

Scenario-Informed Fossil Fuel Phase-Out Roadmaps

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The Case for Conditional Roadmaps

The global transition away from fossil fuels requires more than political ambition. It requires credible, transparent, and actionable pathways that enable governments, financial institutions, and communities to understand what a managed phase-out looks like in practice. While the scientific community has produced hundreds of energy and emissions scenarios exploring possible futures, the diversity of approaches and assumptions often makes it difficult for decision-makers to interpret and use this knowledge effectively.

The feasibility of fossil fuel phase-out depends on variables requiring national and global deliberation. Quantitative signposts are needed to tie together assumptions about technology deployment, policy ambition, and international cooperation. A conditional roadmap acknowledges that different outcomes for technologies like CCS or bioenergy imply different requirements for fossil fuel phase-out rates. If CCS deployment falls short or if expectations are corrected, coal must decline faster. If demand reductions and efficiency gains are slower, decarbonization of supply must proceed faster.

The Scenario Compass Initiative (SCI) is a global community effort designed to address this challenge. Building on and extending the scenario assessment undertaken in the IPCC Sixth Assessment Report, SCI provides an open platform and analytical framework that helps users navigate the growing landscape of climate and energy transition scenarios. The initiative synthesizes a rapidly expanding body of new scenario evidence and translates complex model results into quantitative benchmarks for policy and planning. SCI's community-driven, continuously updated database includes more than 1,500 global emissions pathways, filtered against real-world observations and assessed for feasibility and sustainability (Riahi et al., 2026).

This submission draws directly on the SCI findings, as well as on complementary research using the MESSAGEix-GLOBIOM and AIM-Technology models that explores the implications of a complete phase-out of fossil fuels specifically (Mori et al., 2025).

Updated Global Climate Mitigation Benchmarks

Recent developments have fundamentally shifted what science can say about achievable climate outcomes. The continued rise of global emissions between 2020 and 2025, and in particular, the failure to achieve a rapid coal phase-down, means that previously assessed scenarios limiting peak warming to 1.5 °C with low or no overshoot no longer pass basic consistency checks against current observations. An assessment of available scenario literature using the SCI framework indicates that the most ambitious viable pathways now feature a peak warming of around 1.7 °C, with a return to 1.5 °C by the end of the century remaining feasible, but only if action is immediate and deep (Riahi et al., 2026).

Across most 1.5 °C-consistent pathways assessed in the updated scenario ensemble, global fossil fuel use declines by roughly two-thirds to four-fifths by mid-century, with coal declining fastest and oil and gas following as electrification and efficiency improvements accelerate. These benchmarks provide a quantitative reference point for understanding the scale and pace of the transformation implied by the latest scenario literature beyond AR6.

Fossil Fuel Benchmarks For 1.7 °C Peak Warming (SCI category GW2)

In pathways consistent with approximately 1.7 °C peak warming, the following near-term reductions are required by 2035:

- Global GHG emissions decline by 57-63% by 2035 relative to 2019, followed by further reductions (84-94%) by 2050.
- Coal declines by 66-88% within the next decade. There is no feasible and sustainable scenario in which coal plays a significant role beyond 2035.
- Oil peaks no later than 2030 and declines by 6-36% by 2035, with further reductions of 57-70% by 2050.
- Natural gas falls by 18-58% by 2035 and 40-90% by 2050.
- Wind and solar deployment increases by approximately 2.0-4.9 times by 2035 relative to 2019 levels.
- Net-zero CO₂ must be achieved around 2050 (range: 2047-2059), leaving approximately two decades for the transformation of the global economy.

These benchmarks are not independent upper limits that can be combined across fuels. Scenario assessment shows that pathways with slower reductions in one type of fossil fuel require correspondingly stronger reductions in others, or greater mitigation effort in non-energy sectors such as land use, industry, or CDR. The ranges describe alternative strategies, not minimum performance standards for individual fuels taken in isolation (Riahi et al., 2026).

The Role of the SCI Framework

The SCI platform (scenariocompass.org) enables decision-makers to explore this scenario space interactively. By making underlying assumptions transparent and adjustable, SCI allows governments and other actors to identify near-term milestones consistent with Paris-aligned pathways, evaluate trade-offs between supply-side constraints and demand reductions, and access regularly updated benchmarks through an annual update cycle.

Implications of a Zero-Fossil Future

Research using the MESSAGEix-GLOBIOM and AIM-Technology global energy system models investigates what a complete phase-out of fossil fuels (going beyond cost-effective 1.5 °C pathways) would require (Mori et al., 2025). The central finding is that defossilisation and decarbonisation are not equivalent objectives. Cost-effective temperature targets allow some residual fossil fuel use in hard-to-abate sectors, offset by CCS or CDR. A complete phase-out requires a qualitatively different energy system

transformation which is more demanding, but also more robust in terms of reduced reliance on uncertain technologies.

Challenges in a Zero-Fossil Future

A zero-fossil energy system by mid-century requires power generation to increase 1.6-1.8-fold compared to conventional 1.5 °C pathways, driven by the need to support both direct and indirect electrification via hydrogen-based fuels.

