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Policy Perspective

Institutional mechanisms to keep unburnable fossil fuel reserves in the soil

Lorenzo Pellegrini [a,b,*], Murat Arsel [a,b], Martí Orta-Martínez [b,c,d], Carlos F. Mena [b], Gorka Muñoa [d]

[a] International Institute of Social Studies (ISS), Erasmus University Rotterdam, the Netherlands
[b] Instituto de Geografía, Universidad San Francisco de Quito, Ecuador
[c] Faculty of Sciences and Technology, Central University of Catalonia-University of Vic, Catalonia, Spain
[d] Institute of Environmental Science and Technology, Autonomous University of Barcelona (ICTA-UAB), Catalonia, Spain

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ABSTRACT

To limit the probable increase in global mean temperature to 2 °C, about 80%, 50% and 30% of existing coal, gas and oil reserves, respectively, would need to remain under the soil. While the concept of 'unburnable fuels' has become prominent, there has been little discussion on institutional mechanisms to identify specific fossil fuel reserves to be left untouched and the financial mechanisms for raising and distributing funds to compensate the right-holders for forgoing extraction. We present an auction mechanism to determine the fossil fuel reserves to be kept untapped – those whose extraction would generate the least rents, ensuring cost efficiency. The auctions could be complemented by other provisions to reap collateral benefits of avoided extraction, for example by prioritizing reserves that coincide with outstanding socio-environmental values that are likely to be disrupted by the extraction of fossil fuels. We also discuss how to raise funds, for example through a fossil fuel producers-based tax, to finance the mechanism compensating right-holders and ensuring commitment. The effective identification of unburnable fossil fuel reserves and the development of accompanying funding mechanisms seems to be the elephant in the room of climate negotiations and we aim at contributing to an overdue discussion on supply-side interventions to mitigate greenhouse gas emissions.

'Keep fossil fuels in the ground.'

People's Demands for Climate Justice, signed by 295,000+ people and 403 organisations, 2020

'Yet amid the clamour is a single, jarring truth. Demand for oil is rising and the energy industry […] is planning multi-trillion-dollar investments to satisfy it. No firm embodies this strategy better than ExxonMobil, the giant that rivals admire and green activists love to hate … [I]t plans to pump 25% more oil and gas in 2025 than in 2017. If the rest of the industry pursues even modest growth, the consequence for the climate could be disastrous.'

(The Economist, 2019)

1. Introduction: unburnable fossil fuel reserves

Approximately 80%, 50% and 30% of existing coal, gas and oil reserves, respectively, would need to remain under the soil in order to limit the probable increase in global mean temperature to 2 °C (Leaton, 2012; McGlade and Ekins, 2015). Even more ambitious targets would be necessary to limit it to 1.5 °C to comply with the commitments made under the Paris Agreement (Allen et al., 2019). The implications of leaving untapped such large portions of existing reserves on the assets of energy companies have hit the headlines globally (Griffin et al., 2015) and prompted a discussion on 'unburnable fuels' (e.g. Bos and Gupta, 2017; Jakob and Hilaire, 2015; The Economist, 2013). Despite their potential significance, however, only recently has there been a surge in interest on supply-side climate policy. Several studies have focused primarily in making the case of supply-side initiatives (e.g. Asheim et al., 2019; Burke and Fishel 2020; Lazarus and van Asselt, 2018; Lazarus et al., 2020) and a number of compelling proposals on how to enact supply-side climate policies are also beginning to be made (e.g. Newell and Simms 2019; Pye et al., 2020). This paper aims to contribute to this literature by discussing how to identify reserves to leave untapped and how to create the necessary financing mechanism.

* Corresponding author. International Institute of Social Studies (ISS), Erasmus University Rotterdam, the Netherlands.
E-mail address: pellegrini@iss.nl (L. Pellegrini).

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In terms of identifying reserves of unburnable fuels, rather than focusing on the spatially explicit distribution of reserves at the continental scale (McGlade and Ekins, 2015), or for limited areas such as the Amazon Basin (Codato et al., 2019), this article proposes a novel mechanism built around a reverse auction model to identify the specific reserves that can be left unextracted. Regarding the financing of the mechanism, it highlights several complementary ideas that seek to combine concerns of ecological sustainability with global social justice. Before attending to these issues, the next section describes the potential strengths of a supply-side initiative, especially when used in conjunction with demand-side measures.

