countries to phase out more steeply and earlier, it transfers fiscal space and market share to lower-ranked producers during the transition period.

The DPOI as an anchor for supply-side climate negotiations?

The DPOI is not designed as an all-encompassing governance framework, nor does it displace the role of domestic and international political negotiations. It represents, rather, a first attempt to make differentiated supply-side responsibility *tractable* by anchoring the conversation in four measurable, evidence-based pillars rather than leaving it at the level of rhetoric. The wave-based structure draws on the long tradition of differentiated commitment schedules in international environmental agreements, from the Montreal Protocol to the Paris Agreement's NDCs, and provides an analogous ladder of differentiated obligations for fossil fuel producers.

An interactive online version of the DPOI tool allows users to adjust pillar weights and observe the effects on country rankings, facilitating legitimate disagreement about normative priorities rather than concealing it. This transparency is itself a form of procedural equity: it makes explicit what is at stake in each weighting choice, rather than embedding contested value judgements invisibly in a black-box methodology.

The COP30 Roadmap's objective of translating the GST1 "transitioning away" consensus into implementation will require precisely this kind of supply-side differentiation framework, one that is grounded in verifiable data, sensitive to diverse national circumstances, consistent with IPCC carbon budgets, and transparent enough to sustain political legitimacy across a highly heterogeneous group of producing nations.

Full paper (see Annex1): Lebdioui, A. (2025). "A differentiated fossil fuel phase-out index: which countries should stop extracting oil and gas first?" Under review, Nature Climate Change.