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# Fossil fuels, stranded assets and COVID-19: Imagining an inclusive & transformative recovery

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ABSTRACT

The 2015 Paris Agreement on Climate Change implicitly requires phasing out fossil fuels; such a phase out may cost hundreds of trillions of dollars and induce widespread socio-ecological ramifications. The COVID-19 'pancession' (pandemic + recession) has rattled global economies, possibly accelerating the fossil fuel phase out. This raises the question: *What opportunities has COVID-19 presented to phase out fossil fuels, and subsequently, how can transformative recovery efforts be designed to utilize these opportunities and promote social, ecological and relational inclusiveness?* We find that: (a) the COVID-19 pancession provides a unique opportunity to accelerate climate action, as it has devalued financial assets, stunned fossil fuel production and paralyzed relevant infrastructure, thus easing the pathway towards stranding global fossil fuel resources and assets; (b) four possible post-pancession recovery scenarios may unravel, of which only one is ecologically, socially and relationally inclusive, transformative, and in line with the Paris Agreement and Agenda 2030; and (c) an inclusive recovery requires that political leadership channels the gargantuan state resources for recovery into prioritizing healthcare and the environment as public/merit goods, conscious investment in non-fossil fuel energy sector recovery accompanied by stringent climate policy, and equitably managing stranded assets to ensure that the burden falls on rich and capable actors, predominantly from the North.



## 1. Introduction

Under the United Nations Climate Change regime, the Paris Agreement on Climate Change (UNFCCC, 2015: Art. 2(1)a) calls on parties to ensure that the average global temperature rise stays well below 2°C above pre-industrial levels and aims towards 1.5°C. Evidence indicates that "one third of oil reserves, half of gas reserves and over 80 percent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2°C" (McGlade & Ekins, 2015: 187), and a significantly larger fraction must be left underground to meet the 1.5 °C target. Since Carbon Capture & Storage (CCS) technologies are not yet proven (Rodriguez, Drummond & Ekins, 2017), we assume that the only viable way to align with the Paris Agreement is by significantly phasing out fossil fuels. Urgent action is needed, as by 2070, 3 billion people may live in unliveable areas (Xu et al., 2020) and even the 1.5°C target may prove to be socially and ecologically detrimental (Hoegh-Guldberg et al., 2018).

The Paris Agreement (Art. 2(1)c) simultaneously calls on:

> "Making ***finance flows consistent*** with a pathway towards low greenhouse gas emissions and climate-resilient development" ***[author emphasis]***

This implicitly acknowledges the financial challenge of adequately phasing out fossil fuels. Financial consistency with a 1.5–2°C future requires ceasing investments in new fossil projects and decommissioning most existing projects – thereby generating *stranded assets* worth trillions of dollars (see 2.2). However, financial ***inconsistency*** seems to be the norm thus far; for example, 35 commercial banks[1] alone lent at least $2.7 trillion to fossil fuel firms from 2016 to 2019 (Rainforest Action Network, 2020). Something clearly must change – urgently and substantially.

COVID-19 has diverted global attention away from the climate change problem (IPCC, 2014, 2019) as the media has almost exclusively focused on the pancession (pandemic + recession). Speculation over the elusive 'COVID-19 recovery' dominates political and economic agendas, with governments debating how resource

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allocation tactics will influence economic recovery. One such forecast is that of Dutch bank ING (2020), which visualizes three unique post-pandemic recovery scenarios: a U-shaped 'base case' recovery to business-as-usual (BAU); a 'best case' V-shape recovery to BAU; and a 'worst case' L-shape recovery where the economy limps forward but eventually returns to BAU. All of these scenarios are *reformist* and neoclassical in nature; they evaluate the success of a recovery based on how effectively and swiftly e.g. GDP growth, unemployment rates and stock markets return to their pre-pandemic state. This reformist mentality is problematic, inter alia, with respect to the fossil fuel sector. As of 2019, global fossil fuel production was set to overshoot levels necessary to limit average global warming to 1.5–2°C by as much as 50–120% (SEI et al., 2019); a more recent report (SEI et al., 2020: 2) found that to "follow a 1.5°C-consistent pathway, the world will need to decrease fossil fuel production by roughly 6% per year between 2020 and 2030", but "[c]ountries are instead planning and projecting an average annual increase of 2%." Not only is the 'return to normal' touted by these reformist recovery paths incoherent with climate objectives, but it is also both socially and ecologically problematic (see 2.3). NGOs (e.g. 350.org, 2020) and academics (e.g. Büscher et al., 2021) have identified such discrepancies, and the former has called for a "Just Recovery" that focuses on addressing deeply rooted social and ecological inequalities. Hence, this paper questions the reformist lens and builds on the Just Recovery narrative by reimagining and designing a ***transformative*** post-pandemic recovery; one that is deeply embedded within Agenda 2030's pledge of "Transforming our World" (United Nations, 2015), holding inclusiveness at its core.

A **transformative plan** to phase out fossil fuels and govern the resulting stranded assets is needed, which is driven by two characteristic forces:

1) **Pull: Urgency to address the climate emergency,** as delaying asset stranding today will exacerbate climate change (Nordhaus, 2018) and generate new assets that are destined to become stranded (Bos and Gupta, 2019);
2) **Push: A catalyst to abruptly and substantially decelerate the growing momentum of the fossil fuel sector**. The multi-trillion dollar industry and its financiers have plans to continue its growth despite a multilateral agreement mandating its abatement; a force is necessary to curb this growing inertia.

The question is – can the COVID-19 pancession provide the necessary push? Recent research shows that COVID-19 has exerted an abrupt and impactful 'force' on global economies (Mofijur et al., 2021), development agendas (Barbier & Burgess, 2020; Oldekop et al., 2020) and climate agendas (Ibn-Mohammed et al., 2021; Wu et al., 2021; Baldwin & Lenton, 2020) significantly more than any recent recession, but it remains to be seen how (if at all) these effects will shape recovery processes (particularly vis-à-vis the fossil fuel sector). This sparks the central question of this study: *What opportunities has COVID-19 presented to phase out fossil fuels, and subsequently, how can transformative recovery efforts be designed to utilize these opportunities and promote social, ecological and relational inclusiveness?*

We answer this by exploring the concepts of stranded assets and inclusive development (see 2) in a multi-method approach (see 3). We analyse the state of fossil fuel assets mid-pancession to identify opportunities for a fossil fuel phase-out (see 4), then use this assessment to develop post-COVID-19 recovery scenarios (departing from those of e.g. ING, 2020) as a function of stranded fossil fuel assets and inclusive development (see 5) and draw conclusions (see 6).

## 2. Conceptual framework

### 2.1. Dual-concept approach

Leaving fossil fuels underground will spur a gargantuan amount of stranded assets (see 2.2), a (conceptual) challenge that occludes the energy transition and contributes to the growing momentum of the fossil fuel industry. Examining this problem from a short- or medium-term and economic perspective distorts the cost of action (phasing out fossil fuels) to appear much higher than the cost of inaction. To counter this, we adopt the inclusive development perspective, which scrutinises economic/financial problems through the lens of social, ecological and relational inclusiveness (see 2.3).

