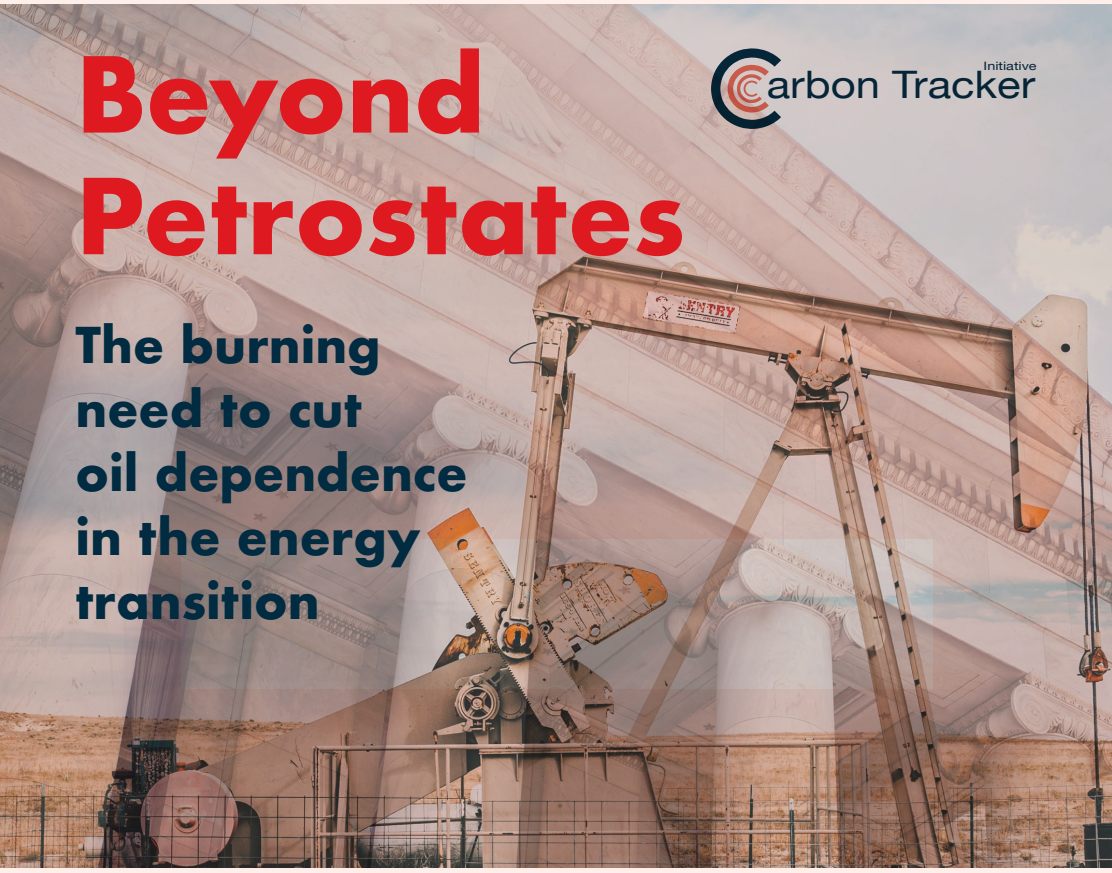
Beyond Petrostates

The burning need to cut oil dependence in the energy transition



Carbon Tracker Initiative

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About Carbon Tracker

The Carbon Tracker Initiative is a team of financial specialists making climate risk real in today's capital markets. Our research to date on unburnable carbon and stranded assets has started a new debate on how to align the financial system in the transition to a low carbon economy.

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Key Findings

In this report we explore the impact on oil and gas-producing government revenues as the world moves away from fossil fuels. The results illustrate the challenges facing hydrocarbon-dependent countries, and highlight the need for urgent policy action to help mitigate the impacts.

Lower fossil fuel demand and prices will have significant implications for fiscal sustainability in oil and gas-producing countries.

Under a low carbon scenario, combined global government oil and gas revenues worldwide could be $13 trillion lower than expected (51% less) over the next two decades compared with business-as-usual expectations of continued growth in demand and firm long-term oil prices.

The 40 petrostates could see a gap of $9 trillion vs expectations; 50% of these countries face a shortfall of over half of their hydrocarbon revenues in the next 20 years under a low-carbon outcome, as both national oil company (NOC) earnings and taxation receipts fall. The most oil and gas-reliant countries (as a % of GDP) are predominantly in the Middle East, North and West Africa and South America.

We produce an indicator of overall fiscal vulnerability to revenue stranding by combining potential oil and gas revenue shortfall with current dependence on hydrocarbon revenues (% of total revenues from oil and gas).

Tier 5 (most vulnerable) countries face an overall potential revenue shortfall of over 40%, including Angola, Azerbaijan, Bahrain, Timor-Leste, Equatorial Guinea, Oman and South Sudan.

Over 400 million people live in the 19 most vulnerable countries (tiers 4 and 5); six petrostate and four "emerging petrostate" countries are already considered as having low human development by the UN.

The petrostates are already at historically high levels of indebtedness, but differ in their financial position and ability to respond to these changes. Some have significant sovereign wealth funds while access to credit varies drastically.

We highlight important policy considerations to mitigate this impact:

- It is in everyone's interests to minimise global temperature rise.
- Petrostates will need to act now to transition away from a dependence on fossil fuel revenues. Propping up a failing oil and gas industry has huge opportunity cost.
- Further, the international community has strong incentives to support this journey. We summarise potential policy options available in the context of the "just transition".
- Petrostates face a prisoner's dilemma – collective supply restraint helps avoid oversupply and support prices, but states individually will want to maintain or boost production. A disorderly transition may lead to even greater government revenue shortfalls.

Image Credit: WORKSITE Ltd.

Executive summary

Highlighting the need for accelerated policy action

The adverse physical implications of climate change are known to weigh most heavily on the world's poor and less developed communities, with poverty and disadvantage increasing for those countries least able to bear it as the world warms. This humanitarian dimension provides one of the key imperatives for the global community to act to prevent climate change.

However, such a fundamental shift as decarbonising the world economy will involve trade-offs, in particular for the populations of economies that are heavily reliant on fossil-fuel production, which face lower government revenues and job losses. Accordingly, this has led to the principle of a "just transition", making sure that populations are helped to manage the transition in a way that is fair and equitable. These discussions aren't new of course, but the increasing pace and inevitability of the energy transition means increased urgency. In this report we explore the broad impacts on government revenues from upstream oil and gas production using a bottom-up, least-cost methodology, in order to both lay bare the scale of the issue and to highlight the most vulnerable as a call to action for policymakers and the wider international community. We hope that our analysis provides a useful data underpin and fresh injection of impetus into the development of decarbonisation pathway that is just for all.

The energy transition will reduce government revenues from oil and gas...

All else being equal, as demand falls, fewer oil and gas projects will need to be incentivised to supply the market, cutting long-term prices compared to assumptions of continued demand growth. Hence, both lower volumes and prices affect government revenues from National Oil Companies (NOCs) and private sector taxes/fees.

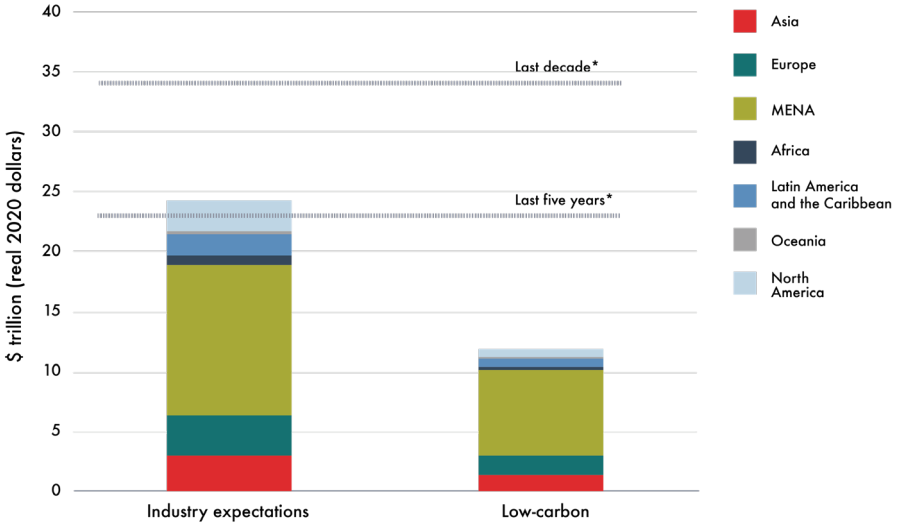
To understand the implications, we use the IEA's Sustainable Development Scenario (SDS, 50% chance of limiting warming to 1.65°C) as a low-carbon demand scenario and illustratively assume a flat real long-term oil price of $40/bbl[1] to model revenues. As a baseline proxy for "industry expectations", we use demand volumes under the IEA's Stated Policies Scenario, STEPS, and assume Rystad Energy's base case price outlook ($60/bbl long-term).

...with global revenues falling short of expectations by $13 trillion to 2040

Compared with industry expectations, total government revenues would be $13tn lower over the next two decades under the low-carbon scenario – a 51% drop (Figure 1). 80% of this gap in revenues is driven by lower prices, rather than lower volumes.

1 *The $40/bbl price is illustrative, and based approximately on the marginal breakeven cost of supply under the IEA's Sustainable Development Scenario in our analysis.*

FIGURE 1. 2021-2040 GOVERNMENT REVENUE UNDER DIFFERENT DEMAND/PRICE SCENARIOS



Source: IEA, Rystad Energy, CTI analysis
*Notes: Industry Expectations = demand pathways from the IEA's STEPS scenario, using Rystad Energy's long-term price assumption ($60/bbl). Low-carbon = demand pathways from the IEA's SDS scenario, using a long-term price assumption of $40s/bbl. MENA = Middle East and North Africa. * 2010-2019 and 2015-2019; averages extrapolated to 20-year values for comparability.*

The impact of reduced government revenues varies regionally

The Middle East and North Africa (MENA) region outperforms most others in the low-carbon scenario due to its production cost advantage, but low prices mean it still experiences average future revenues over 40% lower than over the downturn of the past five years (2015-2019), and significantly lower than levels of the past decade.

TABLE 1. IMPACT OF LOW-CARBON SCENARIO ON OIL AND GAS REVENUES, REGIONS – CHANGE VS INDUSTRY EXPECTATIONS

Region	Low-carbon vs Industry expectations
Asia	-57%
Europe	-50%
MENA	-43%
Africa	-58%
Lat. Am. & Caribbean	-66%
Oceania	-30%
North America	-77%

Source: IEA, Rystad Energy, CTI analysis

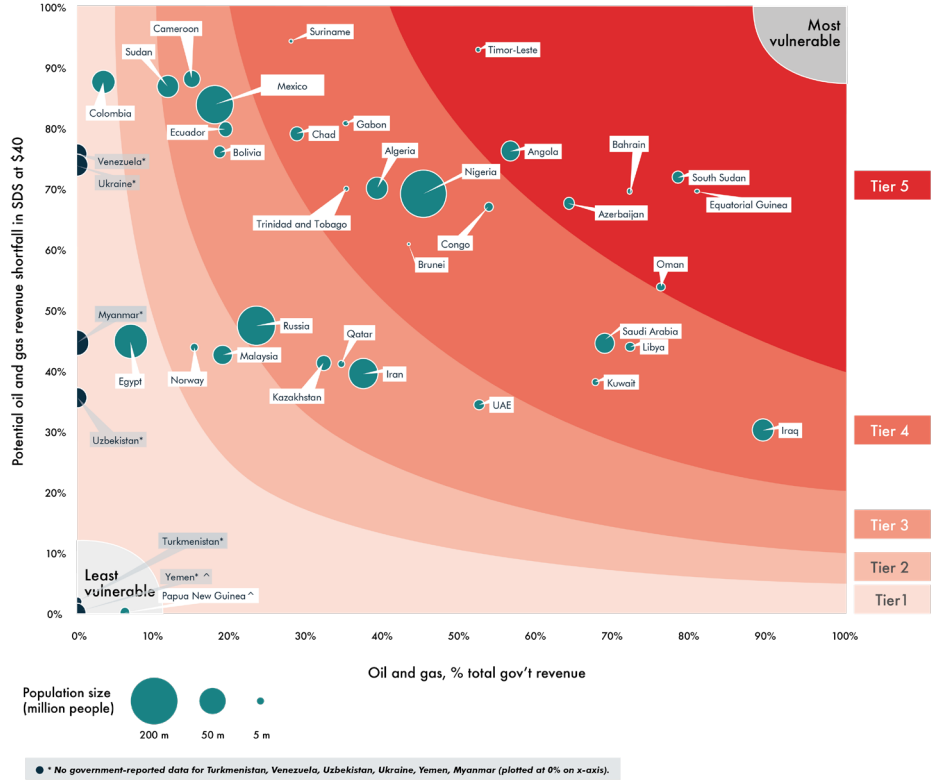
Petrostates' fiscal budgets vary in vulnerability

We focus on the 40 countries with the greatest fiscal dependence on oil and gas revenues ("petrostates"); for this group, the revenue gap under a low-carbon scenario is $9 trillion (46%) vs industry expectations.

Given these countries' fiscal budgets presently rely heavily on oil and gas revenues, our analysis primarily focuses on quantifying the potential shortfall under a low-carbon scenario vs revenue levels over the past decade. Combining dependence with % of average potential oil and gas revenue shortfall under the low-carbon scenario allows us to group the petrostates by vulnerability tier (Figure 2) based on the percentage shortfall in overall government revenues.

We identify seven countries within our highest vulnerability tier (potential government

FIGURE 2.VULNERABILITY OF PETROSTATES TO LOW OIL AND GAS DEMAND AND POPULATION SIZE



Source: Rystad Energy, IMF, IEA, SSB (Norway), CBL (Libya), CBI (Iran), CTI analysis
*Notes: Vulnerability = potential total government revenue shortfall [multiplication of axes] over 2021-2040. Tiers roughly equate to a shortfall of <5% (1), <10% (2), <20% (3), <40% (4), >40% (5) of total revenue. Potential revenue shortfall = 2021-2040 average vs 2015-2019 average. Shares on x-axis are 2015-2018 average due to lack of 2019 data. * No government-reported data for Turkmenistan, Venezuela, Uzbekistan, Ukraine, Yemen, Myanmar (plotted at 0% on x-axis). ^ PNG and Yemen would see their revenues in our modelling, though this stems in part from difficulties with accurately estimating future gas prices and regional demand.*

revenue shortfall of over 40%): Angola, Azerbaijan, Bahrain, Timor-Leste, Equatorial Guinea, Oman and South Sudan.

