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LETTER

Hybridizing low-carbon technology deployment policy and fossil fuel subsidy reform: a climate finance perspective

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Abstract

The environmental argument behind fossil fuel subsidy reform is strong, particularly among international finance institutions wishing to support 'transformational' low-carbon development. However, supporting reform in practice has often met methodological and political barriers. Instead, a large share of international climate finance has flowed to national policies and measures that incentivize the deployment of low-carbon technologies such as renewable energy technologies. In this paper, we propose that 'hybrid' policies that package fossil fuel subsidy reform with low-carbon technology deployment policy offer an opportunity for donors to support mitigation activities that achieve both concrete environmental impacts as well as long-term structural change. Specifically, we model the abatement cost, fossil fuel subsidy savings, and generation cost resulting from combining wind and solar photovoltaic deployment policy with fossil fuel subsidy phase-out in four country case studies. Our results not only show the extent to which fossil fuel subsidies can undermine the financial viability of low-carbon energy technologies, but also how cost uncertainties can be buffered by combining fossil fuel subsidy reform with renewable energy deployment. Furthermore, we assess the proposed hybrid policy against typical climate finance criteria and thus contribute to debates surrounding donor strategies to support low-carbon development.

1. Introduction

Under the paradigm of shared global responsibility to address climate change, all Parties of the Paris Agreement have set nationally determined emissions reduction targets. As countries begin to translate these targets into concrete mitigation actions, climate finance can play an important role in shaping the direction of climate action (Newell and Bulkeley 2016). Given the scarcity of their financial resources, international climate finance providers aim to support national mitigation actions that can demonstrate not only their direct emissions reduction impact, but also their potential for self-sustained implementation and 'transformational change' (Winkler and Dubash 2015). At present, one key reality that threatens these principles in many climate finance recipient countries is the pervasiveness of fossil fuel consumption subsidies, estimated at 493 billion USD in 2014 (IEA 2015b).

These subsidies impede climate goals directly, by encouraging consumption of and reliance on fossil fuels, and indirectly, by economically and politically undermining mitigation actions. Consequently, the reform of perverse fossil fuel subsidies is increasingly climbing the climate policy agenda, including among international financial institutions looking to support low-carbon development (Rentschler and Bazilian 2016). While fossil fuel subsidy reform (FFSR) has been proposed to be developed as a national-level climate policy (Schmidt *et al* 2012, Merrill *et al* 2015), moving this rhetoric into reality has proven challenging for two reasons.

Firstly, emissions reductions from FFSR are difficult to measure, report and verify (MRV) (Wooders *et al* 2016). Ex-ante mitigation estimates are derived from economic models that predict decreases in fuel consumption as domestic prices increase to the international level (Burniaux and Chateau 2014, Schwanitz *et al* 2014). Such methodologies are problematic given that fuel price elasticities are low in the short-term and uncertain in the long-term (Ellis 2010). These difficulties are compounded by the uncertainty in world fuel prices (McCollum *et al* 2016). Furthermore, ex-post attribution of emissions reductions specifically to the FFSR policy is difficult, as disentangling the policy effect from other drivers of fuel consumption may prove infeasible (Okubo *et al* 2011, Fouquet 2016). Thus, while environmental arguments are a key motive behind international ambition to support reform (Lockwood 2015), justifying climate finance flows to national FFSR policies will likely require more robust MRV approaches.

Secondly, on top of these methodological challenges lies the national political challenge accompanying any FFSR effort (Victor 2009, Lockwood 2015). Historically, the national political will to introduce reform has often arisen from the urgent need to correct fiscal imbalances (Rentschler and Bazilian 2016). This context gave international lending institutions such as the IMF significant leverage in coercing subsidy removal, but also forced fiscal tightening at a time when social grievances were high and already weak national institutions were ill-equipped to manage the negative distributional repercussions of FFSR (Wamukonya 2003). Many of these reforms spurred public protest, leading to the reintroduction of subsidies and a perception of international involvement in FFSR policies as politically insensitive to national contexts.

Since the end of 2014, the drop in global fuel prices has renewed the national political will to introduce FFSRs (Rentschler and Bazilian 2016). Although low fuel prices soften the immediate societal impact of reducing subsidies, the persistence of these reforms is questionable if and when fuel prices rebound. Given that economic and environmental benefits of FFSR are realized over longer terms (Fouquet 2016), capturing these benefits requires a shift away from 'short-termism' drivers and reactive measures. This paper thus explores a new policy concept to allow international *climate finance* providers to proactively help enable and realize the long-term benefits of FFSR.

