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Climate change, fossil fuels, and the energy transition in the Global South

Governance pathways to leave fossil fuels underground

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Publication date

2026

[Link to publication](#)

Citation for published version (APA):

Heras, A. (2026). *Climate change, fossil fuels, and the energy transition in the Global South: Governance pathways to leave fossil fuels underground*. [Thesis, fully internal, Universiteit van Amsterdam].

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**4 Fossil fuels, stranded assets,
and the energy transition
in the Global South:
A systematic literature review**

Note on publication³⁴

This publication undertakes a systematic literature review of academic and grey literature to evaluate the state of scholarship on the energy transition in the Global South, focusing on LFFU and stranded assets. The paper answers CSQ4 (Table 1):

RQ3: What can be learnt from reviewing the scholarship on the Global South's energy transition, focusing on LFFU and the issue of stranded resources and assets?

Overview

Recent research in development studies and economics links the energy transition, the Paris Agreement, and stranded asset risks. While some scholars recognise the structural stranding risk in today's energy systems, most remains centred on investors and developed countries rather than the Global South (IPCC, 2018). Existing studies on stranded asset risks and alternatives for energy incumbents largely overlook the Global South. Similarly, few studies have examined LFFU from a North-South perspective. To address this gap, the paper conducts a systematic literature review integrating energy transition and international development scholarship, focusing on climate change and fossil fuels. Using a modified PRISMA search flow, 327 records were identified on SCOPUS and Web of Science,³⁵ supplemented with additional records obtained through citation tracking, journal manual research, and Google Scholar, totalling 47 records. After excluding studies that did not meet the criteria, 96 articles and 15 reports in English were assessed (see Figure 10 and Annex 9). The review mapped the main trends in the literature, including academic journals, publication years, authors' institutional affiliations, and methodologies (see 4.3). Substantively, it situates these trends within three identified discussion lines – renewable energy deployment, fossil fuel supply-side, and governing the energy transition – from which key inferences are drawn:

- a) RES investment in the Global South remains limited, mainly from private capital and concentrated in a few countries (e.g., Brazil, China, India). This is due to financial constraints in the form of prohibitive cost of capital and indebtedness, perceptions of higher risks for RES and the influence of external private actors, not always aligned with the recipient country's concerns. As a result, a disordered global energy transition, in the form of green races between decarbonisation leaders (e.g., Europe, China) competing for future markets, could create disparities between frontrunners, laggards and 'stranded nations', exacerbating inequalities within countries.
- b) The Global South is adding RES to the energy mix without displacing FF. At the same time, it is expanding – also with the contribution of Global North actors (e.g., US and Japan) and China – its fossil-based energy systems, discouraged from phasing out by Global North's continuing investment in FF following the Russian

³⁴ Heras, A., & Gupta, J. (2024). Fossil fuels, stranded assets, and the energy transition in the Global South: A systematic literature review. *WIREs Climate Change*, 15(1), e866. <https://doi.org/10.1002/wcc.866>

³⁵ The records were extracted on April 19, 2022.

invasion of Ukraine. The risks of carbon lock-in and stranded assets are rarely considered (e.g., in coal exporters countries) but increasing.

- c) The limited literature on supply-side measures emphasises the need for a coordinated mix of supply and demand instruments to shape a policy toolkit for the energy transition, particularly for Global South countries that will have to manage the socioeconomic impacts of a phase out in terms of lost revenues, capital losses, fiscal vulnerability, debt, stranded jobs, and socio-political unrest.
- d) Emerging economies (e.g., Brazil) could set governance examples and accounting for stranded assets through tailored Low-Emission Development Strategies (LEDS) with redistributive measures, demonstrating that deep decarbonisation pathways are not necessarily detrimental to economies and societies and can improve assessments of returns on FF investments, making LFFU more attractive.
- e) Power asymmetries hinder RES energy growth. However, when cohesive domestic coalitions, integrating economic and climate considerations with alternative energy futures, support RES as a viable substitution of FF, RES deployment accelerate (e.g., Thailand, Philippines).
- f) Liberalisation and privatisation in Global South's energy markets exacerbate inequality and FF expansion, fuelling the additive character of RES (e.g., in Madagascar, Nigeria, and Philippines), while technological decisions in electricity access provision act as an additional driver for carbon lock-in and unequal outcomes.

Conclusions

Following the discussion lines, three conclusions can be inferred. First, RES investment in the Global South remains insufficient relative to the scale of transformation required to shift away from FF, considering ongoing FF expansion (extraction, production, and infrastructure), and deployment has largely been additive rather than substitutive of fossil fuels. Yet, in several non-OECD countries RES consumption has contributed more to economic growth than FF and more than in OECD countries (i.e., 1% increase in RES consumption is associated with a 0.1%-0.2% rise in output over time). Second, the RtD narrative shapes governance and justice debates in the energy transition, influencing Global South's aspirations in the North-South context. RES are often perceived as riskier than fossil fuels from a profit standpoint, discouraging investment. Third, governance gaps (e.g., institutional capacity, limited data collection and systematisation, weak participation of stakeholders, policy and regulatory coordination, centralisation versus decentralisation), privatisation, and liberalisation in the energy sector further sustain FF expansion and inequality. The fossil fuel-based energy system and incumbent actors obstruct the energy transition, using their power to maintain the status quo. However, prospective change agents in the Global South may form coalitions capable of altering power relations.

Relation with thesis and possible discrepancies

As per the CLIFF Research Protocol, this review sets a baseline on the policies, drivers and contexts influencing LMICs' energy transitions. It confirms CLIFF-identified research gap on the global politics of stranded resources and assets, particularly concerning the Global South's role in LFFU. Since this paper's publication, scholarship on these issues has advanced, possibly influenced by this review: more recent literature is incorporated into subsequent Chapters. In this paper, 'Global South' refers to non-Annex I/B Parties to the UNFCCC and Kyoto Protocol, a conceptualisation refined in later Chapters (overlapping with LMICs, see 1.3.2.1) and culminated in Chapter 3. For the thesis, the paper:

- a) outlines the knowledge gaps (see 1.2.2) specific to LMICs in the energy transition, fossil fuels, and climate change: (i) Global South's energy transitions and stranded assets remain underexplored, with scant analysis on the implications for revenues, employment and fiscal vulnerability; (ii) power relations within and between countries in energy systems and transitions remain weakly studied; and (iii) research on the feasibility and desirability of energy leapfrogging in the Global South is sparse, despite its potential to avoid new stranded assets;
- b) proposes a political economy perspective for governing stranded assets within the wider politics of energy transitions, arguing that a global, multilevel, just transition is necessary to LFFU (see Chapter 3). This is applied in the thesis by: (i) incorporating this perspective in the neo-Gramscian theoretical framework (2.4.2); and (ii) mapping power relations and incumbency to identify material and discursive mechanisms of entrenchment and coalition pathways for transformation (Chapters 5 and 7); and (iii) further developing the analysis over the narratives by incumbents of gas as a transition fuel and the RtD use (Chapters 5, 6, 7); and
- c) informs the conceptual scheme with lessons learnt and knowledge gaps (Figure 8; see 2.5 and 8.2), identifying: (i) financial constraints (cost of capital and debt), higher risk perception of RES and fossil fuel profitability as direct drivers; stranded labour and potential revenue shortfall from LFFU as indirect drivers; (ii) gas as a transition fuel and the RtD employed as FF narratives; (iii) governance gaps (see above), energy addition, nurtured with FF subsidies, and liberalised decarbonisation as part of the policy context; (iv) leapfrogging potential as a counter-hegemonic narrative.

4.1 Introduction

Limiting average global warming to between 1.5 and 2°C above pre-industrial levels (UNFCCC, 2015) under the Paris Agreement on Climate Change implicitly requires leaving most fossil fuels underground (LFFU). This means that FF reserves become “unburnable” and therefore stranded: to meet the 2°C target, 33% of oil, 49% of gas, and 82% of coal reserves should remain untouched globally by 2050 (McGlade & Ekins, 2015), while for 1.5°C almost 60% of oil and gas, and 89% of coal should remain unextracted (Welsby et al., 2021). The mapping of “carbon bombs”, extraction projects that would release ≥ 1 Gt CO₂ emissions if fully exploited (Kühne et al., 2022), emphasises the imperative for LFFU. However, since fossil fuels drive growth and emissions, the necessity of LFFU and the resulting stranded resources (untapped FF) and assets (infrastructure, labour, etc. to extract FF) (Bos & Gupta, 2019) raise justice issues and development trade-offs in the allocation of “burnable carbon” among countries (Calverley & Anderson, 2022; Fankhauser & Jotzo, 2018; IEA, 2021c; IPCC, 2022b).

