Managing tradeoffs in green industrial policies: The role of renewable energy policy design

Journal Article

Author(s):
Matsuo, Tyeler; Schmidt, Tobias

Publication date:
2019-10

Permanent link:
https://doi.org/10.3929/ethz-b-000345073

Originally published in:
World Development 122, https://doi.org/10.1016/j.worlddev.2019.05.005

Funding acknowledgement:
166905 - Opening the black box of the co-evolution of policy and technology in the energy sector (SNF)

ETH zürich D GESS

Energy Politics Group

Managing tradeoffs in green industrial policies: The role of renewable energy policy design

Tyeler Matsuo[1], Tobias S Schmidt[2]

Published in *World Development*
Please cite article as: Matsuo, T., & Schmidt, T. S. (2019). Managing tradeoffs in green industrial policies: The role of renewable energy policy design. *World Development*, *122*, 11-26.

https://doi.org/10.1016/j.worlddev.2019.05.005

Abstract:

Green industrial policies around renewable energy (RE) are growing increasingly prevalent in emerging economy contexts as a means to foster low-carbon industrialization pathways. However, policymakers often face a tradeoff in their policy designs. In this paper, we focus on the tradeoff between minimizing the cost of low-carbon energy generation to fuel traditional input-intensive industrialization strategies, and implementing potentially costly measures to build local industries around low-carbon energy technologies. Specifically, we utilize the cases of Mexico and South Africa to investigate how each country's distinct prioritization of these two objectives led to a divergence of their RE auction designs and outcomes. Specifically, using data on the involvement of local and foreign actors in Mexican and South African RE projects, policy documents, and interviews with public and private stakeholders in the two countries, we show how each country's policy design shaped RE market and bid price developments, and the formation of local RE value chains. We find that the prioritization of low-cost RE generation can result in a greater reliance on existing foreign value chains and capital, without building the local capabilities that could result in greater long-term benefits for the market. We further discuss the implications of our results for policymakers, focusing on providing recommendations for RE industrial policy design in general, and the calibration of local content incentives in particular.

Keywords: renewable energy auction; Mexico; South Africa; capability-building; local content; value chain networks

https://doi.org/10.1016/j.worlddev.2019.05.005

The Energy Politics Group (EPG) within the Department of Humanities, Social, and Political Sciences of ETH Zurich investigates questions related to the governance of technological change in the energy sector.

[1] ETH Zurich, Haldeneggsteig 4, 8092 Zurich, Switzerland. E-Mail: tyeler.matsuo@gmail.com
[2] ETH Zurich, Haldeneggsteig 4, 8092 Zurich, Switzerland. E-Mail: tobiasschmidt@ethz.ch

1 Introduction

Policymakers in emerging economies are increasingly enacting green industrial policies (Rodrik, 2014; Schmidt & Huenteler, 2016), which can entail both the decoupling of emissions from growth as well as industrialization based on the production of green technologies and services (Bowen & Fankhauser, 2011). With the growing cost-competitiveness of renewable energy (RE) technologies, as well as the economic opportunities presented by the global takeoff of RE markets, RE deployment increasingly forms a cornerstone of many green industrialization strategies (Schmidt & Sewerin, 2017). On one hand, the widespread deployment of cost-competitive RE technologies may help keep domestic electricity prices affordable and stable (Matsuo & Schmidt, 2017), thereby providing the low-cost energy inputs that have proven crucial for successful industrialization in the past (Fouquet, 2016; Moe, 2010). At the same time, many countries are utilizing their RE deployment policies as a means to foster RE industry localization, for example by coupling RE deployment with local content incentives or mandates (Lewis & Wiser, 2007).

However, because such localization measures may impose an additional cost to RE deployment (Lewis & Wiser, 2007), green industrial policies around RE can face a tradeoff between the objectives of minimizing RE generation costs – and thus domestic electricity prices – and implementing potentially costly measures to foster the buildup of local RE industries. Importantly, the different weighting of these two objectives can lead to a significant divergence in green industrial policy design (Howlett, 2009). Literature on policy design has provided a structured framework for understanding how such higher level policy objectives shape the on-the-ground policy calibrations that are often most important for steering policy outcomes (Del Río, 2012; Howlett, 2009; Kemp & Pontoglio, 2011). However, much of this literature has focused on the policy design itself as the key variable of interest (Howlett & Cashore, 2009; Kern & Howlett, 2009; Schmidt & Sewerin, 2018), rather than exploring how specific design calibrations shape green industrial policy outcomes. In contrast, literature on technological capability-building have provided in-depth analyses of how low-carbon energy policy influences the build-up of local green industries (Baker & Sovacool, 2017; Binz, Gosens, Hansen, & Hansen, 2017; Nahm & Steinfeld, 2014; Pueyo, Garcoa, Mendiluce, & Morales, 2011;

Rennkamp & Boyd, 2015; Zhang & Gallagher, 2016), however thus far comparative studies investigating countries' policy designs are limited.

In this paper, we combine literature on policy design (Cashore & Howlett, 2007; Howlett, 2009; Howlett & Cashore, 2009) with literature on capability-building (M. Bell & Pavitt, 1993; Martin Bell & Figueiredo, 2012; Hansen & Nygaard, 2014; Lall, 1992; B.-Å. Lundvall, Johnson, Andersen, & Dalum, 2002) to unpack how specific policy design calibrations, driven by different prioritizations of policy objectives, influence green industrialization outcomes. Specifically, we explore how the traditional industrialization objective of cheap energy provision interacts with the new wave of green industrialization policy objectives such as promoting local learning, capability-building, and the eventual formation of competitive firms along the RE value chain. Using a comparative case study research design based on both data collected from RE projects and interviews with public and private stakeholders in Mexico and South Africa, we highlight how local capabilities in the RE industries[3] in two latecomer countries evolved under their low-carbon energy auctions, which feature distinct instrument calibrations.

The remainder of the paper is structured as follows. Section 2 provides the theoretical background for this paper, including a framework for structuring the elements of policy design (2.1) as well as a background on policies for fostering RE industry localization (2.2). Section 3 explains the case selections of Mexico and South Africa and the case study methods. Results, including a categorization of each country's policy design and their outcomes for wind and solar PV market formation, bid prices, and local value chain formation are presented in section 4, before concluding by discussing implications for policymakers wishing to pursue green industrialization strategies in section 5.

[3] Note that recent literature on green industrial policy and industry localization has discussed technology differences as key moderator of policy outcomes (Binz et al., 2017; Schmidt & Huenteler, 2016). While here we look at two technologies, namely wind and solar PV, and discuss technology differences, the focus of this paper is policy design differences.

2 Theoretical background

This section provides an overview of existing theoretical frameworks on policy design (section 2.1) and a review of literature on policies to foster RE industry localization (section 2.2).

2.1 Policy design

Due to the presence of natural monopolies, negative externalities, and path-dependencies in techno-institutional systems, the electricity sector is often subject to policy intervention (Gillingham & Sweeney, 2010; Meadowcroft, 2011; Unruh, 2002). Given the importance of policy in steering technological change in the energy sector, a range of studies has investigated their effectiveness in promoting innovation in and diffusion of RE technologies. For example, several studies have compared the role of market-based versus regulatory approaches (Kemp & Pontoglio, 2011), demand-pull versus technology-push (Hoppmann, Peters, Schneider, & Hoffmann, 2013; Nemet, 2009) or various instrument types[4] (Lipp, 2007; Polzin, Migendt, Täube, & von Flotow, 2015). However, many of these studies have found that the design of specific policies – rather than the instrument choice – often carries greater importance in determining policy outcomes (Del Río, 2012; Haelg, Waelchli, & Schmidt, 2018; Schmidt & Sewerin, 2018).

Alongside the empirical observations in energy and innovation studies highlighting the centrality of policy design for steering policy outcomes, theoretical frameworks for understanding policy design have also evolved. While policy design theory emerged in the 1980s, policy design literature subsequently shifted its focus to questions of governance and instrument choice (Howlett, 2014). Only recently has this literature revisited policy design theory, developing frameworks that integrate these "macro-level" (e.g., governance) elements with more "micro-level" considerations such as the on-the-ground calibrations of policy objectives and instruments (Considine, Alexander, & Lewis, 2014; Howlett, 2009).

In particular, based on Hall (1993), Howlett (2009), Cashore and Howlett (2007), and Howlett and Cashore (2009) have developed a hierarchical framework for structuring policy design elements that links different

[4] Policy instruments are described as the techniques used by governments to "transfer the abstract principles and rules set out by policies into concrete and substantive action" (Schaffrin, Sewerin, & Seubert, 2015, p. 260, drawing on May (2003))

levels of policy abstraction (i.e. from the macro- to the micro-level), with the respective policy aims and means (see Figure 1). In this framework, the logic of policy design begins at the macro-level, including the abstract policy goals (aims) and the general logic to achieve these goals (means). To illustrate, consider the simplified example of a policy with a macro-level goal of climate change mitigation and a market-based logic. At the meso-level, this abstract goal and instrument logic need to be operationalized into specific policy objectives (aims) and the instrument choice (means). For example, achieving climate change mitigation can be achieved through the meso-level objective of increasing RE in the generation mix. Given the market-based logic, a competitive RE auction could be selected as the policy instrument. Finally, the micro-level of policy design includes specific policy targets (aims), such as the capacity of RE that is procured, and the on-the-ground instrument calibrations (means), such as the terms of the awarded contracts, the bidding requirements, or the technology-specificity of the auction. Importantly, this framework presents a nested logic of policy design, as design choices at higher levels of the hierarchy constrain and set the agenda for policy design at lower levels (Howlett, 2009).

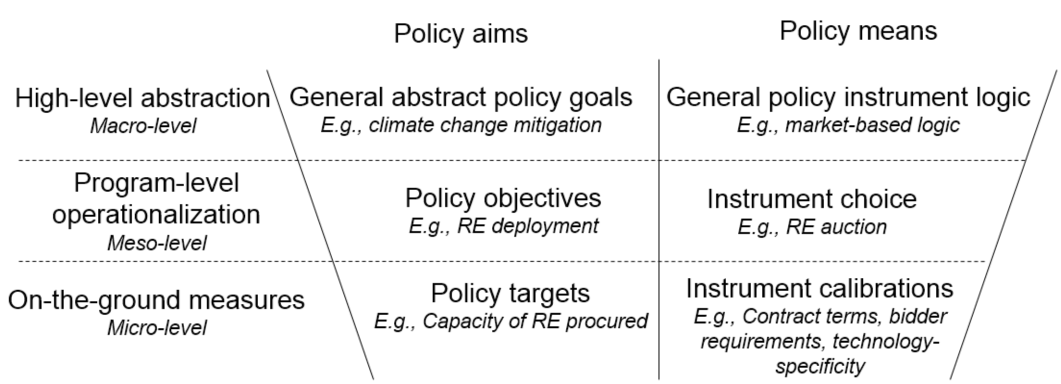

Figure 1: Hierarchy of policy design elements according to Cashore and Howlett (2007), Howlett (2009), and Howlett and Cashore (2009), and adapted from Haelg et al. (2018), where the six policy design elements can be organized according to their level of abstraction and whether they define policy aims or policy means

The simplified example of an RE auction intended to illustrate this hierarchical logic of policy design in theory; in practice, characterizing policy design is often less straightforward for at least two reasons. Firstly, in many cases policies have multiple objectives (Schmidt & Sewerin, 2018). For example, in the case of green industrial policies in an emerging economy context, such policies often aim to achieve low-carbon economic development (general abstract policy goals) through the dual objectives of low-cost RE deployment and RE industry growth (policy objectives). While both may be stated policy objectives, policymakers may *weight* these objectives differently (Kern, Kuzemko, & Mitchell, 2014), leading to different policy design choices at lower levels of the hierarchy. To date, literature has largely overlooked how the *prioritization* of objectives shapes the subsequent policy design. Note that often differing prioritizations may be the result of more complex upstream political processes.[5] However, the purpose of the policy design framework is to provide a structure for characterizing policy outputs, rather than policy inputs. Secondly, norms governing instrument logic are often mixed (i.e. not purely market-based or purely regulatory). Using the previous example of an RE auction, although the use of competitive bidding could be considered to follow a market-based logic, RE auctions can exhibit regulatory characteristics such as local content mandates or by specifying the shares of each RE technology (i.e. technology-specific auctions) (Azar & Sandén, 2011). Thus, while previous literature often stipulated that instrument logic tends to restrict instrument choice to a certain subset of instrument types, differing instrument logics can still lead to the same instrument choice. In such cases, the impact of different instrument logics may manifest again only at the micro-level in instrument calibrations.

2.2 Policies to foster renewable energy industry localization

With the increasing enactment of policies that seek to create local RE industries, an array of literature focused on these policies has emerged – including their potential benefits (Hallegatte, Fay, & Vogt-Schilb, 2013), various instruments (Lewis & Wiser, 2007; Rodrik, 2014), technology-specific strategies (Binz et al., 2017; Quitzow, 2015b; Schmidt & Huenteler, 2016), or offering case studies of specific country experiences (e.g., Baker & Sovacool, 2017; Hochstetler, 2015; Pueyo, Garcoa, Mendiluce, & Morales, 2011; Rennkamp & Boyd, 2015; Surana & Anadon, 2015). According to this literature, policies that promote RE industry localization frequently combine interventions aimed at directly promoting local learning and capability-building along the RE value chain – such as local content requirements, tax incentives, or targeted

[5] For example, as has been noted in the case of South Africa, the differing priorities of local content and cost-competitiveness were reflected by the Department of Trade and Industry and the National Treasury, respectively, rather than a single political entity (Baker & Sovacool, 2017).