Historically, a large share of international finance for supporting climate change mitigation in developing countries was channeled through the Clean Development Mechanism (CDM)—a market mechanism that allowed industrialized countries to offset a share of their emissions by purchasing emissions reductions credits from projects in developing countries. As the CDM operated with the aim of generating credible emissions reductions, it has resulted in a portfolio of internationally accepted MRV methodologies (Okubo *et al* 2011). However, renewable energy technologies[2] (RETs), which often face high risks and non-financial barriers, were underrepresented under the purely market-driven CDM (Schneider *et al* 2010).

With the Paris Agreement, the paradigm has shifted towards a bottom-up governance structure in which developing country governments formulate nationally-determined mitigation actions in line with their respective capabilities and development goals (UNFCCC 2015). Unlike under the CDM, a large number of the proposed actions have been policies that support the deployment of RETs (DTU and UNEP 2016, Schmidt and Huenteler 2016). Many of these renewable energy deployment policies (REDPs) are seeking climate finance support, in part due to the ability to quantify their climate impacts using established CDM MRV methodologies (Okubo *et al* 2011). However, often these REDPs are proposed in countries with subsidies for fossil fueled electricity, creating both a dissonance in policy objectives at a national level and an additional financial burden to climate finance providers expected to cover incremental policy costs (Schmidt *et al* 2012).

While some research has begun to investigate the effects of recycling savings from FFSR into RET investments (Merrill *et al* 2015), it has focused on FFSR as the cornerstone policy. Instead, we seek to fill a gap by investigating the synergies of a *hybrid FFSR+REDP* policy in four illustrative case studies, particularly from a climate finance perspective. Importantly, REDPs do not just provide incentives for RET investments (e.g. via a feed-in-tariff or power purchasing agreement). They also help establish the regulatory and institutional framework necessary for RET diffusion (e.g. grid codes, a framework for independent power producers, long-term targets) (Glemarec *et al* 2012) and, by incentivizing domestic low-carbon industrial activity, help build 'winning coalitions' for decarbonization (Meckling *et al* 2015). We thus argue that hybridizing FFSR, a policy with complicated implementation but high transformative potential in the long-term, with REDP, a well-established mitigation action that spurs change in the near-term, can help balance the methodological, political and financial dimensions that climate finance providers face when evaluating national mitigation actions.

Specifically, we develop a bottom-up techno-economic model that incorporates country- and technology-specific characteristics to quantify the policy costs and abatement potential for a REDP and FFSR policy (see section 2). In a first step, we model a deployment policy that provides 20-year support for a 10-year phase-in of wind and solar photovoltaic (PV) generation, in order to understand the impact of fossil fuel subsidies on the REDP costs (the results and their interpretation are presented in

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[2] Excluding hydro.

section 3.1). In a second step, we analyze the effect of fossil fuel subsidy phase out on average generation costs in 2025 and compare it with the case in which it is enacted alongside renewable energy deployment (section 3.2). In section 4 we assess the FFSR+REDP hybrid policy against typical climate finance criteria (see supplementary table S8 available at stacks.iop.org/ERL/12/014002/mmedia) before concluding in section 5.

2. Methods

The model operates on two layers which are described in sections 2.1 and 2.2. We apply our model to the four cases of Lebanon, Saudi Arabia, South Africa and Tunisia. This country selection represents a mix of net exporters and importers of the fuels that they subsidize. They were chosen to reflect variation in their baseline generation costs and emissions and their subsidization levels (see supplementary tables S1 and S2). These differentiating characteristics translate to wide variation in policy costs, and thus different implications for international support.

2.1. Modelling electricity generation costs and emissions

The inner layer of the model calculates the after-tax cost of electricity generation and grid emissions factor (GEF) of the four baseline fuel inputs relevant in our case studies—natural gas, coal, diesel and heavy fuel oil—and two RETs—wind and solar PV. We focus on these RETs due to their relative maturity, the availability of data on their cost, and their resource potential in the case countries.