### 2.2. Stranded fossil fuel assets

Phasing out fossil fuels creates *stranded assets* (Caldecott, McSharry & Howarth, 2013; Clark & Herzog, 2014; van der Ploeg, 2016; Caldecott et al., 2016), or "assets that have suffered from unanticipated or premature write-downs, devaluations, or conversion to liabilities" (Caldecott, Howarth & McSharry, 2013: 7). These include *physical* (e.g. fossil fuel equipment, infrastructure), *financial* (e.g. equity and debt); *natural* (e.g. fossil fuel resources); *human* (e.g. expertise, jobs); and *social* (e.g. networks and communities) assets – drawing on the typology by Caldecott et al. (2013). Infrastructure like fossil power generators and production plants have expected lifetimes of 35–40 years (Davis & Socolow, 2014) and up to 75 years (Rode, Fischbeck & Paez, 2017), respectively, which would inevitably become *physical stranded assets* if decommissioned prematurely due to e.g. new legislation. *Financial stranded assets* would subsequently arise as revenues are lost and debts/equity remain on balance sheets; dependent jobs would be stranded (*human assets*) and communities dismantled (*social assets*), in addition to the resources themselves that potentially are no longer viable for commercialisation (*natural assets*).

Bos and Gupta (2019) posit that stranded assets and resources are catalysed by six types of drivers: 1) geographical or spatial accessibility (Desai et al., 2016); 2) technological availability (e.g. Economides & Wood, 2009); 3) adverse ecological and environmental impacts (Rautner, Tomlinson, & Hoare, 2016); 4) litigation & regulation (e.g. Dong, Wei & Zhang, 2008; Cairns, 2018); 5) social opposition (Broad & Fischer-Mackey, 2017); and 6) market conditions (e.g. Khalipour & Karimi, 2011; Johnson, et al., 2015; Attansi & Freeman, 2013; Bergbauer & Maerten, 2015). Geographical and technological barriers to accessing fossil fuel resources exist but, given current production rates (e.g. SEI et al., 2019; SEI et al., 2020), they have proven to be insufficient for reaching global climate goals; it is the adverse ecological and environmental impacts (the 'pull') – addressed through both the Paris Agreement and social opposition – and market conditions (the 'push') that function as catalysts for leaving fossil fuels underground.

Under 'normal' (i.e. non-pancession) circumstances, this 'push' factor is arguably insufficient as phasing out fossil fuels may cost between \$16 trillion and \$200 trillion (Linquiti & Cogswell, 2016) (in 2020 USD), which could jeopardise economic stability with an abrupt drop in discounted global wealth by \$1–4 trillion (Mercure, et al., 2018), though "additional economic damage could be avoided… by decarbonizing early" (Hubacek & Baiocchi, 2018: 1409). Note that this range (\$16-200 trillion) is vast because of methodological discrepancies: some methods account for ***reserves*** (already commercially extractable fossil fuels), others for ***resources*** (estimates of total existing resources with varying likelihoods of extractability). Resources are much greater than reserves, particularly for coal (Johnsson, Kjärstad & Rootzén, 2019; Linquiti & Cogswell, 2016). Additionally, some methods consider ***profits*** generated while others ***revenue*** streams (Linquiti & Cogswell, 2016) – see Fig. 1. Note that these methods ***quantify economic costs and neglect externalized socio-ecological implications***.

These costs will have to be borne by someone: firms, shareholders, governments, first comers and/or late comers to development. While most Global North countries have already consumed a large fraction of their fossil fuel reserves, many Global South countries have fossil fuel resources that are yet to be commercialised; as of 2019, 85% of global proven oil reserves and 91% of gas reserves were outside of Europe and North America (BP, 2020). Many Global South countries accordingly argue that their right to development justifies using these resources (Gupta & Chu, 2018); however, by investing in fossil fuel, developing countries exacerbate climate change (to which they are already more vulnerable) and expose themselves to the risks of stranded assets (see 2.3).

### 2.3. Inclusive development

Clearly when the financial risks and implications are so vast, economic perspectives dominate at the expense of social and ecological issues and distort efforts to implement a sustainable development agenda. Inclusive development reacts to the propensity within sustainable development to prioritize economic over socio-ecological aspects by adopting a *social, ecological and relational lens* to scrutinise economic issues (Gupta & Pouw, 2017). *Social inclusiveness* is concerned with addressing inequalities, ensuring access to basic needs, upholding human rights, and equitably allocating resources from local to global levels. This includes guaranteeing ''not only basic political rights but also access to water, food, health services, housing, justice" based on a rights-based approach that enhances human wellbeing ''according to people's own priorities" (Gupta & Pouw, 2017: 97). Fossil fuel production and combustion have a mixed relationship with social inclusivenes. While fossil fuel industries provide job opportunities, with 2.7 million people employed by China's coal mining industry in 2020 (CEIC, 2020), coal (and oil and gas) combustion releases incredibly harmful pollutants, like sulphur dioxide ($SO_2$) and nitrogen oxides ($NO_X$), which, when inhaled, can lead to respiratory inflammation, reduced lung capacity, and in some instances death (Burt, Orris & Buchanan, 2013). This is in addition to the threats posed by the adverse impacts of climate change (IPCC, 2014, 2019). Leaving fossil fuels underground thus aspires to address the latter while taking into account the former by adopting a socially-inclusive approach to governing stranded assets. This would ensure that, as fossil fuels are phased out, under-resourced, under-represented and marginalised people who currently depend on the fossil fuel sector (for e.g. employment, income, energy) have access to new jobs, alternative and affordable energy sources and improved livelihoods – meeting the Goals in Agenda 2030 while removing opposition to a fossil fuel phase out from these actors.

*Ecological inclusiveness* finds its roots in respect for planetary boundaries and access to ecosystem services by those most marginalised (Gupta & Vegelin, 2016). 'Ecosystem services' in this context includes provisioning services (e.g. food), supporting services (e.g. circulating nutrients), regulating services (e.g. cleaning water) and cultural services (e.g. religious uses) (Hassam & Scholes, 2005). These services have been modified as material, non-material and regulating contributions of nature, each referring to a symbiotic relationship between humans and nature (Díaz et al., 2018). As such, this dimension ''implies the continued access to and allocation of resources by and for the poorest... ensuring that affected [ecosystem services] do not exacerbate the vulnerability of the poorest" (Gupta & Pouw, 2017: 99). The ecological risks posed by the unabated combustion of fossil fuels are both ample and well-documented; at the global level, failure to curb average warming to at least 2°C will, inter alia: (severely) curtail agricultural production, particularly in some of the poorest nations in the world (''West Africa has... been identified as a climate-change hotspot with negative impacts from climate change on crop yields and production" (IPCC, 2019: 197)), subsequently resulting in intensified and prolonged famine; increase both the frequency and intensity of droughts and floods, particularly in southern Europe, northern Africa, the middle East and southern Africa (IPCC, 2019); and disturb the concentrations and lifecycles of critical nutrients, like nitrogen & phosphorus and dissolved oxygen (IPCC, 2019). At the local level, coal, oil and gas production is notorious for ecological exploitation, like water and land degradation and soil infertility resulting from unsustainable mining practices (Bian & Lu, 2013), permanent ecosystem destruction from oil spills (Beyer et al., 2016), or the deleterious 3-D seismic surveying technique used for offshore oil and gas exploration (Raynolds, et al., 2020). It is clear that the status-quo of the fossil fuel sector is ecologically exclusive on all accounts, and therefore, ***phasing out fossil fuels is both imperative and central to ecological inclusiveness***. However, ecological inclusiveness goes beyond phasing out fossil fuels and questions whether existing fossil assets are properly decommissioned and alternative energy sources are themselves not detrimental – e.g. the extractive rare earth metal industry for battery production (Scholten, Bazilian, Overland, & Westphal, 2020).

