Title: How do interest rates affect decarbonisation pathways? A stakeholder-driven modelling analysis

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Summary (100 words)

Models used to assess decarbonisation pathways typically assume a uniform cost of capital; such assumption, however, does not do justice to real-world conditions and may therefore lead to inaccurate policy recommendations. Here, we apply an empirical dataset of estimated cost of capital differentiated by technology and country and explore stakeholder-driven pathways of (de-)risking investments in clean energy vs. fossil-fuel technologies, using GCAM. We also attempt to incorporate a corrective justice dimension in our narratives, by assessing the impacts of risk underwriting for low-carbon investments through taxing corporate windfall profits for 2022 and distributing the revenue as subsidies towards high-risk regions.

Extended abstract (1,000 words)

Decarbonising the economy necessitates global action to address fundamental economic disparities and overcome the climate investment trap faced by developing nations (IPCC, 2023). About USD 2.8 trillion was invested in energy in 2023, with over 60% in clean energy, and the remainder in fossil fuels (IEA, 2023a). If the world is to meet the Paris Agreement global temperature goal of limiting warming to 1.5°C above pre-industrial levels, over USD 5 trillion in annual terms of additional investment are required (IRENA, 2023). The climate financing gap also reflects persistent geographic misallocation of global capital, as almost all recent clean energy investment growth flows towards advanced economies and China, while capital flows remain flat in emerging economies and developing countries (only 15%), despite the latter hosting two-thirds of word population and contributing to one-third of global GDP (IEA, 2023b).

Low-carbon technologies require large upfront investments, unlike fossil-fuel technologies where fuel costs are the dominant part of lifecycle costs (Hirth and Steckel, 2016). The private cost of capital (CoC)—i.e., the discount rate employed in evaluating private investments—becomes essential to assessing the investment choices of companies that must decide between various alternatives, such as different power generation technologies (Steffen, 2020). CoC is thus used in investment appraisals, such as in levelised cost of energy (LCOE) calculations, and the capital-intensive nature of low-carbon technologies implies that their LCOE is more sensitive to the CoC rate (Lonergan et al., 2023). CoC is thus a major determinant of the cost of electricity from renewable power generation technologies and of their deployment.

Reliable data and improved understanding of the composition of CoC and its drivers are essential to developing support mechanisms and market designs that appropriately consider varying technology and country risks (Anatolitis et al., 2023). These are commonly represented in the weighted average cost of capital (WACC), a CoC case that considers the proportion of debt and equity in a company's capital structure. Essentially, WACC is a weighted average of the cost of debt and the cost of equity, where weights are determined by the proportion of each in a company's total capital (Breitschopf and Alexander-Haw, 2022). In case of energy projects featuring elevated perceived risk, such as those in politically unstable regions or involving newer and highly uncertain technologies, WACC is higher, signifying that investors require greater returns to offset the higher risk of potential financial losses (Ellenbeck and Lilliestam, 2019).

Most integrated assessment models (IAMs) typically use uniform WACC values across regions over time, which can disproportionately impact mitigation pathways for developing economies (Ameli et al., 2021). There exist scarce datasets of empirically-grounded WACC values for power-sector technologies; the International Renewable Energy Agency (IRENA) has put together such a dataset at the global level (Anatolitis et al., 2023), including green hydrogen (IRENA, 2022), while recent research has focused on developing regionally-disaggregated WACC values for a subset of electricity production technologies, in the EU (Polzin et al., 2021), Africa (Sweerts et al., 2019), and globally (Ameli et al., 2021; Calcaterra et al., 2024).

Here, we use empirically-calibrated WACC values by region and technology from (Calcaterra et al., 2024) and (IRENA, 2022) in GCAM, a well-established global IAM (Calvin et al, 2019). As one of the largest uncertainties lies in how WACC values will evolve over time, we combine the empirical estimates of baseline WACC values with an expert-based approach (Meng et al., 2021) to produce forward-looking scenarios of evolving WACCs over time. We draw experts' opinion on how much investment risks may change for a set of technologies in 2050 in high-, middle-, and low-income countries, considering possible finance and policy derisking or divestment mechanisms that may play out, to determine the final risk percentage change. Figure 1 shows a representation of baseline and future aggregated WACC values by region and technology for each scenario, alongside the distribution of windfall profits by region.