R&D – with complementary policy actions that create a domestic market for RE technologies (Lewis & Wiser, 2007). For the latter, creating stable domestic markets through RE deployment instruments (e.g., an RPS or an RE auction scheme) may be required in order to justify investments in the local RE innovation system. For example, a critical market size may be required to amortize investments in manufacturing facilities or to provide incentives for R&D investments (Pueyo et al., 2011; Rennkamp & Boyd, 2015). However, beyond simply providing justification for local investments in the RE value chain, home markets can act as crucial venues for experimentation and local learning (Chaminade, Lundvall, Vang, & Joseph, 2009; B.-Å. Lundvall et al., 2002).

Literature on the catching-up of latecomer firms has shown that learning is fundamental for successful industry localization (M. Bell & Pavitt, 1993; Martin Bell & Figueiredo, 2012; Fu, Pietrobelli, & Soete, 2011; Hansen & Nygaard, 2014; Lall, 1992). Learning – or the accumulation of technological, managerial, and organizational knowledge – fosters the build-up of the local technological capabilities needed for latecomers to absorb, adapt, and eventually become competitive players in the value chains of RE technologies (Morrison, Pietrobelli, & Rabellotti, 2008). Often this build-up occurs through a costly and dedicated process, involving iterative processes of experimentation and adaptation, including through learning-by-using a technology (Fagerberg, 1995; Mowery & Rosenberg, 1982), learning-by-doing in executing processes (Sagar & van der Zwaan, 2006; Shum & Watanabe, 2008), or learning-by-interacting among actors in the RE innovation system (B.-Å. Lundvall et al., 2002; Malerba, 1992; Pietrobelli & Rabellotti, 2011; Uzzi & Lancaster, 2003).

Several studies have investigated the relevance of these learning mechanisms for latecomers to the RE industry, in particular highlighting how the importance of various mechanisms differs across technologies of differing complexities, and therefore require different policy strategies to foster these mechanisms (Binz et al., 2017; Quitzow, Huenteler, & Asmussen, 2017; Schmidt & Huenteler, 2016). In particular, this literature has outlined that local learning-by-using is important for localizing the production of more complex RE technologies such as wind turbines, whereas learning-by-doing and exploiting economies of scale in manufacturing is crucial for localizing the production of simpler but more manufacturing-intensive technologies such as solar modules (Schmidt & Huenteler, 2016).

While this literature has provided valuable insight into the relationship between specific learning mechanisms and the localization of upstream value chain activities such as technology production and/or design, it has two key limitations. Firstly, the majority of these studies focus on the supply of core components (i.e. the wind turbine rotor or solar PV panel) (see e.g., Hansen and Nygaard, 2014; Quitzow, 2015; Surana and Anadon, 2015; Zhang and Gallagher, 2016). Localizing the production of these core components may be difficult to achieve for latecomers as they require significant technological capabilities in order to compete in these relatively mature technologies characterized by highly globalized value chains (Baker & Sovacool, 2017; Schmidt & Huenteler, 2016). However, the development of an RE project involves a much wider set of value chain activities, encompassing not just the upstream activities associated with its production, but also downstream activities related to its deployment (see Figure 2) (Morrison et al., 2008; Zhang & Gallagher, 2016).

Within the upstream value chain activities, in addition to the supply of the core components, complementary or more peripheral components are needed – such as wind turbine towers or PV mounting systems. While a core component of a technology may be characterized as complex in its design or production, subcomponents or complementary components may exhibit entirely different complexities, requiring different types of capabilities and learning mechanisms to promote their localization. Furthermore, most literature on industry localization has focused on the capabilities needed to localize technology supply (i.e. design and production), but have yet to explore the potential to localize and build capabilities in downstream activities such as project development; engineering, procurement and construction (EPC); and financing (with a few exceptions, such as Baker & Sovacool (2017), who also look at EPC players). However, these downstream activities can also have a high value added to the RE project (Baker, 2015; Bergek, Mignon, & Sundberg, 2013; Gann & Salter, 2000; Mazzucato & Semieniuk, 2018; Steffen, Matsuo, Steinemann, & Schmidt, 2018). While significant technology differences exist in the upstream value chain (Baker &

Sovacool, 2017; Binz et al., 2017; Quitzow, 2015a; Schmidt & Huenteler, 2016), the technological capabilities needed for these downstream activities are likely to be more similar across solar PV and wind projects, allowing for greater project-to-project learning-by-doing (Steffen et al., 2018). Finally, looking at the broader RE value chain allows for a greater understanding of the learning-by-interacting linkages that occur not only horizontally between global and local actors, but also vertically along the value chain.

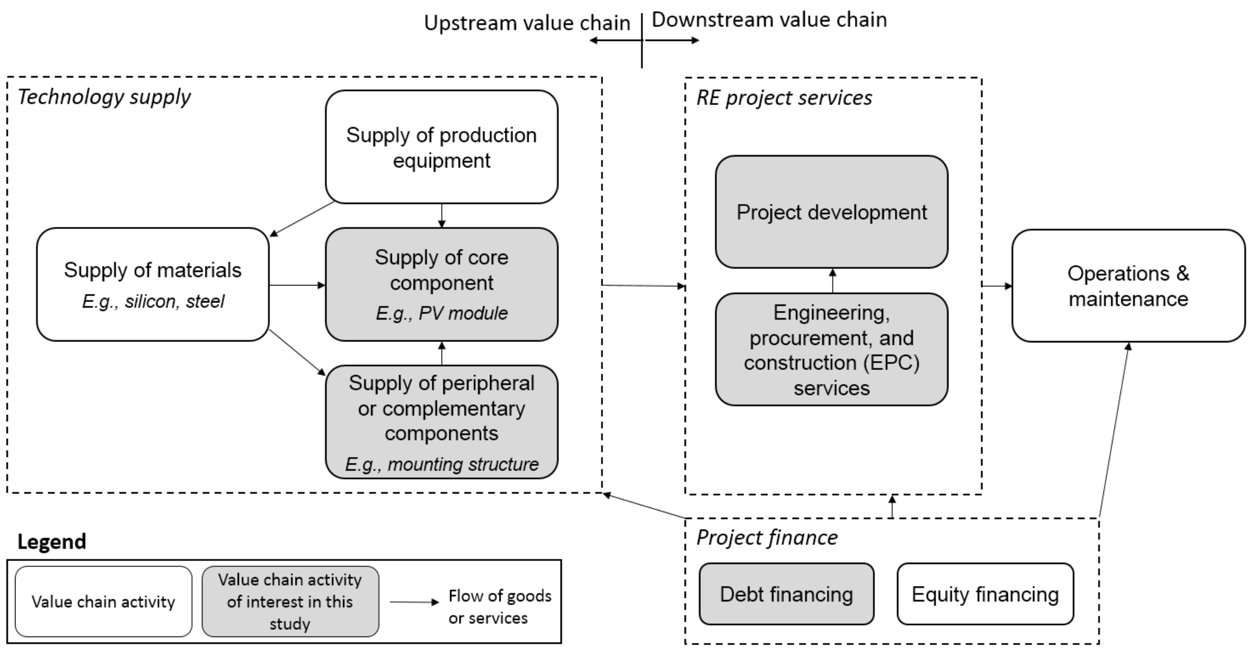

Figure 2: Stylized value chain for an RE project, adapted from Huenteler et al. (2016), where the three key activities prior to project operation are the upstream activity of technology supply, and the downstream activities of RE project services, and project financing. In practice, goods and services would also flow between individual value chain activities within each of these broader value chain steps (e.g., from core component suppliers to project developers or EPC contractors), but have been omitted in the figure for simplicity[6]

Secondly, RE industrial policy literature has predominantly focused on the relevance of different instrument types for RE industry localization. However, beyond the instrument type, different instrument calibrations will influence both the mechanism and locus of learning within the RE value chain. For example, a single instrument such as a tax incentive can be calibrated to target investments in manufacturing facilities

[6] In this paper, we do not focus on the supply of raw materials and the supply of production equipment, as these are highly globalized and competitive industries and are therefore generally not targeted in emerging economies' green industrial policies. Operations and maintenance frequently is localized even in the absence of policy support, and is therefore also not investigated in this study.

(learning-by-doing in technology production), RE projects themselves (learning-by-using a technology and learning-by-doing in project development), or can even target specific company types such as joint ventures (learning-by-interacting) (Lewis & Wiser, 2007).

3 Research design

This study utilizes comparative case study methods to investigate how policy design influences RE industrialization outcomes. We describe the case selections in section 3.1 and the methods in 3.2.

3.1 Case selection

In this study, we investigate the technology cases of wind and solar PV. While Mexico and South Africa, the two county cases analyzed in this study (see below), targeted a broader set of clean energy technologies in their auctions, we focus on wind and solar PV as they are two of the fastest growing RE technologies that represented the largest markets in terms of global RE capacity additions in 2017 (REN21, 2017). These technologies are also commonly targeted in green industrial policies (Schmidt & Huenteler, 2016), however are characterized by highly globalized and often integrated value chains (Baker & Sovacool, 2017; Huenteler, Niebuhr, et al., 2016) that can pose entry barriers to latecomers.

Mexico and South Africa, both latecomers to the RE industry, were chosen in line with a most similar case selection method.[7] Mexico and South Africa exhibit variation along their RE policy designs (independent variable), which diverged due to different priorities and visions of economic development (explained in further detail in section 4), as well as their policy outcomes, including the extent and modes of localization across solar PV and wind value chains. Aside from these key differences, the two case countries exhibit similarity on several key background aspects. Firstly, RE investments in both countries are attributed to one policy instrument, the national RE auctions, both of which have been largely celebrated worldwide for their success in mobilizing private investment into renewables (Baker, Newell, & Phillips, 2014; Eberhard, Leigland, & Kolker, 2014; IRENA, 2017). Therefore, the technological change in the energy sector that has

[7] A most similar case selection chooses cases that are similar across background conditions that might be relevant to the outcome of interest, but different on the independent variable of interest and the outcome of interest (Seawright & Gerring, 2008).

occurred in these contexts has been predominantly policy-induced. Note that beyond Mexico and South Africa, RE auctions are an increasingly popular instrument globally. This instrument typically entails the competitive procurement of RE generation, where successful bidders are awarded contracts, or power purchasing agreements, that guarantee the price per unit of electricity generated that cleared in the auction (Del Río & Linares, 2014). Secondly, Mexico and South Africa are both upper-middle-income economies[8] with a similar level of existing technological capabilities and energy demands from the industrial sector. In particular, Mexico has an industrial base in automobile manufacturing and – to a lesser extent – electronics production (Alvarez & Valencia, 2015), while South Africa has a strong mining and extractives industry, with some automotive manufacturing as well (Fine & Rustomjee, 1996; Stats SA, 2017b). As a result, it can be expected that, although these countries can leverage some existing industrial bases to break into RE value chains – for example manufacturing capabilities or capabilities in managing large EPC contracts – maintaining low electricity prices will also be crucial for the competitiveness of existing manufacturing industries. Finally, both countries have high solar and wind resources (IEA, 2014, 2016), and had seen similar levels of cumulative contracted wind and solar PV capacity (~7.7 GW and 5.6 GW, respectively), making them relatively comparable in terms of RE market potential and maturity.[9]

From a practical standpoint, the cases of Mexico and South Africa may offer greater insights for the wave of medium-sized emerging economies that are increasingly implementing green industrial policies. Thus far, studies investigating the catch-up of latecomers in RE industries have largely focused on China and India (see e.g., Binz et al., 2017; Curran, 2015; Lewis, 2011; Nahm & Steinfeld, 2014; Surana & Anadon, 2015; Zhang & Gallagher, 2016), whose large domestic markets have given them a unique advantage in developing local industry (Pueyo et al., 2011), particularly through protectionist approaches. Note that while Mexico and South Africa have comparatively smaller internal markets than e.g., China, Mexico is part of a

---

[8] According to the World Bank classification, upper-middle-income countries are those with per capital Gross National Incomes between 3,956 USD and 12,235 USD.

[9] Please refer to appendix for key metrics of each country.

free trade agreement, which gives it a different market outlook than South Africa, as discussed further in the results section.

3.2 Methods

This study utilizes a comparative case study to explore the impact of Mexico's and South Africa's policy designs on three outcomes: the formation of domestic RE markets, the development of RE bid prices, and the formation of local value chains for RE technologies. We focus on these three outcomes due to the potential importance of domestic RE markets for industry localization (as explained in section 2.2) and to understand the possible tradeoff between achieving the lowest-cost RE projects – and therefore maintaining competitive electricity prices for existing industry – and fostering the insertion of local firms into RE value chains, thereby helping create new industrial activity.