The *relational* lens of the inclusive development approach accepts that financial costs in various forms will be incurred by leaving fossil fuels underground (e.g. as opportunity costs and sunk costs, the latter including devalued equity (shares) that cannot/should not be sold and/or bought), resulting in 'winners' and 'losers' (e.g. van de Graaf, 2018; Overland et al., 2019) and aspires to allocate those costs on the broadest shoulders – i.e. the richest and most capable members of the global society, who are also often those who have benefited most from fossil fuel exploitation. Moreover, stranding (fossil fuel) assets threatens social and ecological inclusiveness in addition to the aforementioned financial burdens: unemployment as e.g. mining and operating jobs are stranded; local pollution and ecosystem disruption if fossil fuel infrastructure is not fully decommissioned; local violence and/or protest from stranding domestic coal, oil and gas reserves; vanished revenues from diminished exports; and energy scarcity (Bos & Gupta, 2019). An inclusive development approach to phasing out fossil fuels will thus focus on managing these risks to ensure the livelihoods of the poorest and most vulnerable people are not jeopardised – see 2.4.

### 2.4. Inclusive stranded assets

Table 1 builds on the above discussion by conceptualising inclusive development as a function of fossil fuels and stranded assets and proposing seven conditions (two social, three ecological, two relational) for an inclusive fossil fuel phaseout. Most important is Condition E1, which maintains that any efforts to support existing or create new fossil fuel projects and/or infrastructure is ecologically exclusive; phasing out fossil fuels is a pre-requisite to ecological inclusiveness.

Conditions E2, S1 and R1-2 focus on inclusive stranded asset governance. An inclusive agenda is one in which: existing infrastructure is fully and adequately decommissioned to avoid further ecosystem disruption (Condition E2); stranded fossil-dependent jobs are replaced by desirable and safe alternatives designed for the poorest and most vulnerable people (Condition S1); the financial burden of phasing out fossil fuels falls is allocated to Northern commercial banks, fossil fuel firms and institutional shareholders (Condition R1); countries from the Global South are financially

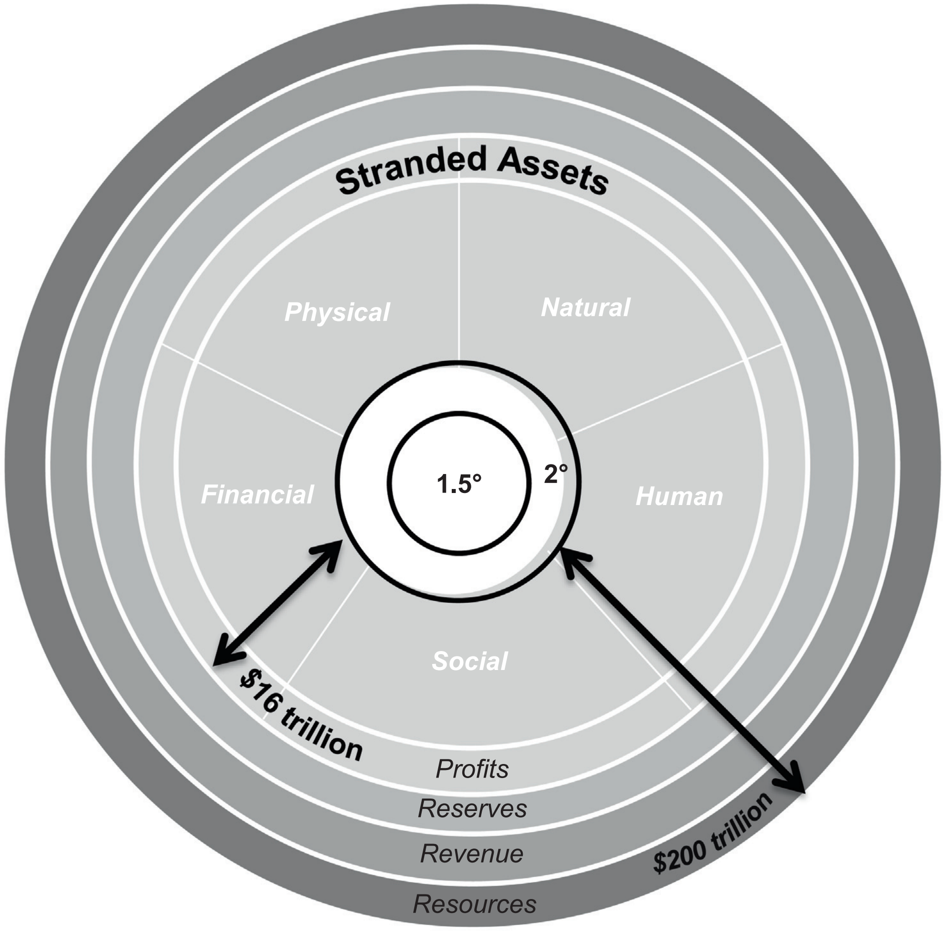


**Fig. 1.** Stranded fossil fuel assets and their financial costs in relation to climate policy compliance. Source: original, inspired by Linquiti & Cogswell (2016), Carbon Tracker (2011) and Caldecott et al. (2013).

compensated by richer actors from the North for leaving their coal, oil and gas reserves underground (Condition R2).

Finally, Conditions E3 and S2 account for inclusively substituting fossil fuels; that is, ensuring that fossil-alternative technologies do not disrupt ecosystems (Condition E3) or violate human rights (Condition S2) through e.g. exploitative and unsustainable metals mining. Note that all conditions build on Condition E1 except S1. *In theory*, Condition S1 can be met by offering safe, desirable and adequately-compensating jobs within or dependent on the fossil fuel industry, but in practice evidence points to the socially exclusive nature of the fossil industry's status-quo (see 2.3).

In summary, inclusive development via stranded assets should be approached through three considerations: 1) **Are fossil fuels left underground?** (E1); 2) **Are the inevitable stranded assets governed inclusively?** (S1, E2, R1-2); and 3) **Are the alternatives to fossil fuels themselves inclusive?** (E3, S2).

## 3. Methods

### 3.1. Key concepts

The conceptual framework in section 2 built on previous (systematic) reviews of stranded assets (Bos & Gupta 2019; Caldecott, Howarth & McSharry 2013; Caldecott et al., 2016) and inclusive development (Gupta & Pouw, 2017) (see 2.2–2.3) in order to identify the key operational conditions (see 2.4) for building post-COVID recovery scenarios (see 5) that transgress from reformist and neoclassical to transformative models.

### 3.2. COVID-19 & fossil fuel assets

To explore whether the COVID-19 pancession provides any opportunities for phasing out fossil fuels (see 4), we studied (based on the typology from 2.2): market capitalization and impact on equity portfolios (*financial assets*); coal, oil and gas infrastructure closures/shut-down (*physical assets*); fossil-related unemployment (*human assets*); trends coal, oil and gas production & implications for proven reserves (*natural assets*); and forecasted changes to capital expenditure (CapEx) (*forthcoming assets*).[2] Specifically, we:

1) compiled news items to scope how COVID-19 was influencing fossil-related infrastructure, jobs, production and CapEx investments in real time to justify the research. We searched on Google News using permutations of the following: "fossil fuel", "coal/oil/gas", "close", "shut down", "plant", "refinery", "pipeline", "reduced", "halted", "unemployment", "job loss", "capital expenditure", "CapEx", "COVID-19", "pandemic".

[2] Note that we exclude "social assets" from our analysis as it is infeasible to decipher the extent to which communities and networks have been affected through a desk study.