"Emerging petrostate" revenues fall far short of hopes

Some countries looking to expand their nascent oil and gas industries (e.g. Guyana, Senegal) do still experience some production growth compared with today. Of the six countries reviewed in this document, four will see future revenues halve under a low-carbon scenario relative to expectations, whilst the other two are reliant on domestic gas demand. These countries should therefore be wary in long-term fiscal decision-making as the world transitions away from fossil fuels.

A significant population is affected, with many countries having already low development levels

Over 400 million people live in the 19 countries in Tiers 4 and 5 (which could lead to a potential shortfall over 20% of current government revenues). Six of the petrostates, and four of the emerging petrostates, are currently categorised as "low" in the United Nations Human Development Index.

Indebtedness is historically high; ability to respond varies by country

Average petrostate central government debt nearly doubled from 24% of GDP in 2010 to 46% in 2018.

Savings in the form of sovereign wealth funds (e.g. Brunei, Kuwait and the UAE) will mitigate risks for a handful of countries in the short-term, but significant reform will still be critical over the next decade to avoid exhaustion. These countries also tend to have investment-grade credit ratings, giving the potential to raise significant capital through debt markets.

Others who lack these options will need to be even more proactive at reducing spending, raising new taxes and diversifying their economies – but less firepower to do so suggests a greater need for external support.

Interest for the petrostates to transition successfully

While the physical consequences of climate change may affect individual countries differently, it remains in the collective interests of all nations to seek to minimise global temperature rise and mitigate some of the potential results, some of which may have effects cross-border.

Similarly, the entire international community has reasons to want the petrostates to navigate the transition successfully on an economic basis, whether due to equity, better climate outcomes, or preventing potential instability.

Diversification solutions and support can take many forms, both at home...

As success with climate goals will inevitably mean the use of less fossil fuels, producer governments must recognise this issue and act now to reduce reliance on income streams that will dwindle over time. This will likely require more sustainable fiscal policy, tax reforms, development of other domestic industries, or all of the above. Avoiding addressing the issue until oil consumption is declining will be leaving it far too late.

Encouragingly, the low oil price environment of the last five years has already incentivised some to make tentative first moves on fiscal diversification. Several of the Middle Eastern

GCC[2] states have introduced measures such as value-added taxes and (with others like Nigeria, Angola and Iran) reduced subsidies, particularly on consumer fuels, which both reduces state spending and disincentivises inefficient fossil fuel consumption.

Petrostates are also actively supporting their non-oil sectors to build new tax, job and foreign currency engines. Examples include GCC government investments into industries like renewable energy[3] and tourism[4] and a $1.6bn deep-sea port in Nigeria[5].

.... And abroad

Helping petrostates accelerate these transitions is an area where the international community can offer support to the most vulnerable, especially those with already disadvantaged populations and a limited capacity to respond. This might be through, for example, supporting the development of new technologies, providing capital to accelerate their deployment and providing support for regulatory and tax reform.

The petrostates would benefit from an orderly transition, but face the prisoner's dilemma

As above, price impacts dominate the financial implications of lower fossil fuel demand. Accordingly, petrostates collectively benefit from an orderly wind down of production where global supply is lowered in tandem with demand, giving prices some support and minimising revenue losses.

However, countries may be tempted act in their own interests and seek to monetise their reserves rapidly, even though loss of discipline across industry would destroy value for all and represents a further downside risk beyond the results in this report. International cooperation between oil producers will likely be hard to maintain with demand falling continuously, and even the Paris Agreement has no mention of co-ordinated action on the supply side of fossil fuels.

States will therefore need to show restraint in their fossil fuel investments, whether through the direct sanction of NOC projects or activities which encourage private investment.

2 *Gulf Cooperation Council: Saudi Arabia, the UAE, Kuwait, Qatar, Oman and Bahrain.*
3 https://www.dewa.gov.ae/en/about-us/media-publications/latest-news/2019/03/mohammed-bin-rashid-al-maktoum-solar-park
4 https://www.theredsea.sa/en
5 https://lekkiport.com/about-lekki-port-lftz-enterprise/the-port/

Preface: Equity and Policy in Mitigating Impacts

The challenges facing fossil fuel-reliant economies

Climate change will make hard lives harder

The adverse physical implications of climate change are known to weigh most heavily on the world's poor and less developed communities, with poverty and disadvantage increasing for those countries least able to bear it as the world warms[6]. Water stresses, sea level rise, food insecurity, population displacements – all are examples of the impacts that are likely to fall hardest on poorer communities, such as agricultural and coastal societies, Indigenous people, children and the elderly, and urban dwellers in African cities. Furthermore, these are risks that are arise even under the 1.5°C level at the most ambitious end of the Paris Agreement goals, while the impacts become ever greater should warming continue to increase through to 2°C or above[7].

This humanitarian dimension provides one of the key imperatives for the global community to act to prevent climate change – whether that is for the altruistic purpose of making life better for others, and/or a more inward-looking rationale of preventing foreign instability with attendant issues of refugees, extremism and so on. Reduced fossil fuel use will also lead to improved air quality, particularly in densely populated cities.

Decarbonisation will bring its own challenges, particularly for fossil fuel-producing nations

However, such a fundamental shift as decarbonising the world economy will involve trade-offs, and these will be felt differently in different parts of the world. Accordingly, this has led to the principle of a "just transition", making sure that populations are helped to manage the transition in a way that is fair and equitable[8]. The populations of economies that are heavily reliant on fossil-fuel production are perhaps the most obvious example where the transition will also have some negatives, for example lower government revenues and job losses. Decisive and forward-looking policies will be required to prevent and mitigate these impacts, both on the part of domestic and overseas authorities.

The desirability of economic diversification away from fossil fuels in reducing poverty is clear even in normal times given the volatility and boom-bust nature of the oil market, an issue that has been made even more

6 *"Poverty and disadvantage are expected to increase in some populations as global warming increases; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050 (medium confidence)"*
IPCC, Special Report on Global Warming of 1.5°C, Summary for Policy Makers. Available at https://www.ipcc.ch/sr15/

7 *IPCC, Special Report on Global Warming of 1.5°C,Chapter 5. Available at https://www.ipcc.ch/sr15/*

8 *See for example Nick Robins and James Rydge, "Why a just transition is crucial for effective climate action" Available at https://www.unpri.org/inevitable-policy-response/why-a-just-transition-is-crucial-for-effective-climate-action/4785.article*

obvious repeatedly in recent years. The long-term nature of the energy transition adds a new and inexorable importance to making this shift – officials won't be able to hope for mean reversion or a new boom being around the corner.

No "one-size fits all" solution

However, the means of doing so is a complex and challenging topic, and different countries will have varying needs, options available to them, and impediments to making the required changes.

Some wealthier Gulf states, conscious of these issues looming large, have developed plans to restructure fiscal regimes, diversify their economies through foreign direct investment, and develop domestic industries. Examples include Saudi Arabia's Vision 2030 strategy, and Qatar's National Vision 2030 and Economic Diversification and Private Sector Development strategy[9]. Indeed, they may also have significant resources for renewable energy deployment – although it has faced a number of difficulties so far, Saudi Arabia has a goal of producing 50% of its electricity from renewables by 2030[10].

For many other countries, and in particular those that already have more disadvantaged populations, finding a low carbon development pathway that increases prosperity while fossil fuels are left untapped – or become a reduced source of income – will require a comprehensive suite of actions to be put in place[11]. However, history shows that in practice making such changes is difficult. As options will be fewer and the road harder for some countries than others, perhaps starting from a position of having fewer financial resources, weaker institutions, and a lower level of non-fossil fuel domestic industry, this raises the importance of international support in making the journey.

Highlighting the need for accelerated policy action

These discussions aren't new of course, but the increasing pace and inevitability of the energy transition means increased urgency. In the same way that decades of inaction on emissions have resulted in the need for a sharper bend in the emissions trajectory, so efforts to find solutions to cushion the landing for vulnerable populations will have to be accelerated to make up for lost time.
In this report, we examine the impact on the government revenues of oil and gas-producing states in order to both lay bare the scale of the issue and to highlight the most vulnerable as a call to action for policymakers and the wider international community. We emphasise that our analysis isn't based on those countries making unilateral sacrifices of production, but rather represents the results of a market-based framework where actions to reduce fossil use in different countries result in lower commodity prices globally.

Given that the need for policy action has been long recognised and debated, there are a range of options already on the shelf. As analysts rather than policy experts we note some of these here to highlight pre-existing work on the topic and that a range of potential solutions have been proposed, rather than to express preferences on the most desirable or likely pathways – these are best in the hands of those better qualified

9 *See for example Oxford Business Group, "Qatar doubles down on economic diversification" Available at https://oxfordbusinessgroup.com/analysis/determined-diversify-country-has-doubled-down-its-drive-broaden-its-economic-bases-and-increase*

10 *Vinod Sekhar, "Saudi Arabia Vision 2030: Solar energy can complement, not rival, oil and gas", Arab News July 2020. Available at https://www.arabnews.com/node/1708961*

11 *See for example Iseoluwa Akintunde, "Nigeria's Recovery Means Rethinking Economic Diversification", Chatham House August 2020. Available at https://www.chathamhouse.org/2020/08/nigerias-recovery-means-rethinking-economic-diversification*

than us. However, we hope that our analysis provides a useful data underpin and fresh injection of impetus into the development of decarbonisation pathway that is just and equitable for all.

Domestic policy actions

The results of this study imply that many oil and gas producing nations will face future government revenues much lower than they might have expected based on history, and their leaders will have a crucial role to play in minimising the damage imposed on their populations.

The World Bank's recent book on this topic, authored by Peszko et al., offers a helpful set of five elements to frame the discussion about what petrostate governments can do domestically to diversify and which we reference and broadly use as a framework here.[12] Its study covers both upstream and downstream, so we have adapted their suggestions slightly to fit the scope of our upstream-only report.

1. Increase the fiscal take of resource revenues and reduce public revenue risks

Some governments, blessed with oil and gas resources that are cheaper to extract, have the flexibility to adjust fiscal regimes (taxes and fees) to capture more revenue from wellhead cash flows. Doing so could effectively be seen as a wellhead carbon tax; however, countries may conversely be tempted to lower taxes to compete for supply in a race to the bottom.

Petrostate policymakers will also need to focus on exploring new sources of tax revenue by formalising and expanding the non-fossil fuel economy (i.e., getting significantly more businesses and income earners on the tax roll) and levying new taxes. These constitute a large potential source of revenue that petrostates have not properly tapped, thanks to the cushioning effect of resource revenues. For instance, Mullins, Gupta & Liu suggest a range of specific tax reform options that low-income countries can implement, such as scrapping inefficient tax incentives, improving VAT efficiency (or indeed, levying VAT in the first place) and boosting progressive taxation.[13]

Tentative steps in this direction have been taken in some of the GCC states over the past few years, with the imposition of VAT ranging from 5-15% and various excise taxes. Developed countries will likely need to provide more technical assistance to lower-income, more vulnerable countries to enable them to embark on similar tax reforms.

2. Create incentives and medium-to-long-term public expenditure frameworks to reinvest the fiscal take of fossil fuel revenues in a diverse range of assets

Creating robust institutional frameworks for long-term investment is crucial. Countries that do not already have sovereign wealth funds (SWFs) may want to create them, drawing on best practices from peers.[14] Many existing SWFs will also need to be repurposed to not just act as temporary fiscal buffers during commodity-price downcycles, but as domestic investment vehicles formally separated from ordinary budget operations. This could include creating several separate funds serving different purposes. For instance, Oman operates multiple SWFs, dividing up its savings into domestic long-term investments and liquid, diversified assets intended for fiscal smoothing.[15]

12 *Peszko et al. 2020, Chapter 6*
13 *Mullins, Gupta & Liu 2020*
14 *Al-Hassan, Brake & Papaioannou 2018*
15 *Base prospectus from October 2020 bond issuance, available at https://www.rns-pdf.londonstockexchange.com/rns/4566D_1-2020-10-28.pdf*

Freeing up more revenues for savings and investment will of course also require difficult spending cuts. All the petrostates have already been faced with this challenge since the oil price collapse in late 2014, and again in 2020 with the renewed price collapse brought about by Covid-19. Unfortunately, petrostate fiscal policy tends to be procyclical – when prices recover and revenues rise, spending does too, reversing some of the cuts made during the downcycle.

Going forward, governments will need to take a much longer-term view on public finance management. This could mean instituting binding medium-term spending targets that are adhered to regardless of oil prices, as well as rethinking big-ticket items like subsidy schemes and public wage bills.[16] These are doubtlessly politically difficult but, encouragingly, several petrostates have cut subsidies in recent years, including the GCC countries, Iran, Nigeria and Angola.

3. Create regulatory incentives to minimise irreversible capital-intensive investments in further oil and gas infrastructure

Governments also need to reassess how they allocate their remaining oil and gas revenues over the coming decades. Crucially, national oil companies should be steered away from reinvesting their earnings into new high-cost projects that may end up wasting public money, an issue explored in greater detail by Manley & Heller.[17] Freed-up capital could instead be directed into public investment funds that support the non-oil economy.

4. Address innovation policies and the role of the state

Diversification away from oil and gas will need to go beyond just fiscal reform – petrostates will also need to actively nurture non-oil industries to create bigger tax bases and reduce the need to maintain large public wage rolls. A foundational factor for enabling such industries is institutional quality, such as low levels of corruption and red tape.[18] Petrostate governments therefore need to identify areas where the business environment may be a hindrance to investment and innovation, for instance with reference to the World Bank's Ease of Doing Business indicators.[19] In addition to removing negative constraints on their economies, governments will also want to consider investing more heavily in human capital to foster greater innovation.[20]

As Peszko et al. suggest, it may also be the case that the state needs to take a more active "entrepreneurial" role in supporting the development of new sectors where a country may have a competitive advantage, but where uncertainty discourages private investors from committing capital. Again, SWFs with the specific mandate of investing domestically can help overcome these barriers, so long as governments are careful not to crowd out potential private sector participants.

