Energy Policy 129 (2019) 1179–1189

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

What explains India's embrace of solar? State-led energy transition in a developmental polity

Sarang Shidore, Joshua W. Busby*

LBJ School of Public Affairs, University of Texas-Austin, USA

ARTICLE INFO

Keywords:
India
Solar energy
Energy transitions

ABSTRACT

In late 2014, India announced plans to increase the deployment of solar technology from 20 GW to 100 GW by 2022 and followed this up by putting in place a set of robust policies to achieve this target. What explains India's strong push to adopt solar electricity? Conventional wisdom mostly credits techno-economic factors, such as falling module prices and competitive bidding to explain this embrace. Though these factors undoubtedly aided the scale-up, solar power was substantially more expensive than domestic coal in the 2014–17 period under study. We conducted 23 elite interviews with former and current Indian government officials, think-tank researchers, consultants, private sector executives, Indian media, and two U.S. officials. We evaluated nine possible drivers behind the Indian government's policy push on solar going beyond the techno-economic emphasis on declining panel prices. Based on the interviews and a review of other observable implications of the various drivers, four chiefly political drivers clearly stood out: *domestic politics, global pressure and partnerships, attracting investment, and energy sovereignty*. Prime Minister Modi embraced solar to bolster his domestic image as a modernizing reformer and to boost India's reputation internationally. Solar also aimed to leverage investment and dampen India's dependence on energy imports.

1. Introduction

In late 2014, India announced plans to increase the deployment of solar technology from 20 GW to 100 GW by 2022. This pledge was not mere words. Between 2014 and 2017, the country increased its installed solar capacity from 2.4 GW to 19.6 GW (Prateek, 2018a; World Resources Institute, 2017). While still only about 6% of the net generation capacity (and 2% of final electricity consumption), a close to 10-fold increase in this figure in four years was dramatic (Bridge to India, 2018).

At the same time, the country sought to reposition itself as a global leader on solar energy. In the midst of the 2015 Paris climate negotiations, India announced that, with the help of the government of France, it would serve as host for the International Solar Alliance, an effort to boost the diffusion of solar technology around the world (Modi, 2015). The scale up of solar electricity represents about half of India's estimated emissions reductions under the Paris climate agreement, and the country has made major progress in meeting these goals (Sivaram et al., 2015; Safi, 2016). The country's 2018 National Electricity Plan set a goal of achieving 275 GW of renewables capacity by 2027, with solar accounting for two-thirds of this figure. What explains the Indian government's push to adopt solar electricity?

Conventional wisdom mostly credits techno-economic factors, such as falling module prices and the adoption of competitive bidding. However, as we argue, solar power was substantially more expensive than domestic coal (the country's main fuel source for the electricity sector) in the 2014–17 period under study, and remains so. Some narratives also credit policy initiatives such as solar parks and payment guarantee mechanisms, but they rarely probe into what drove this policy focus in the first place. If, as we argue, techno-economic factors do not alone or even primarily explain the Indian government's embrace of pro-solar policies, what then does? This question animates this article.

Answering this question is important as the United States' intended withdrawal from the Paris agreement has called into question the durability of country commitments to mitigation targets. India is key to whether these targets will be met (Sivaram et al., 2015). A better understanding of Indian motivations is therefore important.

This research is also relevant to examine a commonly-held view that market dynamics will alone or mostly enable the solar revolution. If policy was an essential factor that drove India's solar rise, then the direction of policy may be critical for other countries, and a methodology for detection of these shifts through isolation of its drivers could empower policymakers and researchers.

* Corresponding author.
E-mail address: busbyj@utexas.edu (J.W. Busby).

https://doi.org/10.1016/j.enpol.2019.02.032
Received 28 June 2018; Received in revised form 6 February 2019; Accepted 11 February 2019

We conducted two rounds of elite interviews in India between October and December 2017 with 23 former and current Indian government officials, think-tank researchers, consultants, private sector executives, and energy experts in the Indian media. Interviews with two U.S. officials were carried out in 2018 (see Appendix A for a list of anonymized interviewees).[1] We sought to ascertain the primary and secondary drivers behind the Indian government's decision in late 2014/early 2015 to target 100 GW capacity of solar power and put in place policies to implement this target. Four drivers stood out from the rest (Fig. 4). These include *domestic politics, global pressure and partnerships, energy sovereignty, and attracting investment*.