2. Supply-side intervention to complement demand-side measures

The overwhelming majority of climate policy efforts have so far been focused on abating greenhouse gas emissions by diminishing consumption and, as a consequence, demand in the global fossil fuels market. However, several reasons suggest that demand-side and supply-side interventions could be complementary. First, having two sets of policies will reduce carbon leakage. According to the logic of inter-country 'carbon leakage' (Babiker, 2005), decreasing demand makes fossil fuels cheaper and encourages countries that do not have binding commitments to consume more, in part offsetting the effect of demand policies. Leakage can also be intertemporal and create a 'green paradox' where the perspective of reduced global consumption of fossil fuels generates an incentive for producing countries to extract as much and as fast as possible to generate rents before the demand for fossil fuels declines (Eichner and Pethig, 2011; Sinn, 2009). A similar dynamic is possible with supply-side policies: when fossil fuels are left unextracted in one country, global supply experiences a contraction, resulting in a marginal increase in price and making it more profitable for other countries to extract more – a supply-side leakage. Implementing supply and demand mitigation policies in conjunction would synergize and improve each other's effectiveness by counterbalancing price-effects and decreasing leakage.

A related issue is the acceptability of supply-side climate policies, if compared to demand-side policies, for fossil fuel interests. Effective demand-side policies decrease the consumption of fossil fuels and reduce their prices across the board, which motivates the opposition of fossil fuel interests to such policies. Supply-side policies would have no such effect on prices and the proposal discussed here (reducing supply through compensation) would create winners as well as losers among fossil fuel interests. The former would include right-holders who see their resources becoming scarcer and, as a consequence, global prices of their products and assets higher, while the latter would include the downstream industry that would process a lower amount of products. The heterogeneity of the effect of supply policies over the fossil fuel industry would undermine any monolithic front against them.

Moreover, having two sets of policies might work as insurance in case one set would not be implemented effectively, increasing the credibility of both (Asheim et al., 2019). Similarly, a supply-side intervention would add an element of concreteness to climate policies based on widespread reductions of consumption (Green, 2018). Additionally, instituting a supply-side policy offers the advantage of low transaction costs since it would be much easier to monitor a limited number of point supply sources of a commodity if compared to diffuse consumption sources of greenhouse gas with uncertain counterfactuals –as discussed in the extensive literature on emission accounting (e.g. Searchinger et al., 2009). Furthermore, the object of verification is more concrete and easier to monitor if compared to greenhouse gas emissions (Newell and Simms, 2019, p. 5) and could also be performed through remote sensing (Facchinelli et al., 2020). Monitoring of compliance can also be supported by civil society actors, such as non-governmental organizations and social movements. Growing and increasingly more effective community based monitoring systems and citizen science practices which are currently focused on ensuring the compliance of oil producers with corporate social responsibility and environmental protection requirements (e.g. Mena et al., 2020) could be repurposed toward monitoring non-extraction.

3. Reverse auctions, climate change mitigation and collateral benefits

Numerous mechanisms could be put in place to enable the conservation of fossil fuel reserves, ranging from command and control instruments (e.g. requiring state authorities to identify and protect unburnable fuel reserves) to market-based instruments (e.g. leveraging on the allocation of property rights and voluntary-based trading, or production taxes) (Lazarus et al., 2015). Here we discuss a hybrid instrument, which combines elements of both which, under certain conditions, would be cost-efficient and could be coupled with strategies to reap collateral benefits of fossil fuel conservation.[1] Cost efficiency is realized when a policy objective is achieved in the least costly manner possible; a mechanism that relies on a carefully regulated market-based mechanism to leave fossil fuel reserves unexploited could deliver cost efficiency by keeping the desired level of fossil fuel reserves untapped and minimizing the expenditure to compensate the right-holders. In the case of fossil fuels, the identity of the right-holders will depend on the domestic legal framework that assigns property rights to subsoil resources and the legal system of concessions (Campbell, 1956). In most legal systems subsoil rights are held by the state unless there are concession rights –the USA being a notable exception among the major fossil fuel producers.[2]

An institutional mechanism to keep fossil fuel reserves in the soil could include the construction of a voluntary framework where the holders of rights over (proved, probable and possible) commercially viable fossil fuel reserves would obtain compensation for forgoing their right to extract them. The compensation amounts could be set through a reverse auction where the right-holder participates to secure a payment against the commitment of non-exercising extraction rights (e.g. Ray et al., 2011). Competitive bidding would then be the mechanism to elicit the desirable amount of fossil fuels that will not be extracted for the lowest possible amount of compensation. This mechanism is akin to the common public procurement practice where bidders compete to provide specified services or goods and the lowest bid is the one securing the contract. The bidding system would guarantee that expenditures on compensation are kept to a minimum and that the right-holders over reserves whose potential to generate rents is the lowest are the ones that accept lower bids. The rent in this instance has to be understood as the net value generated by the extraction of fossil fuels. Thus, lower rents would be associated with reserves of lower quality, situated in remote locations or, more generally, of lower market value and/or costlier to extract, transport and process.