In this intricate context, focusing on developing countries' energy transition and LFFU is important for two primary reasons. First, developing countries hold the majority of fossil fuel reserves (BP, 2022b). As of 2020, non-OECD countries (including Colombia and Mexico) had almost 85% of proved oil reserves, 89% of fossil gas and 53% of coal (own calculations based on BP, 2022b). While these countries may use their resources to foster growth and industrialisation, fulfilling their RtD (UNGA, 1986) and improving their people's well-being (Newell, Shankland, et al., 2022), reliance on FF-based development can be a double-edged sword. It worsens climate change impacts, which these countries are already more susceptible to (IPCC, 2022b), and they risk ending up with carbon-locked societies and stranded assets, including outdated *know-how* (Seto et al., 2016). Second, developing countries' governments play a pivotal role in driving fossil fuel production. State-owned companies (SOEs) control most reserves (Lenferna, 2018; Van de Graaf, 2018) and over half of global output, while governments exert considerable influence over the decisions of private firms and investors through production targets, goals, and projections (SEI et al., 2021). Also, governments in non-OECD countries ultimately bear the potential loss arising from stranding fossil fuel assets (Semieniuk et al., 2022).

The literature linking the energy transition, the Paris Agreement, stranded assets, and developing countries is recent, mainly in the fields of development studies and economics. Although some scholars recognised that stranding risk is a structural issue within the current energy system (Firdaus & Mori, 2023, p. 83), few studies have examined this risk from the perspective of developing countries (Ansari & Holz, 2020; Bond et al., 2020; Bos & Gupta, 2019; Coffin et al., 2021) rather than financial investors (IPCC, 2018). Firdaus & Mori (2023) reviewed energy incumbents' options regarding stranded assets risk, but without a focus on the Global South, while few papers review

the LFFU scholarship from a North-South³⁶ perspective. Hence, this review paper addresses the question: *What can be learnt from reviewing the scholarship on the Global South's energy transition, focusing on LFFU and the issue of stranded resources and assets?* We systematically review (a) energy transition studies, and (b) international development literature, focused on climate change and fossil fuels. This paper presents our method (see 4.2), a meta-analysis (see 4.3), results (see 4.4) and conclusions (see 4.5).

4.2 Methods

Our systematic literature review assessed energy transition scholarship in the Global South to synthesise findings and identify research gaps (Galvan & Galvan, 2017; Sovacool et al., 2018). We used and modified the “PRISMA” (Page et al., 2021) search flow (see Figure 10). We searched for articles (see Annex 9) in SCOPUS (title-abstract-keywords) and Web of Science (all-fields), including relevant social science fields,³⁷ focusing on the energy transition in the Global South (query 1) and FF-related stranded assets in the Global South (query 2): (1) “energy transition” OR “energy transformation” OR “green transition” AND “global south” OR “developing country” OR “emerging economy” OR “LMICs” OR “resource-rich country” and (2) “fossil fuel” OR “oil” OR “gas” OR “coal” AND “stranded assets” OR “stranded resources” OR “phase out” AND “global south” OR “developing country” OR “emerging economy” OR “LMICs” OR “resource-rich country” for 1990–2022.³⁸ After deduplication, we identified 327 records. We added 47 records detected through Scopus secondary sources,³⁹ citation tracking, journal manual research, and Google Scholar for grey literature.

We screened the records using Rayyan (Ouzzani et al., 2016) by title, abstract, and keywords, followed by a full-text screening. We used Rayyan's labeling feature to

³⁶ We begin with two caveats. First, we use “Global South” to refer to non-Annex I/B parties to the UNFCCC/Kyoto Protocol, and its origins may be traced back to the 1964 establishment of the Group of 77. Although the Global North and South are a “metacategory” (Haug et al., 2021), they remain an effective term for showing differences in histories, political structure, governance, and context (Abdenur, 2021; Gupta, 2007; Uddin, 2017). These distinctions are mirrored in the UNFCCC, which recognises that most emissions have cumulatively come from the Global North (Happaerts, 2015; Uddin, 2017). Despite growing heterogeneity among its 134 members, the G77 continues to co-shape discussions on North–South issues such as climate change (Happaerts, 2015). Second, the Paris Agreement is a legally binding agreement, and countries are therefore expected to meet their obligations. The Agreement requires ratcheting up targets till the objective is met, and if parties behave in “good faith” as required by law, they will try to meet the obligations. Hence, we assume that there is no reason why the Paris Agreement, currently ratified by 194 countries, will not be implemented. Regardless of how rapidly the phase-out occurs, the risk of asset stranding is quite real for the Global South. Since inaction has a higher long-term cost, enhanced near-term climate policies can lessen or reduce stranding risk (Ansari & Holz, 2020; Firdaus & Mori, 2023).

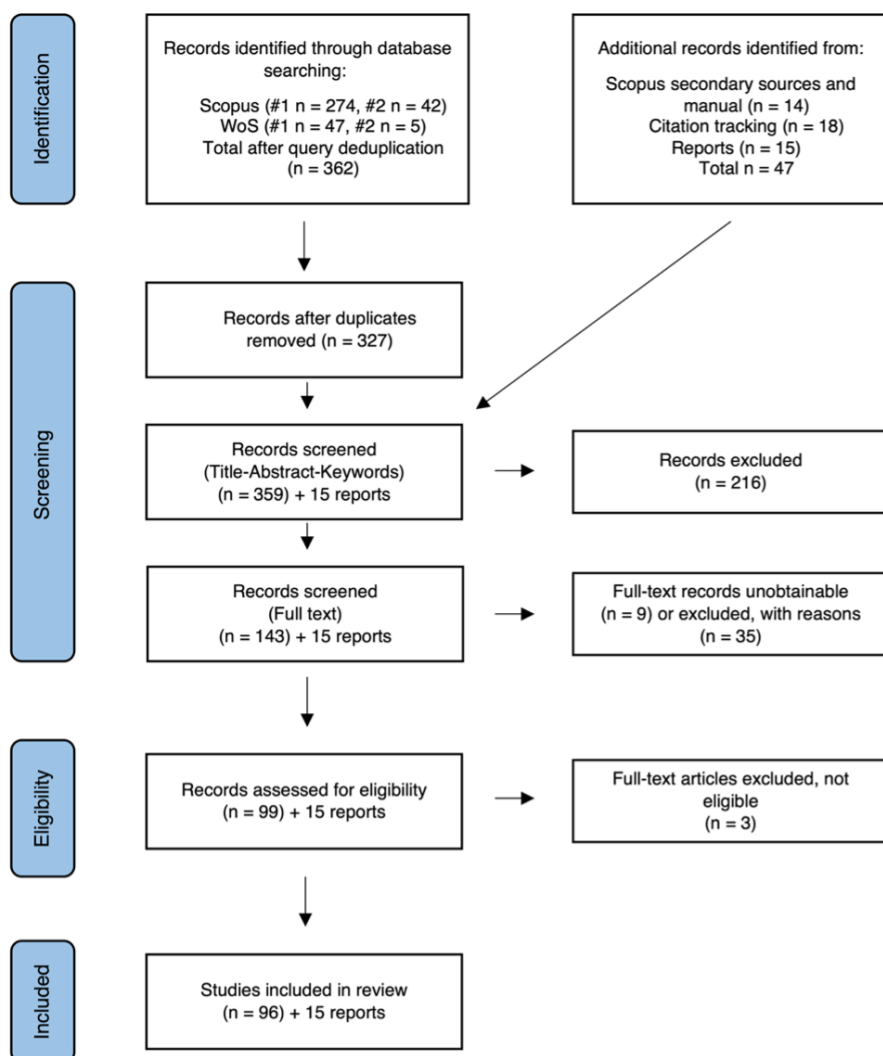
³⁷ Within SCOPUS, excluded fields are mathematics, arts and humanities, medicine, physics and astronomy, biochemistry, genetics and molecular biology, chemical engineering, chemistry, pharmacology, toxicology and pharmaceuticals, computer science, materials science, health professions, psychology, agricultural and biological sciences. Within WoS, excluded fields are engineering chemical, engineering electrical electronic, meteorology atmospheric sciences. The records were extracted on April 19, 2022.

³⁸ The search terms and synonyms or variations were identified considering the context exposed in the introduction and the research question, accounting for the databases' features regarding inflected forms. In case of capturing developed countries, they were excluded in the screening phase against the exclusion criteria considered.

³⁹ Scopus secondary documents are records extracted from reference lists but not indexed on Scopus.

inductively code the records. Considering the exclusion criteria in the two screening phases (see Annex 9), we excluded those records focusing solely on renewables without engaging with fossil fuels (because renewables contribute to total energy generation but do not necessarily imply a shift away from FF; York & Bell, 2019, p. 43), on the demand-side of FF (i.e., consumption, while LFFU is a supply-side perspective on FF) or on the Global North. By carefully searching for studies on the energy transition, fossil fuel supply, and the Global South, we selected 96 articles and 15 reports in English (see Annex 10).

Figure 10 – Modified PRISMA flow diagram of the literature review on energy transition and Global South



Source: Authors.

We divided the included articles into eight geographic clusters (including non-geographical groups, such as OPEC or BASIC⁴⁰) and three discussion lines: renewable energy sources (RES) deployment, FF supply-side, and governing the energy transition (Table 5). While multiple themes overlapped, we classified each article into a single category based on our subjective appraisal of the articles' primary topic.

Table 5 – Geographical coverage and discussion lines of included articles

Geographical coverage	Discussion lines
Global South and synonyms/samples from different regions	RES deployment
BASIC	FF supply-side
OPEC /OPEC+	Governing the energy transition
Small Island Developing States (SIDS)	
Africa, not included above	
Asia, not included above	
Latin America & Caribbean (LAC), not included above	
Middle East, not included above	

Source: Authors.

