

“Geological Net Zero” (Geological Carbon Neutrality) – How could we get there?

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25 March 2022 (supersedes previous version dated 30 January 2022; new text is in blue type)

Introduction

Our purpose here is to set out, in as simple terms as we can, our current perspective on how the global fossil carbon problem could in large part be solved (given sufficient political will). Our focus is on what we think are key “supply-side” aspects that have so far received insufficient attention as potentially vital components of the global “ecosystem” of climate policies, **which is currently so dysfunctional that it has not yet delivered any reduction in global carbon emissions.**

Our immediate goal is to stimulate discussion towards the development of a simple set of policy instruments (and/or industry initiatives) that would set the world on a steep pathway to what we call “geological net zero” (GNZ) or geological carbon neutrality. By this we mean real-time balancing of extraction of fossil carbon by equal implementation of “geological-timescale carbon sequestration/storage” (GCS)¹. The concept of GNZ should apply to all types of extracted fossil carbon: i.e. natural gas, oil, coal and limestone (for cement manufacture). GCS could encompass any technique that securely prevents CO₂ from entering the atmosphere for millenia.

For the avoidance of doubt, we aspire to be technology-neutral; we do not have in mind any particular goal for the scale of the contribution of GCS to reaching GNZ.

The existing proposal that most closely aligns with our perspective is “Carbon Takeback Obligation” (CTBO) (carbontakeback.org), so what follows includes commentary on its strengths and weaknesses.

Motivations

We are both geoscientists, late in our careers as applied scientists in various parts of the energy sector (hydrocarbons, geothermal, nuclear and hydrogen). Driven by a strong sense of urgency, we have become increasingly concerned by the failure of current climate policy frameworks to have any discernible effect on global extraction and emission of fossil carbon. The world is consequently in the midst of a very rapid geological event, the magnitude of which will be largely determined by what happens to rates of net fossil carbon extraction in the next 10 to 15 years. It is no exaggeration to speak of a “climate emergency” (as the UK Parliament did in 2019), especially while many political and industry leaders have evidently not yet truly grasped the scale and speed of changes to the global energy system needed to ensure that global warming does not substantially exceed 1.5°C and increase the risk of “runaway climate change”. Quantitatively unconstrained rhetoric, bordering on magical thinking, still seems to be prevalent. We also observe a great deal of national exceptionalism and a general disregard among developed countries to take seriously the Paris Agreement’s principles of “common but differentiated responsibilities” and “respective capabilities” when setting their Nationally Determined Contributions on emissions reductions.

This brings into question whether the UN Convention on Climate Change dating from 1992 should be amended to take into account the climate emergency we are now in; of particular concern is Article 3 stating that the *“Parties should cooperate to promote a supportive and open international economic system that would lead to sustainable economic growth and development in all Parties”*. What if “economic growth” (understood as defined at the time of the Convention as GDP growth) is no longer compatible with the decisions that must now be taken

¹ We are using the definition of GCS given by Stuart Jenkins and co-authors in their October 2021 paper in Joule. [See Sources listed at the end of this paper.]

to minimize the risk of global climate catastrophe? Is the UN Climate COP process still the only place where international policy and economic decisions affecting the course of climate change should be negotiated?

Against this background, we want to be assured that the potential for supply-side control of fossil carbon will be taken as far as it can be in these next few critical years.

Some strengths of CTBO

We support the principle of CTBO for a number of reasons – some given prominence by its proponents, others not so much.