Average annual energy supply investments over the period 2026-2050 increase by up to 75% compared to cost-effective 1.5 °C scenarios or 75 to 125% compared to 2025, dominated by an increase in renewable energy investments which scale up by a factor of 2.5 to almost 3 compared to today. Demand-side investment increase by up to 50% compared to cost-effective 1.5 °C scenarios.

Sharper peaks in solar and wind installation in the first half of the century create potential supply chain bottlenecks.

Steel, chemicals, aviation, and maritime shipping require accelerated deployment of hydrogen and hydrogen-based fuels (ammonia, e-fuels). These sectors cannot wait for later phases of the transition.

Greater use of biofuels as non-fossil hydrocarbon alternatives increases pressure on land for energy crops.

Opportunities in a Zero-Fossil Future

Cumulative geological CO₂ storage is reduced by 37-77% compared to cost-effective 1.5 °C scenarios, addressing longstanding concerns about CCS feasibility and social acceptability.

Zero-fossil scenarios achieve greater reductions in fossil CO₂, leading to lower peak and end-of-century temperatures and reduced climate impacts.

A uniform phase-out of all fossil fuel consumption sends an unambiguous signal to producers to cease investment in fossil fuel exploration and infrastructure.

International fossil fuel trade is replaced by expanded trade in biomass and hydrogen-based energy carriers, creating new economic opportunities for countries currently dependent on fossil fuel revenues.

Policy Solutions

The TAFF initiative aims to move the global conversation from ambition to implementation of a just, orderly, and equitable transition away from fossil fuels. The SCl community can contribute directly to this objective by supporting the development of evidence-based phase-out roadmaps. Through its platform and global research network, SCl can help identify key milestones consistent with climate goals (such as timelines for reducing fossil fuel production, scaling clean energy deployment, and managing stranded assets) while also highlighting uncertainties and trade-offs across different

transition pathways. Three concrete directions follow from the scenario evidence, aligned with the conference's thematic pillars.

Solution 1: Translating Global Pathways into Actionable Benchmarks

SCI synthesises insights from hundreds of peer-reviewed scenarios to provide quantitative reference points for the pace of fossil fuel phase-out, energy system transformation, and emissions reductions compatible with the Paris Agreement. The most urgent near-term action is accelerating direct electrification across energy end-use sectors (transport, buildings, and portions of industry) supported by a 2.5- to 3-fold increase of average annual investments in non-fossil electricity generation in the period 2026 to 2050 compared to today (Mori et al. 2025). SCI benchmarks show that no feasible Paris-consistent pathway avoids this transformation; they differ only in how much residual fossil fuel use is tolerated in exchange for greater CCS or CDR deployment.

Solution 2: Supporting Just and Orderly Transition Planning

By comparing scenarios with different socioeconomic and policy assumptions, SCI helps illuminate alternative strategies for countries with varying levels of fossil-fuel dependence, providing insights into how transitions can be sequenced while safeguarding development priorities. For sectors where direct electrification is not currently viable (steel, chemicals, aviation, maritime shipping) hydrogen and hydrogen-based fuels (ammonia, e-fuels) represent the primary non-fossil alternative. Scaling these supply chains requires immediate investment in research, demonstration, and deployment at commercial scale (Mori et al. 2025).

Solution 3: Strengthening International Cooperation Through Transparent Evidence

SCI's open platform enables governments, researchers, and civil society to explore scenario results interactively, helping build shared evidence for international dialogue on fossil fuel phase-out strategies. The SCI framework can directly support the development of internationally agreed milestones for coal, oil, and gas reduction by 2035 and 2040, providing a shared and regularly updatable evidence base. These milestones should be explicitly conditional, linking the pace of fossil fuel decline to progress on clean energy deployment, CDR, and demand-side transitions, making them both credible and adaptive to evolving real-world trajectories.

Conclusion

At a moment when countries are seeking to translate climate commitments into concrete transition plans, the SCI offers a bridge between the global scientific scenario community and real-world decision-making, enabling policymakers to navigate trade-offs under uncertainty rather than relying on static, inflexible and rapidly out of date targets.

The most important message from the updated evidence base is that the window for an orderly transition is narrowing. The failure to reduce coal by 2025 has permanently raised the minimum achievable peak warming by approximately 0.1 °C. Every additional year of delay further narrows the corridor within which a managed, just, and equitable transition remains feasible.

By making scenario knowledge more transparent, comparable, and policy-relevant, SCI can help support the goal of advancing practical pathways for transitioning away from fossil fuels in a way that is both ambitious and equitable. The SCI stands ready to support the TAFF initiative with transparent, regularly updated, and policy-relevant evidence.

References

Riahi, K. et al. (2026). Mitigation benchmarks from the 2025 community update of global emissions pathways. Research Square preprint. <https://doi.org/10.21203/rs.3.rs-8891091/v1>

Mori, S. et al. (2025). Challenges and opportunities of the full phase-out of fossil fuels under the 1.5°C goal. Nature Communications, in review [Preprint available at Research Square: <https://doi.org/10.21203/rs.3.rs-5698098/v1>].