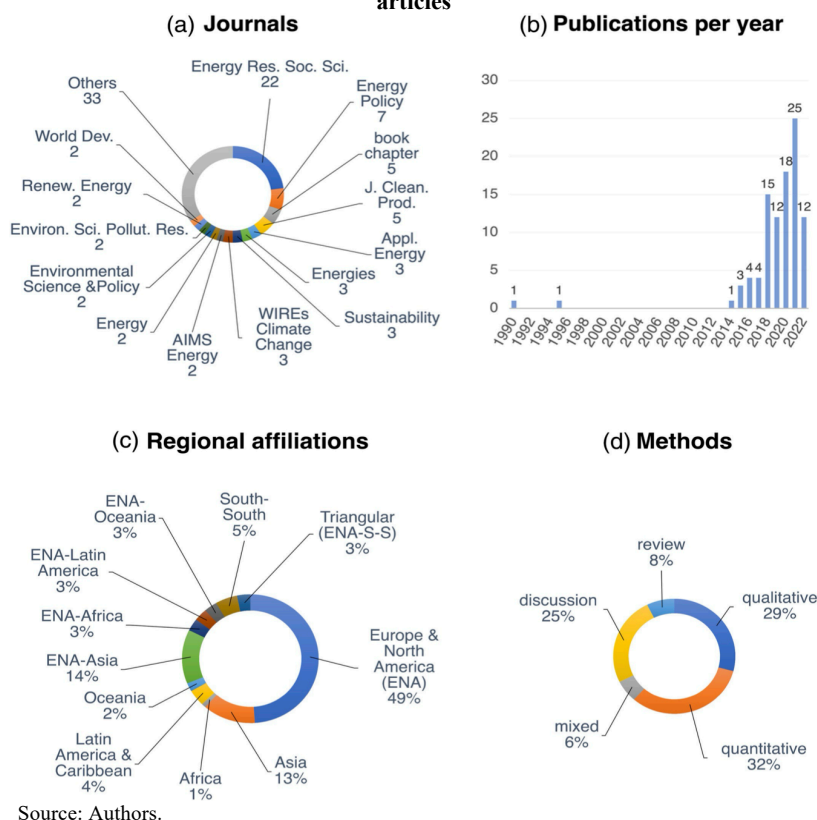
4.3 Results: trends in literature

4.3.1 Metadata

The 96 included records (Figure 11a) were largely published in three journals: *Energy Research & Social Science* (23%), *Energy Policy* (7%), and *Journal of Cleaner Production* (5%). Books were another significant source of records (5%), mostly published by Springer Nature.

⁴⁰ BASIC are BRICS minus Russia which is an Annex I country.

Figure 11a-d – Journals, publication year, institutional affiliations, and methods of included articles



Analysing the search period (1990–2022), 38% of the included studies ($n = 37$) were published after 2021 (Figure 11b), possibly because of renewed interest in the energy transition following the COVID-19 pandemic and the 2021 Glasgow Conference of the Parties.

Author institutional affiliations by geographical location (Figure 11c)⁴¹ show that single-region affiliations (in Europe and North America) account for about half of the papers. Articles with solely Asian institutional affiliations represent 13% of the sample, whereas Latin American and African research institutions represent 4% and 1% respectively. When looking at records with multi-region affiliations, writers from North America, Europe, and Asia have collaborated more than others (14% of the sample). Other multiple and transregional affiliations have the same sample weight (3%), while “South–South” research papers account for just 5% of the sample. This, together with the language barrier, might explain the low interest in this topic.

⁴¹ We classified affiliations along geographical lines. For example, “South–South” includes authors affiliated with institutions located in more than one world region, excluding Europe and North America. “Triangular” means institutional affiliations across continents, including Europe and North America.

4.3.2 Research methods

We divided the almost 70 empirical records into qualitative, quantitative, and mixed methods; among the non-empirical articles, we included reviews and discussion papers, which do not provide a methodology. Each methodology accounts for around one-third of the records, with few using mixed methods. Discussion papers (25%) dominate non-empirical research (Figure 11d).

4.3.3 Geographical coverage and discussion lines

Table 6 illustrates how the 96 included articles are distributed geographically and along the discussion lines.

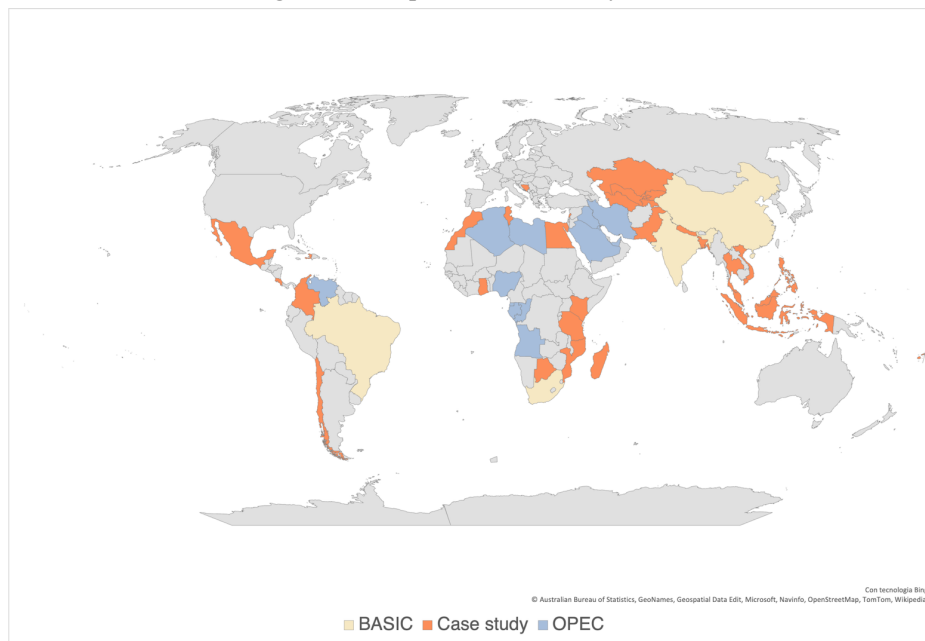
Table 6 – Included articles distribution according to geographical clustering and discussion lines

	RES deployment	FF supply- side	Governing the energy transition	Total
GS/samples	14	16	8	38
BASIC	6	4	3	13
OPEC/OPEC+	2	6	4	12
SIDS		1		1
Africa	9	1	4	14
Asia	3	3	7	13
LAC	1	1	2	4
Middle East	1			1
Total	36	32	28	96

Source: Authors.

Geographically, records mentioning “Global South” or synonyms (developing countries, non-OECD countries, etc.) or samples of developing countries from different regions (specific countries from different areas or groups of countries e.g., “non-OECD countries”) account for nearly 40% of the sample. Publications that include states in geographical categories or belonging to certain blocs are skewed toward Asia ($n = 14$, particularly Bangladesh and the Philippines), followed by BASIC and African countries ($n = 13$ each, especially Sub-Saharan countries like Kenya), then OPEC (or OPEC+) countries ($n = 12$). Small island developing states (SIDS), Middle Eastern and Latin American nation cases (not included in other groups) are underrepresented in the sample (except for Haiti, Lebanon, Chile, and Colombia). The map (Figure 12) of covered country cases (e.g., when mentioned in small samples or case studies) reveals that there are few papers on specific countries in large sections of Africa and LAC.

Figure 12 – Map of covered country cases⁴²



Source: Authors.

4.4 Discussion

We now review the findings along three discussion lines. First, merely financing RES adds rather than substitutes for FF supply especially in Global South contexts (see 4.4.1). Second, phasing out FF supply is required, but the RtD and the aspirations for rapid economic growth lead to increased FF use, carbon lock-in (Unruh, 2000) and a growing risk of stranded assets (see 4.4.2). Third, such a phase-out depends on the energy transition’s governance challenges, including power relations and justice (see 4.4.3).

4.4.1 RES deployment: Financing RES in the Global South is relatively low and energy additive rather than substitutive

4.4.1.1 *Finance for RES is relatively low, influenced by external actors and their risk perceptions*

A shift away from FF requires large-scale RES deployment, particularly in the Global South, where the impacts of climate change, rising energy demand, and energy security concerns are more pressing (IEA, 2021b). Nevertheless, such RES investments remain limited, especially from private capital, geographically concentrated in few frontrunner countries, and skewed toward specific technologies, such as grid-connected electricity generation (Azarova & Jun, 2021; IPCC, 2022a; Quitzow et al., 2019; Ragosa & Warren, 2019).

⁴² We note that there are some contested boundaries in the map.