Specifically, the methods proceeded in three steps. Firstly, desk research on each country's cornerstone utility-scale RE policy, a competitive auctioning scheme, was conducted. In addition to a literature review, the policies themselves are coded according to the policy design framework shown in Figure 1. Note that for the REIPPPP, as bid and policy documents are not publicly available, research on the REIPPPP policy design relied more heavily on secondary sources, including interviews, academic and grey literature. Several key preceding policies later identified in interviews were also investigated and coded for each country, as listed in Table 1. The empirical understanding of each policy was also refined through interviews. Secondly, we compiled data from the Bloomberg New Energy Finance database, government documents, and press releases on all solar PV and wind projects that won a contract in the RE auctions. The data, depending on availability, included information about the awarded capacity; the bid price; and the origin of the project developer, EPC contractor, and debt provider.[10] We also utilized this data to create a network visualization of the global and local value chain linkages in each country, where nodes are project developers – where project developer node size represents market share by RE capacity – EPC companies, and debt providers, and a linkage is defined as co-participation in a project through a project developer contracting an external

[10] Note that we treat subsidiaries as local if they are registered locally and are owned at least 50% by local entities.

EPC company, a debt provider financing an RE project, or a joint venture in EPC or project development. Links are weighted according to the number of project collaborations between actors. These networks were created in Gephi using a force-directed algorithm, Force Atlas, suited for smaller network sizes. Thirdly, 39 semi-structured interviews with public and private stakeholders in Mexico and South Africa were conducted in order to understand the link between policy design choices and policy outcomes (see Table 2 for an overview of interviewed partners[11]), particularly with respect to localizing the following value chain activities: project development, EPC, debt provision, and technology supply. For these interviews, which were conducted in English or Spanish in-person[12] over a period spanning May 2017 to May 2018, we targeted project developers, technology and engineering/project service suppliers, and financiers that had been involved in successful bids, as well as policymakers involved in formulating the RE industrial policy strategy and/or its implementation. These interviews were transcribed in their original language, and coded by policy design elements as outlined in the policy design framework, learning mechanisms, and RE localization outcomes. While this approach, involving literature review, data collection, and interviews, intends to triangulate results and provide a comprehensive empirical overview of the Mexican and South African RE markets, this paper does not claim to be exhaustive, particularly as RE markets tend to evolve rapidly.

Table 1: Policies included in the analysis, with the cornerstone policy listed in bold and the policy adoption date noted in parentheses

Mexico
• **Mexico capacity and power auctions supported by Clean Energy Certificates (CELs) (2016)**
• Clean Energy Auction manual (large-scale projects) (2015)
• Basis for the large-scale Clean Energy Auctions (2015)
• Guidelines establishing and issuing Clean Energy Certificates (CELs) (2014)
• Electricity industry law (2014)
• Special program for the use of renewable energy (2014)
South Africa
• **Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) (2011)**
• Integrated Resource Plan (2011)

[11] Note that the distinction between roles can be blurred due to vertical integration (e.g., a developer or an OEM can also provide EPC services); additionally, policymaker roles are not provided to maintain interviewee confidentiality.
[12] Except for seven interviews that were conducted by phone

Table 2: Overview of interview partners

	Organization role[13]	Technology[14]	Country	Interviewee role
1	OEM	Wind	Mexico	General Manager
2	OEM	Wind	Mexico	Manager
3	Component supplier	Wind	Mexico	Manager
4	Project developer	Wind	Mexico	Managing Director
5	Project developer	Wind	Mexico	Sustainability Manager
6	Project developer	Wind/Solar PV	Mexico	Chief Executive Officer
7	Industry expert	Wind	Mexico	Executive Director
8	Finance provider	Wind	Mexico	Energy Specialist
9	OEM	Solar PV	Mexico	Project Development Manager
10	Component supplier	Solar PV	Mexico	Senior Director
11	Project developer	Solar PV	Mexico	Development Director
12	Project developer	Solar PV	Mexico	Partner
13	Project developer	Solar PV	Mexico	President
14	Industry expert	Solar PV	Mexico	Senior Analyst
15	Industry expert	Solar PV	Mexico	Executive Director
16	Policy consultant	General	Mexico	Independent consultant
17	Policy consultant	General	Mexico	Chief Executive Officer
18	Policymaker	General	Mexico	Secretariat of Energy
19	Policymaker	General	Mexico	Secretariat of Energy
20	Policymaker	General	Mexico	Ministry of Economy
21	OEM	Wind	South Africa	Manager
22	Component supplier	Wind	South Africa	General Manager
23	Component supplier	Wind	South Africa	Managing Director
24	Component supplier	Wind	South Africa	Business Manager
25	Project developer	Wind	South Africa	Development Manager
26	Project developer	Wind/Solar PV	South Africa	Executive
27	Industry expert	Wind	South Africa	Chief Executive Officer
28	OEM	Solar PV	South Africa	Managing Director
29	Component supplier	Solar PV	South Africa	Managing Director
30	Project developer	Solar PV/Wind	South Africa	Chief Executive Officer
31	Project developer	Solar PV	South Africa	Managing Director
32	EPC	Solar PV	South Africa	Business Development Manager
33	Industry expert	Solar PV	South Africa	Associate Director
34	Finance provider	Solar PV	South Africa	Principal
35	Finance provider	Solar PV	South Africa	Manager Renewable Energy
36	Industry expert	General	South Africa	Research Group Leader
37	Industry expert	General	South Africa	Senior Energy Analyst
38	Policymaker	General	South Africa	Department of Science & Technology
39	Policymaker	General	South Africa	Department of Trade & Industry

4 Results

The following section describes the results, including a description of the auction designs in Mexico and South Africa (section 4.1) and how specific design calibrations influenced policy outcomes, including the capacities awarded and bid prices in each auction round (section 4.2.1) and the localization of both upstream and downstream value chain activities (section 4.2.2).

[13] OEM, or ordinary equipment manufacturer, denotes a wind turbine manufacturer.
[14] For project developers involved in both wind and solar PV projects, the technology listed first is the technology with which the developer had more experience and knowledge.

4.1 Policy design

4.1.1 Mexican renewable energy policy

The Mexican electricity sector relies heavily on fossil fuel-based generation, which accounts for about 80% of generated electricity (CFE, 2018).[15] While Mexico is a producer of both petroleum products and natural gas, underinvestment in the oil and gas sector has led to an increasing reliance on imported gas as well as expensive measures to ensure adequate fuel supply, such as the purchase of liquefied natural gas (Robles, 2016). Furthermore, a monopolistic and vertically integrated public utility, the Comisión Federal de Electricidad (CFE), historically managed investments and operation of Mexico's electricity sector. However, this organization had been experiencing rising levels of debt, leading to insufficient investments in electricity infrastructure, and high operational and technical inefficiencies (Carreon-Rodriguez, Vicente, & Rosellon, 2003).

As industrial electricity prices are unsubsidized, these end-user tariffs have risen steadily since 2009 and by 2015 were nearly double the average industrial electricity price in the US (Alvarez & Valencia, 2015). However, the industrial sector – and particularly the manufacturing sector – is both a key driver of Mexico's economy as well as a large consumer of electricity: the industrial sector represented about 24% of Mexico's national income in 2016 (OECD, 2018b) and 57% of electricity consumption (IEA, 2018). In this context of high inefficiency and lagging investments in the electricity system, reliance on fossil fuels subject to price volatility, and increasing electricity tariffs for the industrial sector, Mexico began to implement policies that radically changed the electricity sector (IEA, 2016).

These changes began with the Energy Reform passed in 2013, which sparked a restructuring of both the oil & gas and power sectors. The Energy Reform was largely implemented to meet the macro-level policy goal of economic development: improving operations in the oil and gas industry would boost national income, while stabilizing and lowering electricity costs would fuel further economic growth in Mexico's leading

[15] In the last two decades, Mexico has experienced a shift from generation based largely on domestic fuel oil to cleaner and less expensive natural gas, with fuel oil accounting for 10% of generation in 2015 (IEA, 2016, 2017)

sectors (Alpizar-Castro & Rodríguez-Monroy, 2016). With both energy sectors facing a lack of investments from the publicly owned energy companies, under the Energy Reform the Mexican government pursued a private sector-led and market-driven logic to revitalize sector productivity. Mexico had pursued a similar approach in the industrial sector in the 1980s, when it transitioned from an inward-looking import substitution strategy towards one based on free trade and foreign direct investment, particularly following Mexico's entry into the North American Free Trade Agreement (NAFTA) (IEA, 2016).

In the power sector, the energy reform led to several follow-up laws in 2014, including the Electricity Industry Law and the Special Program for the Use of Renewable Energy. The Electricity Industry Law provided a new regulatory framework for the electricity sector. Notably, this law mandated the unbundling of CFE, introduced private sector participation in electricity generation and supply, and created competitive markets for capacity and energy. In addition to these measures, the Electricity Industry Law set an objective for greater RE deployment, with the Special Program for the Use of Renewable Energy further elaborating these meso-level objectives to include: (i) the deployment of RE technologies in order to diversify the electricity mix and "meet the national demand for electricity with competitive costs and respect for the environment" (Diario Oficial de la Federación, 2014, p.14); (ii) increase public and private investment in generation; and (iii) "promote technological development, talent, and value chains in renewable energy" (Diario Oficial de la Federación, 2014, p.19).[16] In line with a market-based logic, The Electricity Industry Law also outlined that competitive clean energy auctions would be the instrument utilized to meet the policy objectives.

Despite outlining multiple policy objectives, almost all of the instrument calibrations sought to maximize competition and drive down the contracted price of energy, thereby placing greater emphasis on meeting objectives (i) and (ii). Firstly, the clean energy auctions are technology-neutral, where all clean energy technologies compete on their offered price for a package of energy, capacity, and Clean Energy Certificates (CELs, further explained in the paragraph below). In comparison to technology-specific auctions (e.g.,

[16] The other two objectives stated in the Special Program for the Use of Renewable Energy were related to biomass energy (e.g., biofuels) and energy access.

where various solar projects would compete for a contract), technology-neutral auctions are thought to lead to the selection of the currently lowest cost clean energy option (Azar & Sandén, 2011). Note that Mexico's definition of clean energy includes technologies such as nuclear and combined cycle natural gas, which have an advantage in offering capacity[17] compared to intermittent renewables.

Secondly, in order to meet the target of 35% RE generation by 2024, RE technologies are allowed to include CELs in their bid, which are granted 20-year contracts. In theory, selling a bundle of CELs adds an additional revenue source to the bid portfolio of RE technologies, allowing them to offer lower – and thus more competitive – bids overall. However, in practice, there is still significant uncertainty surrounding the price of CELs. CELs are intended to help electricity retailers and large consumers lower their cost of compliance in meeting Clean Energy Quotas. However, for the first 3-year compliance period, this quota has been set at only 5% of electricity consumption, which interviewees have said provides little certainty for future CEL price development.

Thirdly, as the auction logic is based on cost competition to drive down bid prices, many design calibrations intended to maximize the level of competition in the auction. Two key calibrations included: (i) relaxing requirements regarding bid qualification and commercial operation dates in order to allow early-stage projects to bid into the auction, and (ii) the 15-year power purchasing agreements (PPAs) could be indexed in Mexican pesos (MXN) or US dollars (USD), which helped increase interest from foreign investors. As seen from these design features, the target of developing RE value chains was not explicitly addressed in the design of the auction. Instead, alongside the auction, a 15% import tariff on solar modules was put in place. However, developers can apply for exemptions from these tariffs from the Ministry of Economy (MoE) if they prove their project contributes to Mexico's economic development.

[17] Capacity is defined in Mexico as the capacity that can be offered during a predefined "100 critical hours" of demand, which varies regionally.

4.1.2 South African renewable energy policy

Like Mexico, South Africa's electricity system is largely fossil fuel-based, specifically relying on domestic coal to meet about 90% of electricity needs (Department of Energy, 2015). Also like Mexico, a state-owned, monopolistic, and vertically integrated utility, Eskom, had controlled investments and operations in the electricity sector. Due to a previous overbuild-out of coal-fired capacity as well as general access to low-cost domestic coal, South Africa had historically enjoyed some of the lowest electricity prices in the world (Baker et al., 2014). These low energy prices in turn fueled the growth of many of South Africa's energy-intensive industries (Burton & Winkler, 2014; Fine & Rustomjee, 1996), including mining and manufacturing which contributed 21% and 22% to South Africa's GDP in 1980, respectively (Stats SA, 2017a). As a result, these industries historically provided the backbone to South Africa's economy.

However, recent decades have witnessed a symbiotic decline in these energy-intensive industries as well as Eskom's technical and financial sustainability (Baker et al., 2014). Electricity tariffs failed to keep pace with inflation and, combined with decreasing access to low-cost coal contracts, eventually dropped below Eskom's cost recovery level. Underinvestment in the electricity sector led to rolling blackouts across the country in 2008 and subsequent approvals for tariff increases (Baker et al., 2014). Alongside increasing energy tariffs and decreasing reliability of electricity services, the economic importance of mining and manufacturing have waned, contributing only 8% and 13% to South Africa's GDP in 2016 (Stats SA, 2017a). However, ideologically, these sectors still feature prominently in South Africa's industrial complex. Thus, South Africa implemented its renewables program in a context of lagging industrial activity, high unemployment, increasing energy prices, and an immediate need for investments in electricity infrastructure (Walwyn & Brent, 2014).