In line with UNFCCC methodology (UNFCCC 2013), we assume that RET deployment will impact the marginal electricity baseline in two ways: (i) by displacing existing power plants, or the operating margin (OM) (see equation (1)), and (ii) by delaying or preventing the construction of new conventional power plants, or the build margin (BM) (see equation (2)). The marginal baseline cost and GEF are calculated as a weighted average of the OM and BM. We follow the UNFCCC recommendation of using weights of 75% and 25% for the OM and BM, respectively, to reflect the intermittency and lower capacity value of wind and solar PV[3] (UNFCCC 2013). In calculating the OM cost, only variable costs—including operations and maintenance (O&M) and fuel—are considered whereas the BM includes the power plant's capital costs, split into shares of debt (Debt) and equity (SE) financing and levelized over its lifetime:

$$\text{OM Cost}_{j,t} = \frac{\text{O\&M}_{j,t} + \frac{F_{j,t} \times E_{j,t}(1-T)}{\eta}}{E_{j,t}(1-T)} \tag{1}$$

$$\text{BM Cost}_{j,t} = \frac{\text{SE}_{j,t} \times \text{INV}_{j,t} + \sum_{\tau=1}^{\text{N}} \frac{\text{O\&M}_{j,t} + \frac{F_{j,t} \times E_{j,t}}{\eta} + \text{Debt}_{j,\tau} - T\left(I_{j,\tau} + D_{j,\tau} + \text{O\&M}_{j,t} + \frac{F_{j,t} \times E_{j,t}}{\eta}\right)}{(1+K_{\text{E}})^{\tau}}}{(1-T)\sum_{\tau=1}^{\text{N}} \frac{E_{j,\tau}}{(1+K_{\text{E}})^{\tau}}} \tag{2}$$

where j denotes technology type, t denotes time, τ denotes plant operating year, F is fuel price, E is yearly electricity production, η is plant efficiency, T is tax rate, INV is investment cost, Debt comprises interest and principal payments on debt, I is interest expense, D is depreciation, and K_{E} is cost of equity (see supplementary note S1 for details).

For each case country, the shares of each technology in the OM and BM were determined using either CDM Project Design Documents or derived by applying CDM methodology (UNFCCC 2013) to local generation data (see supplementary table S1). Country-specific input factors were used for each case study, most notably inputs related to investment risks (see supplementary table S3).

The cost of the RETs represents the levelized cost of generation (see equation (2)) excluding grid integration costs (see supplementary table S5 for sensitivities to these costs)[4]. The country-specific cost of equity and cost of debt for the baseline technologies were assumed 15% lower than for RETs to account for the relative immaturity—and thus higher perceived investment risk—of RETs compared to conventional technologies (Waissbein *et al* 2013). Additionally, in line with the approach taken by Huenteler *et al* (2014), RET investment and O&M costs in the model decrease with cumulative installed capacity due to technological learning at both local and global levels (see supplementary note S2). Investment costs of the baseline technologies were also assumed to experience cost reductions of 2% per year.

2.2. Policy costs and assumptions

The outer layer of the model calculates the policy costs related to supporting RET generation[5]. The REDP modeling case assumes a 20% national renewable energy generation target will be reached by year 10 of

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[3] Due to their intermittency, wind and solar PV technologies require reserve capacity which is assumed to come from existing capacity. Therefore when these technologies generate electricity, it is assumed they displace a larger share of power plants in the operating margin (UNFCCC 2013).

[4] While including the grid integration costs can have an impact on calculated REDP costs, the main findings remain robust to these sensitivities.

[5] For example, these costs could be a feed-in-tariff premium for RET generation. Although these costs exclude the transaction costs associated with the set-up of the policy, past studies have found these costs to be marginal (Waissbein *et al* 2013, 2015).

the policy[6] using equal shares of wind and solar PV and following an exponential deployment trajectory, in line with the early diffusion patterns of technologies (Grubler *et al* 2016) (see supplementary figure S1 and supplementary table S4).

We calculate the incremental cost of the REDP against both subsidized and unsubsidized baselines. The subsidized baseline assumes that real domestic fuel prices remain at their current level (see supplementary table S6 for a sensitivity to this assumption). The unsubsidized fuel prices use 2015 averages of world market prices, adjusted for transportation cost (see supplementary note S3), as a starting prices, then are extrapolated to parallel IEA's medium fuel price scenario. This fuel price scenario is based on predicted energy demands assuming all energy and climate policies planned or under construction as of 2015 will be implemented (IEA 2015a). All policy costs are reported as their net present value assuming a 6% discount rate consistent with other studies that have taken a public investor perspective (Waissbein *et al* 2013).