The argument that market-based instruments, including reverse auction mechanisms, are cost-efficient and can achieve socially desirable results is based on numerous assumptions related to perfect markets. However, given pervasive market failures with respect to extractive

[1] The instrument presented here is compatible with other policy instruments and could be hybridized in different ways, for example by matching auctions with taxation as discussed in Section 4.

[2] In terms of mitigation, paying resource owners to forgo extraction would be equivalent to purchasing property rights. However, while paying resource owners to forgo extraction would entail a substantial diminution of their property rights (withdrawal and alienation rights; Schlager and Ostrom, 1992), acquiring the property rights *tout court* would transfer ownership (and the associated bundles of rights) over the resource. From an institutional perspective, the latter solution might be more complex to implement, because of (constitutional) limitations to the transfer of ownership of the subsoil that are present in many legal frameworks (Campbell, 1956).

industries in general, and fossil fuels in particular, the price mechanism by itself is unlikely to provide sound economic incentives to achieve socially desirable outcomes beyond climate change mitigation. This is because rents generated by extractive industries are not affected by the socio-environmental costs created by extractive operations – they are externalities. These costs are exemplified by extraction operations interfering with indigenous territories inhabited by people in voluntary isolation and coinciding with globally relevant biodiversity hotspots (Finer et al., 2008). More generally, fossil fuel industries are associated with the generation of waste, deforestation, oil spills and numerous cases of socio-environmental conflict, just to mention a few of the impacts, and market mechanisms alone are notoriously ill-suited to guide the allocation of resources in such contexts (Bromley, 2007; Muradian et al., 2013; Orta-Martínez et al., 2018).

It follows that a hybrid mechanism might be preferable and the reverse auctions proposed here could be adjusted to accommodate also non-monetary values. By creating incentives for keeping specific fossil fuel reserves underground, the mechanism would offer the opportunity to generate collateral benefits by incorporating socio-environmental values into the decision to preserve specific reserves. For example, the auctions could be implemented incrementally, beginning with reserves that coincide with specific socio-environmental values. Fig. 1 exemplifies the overlap of global fossil-fuel distribution with biodiversity hotspots. For instance, the first compensation auctions might include only fossil fuel reserves that coincide with biodiversity hotspots and the extra costs associated with limiting the supply of actionable reserves would be countervailed by the conservation of globally relevant biodiversity values. This incremental approach could also be practical in view of the time needed to generate sufficient funds to keep the necessary amount of existing fossil fuel reserves underground. Another option would be that reserves coinciding with the specific socio-environmental values are subject to a bonus over the value of the reverse auction –i.e. the bonus would reflect social value and internalize externalities.

Additionally, the use of auctions (with or without instruments to reap collateral benefits) would be compatible with right-holders considering non-monetary motivations to identify unburnable fossil fuel reserves. Public authorities might pursue multiple objectives, apart from maximizing rents, and could privilege the conservation of fossil fuel reserves whose extraction would damage some of these objectives. For example, state authorities might want to accept compensation for avoiding the exploitation of highly contentious projects or to achieve environmental conservation, or both (Pellegrini et al., 2014). Furthermore, the instrument would be compatible and could be combined also with other non-market-based instruments, such as non-proliferation treaties (Newell and Simms, 2019). For example, a 'coal elimination treaty' could be implemented, while gas and oil reserves could become part of the mechanism outlined here (Burke and Fishel, 2020).

The main actors into the operation of this market-based mechanism would be (national) state agencies, who are in most jurisdictions the owners of the resources in question. The involvement of states in the functioning of this mechanism would endow it with additional legitimacy since it would also circumvent most of the (often legitimate) criticisms of market-based environmental policy instruments (Lohmann, 2011) by separating the pricing process from (corporate) profit motives. To the extent that nature would be commodified, this would not purport to be the 'true price' nor would it involve further transactions. All it would do is to articulate a monetary compensation for right-holders who agree *not* to commodify nature through extractive processes and might also elicit and compound non-profit-based motives of right-holders (Ezzine-de-Blas et al., 2019).