- Something like CTBO is what the fossil carbon extraction industries (and the countries that host them) should have been subject to since the problem of anthropogenic climate change was first universally acknowledged at the 1992 Rio Earth Summit.
- As proposed, CTBO recognises that only GCS is a valid way of compensating for extraction of fossil carbon. We do not see “nature-based climate solutions” as legitimate substitutes for GCS. This is not to say that we are against nature-based climate solutions *per se*; quite the contrary.
- CTBO implementation globally would smooth the transition to GNZ, reducing risks of energy price shocks (upward or downward) and associated economic and geopolitical shocks, especially for countries and corporations most invested in fossil carbon extraction at present.
- The primary metric of CTBO is a real substance (carbon), not a monetary one. Implementation of CTBO would enable unit costs of GCS to be “discovered” through market forces. The resulting increased costs (which would not be very great in comparison to oil and gas price fluctuations in recent years) would flow through supply chains to consumers. There would be no need for pricing/taxation of “embedded fossil carbon” associated with manufactured products (which may in any case be practically unachievable). Trade disputes under the banner of carbon border adjustments would not be able to tarnish core climate policy.
- CTBO transactions would be much easier to monitor and verify than those relying on emissions-based carbon accounting. As long as carbon accounting under CTBO is kept separate from emissions-based accounting, the former should not be open to double-counting or other deliberate or inadvertent inaccuracies.
- CTBO would generate a huge competitive market for GCS, ensuring that a mature and cost-optimised GCS industry would be available in the likely event that the world will need to achieve net negative CO₂ emissions in mid-to-late century.

Some weaknesses of CTBO

As we see it, the main design problem with CTBO as currently proposed is that it is framed solely in terms of being mandated by national governments, acting independently (or at best in regional groupings), with no globally effective governance. The best-case scenario we can imagine under these conditions is early adoption by the Netherlands, followed over a few years by most of the EU and a host of countries with globally insignificant use of imported fossil fuels or indigenous fossil carbon resources at stake. In such a case, we find it incredible that the world would arrive in the late 2030s with global net fossil carbon extraction and emissions anywhere near a pathway compliant with the Paris Agreement.

A more fundamental problem (not unique to CTBO) is the lack of a self-evident basis upon which to determine the (explicit or implicit) fossil carbon extraction budget for a given country. Politically, the easy answer for early adopters would be to aim for GNZ by 2050. However, that approach fails to consider what that country’s share of the global fossil carbon budget should legitimately be. Targeting GNZ by 2050 would give the appearance of being in line with a 50% chance of limiting global warming to 1.5°C, but that will only be the case if all major fossil fuel producing countries will do the same or better, regardless of “respective capabilities”. That to us seems highly unlikely in the absence of globally effective controls on fossil carbon extraction.

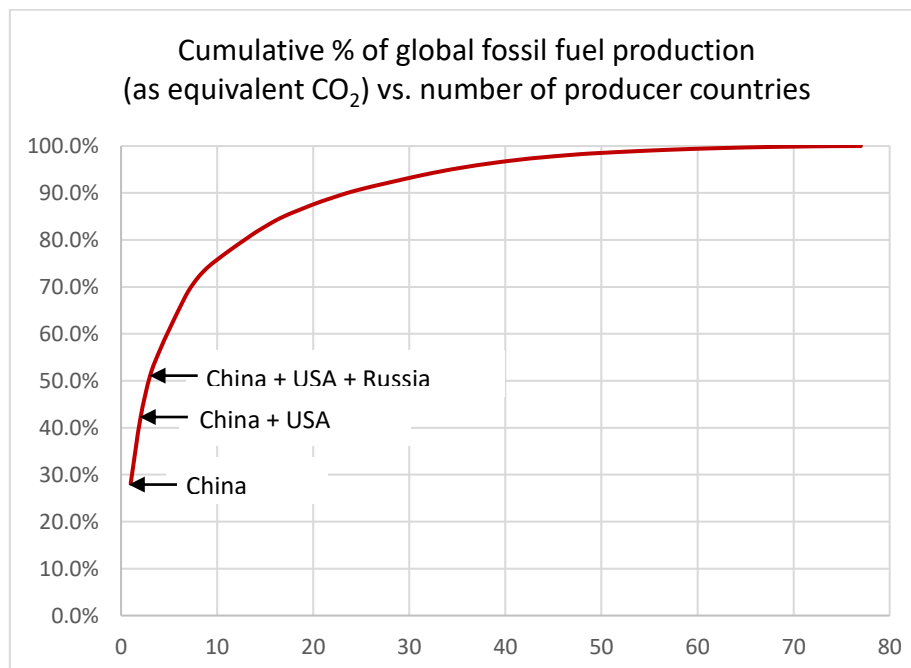
In the case of a country imposing a CTBO on imported fossil fuels, we foresee difficulties of accurate accounting if there are wide variations in CTBO between producer countries (e.g. different dates for achieving GNZ).