In calculating average generation costs, we model the hypothetical fleet in 2025 in a scenario that assumes no RET deployment, and the scenario in which the 20% RET target has been met (see supplementary figure S2). While the scenario assuming no RET deployment may be extreme, in the absence of dedicated RET support policies, deployment of grid-connected RETs in the case countries would be unlikely (Glemarec *et al* 2012) (see supplementary table S6 for a sensitivity to this assumption). In both scenarios, we first determine the 2025 demand by projecting 2015 generation data using country-specific growth rates. Second, we apply UNFCCC assumptions regarding how these demands would be met (UNFCCC 2013). In the case that assumes no RET deployment, we assume that 75% of new power plants, the type of which are determined according to each country's BM, will provide additional generation, while 25% will replace existing plants in the OM. Note that the OM weight is now reduced to reflect both the dispatchability of the BM technologies as well as the conditions of constrained capacity typically seen in developing countries. In the RET deployment case, we assume the same RET deployment as modelled previously, and that BM plants will close the remaining generation gap (again with 75% of this deployment representing additional generation).

These generation costs are calculated for three fuel price scenarios based on IEA scenarios published in 2015 (IEA 2015a, 2015b) (see supplementary figure S3). The same energy demands are assumed across all scenarios. In reality, higher fuel prices could result in lower energy demands, however given the model's relatively short time period of 10 years, as well as the rapidly growing energy hunger in the case countries, we assume that short-term energy demands are rather inelastic.

3. Results

This section presents the results of the model. We discuss policy costs of the REDP in section 2.1 and generation costs in a scenario in which fossil fuel subsidies have been phased out in section 2.2.

3.1. The impact of fossil fuel subsidies on REDP costs

The results in figure 1 show the economic barrier that fossil fuel subsidies pose to the diffusion of RETs. In each of the four case countries, incremental costs of renewable generation over *subsidized* baselines are positive, leading to marginal abatement costs ranging from 22 USD/tCO$_2$ in South Africa to 46 USD/tCO$_2$ in Tunisia. The marginal costs also reveal the large distortion that subsidies introduce to incremental cost calculations: although Lebanon's baseline is dominated by expensive diesel and heavy fuel oil, renewable generation appears one of the *least* competitive of the four countries, whereas in South Africa, whose coal-based generation mix is the cheapest of all the countries', renewables appear *most* competitive.

Correcting the fossil fuel subsidy distortion can lower the REDP abatement cost by as much as 259% in Saudi Arabia to 44% in South Africa. From the policy financing perspective, in countries with high subsidies and expensive baseline fuel inputs (e.g. Saudi Arabia and Lebanon) these avoided subsidies, which can also be considered as the unilateral financial contribution to the policy, are theoretically sufficient to support RET generation without further international finance. International support would therefore play a more indirect role, for example by assisting in the policy design or by helping lower non-financial barriers to RET diffusion, discussed further in section 4. In countries with both lower fuel costs and subsidy levels, the REDP incremental costs would likely entail a sharing of unilateral and international finance. Proper accounting of subsidies helps in allocating financing responsibilities of the REDP in the near-term (Schmidt *et al* 2012); however if low-carbon technology deployment is to be sustainable in the long-term,

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[6] Compared to each case country's national RET targets, this modelling assumption is reasonable for South Africa, Tunisia and Lebanon, and ambitious for the case of Saudi Arabia. The South African Integrated Resource Plan for Electricity 2010–2030 outlines 2030 targets of 9.2 GW capacity of wind (~10%) and 8.4 GW of solar PV (~9%). The Tunisian Solar Plan set renewable energy generation targets of 15% for wind and 10% for solar PV by 2030. Lebanon's Intended Nationally Determined Contribution (INDC) set a conditional target that 20% of its power and heat demands would be met by renewable energy by 2030. The Saudi Arabia Vision 2030 paper outlined a target of 9.5 GW of renewable energy capacity by 2030 (~5–10%). Still, given the high potential for wind and solar in all the case countries, it is reasonable to assume that any renewable energy target would be met using a mix of both technologies.