The possibility of strategic over-estimation of the size of fossil fuel reserves is a potential concern. In fact, regardless of climate policies, the assessment of reserves lends itself to over-estimation, since the value of energy companies is determined (in part) by the size of the reserves they control (Misund and Osmundsen, 2017). We would expect similar issues in estimating the size of unburnable reserves and reporting and disclosure standards similar to those applied in the oil and gas industry should be adopted (Bebbington et al., 2019). Alternatively, *ad hoc* methodologies could be developed –like those prototyped by the 'Fossil Fuel Non-Proliferation Treaty Initiative' (Byrnes, 2020).

4. Funding and commitment

Establishing the framework to compensate right-holders who forgo their extraction rights over fossil fuel reserves will have to be matched by mechanisms to generate the necessary funds and address the challenge of avoiding free-riding in the provision of a global common good (Nordhaus, 2015). There are several (complementary) possibilities.

The concept of ecological debt could be used to assign responsibilities for the consumption of the global carbon sink (i.e. greenhouse gas emissions in the atmosphere) and funding could be collected based on accumulated past emissions (Martinez-Alier, 2002). Another option would be to collect voluntary contributions into a fund. The Yasuní-ITT initiative from Ecuador, for instance, had aimed to combine the concept of global ecological debt with a voluntary mechanism to keep unexploited oil reserves from a biodiversity hotspot inhabited by people in voluntary isolation in the Amazon (Arsel, 2012; Pellegrini et al., 2014). Debt-for-nature swaps, which are no longer common, had taken a different approach, focusing on the financial debt of developing countries and cancelling them out in exchange for conservation commitments (Macekura, 2016). While voluntary funding would face the typical free-riding problems of contributing to global commons, it could be complementary to other ways to raise funds and, if compared to the Yasuní-ITT initiative and debt-for-nature swaps, it would be undergirded by a multilateral structure providing for a more level playing field for negotiation between developing and developed countries.

An alternative could be to revive and adjust the Daly-Correa tax proposal. Based on an idea of Herman Daly that was tabled at OPEC by Ecuadorian President Rafael Correa in 2007 (Antón, 2020; Le Quang, 2016, p. 197), this proposal aimed at creating a mechanism to finance climate change adaptation projects in the developing world by instituting an oil export tax levied by oil producers. In the adjusted version, the tax revenues would instead be used to compensate countries that forgo their fossil fuel extraction rights. As a consequence, and compared to a regime limited to demand-side climate policies, the relative scarcity of the remaining reserves would increase as well as, at least in the short to medium run, their value and oil-producing countries would be given a concrete incentive to support such a tax.

The details of the institutions overseeing the instrument will have to be worked out through negotiations among the participating partners, but we anticipate some of the challenges that will be faced. A fundamental conundrum accompanying the funding mechanism would be that the right-holders, after being compensated for forgoing extraction rights, could face the temptation of breaking their promise by keeping the compensation and still engaging in extraction activities. The risk would be amplified by political cycles and the volatility of fossil fuel prices. Therefore, credible commitment instruments should be nested in the mechanism. These instruments could include international arbitration, similarly to the ones routinely included in international investment agreements.[3]

Alternatively, compensation rights could also be limited to the interest generated by a fund in which the compensation would be deposited. The capital in the fund could be withdrawn progressively over an extended period of time in a process that would terminate when the transition to renewable energy resources is expected to undercut the market value of fossil fuels. An intergovernmental structure, such as the

[3] While arbitration has been used most commonly by companies to file claims against states, they can be used to enforce contracts between any party. Furthermore, proposals for reform include the possibility for states and third parties to use arbitration against companies (Pellegrini et al., 2020, p. 467).