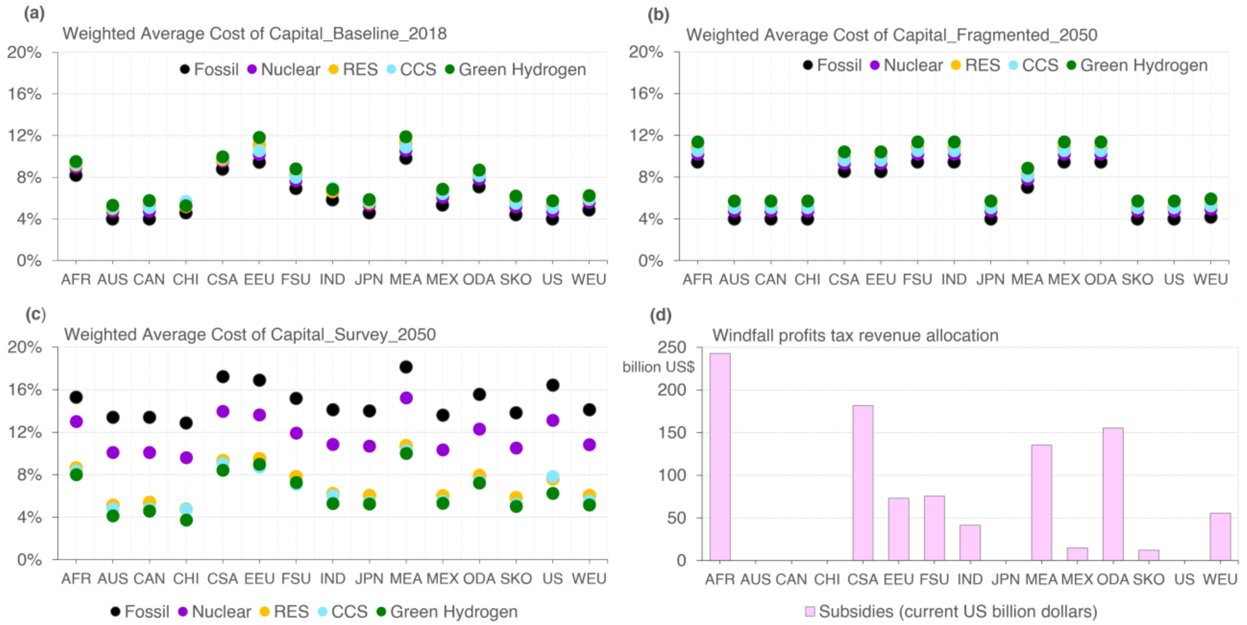
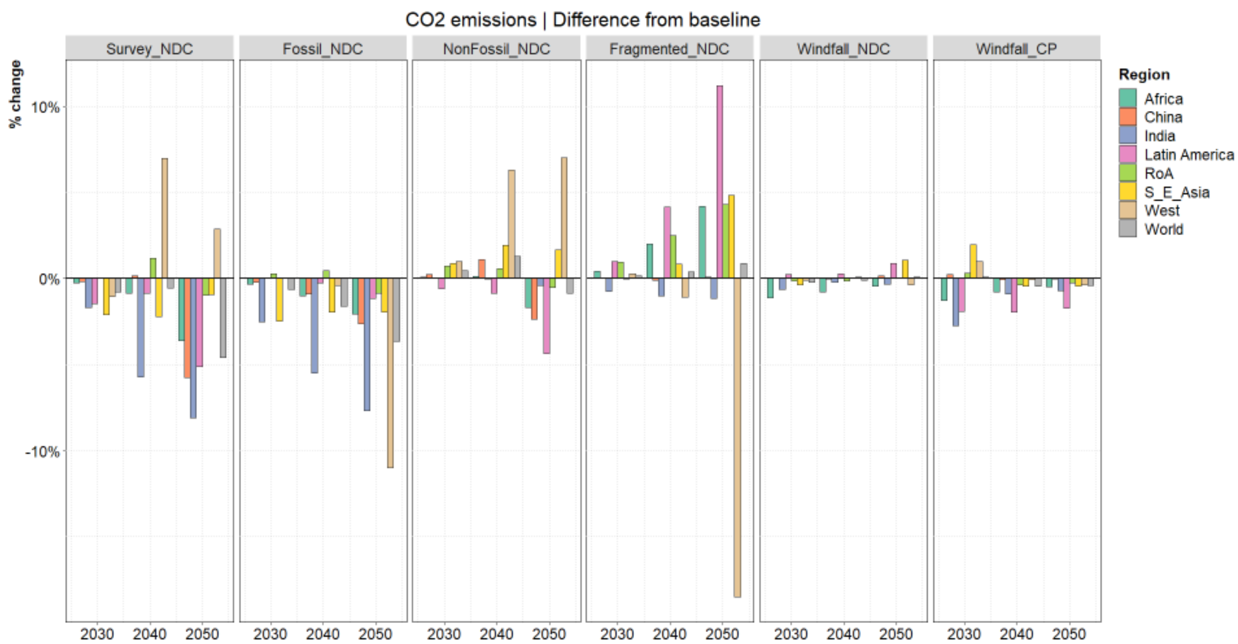