**Table 1**
Conceptualising Inclusive Development through fossil fuels & stranded assets.

| | Dimension | Conditions |
|---|---|---|
| ***Inclusiveness*** | *Ecological* | E1. Investments in **new fossil fuel assets** are terminated immediately, and existing coal, oil and gas facilities are stranded/phased out**;** |
| | | E2. **Physical assets** (like coal-fired power stations) are **adequately and fully retired/decommissioned** so that they do not threaten local air, water and soil resources; |
| | | E3. **Fossil fuel alternatives** (e.g. grid-scale solar PV) **do not themselves disrupt ecosystems** and are respectful of water, land and other planetary boundaries |
| | *Social* | S1. **Safe, high quality and desirable jobs** are for the poorest, most under-resourced and vulnerable unemployed people, and their livelihoods and well-being are both sustained and prioritized; |
| | | S2. Investments in **fossil-alternative assets do not hamper universal access to basic needs** and services, like energy, healthcare, water, food, housing, and justice |
| | *Relational* | R1. **Financial costs (stranded assets)** of phasing out fossil fuels are allocated to large (fossil fuel) multinational firms and capable financial institutions; |
| | | R2. **Compensation for stranded natural resources** (e.g. recoverable coal, oil and gas reserves) is paid from richer governments, firms and investors from the North[1] to poorer nations with ample reserves and dependence on developing said reserves |

[1] By 'North' we refer to Europe, North America (US & Canada), Japan, China and Korea as they are the dominant fossil fuel investors.

We identified 80 relevant events[3] for analysis that took place between February 15, 2020 and 31 December 2020 (for a complete list see Supplementary Document A);

2) surveyed the market capitalizations of 42 coal, oil and gas firms (inspired by Fossil Free, 2019) on three dates: pre-pancession (December 31, 2019), early-pancession (March 31, 2020) and mid-pancession (September 25, 2020) from the Yahoo! Finance database;
3) simulated the impact on the equity portfolios of 15 pension funds from 2019 by building on data recently published by Rempel & Gupta (2020), surveying the share values of the same 42 firms from (2) during the same time periods. We assume that the volume of shares in the 2019 portfolios remained constant into 2020 and apply the changed share prices. Although this assumption is unrealistic, it is not limiting because we are not concerned with exactly how much equity these pension funds managed mid-pandemic, but rather the impact that the pancession has borne on *financial stranded assets*; and
4) reviewed the IEA (2020a; 2020b; 2020c) Global Energy Outlooks, comparing coal, oil and gas production from 2019 to 2020.

### 3.3. Developing post-pancession recovery scenarios

Finally, we construct four possible ideal-typical post-pancession recovery scenarios that tend from *reformist to transformative* by applying the conceptualisation from Table 1 (see 2.4), and subsequently discuss the conditions under which an inclusive and transformative pancession recovery may arise (see 5). These recovery scenarios are speculative in nature – as are any forecasts – but by designing them as a function of social, ecological and relational conditions, we introduce an element of objectivity based on the existing scholarship. Section 5 thus bridges the four scenarios to the conditions (from Table 1) necessary for them to manifest.

## 4. COVID-19: An unprecedented opportunity

### 4.1. Introduction

In order to assess the potential opportunity that COVID-19 presents to 'push' against the fossil fuel sector, we explore the impacts of the pancession on global fossil fuel financial (see 4.2), physical (see 4.3), human (see 4.4) and natural (see 4.5) assets, and speculate over avoided fossil fuel assets (see 4.6). COVID-19 is still unfolding – with national vaccine rollouts beginning in Europe and North America, and much slower rollouts taking place in many African, Asian and Latin American countries – so we aim less at being exhaustive and more at identifying opportunities for a fossil fuel phaseout.

### 4.2. Financial assets

We compare the market capitalizations (market cap; a proxy measure of a company's worth, equal to its share price × the total number of listed shares) of 42 major coal, oil and gas producing firms at three moments: pre-pancession (31/12/19); early-pancession (31/3/20) and mid-pancession (25/9/20). Fig. 2 presents the aggregated and summarised results – for the full sample data, see Supplementary Document A.

The total market cap of the sample decreased from roughly $2.50 trillion to $1.35 trillion at the beginning of the pancession (46% decrease) and sat at $1.45 trillion mid-pancession (42% drop compared to pre-pancession levels). Such a drop occurred as a result of plummeting share prices (compared to pre-pancession levels) for some notable multinationals, like Anglo American (18%), BP (52%), Chevron (43%), ExxonMobil (54%), and Shell (62%). Furthermore, mid-pancession market caps have only marginally increased compared to early-pancession levels (by about $100 billion), suggesting that COVID-19 has stunned global fossil fuel markets for months. In fact, COVID-19's force has shrunken fossil firms beyond the timeframe of this analysis; market caps listed on February 23, 2021 still sat significantly below their December 2019 values, like those of Shell ($127 billion vs. $241 billion), BP ($77 billion vs. $116 billion) and Rio Tinto ($38 billion vs. $124 billion). These firms have, therefore, been bound to their shrunken state for almost an entire year at the time of writing.

Decreased share prices and market caps impact shareholder equity portfolios; to explore this, we *simulate*[4] the equity loss that the investment portfolios of 15 leading pension funds endured as a result of the denoted stock market fluctuations in Fig. 2 – see Fig. 3. Pre-pancession, these pension funds managed roughly $68 billion in equity of the 42 sampled fossil fuel firms – approximately $53 billion in oil & gas and $15 billion in coal (Rempel & Gupta, 2020). However, the value of this equity decreased to approximately $40 billion by early-pancession (40% decrease) and remained fairly constant at $42 billion mid-pancession (37% decrease compared to pre-pancession levels). Since the market caps (and share prices) have not

[3] 'relevant' meaning that the event discussed a direct linkage to one of the four types of stranded assets.

[4] Note that these pre-, early- and mid-pancession dates differ slightly than those from Fig. 3 due to data availability.

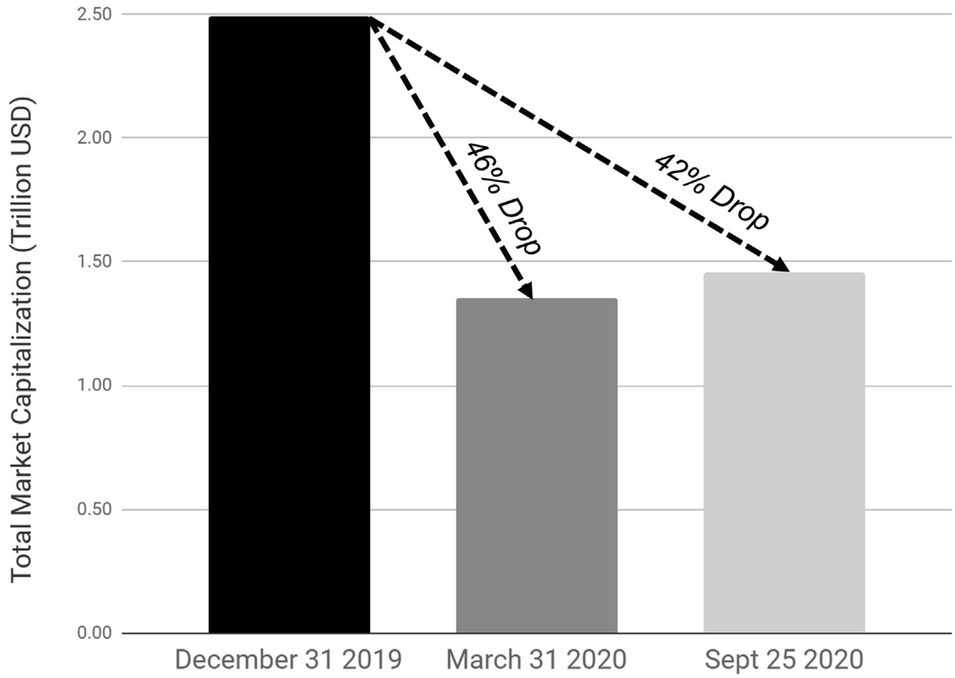


**Fig. 2.** Aggregate market capitalisation for major coal, and oil & gas producing companies pre-, early- and mid-pancession. Source: original.