5. Manage the politics of the transition and established vested interests

Of course, meeting the policy challenges above is contingent on the successful navigation of countries' current political economies, for example vested interests that benefit from existing arrangements and will resist attempts at structural reform. Clearly, this problem is not unique to oil and gas exporters, but it is particularly complex given the scope of the reforms needed.

16 *Danforth, Medas & Salins 2016*
17 *Manley & Heller 2021, forthcoming*
18 *Gelb 2010*
19 *www.doingbusiness.org*
20 *Gelb 2010*

One important aspect of overcoming these barriers is to create buy-in for reforms from the wider population. Revenues not invested in new fossil fuel projects, or redirected from inefficient subsidies and tax exemptions, should be clearly earmarked for uses that have a positive impact on peoples' day-to-day lives, especially the poor. Infrastructure investments, greater spending on health and education and targeted transfers to low-income earners are all policies that could help build political capital for more contentious reforms.

At the same time, in order to maintain political support, governments must take care not to let the readjustment burden fall disproportionally on the poor, for instance by balancing regressive taxes (e.g. VAT) with progressive ones (e.g. income / capital gains). Issues of equity in the transition apply within countries as well as between them.

International actions

There are also strong reasons for overseas economies to support domestic authorities in overcoming these challenges, echoing the humanitarian reasons for mitigating climate change above.

First, many will feel a strong moral imperative. Our results show that many of the countries set to suffer the most from revenue losses are also the poorest. In some cases they also have large and rapidly growing populations, for example in Nigeria and Angola.

Second, helping other economies shift away from a fossil fuel-basis may lead to lower emissions and better climate outcomes to the benefit of all, by easing the path of both domestic decarbonisation and international target-setting.

Third, weaker petrostates could become less stable – with impacts beyond their borders – either because of social unrest as a response to fiscal consolidation, or because under-funded security services fail to contain existing militant threats. Coupled with other economic challenges, there may also be increased migratory flows.

The role of international cooperation

The international community can take several different approaches to addressing these issues. Bilateral aid is one component – but likely only for the poorest countries, and only where it has the greatest impact, in line with accumulated experience from aid programmes over the past several decades.[21,22] Technical assistance – for instance, helping countries design and implement new tax systems – is of greater importance, since petrostates need sustainable, long-term fixes. These efforts are already taking place, particularly under the auspices of IMF and World Bank programmes, but they need to be accelerated.

Aside from targeted fixes, the scale of the challenge raises the question of whether a bigger, multilateral effort is also needed. This may seem like a return to the hard-to-negotiate issue of systematic transfers between developed and developing countries. However, where in the past these debates focused on assigning responsibility for historical emissions, the narrative is now slowly shifting towards *sharing the gains* of the energy transition. This possibility has been raised as part of emerging supply-side initiatives like the Fossil Fuel Non-Proliferation Treaty.[23] Its proponents argue capital raised through policies like carbon taxes and fossil fuel subsidy cuts could be pooled into a so-called Global Transition Fund, which is then used to help fossil-fuel

21 *Kenny 2021*
22 *McKee et al. 2020*
23 https://fossilfueltreaty.org/

rich countries transition to low-carbon alternatives.[24]

Alternatively, the World Bank (Peszko et al.) suggests a more bilateral option in which petrostates agree to levy wellhead carbon taxes in exchange for importer countries avoiding border carbon taxes, with the revenues shared between both parties. Any of these policies are clearly challenging to design and implement, but offer options for the path forward.

24 Newell & Simms 2020

Introduction

Success under climate goals will mean less oil and gas use

Global temperatures are driven by the cumulative stock of greenhouse gases in the atmosphere, meaning that for them to stabilise – at any level, whether 1.5°C or "well below 2°C" under the Paris Agreement, or higher – worldwide carbon emissions will need to reach zero on a net basis. Whether the catalyst is out-competition by renewables, government policy, changing behaviours, or all three, the impact to oil and gas producers is the same: reduced demand and lower prices for their products.

The energy transition to a low-carbon world will impact states as well as investors

Over the last decade Carbon Tracker has produced a series of reports looking at the financial impact of this dynamic, highlighting the risks to fossil fuel producing companies for investor audiences.[25] Over this period, wider recognition of these issues has led to significant recent changes in corporate positioning, with new "climate" strategies announced, project portfolios re-assessed in light of downwardly revised long-term commodity price assumptions, and significant impairments.[26]

However, the transition will also have significant impacts for nation states – the focus of this report.

Whether or not individual countries are concerned by the physical risks of climate change, the fact remains that changes in commodity demand anywhere in the world impact global market dynamics. Lower global demand and prices will lead to lower oil and gas revenues for the governments of producing nations. The countries most reliant on those revenues – the petrostates – could experience major negative economic effects if they do not anticipate this and take mitigating actions well in advance.

In this report we explore the broad impacts on government revenues from upstream oil and gas production in order to both lay bare the scale of the issue and to highlight the most vulnerable as a call to action for policymakers and the wider international community.

This means answering some key questions:

- Which countries have the greatest **potential shortfall of oil and gas incomes/rents** through the energy transition?
- How **dependent are countries** on these oil and gas incomes?
- Together, **which countries are most vulnerable** to reduced oil and gas demand?
- What are the implications for these countries in terms of **resilience and their ability to adapt** to significant revenue losses?

25 *See Carbon Tracker, "Fault Lines: How diverging oil and gas company strategies link to stranded asset risk", October 2020. Available at https://carbontracker.org/reports/fault-lines-stranded-asset/*

26 *Bp, Chevron, ConocoPhillips, Eni, Repsol Shell and Total; Carbon Tracker Analysis, as published here: https://www.theguardian.com/business/2020/aug/14/seven-top-oil-firms-downgrade-assets-by-87bn-in-nine-months*

Carbon Tracker's least-cost approach

We approach this issue using the same least-cost framework as in our reports on company stranded asset risk – see the methodology document that accompanies *Breaking the Habit*[27], updated in *Fault Lines*.[28]

To understand the impact that the energy transition could have on both future project viability and incomes for companies and governments, we consider demand under a low-carbon world using scenarios from the International Energy Agency (IEA).

Oil demand falls rapidly under a well below two degree scenarios

The low-carbon demand scenario used in this report is the IEA's Sustainable Development Scenario (SDS, 50% likelihood of limiting warming to 1.65°C).[29,30] As a proxy for industry expectations of future demand levels when looking at global results, we take the IEA's Stated Policies Scenario (STEPS, 2.7°C warming by 2100).[31]

Figure 3 shows a comparison of these two scenarios for oil, with demand falling increasingly rapidly to 2040 under the low-carbon scenario (and beyond), whereas demand continues to rise under STEPS. We note that OPEC forecasts a similar rise in oil demand from 2021 to 2040, consistent with our use of STEPS as an appropriate proxy for countries' present views of future oil demand.[32] Later in the report, we also compare low-carbon revenue against revenue in the last five years (2015-2019, also referred to as "current revenues" through the report) to show the scale of the readjustment for fossil fuel-dependent countries from the levels they are currently accustomed to. On average, current revenues are approximately on par with STEPS; see the next section for more detail.

As existing production declines, demand is met first from the lowest cost projects

These demand levels are compared to supply data using Rystad Energy's UCube. Our model treats oil as a single global market, along with four regional gas markets (North America, Europe, Russia and Australia) and global LNG. Gas produced for consumption outside of these markets is modelled as going ahead irrespective of the scenario under consideration, and so production volumes do not change; consequently, our assessment of the reduction in gas demand under a low-carbon scenario is likely to be conservative.

Figure 3 shows Rystad Energy base-case future production from existing fields (including those under development) for liquids out to 2040 alongside the demand pathways; the resultant supply gap under low-carbon demand levels (SDS) is less than half of that under projections based

27 *See Carbon Tracker, "Breaking the Habit: Methodology", September 2019. Available at https://carbontransfer.wpengine.com/wp-content/uploads/2019/09/Breaking-the-Habit-Methodology-Final-1.pdf*

28 *See Carbon Tracker, "Fault Lines: How diverging oil and gas company strategies link to stranded asset risk", October 2020. Available at https://carbontracker.org/reports/fault-lines-stranded-asset/*

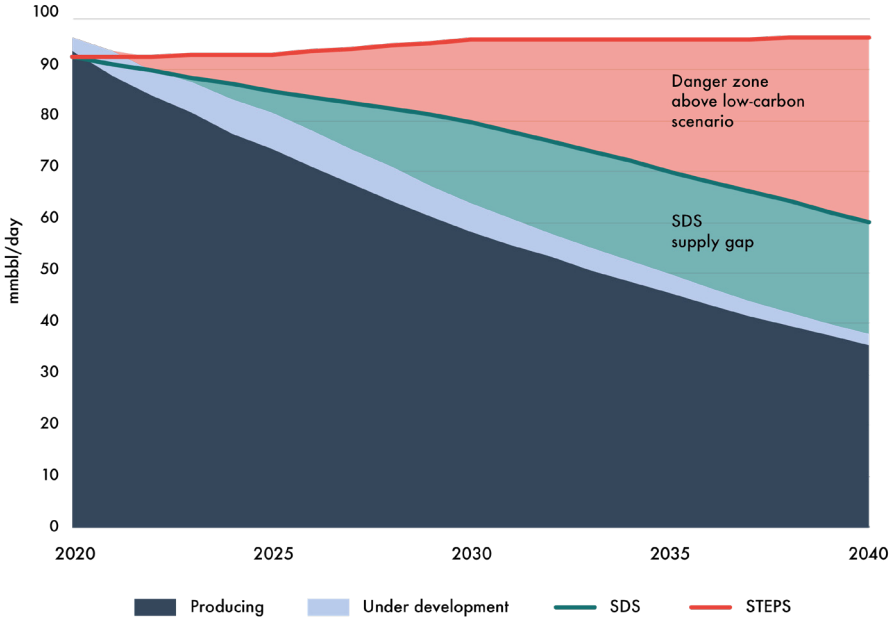
29 *The IEA models the SDS emissions trajectory to 2050, and notes that if this trajectory is extrapolated beyond this point it would result in net zero emissions in 2070. If emissions are assumed to stay at zero thereafter, the IEA concludes this would result in a 66% chance of limiting warming in 2100 to 1.8°C, or a 50% chance of 1.65°C.*

30 *In our company analysis, we have also considered the impacts of the IEA's B2DS scenario (1.6°C warming outcome in 2100) and the P1 (1.5°C, very limited carbon capture and storage) and P2 (1.5°C, some carbon capture and storage) scenarios from the Intergovernmental Panel on Climate Change (IPCC).*

31 *The Stated Policies Scenario was renamed from the New Policies Scenario in the 2019 World Energy Outlook.*

32 *OPEC World Oil Outlook 2020*

FIGURE 3. GLOBAL OIL DEMAND (2020-2040) UNDER LOW-CARBON SCENARIO (SDS) AND BUSINESS AS USUAL (STEPS), ALONGSIDE FUTURE SUPPLY FROM SANCTIONED ASSETS



Source: IEA, Rystad Energy, CTI analysis
Notes: Adapted from Figure 11 in "Fault Lines" (October 2020) to incorporate updated demand scenarios from the 2020 World Energy Outlook for SDS and STEPS.

on current policy announcements (STEPS). Consequently, if new projects are sanctioned based on expectations of business-as-usual demand, they may be outcompeted for limited demand under lower price conditions by lower cost projects, failing to deliver the hoped for returns as a result – becoming "stranded".

We use a cost curve approach to understand the merit order of unsanctioned potential project options, and which fit within a given level of demand based on each asset's breakeven costs.

We note that if a 1.5°C scenario is chosen, rather than SDS or STEPS, then this means commensurately lower space for fossil fuel development. For example, the P1 scenario from the Intergovernmental Panel on Climate Change (IPCC), implies no space for any new projects.[33] The IEA's recently released Net Zero Emissions 2050 scenario similarly has oil demand falling at a rate where it would be satisfied by continued investment in existing fields alone.

Aggregating the impacts at a country level

Having identified those projects that fall within (or outside) a given scenario, they can then be aggregated to understand the impact to different parties – at the country level in this analysis. See next section for more details of the different revenue streams included by country.

33 *See Carbon Traker, "Breaking the Habit", September 2019. Available at https://carbontracker.org/reports/breaking-the-habit/*

Finally, and in contrast to our previous capex-focused work, we additionally consider the impact of changing prices – that is, the price received for each unit of oil or gas – as well as production volumes on the projected government revenue streams (see the next section for further detail).

Building on a market-focused perspective

This report builds on previous literature attempting to quantify "stranded revenues" on a regional and country level.[34,35] The least-cost approach enables us to distribute volumes on a country level based on a few simple assumptions; the market effectively decides who produces what purely on the basis of relative economics without any subjective allocation.

Naturally, this is not the only way of approaching the issue. For instance, the production gap methodology developed by the UN and others[36] offers an alternative way of quantifying excess fossil fuel production, and its use of "planned" production levels has strong parallels to our use of a business-as-usual/industry expectations scenario. Our approach builds on this with a market-based, bottom-up framework.

The least-cost methodology gives an outcome that is theoretically financially optimal globally in terms of supplying the world's energy needs as cheaply as possible. Ultimately however, the value of the least-cost methodology is not that it is fair – rather, it shows where the chips will fall if the distribution of fossil fuel production in the transition is left to the market, without further policy intervention. Particular audiences may not see these outcomes as equitable and may see other effects as undesirable, such as an unwanted concentration of supply. This report therefore highlights some of these issues, which we expand further.

A note on Covid-19

The Covid-19 pandemic has had a significant impact on global energy markets, and oil demand in particular, with sharp volatility in commodity prices. This has been accompanied by a reduction in project sanction, with future projects likely also delayed or in some cases cancelled.

We note here that the data used in our analysis was collected at different points in time during the crisis, and therefore reflects differing states of knowledge of the implications:

- **Supply data**: Rystad Energy UCube database as at March 2020.
- **Demand data**: International Energy Agency (IEA) World Energy Outlook published October 2020 (STEPS and SDS).