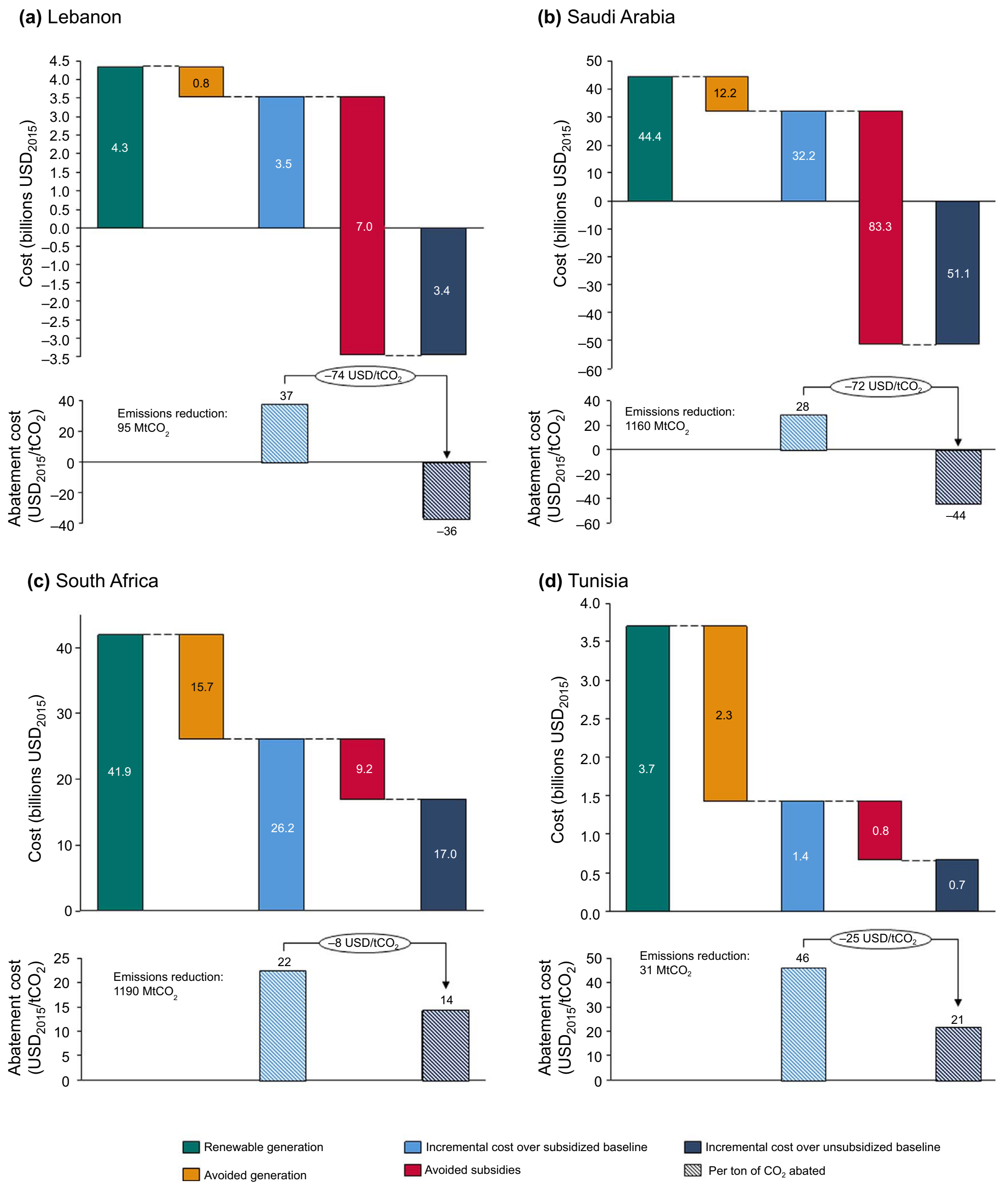

Figure 1. Overview of the present value of wind and solar PV deployment policy costs. The green bars depict the cost of RET generation over the policy lifetime. Country differences in RET generation costs arise predominantly due to differing electricity demands and demand growth rates—and hence different nominal generation targets—but also occur due to country-specific differences related to investment risks and resource potential (see supplementary tables S3 and S4). The orange bars represent the avoided cost of generation due to the displacement of conventional power plants with renewable energy; thus the light blue bar depicts the incremental cost of the REDP over the subsidized baseline. The red bar accounts for the avoided fossil fuel subsidies, or the amount that the government would have paid conventional generators if RETs had not been deployed. Finally, the dark blue bar gives the present value cost of the REDP once subsidies have been properly accounted. Marginal abatement costs (MAC) considering unsubsidized and subsidized baseline costs are denoted in an additional chart below the respective bars, as well CO_2 emissions reductions over the policy lifetime due to the deployment of RETs. (*a*) The case of Lebanon, (*b*) the case of Saudi Arabia, (*c*) the case of South Africa, (*d*) the case of Tunisia.

the baseline must not only be *accounted* but also *reformed* through the removal of fossil fuel subsidies.