A supply-side treaty?

Recognition of the existential threat to human civilisation posed by fossil carbon extraction and emission has led some to propose a supply-side “Fossil Fuel Non-Proliferation Treaty” (FF-NPT), drawing inspiration from the nuclear NPT. This proposal has been put forward by an alliance of largely progressive/left-leaning and green/environmentalist organisations, with associated stridently anti-fossil-fuels messaging. To date, it does not appear to recognise the concept of GNZ or a role for GCS, let alone the potential role that the fossil fuel carbon extraction corporations and countries could have in delivering GNZ. The only public figure we are aware of who has advocated putting GCS into a FF-NPT is the senior British Conservative Member of Parliament Sir Bernard Jenkin (in an essay published in July 2021). He envisages that the treaty would involve an explicit share-out between countries of an agreed fossil carbon budget and the setting up of a supranational institution to issue tradable carbon extraction units and equivalent carbon sequestration units (effectively creating a global CTBO scheme). However, we are not aware of this concept being developed further so far.

A well-designed supply-side treaty would be capable of delivering the necessary rapid halving of the net global fossil carbon extraction rate, regardless of the contribution of GCS. However, allowing a role for GCS seems to us to make an effective supply-side treaty a more realistic prospect than would otherwise be the case. Therefore, our main plea here is for the proponents of CTBO and of a supply-side treaty to bring these concepts together into a credible integrated proposition. An addendum to this note presents complementary framings of a supply-side treaty, intended to appeal to a broad spectrum of perspectives.

As things stand, we do not take issue with a petroleum industry insider who wrote to us that although “a logical necessity, global agreements of the type you imagine are almost impossible”. But the geopolitical situation could change rapidly, so it would be wise to have a worked-out design available, should the need for a supply-side treaty involving GCS start to be recognised at the top level². One factor to consider is that (by our calculations using IEA data for 2020; see graphic below), 90% of the world’s annual fossil fuel carbon extraction is currently in just 24 countries (of which the UK is the 24th, just ahead of Egypt)³. China and the USA (together accounting for 42%) would have to be among the initiators, perhaps bilaterally in the first instance (or trilaterally including Russia with 9%), analogous to the bilateral “great power” USA/Soviet Union nuclear weapons reduction treaties that heralded the end of the Cold War.



² This paragraph was written in January 2022, before the Russian invasion of Ukraine.

³ Assuming that Russia would not be involved, a slightly smaller number of countries would account for 80%.

A global CTBO pact?

In the absence of support for a legally binding treaty, could there be an opportunity to create some form of non-binding agreement or pact that would go a long way towards addressing the weaknesses of CTBO discussed above? To be clear, we are talking here of something much more robust than, for example, our (limited) expectations for the effectiveness of the “Powering Past Coal Alliance” or the “Beyond Oil and Gas Alliance” launched at COP26. As with the supply-side treaty option discussed above, it would have to start with at least some of the major extractor countries involved and include coal from the outset. The main challenge would seem to be to find sufficient incentives to attract the necessary participation by almost all the major players. Perhaps those who espouse CTBO (or similar) but not a supply-side treaty could come forward with proposals that should attract such a level of participation⁴.

A globally effective CTBO pact could perhaps be developed under or alongside the UNFCCC, and could be a focus for COP27 and efforts by the outgoing UK and incoming Egyptian presidencies. After “keeping 1.5 alive” as the slogan for COP26, could “geological net zero” be a key buzz phrase (at least in policy circles) for COP27?

A regional CTBO agreement (e.g. for the North Sea hydrocarbon province) could perhaps be a trailblazer for a global CTBO pact (or even a supply-side treaty), but we think there is not time to await the conclusion of such regional agreements before starting to pursue a globally effective goal.