The data therefore does not reflect all of today's knowledge. However, we continue to consider the results valid, for reasons including the following:

- The intent of the analysis is to understand the macro picture over decades, during which time there will no doubt be plenty of unforeseen events and cyclical market changes. This uncertainty is considered in our approach. Further, the extent of the longer-term impact of Covid-19 remains an unknown and subject to much debate.

34 *Nelson et al. 2014*
35 *McGlade & Ekins 2015*
36 *SEI, IISD, ODI, E3G & UNEP 2020*

- Our focus is also on the relative impact to countries, which are more likely to hold in times of turmoil than absolute conclusions particularly when all countries are impacted by the same factor.

- While oil price moves have been extreme, we do not seek to make oil price predictions, and certainly not on an annual timescale. The marginal costs derived from our analysis (and used illustratively in the place of prices in this analysis) are not forecasts. They are the theoretical prices needed for sufficient projects to be developed to meet a given demand scenario. While prices may fall, to first order the relative cost-competitiveness of projects will remain similar.

Global Implications of Lower Demand

To understand the impact that reduced demand will have on overall government revenues, we need to consider the full range of payments to national governments from upstream oil and gas activities. Governments earn revenues from their fossil fuel resources in two main ways: 1) by investing directly in their extraction through national oil companies (NOCs) and 2) though granting exploration and production leases and then taxing the subsequent hydrocarbon production.

In this section, we first consider the impact that the energy transition will have on NOCs, and the viability of the project options in their portfolios. We then consider the impact that a scenario of reduced oil and gas activity will have on overall oil and gas government "revenue" (see box), combining both elements.

Government Revenue Definition

We define government revenues as the sum of:

1. Publicly-owned share of national oil companies' (NOC) free cash flow (from both domestic and foreign investments). These can be from both operated assets, or from equity stakes in projects operated by others (often through a joint-venture company).

2. Government take (the term used by Rystad Energy to describe all cash flows destined exclusively to the authorities and landowners), through the principal range of fiscal tools used[37], including:

- Royalties
- Corporate income taxes
- Bonuses
- Withholding taxes
- Resource rent taxes
- Surface rental payments

Note that this differs from oil and gas exports as a share of GDP. Government revenues do not necessarily cover the entire economic impact of the oil and gas industry, especially in countries where private companies play a more significant role upstream or where fiscal regimes capture smaller shares of overall rents. Equally, governments can also capture revenues that accrue abroad through national oil companies' foreign ventures, whereas exports are geographically constrained.

This analysis applies to upstream activities only; falling oil use will also lead to falling revenues from other parts of the value chain which are out of scope including midstream (e.g. pipelines), downstream (e.g. refineries), and retail, but these are likely to be relatively small in comparison.

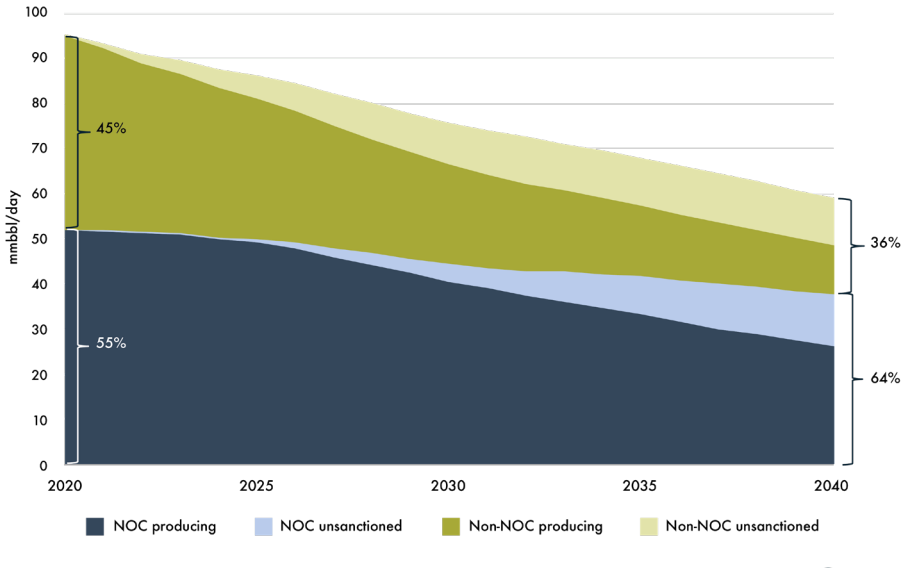
NOCs, as well as private sector companies, will be impacted under lower demand outcomes

A common contention made by private sector oil and gas companies is that undue focus is given to their activities (and emissions), with NOCs allowed to be effectively let off the hook with less scrutiny, and reduced disclosure requirements. The concern is that the NOCs are able to produce unabated as the rest of the industry "decarbonises" by reducing output.

Implicit in this argument of course is that the world will fail the Paris Agreement goals (otherwise the additional assets would not be economic), and it appears to carry an element of fear of missing out or "FOMO". If private sector companies are concerned about value rather than volume, and see a prospect of the planet decarbonising, then perhaps they should be content to see others take the risk of investing in the marginal projects that have a higher likelihood of being stranded.

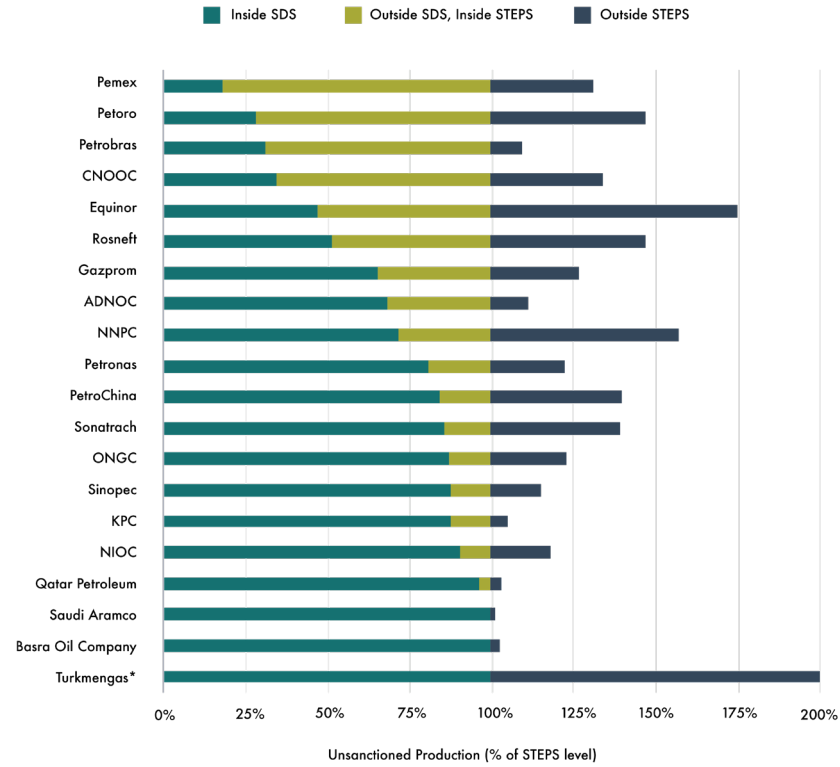
Their on-average lower production costs mean that under our modelling it is true that NOCs – and particularly those in the Middle East – will assume a more prominent role in global oil and gas supply over the next few decades, but they do not come to dominate it. NOC share of production rises from an average of 55% in 2020 to 64% in 2040 in our analysis, but their production volumes still fall by 28% (52 to 38 mmbbl/day in

FIGURE 4. LIQUIDS PRODUCTION (2020-2040) UNDER SDS BY PROJECT SANCTION STATUS FOR BOTH NOCS AND NON-NOCS, SHOWING CHANGING SHARE OF TOTAL



Source: Rystad Energy, IEA, CTI analysis

FIGURE 5. OIL & GAS PRODUCTION VOLUMES UNDER A LOW-DEMAND SCENARIO (SDS) VS BUSINESS-AS-USUAL (STEPS), LARGEST 20 NATIONAL OIL COMPANIES BY 2019 PRODUCTION



Source: Rystad Energy, IEA, CTI analysis
*Notes: Companies ranked from most-exposed to least-exposed. * 231%.*

absolute terms) over the next two decades (Figure 4).

While on average a greater proportion of NOC potential future capex falls within SDS compared with private sector companies, stranded asset risk remains very real for NOCs (Figure 5). Of the 20 NOCs shown here, five would need to reduce production by at least 50% compared to a business-as-usual scenario. Moreover, all but a few (Basra Oil Company, Saudi Aramco, Qatar Petroleum and Kuwait Petroleum Company) have a significant quantum of project options in their portfolios that are incompatible even with business-as-usual volume growth (see ">STEPS" bars in Figure 5).

For the minority of countries where the NOC is the dominant upstream player (e.g. KPC in Kuwait) the loss of NOC income will likely have the biggest impact on government revenues; for most, however, the loss of tax receipts as private sector companies reduce activities should be of bigger concern.

Granted, NOCs may view a lower rate of return as "adequate" compared to private sector companies and consequently may

sanction assets that private companies would not, perhaps gaining further market share. Regardless of whether these assets are technically viewed as "stranded", government earnings are still likely to fall sharply.

Lower levels of demand impact government receipts through lower prices...

However, a fall in sanctioning activity and production volumes still only highlights part of the impact of a low-carbon world with lower oil and gas demand. As we showed in *Handbrake Turn*,[38] the consequent impact of lower demand on marginal breakeven prices can be very significant. Lower volumes will result in lower taxation, but reduced volumes combined with lower prices will lead to *significantly* lower tax take.

The effects of both reduced production volumes and prices on future global government revenues over the next two decades are illustrated in Figure 6, which shows revenues under three different scenario and long-term price assumption combinations:

1. **STEPS at $base – "Industry Expectations"** - Business-as-usual production at Rystad Energy's base case long-term price assumption at the time of our data download ($60/bbl)– our proxy for present-day industry expectations of the future.

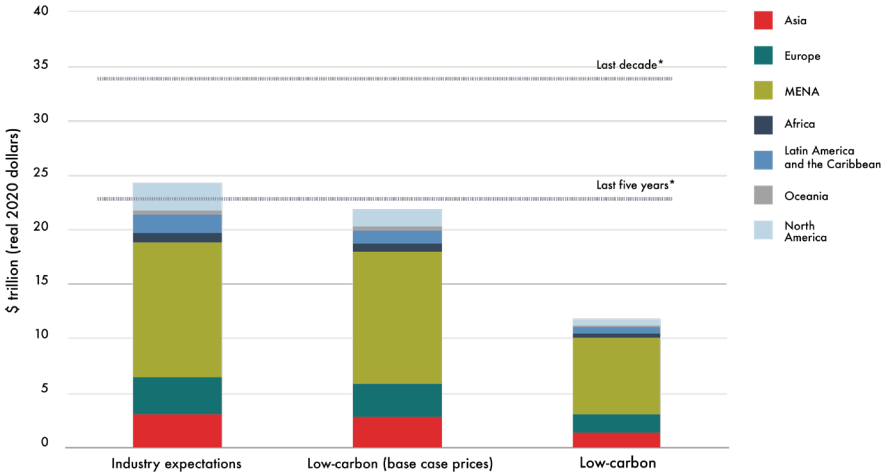
2. **SDS at $base** - Reduced demand under a low-carbon scenario, using Rystad Energy's base case assumption as in "industry expectations" above to allow like-for-like comparison.

3. **SDS at $40 – "Low Carbon"** - Reduced demand under a low-carbon scenario combined with an illustrative future flat real long-term oil price[39] assumption of $40/bbl – a price which roughly corresponds to the marginal breakeven price for the SDS in our analysis.

38 *Carbon Tracker analyst note, "Handbrake Turn", January 2020. Available at: https://carbontracker.org/reports/handbrake-turn/*

39 *Implicit within our use of lower oil prices under lower demand scenarios is that gas prices would fall similarly. Together these two factors could lead to either over- or under-estimation of countries' exposure to transition risk, however we believe it is appropriate to include gas within this analysis for a number of reasons. First, if only oil were considered, countries which have a higher-than-average proportion of revenues from gas could appear to be more vulnerable to reduced demand under the energy transition; this would be particularly true for those countries that have deliberately shifted to gas for the medium term as a "transition" fuel. Second, significant volumes of gas are traded relative to the oil price, and so the price-correlation is valid. Finally, updating our analysis to model gas across a greater number of regional markets would introduce significant additional complexity without necessarily greatly improving the accuracy of overall conclusions.*

FIGURE 6. FUTURE (2021-2040) GOVERNMENT REVENUE UNDER DIFFERENT DEMAND/PRICE SCENARIOS COMPARED TO LAST FIVE YEARS AND LAST DECADE



Source: IEA, Rystad Energy, CTI analysis
*Notes: * 2010-2019 and 2015-2019; extrapolated to 20-year values for comparability.*

...with a potential revenue gap of $13 trillion to 2040 under a low-demand world

Given that lower demand will lead to lower pricing, all else equal, we believe it is appropriate to utilise lower future price assumptions as part of the scenario analysis. The comparison of combinations 1 and 3 in Figure 6 shows the dual impact of both price and volume effects: under a low-carbon world with subdued prices (SDS at $40) total revenues are 51% less than expectations under a business-as-usual scenario (STEPS at $base).[40] In total, the gap amounts to 13 trillion dollars over the next two decades, as the transition towards a low-carbon economy – critical to avert the worst impacts of climate change – gathers pace.

The SDS at $base price case is given not to suggest that it is plausible that prices will remain unchanged at BAU levels under lower demand conditions, but to allow us to separate the differing effects of price and volume. It can be clearly seen that of the $13tn, the price impact is far more important than the volume impact, making up 80% of the difference.

The flat real long-term price of $40/bbl used to calculate revenues under the low-carbon scenario (SDS) is used illustratively. Clearly, we do not expect the oil price under a low-carbon scenario to stay flat at $40 come what may, but use this benchmark to illustrate the impact of lower prices related to lower demand.[41] Using base case pricing would significantly underestimate the potential shortfall in future cash flows under a world of reduced demand.

40 See appendix to see the impact on total revenues split by government taxation and income from NOCs.
41 Theoretically, as we calculate $40 as the highest cost project required to fill supply under the SDS scenario for an aggregate period of 2020-40, it would be the maximum price for that period required to supply the last barrel of oil, rather than a flat price. Again, we use it here on a flat real basis for illustrative purposes.