In order to mitigate some of the issues stemming from the electricity sector, in 2010 the South African government initiated an electricity planning process, or Integrated Resource Plan (IRP), setting out how long-term electricity demands would be met (Baker & Sovacool, 2017). The goal of economic development featured strongly in the draft IRP, outlining objectives to achieve "an affordable electricity price to support a globally competitive economy, a more sustainable and efficient economy, the creation of local jobs," (Republic of South Africa Department of Energy, 2010, p. vi) as well as meet climate objectives. Importantly, the IRP outlined plans for RE deployment and private sector participation in power generation in a traditionally coal-dominated and monopolistic sector. Initially, the IRP indicated that a feed-in tariff – the prevailing instrument favored by international investors at the time – would be employed to meet RE deployment objectives (Republic of South Africa Department of Energy, 2010). However, after significant debate surrounding this instrument, including a downward readjustment of tariff levels, a feed-in tariff was deemed unconstitutional, as it failed to comply with competitive procurement mandates (Eberhard et al., 2014). Instead, a framework for a competitive RE auctioning instrument, known as the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), was introduced in 2011. While following a market-based logic, the REIPPPP stipulated several regulatory requirements in order to foster certain socio-economic development outcomes.

Several key factors differentiate the design of South Africa's auctions from Mexico's. Firstly, South Africa ran technology-specific auctions, aiming to provide more certainty regarding the market size for each technology. Secondly, unlike Mexico in which bids were evaluated on price only, South Africa offered contracts to bids that optimized price and socio-economic development criteria, with a weighting of 70% and 30%, respectively. These socio-economic criteria included objectives such as job creation, local content, black economic empowerment[18], and community ownership (Baker & Sovacool, 2017; Rennkamp & Boyd, 2015). Thirdly, the REIPPPP had more stringent bid qualification criteria, both with regards to the maturity of the project as well as to meeting a certain minimum of socio-economic development objectives. To qualify, bidders needed to submit signed bank letters, essentially providing greater certainty that projects would come to financial close and could be built as contracted. They also had to meet minimum local content

[18] These criteria, which included both black shareholding in companies involved in the project as well as creation of jobs for black citizens, reflects traditional socio-economic development objectives of resolving economic disparities after Apartheid, and is rather specific to South Africa.

requirements, defined by share of investment, which increased across the auction rounds[19] in an attempt to foster local RE value chains. Finally, the PPAs are paid in South African Rand (ZAR), however could be indexed to inflation.

In sum, Mexico and South Africa took similar policy approaches at various stages of the macro- and meso-levels of the policy design hierarchy (see Figure 3). Both countries set a macro-level policy goal of economic development through RE deployment, which would lower system generation costs and create local RE industry (policy objectives). While these goals and objectives appear to be operationalized in both countries using the same instrument of clean energy auctions, the different *prioritization* of low-cost RE deployment versus local RE value chain development (policy objectives) and ideology of economic development (instrument logic) led to a divergence of policy design at the micro-level, resulting in distinct policy outcomes described in the following section.

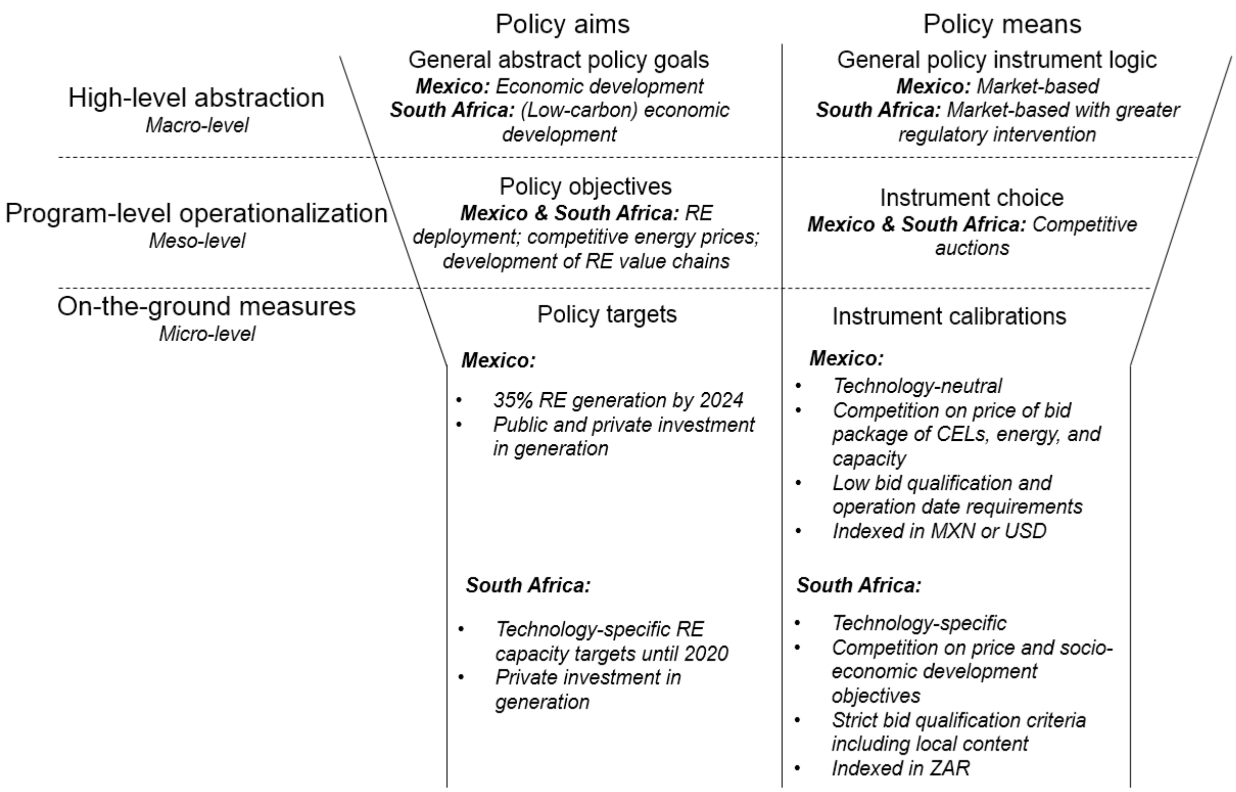

Figure 3: Overview of policy designs in Mexico and South Africa according to the hierarchy of policy design

[19] Local content thresholds increased from 25% (Rounds 1 & 2) to 40% (Rounds 3&4) for wind, and from 35% (Rounds 1 & 2) to 45% (Rounds 3 & 4) for solar PV

4.2 Policy outcomes

4.2.1 Mexican renewable energy market and bid price development

Mexico's clean energy auctions have rapidly mobilized private sector interest, awarding around 8 GW of power capacity in one and a half years (see Figure 4a). Although wind and solar PV compete with more mature technologies such as natural gas, these two RE technologies have been successful in all three rounds.[20] In part, this success can be attributed to the large cost reductions of these technologies – particularly for solar PV – making them cost-competitive on a per MWh basis (see Figure 4b) (Steffen et al., 2018). In addition to the reductions in capital costs of RE technologies, wind and solar PV costs in Mexico have been driven down by competition due to high private sector interest in these technologies. Despite the technology-neutral design of the auctions, several interviewed RE developers have indicated confidence in the long-term market outlook for renewables as the electricity sector reforms send a strong signal of the political will to support RE.

Mexico has been widely recognized for achieving low solar PV and wind bid prices, demonstrating the potential for competitive auctions to drive down margins and prices. However, some interviewees have called the published bid prices "artificial," as the design of the auction allows developers to submit a *package* of three products: capacity, CELs and energy. This advantage is not necessarily available to developers in other contexts. Furthermore, developers also have the option to sell a portion of their energy on the competitive wholesale market, where they can potentially capture higher prices. As a result, direct comparisons of bid prices across countries' auctions is difficult.

[20] In round one, the capacity price ceiling set by the regulator was only 10,000 MXN/MW – too low to incentivize any offers of capacity – making round one a pure energy and CEL competition, which favored wind and solar PV bids. This mix changed in round two when the ceiling price was increased to 1.7 million MXN/MW, allowing combined cycle gas and hydro to win solely by bidding capacity and geothermal to win a single bid.

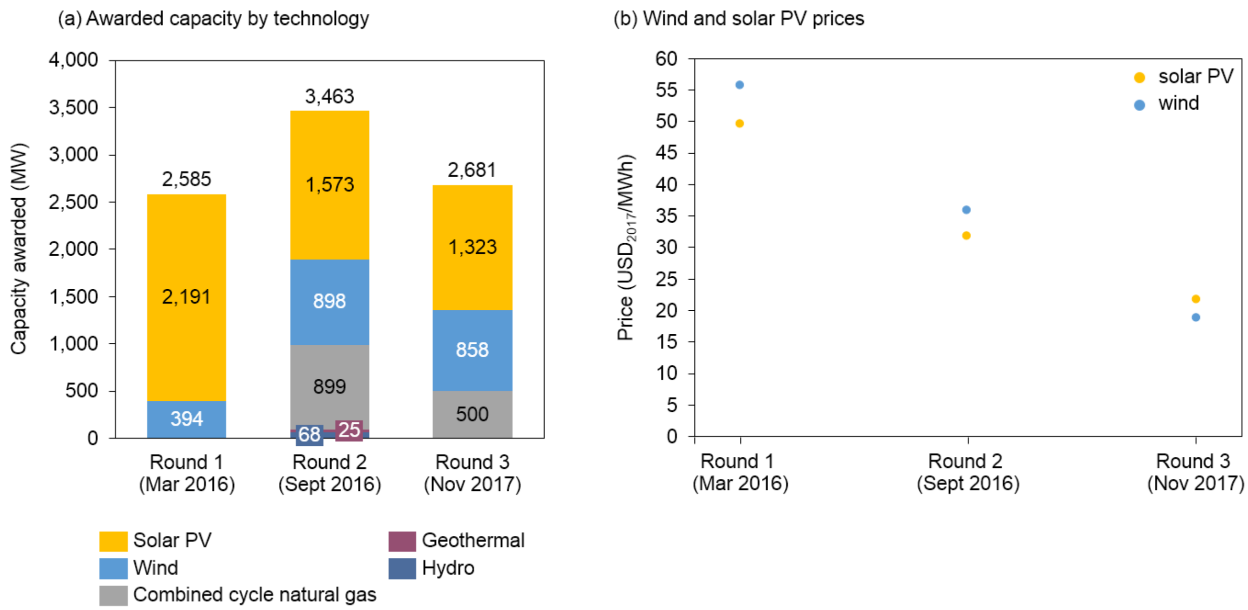

Figure 4: Auction results in Mexico by (a) awarded capacity by technology and (b) average wind and solar PV bid prices (CENACE, 2018)

In addition, the capacities and prices shown in Figure 4 are the awarded contracts; many of these projects are not yet built. As explained previously, the government faced a "trade-off between the volume of supply to drive prices down, versus the certainty that projects would get executed. Both are valuable goals that are in conflict, one with the other [...]. The policymakers understood [this] point, and were explicit and said, 'Look, we know we'll have some attrition, but at the end of the day, we want to celebrate these first auctions to be of massive volumes of participation and low prices,'" (Interviewee 11). While a letter of credit is required in case projects fail to meet contracted obligations to ensure payment of the penalty for non-compliance, many of the first round projects are still not operating, despite a mandate that projects should be operational by 2018. As several contracted projects continue to struggle to reach financial close, interviewees have noted that these delays have cast uncertainty regarding the actual volume of RE capacity that will be deployed in the coming years.

4.2.2 Formation of local value chains in Mexico

As highlighted by several interviewees, the Mexican incentive scheme for RE is complex, and requires significant capabilities from the developer in navigating regulatory frameworks, and optimizing portfolios and financing arrangements. Furthermore, Mexico designed its bid evaluation scheme to optimize ‘economic surplus,’ which it defines as minimizing bid costs. Given that RE plants are capital-intensive and financing costs can account for a large share of their levelized cost of energy (LCOE) (Schmidt, 2014), Mexico’s method of evaluating bids generally translated to a competition for access to low-cost financing. Furthermore, indexing PPAs in USD opened the auction to many interested international financiers.