Among the economic factors, the existing energy supply gap and financial constraints, when combined with RES higher capital costs and low capacity factors, may result in increased energy costs and an aggravated degree of unmet energy demand, exacerbating the already limited affordable access to energy (Afful-Dadzie et al., 2020). Limited RES investment also results from political economy reasons affecting FDI, development cooperation, and public finance, which have inadequately scaled up national energy transitions toward renewables (Marquardt et al., 2016; B. Steffen et al., 2018). International private developers have been pivotal first movers for wind and solar in some developing countries (e.g., Algeria, or Pakistan), with an increasing level of internationalisation and spill-over effects of RES-support measures (B. Steffen et al., 2018). The supportive role of international public finance, regulatory backing, and commercial ties with the recipient country explains, with variations, private capital's decision to invest in renewables in, for example, South Africa or Indonesia (Azarova & Jun, 2021; Ragosa & Warren, 2019). If consistent with the recipient country's main energy goals and concerns, development cooperation can drive RES experimentation at the *niche* level to enable energy *regime* change (Geels, 2010; Marquardt et al., 2016).

However, if there is no concomitant FF phase-out (Quitow et al., 2019, p. 13), foreign investments, export-credit agencies (Gupta, Rempel, et al., 2020) and international cooperation, despite driving RES deployment and economic growth, may increase developing countries' ecological footprint (Murshed et al., 2022), foster unsustainable fossil-fuel lock-ins and unjust transitions (Quitow et al., 2019). This occurs when such cooperation seeks to secure revenue for the investor without addressing country-specific constraints, while energy independence, security, and access outweigh climate or sustainability concerns in influencing when and whether RES are rolled out (Marquardt et al., 2016; Quitow et al., 2019).

Since RES involves significant up-front investment and developing countries face financial constraints, quantitative studies focus on political, commercial, and regulatory risk perceptions by private capital in funding RES projects (Gul et al., 2020). However, findings are inconclusive: depending on the technology and developing countries considered (in this case, Algeria, Egypt, Morocco, and Tunisia), de-risking investments, with a contextual and marked reduction in electricity costs, may still not enable RES to compete with subsidised FF-based energy (Schinko & Komendantova, 2016). The latter, however, neglects the recent considerable drop in CSP (concentrated solar power) costs (Hansen et al., 2019). Other studies show that by developing new risk assessment methods or modifying contracts with O&G companies to include a “renewable clause,” RES can show attractive returns and large potential, interestingly, in FF-producing countries such as Iran and Lebanon (Olleik et al., 2021; Shimbar & Ebrahimi, 2020).

4.4.1.2 *RES imply energy addition rather than transition*

Scholarship's findings and arguments may motivate more investigation into whether the Global South is undergoing an energy transition or addition (York & Bell, 2019). Governments worldwide plan to produce more than twice as much FF in 2030 than would be consistent with the 1.5°C target, and 45% more than consistent with limiting warming to 2°C (the 'production gap') (SEI et al., 2021). NOCs widen the gap, accounting for 40% of total global investment in O&G, and may invest ± USD 2 trillion by 2030 on projects that would break even only if consumption exceeds the Paris Agreement's carbon budget (SEI et al., 2021, p. 29).

Currently, the energy transition does not LFFU, but rather adds RES energy without displacing FF (York & Bell, 2019) or even goes back to FF (coal in Asia and fossil gas in Africa), to realise the RtD, tackle energy poverty, meet demand or become an established FF exporter (Afful-Dadzie et al., 2020; Bugaje et al., 2022; Delina, 2018; La Rovere, 2020; Murshed et al., 2021; Nalule, 2019; Oskarsson et al., 2021; Quitzow et al., 2021; Zaman et al., 2018). Developing countries are replicating traditional growth patterns by expanding their fossil-based energy systems while adding RES to the energy mix (IPCC, 2022a; Schaffartzik & Fischer-Kowalski, 2018). Developing countries are discouraged from costly investments to phase out FF as developed countries continue to invest in FF as a result of the war on Ukraine.

Interestingly, the literature diverges geographically. Some studies show that sub-Saharan Africa is not prepared for LFFU (Adewuyi et al., 2020; Afful-Dadzie et al., 2020; Bugaje et al., 2022; IEA, 2021b; Nalule, 2019). The energy trilemma (the choice between energy security, equity, and sustainability), combined with the economic development imperative, makes Africa's energy transition a "progressive" process (Nalule, 2019, p. 264). The degree of unmet electricity demand, even with RES deployment, and the cost of energy generation under fiscal constraints impact the trilemma, putting sustainability in last place (Afful-Dadzie et al., 2020). Studies emphasise fossil gas as a transition fuel in Africa (Adewuyi et al., 2020; Bugaje et al., 2022; Nalule, 2019; Okafor et al., 2021; Verdeil et al., 2015) but scarcely account for the risk of carbon lock-in and stranded assets resulting from investment in fossil gas (Bos & Gupta, 2016; Kemfert et al., 2022).

Studies on India, Bangladesh, and Brazil reveal how they experience an energy addition or a transition *to* fossil fuels (La Rovere, 2020; Lazaro et al., 2022; Murshed et al., 2021; Oskarsson et al., 2021; Zaman et al., 2018). In Brazil (São Paulo state, leader in renewable energy generation), the increasing RES share has not substituted FF consumption or significantly reduced emissions (Lazaro et al., 2022). Additionally, the coal-fleet expansion in India and Bangladesh underscores the endurance of coal (imported and produced), despite the risks of stranded assets and carbon lock-in (Murshed et al., 2021; Oskarsson et al., 2021; Zaman et al., 2018). Furthermore, some literature emphasises that reducing overall energy consumption is a key assumption for a LFFU-focused sustainable

energy transition: in this regard, scholarship must go beyond merely tracking RES contribution to the energy mix, as this may give the false impression that *all* existing FF consumption must be replaced with RES to achieve a shift in energy sources (Gładkykh et al., 2021; Lazaro et al., 2022).

Some scholars emphasise the risks of an uneven low-carbon energy transition, given developing countries' unequal access to finance and technology (Eicke & Goldthau, 2021). An EU CBAM⁴³ analysis shows the impacts on the Global South, particularly Africa, which is more exposed and vulnerable in terms of trade diversification, emissions, and institutional capacity to monitor and report emissions embodied in products, reproducing new types of North–South inequalities (Eicke et al., 2021). Research on Africa (Adewuyi et al., 2020; Afful-Dadzie et al., 2020; Bugaje et al., 2022; Kincer et al., 2022) stresses this potential unequal outcome, calling for development institutions to be flexible in tailoring their support to low-emitting developing countries based on their endowments and needs, rather than financially banning all FF (Kincer et al., 2022).

The COVID-19 crisis and policy responses have widened the gap between energy transition leaders and laggards. The challenging investment climate for RES in developing countries has further deteriorated (due to lower fiscal revenues, debt, increased borrowing costs, and lack of fiscal leeway), while FF investments have persisted despite the pandemic (Gribkova & Milshina, 2022; Quitzow et al., 2021). Such patterns might replicate the North–South divide in a low-carbon world, increasing risks of economic instability, stranded assets, and diminished competitiveness for late decarbonisers (Eicke & Goldthau, 2021). Furthermore, feedback cycles may kick in, affecting international relations (conflict between frontrunners and laggards, and a ruthless green race between decarbonisation leaders competing for future growth markets, leading to escalations and major risks for the global political economy) and global equity (“stranded nations”) (Eicke & Goldthau, 2021). These potential outcomes make the timing of implementing transition policies critical (Eicke et al., 2021). Hence, a gradual increase in RES *share* is inadequate for a pervasive change in energy systems (Quitzow et al., 2021; Schaffartzik & Fischer-Kowalski, 2018; York & Bell, 2019) but such change must take energy poverty, access and security into consideration (Kincer et al., 2022). With the exception of Ecuador and Costa Rica, however, clear LFFU commitments to mitigate transition risks are uncommon in the Global South (Quitzow et al., 2021). This requires political-economic analyses of the energy transition and justice, along with better multilateral decision-making on LFFU (Eicke & Goldthau, 2021; Quitzow et al., 2021).

⁴³ The proposed carbon border adjustment mechanism (CBAM) would charge levies on goods imported into the EU based on their carbon content to deter carbon leakage.

4.4.1.3 However, there is greater potential for leapfrogging in the Global South

RES are currently growing faster, as a unit of GDP, in the Global South than in the Global North (Swilling et al., 2022) with deep decarbonisation pathways becoming technologically and economically more feasible, and opportunities for leapfrogging (Fankhauser & Jotzo, 2018). Indeed, leapfrogging potential in unmet electricity markets (e.g., Africa or SIDS) may be greater than in developed countries, with development opportunities (Batinge et al., 2019; Cholibois, 2020; Global Commission on the Geopolitics of Energy Transformation & IRENA, 2019). On a global level, leapfrogging to an almost 100% RES energy system is technologically, economically, and socially feasible in the Global South (Bond et al., 2021; IEA, 2021c; D. Schwartzman, 2020; P. Schwartzman & Schwartzman, 2021). It is technologically possible to meet the 1.5°C target, transitioning in 20 years to a 100% renewable supply and phasing out coal and fossil gas, whose CO₂-equivalent emission factor has been underestimated in previous studies (Kemfert et al., 2022; P. Schwartzman & Schwartzman, 2021). The resulting RES supply is predicted to be no more than 1.5 times the current level (with improved storage and efficiency, and contextual decrease in consumption), and capable of eliminating global energy poverty (P. Schwartzman & Schwartzman, 2021). Moreover, unlike the linear energy transition trajectory of developed countries, the size and development of RES market and technology in emerging electricity markets may imply increased access to energy, rapid electrification, and a growing share and levels of RES in the energy mix, allowing for even double or triple leapfrog (Bond et al., 2021).