Future revenues are significantly lower than the average over the past five years (2015-2019)

Comparing future revenues against business-as-usual expectations (STEPS at $base) is an important aspect of assessing transition risk as it highlights the potential scale of the mismatch between expectations of the future and the reality. This is conceptually similar to the production gap approach, and to the results presented in our company analysis. It therefore incorporates the lost perceived growth opportunity as well as impact relative to the status quo.

An alternative way of assessing the transition risk is to compare future oil and gas revenues to the level governments have become accustomed to in recent history, rather than a forward-looking scenario. For this we use average annual revenues over the last five years (2015-2019) and extrapolate for the future period, shown as the dashed line on Figure 6. Revenues to 2040 calculated on this basis ($23tn) are within 10% of those using industry expectations as above ($24tn). Accordingly, total global government revenues are $11tn (47%) lower under the low-carbon scenario than projected average levels over the last five years.

While this difference is larger than that to industry expectations, we note that the last five years is quite a conservative historical benchmark (an industry downturn) - for reference, average revenues in the last ten years (2010-2019) were roughly 50% higher.

The impact of reduced government revenues varies regionally

Under a low-carbon scenario, revenues for all regions are reduced significantly compared to averages over the last five years. Although Middle East - North Africa (MENA) countries may increase their share of global revenues as overall demand falls, their aggregate revenues are still 43% lower (Table 2). North America is most impacted (77% reduction), closely followed by Latin America (66%). It is worth noting that the impacts of price falls are not necessarily linear due to the different licensing terms and production contracts in place in different countries.

TABLE 2. IMPACT OF LOW-CARBON SCENARIO ON OIL AND GAS REVENUES, REGIONS - % CHANGE VS INDUSTRY EXPECTATIONS

Region	Low-carbon vs Industry expectations
Asia	-57%
Europe	-50%
MENA	-43%
Africa	-58%
Lat. Am. & Caribbean	-66%
Oceania	-30%
North America	-77%

Source: IEA, Rystad Energy, CTI analysis

The need for global supply side discipline and the benefits of an orderly transition

As above the negative impacts of price, rather than volume, dominate the revenue impacts of declining demand.

An orderly transition, with global supply managed to fall in line with decreasing demand, therefore benefits all producers collectively by supporting prices. However, there remains an incentive for each individual country to increase production in an attempt to capture more market share and revenues.

The situation has all the hallmarks of the prisoner's dilemma – maintaining supply discipline between several different countries with varying supply costs and fiscal break evens is notoriously difficult, as past experience with OPEC (+) has shown; it will likely become increasingly difficult in an environment of continually falling fossil fuel demand. Any individual attempts perceived to be taking advantage of collective supply discipline could rapidly lead to destabilisation of a delicate balance, resulting in reduced pricing and revenues for all.

In our modelling we assume that producers do not sanction any assets that do not fit in a low carbon world; excess sanction represents further downside risk.

The public sector situation therefore has parallels to the private sector, where we have argued that company returns are maximised and risk minimised with "value over volume" strategy and exercising discipline on investments. Crucially, this requires action in advance rather than waiting until the value is destroyed.

Impact at the Country Level

Having reviewed the global impacts of a fall in demand and lower prices, we now turn to the impact on individual countries; our primary focus is on those most vulnerable to reduced incomes.

Specifically, we are interested in the size of the impact on total government revenues and the implications that this will have for fiscal sustainability.[42] This depends in large part on a country's dependence on oil and gas revenues – the same proportionate shortfall in oil and gas revenues under a low-carbon scenario will have a lesser impact in countries where the blow is cushioned by greater revenues from other (uncorrelated) sources.

By combining both dependence and potential revenue shortfall, we can quantify the degree of vulnerability to the energy transition for each country. We then consider the impact that this will have on populations and touch on where humanitarian impacts will be felt the most.

Identifying the "petrostates"

For the purposes of this report we focus on the top 40 countries in terms of oil and gas revenues as a share of GDP, which we refer to as the "petrostates", shown in Figure 7 (n.b. due to widespread data availability we use GDP to define the petrostates, however Figure 7 shows this group by fiscal dependence to match subsequent figures).[43]

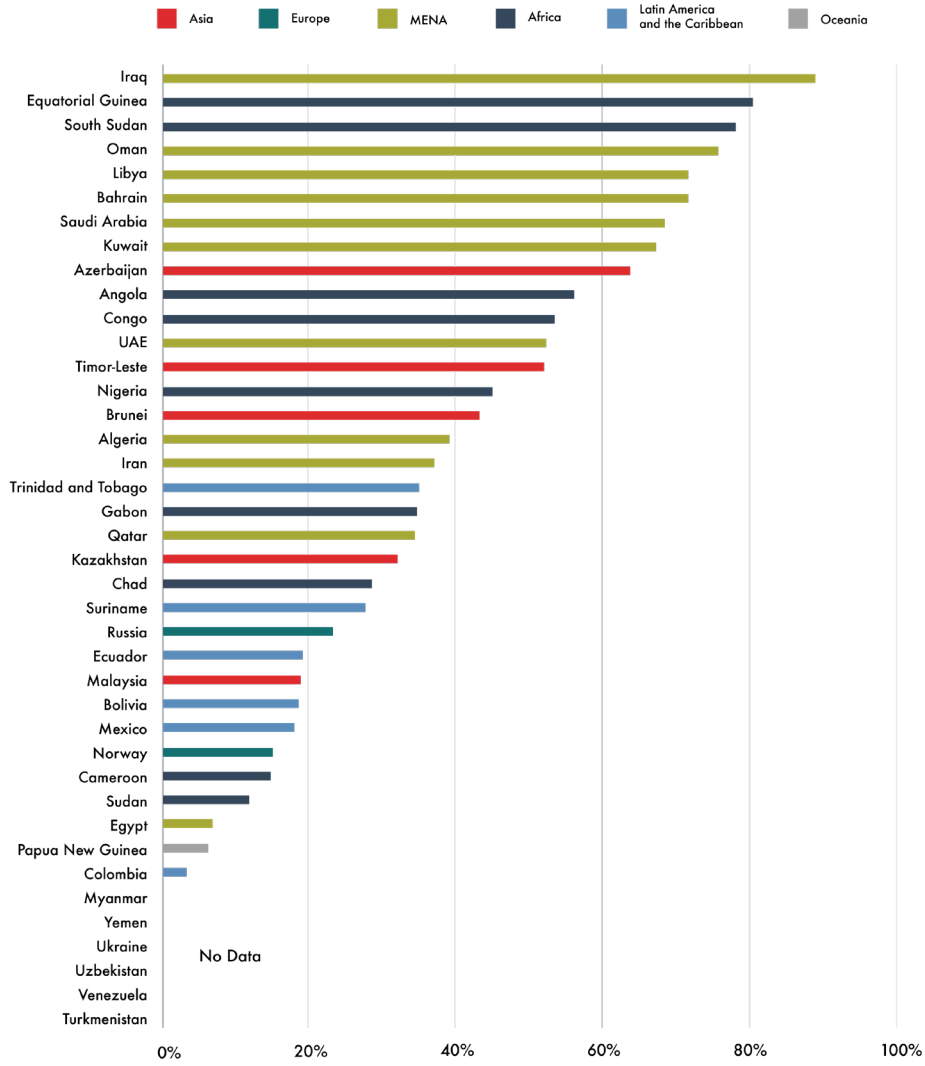
This captures all the well-known high-rent countries, including most Middle Eastern oil producers and Russia, and generally leaves out developed economies; the one exception to this rule is Norway. For example, while the US state and federal governments collect some of the largest sums of fossil fuel revenue in absolute dollar terms (3rd largest globally), the vast majority of overall revenues come from non-oil sources, such as personal income tax, sales tax and so on. As a result the impact of oil and gas revenues on fiscal sustainability is ultimately small.

Other countries that appear among the 25 largest rentiers in absolute terms but fall outside the top 40 "petrostates" include China, India and Brazil. Other nations with significant oil and gas sectors are also not included; the Netherlands and the UK are European examples.

42 *We recognise that the issue of stranded revenues goes far beyond government budgets, with wider impacts on economic activity, employment and investment. Nevertheless, these issues are unfortunately beyond the scope of this report and will not be dealt with in detail.*

43 *See Figure 15 in Appendix 2, which is based on Rystad Energy revenues as a percentage of GDP for consistency (as oil revenues as a share of total revenues are not widely reported outside rent-dependent economies. See the methodology appendix for a further discussion on data limitations.*

FIGURE 7. FISCAL DEPENDENCE ON OIL AND GAS REVENUES BY COUNTRY (2015-2018 AVERAGE REVENUES AS A % OF TOTAL GOVERNMENT REVENUES) – TOP 40 COUNTRIES, "PETROSTATES"



Source: Rystad Energy, IMF, CTI analysis
Notes: Petrostates = top 40 countries in terms of government oil and gas revenue as % of GDP. See Appendix 1 for notes on data.

Potential revenue shortfall

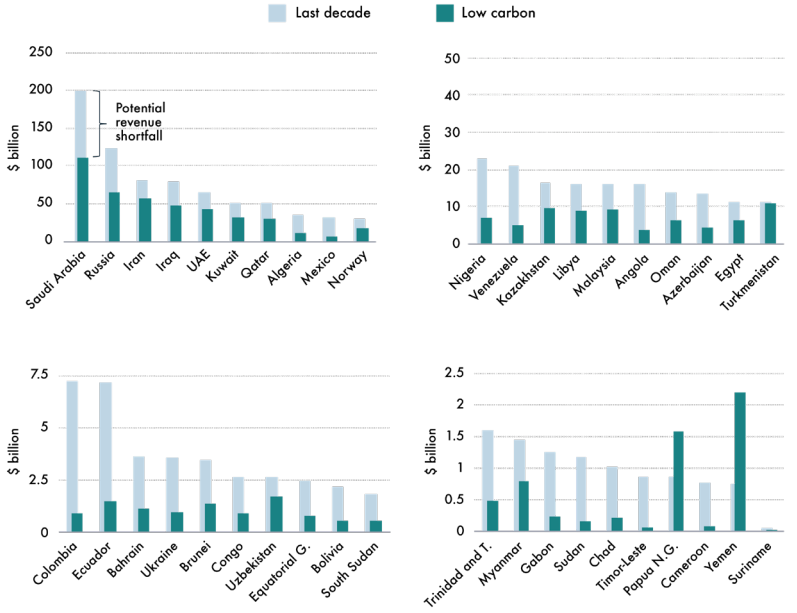
Having defined those countries most dependent on oil and gas revenues, we now turn to understanding the percentage revenue reduction under a low-carbon scenario with reduced oil and gas demand – the potential revenue shortfall.

The petrostates face a potential combined shortfall of $9 trillion to 2040

For the 40 petrostrates, the total potential shortfall under a low-carbon scenario is $9 trillion (46%) over the next two decades – 70% of the global total of $13 trillion. In addition to today's petrostates, there is also the group of countries that have little production currently and are seeking to grow oil and gas output in the future (see Box 1: "The Emerging Petrostates").

The gap between revenues under a low-carbon scenario and industry expectations reveals the overall potential loss. However, we believe the comparison of future revenues with levels to which countries have become accustomed offers the clearest indication of the scale of the challenge for individual countries, and the reform needs of today. Accordingly, in this chapter we focus on future revenues under a lower carbon scenario (SDS at $40) compared with governments' revenues from upstream oil and gas over the last five years.

FIGURE 8. POTENTIAL AVERAGE ANNUAL GOVERNMENT REVENUE SHORTFALL UNDER A LOW DEMAND SCENARIO (SDS AT $40) VS LAST FIVE YEARS FOR THE PETROSTATES



Source: Rystad Energy, IEA, CTI analysis
Notes: Petrostates = top 40 countries in terms of government oil and gas revenue as % of GDP.

Figure 8 shows the annual potential hydrocarbon revenue shortfall by country (as four panels, with varying scale of the vertical axis), showing that 50% of the petrostates receive less than half of current (last five years) revenues under a lower demand scenario with lower pricing.

It seems generally true that the petrostates with the highest absolute revenue take also stand to lose the least in relative terms. This mainly reflects the fact that Middle Eastern governments tend to capture a high share of total oil and gas rents while also having very favourable supply costs. Meanwhile, most of the smallest earners (lower two panels) stand to lose at least half of their current revenues, suggesting a lopsided distribution towards the biggest earners.

Vulnerability

Understanding the vulnerability of fiscal budgets in these 40 petrostates involves comparing the figures presented in Figure 7 (fiscal dependence on oil and gas revenues) and Figure 8 (potential oil and gas revenue shortfall in a low-carbon world). More specifically, we use the following definitions and data:

- **Hydrocarbon dependence, % total government revenue:** The share of total government revenue that comes from the sale and taxation of hydrocarbons, as reported to the IMF in Article IV report and loan documentation.[44]
- **Potential revenue shortfall in SDS at $40:** The change in annual average revenues over the next two decades under SDS (using a flat $40 price assumption), compared to average revenues over the last decade based on data from Rystad Energy.