3.2. The impact of adding REDP to FFSR on average generation costs in 2025

Figure 2 presents the effect of fully removing subsidies on average 2025 generation costs in three fuel price scenarios (see supplementary figure S2) and two hypothetical generation mixes: the mix that assumes continued utilization of non-renewable generation to meet electricity demands (pure FFSR), and the previously modelled mix that assumes renewables comprise 20% of 2025 generation (REDP + FFSR). The average generation cost presents an end-user perspective of subsidy removal, given that the public impact and response to reform can pose a barrier to its

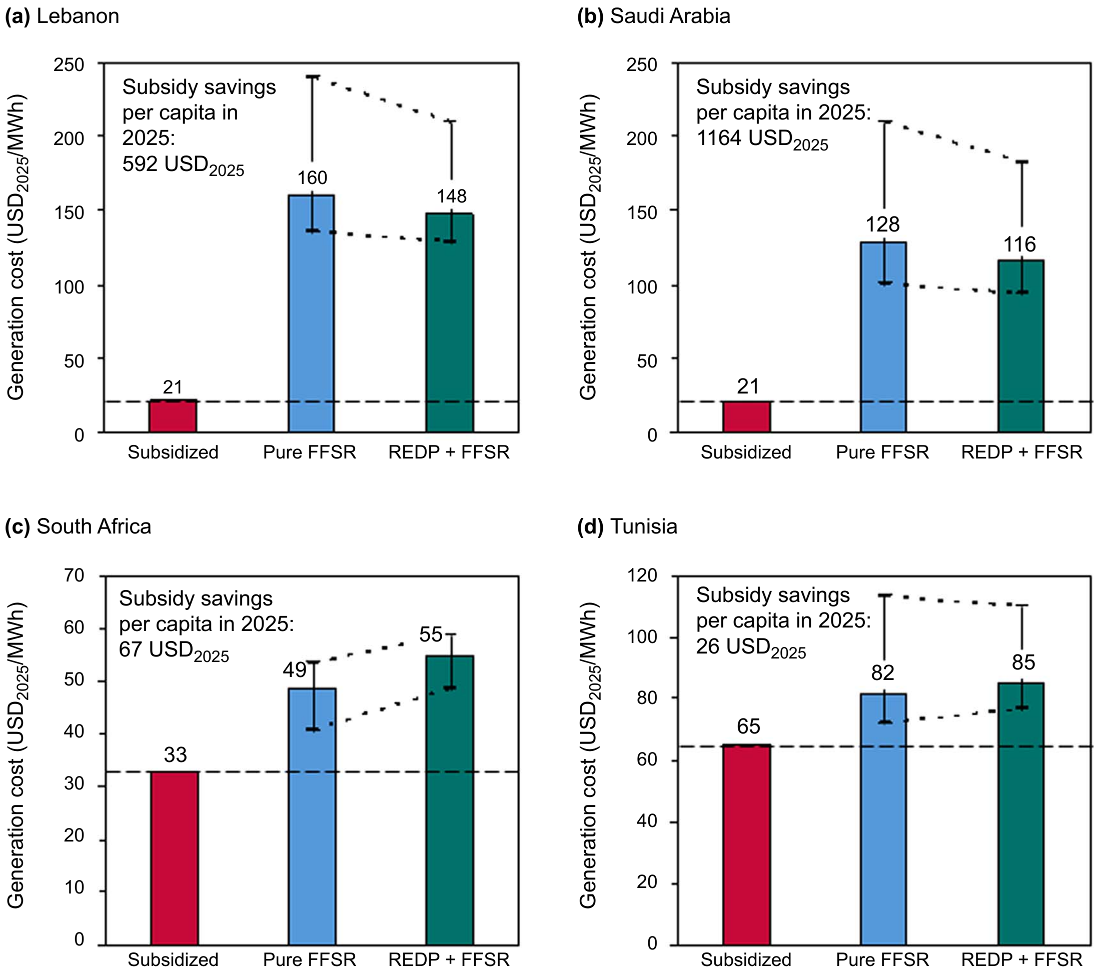

Figure 2. Overview of the average generation cost in 2025. The red bar shows the average generation cost in USD$_{2025}$/MWh assuming domestic prices remain at their subsidized levels. The blue bars depict the average generation cost assuming subsidies have been fully phased out but no deployment of wind or solar PV has occurred. The green bars then depict the generation cost after subsidies have been removed and assuming wind and solar PV each comprise 10% of the 2025 generation mix. These generation costs are presented in a range of hypothetical fuel price scenarios, depicted by error bars. For the percentage increase in generation cost under each policy, please see supplementary table S7. Estimated fossil fuel subsidy savings per capita in 2025 in the moderate fuel price scenario are also denoted. (*a*) The case of Lebanon, (*b*) the case of Saudi Arabia, (*c*) the case of South Africa, (*d*) the case of Tunisia.

implementation (Arze del Granado *et al* 2012, Williams and Kahrl 2008).

In all cases, the addition of REDP to FFSR has relatively little impact on average generation cost compared to the pure FFSR case. In Saudi Arabia and Lebanon, where renewables are already cheaper than the unsubsidized baseline, the REDP even reduces the generation cost increase. In South Africa, where the addition of the REDP has the greatest impact on generation cost, this increase is only 13% greater than the pure FFSR case in the moderate fuel price scenario. However, in all cases, the 20% share of RETs in the REDP + FFSR mix reduces exposure to world fuel prices, thus cushioning the impact of a fuel price shock. This effect is most pronounced in countries in which fuel is the dominant factor in determining generation costs: in Lebanon and Saudi Arabia, it buffers cost increases in a high fuel price scenario by 22% and 19%, respectively. Reducing the uncertainty of the magnitude of a fuel price shock has two benefits. In case of high price shocks, it facilitates government planning for social safety nets to reduce impacts on vulnerable members of the population. In case of low price shocks, it constrains the incremental cost of the REDP that would need to be covered either by international commitments or domestic budgets (Huenteler 2014).

4. Discussion