Certain studies (Kemp & Never, 2017; Swilling et al., 2022) highlight the prospects for a green industrial policy in the Global South: experiences with phasing-in low-carbon technologies in India and China show that rather than detecting new technological niches that are difficult to finance, a green industrial policy takes advantage of existing opportunities that converge with development objectives (i.e., job creation, energy access) and accounts for governance and implementation limitations (Kemp & Never, 2017). Existing vested interests, policies and socio-cultural norms, however, hinder the transition (Batinge et al., 2019; Bond et al., 2021; IPCC, 2022a; Schaffartzik & Fischer-Kowalski, 2018; P. Schwartzman & Schwartzman, 2021), while in other contexts, external actors such as private capital may bypass weak state structures to achieve leapfrogging (e.g., in Madagascar) without improving institutions in line with international development mandates and practices (Cholibois, 2020).

Some quantitative studies examine the two-way relationship *between* energy transition and growth (Fankhauser & Jotzo, 2018; Ivanovski et al., 2021; Murshed et al., 2021; Taghizadeh-Hesary & Rasoulinezhad, 2020). Taghizadeh-Hesary and Rasoulinezhad (2020) estimate that while growth positively influences the energy transition (operationalised as the ratio between RES consumption and FF consumption) in 45 Asian countries by income level groups between 1993 and 2018, the CO₂ emissions associated with growth slow down the transition. Interestingly, when compared to the higher-income

group, low and lower-middle-income countries show a larger positive effect of economic growth and a smaller negative impact of growth-related CO₂ emissions on the energy transition. This suggests that a more granular analysis of developing countries by income level and their dissimilar transition patterns could provide insights for improving their energy policies. Some studies, on the other hand, look at the impact of the energy transition *on* growth (Ivanovski et al., 2021; Nasirov et al., 2020; Zhang et al., 2019). Previous studies, according to Ivanovski et al. (2021), assumed an inaccurate linear relationship between energy consumption and growth over time. Using non-parametric estimates to grasp the time-dependence relationship between energy use and growth, Ivanovski et al. (2021) identify differences in the impact of RES consumption on economic growth between OECD and non-OECD countries. Between 1990 and 2015, both RES and non-RES consumption have contributed to economic growth in non-OECD countries, with a 1% increase in RES consumption associated with a 0.1%–0.2% rise in output (p. 8). Compared to non-RES, RES consumption contributed more to growth over time. Since RES consumption has not significantly influenced growth in OECD countries, these findings suggest that the Global South, despite financial and technical constraints, could lead the way in the global energy transition away from FF, promoting RES deployment, achieving economic development, and addressing climate change (Babayomi et al., 2022; Ivanovski et al., 2021; Zhang et al., 2019). Through LFFU and leapfrogging, latecomers to the energy transition may set a precedent for other developing nations (Cholibois, 2020; Quitzow et al., 2021; Schaffartzik & Fischer-Kowalski, 2018).

4.4.2 The FF supply-side: LFFU approaches are under-researched, subsidies are over-emphasised, while FF stranding risk grows

4.4.2.1 Supply-side measures are under-researched

Scholarship has mostly focused on renewables or demand-side policy instruments (e.g., carbon emissions tax or tradeable emissions permits, among many others) promoting energy efficiency and limiting consumption; these have unsatisfactory results in LFFU (IPCC, 2018; Krieglger et al., 2020; Le Billon & Kristoffersen, 2020). This requires a focus on interventions targeting FF supply, its volume and features, the economic circumstances of producing countries, past FF production, and FF producers' willingness to cut supply (Le Billon & Kristoffersen, 2020). Supply cuts have been investigated, inventoried (Le Billon & Kristoffersen, 2020)⁴⁴ and assessed in terms of efficiency, effectiveness, viability and fairness (Rempel & Gupta, 2022). FF phaseouts mainly target

⁴⁴ Le Billon and Kristoffersen (2020) classify supply constraints into: financial (instruments that seek to incorporate externalities into the total production cost) and material (measures that reduce supply by creating institutional or physical barriers to production). Financial: subsidy removal, fossil fuel export tax, emission-related production/extraction tax, finance swap/compensation, divestment, engagement, asset write-off. Material: tradeable production quotas (TPQs), blockades, production bans and moratoria, court cases/litigation, retire/phasing out existing fossil-intensive infrastructure (Le Billon & Kristoffersen, 2020; Rempel & Gupta, 2022).

coal, with oil in the background, while gas is frequently viewed as a transition fuel (Le Billon & Kristoffersen, 2020).

Individually, the analysed LFFU initiatives are inequitable or institutionally problematic, because the approaches seldom recognise the resulting stranded assets and resources (Rempel & Gupta, 2022). According to Rempel & Gupta (2022), there are instruments that are cost-effective but inequitable (e.g., divestment or FF subsidy removal), others that are just but not institutionally feasible (e.g., compensation or asset write-offs), and others that are environmentally effective but neither just nor efficient (e.g., capping electrical grid). To account for these trade-offs between effectiveness, feasibility, and equitability of LFFU approaches, the literature suggests a wider array of instruments, implementing a coordinated mix of supply- and demand-side FF policies, to shape a policy toolkit for energy transition losers (Le Billon & Kristoffersen, 2020; Rempel & Gupta, 2022). Governments, which directly hold more than half of global FF production (SEI et al., 2021, p. 10), may be interested in limiting supply in concert with demand in order to provide markets greater confidence and avoid price volatility (Coffin et al., 2021; SEI et al., 2021). Yet, FF producers are unwilling to cut supply and are allegedly overly involved in FF markets, regardless of their institutional or economic capacity to implement production constraints (Coffin et al., 2021; Le Billon & Kristoffersen, 2020; SEI et al., 2021).

A climate-driven energy transition entails deep geopolitical reconfigurations that FF producer countries, particularly in the Global South, would have to manage in terms of economic impacts (capital losses from stranding, lost rent and income from low global demand, low prices and exports up to USD 7 trillion (IEA, 2018), fiscal vulnerability and indebtedness) and socio-political aftermaths (loss of state legitimacy in providing social programmes, political unrest and social instability, or even violence and conflict) (Bond et al., 2020; Coffin et al., 2021; Global Commission on the Geopolitics of Energy Transformation & IRENA, 2019; Le Billon & Kristoffersen, 2020; Okafor et al., 2021; Van de Graaf, 2018; Van de Graaf & Verbruggen, 2015). The capacity to respond differs by region, but with the COVID-19 pandemic and mounting debt, petrostates are likely to undergo a period of structural adjustment with limited fiscal flexibility, particularly Venezuela, Nigeria, and Angola (Bond et al., 2020; Coffin et al., 2021). Petrostates could face a USD 9 trillion shortfall in O&G revenues compared to industry expectations, significantly in Asia (−57%), Africa (−58%), and Latin America (−66%) (Coffin et al., 2021, p. 7), and emerging petrostates like Uganda would see their revenues entirely disappear (Coffin et al., 2021, p. 34). Nonetheless, repurposed fossil infrastructure, such as pipelines for hydrogen, or low-cost and short-duration assets, which are less vulnerable to stranding, may mitigate FF producers' exposure (Bond et al., 2020).

Hence, in a carbon-constrained world and time of FF abundance (Van de Graaf & Bradshaw, 2018), scholars call for examining incumbent FF producers, to identify

rationales, paths and power relations regarding LFFU approaches (Le Billon & Kristoffersen, 2020; Rempel & Gupta, 2022; Van de Graaf & Verbruggen, 2015). Papers focusing on OPEC and their NOCs present some petrostates' bleak economic prospects, identifying possible strategies (e.g., quota agreements, price wars, production efficiency, compensation for lost revenues, and economic diversification), and advocating for better inclusion of oil exporters' strategic behaviour in climate policy analysis and negotiations, as it can significantly impact the pace and trajectory of decarbonisation (SEI et al., 2021; Van de Graaf, 2018; Van de Graaf & Verbruggen, 2015). Research on established oil exporters emphasises the problem of stranded resources and assets but disregards equity implications (Van de Graaf, 2018; Van de Graaf & Bradshaw, 2018). Some analysts argue that international burden-sharing mechanisms (e.g., differentiated targets and timetables, international emissions trading/carbon price differentials, direct transfers) are required to account for the distributional implications of LFFU (Kriegler et al., 2020); others argue that an agreed-upon redistributive supply system to assist fragile petrostates would be counterproductive, since it would lock them into FF dependence and raise overall system costs by extending uneconomic oil production: thus, governments should expect a market-driven supply distribution (Coffin et al., 2021).

This body of research focuses less on FF-importing countries that are coping with pollution, FF imports, and rising energy demand. It may be argued that these countries will welcome a transition away from FF since they will be able to keep USD 1–3 trillion in wealth that they transfer to petrostates each year (Bond et al., 2020, p. 7). On the other hand, unless offset by substantial RES deployment (see 4.4.1), they will confront pricing pressures that may exacerbate energy insecurity and energy poverty.