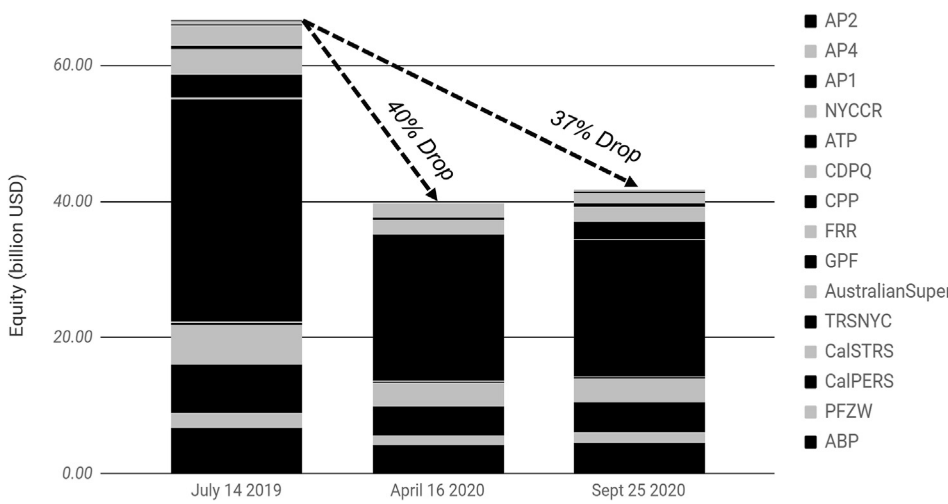


**Fig. 3.** Simulated equity loss in the portfolios of 15 leading pension funds as a result of decreased share values. Source: original.

yet risen as of February 2021, these simulated portfolios are likely still only worth a fraction of their pre-pandemic values.

### 4.3. Physical assets

We now explore the degree to which physical fossil fuel assets are being affected; Table 2 summarises our findings (see Supplementary Document A for details).

Table 2 shows that 5 coal-fired power plants have closed during the pancession, which yielded first-quarter profit drops ranging from 37% (BASF) to as high as 97% (PT Bumi Resources). Similarly, we found two instances of halted offshore exploration and drilling, multiple refinery closures and reduced production at operational refineries, indicating reduced oil and gas activity and stagnated infrastructure at a global level. Conversely, five instances of increased oil and gas activity were noted (mainly in Africa and

**Table 2**
Frequency Chart of Fossil Industry Related Events During COVID-19.

| Event | Frequency | Country |
|---|---|---|
| Coal-fired power plant closures | 5 | USA, UK, Austria |
| Net earnings drops in coal sector | 5 | Indonesia, Germany, USA, China |
| Oil & gas exploration and drilling paused | 2 | New Zealand, Australia |
| Oil refineries shut down or reduced production | 11 | Canada, Italy, Pakistan, USA, Brazil, South Africa, Russia, Thailand, South Korea, Global (OPEC) |
| Forthcoming oil projects continued or oil investments increased | 5 | Uganda & Tanzania, USA & Canada, Indonesia, Mozambique |

Asia), including plans for continuing the East Africa Crude Oil Pipeline (EACOP) from Uganda to the Tanzanian, which reached the final stage of financial negotiations in June 2020. This suggests that some investors and companies are either unaffected by the stunned global economy or are resorting to cheap oil and gas as a means for quick and lucrative economic growth.

### 4.4. Human assets

Unemployment across global economies has been a recurring conundrum in the midst of the pancession. Roughly 435 million (formal) jobs were lost (globally) in the first half of 2020 (ILO, 2020), and the fossil fuel industry is no exception. Multiple reports indicate that mining, construction, operation and maintenance jobs around the globe for coal, oil and gas projects have reduced, stalled or vanished altogether. For instance, by December 2020, the US mining industry "exhibited the second highest [unemployment] rate... across all industries (13.1%)" (US Congressional Research Service, 2020: 5), with at least 6000 US coalminers becoming unemployed in March and April 2020 alone (Sainato, 2020). Some nations (like South Africa) curbed underground mine operations by 50% while others (like Poland) temporarily shut down underground mines altogether for fears of expedited virus spreading in compact mineshaft elevators (Ramdoo, 2020). Moreover, South Africa's mining industry relies on migrant workers from neighbours Mozambique and Lesotho, and "closed borders are halting the temporary use of cross-border migrant workers," and since many mining companies operate on a 'no work, no pay' principle, it seems likely that many of these workers are left without income (Ramdoo, 2020: 6).

The pancession has also taken a toll on oil and gas jobs; by September 2020, the US had lost over an estimated 100,000 oilfield services jobs, with Texan oil unemployment numbers almost hitting 60,000 (WorldOil, 2020). Russian unemployment almost doubled from February to May 2020, largely explained by tanking crude oil exports (Gofman, 2020), and Saudi Arabian national unemployment rose to 15% by September 2020 after its oil sector production dipped by roughly 6% (Nereim, 2020).

### 4.5. Natural assets

This section gauges the degree to which coal, oil and gas reserves have been impacted by the pancession. The IEA (2020a) estimates that global 2020 coal demand decreased by almost 400Mt (8%) compared to 2019, from roughly 5400 to 5000Mt per annum. Regional discrepancies are expected: US: 25%; EU: 20%; 5–10% in Korea and Japan; and an "even greater decline in coal demand... in India" (IEA, 2020a: n.p.). A similar tale is told for oil demand, which had dropped by 57% in Q1 of 2020 compared to Q1 of 2019 (IEA, 2020b). By the end of 2020, global demand was expected to have dropped by an average of 9.3 million barrels per day compared to 2019 (IEA, 2020b), and the IEA, OPEC and US EIA agree that oil demand is unlikely to recover until 2022 at the earliest (Lee, 2020). Further, global natural gas consumption fell by over 3% in Q1 2020 alone and dropped by roughly 5% by the end of 2020, denoting the first drop in annual natural gas consumption since 2009 (IEA, 2020c).

Decreased coal, oil and gas production during the pancession correlates to an increase in fossil fuel resources that were not extracted, produced and commercialised. This *in theory* suggests that reserves did not decrease by as much as they would have if production had not dipped in 2020, which means that fossil resources (i.e. natural assets) remained underground for the time being.

### 4.6. Avoided stranded assets?

Finally, we surveyed changes in fossil industry Capital Expenditure (CapEx) (i.e. annual expenses for, inter alia, new infrastructure and projects) to assess potential changes to planned expansions, exploration and production. Decreases in CapEx on fossil fuels can indicate potentially avoided stranded assets; if a firm decides not to invest in e.g. a pipeline, then that *physical asset* and its accompanying *human assets* (e.g. jobs), *financial assets* (e.g. debt) and *social assets* (e.g. communities built around the pipeline) are avoided. 30 major firms have made announcements regarding their 2020–2021 CapEx – summarised in Table 3 (see Supplementary Document A for full details).