The results of the model have shown the need to level the playing field for low-carbon technologies: the removal of subsidies is arguably a necessary, but insufficient, condition for unlocking current and future mitigation activities. At the same time, combining REDP with FFSR has only a marginal impact on overall generation costs yet an added benefit of reducing fuel price exposure. While it has been suggested that subsidy savings could be *recycled* into supporting RETs (Merrill *et al* 2015), we instead argue that a hybrid policy approach in which REDP is packaged with subsidy reduction would be effective from a climate finance perspective given its *mitigation potential*, *cost* and *self-sustainability*.

Regarding *mitigation potential*, the REDP—unlike the pure FFSR policy—guarantees a minimum 'MRVable' mitigation volume, relatively independent of both elasticities and international fuel prices. Any additional long-term mitigation resulting from the FFSR would be 'net mitigation'. Financing a hybrid REDP + FFSR policy can therefore potentially leverage large mitigation volumes.

Regarding *cost*, international finance could support a portion of the incremental REDP cost through a payment mechanism contingent on a FFSR schedule. Unlike past conditional lending used to coerce subsidy removal as a means to free up immediate fiscal space, the process-oriented conditionality (Winkler and Dubash 2015) suggested here would entail a country gaining access to climate finance provided it develop and implement a FFSR strategy. Crucially, this process should be nationally-driven in order to outline a FFSR strategy adapted to national political and socio-economic contexts—rather than the one-size-fits-all approach historically dictated by international organizations. In the past, such open consultation processes that engaged public opinion played a key role in helping overcome political economy barriers to policy implementation (Rentschler and Bazilian 2016, IMF 2013). At the same time, this payment mechanism can help hold national policymakers accountable to both maintaining and credibly allocating the benefits of subsidy removal, and also provides leverage to international climate finance providers—actors who typically cannot directly influence fiscal policy—in supporting FFSR.

The effectiveness of such a scheme, however, requires a degree of political will for FFSR and REDP at the national level (Hansen and Nygaard 2013). Willingness to reform subsidies is likelier witnessed in importing countries where subsidies are more transparent and explicitly strain state budgets. Subsidy reform has moved up political agendas in many net-importing countries, even those in which subsidies are deeply embedded in the social contract (e.g. Tunisia and Egypt). However, the viability of using RET support to leverage FFSR in the two exporting countries reviewed in this paper remains questionable. In South Africa, where coal subsidies are rather hidden, the renewable energy power purchasing agreements are financed unilaterally, although international actors provided technical and financial assistance in the program set-up (Eberhard *et al* 2014). And, while Saudi Arabia does aim to cut subsidies to alleviate its growing budget deficit (Ball 2015), RET development will likely be seen as a unilateral responsibility[7].