4.4.2.2 *FF subsidies are over-emphasised*

Scholars predominantly focus on removing FF subsidies (Rempel & Gupta, 2022). FF subsidy estimates vary depending on definitions, methods, and assumptions (e.g., what economic variable they subsidise—consumer or producer prices, enterprise revenues, production factors— or how they are calculated—price-gaps method, accounting for unpriced externalities), but FF subsidies were double subsidies for renewables (IPCC, 2022a). Subsidies to FF consumption in emerging and developing countries (excluding China) were anticipated in 2015 to be approximately USD 160 billion in 2020 (IEA, 2021b, p. 177), while FF production subsidies have been increasing worldwide in recent years (SEI et al., 2021).

FF subsidies have long been considered to be economically inefficient. Phasing out subsidies on petroleum products paired with energy-efficiency improvements in three OPEC countries was expected to reduce domestic oil demand, with additional oil revenues from exports (Biroi et al., 1995). Subsidies in oil exporting countries can range from 5% (e.g., in UAE or Argentina) to 30% (e.g., in Iran) of their GDP (Burniaux & Chateau, 2014, p. 73), triggering domestic demand increases, energy intensity peaks and

wealth creation. However, high energy use reduces export potential (Moghaddam & Wirl, 2018), particularly if these fuels must be phased out. Nonetheless, the domestic price increase caused by removing subsidies can be politically self-destructive for petrostates, while authoritarianism, low transparency, high oil revenues, and redistributive motives (even if disproved by evidence) make subsidy removal even more difficult (Moghaddam & Wirl, 2018). Low international prices could lower the political costs of the price jump, but building political coalitions supporting the reform is crucial (Burniaux & Chateau, 2014; Moghaddam & Wirl, 2018).

Some estimates suggest that removing subsidies (multilaterally and gradually) from 2013 to 2020 in 37 non-OECD countries would reduce global CO₂ emissions by 10% in 2050, with substantial regional differences (−16% in non-Annex I countries, and −45% in oil exporting countries) (Burniaux & Chateau, 2014, p. 78). Others estimate that if a subsidy reform had set a completely efficient fuel pricing in 2015, it would have resulted in a 28% decrease in global CO₂ emissions (with regional variations), health benefits (reduced air pollution mortality), and economic welfare gains (Coady et al., 2019, p. 24). In terms of income variation, multilaterally removing subsidies would result in improved terms of trade and welfare benefits for FF-importing nations and no real income loss for FF-producing countries in 2050 (Burniaux & Chateau, 2014).

As in 4.4.2.1, non-FF-producing countries receive less scrutiny from the included literature also when it comes to FF subsidies. Focusing on Haiti, Perry (2020) calls for a more nuanced understanding of the interplay of social, political, historical, and institutional factors, especially when a FF reform is imposed by foreign actors on low-income countries struggling to adapt to climate change and address development issues such as energy access. Power imbalances, within and between countries, should be better included in FF subsidy removal research, along with a deeper analysis of developing FF-importing countries.

4.4.2.3 Accounting for stranded resources and assets could make LFFU attractive

The Global South faces a double risk: the ongoing installation of FF infrastructure will result in carbon lock-in (IPCC, 2022a). Such lock-in, coupled with international climate policy, exposes these countries and their NOCs to considerable financial and legal risks, since FF assets and resources are projected to be at risk of being stranded soon (2030 for coal, mid-century for oil and gas; IPCC, 2022a), leaving the Global South with significant financial losses and debt (Bond et al., 2020; Bos & Gupta, 2018; Goldthau et al., 2020; IPCC, 2022a; Shen, 2020).

The scholarship emphasises the contribution of external actors to the Global South's carbon entrenchment. Between 2000 and 2018, bilateral overseas finance from the US, China, and Japan in developing countries prioritised FF-based power generation, committing 24 Gt CO₂ emissions by 2060 and producing long-term climate and financial risks. If multilateral financing shows a trend toward RES, bilateral finance should be

scrutinised more closely (X. Chen et al., 2021). China's role in Africa's energy transition (power plants, grid expansion projects, and investments and loans totalling USD 25–96 billion since 2000; Shen, 2020, pp. 3–5) facilitates lock-ins, strengthens coal incumbency coalitions and discourages political and commercial interests in RES (Shen, 2020). However, while China's energy activities in Africa are linked to changes in the Chinese domestic market and policy (Shen, 2020), Chinese government-backed investments in new coal-fired power plants in South and Southeast Asia have been driven by recipient country policies that favour coal over RES and have no environmental standards for new plants. The recipient country's agency and capability are critical factors (Gallagher et al., 2021).

Hence, research on Southeast Asia and Latin America is increasingly scrutinising the role of developing countries' domestic policies in carbon lock-in (X. Chen & Mauzerall, 2021; Oei & Mendelevitch, 2019; Vahl & Filho, 2015). Energy sectors in developing countries are building on FF expansion (De La Peña et al., 2022; Vahl & Filho, 2015). Regardless of market trends, today's coal exporters are disregarding the risk of having hyper-specialised regions trapped in a race to the bottom regarding environmental standards, unable to move toward alternatives, and burdened by additional stranded assets (Oei & Mendelevitch, 2019). Indeed, it is expected that the overexpanding FF-based power generation capacity would be underutilised, committing long-term emissions, crowding out cost-competitive RES, and amplifying stranding risk (Bond et al., 2020; X. Chen & Mauzerall, 2021). Furthermore, prospective FF producers should carefully evaluate their FF investment decisions since risks range from political/legal (global pressure/sanctions), ecological (water, pollution, climate), economic (decline in projected revenues, lock-in, low diversification, premature write-off) to social (health impacts, stranded jobs, violence) (Bos & Gupta, 2018; Coffin et al., 2021). Using a stranded asset index, Ansari and Holz (2020) highlight that Middle Eastern and Latin American crude oil sectors and Chinese coal production face large stranding potential by 2055. Thus, the peril of structural stranded assets resulting from carbon lock-in exists, posing long-lasting challenges for developing countries (Ansari & Holz, 2020; Bos & Gupta, 2018). Anticipating carbon constraints and avoiding new FF investments are the least hazardous options, from short- to long-run risks (Bos & Gupta, 2018; Fankhauser & Jotzo, 2018; Gupta & Chu, 2018). Nevertheless, the issue needs to be addressed globally, to avoid green paradoxes (the incentive provided by climate policies for FF producers to accelerate extraction; Sinn, 2012) and to alleviate the burden of stranded assets on the Global South (Ansari & Holz, 2020; Bos & Gupta, 2019; Lahn & Bradley, 2016). Accounting for such stranded asset risk could change how developing countries think about fossil fuels.

4.4.3 Governing the transition: the RtD shapes the limited governance capacity for LFFU, power relations are understudied, while just transition narratives remain rhetorical

4.4.3.1 *The RtD and the growth imperative influence the governance and justice issues involved in the transition*

In the political arena, much of the debate on LFFU is linked to the RtD over the last 30 years. However, very few articles mention the RtD and its implications for LFFU in developing countries (Bos & Gupta, 2016, 2018, 2019; Gupta & Chu, 2018). The RtD (UNGA, 1986) implies that the Global South has the right to develop; in the climate context, the concept evolved into the Right to, and duty for, advancing Sustainable Development (RtSD) in the 1992 UNFCCC (Gupta & Chu, 2018; UNFCCC, 1992). Relying on this, developing countries have prioritised “growth and development” and claimed that the North should let them use their FF (Gupta & Chu, 2018). Between 1992 and 2020, the Global North has not significantly reduced its FF use to make space for developing countries and has established a poor track record (Stoddard et al., 2021).

In 2017–2021 the Global South, including China, accounted for almost 4/5 of the global population and nearly 2/3 of total annual emissions: its decisions today will determine the world's energy future (Fankhauser & Jotzo, 2018, p. 2; IEA, 2021b; Zhang et al., 2019, pp. 26377–26378). Hence, the RtD must adapt to a carbon-constrained world. Achieving the Paris Agreement targets means that the opportunities to argue for the right to emit are shrinking and the RtD validity, as it is formulated around FF, remains questionable (Gupta & Chu, 2018). It is uncertain whether fostering FF investment (e.g., China) and extraction (e.g., established petrostates like Nigeria or prospective producers like Kenya) will advance fair and sustainable development as stated in the UNFCCC, especially if revenues and ROIs are not used to diversify the economy, redistribute income and develop inclusively (Bos & Gupta, 2016; Gupta & Chu, 2018). Indeed, about 5% of the global population collected half of the FF rents between 1970 and 2010 (Karthi et al., 2016; Le Billon & Kristoffersen, 2020, p. 3), without significant development improvements (Gupta & Chu, 2018). Because the risk of stranded resources and assets exists (Bos & Gupta, 2018), prospective FF investors and producers are more likely to fall into the resource curse, deeper poverty, asset stranding, financial burdens, and market disadvantages vis-à-vis established competitors (Bos & Gupta, 2016; Bradley et al., 2018; IPCC, 2022a). In deciding what kind of energy mix to pursue, developing countries may need to reshape the RtD's medium-term justice issue into a longer-term risk management matter, to harness RES development potential (see 4.4.1.3) and address FF stranding risk (see 4.4.2.3) (Bradley et al., 2018; Gupta & Chu, 2018). More coordinated donors and financial institutions may provide prospective producers with better information to evaluate and manage risks, delivering a firmer basis for decision-making (Bradley et al., 2018; Lahn & Bradley, 2016). Some scholars emphasise that the Global South will not be able to, and should not, follow the same linear and carbon-intensive growth path

followed by the global North (Fankhauser & Jotzo, 2018; Gupta & Chu, 2018). In the North–South context, the RtD influences the governance and justice issues involved in the transition, shaping developing countries' demands from the national to the global (see 4.4.3.2 and 4.4.3.4).