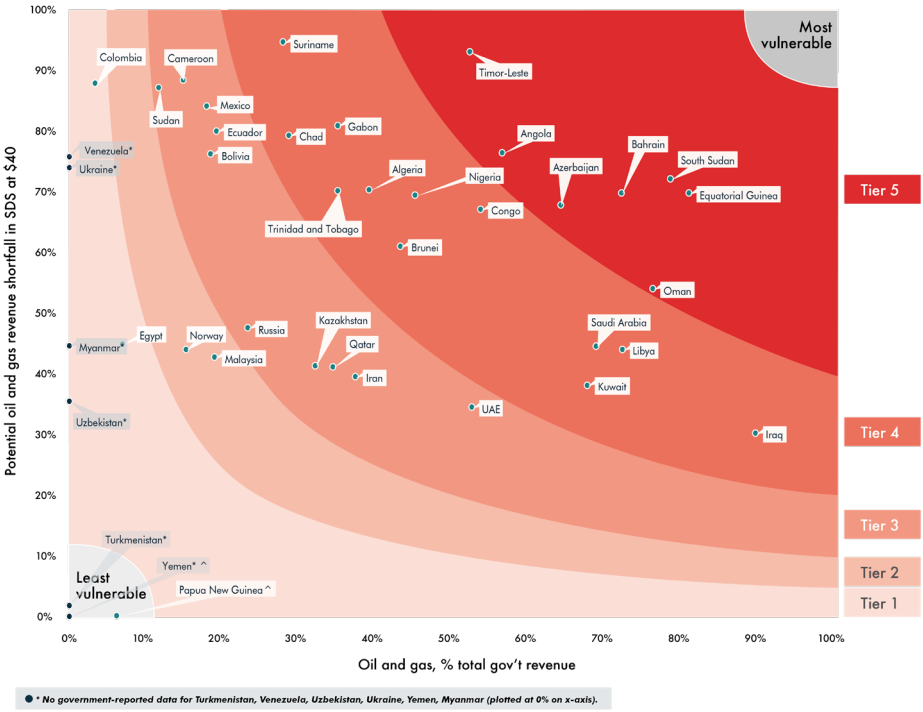
The multiplication of the two axes gives a proportion of potential overall government revenue shortfall – our conceptualisation of vulnerability (Figure 9).

As with our company analysis, our primary focus is on identify those countries which are relatively more at risk through the energy transition at this point in time, rather than seeking to precisely determine the percentage future revenue shortfall. The latter would require assumptions about future non-oil revenue and GDP growth, which are beyond the scope of this report, and subject to notoriously unpredictable long-term oil prices.

We therefore focus on the tiers (indicated by the bands on Figure 9) that countries fall into, which summarise the relative level of vulnerability and hence risk through the energy transition. The tiers range from 1 (lowest level of vulnerability) to 5 (highest level of vulnerability).

44 *See methodology appendix for notes on data selection.*

FIGURE 9. VULNERABILITY OF PETROSTATES' TOTAL GOVERNMENT REVENUES TO LOW OIL AND GAS DEMAND IN THE ENERGY TRANSITION



Source: Rystad Energy, IEA, IMF, SSB (Norway), CBL (Libya), CBI (Iran), UN, CTI analysis
*Notes: Vulnerability = potential total government revenue shortfall [multiplication of axes] over 2021-2040. Tiers roughly equate to a shortfall of <5% (1), <10% (2), <20% (3), <40% (4), >40% (5) of total revenue. Potential revenue shortfall = 2021-2040 average in SDS vs 2015-2019 average. Shares on x-axis are 2015-2018 average due to lack of 2019 data. * No government-reported data for Turkmenistan, Venezuela, Uzbekistan, Ukraine, Yemen, Myanmar (plotted at 0% on x-axis).*

Nearly half (19) of the 40 petrostates are in the two highest vulnerability tiers with a potential shortfall of >20% . These countries, including ones with major populations like Nigeria and Angola, face tough decisions as the global economy decarbonises and fossil fuel demand falls. For some countries in tier 5, potential shortfalls account for more than half of total government revenue.

Countries whose budgets seem more likely to be relatively resilient to the loss of hydrocarbon revenue include Norway, Egypt and Colombia, which mainly reflects lower level of hydrocarbon dependence. The vulnerability of the major OPEC producers varies, with some in tier 4 – such as Saudi Arabia, Kuwait and Iraq – and others in tier 3. All have potential revenue shortfalls that still imply a need for concerted revenue diversification and spending reductions.

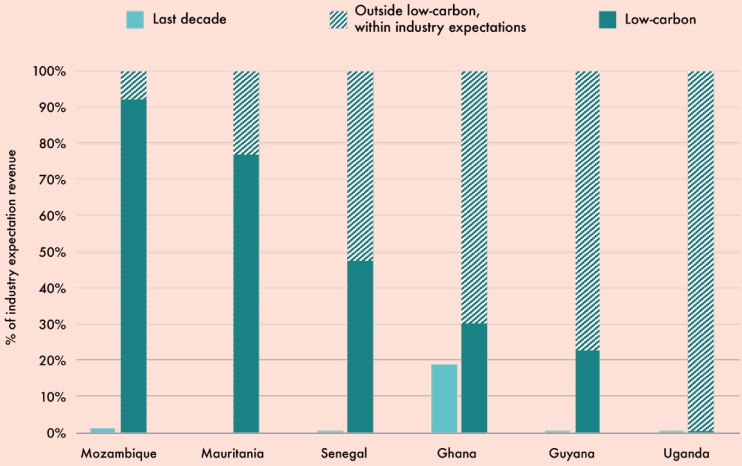
BOX 1: THE EMERGING PETROSTATES

For some countries, revenue risks are much less about adapting to the loss of existing cashflows than about losing *potential* cashflows. These are countries that have undeveloped oil and gas resources that are significant compared to the size of their existing economies, where expansion plans would sharply increase oil and gas revenues as a % of GDP from current low levels.

Like for existing producers, relying on optimistic revenue expectations may have negative consequences despite starting from a position of low or no existing hydrocarbon industry. A government with limited revenue streams that expects an influx of new income in the future might be tempted to go on a debt-fuelled spending spree, only to find itself dangerously overstretched down the line. Public money would also be wasted on investments that end up stranded in the future instead of being invested into transition-resilient industries. Previous analysis has aptly named this problem the "presource curse" – a play on the "resource curse" phenomenon, which holds that resource-rich countries tend to have underperforming economies and weak institutions.[45]

Figure 10 shows data for a selection of six countries that fit the description above and could reach oil and gas dependency levels comparable to the 40 petrostates in our analysis; we refer to this group as the "emerging petrostates" in this document. Four out of six countries would see less than half of the revenues projected under industry expectations materialise in a low-carbon scenario; Uganda's revenues would fail to materialise completely. Future revenues for both Mozambique and Mauritania are heavily-reliant on gas supplied to local markets, which are outside the scope of our least-cost methodology. Accordingly the revenue shortfalls under a low-carbon scenario vs industry expectations could be greater than shown.

FIGURE 10. 2021-2040 GOVERNMENT OIL AND GAS REVENUES IN LOW-CARBON, INDUSTRY EXPECTATIONS AND LAST DECADE – SELECTED "EMERGING PETROSTATES"



Source: IEA, Rystad Energy, IMF, CTI analysis

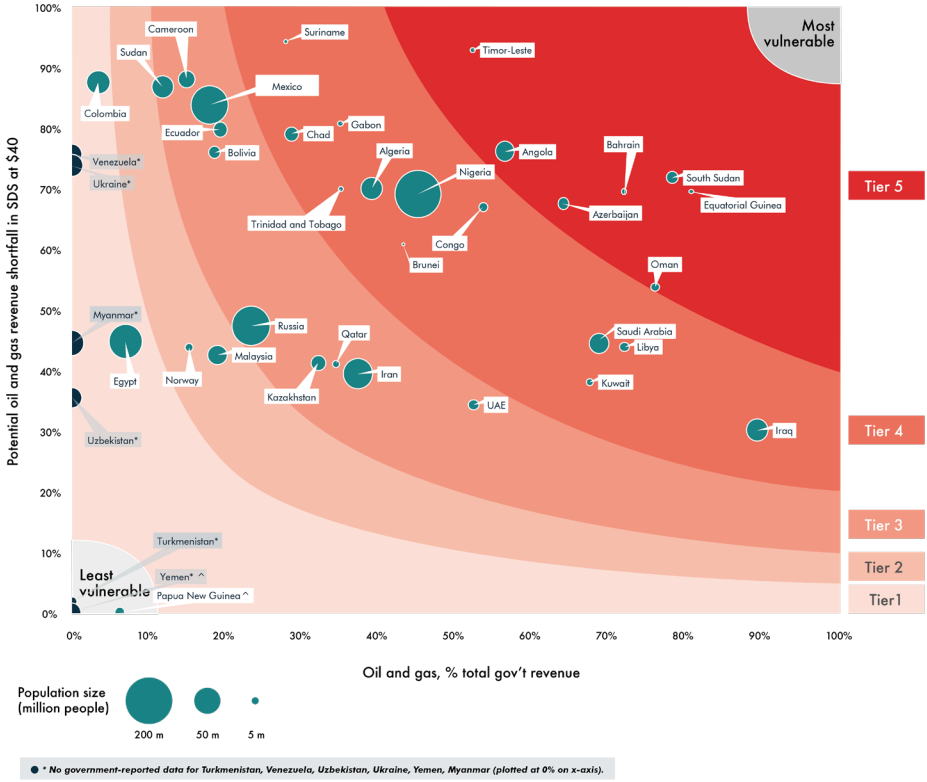
Impact on Populations

Adding population size (bubble size in Figure 11) highlights how many people may be affected to different degrees by the changing dynamics of the energy system.

The two highest vulnerability tiers contain over 400 million people in 19 countries, including several countries with individually large populations – notably Nigeria with 206m people, but also Algeria (43m) and Angola (33m).

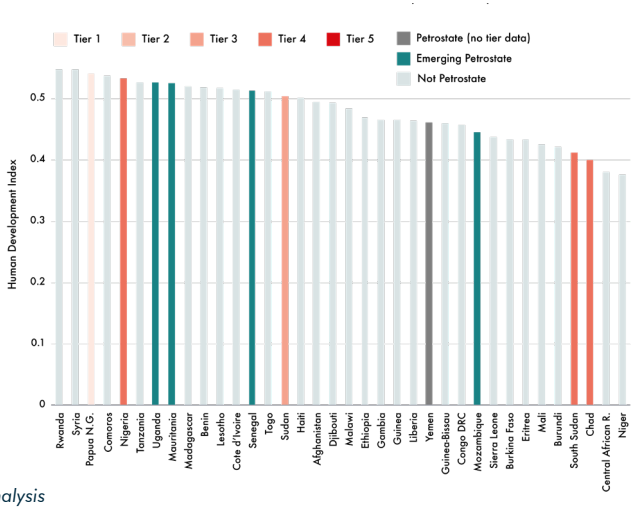
This also indicates countries that, based on their potential revenue risks, appear less fragile, but where large populations may amplify the real-world impact of revenue losses. Such countries include Mexico (tier 3, 134m people) and Russia (tier 3, 144m people).

FIGURE 11. VULNERABILITY OF PETROSTATES TO LOW-DEMAND OUTCOMES WITH POPULATION SIZE



Source: Rystad Energy, IEA, IMF, SSB (Norway), CBL (Libya), CBI (Iran), UN, CTI analysis
*Notes: *=No x-axis data. See Figure 9 for further notes on revenue data. ^PNG would see its revenues increase in our modelling, though this stems in part from difficulties with accurately estimating future gas prices and regional demand.*

FIGURE 12. COUNTRIES WITH LOW HUMAN DEVELOPMENT (INDEX <=0.55)



Source: UN, CTI analysis
Notes: Petrostate = Top 40 countries in terms of government oil and gas revenue as % of GDP. Emerging petrostate = Selection of countries that may increase oil and gas revenues as a % of GDP to petrostate levels, see Box 1.

Many of these countries are also experiencing relatively high population growth. The UN expects Nigeria's population to grow by 60% (to 329m) in the next two decades, compared with just 7% for the UK and 11% for the US.[46] This will increase spending pressure on the Nigerian government, all while revenues are being drained by weaker oil and gas receipts.

Many of the petrostates also have low current human development levels

Differing levels of development is another reason to look beyond simply revenue risks. The UN Human Development Index, which considers income per head, educational attainment and basic health indicators, is a well-recognised way of scoring development levels. This gives a score between 0 and 1, with scores below 0.55 indicating "low human development"; 33 countries fit this description globally. Of these 33, nearly one-third (10) are either petrostates (6 countries) or emerging petrostates (4 countries, defined in Box 1) – see Figure 12. This includes three countries that place in the top two tiers of revenue vulnerability – Chad, South Sudan and Nigeria.

These findings add a new dimension to the argument, expressed by the IPCC among others, that the physical effects of climate change fall disproportionately on the poor.[47] As it turns out, the challenges of shifting from a carbon-heavy economy will also be borne disproportionately by some poorer producer states. Further, there is a clear negative relationship between the HDI and measures of political stability, indicating the possibility of instability in future.[48] While the energy transition will benefit developing countries in the form of mitigated climate impacts, clearly thought – and most likely international help – will still be needed for these countries to navigate the shift.

46 UN probabilistic projection medians for 2020-2040 period. The figures for our other examples are: Algeria (27%), Angola (82%), Mexico (16%), Russia (-5%).
47 IPCC 2018
48 The correlation between HDI and the World Bank's "Political Stability and Absence of Violence/Terrorism" indicator was 64% in 2019.

Fiscal Flexibility

Structurally lower oil prices put greater weight on fiscal flexibility

In this chapter we consider one of the dimensions that affects governments' ability to withstand structurally lower revenues: fiscal flexibility, defined as availability of additional financing. This focus is informed by the main purpose of this report, which is to identify countries that are most at risk of fiscal sustainability issues due to lower oil and gas revenues, rather than to assess countries' prospects for economic diversification more broadly. As such, we only hope to address part of the wider issue, recognising that a country's ability to adapt to revenue stranding over the longer term will depend on a much wider set of macroeconomic and political-economic variables. For instance, see Peszko et al.[49] for a more comprehensive consideration of economic "resilience" (an overlapping term) to external macroeconomic shocks.