An industry-led approach?

We are not aware of any serious proposals for fossil carbon extractors to start accepting CTBOs in the absence of regulation. We are aware of the Sustainable Markets Initiative proposals for a carbon reporting/accounting framework based on a “carbon storage obligation” (CSO) and carbon storage units (CSUs). However, we do not think this is a strong enough proposal, as it does not cover coal, does not go upstream far enough (it puts the CSO on suppliers of oil and gas rather than extractors/producers) and seems to rely heavily on voluntary commitments by companies in the downstream value chain to create demand for CSUs. There seems to be minimal role for regulation. For a given jurisdiction’s CSO, who would determine the GNZ date and the pathway to it, and how would the CSO be imposed on reluctant companies? In comparison to CTBO, this version of CSO seems to have avoidable complexity, making the proposals difficult to communicate to policy-makers, NGOs and general citizens, and making their implementation potentially open to being undermined by opaque accounting.

However, enlightened self-interest could lead the extractors that are best placed to implement GCS to ask relevant governments to mandate CTBO in the name of “levelling the playing field” (as recently suggested by Hugh Helferty, a former senior Exxon employee), while also making themselves more attractive to longer-term investors.

Some technological considerations

In various contexts, we have encountered scepticism that GCS can be scaled up at anything like the speed needed to make a material contribution to reaching global net zero emissions. One of us (HR) shared at least some of that scepticism until having read Daniel Yergin’s account (in “The New Map”) of the explosive growth of first shale gas and then shale oil in the USA in the first two decades of this century, and the simultaneous rapid growth in the global trade in liquefied natural gas. We are not passing judgement on whether these developments were or were not a good thing for the world; we are just pointing out how quickly an industry can be put together from a basic toolkit of directional well drilling, pumping fluids, and constructing gas pipelines and tanker infrastructure – essentially the same toolkit as required for “traditional” GCS.

⁴ We are aware of the proposals advanced by Paul Zakkour and co-authors in their August 2020 paper in Climate Policy. However, they do not discuss how their proposals would rapidly become globally effective.

Then there is the currently unknown potential for other forms of GCS, such as underground mineralisation, “turquoise”⁵ hydrogen production, basaltic rock dust weathering, manufacture of artificial carbonate aggregates and oceanic carbon dioxide removal techniques.

The speed of the USA’s shale revolution also increases the credibility of there being something to offer currently coal-dependent countries that may be reluctant to abandon their fossil carbon resources in the pursuit of net zero emissions and/or GNZ. For such countries, retrofitting coal-fired power plants with carbon capture and GCS may have some role to play – perhaps supported by climate finance. But the bigger picture could be a much larger than foreseen role for hydrogen. “Blue” hydrogen could be derived from coal, one way or another, whether from coalbed methane, underground coal gasification or even underground hydrogen production. Coal mining, however, has no long-term future, as far as we can see.

We also see great potential for synergies and integration from linking the development of the technologies needed for GNZ use of fossil carbon to some non-fossil energy technologies (e.g. “green” hydrogen, biomethane, bioenergy with GCS or biochar-enabled energies). Such opportunities could further help smooth the global transition to net zero and eventually net-negative emissions.

Acknowledgements

We are very grateful to Margriet Kuijper for constructive comments on the original version of this paper, and for pointing us to Hugh Helferty’s December 2021 article. [Comments from Paul Zakkour prompted some of the revisions and clarifications in the current \(March 2022\) version of this paper.](#)