The paper is structured as follows. Section 2 lays out the theoretical framework that informs our work. It is centered on the less-emphasized lens of politics in explaining India's energy transition push. Section 3 explains our methods. Section 4 provides details of India's solar takeoff. Section 5 demonstrates the adverse techno-economic factors at play for Indian solar in the 2014–17 time frame. Section 6 lays out our key findings of the four drivers that we argue were responsible for policy prioritization of solar in India. The final section discusses the implications for the sustainability of India's solar plans and ties our findings back to the theoretical framework.

2. Theoretical framework

Energy transitions have been the focus of much research in past years. In a comprehensive summary, Cherp et al. identified three major theoretical frameworks in the energy transitions literature – energy flows and markets, socio-technical, and political (Cherp et al., 2018). For the energy flows approach, energy transitions are a function of the emergence of new energy sources that become more competitive on global markets with new discoveries. For the related socio-technical approach, energy flows are facilitated by innovations in new technologies, management strategies, and infrastructure (Kern and Markard, 2016). While policy choices may be relevant in socio-technical explanations (Wu et al., 2018; Horbach and Rammer, 2018; Vazquez and Hallack, 2018; Rogge et al., 2017), political approaches emphasize the role of interest groups, electoral considerations, ideology, moral concerns, and other factors (Healy and Barry, 2017; Jenkins et al., 2018; Frei et al., 2018; Della Bosca and Gillespie, 2018; Pollitt, 2012).

Each of these frameworks has its origins in different fields of study – energy flows and markets in economics and engineering, socio-technical frameworks in innovation studies, and political frameworks in political science. The three frameworks rarely engage with each other and focus on different aspects of what is in fact a unified phenomenon of energy transitions. We accept Cherp's argument of the need to bridge the three theoretical frameworks in energy transitions research.

Our study contributes to the energy transitions literature in three ways. Our first is to bridge the political with the techno-economic to explain India's solar push more fully.[2] Energy transition studies have only recently engaged with political frameworks (Breetz et al., 2018). We agree with Meadowcroft on emphasizing the "everyday politics that stand behind everyday policy" (Meadowcroft, 2009). Given that renewable technologies are still governed to some extent by support mechanisms such as subsidies, quotas, and standards, understanding the political drivers behind the formulation of pro-renewables policies is vital for understanding their longer-term sustainability. This is especially important in energy transitions, as historically they have taken anything from 25 to 50 years or more (Fouquet, 2016; Smil, 2016, 2017; Fouquet and Pearson, 2012), though the speed of a possible clean energy transition remains highly contested (Sovacool, 2016; Sovacool and Geels, 2016; Grubler, 2012; Allen, 2012; Madureira, 2012).[3] When it comes to goods deemed private but with strong implications for the public interest such as healthcare and energy, states in coalition with advocates (such as civil society actors) have often been market-makers (Kapstein and Busby, 2013). In existing political explanations for the rise of renewables, crises like the 1973 oil embargo created an opening for renewables' entry in to the market and provided a rationale for diversification from fossil fuels, aided by strong support from national leadership and domestic environmental lobbies. Over time, the rise of renewables industries created a built-in constituency for their continuation (Breetz et al., 2018; Aklin and Urpelainen, 2018; Fouquet, 2012). In the Indian experience, there was no crisis triggering the 2014 decision to scale-up solar, nor was there an environmental lobby with significant clout in favor of scale-up. We thus have to look for other explanations.

Second, we extend past researchers' focus on national politics to include international political factors by incorporating insights from an international relations understanding of India's priorities. Such factors turn out to be important in a developing country with global aspirations such as India, engaged in a major shift in its geopolitical orientation from the 1990s onwards. As we show, global factors – specifically global pressures on India on climate action and an Indian desire for enhanced partnerships with major powers such as the US and France – were a key motivator of India's solar ambitions.