Figure 1: WACC values aggregated by region (AFR: Africa, AUS: Australia & New Zealand, CAN: Canada, CSA: Central & South America, EEU: Eastern Europe, FSU: Russia & Central Asia, IND: India, JPN: Japan, MEA: Middle East, MEX: Mexico, ODA: (Other) South & Southeast Asia, SKO: Republic of Korea, US: USA, WEU: Western Europe) and technology (fossil fuels, renewables, nuclear, CCS, and green hydrogen) (a) in the baseline year, (b) in 2050 for the WACC_fragmented scenario, (c) in 2050 based on survey results and (d) Windall profits tax revenues allocation by region in US current billion $.

Our scenario logic reflects different levels of post-COP26 ambition, including Current policies (CP_EI): level of short-term ambition likely to be materialised through actual policies or concrete policy targets; National Determined Contributions (NDC_EI): used as a baseline, where current policies are explicitly represented and NDCs are enforced on top until 2030, while the rate of change in emissions intensity of GDP in each region from 2020 to 2030 is kept constant post-2030 (Fawcett et al., 2015); Long-term targets (NDC_LTT): level of longer-term ambition that many countries have explicitly stated, but is mostly not backed with actual policy agendas (on top of pledged NDC targets fostering another increased level of ambition). All scenarios include empirical WACC values differentiated by region and technology to reflect non-uniform risk perceptions. The comparison among scenarios would thus reveal the impacts of varying WACC values over time via derisking non-fossil fuels ("*IAMCOM_NonFossil_NDC_EI*"), fossil-fuel divestment ("*IAMCOM_Fossil_NDC_EI*"), and their combination ("*IAMCOM_Survey_NDC_EI*"), increasing differences of risk perceptions among high- and medium-/low-income regions ("*WACC_Fragmented_NDC_EI*"), as well as the impact of subsidies towards low-carbon technologies on top of current policies and NDCs ("*Windfall_allocation_CP_EI*"; *"Windfall_allocation_NDC_EI*").

We find that increasing the risk of fossil fuels would lead to divestments in coal, oil, and gas, and lower CO_2 emissions globally—mostly in the West, India, and China (Figure 2a). With mitigation efforts fixed, future WACC values according to our survey results would contribute towards achieving LTT targets, closing the NDC-LTT gap as much as 18% in Africa, and 6% globally (Figure 2b). Derisking renewables would reduce CO_2 emissions in Latin America, China, and Africa through capacity additions in solar, wind, and biomass w/CCS and increased green electrification (Figure 3). A fragmented world shows decreased renewables in electricity generation in Africa, India, South and East Asia (Figure 3), substituted by coal or gas, leading to a 5-10% increase in CO_2 emissions in those regions (Figure 2a). The most significant climate and equity benefits are achieved through an increased risk of fossil-fuel technologies combined with subsidies in countries facing high CoC. Subsidies alone would not drive clean energy investments when fossil fuels remain competitive; they would, however, lower CO_2 emissions in regions receiving high amounts (Africa, Latin America).

(a)



(b)