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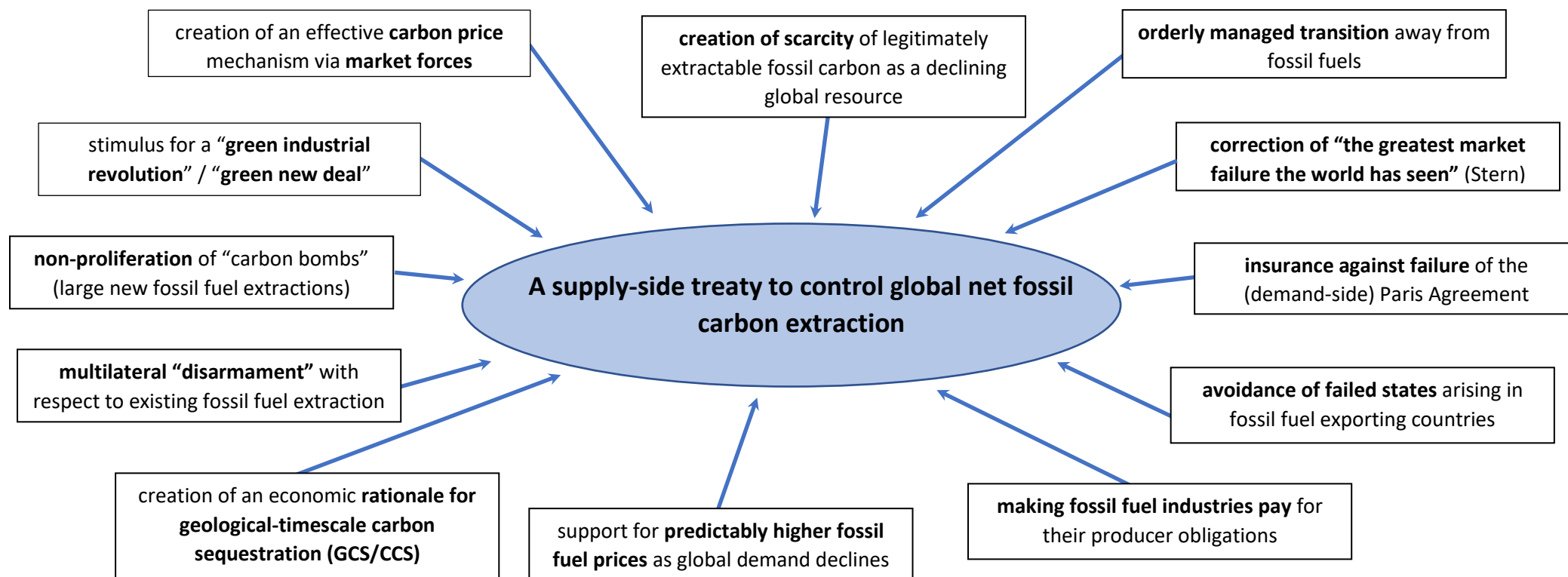
Patrick Portolano is a civil engineer turned energy resources geoscientist. He started his career in oil and gas field developments in Europe, Africa and North America. He then created EOSYS, a company specialising in geosciences which has been involved for more than 25 years in exploration/development projects for hydrocarbons, metals, groundwater and geothermal resources. EOSYS now focuses its development on the exploration of naturally-occurring hydrogen and the conversion of hydrocarbon production sites into hydrogen production and carbon storage sites. He leads the H₂-CO₂ working group of the French Association of Petroleum Consultants (www.acp-france.org).



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This and our other writings on the fossil carbon problem have all been done *pro bono*.

**Addendum: Complementary framings for a multi-nationalⁱ supply-sideⁱⁱ treatyⁱⁱⁱ
to control global net transfer^{iv} of fossil carbon^v from the geosphere^{vi} to the atmosphere**



ⁱ multi-national = eventually including as many countries as possible, necessarily including most of those with substantial domestic fossil fuel extraction industries and/or unexploited fossil fuel resources

ⁱⁱ supply-side = controlling supply/extraction rather than consumption/emissions

ⁱⁱⁱ treaty or other legally binding agreement

^{iv} net transfer = extraction minus geological-timescale carbon sequestration/storage (GCS - also commonly known as carbon capture and storage; "CCS")

^v fossil carbon = carbon in fossil fuels and in limestone used for cement manufacture (the latter may or may not need to be within the scope of the treaty)

^{vi} geosphere = (in this context) the deep subsurface and geologically stable materials at the earth's surface