4.4.3.2 Limited governance capacities hamper LFFU

The RtD and proactive energy transition management can accelerate these transformations (La Viña et al., 2018), but this depends on developing countries' governance capabilities (Alvial-Palavicino & Opazo-Bunster, 2018). Poor data collection and systematisation, as well as politics (political choices, civil wars), are challenges to LMICs' energy transition policies (Relva et al., 2021). This may be addressed by examining contextual factors in order to understand the linkages between the energy sector and the country's growth (de Oliveira & Girod, 1990). Governments can only implement an effective transition policy if they encourage long-term energy planning based on a thorough diagnosis of the energy system, provide information and develop “carbon risk competencies,” ensuring effective public engagement and stakeholder involvement (Bradley et al., 2018; de Oliveira & Girod, 1990; Relva et al., 2021; Vanegas Cantarero, 2020).

The ability of the state to steer the energy landscape is required for the transition (Edomah, 2021; La Viña et al., 2018; Maswabi et al., 2021; Zaman & Brudermann, 2018). If governments wish to meet the sustainability pillar of the energy trilemma, they must balance competing, overlapping, and frequently contradictory agendas, which frequently change causing regulatory instability and uncertainty, and, when combined with techno-institutional constraints, may result in poorly governed transitions (Edomah, 2021; La Viña et al., 2018; Maswabi et al., 2021; Zaman et al., 2018). Transparent, consistent, and long-term planning, with context-specific adjustments, precise operational frameworks, and a coordinating agency with clearly defined responsibilities and mandates, may enable a better energy transition (Maswabi et al., 2021).

Emerging economies can serve as models for LEDS, helping other developing nations to avoid a carbon-intensive pathway. LEDS, if combined with policies to reduce inequalities (e.g., transfers, social security systems, and financial assistance to businesses and regions), can be tailored to mitigate the transition's economic and social consequences, demonstrating that deep decarbonisation paths do not have to be economically and socially costly. An adequate response to these challenges may be essential in making LEDS politically acceptable and quickly implemented (La Rovere, 2020).

The current governance narrative is structured around a state-coordinated approach, in which governments shape the values within which the market operates to ensure adequate power supplies (Alvial-Palavicino & Opazo-Bunster, 2018; Zaman & Brudermann, 2018, p. 453). However, some scholars emphasise local and decentralised energy transitions that may be more inclusive, increasing energy security (Lazaro et al., 2022; Zaman &

Brudermann, 2018). Local governments, if empowered and have the capacity, may be enablers of the transition, and multilevel governance, through consensus-building and participation, can challenge state-centred approaches that favour energy additions or unsustainable transitions (Alvial-Palavicino & Opazo-Bunster, 2018; Lazaro et al., 2022; Zaman & Brudermann, 2018). To overcome these issues, a *polycentric energy governance system* is required (Edomah, 2021). Scholarship emphasises the individual's role in actively interacting with the energy system as a result of local empowerment and action (examples can be found in India and Ethiopia), and how public engagement in energy planning and policymaking under the notions of energy sovereignty and decolonisation may improve energy supply governance in the Global South (such as in Mauritius or Nicaragua) (Vanegas Cantarero, 2020). In this sense, energy democracy relates to decentralised energy governance, which is critical for public policy implementation (Lazaro et al., 2022) as well as decentralised electricity generation, which is linked to higher social sustainability (Gladkykh et al., 2021). Nonetheless, to avoid decentralisation from being exclusive and favouring the better-off, the challenge is to establish a centralised system that allows some decentralisation while simultaneously providing for the poor. Cross-sectoral collaboration and planning centred on territorially oriented solutions may strengthen the spatial dimension of the energy transition by incorporating local-level capabilities into multilevel energy governance, where local governments can promote LEDS and energy public policy (Lazaro et al., 2022). Integrating unrepresented viewpoints, democratically restructuring energy systems and institutions (energy democracy), and redistributing power and possibilities for imagining future visions and values are at the heart of an effective and inclusive energy governance (Alvial-Palavicino & Opazo-Bunster, 2018; Vanegas Cantarero, 2020).

4.4.3.3 Power relations are understudied but shape the political economies of the energy transition

Power dynamics constrain the limited governance capacities in LFFU. Power relations within and between countries and the political economy of energy ultimately shape energy systems but are understudied (Apfel et al., 2021), and the same holds true for a LFFU-focused energy transition. Exogenous actors and regime incumbents wield power to prevent RES technology from growing in the Global South, shaping the energy transition to a fossil-based energy system (Corral-Montoya et al., 2022; Osunmuyiwa et al., 2018; Saculsan & Mori, 2020; Sharma et al., 2021). A dense web of power relations entrenched the Philippines in a coal-dependent energy path: foreign investors and multilateral banks pressed the government to liberalise the power system and support coal development, energy oligarchs built and replicated a new private oligopolistic energy structure, and the government persuaded foreign capital and oligarchs to continue investing in coal (Saculsan & Mori, 2020). Analysing a rentier developing country like Nigeria (where the oil industry accounts for approximately 95% of all foreign exchange revenues; Osunmuyiwa et al., 2018, p. 144), scholarship highlights the tactics used

through energy patronage networks by incumbent actors to hinder the energy transition: defensive strategies such as privatisation of the power generation system and corruption, discursive tactics through media framing, or strategic use of structural or institutional resources to frame environmentally degrading technologies as alternatives to RES (Osunmuyiwa et al., 2018). In Madagascar, climate finance enables the energy transition, but because it is derived from external financial resources and expertise, it is subject to power structures that rely on public finance to catalyse private investment (Cholibois, 2020). These country cases show that the process of liberalisation and privatisation of the electricity market may not create a level playing field, but rather intensify the transition *to* a fossil-based energy system (Edomah, 2021; Osunmuyiwa et al., 2018; Saculsan & Mori, 2020) and exclusion: 53% of Madagascar's population faces exclusion from energy access by 2030 if only privately financed projects are implemented (Cholibois, 2020, p. 360).

Power and politics promote market- and growth-led imaginaries (Delina, 2018) and shed light on factors affecting LFFU (Corral-Montoya et al., 2022; Sharma et al., 2021). Through securitisation, state capture, and market-oriented narratives linking FF to development and progress, powerful actors have influenced policy processes, socio-cultural identities, and institutions, ultimately favouring the FF industry and making its *imaginary* hegemonic (Corral-Montoya et al., 2022; Delina, 2018; Osunmuyiwa et al., 2018; Saculsan & Mori, 2020; Sharma et al., 2021).

However, counter-narratives can succeed (Delina, 2022; Marquardt & Delina, 2019; Rennkamp et al., 2017). For instance, when RES initiatives are supported by wide coalitions (from the government, industry, and civil society), they become viable policy alternatives in FF-rich middle-income countries. Different coalitions show comparable structures and discourses, integrating environmental and economic considerations and removing the apparent trade-off between socioeconomic development and emission reductions (Rennkamp et al., 2017). Local anti-FF movements may help to diversify climate action mobilisations: social movements and community activism can use the courts to halt FF projects or promote RES deployment, imagining energy futures that are diametrically opposed to the dominant FF-based narrative, challenging power dynamics, and threatening the established energy imaginaries and the social order embedded in them (Delina, 2022; Marquardt & Delina, 2019).

4.4.3.4 Despite political deadlocks, LFFU may be achievable through a global and multi-level just transition

There is growing interest in a “just transition” away from FF (Hirsch et al., 2017; Wang & Lo, 2021). Yet, because the term has multiple meanings and interpretations, it has become confusing (Wang & Lo, 2021). Understandings of the causes of injustice, who should be considered vulnerable, perceptions, narratives, and visions of justice in energy transition are as diverse as their claimants, and frequently in conflict (Hirsch et al., 2017;

Wang & Lo, 2021). Moreover, global to local just transition narratives are frequently rhetorical and trapped in political stalemates (see 4.4.3.3).

A just distribution of harm and benefits within the existing energy system entails assessing where injustice emerges, who is affected, and what processes can be implemented to identify and reduce these injustices (Wang & Lo, 2021). Energy justice encompasses procedural justice (fair and inclusive decision-making), distributive justice (allocating harm, benefits, and responsibilities), and recognition justice (acknowledging the rights of “others”) (Hazrati & Heffron, 2021; Wang & Lo, 2021).