Third, existing analyses and case studies in the energy transitions literature overwhelmingly focus on advanced economies. But, given their latent energy demand and imperative to catch-up economically with advanced countries, large developing economies such as India and China are sites of the more important energy transitions. We hope that our approach on analyzing India's energy transition can be extended to other developing countries.

The lens of political science provides a useful complement in understanding India's solar scale-up for several reasons. Electricity is a major political issue in India due to the fact that around 250 million Indians lack access, and many others receive only a limited supply. "*Bijli-sadak-pani*" (electricity-roads-water) is often a staple slogan in election campaigns. Indian electricity consumers are highly tariff-sensitive, and farmers get free or low-cost electricity in most states, creating barriers to reform. India's electricity sector has evolved in a hugely path-dependent manner, linked deeply to regional evolution of its politics, with its roots before independence (Kale, 2012). Currently, it has significant private sector participation – solar generation, for example, is predominantly in private hands, and new coal plants have been mainly private-sector driven. However, due to legacy effects, a majority of power generation still remains state-owned, as does the entirety of transmission and practically all distribution. Thus the state turns out to be both a critical enabler and potential deterrent in shaping solar's rise. We show that enhanced solar policies executed since 2014 by the central government have a strong political logic, without which the scale-up would have been much more modest.

Two theories of the modern state exist (Hall, 1993). A pluralist model sees it as essentially an algebraic sum of the competing influences of various domestic interest groups (Hess, 2014; Breetz et al., 2018). In this largely bottom-up model, policy outcomes are the result of the relative power and efficacy of these interest groups. An alternative top-down theory of state-led development frames the state as a chiefly autonomous actor driven by its own preferences and national goals. Theories of developing countries also distinguish between predatory and developmental states (Johnson, 1982; Kohli, 2004). A predatory state is a rent-seeking entity that undermines development by

[1] Seven interviewees were repeated as the second author participated in a second round of fieldwork.

[2] The socio-technical framework is less relevant to India's energy transition, as the country is largely an "innovation-taker" rather than "innovation-maker" in the solar space, importing 90% of its panels from China.

[3] Fouquet himself did not see public support as necessary in every energy transition, notably the steam engine. We thank an anonymous reviewer for this point.

Plural, Developmental	Plural, Predatory
(United States in the 20th century)	*(Haiti after Duvalier)*
Autonomous, Developmental	**Autonomous, Predatory**
(Asian Tigers)	*(Zaire under Mobutu)*

Fig. 1. Typology of state types.

diverting national resources to narrow, private interest groups. A developmental state however aims to fulfill certain national goals, often led by a political and/or bureaucratic class that has some autonomy. We can identify examples of predatory and developmental varieties for both plural and autonomous states, generating the typology below (see Fig. 1 above).

High-growth East Asian economies most closely fit the autonomous, developmental state category. States can, of course, also lie between these ideal types in both dimensions (Evans, 1995). In "semi-autonomous" states, spaces of autonomy in some sectors can co-exist with spaces of pluralism. Some sectors may be more developmental with others more predatory. India is both semi-autonomous and semi-developmental, but major subnational variations in institutions complicate this characterization (Sinha, 2003).

If, as we argue in section 4, that declining market prices alone are not responsible for the solar take-off in India in and after 2014, then political factors must be part of the equation, helping explain the 100 GW target and subsequent policy push. While elements of pluralism exist in India, there was no bottom-up demand for solar from established interest groups.[4] Indeed, the most powerful interest groups in the energy space, namely coal lobbies and electricity distribution companies (Discoms), have interests that conflict with the growth of solar.

That leaves us with a semi-autonomous state, neither fully pluralist nor fully autonomous, to understand the solar scale-up. At the level of the central government, we see more of an autonomous state operative with pluralist dynamics around solar policy more evident in Indian states. This paper is focused on governance at the national level in India. In the conclusion, we come back to what evidence might suggest whether developmental or predatory best describes the national state in the solar space.