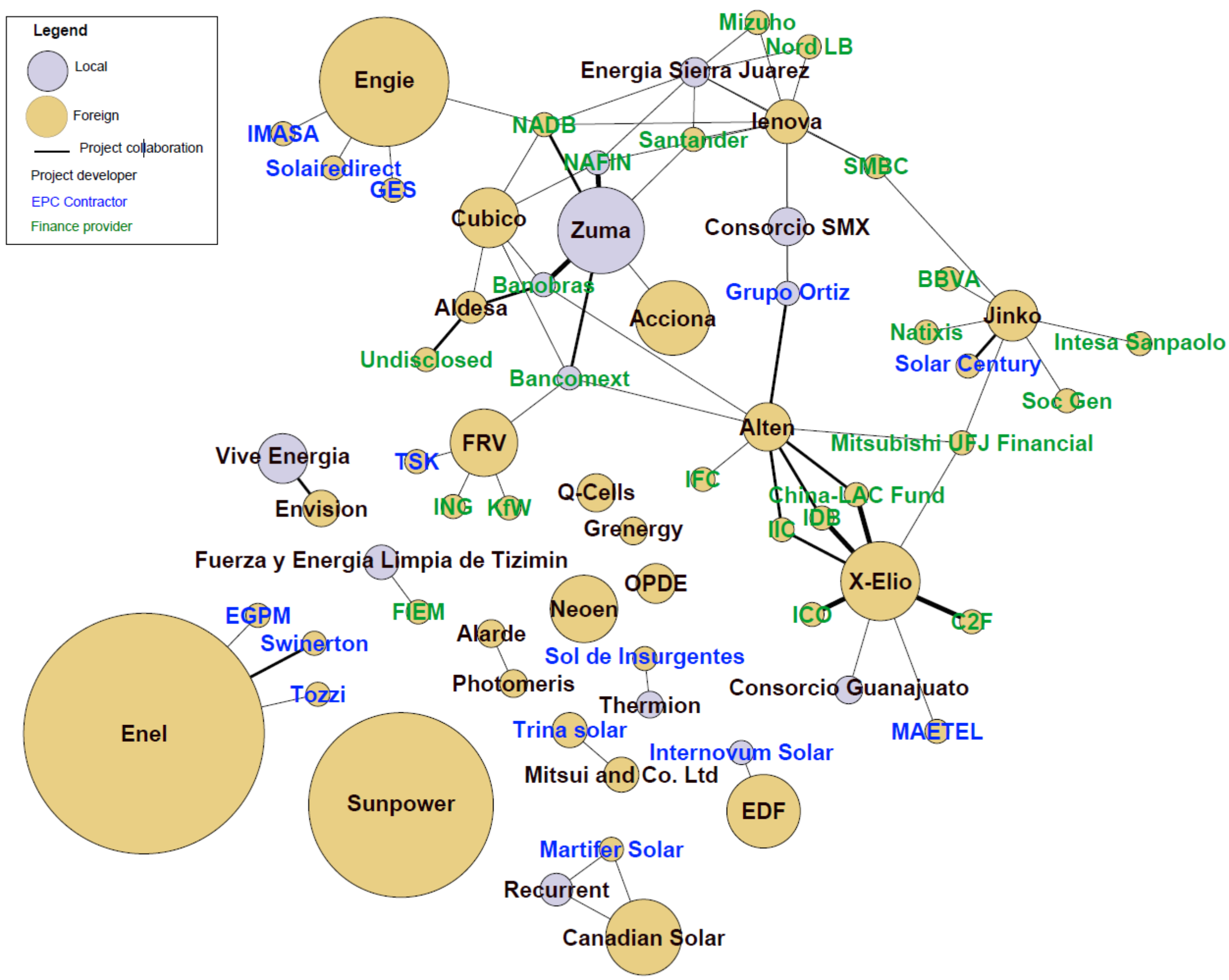

Figure 5: Networks formed in the downstream value chain comprising project developers (market share weighted by node size), EPC contractors and debt providers in Mexico, where the edge (i.e. link) weight represents number of project collaborations

The implications of this highly complex and finance-driven competition can be seen in the profile of winning bidders shown in Figure 5,[21] which displays the networks of project developers (where the node size indicates market share), EPC contractors, and debt providers under Mexico's three auction rounds. Large foreign developers such as Enel (Italy), Engie or EDF (France) play a large role in the Mexican market. Interviewees explained that they believe these large utilities have an advantage because they can utilize lower-cost balance sheet finance, rather than project finance that is traditionally used in RE finance (Steffen, 2018). According to interviewees, these large players, due to their large portfolio with a diverse array of projects across the globe, can generally underprice project-specific risk if needed to capture new markets, while still maintaining bankability as a company. Aside from these foreign utilities, other key developers are specialized RE companies with a proven track record and experience, many of which have origins in forerunner RE markets. Not only do these specialized companies have greater capabilities in managing the complex RE policy due to their experience learning-by-doing in project development in other markets, they are also typically more creditworthy than local developers with less RE experience. Furthermore, many of these specialized RE firms are vertically integrated, and therefore manage their own EPC and/or technology supply in order to lower transaction costs along the value chain.

The competition for access to low-cost financing also affected the entities involved in debt financing. In particular, many local commercial banks were not involved in financing RE projects, either due to developers using balance sheet finance in the auctions or because developers sought support from development banks[22] or foreign commercial banks that have prior experience financing RE in competitive markets. This reliance on predominantly foreign capital, while it helped to lower LCOEs, results in fewer opportunities for local commercial banks to build the capabilities required for engaging in RE project finance and understanding how to capture value in the complex Mexican energy market. One developer explained this chicken-and-egg problem: "When you go to a bank and you explain how the market works,

[21] Note that EPC and debt providers are not always disclosed, particularly for the most recent auction winners as these projects are still in early stages of development.
[22] Mexican development banks include Bancomext, Banobras, and NAFIN.

they don't understand. We are experts in electricity and for us it's even difficult to understand. In one year we've taken these [policy] documents and we've started to read, and read, and read, and we still don't understand all of it. So when you go to a bank and you see their director of energy, he doesn't understand all of this either [...] So in the end we obtained financing from six banks [...] all private banks, but foreign. Because they can understand," (Interviewee 10). In sum, while Mexico was successful in achieving low RE prices, it saw little involvement of local developers and commercial financial institutions, providing few opportunities for local learning-by-doing.

The large presence of foreign project developers also had repercussions for localizing other parts of the value chain by reinforcing path dependencies in value chain networks. Specifically, the involvement of foreign developers often led to the involvement of foreign EPCs and technology suppliers, as developers frequently brought a large share of the value chain from their home market to Mexico. Through learning-by-interacting processes in their home markets, developers will often form relationships with EPC contractors and technology providers, allowing them to mobilize project teams with less internal 'due diligence.' Tapping existing home networks has generally been a strategy used by international project developers when entering new markets (Steffen et al., 2018). For example, one Spanish developer explained: "As a Spaniard, it is much easier to contract a Spanish company – the culture, the contacts – I already know these because we've done projects, many projects in Spain and all of these with a Spanish EPC that I know really well, that I've worked with. So when I came to Mexico and had to do my first [wind] park, for me the easiest was just to say to this [EPC] company, 'Ok, come to Mexico with me,'" (Interviewee 10). These path dependencies are reinforced by business structures in the Mexican electricity market, which until the 2013 reform had been run noncompetitively by the national utility. Several interviewees have noted that, due to this previous market structure, there is a vacuum of local private developers and EPC contractors with the organizational and managerial capabilities to manage the complexities of an RE project. These local firms also often fail to meet bankability requirements, as they have insufficient balance sheets to take on the high-risk low-return profile that are typical under Mexico's competitive auctioning scheme. As a result, the competencies for these RE service activities have yet to be built in the local market.

A similar lack of organizational capabilities was noted in the upstream value chain for local technology suppliers. A policymaker involved in helping these local firms break into RE value chains explained that, because many companies have grown accustomed to working through a noncompetitive procurement process with CFE, these companies are struggling to adapt to the business culture of organizational due diligence. As a result, although several interviewees from the private sector have speculated that local value will come naturally with market maturity, many firms with the necessary technological capabilities to supply balance of plant components and engineering services, are failing to break into value chains due to organizational processes that have developed through decades of interacting with the national utility.

In part, these entry barriers for local technology suppliers are also due to a lack of incentives to localize these upstream value chain activities. As there is no incentive for international developers or OEMs to seek out local component suppliers, for example for more peripheral components such as the electrical balance of system, there is little direct interaction between local and global value chains. Instead, this interaction has been channeled through the MoE, which is responsible for matching the demand for RE goods and services with local supply. While the MoE has developed a practical and comprehensive strategy for this task, the process has proven slow due to its limited resources.

Despite the slow process in localizing peripheral or complementary RE components and RE services, the production of several core RE components has been localized in Mexico. For solar PV, this includes a small solar module manufacturing hub in northern Mexico with both foreign and local suppliers. The foreign companies that have invested in module manufacturing are predominantly non-Chinese (e.g., American or Japanese[23]), in which domestic manufacturing would likely not be competitive with Chinese manufacturers, making Mexico comparatively attractive due to its low input costs, proximity and transport links to the US, and stable macro-economic environment. As little learning-by-using and feedback from end users is needed for PV module production (Huenteler, Schmidt, Ossenbrink, & Hoffmann, 2016), manufacturing can be

[23] These include US-based Sunpower as well as Japanese-based Kyocera and Panasonic. One Chinese module manufacturer has a footprint in Mexico, in part as a means to circumvent import tariffs on Chinese modules in the US.

offshored to serve a large market such as the US. These module manufacturing facilities are generally not cost-competitive in the domestic utility-scale solar market, and instead serve the US (in the case of foreign-owned facilities) or the domestic distributed PV market (in the case of both foreign- and Mexican-owned facilities). The existence of these facilities can be explained in part by an import tariff of 15% on non-Mexican solar modules. While these tariffs are meant to apply generally, the MoE allows utility-scale developers to apply for tariff exemptions. As a result, these tariffs mainly affect the distributed PV market.

For wind, several components are manufactured in Mexico, including turbine blades and towers to serve the domestic market. Much of this is driven by foreign OEMs, including Vestas and Acciona, that localize the production of bulky components due to sufficient market volumes in Mexico. These foreign entities bring the technological knowledge associated with the design of these components, and train local actors in the relatively simple production processes. As a result, there is little technological capability-building in the higher value-added activities of designing wind turbine components. However, there are instances of local companies attempting to break into global wind value chains using innovative tower designs. Developing such a design requires significant learning-by-using and learning-by-interacting with turbine OEMs, through iterative design cycles. However, such innovative components have faced entry barriers into the highly integrated wind value chain due to limited support from international OEMs.

In sum, Mexico's competitive auction design led to the tapping of existing and often foreign-driven value chains, providing little opportunity for additional learning-by-doing and learning-by-interacting for local firms that currently lack these capabilities. While Mexico did localize some RE components, many of these were components that required limited knowledge transfer between global and local actors.

4.2.3 South African renewable energy market and bid price development

Compared to Mexico, South Africa has contracted fewer megawatts of capacity in each auction round (see Figure 6a). While Mexico has been noted for achieving low energy prices, South Africa had been successful in achieving rapid cost *reductions* (Walwyn & Brent, 2014), with average bid prices between rounds one and four for solar PV and wind dropping 75% and 50%, respectively. Several interviewees indicated that, in addition to the drop in capital costs of these technologies, the procurement design may have helped foster these cost reductions: auctioning smaller tranches of capacity over multiple rounds created conditions for learning across auction rounds, particularly with respect to project development. Some interviewed developers explained that they bid smaller projects initially, giving foreign companies the opportunity to gain tacit knowledge about the local market and the auctioning policy – a relatively new instrument in global RE policy – and local developers the opportunity to develop their technological capabilities, particularly regarding translating generic project development capabilities to RE projects specifically. Note that the observed cost reductions are not wholly South Africa-specific but reflect global trends at the time.[24] In the first round of the REIPPPP, solar PV was rather expensive on a global level, but subsequently traveled down the global cost learning curve rapidly (a development from which Mexico, due to the later start of their auction schemes, already profited in the early auctions). These cost reductions due to technological learning were further magnified in South Africa due to an oversupply of solar modules globally (Baker & Sovacool, 2017).

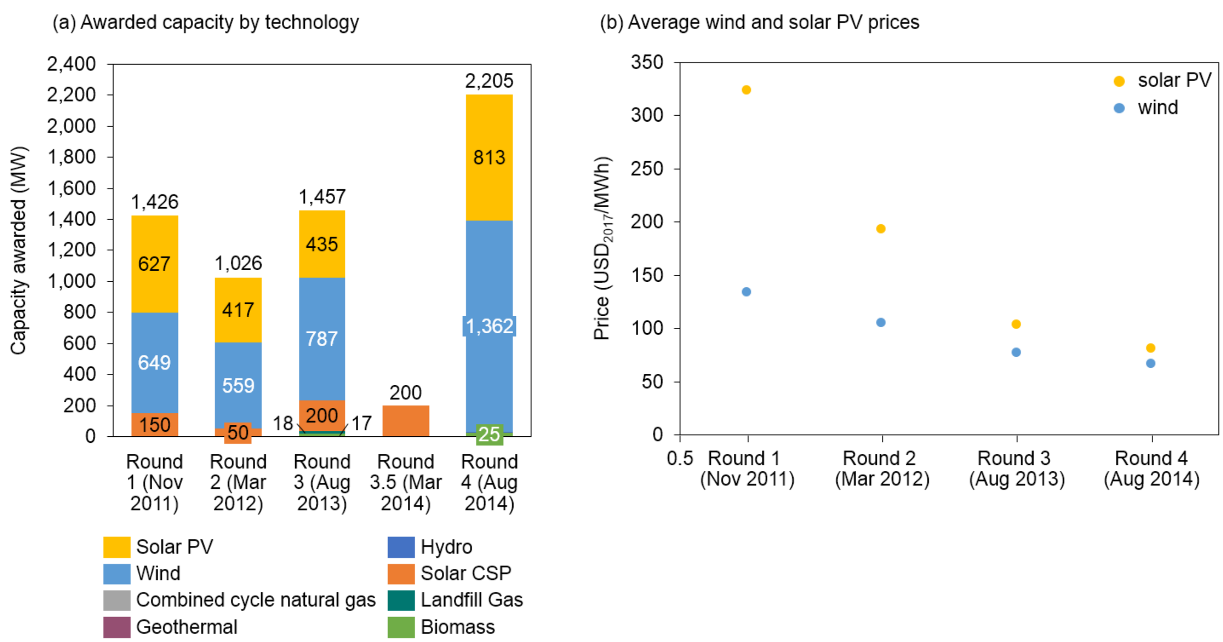

Figure 6: Auction results in South Africa by (a) awarded capacity by technology and (b) average wind and solar PV bid prices (Republic of South Africa Department of Energy, 2015)

[24] Note that some of these reductions are due to the drop in hardware costs of these technologies between 2011 and 2014. The large drop in bid prices between Round 1 and Round 2 is also attributed to differences in competition levels, which were significantly lower in Round 1.