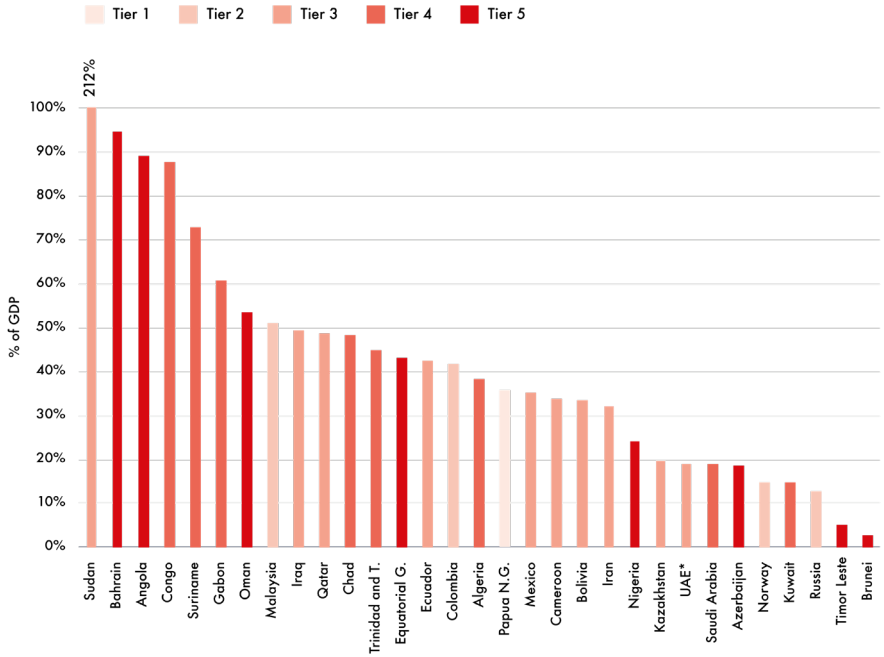
Petrostate indebtedness is already high

Among the 33 petrostates for which the IMF has consistent data, average central government debt nearly doubled from 24% of GDP in 2010 to 46% in 2018; this is the group's highest rate of indebtedness since 2004. Most of the recent build-up occurred in 2014-2016, clearly reflecting the impact of the oil price crash at that time.

With Covid-19 having crashed oil prices in 2020 and put additional spending pressure on governments, much suggests that debt levels have continued to rise since the last data point in 2018. In short, the petrostates are entering a period of difficult structural adjustment with less fiscal flexibility than at any point in recent history.

49 *Peszko et al. 2020*

FIGURE 13. PETROSTATE CENTRAL GOVERNMENT DEBT AND REVENUE VULNERABILITY TIERS



Source: IMF, CTI analysis
*Notes: * General government debt. No data for Venezuela, Yemen, Ukraine, Myanmar, Turkmenistan, Libya, South Sudan, Egypt, Uzbekistan.*

Additionally, indebtedness is asymmetrically distributed within this group and is linked with revenue risk. As Figure 13 shows, four of the five most heavily indebted petrostates are also some of the most exposed to potential revenue shortfalls (in the top two vulnerability tiers). These structural weaknesses are already clearly on show in the worst-off countries. Bahrain took a $10bn bailout from its wealthier Gulf neighbours and had to embark on a programme of considerable belt-tightening in 2018 to stave off a debt crisis; about one-fifth of Congo's oil revenues go directly towards repaying oil-backed debt;[50] and Angola spent a quarter of its total revenues just on interest payments in 2019.[51]

Debt levels and debt servicing costs could also rise in the future as a result of currency depreciation, which would presumably follow from persistently depressed oil revenues (a crucial source of foreign currency); forecasting these changes is outside the scope of this report, however.

Vulnerable governments already have poor credit ratings

Access to additional financing from debt markets is largely driven by countries' credit ratings, which encapsulate factors such as existing indebtedness, budget balance, economic growth and future revenue prospects. Credit ratings as issued by the

50 *Republic of Congo, 2019 Article IV Consultation*
51 *Angola, 3rd EFF review September 2020*

three major agencies (S&P, Moody's and Fitch) are categorised as either investment grade or "speculative" (high yield). Which of these two labels a country's debt has matters significantly – for instance, many institutional investors have mandates that limit them to investment-grade bonds.

As Table 3 shows, the governments with the highest degree of revenue risk tend to either have speculative-grade credit ratings or no ratings at all, which both typically indicate a difficulty in sourcing new external debt at acceptable yields. These governments have two broad options left. They can tap domestic markets, though this comes with the risk of crowding out private sector borrowers and is of limited use for foreign currency needs. They can also turn to concessional borrowing (IMF and others), but with strings attached in the form of potentially painful structural adjustments, and these loans are only ever designed to plug temporary funding gaps. Other, more unconventional (and less desirable) options include signing off future oil production in exchange for debt, as both Angola and Congo have done.

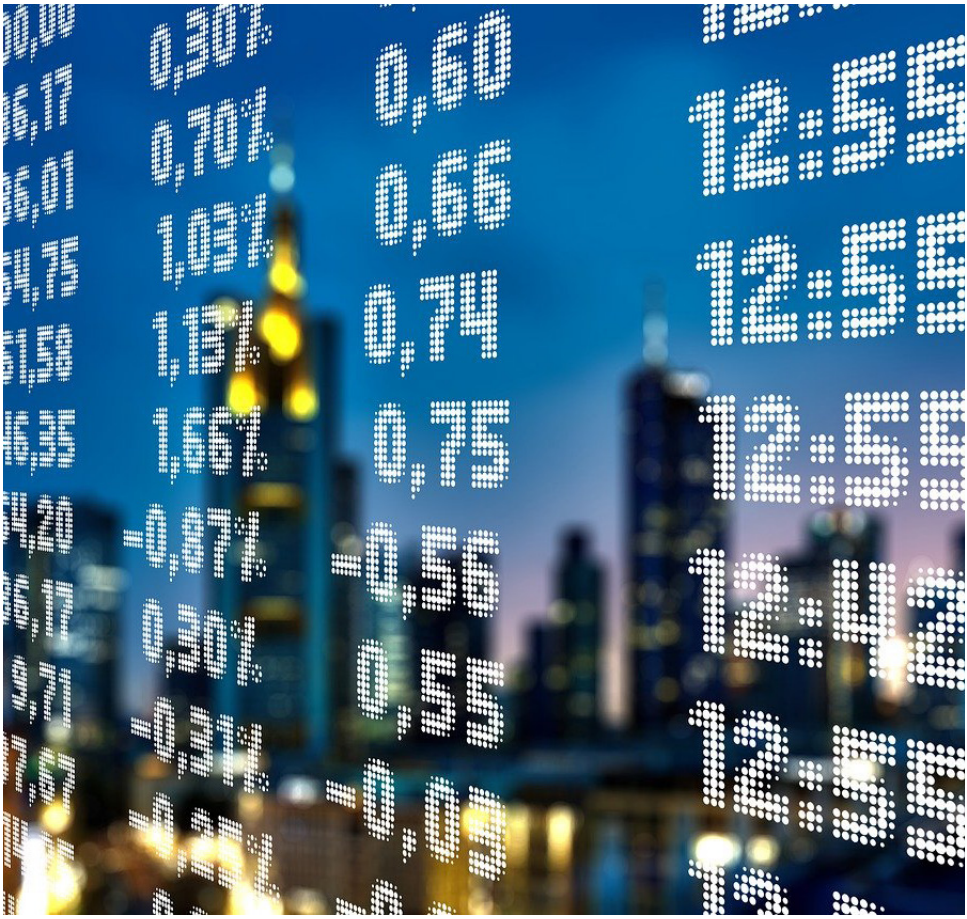
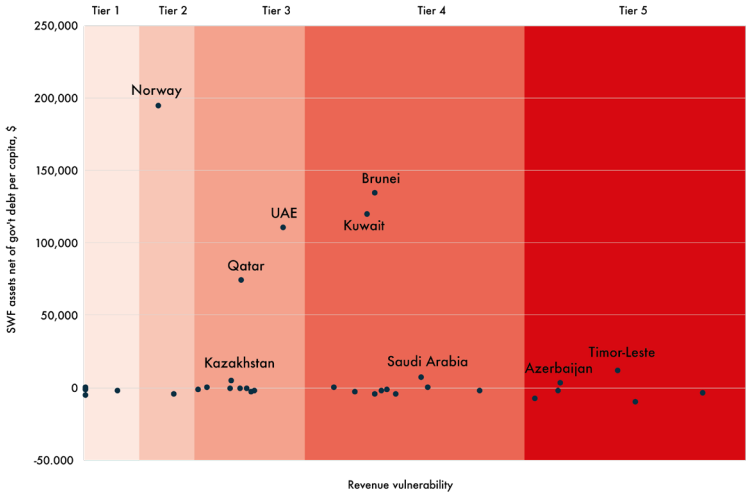


TABLE 3 SOVEREIGN CREDIT RATINGS AND REVENUE VULNERABILITY TIERS

Country	Rating Speculative / Investment-grade			Revenue vulnerability tier
	Moody's	S&P	Fitch	
Equatorial Guinea	No rating	No rating	No rating	5
South Sudan	No rating	No rating	No rating	5
East Timor	No rating	No rating	No rating	5
Angola	Caa1	CCC+	CCC	5
Bahrain	B2	B+	B+	5
Oman	Ba3	B+	BB-	5
Azerbaijan	Ba2	BB+	BB+	5
Libya	No rating	No rating	Withdrawn	4
Brunei	No rating	No rating	No rating	4
Chad	No rating	No rating	No rating	4
Algeria	No rating	No rating	No rating	4
Suriname	Caa3	SD*	C	4
Congo	Caa2	CCC+	CCC	4
Gabon	Caa1	No rating	CCC	4
Iraq	Caa1	B-	B-	4
Nigeria	B2	B-	B	4
Trinidad and Tobago	Ba1	BBB-	No rating	4
Saudi Arabia	A1	A-u	A	4
Kuwait	A1	AA-	AA	4
Iran	No rating	No rating	Withdrawn	3
Sudan	No rating	No rating	No rating	3
Ecuador	Caa3	B-	B-	3
Cameroon	B2	B-	B	3
Bolivia	B2	B+	B	3
Kazakhstan	Baa3	BBB-	BBB	3
Russia	Baa3	BBB-	BBB	3
Mexico	Baa1	BBB	BBB-	3
Qatar	Aa3	AA-	AA-	3
UAE	Aa2	No rating	AA-	3
Malaysia	A3	A-	BBB+	2
Norway	Aaa	AAA	AAA	2
Papua New Guinea	B2	B-	No rating	1
Egypt	B2	B	B+	1
Colombia	Baa2	BBB-	BBB-	1

Source: Bloomberg, CTI analysis
Notes: Petrostates without vulnerability data (Venezuela, Turkmenistan, Uzbekistan, Ukraine, Yemen, Myanmar) excluded. Long-term foreign currency issuer ratings. Ordered within tiers by Moody's rating, worst to best; S&P for ties.
** Selective default.*

FIGURE 14. PER-CAPITA SOVEREIGN WEALTH FUND ASSETS NET OF GOVERNMENT DEBT, AND REVENUE VULNERABILITY TIERS



Source: SWF Institute, US Department of State, IMF, CTI analysis
Notes: Only countries with positive y-axis values labelled for the purpose of readability. Petrostates without vulnerability data (Venezuela, Turkmenistan, Uzbekistan, Ukraine, Yemen, Myanmar) excluded. No SWF data for Gabon, Sudan. No debt data for Libya, South Sudan, Egypt.

Only a handful of governments have significant savings

Credit ratings also reflect existing the varying size of existing savings. These sovereign wealth funds (SWFs), built up in past years of high prices, serve several mitigating functions. First, they provide ready access to funding during revenue downturns, acting as a counterweight to commodity price cycles. Second, they are sources of revenue in themselves by generating investment income, typically from a diversified global portfolio; 15% of the UAE's total government revenue in 2017 came from SWF income alone.[52] Finally, they can act as drivers of economic diversification by providing the capital needed to nurture emerging industries. Example of such domestically active SWFs include the Public Investment Fund in Saudi Arabia and Khazanah in Malaysia.

SWFs are common in petrostates, but only a handful are genuinely large when assessed on a per-capita basis and with government debt netted out. As Figure 14 above shows, just Norway, Brunei and a few of the Middle East producers have significant savings; the next country down the list from Qatar is Timor-Leste, with only 1/7th as much in net per capita assets.

It is worth noting that SWFs are not a Get out of Jail Free card, at least not in the long term. Even for governments with considerable savings, persistently weak oil prices would soon wipe them out in the absence of sharp fiscal adjustments; the IMF estimated before the pandemic that a long-term oil price of $55/bbl would turn the GCC[53] countries into net debtors by 2034, or as soon as 2027 at $20/bbl.[54] The upshot is that for all the petrostates, even those with money in the bank, the time for ambitious fiscal reform is now, not later.

52 *United Arab Emirates 2018 Article IV Consultation*
53 *Gulf Cooperation Council: Saudi Arabia, UAE, Qatar, Kuwait, Bahrain, Oman.*
54 *Mirzoev et al. 2020.*

Considerations and Recommendations

The data that we have presented in this report should be a call to action, not just for petrostate governments, but for policymakers across the globe.

Diversification is an urgent task for domestic policy makers

Governments, both national and international, across the globe need to respond proactively to the challenge. For the petrostates, earlier recognition of the need to reduce reliance on fossil fuels means more time to make the necessary changes in terms of fiscal structure and investment in alternative domestic industries. Government budgets will of course still be negatively impacted, but the risk of sudden fiscal crisis will be lower compared to continuing on a busines as usual path.

Adapting to a long-term decline in revenues will require a fundamental re-think about the size of the state and the social contract between state and citizen. Diversifying fiscally will also imply diversifying economically, since governments will need to lean more on the non-oil economy for tax; there is already a rich literature on this topic to which we refer readers.[55,56]

Some countries, particularly the GCC states, have already begun to recognise these issues in the form of long-term economic diversification plans, though these are less likely to be useful as blueprints for other countries with different economic structures and less financial muscle.[57] The shape of diversification programmes will ultimately need to be tailored to each country's circumstances, although, as we noted in the preface, there are some useful starting points suggested by existing research.[58,59] These include growing the stock of human capital through investment in education as well as improving institutional quality, for instance through business environment reforms.

Moreover, capital not invested in oil and gas will need to be used to stimulate growth in new industries that are more resilient to the energy transition. This may require restructuring institutional arrangements between central governments and national oil companies.[60]

International actors can also play an important role

The key to the Paris Agreement's success lay in its recognition that each country needs to forge its own path in meeting the climate crisis. The same will be true for the petrostates, but that does not mean that they should stand alone in facing the economic challenges to come. Support can take the form of technical assistance, such in regulatory, governance and tax reform.

There is also scope for fresh foreign investment into alternative industries, not least in developing countries with fast-growing labour pools. Finally, as we noted in

55 *Gelb 2010*
56 *Lashitew, Ross & Werker 2020*
57 *https://blogs.lse.ac.uk/mec/2020/08/07/why-the-gccs-economic-diversification-challenges-are-unique/*
58 *Chang & Lebdioui 2020*
59 *Gelb 2010*
60 *Manley & Heller 2021*

the preface to this report, there is a growing discussion around multilateral arrangements to ease the burden of diversification for the petrostates. Irrespective of the path chosen, providing assistance would have benefits not just the petrostates but for the climate and the global community as a whole.