Of the 30, only one firm (Gazprom) declared no changes to their 2020 CapEx. Most (15/29) firms announced CapEx reductions between $1–4.9 billion, and four firms announced larger CapEx reductions, including Shell ($5 billion), ExxonMobil ($10 billion) and Saudi Aramco ($25–30 billion). Based on these announcements, we estimate a total reduction of at least[5] $79 billion.

### 4.7. Discussion: COVID-19 as an opportunity

This brief analysis reveals that the COVID-19 pancession has to some degree impacted key fossil fuel assets that risk becoming stranded in the event that fossil fuels are extensively phased out. Fossil-related portfolio equity (*financial assets*) for leading European and North American pension funds plummeted by almost 40% from July 2019 to September 2020 (see 4.2); multiple coal-fired power stations and oil refineries (*physical assets*) have been (temporarily) shut-down (see 4.3); hundreds of thousands of coal, oil and gas related jobs (*human assets*) have been lost (see 4.4); 2020 coal, oil and gas production dropped by 5–10% compared to 2019, implying a greater fraction of fossil fuel resources (*natural assets*) remained underground (see 4.5); and finally, CapEx for forthcoming projects decreased by at least $79 billion (see 4.6), potentially indicating a slew of *avoided* stranded fossil fuel assets. There is no guarantee that any of these assets have been or will remain stranded; share prices could swiftly recover and mend the wounds of investor portfolios, coal plants and oil refineries could be mothballed and subsequently reinstituted in the coming months or years, and post-pandemic fossil fuel production could increase as demand for aviation and international travel rebounds. However, the very fact that these financial assets have devalued, physical assets have been stunned, human assets have been unemployed, and natural assets have remained underground *presents an opportunity to shape recovery strategies in alignment with an inclusive governance of these assets*. The COVID-19 pancession has seemingly granted us a socio-ecological lifeline by *pushing against and decreasing the growing momentum of the fossil sector*. There is also no clear end of the pancession in sight – vaccinations do not imply the eradication of this disease, and many non-European, non-North American countries may be deprived of sufficient vaccine doses well into 2022 or 2023. Even as populations are vaccinated, the idealistic return to 'normal' is farfetched and unrealistic, at least in the short term. Now, it is up to policymakers and heads of state to gather the courage and use this opportunity to permanently phase out fossil fuels and inclusively govern the accompanying stranded assets.

5 Seven firms announced CapEx reductions but did not specify an amount, implying that this is very likely an underestimate.

**Table 3**
Summarised CapEx Announcements by Fossil Firms During COVID-19 Pancession.

| CapEx Reduction Range (billions USD) | Frequency |
|---|---|
| No Change Indicated | 1 |
| 0–0.9 | 3 |
| 1–4.9 | 15 |
| 5–9.9 | 2 |
| 10+ | 2 |
| Amount Not Specified | 7 |
| ***Estimated Total Reduction*** | ***USD79 + billion*** |

## 5. Post-pancession recovery scenarios

### *5.1. Scenarios: from reformist to transformative?*

COVID-19 has potentially decelerated the growing inertia of the global fossil fuel sector (see 4) in addition to rattling global economies, the latter to the point where stimuli packages worth tens of trillions of dollars will be allocated for a recovery. Political leaders are assigned the tremendous responsibility to allocate these resources wisely to promote long-term socially, ecologically and relationally inclusive development. They may need to question reformist, 'back to normal' recovery scenarios (e.g. ING, 2020 – see 1), and visualize alternative approaches that may effectively phase out fossil fuels while meeting many of the goals in Agenda 2030. That is not to say that GDP growth is per se completely incompatible with inclusiveness; however, designing recovery plans *that blindly pursue economic 'normalcy' measured by familiar metrics like GDP* runs the high risk of returning to and supporting the extractive and exploitative industries that ***are*** *incompatible with inclusive development*. As such, we develop four recovery scenarios that *pivot from this reformist tendency towards a transformative alternative* by applying the conceptualised conditions from Table 1. They are: 1) Exclusive & Reformist Recovery; 2) Social Recovery; 3) Ecological Recovery; and 4) an Inclusive & Transformative Recovery (see Fig. 4). We stress that these recovery scenarios are extremes, and in reality recovery processes may contain elements from multiple scenarios and (partially) meet various conditions; they are nevertheless presented as if they were mutually exclusive.

#### *5.1.1. Exclusive & reformist recovery (ERR)*

The ERR scenario (top-left quadrant of Fig. 4) runs parallel to reformist recoveries of all shapes and sizes that prioritise the return to 'normal' both driven and measured by neoclassical economic indicators like GDP growth. Here, governments fiscally prop-up existing (fossil fuel-dependent) infrastructure, businesses and markets for short-term economic growth. As a result, ***condition E1 is immediately violated***, rendering the recovery exclusive on all ecological accounts as it supports the survival and/or growth of the fossil fuel sector and inherently threatens the stability of the global climate system with impacts on humans and nature at glocal (global + local) levels (see 2.3). Further, efforts are predominantly geared towards rescuing 'the economy' and its accompanying financial assets (e.g. shareholder portfolios, see 4.2); accordingly, share prices and market caps rise, oil refineries resume production, employment at coal mines return, global fossil production rebounds and fossil firm CapEx increases – implying that the burden of stranding fossil-related assets is postponed and amplified. Climate commitments are ignored and low fossil fuel prices hamper the competitiveness of alternative energy, further hoisting up carbon assets; as a result, no progress is made towards solving the stranded asset problem or combatting the climate emergency. Furthermore, the wellbeing and livelihoods of vulnerable and unemployed citizens are side-lined, so apart from a stimulus check or few job opportunities, they are by and large excluded from the recovery process. Hence, ***condition S1 is also not met***, and since all other conditions rely on fossil fuels being phased out, ***no conditions are met in this scenario*** and it is exclusive on all accounts.

Investments in existing and new fossil fuel assets may increase the likelihood of the Intergovernmental Panel on Climate Change's (IPCC, 2014) most dire RCP 8.5 scenario taking place, thus moving away from likely scenarios into dangerous upper-estimates (van Vuuren et al., 2011; Pedersen et al., submitted). This scenario may spur *minor* short-term developmental progress as jobs are generated in the quest for GDP points. However, ignoring ecological issues will exacerbate climate change impacts and intensify stranded asset risks for the global South (see 2.2), eventually reaching a tipping point and sending net inclusiveness spiralling down in the long term.

#### *5.1.2. Social recovery (SR)*

In the SR scenario (bottom-left quadrant of Fig. 4), socio-economic pressures lead to greater investment in fossil fuel as resources are tight and actors are traumatized by the forced degrowth during the COVID-19 pancession, once again ***violating condition EI*** (***de facto violating all other conditions bar S1***), running parallel to the ERR scenario. The need for protecting jobs in fossil-related sectors, not raising fuel costs for the middle class and ensuring access to energy for the poorest, puts climate concerns into the background. Fuel-rich, developing country governments justify this by using the Right to Development – e.g. Uganda, Nigeria, Mozambique, Angola, and many others in sub Saharan Africa (Associates, 2017). As a result, fossil fuel assets are revalued and reinstituted, prolonging the burden of stranding assets and phasing out fossil fuels, again analogous to the ERR scenario. Short-term (social) developmental progress is pursued at the expense of climate stability, and as planetary boundaries are eventually transgressed, both the adverse impacts of climate change and the stranded asset burden are likely allocated to the poorest and most vulnerable and the climate tipping point is reached within this century. However, unlike the ERR scenario, efforts are made to address the social risks posed by coal, oil and gas production, for instance by increasing wages or providing improved healthcare services; this ***partially or fully meets condition S1*** in the short term, but the accruing pressure on planetary boundaries renders these efforts moot in the long-term as the climate reaches its tipping point. Social inclusiveness in the short-term therefore compromises inclusive development prospects in the long-term.