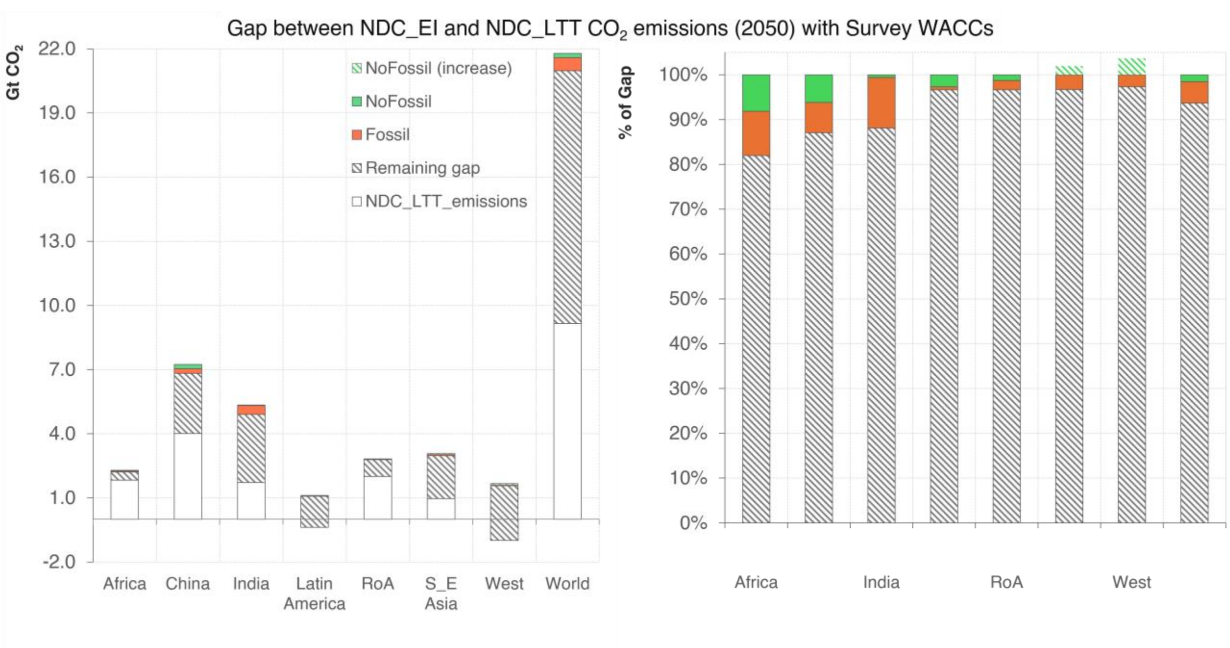


Figure 2: (a) Percentage change of CO_2 emissions from energy and industrial processes in all scenarios and regions compared to NDC_EI (b) Gap between NDC_EI and NDC_LTT CO_2 emissions in 2050 when Survey WACCs are applied; Fossil & Non-Fossil contribution is shown separately.

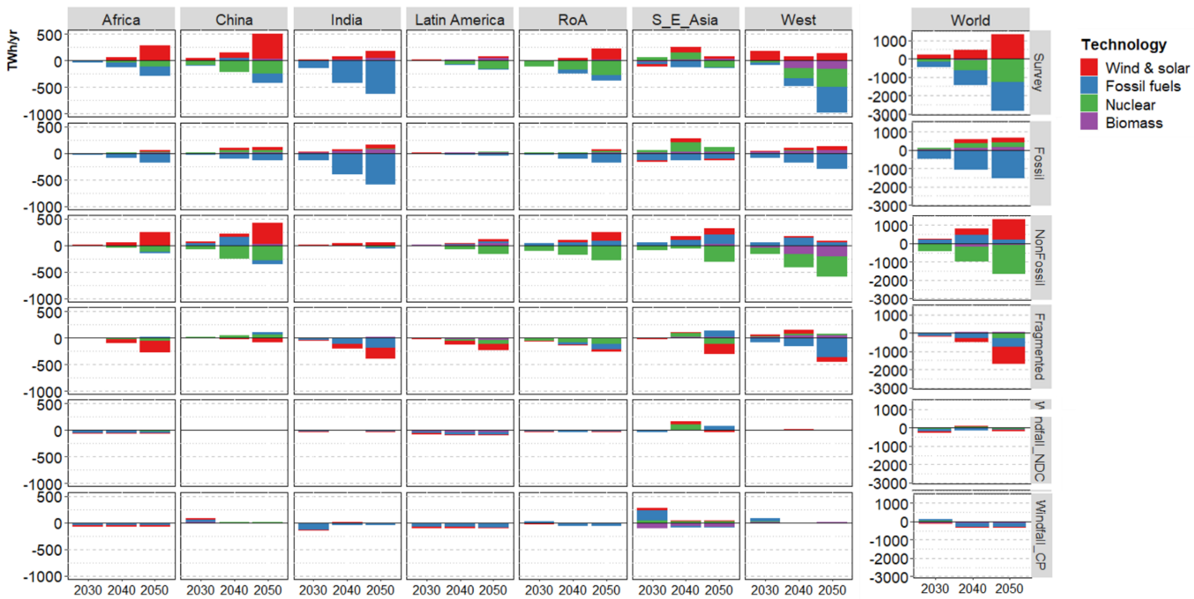


Figure 3: Absolute difference of electricity generation (TWh/yr) by region and technology in all scenarios compared to NDC_EI

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