An orderly transition that avoids oversupply helps limit downside

Since the signing of the Paris Agreement, recognition has grown in favour of the need to counter climate change not just on the demand side of fossil fuels, but on the supply side as well.

As discussed above, producing governments will collectively benefit from showing restraint and hence supporting commodity prices, despite each individual country having a temptation to increase volumes. For NOCs this will mean avoiding sanctioning those projects that fall outside the limits of a low-carbon scenario, and for governments not incentivising private investment in the fossil fuel industry. Such an approach both reduces exposure to the impacts of a disorderly transition and crucially leaves more capital available for diversification.

The "just transition" doesn't mean prolonging uneconomic oil production in certain countries

In this document we have highlighted issues of fairness and the principle of the "just transition" – some have argued for a global supply arrangement on this basis.[61] One interpretation would potentially involve allocating a bigger slice of global supply to the vulnerable producers in an attempt to perpetuate domestic oil development that would have otherwise been sub-economic under the market-based approach.[62] We think this is a far from optimal solution. Modelling from previous research has shown that a redistributive supply system designed to prop up (in volume terms) poorer producers with higher production costs would raise overall system costs and lock-in fossil fuel dependence for those countries[63], which is a poor consolation prize.

Accordingly, we see it is as rational for individual countries to prepare for a market-led supply distribution, as assumed within our modelling.

61 *Asheim et al. 2019*
62 *Caney 2016*
63 *Pye et al. 2020*

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Appendix I: Methodology

This section expands on a few methodological points that were not detailed in the main text. Our least-cost methodology, which forms the backbone of this report, is described in the Introduction.

Assigning cash flows based on government project ownership

Our calculation of government oil and gas revenue includes both government take (taxes and fees) and share of free cash flow (FCF) from national oil companies. The latter component requires some particular adjustments to Rystad Energy's data to make sure that project cash flows are correctly assigned to each individual government. First, we determine government stakes in their respective NOCs using data from the Natural Resources Governance Institute[1]. Next, we identify the projects that are owned by NOCs but located in countries which are not the NOC's homeland, and re-assign the NOC's home government share of the NOC's FCF to the company's homeland. For instance, the Chinese Government's share of FCF from a CNOOC project in Canada is assigned to China, not Canada, based on its proportionate ownership. All revenues are calculated on a real basis (2020) in US dollars.

Estimating revenues on a per-barrel basis

The data presented in this report relies in large part on the effect of different long-term oil and gas prices to determine the overall impact of lower demand on government oil and gas revenues. Asset-level data is sourced from Rystad Energy on government take, FCF, production and other variables at different long-term oil price assumptions. These price assumptions affect both the volumes and unit cash flows for each asset. Gas prices are assumed to be linked to oil, with the relationship varying based on e.g. geography and known contracts. We recognise that gas prices may not necessarily follow the same pathway as oil and may experience different regional dynamics. However, a more granular approach of trying to reflect gas prices on a per-market basis would add considerable complexity without materially changing the overall conclusions given that gas represents a much lower proportion of government revenue than oil (13% in the last decade).

Further, the interrelationships of oil and gas prices, production volumes, costs and government revenues are complex, and may change in unknown ways as the world shifts to a decarbonising pathway. To simplify analysis, we use a per-barrel approach to estimating government take under different price scenarios.

For STEPS at $base and SDS at $base we aggregate cash flows from projects that fit within each scenario – derived from our least cost modelling – using base case prices. To estimate cash flows under our low-carbon scenario (SDS at $40/bbl long term) we use a per-barrel approach. First, we select those projects that fit within SDS, based on the same least cost methodology. Then, we use Rystad Energy's $40/bbl price scenario to determine the average $/boe cash flows (government take, and free cash flow) at the individual country level. Finally, we then

1 https://www.nationaloilcompanydata.org/

apply these per-barrel multipliers to the SDS project using Rystad Energy's base case volumes.

Using GDP to define the petrostates

We opt to define "petrostates" as the world's top 40 countries in terms of 2015-2019 oil and gas revenues as a share of 2015-2019 GDP. While we would have liked to select countries based on the share of oil and gas revenues in total government revenues, as it gives a more accurate picture of fiscal dependence, such data is only available for the most-dependent countries. GDP data is widely and consistently available, allowing us to rank virtually every country in the world. The two approaches are unlikely to generate significantly different countries included the top 40, even if countries' relative ranks within that group may differ.

Collecting dependence data for the petrostates

We source our data on dependence, i.e., the share of oil and gas revenues in total government revenues, from IMF staff reports. These staff reports are mainly those released in conjunction with Article IV assessments (mandatory periodic assessments that the IMF makes of all its members) and less commonly those released as part of countries' ongoing loan programmes with the IMF. This data has several limitations:

- Time lags: Data for 2019 is widely unavailable, as many staff reports released in 2020 did not have access to complete data from governments themselves. Our dependence term is therefore an average of 2015-2018 data. In a few cases, the 2018 data point is an IMF staff estimate from the most recent report available.
- Time gaps: Article IV staff reports are ideally released every year, but for various extraneous reasons, such as instability and war, considerable time gaps can occur. See country-specific notes below.
- Cross-sectional inconsistency: Oil and gas revenue is not a line item in standardised revenue databases, such as the IMF WoRLD. As such, any oil and gas revenue reported by governments is necessarily defined by the government itself. Governments also tend to report on a fiscal year basis, which may or may not align with calendar years. We have tried to be consistent where possible (for instance by excluding income from sovereign wealth funds, which can sometimes be counted as oil and gas revenue).

In three cases (Norway, Libya, Iran) where these were absent, we supplemented with data from national sources.

Data notes on selected countries:

- Algeria: 2018 is IMF projection from most recent staff report.
- Brunei: Fiscal year runs April-March, such that 2018 = FY2018/19.
- Congo: 2015 is IMF projection from staff report of same year due to reporting gaps.
- Egypt: Fiscal year runs June-May, such that 2018 = FY2017/18. No data for FY2009/10 and FY2010/11.
- Equatorial Guinea: 2010-2014 reporting uses line item "Resource revenue", more recent reporting uses "Hydrocarbon revenue"; we assume both cover same items based on similar overlapping data.
- Iran: Limited IMF data, so Central Bank of Iran data used instead. Fiscal year runs April-March. 2018 data (FY2018/19) based on first nine months of fiscal year.
- Libya: IMF reports not available; data supplemented from Central Bank of Libya. This may only cover operations by

the western Tripoli-based government, which should nonetheless be indicative.

- Nigeria: 2018 value is IMF estimate.
- Norway: Oil revenue not reported in IMF reports; data supplemented from Statistics Norway.
- Oman: 2018 value is IMF estimate.
- Papua New Guinea: Uses line item "Resource revenue" – this covers mining as well. Internal split by commodity is not available.
- South Sudan: Fiscal year runs July-June, such that 2018 = FY2017/18. No data from FY2009/10 to FY2012/13 since these years cover pre-independence and immediate post-independence periods. FY2015/16 value is IMF projection from 2016 report due to reporting gaps.
- Suriname: Uses line item "Mineral resource revenues" – these likely cover gold mining as well. No internal split available.
- Trinidad and Tobago: Fiscal year runs October-September, such that 2018 = FY2017/18.
- UAE: 2018 value is IMF projection from most recent staff report.

Combining potential revenue shortfall and dependence into vulnerability

Our approach to creating a vulnerability index involves some important assumptions. Because we combine data from two different sources (Rystad Energy for potential shortfall, and the IMF for dependence) we implicitly assume that both would fall by the same proportion in our various scenarios. This assumption could be compromised in cases where some oil and gas revenues are routinely kept off the government budget, for instance by being transferred to the SWF, or worse, through misallocation. In those cases, reported government revenues might react asymmetrically compared to wellhead (Rystad) revenues in a low-carbon outcome. Lack of information, however, on the extent of these arrangements prevents us from improving our estimates.

In calculating our relative company positionings, we assume that the ratio of oil and gas revenues to total revenues is fixed for the next 20 years. This is partly a practical choice – it is simply not possible to forecast non-oil revenues over such a long time period for such a wide range of countries. However, we would argue that it also carries an important message: that our vulnerability figures are only true so long as governments do nothing to improve their non-oil revenues. Each country can mitigate their vulnerability by increasing the rate of tax collection from the non-oil economy.

Appendix II: Additional Results

Table 4 shows data for the two variables that combine into our overall vulnerability indicator – potential oil and gas revenue shortfall (revenues under a low-carbon scenario as % of last decade oil and gas revenue and dependence (oil and gas revenue as % of total government revenues). Six countries have not disclosed data to the IMF on dependence: Ukraine, Venezuela, Myanmar, Uzbekistan, Turkmenistan and Yemen.

TABLE 4. COMPARISON OF LAST DECADE REVENUES VS FUTURE REVENUES UNDER A LOW-CARBON SCENARIO (SDS), AND OIL & GAS REVENUES AS PROPORTION OF TOTAL REVENUES - FOR 40 "PETROSTATES"

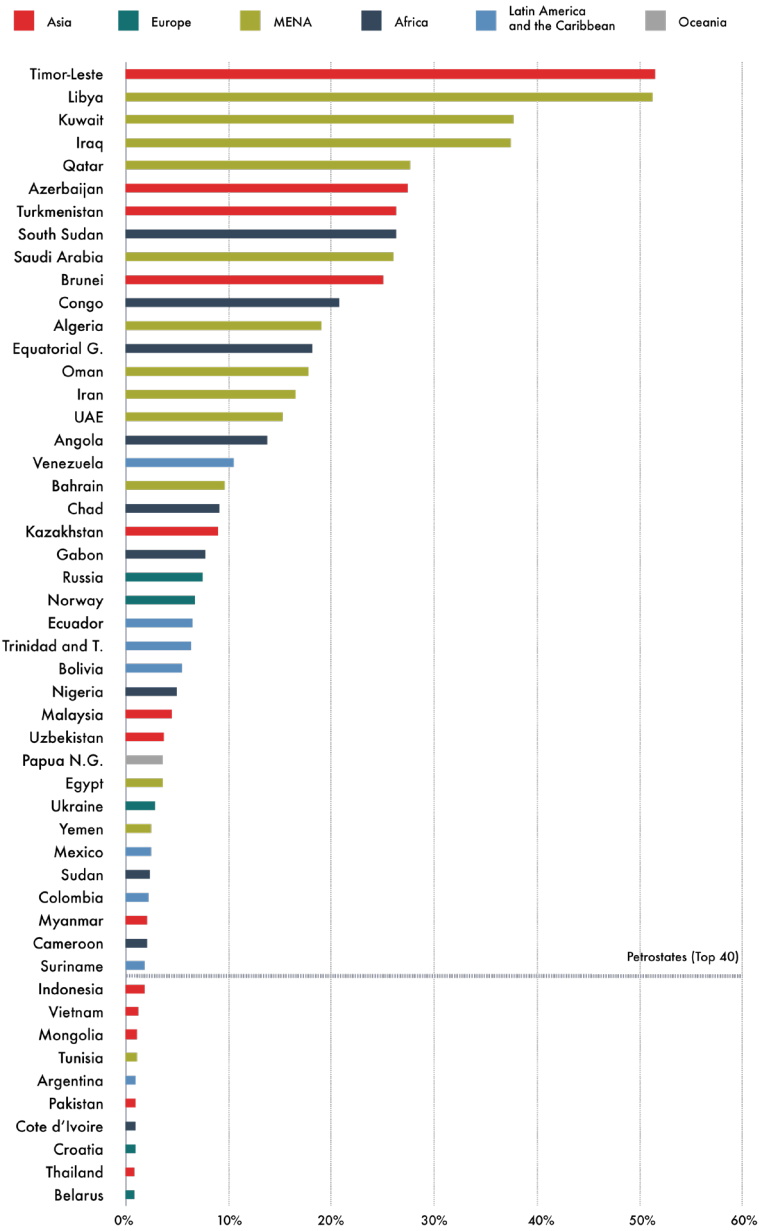
Country	Potential oil & gas revenue shortfall (%)	Oil & gas revenue as % of total gov't revenues
Suriname	94%	28%
Timor-Leste	93%	52%
Cameroon	88%	15%
Colombia	88%	3%
Sudan	87%	12%
Mexico	84%	18%
Gabon	81%	35%
Ecuador	80%	19%
Chad	79%	29%
Angola	76%	56%
Bolivia	76%	19%
Venezuela	76%	N/D
Ukraine	74%	N/D
South Sudan	72%	78%
Algeria	70%	39%
Trinidad and Tobago	70%	35%
Bahrain	70%	72%
Equatorial Guinea	70%	81%
Nigeria	69%	45%
Azerbaijan	68%	64%
Congo	67%	54%
Brunei	61%	43%

Oman	54%	76%
Russia	47%	23%
Egypt	45%	7%
Myanmar	45%	N/D
Saudi Arabia	44%	69%
Libya	44%	72%
Norway	44%	15%
Malaysia	43%	19%
Kazakhstan	41%	32%
Qatar	41%	34%
Iran	39%	37%
Kuwait	38%	67%
Uzbekistan	35%	N/D
UAE	34%	52%
Iraq	30%	89%
Turkmenistan	2%	N/D
Papua New Guinea	0%	6%
Yemen	0%	N/D

Source: Rystad Energy, IEA, IMF, SSB (Norway), CBL (Libya), CTI analysis
Notes: Potential revenue shortfall data is 2015-2018 average due to widespread lack of 2019 data. N/D = No data.

Figure 15 shows our case selection for the petrostates group, comprising the top 40 countries based on oil and gas revenues (from Rystad Energy) as a % of GDP. While this universe does exclude some well-recognised producers like Brazil that fall just outside the top 40, those countries would most likely place in vulnerability tier 1 due to their low levels of fossil fuel dependence, making them less relevant for the purposes of our study.

FIGURE 15. PETROSTATE CASE SELECTION – RYSTAD ENERGY OIL & GAS REVENUES AS % OF GDP - TOP 50 COUNTRIES GLOBALLY



Source: Rystad Energy, IMF, CTI analysis

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