The second characteristic, or the ambition to introduce REDPs, largely stems from non-climate concerns. In net importing countries, energy security—as is the case of Tunisia (Laumanns *et al* 2012)—is a key driver, whereas in exporting countries hit economically by declining commodity prices, REDP may be viewed as a component of industrial policy. In South Africa, for instance, local content requirements form a cornerstone of its renewable energy program (Baker *et al* 2014) and in Saudi Arabia, investments are flowing to solar manufacturing facilities in hopes of creating jobs for its unemployed youth (Ball 2015). Consequently, capacity building and technical assistance to help achieve these co-benefits will also be important to leverage national political buy-in to the policy support package. In this way, we argue that successful FFSR also requires supporting the *winners* of a low-carbon transition, rather than simply utilizing subsidy savings to compensate the *losers* of reform.

Finally, and related to the above point, a hybrid approach can also create mutually reinforcing characteristics to help safeguard the self-sustainability of both policies. While the removal of fossil fuel subsidies, and carbon pricing reform in general, is theoretically the most efficient means of achieving emissions reductions (Edenhofer *et al* 2015), political barriers often prohibit such a direct policy approach (Jenkins 2014). In the short-term, REDPs are more politically feasible and, because of their quantifiable environmental impacts, can seek climate finance more justifiably than carbon pricing policies alone (Wooders *et al* 2016). For example in South Africa—a country characterized by powerful coal interests—RET has grown, with some bilateral support, from a niche perceived as unthreatening to fossil fuel incumbents; the introduction of a carbon tax, on the other hand, has been delayed several times due to political push-back (Baker *et al* 2014). Yet we argue that a hybrid package in which REDP is strategically sequenced before FFSR can make reform more sustainable in the long-term for two reasons. Firstly, diversification of the energy mix away from subsidized fuels erodes the necessity for subsidies and the impact of their removal. Past successful reforms often involved the provision of a suitable energy alternative, such as Indonesia's support for liquefied petroleum gas technologies during its kerosene subsidy removal (Vagliasindi 2013). Secondly, while not the direct focus of this paper, green industrial policies such as a feed-in-tariff or renewable portfolio standard can help build stronger green coalitions and therefore carve a political landscape conducive to more transformational, yet presently politically contentious, long-term change. This argument has recently been made with regards to carbon pricing (Meckling *et al* 2015), but a similar rationale can be applied to subsidy removal, which is synonymous with the removal of a negative carbon price.

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[7] As also reflected in Saudi Arabia's INDC.

5. Conclusion

In this paper, we proposed that 'hybrid' FFSR and REDPs can package mutually reinforcing near-term environmental outcomes with long-term 'transformational' objectives. As we focused on the climate finance perspective, an analysis of the country-specific distributional impacts and sociocultural considerations of REDP and FFSR policies was beyond the scope of this paper. Past research has and should continue to conduct country-specific analyses to advance our concept of policy hybridization in light of different political economy constraints, as other innovative approaches for coupling climate finance with FFSR have been proposed in literature (e.g. Jakob and Hilaire 2015) may also be appropriate in some circumstances.

Instead, our proposed hybrid policy aimed to find a balance between the politically controversial one-size-fits-all approach characterized by past international involvement in structural reform, with ad-hoc country analyses that may offer little generalizability to international climate finance providers wishing to support reforms more broadly. We have argued that supporting REDPs that quantifiably reduce emissions is not simply a means of correcting an environmental externality, but also a means of fostering a low-carbon transition: strengthening national allies, inducing cost reductions through local technological learning, and localizing a low-carbon industry. All of these effects, however, manifest on a timescale longer than the typical supported climate policy lifetime. Leveraging these transformational changes therefore requires that low-carbon technology deployment be self-sustaining in the long-term. Introducing structural reforms necessary for a greener growth trajectory, such as removing fossil fuel subsidies, should thus be viewed as more than simply correcting a market failure, but as enabling an environment in which low-carbon alternatives can compete fairly with incumbent technologies—both economically and politically. While here we focused on REDP and FFSR in the power sector, hybridization of concrete near-term measures with longer-term structural reforms may help overcome the 'carbon lock-in' (Unruh 2002, Erickson *et al* 2015) of other policy constellations and of other climate-relevant sectors.

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