Energy justice scholars question Western paradigms (Wang & Lo, 2021), enriching the debate with postcolonial critiques of development, non-Western philosophy, or empirical applications of restorative and energy justice theory (Castán Broto et al., 2018; Gladkykh et al., 2021; Hazrati & Heffron, 2021; Malakar et al., 2019). Developing an energy justice theory in the Global South may require discarding universalising ideas derived from a Western tradition of justice (Castán Broto et al., 2018). In Mozambique, Castán Broto et al. (2018) call for emancipatory understandings of energy justice that incorporate autonomy, self-determination, and energy sovereignty. Understanding people's energy demands and how they are satisfied within the country's (unjust) political economy is critical to enacting reforms that fit within people's ambitions in a just energy transition.

Malakar et al. (2019) apply a decision-making framework drawn from Hinduism to India's energy dilemmas. They use two time-based Hindu notions (“duty-focused,” intra-generational, and “consequence-sensitive,” inter-generational, decision outcomes) to ensure reliable and affordable access to modern energy for all and the equitable allocation of energy benefits and burdens. This requires moving beyond the binary focus on duty versus consequence (or urgency versus justice) (Höffken et al., 2021; Malakar et al., 2019), striking a balance and addressing fairness, timing, equity and realised justice in policy-making (Höffken et al., 2021; Malakar et al., 2019). However, scholars seem more interested in developing diverse analytical frameworks than in applying them to actual research, resulting in a scarcity of empirical studies (Wang & Lo, 2021). Among the few, Hazrati and Heffron (2021) investigate the use of restorative justice in the O&G sector in Malaysia and Iran, demonstrating that energy justice can be delivered through practical mechanisms (e.g., EIA, among others). Furthermore, energy justice principles in energy system modelling can enable the selection of socially sustainable technologies, providing an alternative to models based exclusively on cost-minimisation (Gladkykh et al., 2021). Indeed, FF-based energy provision is less compatible with a socially sustainable energy system, and even when solely cost-minimisation principles in electricity generation are used (excluding environmental externalities), FF-based technologies are less competitive than centralised and decentralised RES (Gladkykh et al., 2021). This finding, contradicting those in 4.4.1.1, raises questions about the rationale for employing FF technology in the Global South. Technological decisions in electricity access provision

(primarily met by FF in developing countries since 2000; Gladkykh et al., 2021, p. 2) may act as an additional driver for carbon lock-in and unjust energy transitions (Gladkykh et al., 2021). Lastly, some studies analyse energy transitions in developing countries to assess how justice is operationalised in each country's transformation (Gass et al., 2021; Hirsch et al., 2017). Hirsch et al. (2017) propose universal just energy transition principles based on three components (climate, socio-economic, and political) to reflect the distinctive characteristics of the Global South. Overall, countries' performance is stronger in climate and energy dimensions, and weaker in the socio-economic component.

Recognising what can be improved, a global and multilevel just transition could be a gradually enabling concept to transform the energy system (Gass et al., 2021; Hirsch et al., 2017), avoid new stranded assets (Gass et al., 2021) and provide the groundwork for LFFU.

4.4.4 Key findings and recommendations

Key findings from the scholarship are: (a) RES consumption has contributed more to economic growth in non-OECD nations over time, and despite financial and technological obstacles, developing nations could potentially leapfrog to a RES system and LFFU; (b) a disorderly international energy transition may result in unequal outcomes between leaders and laggards, and ruthless green races between frontrunners; (c) the Global South is currently adding RES, but nevertheless following the same linear and carbon-intensive growth path that wealthier nations are still pursuing. Emerging economies could set a governance example by implementing LEDS alongside inequality-reducing policies, demonstrating that deep decarbonisation paths do not have to imply severe economic and social consequences; (d) liberalisation and privatisation processes frequently implemented in Global South's energy markets may worsen exclusion and inequalities, driving a switch to FF; (e) scholars develop diverse just transition theoretical frameworks, often without applying them empirically; (f) power dynamics prohibit RES technology from growing in developing countries, but coalesced domestic political actors can remove the trade-off between socioeconomic growth and climate mitigation, making RES viable, politically acceptable, and speedily deployed. Based on these key findings, we can derive some research and policy recommendations focusing on the supply side of energy politics: (a) given the decreasing costs of RES (especially solar PV, but also wind and CSP), and the potential for a 100% RES-based energy system (Hansen et al., 2019), research should focus on leapfrogging opportunities and equity implications in the developing world. This involves exploring why RES investment remains insufficient to meet SDG#7 for everyone in the Global South, even though most investments have been in developing countries in recent years, as well as how stranding risk could be incorporated in energy-related investment decision-making processes of a developing country's government. Neglecting FF-importing countries may obscure the competition between RES investments and FF subsidies; (b) investigate the role of fossil gas as

“bridge fuel,” as it may expose developing countries to lock-in and stranding risk, particularly if FF asset conversion does not occur quickly. It could be argued that, despite RES prices decline, the continued use of the bridging narrative legitimises FF combustion and postpones the transition (Kemfert et al., 2022); (c) examine the exclusive impacts of the Global South's energy sector liberalisation and privatisation process and explore alternative strategies for achieving a just and inclusive energy transition. This implies considering the circumstances under which these strategies would work, at a time when many governments have ceded control over their energy sector (Newell & Phillips, 2016); (d) scholars emphasise that institutional barriers such as legal frameworks are the main obstacle to polycentric energy governance (Vanegas Cantarero, 2020), but scholarship should also investigate how incumbents exploit their position to hinder democratic, decentralised and participatory energy planning (Newell & Phillips, 2016), and (e) investigate the power dynamics in the energy transition, particularly in light of the contradictory results in 4.4.1.1 and 4.4.3.4 on RES versus FF, as power determines which energy source is prioritised, by whom and why, as well as the winners and losers in the transition (Newell & Phillips, 2016), to prioritise RES and LFFU in a just and equitable manner.

4.5 Conclusion

This article evaluated the state of the literature on the energy transition in the Global South, focusing on LFFU and the issue of stranded assets. Following our three discussion lines, we infer that: first, investment in RES in the Global South may be inadequate for the scale of change needed, particularly in relation to continued FF investments; such RES deployment is more additive than substitutive. However, the Global South has significant potential to leapfrog in the energy transition. Second, there is limited literature on LFFU in the Global South, and much of it focuses on phasing out subsidies. However, there is considerable potential for the South to incorporate in the accounting (a) stranded assets; and (b) the costs of inaction on climate change (i.e., the costs of impacts and adaptation), to better assess the returns on FF investment and make LFFU attractive. Third, the RtD influences the governance and justice issues involved in the transition, shaping the demands of many developing countries in the North–South context. Moreover, limited governance capacity hampers LFFU, while understudied power dynamics shape the political economies of the energy transition. However, despite political deadlocks, a global and multilevel just transition might have the potential for LFFU. From these findings, we derive three significant conclusions:

- There has been little investigation into the ties between the energy transition centred on phasing out fossil fuels, the issue of stranded assets and resources, and the significance for the Global South in terms of equity, development, and climate change impacts. Indeed, research seldom addresses the dilemmas and hazards of stranded assets and resources from a developing country's perspective. The RtD, as it is currently formulated around FF-based economic growth, and addressing energy

concerns in the immediate term outweigh the dangers of ending up worse off in the future, carbon locked in, and bearing the financial burden of stranded assets. This is related to a risk perception issue: despite some encouraging developments, RES deployment in the Global South is still considered riskier than FF. To reshape the RtD's medium-term equity issue into a longer-term risk management issue and tap RES development potential, it may be necessary to better assess the risk of stranded assets in the FF expansion and the risk of debt spirals for already indebted poor countries. As a result, a stranded assets and resources political economy within the wider political economy of energy transition may support inclusive development (Gupta & Chu, 2018).

- Rather than phase out FF anytime soon, the current energy transition in the Global South appears to be focused on renewables additions to the overall energy mix and FF expansion. There is a scarcity of research evaluating the (political) feasibility and desirability of energy leapfrogging in the Global South. A critical view of fossil gas as a transition fuel is essential, particularly in poorer countries already facing energy poverty, development challenges, and climate change impacts. Rejecting the “bridge” narrative in favour of decarbonisation may avoid stranded assets and speed up the transition toward a true FF phase-out. Although leapfrogging is contested in the literature, we hypothesise that there is strong potential in the Global South, and, in nurturing this potential, climate change risks should drive policymaking.
- The literature overlooks power relations in addressing persistent carbon lock-ins in the Global South and the role of incumbents and potential agents of change. Developing countries are currently following Global North's fossil-intensive path, influenced by liberalisation processes which appear to solidify the FF-based energy systems. The energy addition has made cost-competitive RES appealing without discouraging FF expansion, keeping FF incumbents' ownership, management, and control of the energy development model unchallenged (Newell, 2019; Newell & Phillips, 2016). Regarding agents of change, there has been little research on the role of leaders, policy entrepreneurs, and social movements in financial coherence and the politics of stranded assets and resources.

Thus, future research should better investigate energy leapfrogging viability in developing countries, critically evaluate the additive rather than substitutive character of renewables in the Global South, and better identify the constraints to an inclusive and just energy transition, posed by North–South power dynamics and FF incumbents.