4.2.4 Formation of local value chains in South Africa

Over the course of its auction rounds, South Africa had localized several parts of the RE value chain. As seen in Figure 7, in the downstream value chain, the REIPPPP attracted a more diverse set of local project developers. According to interviewees, this outcome could be attributed to several factors. Because auctioning schemes were new on a global level, both international and local developers started with the same capabilities in navigating this policy space. In addition, the socio-economic requirements of the REIPPPP, including black enterprise and community development, made local tacit knowledge more valuable, as explained by one developer: “we understand the [local context] better. We’ve built up that capability. If you’re a typical European or US or Asian company for that matter, you’re not going to be able to engage. You won’t understand the culture, the business culture, the conditions,” (Interviewee 26).

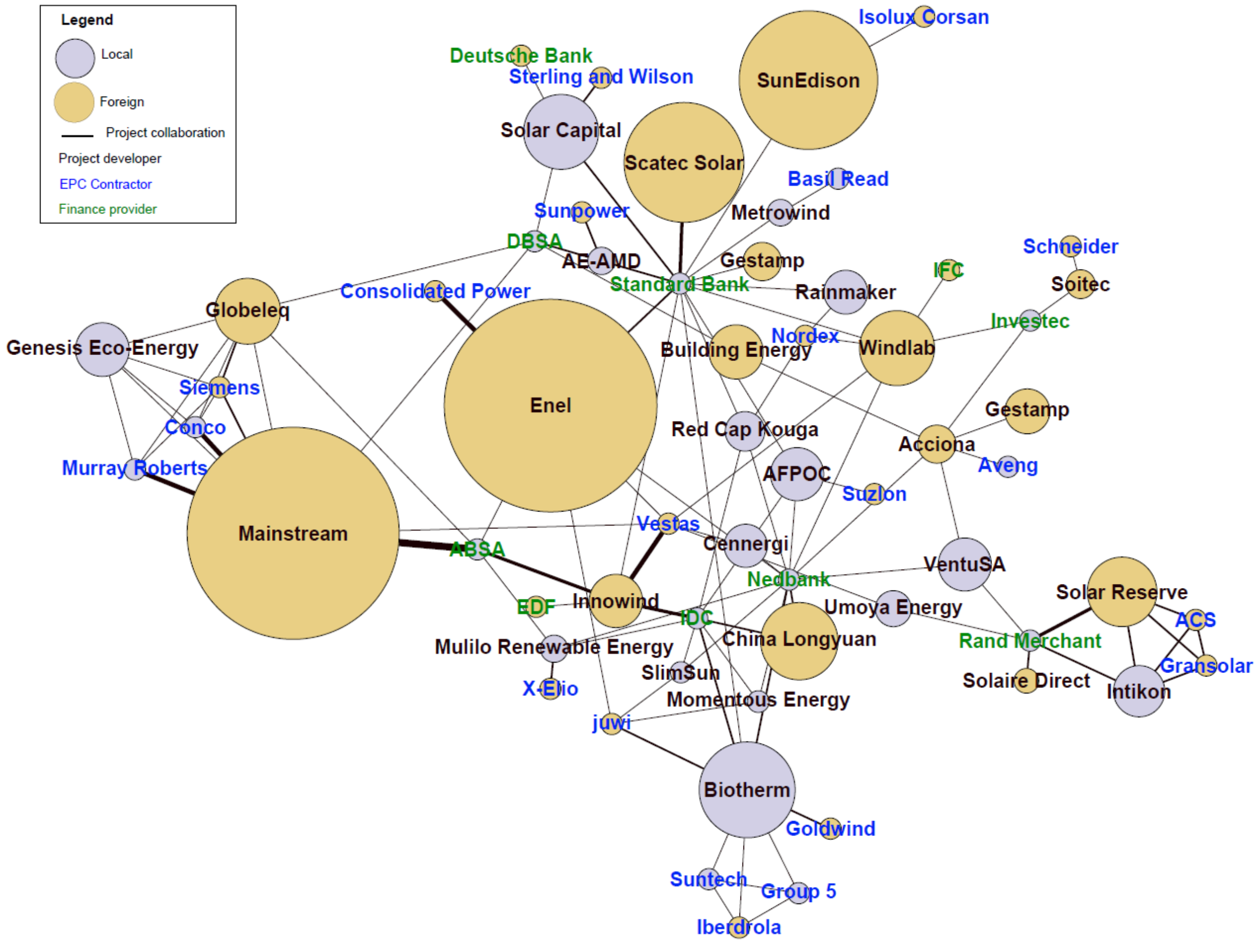

Figure 7: Networks formed in the downstream value chain comprising project developers (market share weighted by node size), EPC contractors, and debt providers in South Africa, where the edge (i.e. link) weight represents number of project collaborations

With regards to localizing RE financing, interviewees noted that the fact that the PPAs were paid in ZAR generally acted as a deterrent for international banks, due to high foreign exchange risk. As seen in Figure 7, South Africa's commercial and development banks instead played an instrumental role in supporting RE projects, particularly in the early rounds of the REIPPPP (Baker, 2015). Although several interviewed developers have complained that the commercial banks were quite risk-averse, these banks proved willing to finance RE projects despite their unfamiliarity with RE project structures and the novelty of the REIPPPP program. As a result, several interviewees have noted that these local banks developed significant capabilities through learning-by-doing in financing these early round projects. In particular, innovative financing, like in Mexico, became a crucial determinant of competitiveness, forcing local banks to learn quickly. This build-up of technological capabilities in financial institutions has actually benefitted the long-term sustainability of RE in South Africa, as several interviewed debt providers noted their experience in the utility-scale market helped build an appetite and competency for financing distributed RE projects and firms.

Another key differentiator of South Africa's auction design was its use of local content requirements. Local content requirements, because they were calculated based on percentage of the total project value, also led to involvement of more local EPC companies compared to Mexico, both as independent contracts as well as joint ventures.[25] Thus, while South African EPCs did not typically take on turnkey EPC projects alone and international EPCs still dominated the market (Baker & Sovacool, 2017), local EPC firms had the opportunity to learn, either by implementing EPC contracts themselves or through interacting with leading global EPC providers: "South Africa has some very large EPC companies generally that are extremely successful [...] but they had no skill in renewable energy. So I remember that in the first round, a South African EPC [...] had a co-venture with a Spanish company [...] because [the South African EPC] didn't necessarily feel that they could carry out the EPC on their own [...]in the later round I think they were probably capable to do so on their own," (Interviewee 27). In later years when the REIPPPP stalled due to political reasons, several South African developers and an EPC contractor were able to leverage these technological capabilities and operate competitively in RE projects across the region.

Local content requirements have also been cited by interviewees as accelerating the process of localizing specific downstream value chain activities. In particular, creating these requirements shifted the responsibility of fostering local value chains to the private sector, resulting in close interaction both horizontally and vertically across global and local value chain actors. These requirements led to a greater interest of foreign firms to develop training programs to build local capacity. Such initiatives included sending South Africans to develop specialized skills in Europe as well as the establishment of local training

[25] Note that the REIPPPP also required EPCs to have 40% local ownership. However, several interviewees noted that local content requirements were a key driver of utilizing local EPC firms, particularly in the first round of the REIPPPP in which local content thresholds could largely be met by localizing aspects of EPC such as the balance of plant.

facilities – most notably the South African Renewable Energy Technology Center (SARETEC), a collaboration that includes the South African Ministry of Higher Education & Training, South African universities and industry associations, as well as local and foreign technology suppliers that provides RE training. These initiatives helped provide the interactive learning and learning-by-doing experiences that have helped build a base of local capabilities in RE services to support localization.

In addition, the incentive to localize technology components led to interaction between OEMs and local component suppliers. Unlike in Mexico, in which wind component development was pursued independently and faced entry barriers, one instance of local tower manufacturing in South Africa was supported by a leading turbine OEM that provided both technological expertise as well as an anchor demand for the nascent component manufacturer. The high degree of intra-industry interaction also led to the formation of stronger industry associations, providing an important platform for the industry to coordinate and communicate its needs to policymakers, including with respect to local content calibrations.

Finally, with regards to localizing RE technology supply, the technology-specificity of South Africa's auctions, which outlined procurement volumes for each technology, was an intentional design calibration meant to provide greater stability of demand to promote investments in manufacturing, as noted by one policymaker: "For localization to happen, you don't only need the volumes, but your procurement needs to be planned with localization in mind. You cannot say you will procure 5 GW today and then 200 MW next year and then 2.5 GW in five years' time. That procurement plan does not support industrial development. Because you have opened the factories and you need to keep them running, meet a continuous demand" (Interviewee 39). While the procurement plan was designed to provide the market stability to foster localization, it had two key weaknesses.

Firstly, with respect to on-the-ground targets, many interviewed private sector actors argued that the procurement volumes were simply too low to support local manufacturing of core components. For solar PV, this limited market size prevented South African solar manufacturing to reach the economies of scale needed for it to compete with the leading Chinese manufacturers. As a result, localization of solar modules was generally the result of 'gaming' the local content rules, in which cheap Chinese panels were imported into South Africa, assembled with little value-added in South Africa, and then subsequently marked up to inflate local content values (known as transfer pricing). Similarly for inverters, while a production facility was set up in South Africa, it remained largely an assembly facility, with the core manufacturing occurring in Europe. For wind, although wind tower manufacturing was localized in South Africa, many wind OEMs noted that localizing the production of wind turbine blades was prohibitive, due to both the small market size (Rennkamp & Boyd, 2015) as well as the level of competition between OEMs, which further cut down market shares for each OEM-specific blade design. Furthermore, while the IRP provided the short-term visibility for market size, political debates and delays surrounding the subsequent IRP and signing of PPAs cast uncertainty over the government's long-term commitment to RE deployment. Secondly, the strict requirements regarding maturity of RE projects submitted under the REIPPPP, while it led to greater certainty that contracts would be realized, also proved detrimental to industry localization. Each procurement round produced a wave of demand, placing strain on local manufacturing facilities that needed to "ramp up to provide local content for all of those [contracted] projects that are running at the same time. Then you ramp up, and you run the risk of closing down at the end of the 18 months, because everything has died down again," (Interviewee 36).

5 Implications for green industrial policy design

The cases of renewable energy auctions in Mexico and South Africa illustrate the importance of micro-level policy design elements in shaping subsequent policy outcomes. Interestingly, both countries exhibited similarity in their policy objectives and instrument choice (meso-level) – which have typically been the focus of existing literature – however differed considerably in their micro-level policy calibrations due to a different *prioritization* of these objectives and differing instrument logics. While both countries sought to deploy low-cost RE while building local RE value chains, Mexico's approach emphasized cost reductions through a competitive free-market instrument logic while South Africa, although it also utilized competitive auctions, implemented an auction policy design that had regulatory components that aimed to meet additional socio-economic objectives, including RE industry localization. Through these distinct approaches, the two cases offer insights on formulating green industrial policy designs consistent with the objectives of low-cost RE deployment and local RE industry development.

Firstly, the results show that the potential benefits of RE industry localization may only manifest in the medium- to long-term. For example, as local RE ecosystems and value chains emerge, costs of transport and procurement can drop, making prices more competitive and the market more sustainable. Furthermore, building local capabilities along the downstream RE value chain can result in additional spillovers to the local market. For instance, local capability-building within commercial financial institutions in South Africa led to their greater willingness and capacity to engage in distributed solar PV projects outside of the REIPPPP. As realizing these long-term benefits may not be possible under a policy design that minimizes current policy costs, policy design may need to consider mechanisms for guiding policy outcomes towards long-term goals. This likely would require both the use of policy strategies (e.g., that outline long-term targets) as well as potential methods for incorporating these objectives into RE project evaluation (e.g., by making them a part of bid evaluation).

Secondly, despite the common notion that RE industry localization will occur naturally given a strong market outlook, the results of the case studies show that sufficient market size and stability is a necessary but insufficient condition for local RE value chain development. In Mexico, for example, despite the private sector's confidence in the Mexican RE market, it often exhibited path dependency with respect to value chain networks. Although local firms may have possessed the technological capabilities to supply goods or services to the RE market, foreign project developers tended to favor tapping existing foreign-based supply chains, rather than helping build organization capabilities within local firms. As a result, policy interventions such as local content may be required to break these path dependencies and to accelerate the process of integrating existing local suppliers into the RE value chain.