#### *5.1.3. Ecological recovery (EcR)*

In the EcR Scenario (top-right quadrant of Fig. 4), an aggressive 'green' recovery is pursued that capitalises on the opportunity to permanently shut-down coal plants and oil refineries, retire coal mines and catalyse an energy transition, thereby ***meeting condition E1***. This scenario acknowledges that the stranded asset problem and climate emergency will result in winners and losers, and is fixated on minimizing the net losses by restraining further carbon lock-in and continued investments in inevitable stranded assets (Overland, et al., 2019; Mercure, et al., 2018; van de Graaf, 2018). Although this ecologically-inclusive mentality minimises the adverse impacts of climate change, the EcR scenario fails to inclusively govern accompanying stranded assets and/or guarantee that (energy) demands are sustainably and affordably met beyond fossil fuels. That is: safe and desirable replacement jobs are not explored; decommissioned infrastructure is (partially or entirely) abandoned; devalued shares and debt (partially or entirely) remain on the balance sheets of governments and institutions from the Global South; no compensation is paid for stranding fossil fuel resources; and investments in solar PV, wind power and grid-scale storage is

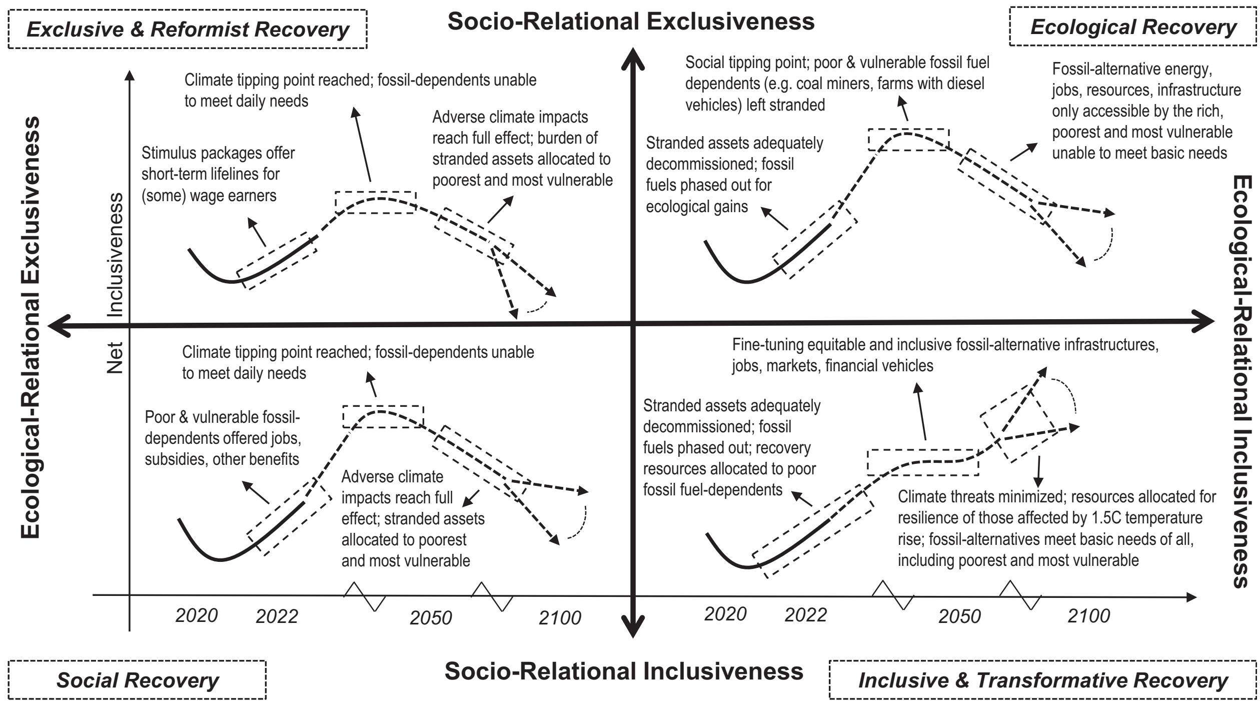


**Fig. 4.** Four post-pandemic recovery scenarios in relation to social and ecological inclusiveness and stranded fossil fuel assets. Source: Original, using the conceptual approach from 2.4 and methodological approach from 3.3.

exploitative and ecologically detrimental (e.g. through land use degradation). As a result, ***one or all of conditions S1-2, E2-3 and R1-2 are violated***. Two additional risks arise: first, if the fossil fuel phaseout and asset stranding process is not synchronised on a global level, countries from the South may invest in cheap fossil assets as richer and better-resourced countries spearhead a green transformation, which de facto allocates a larger fraction of the (financial) stranded asset burden to poorer countries (Gupta, Rempel & Verrest, 2020); second, major social disruption will arise as fossil fuel users and laid-off personnel are not supported. Unlike earlier scenarios, this recovery builds on the devaluing and destabilising fossil fuel asset 'push' by the COVID-19 pancession; however, like in previous cases, long-term inclusive development is compromised in spite of radical ecological inclusiveness.

### *5.1.4. Inclusive & transformative recovery (ITR)*

An *Inclusive and Transformative Recovery* (bottom-right quadrant of Fig. 4) builds on earlier scenarios by phasing out fossil fuels, catalysing the asset stranding process (thereby ***meeting condition E1***) and directing recovery resources to fossil-alternatives to comply with a 1.5℃ future. In doing so, rich investors, shareholders and companies from the North are encouraged to write-off stranded assets (if not mandated) – namely, incurring the inevitable stranded asset losses on their own balance sheets rather than exporting these losses at a cheap rate to poorer and more vulnerable actors in the South through e.g. divestment (***thereby meeting condition R1***) and compensating poorer governments for their stranded fossil fuel resources (***meeting condition R2***). State support also cushions the impact for the unemployed by investing in safe, desirable and high quality jobs in other economic sectors (***meeting condition S1***) and fossil users by investing in affordable, reliable and non-exploitative solar PV, wind power and grid-scale storage (***meeting conditions R2 and E3***). Furthermore, existing physical stranded assets are fully decommissioned to protect ecosystems disruption (***meeting condition E2***). There may be a period of transition (denoted by the slight plateau in the bottom-right curve of Fig. 4) in the short- to mid-term as equitable and inclusive approaches to replacing fossil fuels are 'fine-tuned' – for example, as economies are built to resist the rise of new oligopolies and extreme wealth concentration in renewable energy markets (Scholten et al., 2020). COVID-19 is used as an opportunity to move towards short- and long-term inclusive development by building on its momentum of already having devalued some fossil fuel assets and paralysed the growth and activity of others.

An inclusive & transformative recovery does not necessarily imply that industrialized economies must experience de-growth nor that post-recovery GDPs must pale in comparison to pre-pancession levels. On the contrary; a transition to a low-carbon economy may generate millions of new jobs by 2050 (Ram, Aghahosseini & Breyer, 2020), and increasing both (renewable) energy consumption and investments in research & development may spur economic development (Zafar, Shahbaz, Hou & Sinha, 2019). It is possible that the 'economy' will benefit from an inclusive and transformative recovery, but blindly pursuing economic growth will very likely deviate towards the ERR scenario. Neoclassical economic metrics can therefore be monitored in the ITR scenario, but such monitoring must be secondary to the socio-ecological and relational efforts to meet the conditions in Table 1.