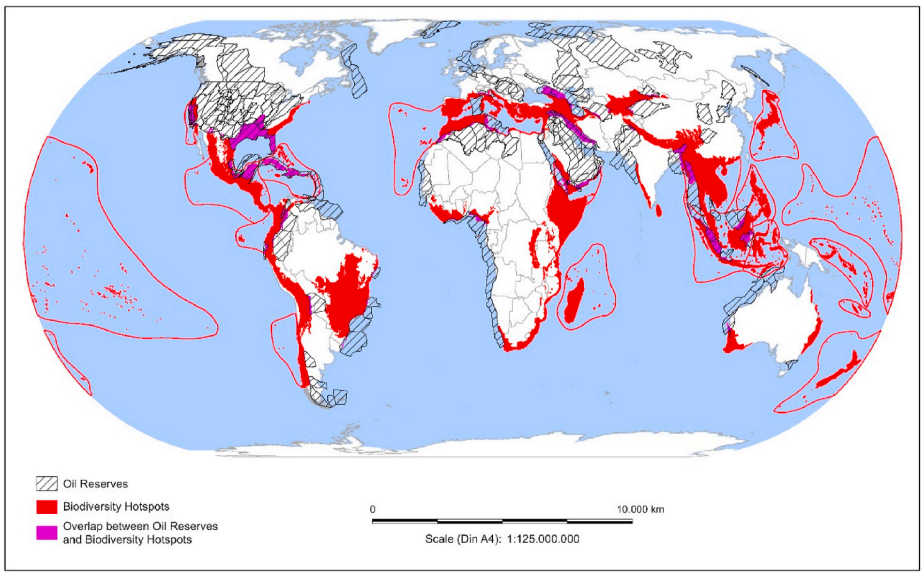

Fig. 1. Biodiversity hotspots and oil reserves.
Data sources: own elaboration based on data from the United States Geological Survey (USGS) and the Critical Ecosystem Partnership Fund.

United Nations Environment Program (UNEP), could be well-suited for creating and implementing the necessary structures to ensure meaningful compliance. These could include a trust fund to collect, manage and disburse the financial resources and disclosure and verification mechanisms to ensure compliance. The specific features of the mechanisms could be lifted from the existing instruments to monitor performance and compliance in environmental agreements and from the standards of reporting and disclosure of the oil and gas industry (e.g. Bebbington et al., 2019).

5. Conclusion

The enactment and the effective implementation of a mechanism to leave fossil fuel reserves underground undoubtedly faces serious challenges, both economic and political. In our view, the main economic challenge is that mechanisms subtracting fossil fuel reserves from the global market might affect the viability of not-yet commercial fossil fuel reserves. In fact, fossil fuel reserves are dynamic since the definition of 'viable reserves' depends on market values of fossil fuels and technological progress (Bp, 2018; Wright and Czelusta, 2004). The implementation of a mechanism to preserve specific fossil fuel reserves could increase the scarcity, and hence the market value, of the remaining reserves. That is, there would be a leakage effect and, at the margin, some reserves will become commercially viable. This effect might be especially salient in the short run, since in the medium-to long-run the effect would be (partially) countered by a decrease in scarcity as the global economy undergoes its transition away from fossil fuels –a process accelerated by the mechanism itself. This challenge could be tackled in various ways: by simultaneously implementing stringent demand-side policies, capping the exploitation of non-viable reserves according to current economic and operating conditions, enacting a moratorium on oil and gas exploration, or increasing research and development spending on renewable energy sources. These could be strings that are attached to the joining of the compensation mechanism outlined above. While putting a ceiling on existing reserves is going to be complex, since the global distribution of oil and gas reserves is concentrated, the participation of major producers would be sufficient to guarantee that the increase in viable reserves would be just a fraction of the unburnable ones.

A seemingly more insurmountable barrier would the absence of political will to create a global institutional mechanism limiting the supply of fossil fuels and compensating foregone oil production. However, climate change has emerged as an issue of global concern and the demands of movements such as Extinction Rebellion, Fridays for the Future and YASunidos might prove to be harder to ignore in the coming years. While it would be a fool's errand to predict the precise tipping point that would render supply-side initiatives more palatable politically, it would not be far fetched to assert that the present moment is rife with possibilities and what appears to be a bold proposal today might become reality soon.

6. Data

Fig. 1 was elaborated using ArcGIS Desktop 10.6.1 and open-access spatial data on a) world oil reserves from United States Geological Survey -USGS- [World Petroleum Assessment 20,001, GIS data retrieved from: https://certmapper.cr.usgs.gov/data/apps/we-data/; file: "wep_prvg.e00 - Geologic Provinces of the World (geographic coordinates)"], b) US oil reserves from the United States Geological Survey -USGS- (National Assessment of United States Oil and Gas Resources, 19,952 and 2012, GIS data retrieved from: https://catalog.data.gov/dataset/1995-national-oil-and-gas-assessment-province-boundaries and https://catalog.data.gov/dataset/33cfbfa1-1078-4713-aa6a-d2cdc118187d), and c) biodiversity hotspots from the Critical Ecosystem Partnership Fund (https://www.cepf.net/our-work/biodiversity-hotspots/hotspots-defined).

CRediT authorship contribution statement

Lorenzo Pellegrini: Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Murat Arsel:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Martí Orta-Martínez:** Conceptualization, Methodology, Writing - review & editing, Data curation, Visualization. **Carlos F. Mena:** Conceptualization, Investigation, Writing - review & editing. **Gorka Muñoa:** Data curation, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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