While local content requirements can be utilized to achieve greater RE industry localization, these thresholds should be carefully calibrated in order to find a balance between pushing the industry to realize greater local value, setting overly ambitious targets that may unnecessarily increase deployment cost, or even setting unreachable targets that may deter private investment altogether. In particular, local content thresholds should consider the following aspects. Firstly, these thresholds must begin with an assessment of existing and technology-specific capabilities, and should be increased over time according to reassessments of locally built capabilities. Provided local content is calibrated in collaboration with industry, this mechanism can be an effective way to foster learning-by-interacting among local and global private sector actors, rather than pushing this role to the public sector, as is the case in Mexico. Higher thresholds can be realized over time by implementing complementary measures, such as supporting capability-building initiatives like South Africa's SARETEC or the formation of green industrial parks. However, setting aggressive local content thresholds that would necessitate the localization of core components or complex components for which no local capabilities exist could damage the bankability of the project, deterring deployment altogether. Unreachable thresholds could also lead to 'gaming,' such as through transfer pricing in South Africa, leading to higher project costs without any local value added, as has been found in similar studies (Baker & Sovacool, 2017; Rennkamp & Boyd, 2015).

Secondly, local content should also account for the dynamic development of technology costs – particularly if thresholds are denominated in terms of percentage of total project investment – as global cost dynamics can significantly affect the cost share of certain components. Thirdly, and related to the previous point, the design of local content policy should consider the creation of incentives to localize downstream value chain activities such as EPC and project development, as was the case in South Africa's design in which local content was measured as a percentage of the total project investment and greater weight was placed on local ownership structures. The typical focus on localizing component manufacturing (e.g., as in Brazil (Hochstetler, 2015)) can lead to a lost opportunity to capture a market share of high value-added and job-creating activities. The long-term benefits of greater localization of these service-oriented value chain activities are likely to grow in importance as global learning drives down the hardware costs of RE technologies. As hardware costs drop, soft cost components become greater differentiators of RE cost-competitiveness (Bolinger, Seel, & LaCommare, 2017). Developing the tacit knowledge for these activities though learning-by-doing in project implementation can be a valuable and 'exportable' activity in itself

(Steffen et al., 2018). While even foreign project developers and EPC players must often create local teams, typically the decision-making centers, and technical and managerial expertise remain in the home country. Finally, if local content is pursued, not only market size but market stability must be considered. Consequently, local content requirements should be accompanied by a deployment policy that outlines and follows through on long-term deployment targets, as well as avoids 'boom-and-bust' demand cycles (e.g., by staggering operation dates of projects). While this paper focuses on RE policies, green industrial policy design is also likely to matter for policy outcomes concerning the deployment of other technologies within the energy sector (e.g., energy efficiency measures in buildings) and beyond (e.g., transport or emissions-intensive industry), as long as these technologies require substantial downstream value chain activities, such as project development, EPC, and project finance.

Finally, while this paper explored how different policy objectives shaped policy design, it had largely taken policy objectives as given, without exploring the drivers behind policy decisions. While previous research has investigated the politics of formulating RE policy design (Baker et al., 2014; Jacobsson & Lauber, 2006; Newell & Phillips, 2016; Rennkamp, Haunss, Wongsa, Ortega, & Casamadrid, 2017), including local content (Baker & Sovacool, 2017)), future research could consider how the outcomes of green industrial policies feedback into the policy making process, both from the standpoint of creating new actors to support low-carbon energy transitions and their role in subsequent calibrations of policy design. Furthermore, this study provided evidence of the role of different auction calibrations in shaping policy outcomes using a qualitative comparative case study research design. Future research using quantitative multi-case analyses (going beyond RE policy) could provide further empirical support for the relevance of certain auction design elements in fostering both short- and long-term policy outcomes.

Acknowledgements:

We gratefully acknowledge the support of our interview partners. We would also like to thank the participants of the "Green transformation and competitive advantage: Evidence from developing countries" workshop hosted by the German Development Institute in Bonn, as well as Martin Beuse, Leonore Haelg, Abhishek Malhotra, Nicolas Schmid, Sebastian Sewerin, Arun Singh, and Bjarne Steffen for providing useful feedback on earlier versions of this work. This work was supported by the Swiss National Science Foundation (Project number PYAPP1_166905), which had no involvement in the research design, implementation, or writing of this paper. All errors remain our own.

6 Appendix

Indicator	Indicator year	Unit	Mexico	South Africa
Population	2017	People	129,163,280	56,717,160
GDP per capita	2017	Current US$	8,902.80	6,160.70
Industry share of GDP	2016	%	23.52	23.86
Manufacturing share of GDP	2016	%	17.99	13.5
External debt as percentage of GDP	2016	%	40.7	50.9
Electricity production	2017	GWh	320,353	252,747
Contracted wind and solar PV capacity	2017	GW	7.7	5.6
CO_2 emissions	2014	Kt	480,271	489,772

Table A.1: Overview of selected economic and energy-related indicators for Mexico and South Africa (OECD, 2018a; World Bank, 2018)

7 References

Alpizar-Castro, I., & Rodríguez-Monroy, C. (2016). Review of Mexico's energy reform in 2013: Background, analysis of the reform and reactions. *Renewable and Sustainable Energy Reviews*, *58*, 725–736. https://doi.org/10.1016/j.rser.2015.12.291

Alvarez, J., & Valencia, F. (2015). *Made in Mexico: Energy reform and manufacturing growth*. *IMF Working Paper* (Vol. 15/45). https://doi.org/10.1016/j.eneco.2016.01.016

Azar, C., & Sandén, B. A. (2011). The elusive quest for technology-neutral policies. *Environmental Innovation and Societal Transitions*, *1*(1), 135–139. https://doi.org/10.1016/j.eist.2011.03.003

Baker, L. (2015). The evolving role of finance in South Africa's renewable energy sector. *Geoforum*, *64*, 146–156. https://doi.org/10.1016/j.geoforum.2015.06.017

Baker, L., Newell, P., & Phillips, J. (2014). The Political Economy of Energy Transitions: The Case of South Africa. *New Political Economy*, *19*(6), 791–818. https://doi.org/10.1080/13563467.2013.849674

Baker, L., & Sovacool, B. K. (2017). The political economy of technological capabilities and global production networks in South Africa's wind and solar photovoltaic (PV) industries. *Political Geography*, *60*, 1–12. https://doi.org/10.1016/j.polgeo.2017.03.003

Bell, M., & Pavitt, K. (1993). Accumulating technological capability in developing countries. *Proc. World Bank Annual Conference on Development Economics, 1992*, (November), 257–281. https://doi.org/10.1093/wber/6.suppl_1.257

Bell, Martin, & Figueiredo, P. N. (2012). Innovation capability building and learning mechanisms in latecomer firms: recent empirical contributions and implications for research. *Canadian Journal of Development Studies/Revue Canadienne d'études Du Développement*, *33*(1), 14–40. https://doi.org/10.1080/02255189.2012.677168

Bergek, A., Mignon, I., & Sundberg, G. (2013). Who invests in renewable electricity production? Empirical evidence and suggestions for further research. *Energy Policy*, *56*, 568–581. https://doi.org/10.1016/j.enpol.2013.01.038

Binz, C., Gosens, J., Hansen, T., & Hansen, U. E. (2017). Toward Technology-Sensitive Catching-Up Policies: Insights from Renewable Energy in China. *World Development*, *96*, 418–437. https://doi.org/10.1016/j.worlddev.2017.03.027

Bolinger, M., Seel, J., & LaCommare, K. H. (2017). *Utility-Scale Solar 2016: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*. Berkeley. Retrieved from https://emp.lbl.gov/sites/default/files/utility-scale-solar-2016-report.pdf

Bowen, A., & Fankhauser, S. (2011). The green growth narrative: Paradigm shift or just spin? *Global Environmental Change*, *21*(4), 1157–1159. https://doi.org/10.1016/j.gloenvcha.2011.07.007

Burton, J., & Winkler, H. (2014). *South Africa's planned coal infrastructure expansion: drivers, dynamics and impacts on greenhouse gas emissions*. Cape Town: Energy Research Centre Research Report Series.

Carreon-Rodriguez, V., Vicente, A. J. S., & Rosellon, J. (2003). *Mexican Electricity Sector: Economic, Legal and Political Issues* (Program on Energy and Sustainable Development No. 5). Stanford. Retrieved from http://fsi.stanford.edu/sites/default/files/WP5,_10_May_2004.pdf

Cashore, B., & Howlett, M. (2007). Punctuating which equilibrium? Understanding thermostatic policy dynamics in Pacific Northwest forestry. *American Journal of Political Science*, *51*(3), 532–551. https://doi.org/10.1111/j.1540-5907.2007.00266.x

CENACE. (2018). Subastas de Largo Plazo. Retrieved from https://www.cenace.gob.mx/paginas/publicas/mercadooperacion/subastaslp.aspx

CFE. (2018). Generación bruta de energía por tecnología. Secretaría de Energía. Retrieved from http://sie.energia.gob.mx/bdiController.do?action=cuadro&cvecua=IIIA1C05

Chaminade, C., Lundvall, B.-A., Vang, J., & Joseph, K. J. (2009). Designing innovation policies for development: towards a systemic experimentation-based approach. In B.-A. Lundvall, K. J. Joseph, C. Chaminade, & J. Vang (Eds.), *Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting* (pp. 360–379). Cheltenham: Edward Elgar Publishing Limited.

Considine, M., Alexander, D., & Lewis, J. M. (2014). Policy design as craft: Teasing out policy design expertise using a semi-experimental approach. *Policy Sciences*, *47*(3), 209–225. https://doi.org/10.1007/s11077-013-9191-0

Curran, L. (2015). The impact of trade policy on global production networks: the solar panel case. *Review of International Political Economy*, *22*(5), 1025–1054. https://doi.org/10.1080/09692290.2015.1014927

Del Río, P. (2012). The dynamic efficiency of feed-in tariffs: The impact of different design elements. *Energy Policy*, *41*, 139–151. https://doi.org/10.1016/j.enpol.2011.08.029

Del Río, P., & Linares, P. (2014). Back to the future? Rethinking auctions for renewable electricity support. *Renewable and Sustainable Energy Reviews*, *35*, 42–56. https://doi.org/10.1016/j.rser.2014.03.039

Department of Energy. (2015). Commodity Flows and Energy Balances. Retrieved from http://www.energy.gov.za/files/media/Energy_Balances.html

Diario Oficial de la Federación. Programa Especial para el Aprovechamiento de Energías Renovables (2014). Mexico.

Eberhard, A., Leigland, J., & Kolker, J. (2014). *South Africa's Renewable Energy IPP Procurement Program: Success Factors and Lessons*. Washington, D.C.: The World Bank Group.

Fagerberg, J. (1995). User-producer interaction, learning and comparative advantage. *Cambridge Journal of Economics*, *19*, 243–256.

Fine, B., & Rustomjee, Z. (1996). *The Political Economy of South Africa: From Minerals Energy Complex to Industrialisation*. Boulder: Westview Press.

Fouquet, R. (2016). Path dependence in energy systems and economic development. *Nature Energy*, *1*, 1–5. https://doi.org/10.1038/nenergy.2016.98

Fu, X., Pietrobelli, C., & Soete, L. (2011). The Role of Foreign Technology and Indigenous Innovation in the Emerging Economies: Technological Change and Catching-up. *World Development*, *39*(7), 1204–1212. https://doi.org/10.1016/j.worlddev.2010.05.009

Gann, D. M., & Salter, A. J. (2000). Innovation in project-based, service-enhanced firms: the construction of complex products and systems. *Research Policy*, *29*, 955–972. https://doi.org/10.1016/S0048-7333(00)00114-1

Gillingham, K., & Sweeney, J. (2010). Market Failure and the Structure of Externalities. In B. Moselle, J. Padilla, & R. Schmalensee (Eds.), *Harnessing Renewable Energy in Electric Power Systems: Theory, Practice* (pp. 69–92). New York: Routledge.

Haelg, L., Sewerin, S., & Schmidt, T. S. (2018). Agency in policy design : the case of the Swiss renewable energy feed-in tariff. In *First international workshop on public policy IWPP1*. Pittsburgh.