## *5.2. Design features for an inclusive recovery*

This section discusses three key design features of an Inclusive & Transformative Recovery: 1) treating a stable climate, ecological integrity and healthcare as public/merit goods (see 5.2.1); 2) building on the COVID-19-induced momentum and accelerating the asset stranding process (see 5.2.2); and 3) equitably and inclusively managing stranded fossil fuel assets (see 5.2.3).

### *5.2.1. Public/merit goods*

A stable climate, ecological integrity and healthcare must be treated as public/merit goods that need state support. The drivers of the climate emergency (and arguably the COVID-19 crisis) include privatization of resources including healthcare, externalisation of environmental impacts and a fixation on growth (Ekins, Gupta & Boileau, (eds.) 2019). Resources and sinks are limited and COVID-19 offers preliminary evidence of the ramifications of crossing planetary boundaries; recovery plans must reconceptualise climate, environment and health as merit goods that society as a whole has the right to.

*5.2.2. Accelerating the fossil fuel asset stranding process*

Recovery must take advantage of COVID-19's 'push' force and permanently phase out fossil fuels, prioritize writing-off fossil fuel assets (as opposed to e.g. divestment, which merely reallocates (financial) assets to potentially more vulnerable countries), and simultaneously invest in non-fossil alternatives. State investment in the recovery process must focus on the recovery of the non-fossil energy sector and green practices in industry. A shift away from the fossil fuel industry requires a conscious choice and will mandate tightening, rather than loosening, environmental constraints and conditions on businesses. Beyond moratoria and/or bans, feebate programmes (taxing new carbon and subsidising cleaner alternatives), subsidies and tax breaks for fossil-alternatives, and energy-efficiency standards for new infrastructure (Rozenberg, Vogt-Schilb, & Hallegate, 2020) are necessary. In practice, this means that e.g. South Africa's oldest, dirtiest and least efficient coal-fired power stations must be decommissioned as soon as possible, and investments in the new East African Crude Oil Pipeline – set to run from central Uganda through to the Tanzanian coast – must be terminated effective immediately. In both cases, the socioeconomic and ecological implications of stranding these assets may existentially threaten vulnerable communities, which we account for in 5.2.3.

Some preliminary evidence suggests that this fossil fuel phase out might be gaining momentum – e.g. Japanese banks Mitsui, Mitsubishi and Mizuho have pledged to stop financing coal-fired projects as of May 1, 2020 (Lectura, 2020); the Philippines recently banned the construction of a new coal plant (Burgos, 2020); and European Climate and Environment ministers wrote an open letter to the EU Commission calling for maintaining environmental standards in a post-pandemic transition (Gewessler, 2020). Other indicators, however, point to the direction of the Exclusive & Reformist scenario. The (former) US government committed at least $73 billion in unconditional fossil fuel subsidies since the beginning of the pancession in March 2020 (IISD, 2020), though since doing so the new Biden administration has successfully re-joined the Paris accord, and thus the US contribution to (solving) the climate emergency remains to be seen.

*5.2.3. Equitable and inclusive management of stranded assets*

Recovery funds must enable fossil fuel dependents – especially the poor – to shift to fossil-alternatives as e.g. diesel vehicles and coal-fired power plants are left stranded. If this does not happen, there will be social unrest as with France's yellow vest protests to President Macron's tax announcement in 2018. Social security programmes and retraining will also be needed to generate new employment opportunities to account for these stranded human and social assets. The burden of stranded assets (particularly in a monetary sense – see 2.2) must be borne by the broadest shoulders – rich shareholders, multinational firms and investors predominantly from the North who have accrued mammoth profits from commercialising fossil fuels over the last decades. Divestment does not solve this problem – it merely 'sends off' financial assets (destined to become stranded) to new buyers, potentially from the South who are eager to catalyse development (Gupta, Rempel & Verrest, 2020). Stranded financial assets must remain on the balance sheets of resource-rich actors to equitably build the path towards truly inclusive future.

*5.3. Limitations and future research*

Uncertainties persist around our scenarios for post-pancession recovery. An inclusive & transformative recovery is the most equitable and desirable, but how feasible is it? What are the legislative, litigative and political obstacles to phasing out fossil fuels and governing stranded assets in the midst of a pancession? How – if at all – can the vested interests and fossil fuel lobbies be persuaded to accept the costs of stranded assets? What does a socially-inclusive governance of stranded fossil fuel assets mean for different stakeholders (e.g. fossil industry employees vs. direct users vs. indirect users), and how does this vary geospatially and geopolitically (e.g. net importers vs. net exporters vs. resource-rich vs. low/middle income vs. high income countries)? How do stranded jobs differ between the most concentrated coal regions in the US (Wyoming) vs. South Africa (Mpumalanga)? And quite importantly, how do these inclusive pathways differ by fossil fuel type? These points are beyond the scope of this work, yet urgent research is necessary to address these gaps so as to advise the policies and stimulus packages as the COVID-19 pancession continues to unfold.

## 6. Conclusion

We set out to answer: *What opportunities has COVID-19 presented to phase out fossil fuels, and subsequently, how can transformative recovery efforts be designed to utilize these opportunities and promote social, ecological and relational inclusiveness?* Stranded assets will inevitably be generated as fossil fuels are phased out in compliance with climate objectives, which may cost as much as $200 trillion. The current owners of these assets who reap their trillions of dollars of financial benefits have strong vested interests in opposing climate policies and delaying climate action; without an initial 'push', the fossil fuel sector will undoubtedly continue to grow (SEI et al., 2020) and invest in new assets that risk future stranding. Our findings suggests that the COVID-19 pancession has provided this initial and unprecedented 'push' by: devaluing fossil-related financial assets; shelving, mothballing or retiring fossil-infrastructure; generating mass fossil-related unemployment; reducing fossil fuel production; and forgoing capital investment (CapEx) in new fossil projects on the order of tens – if not hundreds – of billions of USD.

The COVID-19 pancession is still unfolding and governments will continue to invest heavily to accelerate economic recovery, but the implications for the future of stranded assets remain uncertain. We propose four post-pancession recovery scenarios *that tend from the neoclassical, reformist forecasts towards transformation* – 1) Exclusive & Reformist Recovery, revitalising the fossil industry and abiding by neoclassical & reformist approaches; 2) Social Recovery, addressing immediate social needs at the expense of ecological inclusiveness; 3) Ecological Recovery, enforcing short-term climate policy but neglecting associated social issues like energy poverty and job, income and livelihood loss; and 4) an Inclusive & Transformative Recovery, promoting social, ecological and relational inclusiveness immediately and simultaneously. Achieving the fourth scenario mandates reimagining recovery pathways through *three key design features: 1) reconceptualising a stable climate, ecological integrity and health care as public/merit goods; 2)* ***building on COVID-19's asset-stranding 'push'*** *by 2a) permanently decommissioning shelved, mothballed or stalled assets, 2b) further phasing out fossil fuels and thereby generating new stranded assets, and 2c) allocating resources to fund and implement legislation in favour of fossil-alternatives; and 3) equitable management of stranded assets to ensure that the livelihoods of poor and vulnerable fossil-dependents are not jeopardised, and that the costs of stranded fossil* *fuel assets falls to the richest and most capable actors, predominantly in the global North.*

We are at a global crossroads with the unprecedented opportunity to eradicate a socially and ecologically harmful industry that has been growing exponentially for decades. It is time to finally uphold the environmental commitments made in Paris in 2015 and capitalise on COVID-19's 'push' to begin permanently and inclusively phasing out fossil fuels.

## 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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## Appendix A. Supplementary data

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