Haelg, L., Waelchli, M., & Schmidt, T. S. (2018). Supporting energy technology deployment while avoiding unintended technological lock-in: A policy design perspective. *Environmental Research Letters*. https://doi.org/https://doi.org/10.1088/1748-9326/aae161

Hall, P. A. (1993). Policy Paradigms , Social Learning , and the State : The Case of Economic Policymaking in Britain. *Comparative Politics*, *25*(3), 275–296. Retrieved from http://www.energy.gov.za/files/media/Energy_Balances.html

Hallegatte, S., Fay, M., & Vogt-Schilb, A. (2013). Green Industrial Policies - When and How. *World Bank Policy Research Working Papers*, (October), 26. Retrieved from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/10/28/000158349_20131028085557/Rendered/PDF/WPS6677.pdf

Hansen, U. E., & Nygaard, I. (2014). Sustainable energy transitions in emerging economies: The formation of a palm oil biomass waste-to-energy niche in Malaysia 1990-2011. *Energy Policy*, *66*, 666–676. https://doi.org/10.1016/j.enpol.2013.11.028

Hochstetler, K. (2015). Green Industrial Policy and the Renewable Energy Transition: Can it be Good Industrial Policy? In *Red de Economia Politica de America Latina*. Montevideo. https://doi.org/10.1017/CBO9781107415324.004

Hoppmann, J., Peters, M., Schneider, M., & Hoffmann, V. H. (2013). The two faces of market support - How deployment policies affect technological exploration and exploitation in the solar photovoltaic industry. *Research Policy*, *42*(4), 989–1003. https://doi.org/10.1016/j.respol.2013.01.002

Howlett, M. (2009). Governance modes, policy regimes and operational plans: A multi-level nested model of policy instrument choice and policy design. *Policy Sciences*, *42*(1), 73–89. https://doi.org/10.1007/s11077-009-9079-1

Howlett, M. (2014). From the “old” to the “new” policy design: Design thinking beyond markets and collaborative governance. *Policy Sciences*, *47*(3), 187–207. https://doi.org/10.1007/s11077-014-9199-0

Howlett, M., & Cashore, B. (2009). The Dependent Variable Problem in the Study of Policy Change: Understanding Policy Change as a Methodological Problem. *Journal of Comparative Policy Analysis: Research and Practice*, *11*(1), 33–46. https://doi.org/10.1080/13876980802648144

Huenteler, J., Niebuhr, C., & Schmidt, T. S. (2016). The effect of local and global learning on the cost of renewable energy in developing countries. *Journal of Cleaner Production*, *128*(August), 6–21. https://doi.org/10.1016/j.jclepro.2014.06.056

Huenteler, J., Schmidt, T. S., Ossenbrink, J., & Hoffmann, V. H. (2016). Technology life-cycles in the energy sector - Technological characteristics and the role of deployment for innovation. *Technological Forecasting and Social Change*, *104*, 102–121. https://doi.org/10.1016/j.techfore.2015.09.022

IEA. (2014). *Africa Energy Outlook. A focus on energy prospects in Sub-Saharan Africa*. Paris.

IEA. (2016). *Mexico Energy Outlook*. Paris. Retrieved from https://www.iea.org/publications/freepublications/publication/MexicoEnergyOutlook.pdf

IEA. (2017). *Energy Policies Beyond IEA Countries: Mexico 2017*. Paris. Retrieved from https://e3gorg.sharepoint.com/GIB Mexico/EnergyPoliciesBeyondIEACountriesMexico2017.pdf#search=position

IEA. (2018). OECD - Electricity/heat supply and consumption. Paris: IEA Electricity Information Statistics. https://doi.org/http://dx.doi.org/10.1787/data-00462-en

IRENA. (2017). *Renewable Energy Auctions : Analysing 2016*. *Renewable Energy Auctions : Analysing 2016* (Vol. 1). Retrieved from http://www.irena.org/DocumentDownloads/Publications/IRENA_REAuctions_summary_2017.pdf

Jacobsson, S., & Lauber, V. (2006). The politics and policy of energy system transformation - Explaining the German diffusion of renewable energy technology. *Energy Policy*, *34*(3), 256–276. https://doi.org/10.1016/j.enpol.2004.08.029

Kemp, R., & Pontoglio, S. (2011). The innovation effects of environmental policy instruments - A typical case of the blind men and the elephant? *Ecological Economics*, *72*, 28–36. https://doi.org/10.1016/j.ecolecon.2011.09.014

Kern, F., & Howlett, M. (2009). Implementing transition management as policy reforms: A case study of the Dutch energy sector. *Policy Sciences*, *42*(4), 391–408. https://doi.org/10.1007/s11077-009-9099-x

Kern, F., Kuzemko, C., & Mitchell, C. (2014). Measuring and explaining policy paradigm change: the case of UK energy policy. *Policy & Politics*, *42*(4), 513–530. https://doi.org/https://doi.org/10.1332/030557312X655765

Lall, S. (1992). Technological capabilities and industrialization. *World Development*, *20*(2), 165–186. https://doi.org/10.1016/0305-750X(92)90097-F

Lewis, J. I. (2011). Building a national wind turbine industry: experiences from China, India and South Korea. *International Journal of Technology and Globalisation*, *5*(3/4), 281. https://doi.org/10.1504/IJTG.2011.039768

Lewis, J. I., & Wiser, R. H. (2007). Fostering a renewable energy technology industry: An international comparison of wind industry policy support mechanisms. *Energy Policy*, *35*(3), 1844–1857. https://doi.org/10.1016/j.enpol.2006.06.005

Lipp, J. (2007). Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. *Energy Policy*, *35*(11), 5481–5495. https://doi.org/10.1016/j.enpol.2007.05.015

Lundvall, B.-Å., Johnson, B., Andersen, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research Policy*, *31*(2), 213–231.

https://doi.org/10.1016/S0048-7333(01)00137-8

Malerba, F. (1992). Learning by Firms and Incremental Technical Change. *The Economic Journal*, *102*(413), 845–859.

Matsuo, T., & Schmidt, T. (2017). Hybridizing low-carbon technology deployment policy and fossil fuel subsidy reform: a climate finance perspective. *Environmental Research Letters*.

May, P. J. (2003). Policy Design and Implementation. In G. Peters & J. Pierre (Eds.), *Handbook of Public Administration* (B). London: SAGE.

Mazzucato, M., & Semieniuk, G. (2018). Financing renewable energy: Who is financing what and why it matters. *Technological Forecasting and Social Change*, *127*(May 2017), 8–22. https://doi.org/10.1016/j.techfore.2017.05.021

Meadowcroft, J. (2011). Engaging with the politics of sustainability transitions. *Environmental Innovation and Societal Transitions*, *1*(1), 70–75. https://doi.org/10.1016/j.eist.2011.02.003

Moe, E. (2010). Energy, industry and politics: Energy, vested interests, and long-term economic growth and development. *Energy*, *35*(4), 1730–1740. https://doi.org/10.1016/j.energy.2009.12.026

Morrison, A., Pietrobelli, C., & Rabellotti, R. (2008). Global Value Chains and Technological Capabilities: A Framework to Study Learning and Innovation in Developing Countries. *Oxford Development Studies*, *36*(1), 39–58. https://doi.org/10.1080/13600810701848144

Mowery, D. C., & Rosenberg, N. (1982). Market demand and innovation. In *Inside the Black Box* (pp. 193–241). Cambridge: Cambridge University Press.

Nahm, J., & Steinfeld, E. S. (2014). Scale-up Nation: China's Specialization in Innovative Manufacturing. *World Development*, *54*, 288–300. https://doi.org/10.1016/j.worlddev.2013.09.003

Nemet, G. F. (2009). Demand-pull, technology-push, and government-led incentives for non-incremental technical change. *Research Policy*, *38*(5), 700–709. https://doi.org/10.1016/j.respol.2009.01.004

Newell, P., & Phillips, J. (2016). Neoliberal energy transitions in the South: Kenyan experiences. *Geoforum*, *74*, 39–48. https://doi.org/10.1016/j.geoforum.2016.05.009

OECD. (2018a). OECD Statistics. Retrieved from https://www.oecd-ilibrary.org/statistics

OECD. (2018b). Value added by activity (indicator). https://doi.org/10.1787/a8b2bd2b-en

Pietrobelli, C., & Rabellotti, R. (2011). Global Value Chains Meet Innovation Systems: Are There Learning Opportunities for Developing Countries? *World Development*, *39*(7), 1261–1269. https://doi.org/10.1016/j.worlddev.2010.05.013

Polzin, F., Migendt, M., Täube, F. A., & von Flotow, P. (2015). Public policy influence on renewable energy investments-A panel data study across OECD countries. *Energy Policy*, *80*, 98–111. https://doi.org/10.1016/j.enpol.2015.01.026

Pueyo, A., Garcoa, R., Mendiluce, M., & Morales, D. (2011). The role of technology transfer for the development of a local wind component industry in Chile. *Energy Policy*, *39*(7), 4274–4283. https://doi.org/10.1016/j.enpol.2011.04.045

Quitzow, R. (2015a). Assessing policy strategies for the promotion of environmental technologies: A review of India's National Solar Mission. *Research Policy*, *44*(1), 233–243. https://doi.org/10.1016/j.respol.2014.09.003

Quitzow, R. (2015b). Dynamics of a policy-driven market: The co-evolution of technological innovation systems for solar photovoltaics in China and Germany. *Environmental Innovation and Societal Transitions*, *17*, 126–148. https://doi.org/10.1016/j.eist.2014.12.002

Quitzow, R., Huenteler, J., & Asmussen, H. (2017). Development trajectories in China's wind and solar energy industries: How technology-related differences shape the dynamics of industry localization and catching up. *Journal of Cleaner Production*, *158*, 122–133. https://doi.org/10.1016/j.jclepro.2017.04.130

REN21. (2017). *Renewables 2017 global status report 2017*. Paris.

Rennkamp, B., & Boyd, A. (2015). Technological capability and transfer for achieving South Africa's development goals. *Climate Policy*, *14*(June), xx. https://doi.org/10.1080/14693062.2013.831299

Rennkamp, B., Haunss, S., Wongsa, K., Ortega, A., & Casamadrid, E. (2017). Competing coalitions: The politics of renewable energy and fossil fuels in Mexico, South Africa and Thailand. *Energy Research and Social Science*, *34*(December 2016), 214–223. https://doi.org/10.1016/j.erss.2017.07.012

Republic of South Africa Department of Energy. Integrated Resource Plan for Electricity (2010) (2010).

Republic of South Africa Department of Energy. (2015). Renewable Energy IPP Procurement Programme Bid Window 4 Preferred Bidders' Announcement.

Robles, A. C. (2016). Tracking the Progress of Mexico's Power Sector Reform. *Wilson Center-Mexico Institute*, (April), 35. Retrieved from https://www.wilsoncenter.org/sites/default/files/tracking_progress_of_mexicos_power_sector_reform.pdf

Rodrik, D. (2014). Green industrial policy. *Oxford Review of Economic Policy*, *30*(3), 469–491. https://doi.org/10.1093/oxrep/gru025

Sagar, A. D., & van der Zwaan, B. (2006). Technological innovation in the energy sector: R&D, deployment, and learning-by-doing. *Energy Policy*, *34*(17), 2601–2608. https://doi.org/10.1016/j.enpol.2005.04.012

Schaffrin, A., Sewerin, S., & Seubert, S. (2015). Toward a Comparative Measure of Climate Policy Output. *Policy Studies Journal*, *43*(2).

Schmidt, T. S. (2014). Low-carbon investment risks and de-risking. *Nature Climate Change*, *4*(April), 237–239.

Schmidt, T. S., & Huenteler, J. (2016). Anticipating industry localization effects of clean technology deployment policies in developing countries. *Global Environmental Change*, *38*, 8–20. https://doi.org/10.1016/j.gloenvcha.2016.02.005

Schmidt, T. S., & Sewerin, S. (2017). Technology as a driver of climate and energy politics. *Nature Energy*, *2*(May), 17084. https://doi.org/10.1038/nenergy.2017.84

Schmidt, T. S., & Sewerin, S. (2018). Measuring the temporal dynamics of policy mixes – An empirical analysis of renewable energy policy mixes ' balance and design features in nine countries. *Research Policy*. https://doi.org/10.1016/j.respol.2018.03.012

Seawright, J., & Gerring, J. (2008). Case Selection Techniques in A Menu of Qualitative and Quantitative Options. *Political Research Quarterly*, *61*(2), 294–308.

Shum, K. L., & Watanabe, C. (2008). Towards a local learning (innovation) model of solar photovoltaic deployment. *Energy Policy*, *36*(2), 508–521. https://doi.org/10.1016/j.enpol.2007.09.015

Stats SA. (2017a). Mining: A brief history.

Stats SA. (2017b). *Quarterly Labour Force Survey*. Retrieved from http://www.statssa.gov.za/publications/P0211/P02114thQuarter2016.pdf

Steffen, B. (2018). The importance of project finance for renewable energy projects. *Energy Economics*, *69*, 280–294. https://doi.org/10.1016/j.eneco.2017.11.006

Steffen, B., Matsuo, T., Steinemann, D., & Schmidt, T. S. (2018). Opening new markets for clean energy: The role of project developers in the global diffusion of renewable energy technologies. *Business and Politics*, (forthcoming). https://doi.org/10.1017/bap.2018.17

Surana, K., & Anadon, L. D. (2015). Public policy and financial resource mobilization for wind energy in developing countries: A comparison of approaches and outcomes in China and India. *Global Environmental Change*, *35*, 340–359. https://doi.org/10.1016/j.gloenvcha.2015.10.001

Unruh, G. C. (2002). Escaping carbon lock-in. *Energy Policy*, *30*(4), 317–325.

https://doi.org/10.1016/S0301-4215(01)00098-2

Uzzi, B., & Lancaster, R. (2003). Relational Embeddedness and Learning: The Case of Bank Loan Managers and Their Clients. *Management Science*, *49*(4), 383–399. https://doi.org/10.1287/mnsc.49.4.383.14427

Walwyn, D. R., & Brent, A. C. (2014). Renewable energy gathers steam in South Africa. *Renewable and Sustainable Energy Reviews*, *41*, 390–401. https://doi.org/10.1016/j.rser.2014.08.049

World Bank. (2018). World Bank Indicators. Retrieved from https://data.worldbank.org/indicator

Zhang, F., & Gallagher, K. S. (2016). Innovation and technology transfer through global value chains: Evidence from China's PV industry. *Energy Policy*, *94*, 191–203. https://doi.org/10.1016/j.enpol.2016.04.014