To the extent India's solar scale-up was a process led by a semi-autonomous Indian state, we need to understand the motivations that factored in to decision-making. Before beginning the research process, we hypothesized possible drivers of the scale-up – (1) to address air pollution and enhance efficiency, (2) to attract foreign investment, (3) to shore up the security of energy supplies, (4) to guarantee energy sovereignty, (5) to enhance the governing party's political fortunes, (6) to lower generation costs, (7) to boost the country's international reputation, (8) to extend energy access, and (9) to address climate change. Some of these like energy access, efficiency, and security have been mooted by others (Ghosh, 2015). Attracting foreign investment and energy sovereignty were either long-standing goals of previous Indian governments, stated priorities of Prime Minister Modi, or both. We also considered electoral calculations as a plausible driver as well as ideational and reputational explanations from international relations (Downs and Jones, 2002; Erickson, 2014).

3. Methods

Having established possible drivers of the India's government's scale-up of solar electricity, we then collected evidence on the drivers through elite interviews, government documents, and news reports. We also identified observable implications to assess the supporting evidence for each driver (King et al., 1994) (Appendix B). Observable implications answer the question, "If this argument is right, what should I expect to see?" The absence of supporting evidence – that is, where we find no find no or limited evidence of the observable implication – suggests a driver was not important.

Our interview goals were to capture a cross-section of people with knowledge of the Indian central government's solar policies and the motivations behind the Modi government's announcement of ambitious solar goals. Thus, our interviewees included government officials, solar analysts and think-tank experts, solar sector consultants and investors, senior officials in industry associations, energy journalists, foreign diplomats and India watchers. Though we did not interview Prime Minister Modi or his innermost circle, we are confident we were as thorough as we could be. There still may be limitations or biases based on those we interviewed, but we sought to cover a wide range of different perspectives.

In our interviews, we asked an open-ended question on the origins of the solar scale-up decision in 2014/2015 and the policies that followed. This was an attempt to elicit people's sense of the drivers without leading them to a particular answer.[5] We often asked follow up questions about drivers not mentioned, careful to frame these questions neutrally. Interviewees would dispute a factor's importance if they felt it was unimportant or add texture to the factor. The interview process enriched our understanding of the drivers and led to more nuanced perspectives for each of them.

We coded what each interviewee identified as the factor or factors most important in the scale-up as well as any secondary factors. In response to our question about the origins of solar scale-up, an interviewee would usually mention the sequence and a number of factors that they thought most relevant in the decision and why. If someone in their initial response mentioned several drivers unprompted, we did not try to assess the relative importance between them but coded them as primary drivers. Over the course of the conversation, they would sometimes mention other secondary factors. We would follow-up and ask them the relative hierarchy of those new factors compared to the ones they first mentioned, noting any discrepancies between the ones they first mentioned in our interview notes. While we counted the number of mentions for each driver, those were used to summarize their relative salience - our explanation goes beyond their quantitative rankings. From the evidence, we inductively developed a narrative linking our major drivers to theories on state autonomy and developmentalism.

4. India's solar take-off

Although solar emerged in India as a source of electricity around 2010, it expanded rapidly only since 2014, soon after the coming to power of a new Indian government headed by Prime Minister Modi. The previous government had kicked off a national initiative for solar electricity, known as the National Solar Mission (NSM), in 2010.[6] The

[4] This imbalance in interest groups is evolving as a significant private solar industry develops in India. But it still remains much smaller than that of Discoms and coal-linked entities.

[5] In the case of interview #20, we additionally provided a list of potential drivers and asked that person to rank order their importance but after the open-ended conversation was completed.

[6] The NSM was outlined as one of the eight national missions in the 2008 National Action Plan for Climate Change (NAPCC), India's first-ever comprehensive plan for tackling climate change.

NSM initially targeted a 20 GW solar capacity by 2022, which was revised to 100 GW by the Modi government after coming to power in 2014. This was to be achieved through a number of policy tools, some of which had been initiated by the previous government, including solar parks, competitive bidding, a payment guarantee mechanism, renewable purchase obligations, capital subsidies, a coal tax, and a "must-run" preference for solar (see Appendix C for more detail) (Ministry of New and Renewable Energy, 2017c).

To ensure lower costs and minimize rent-seeking, India adopted competitive bidding from the beginning, with the first auctions held in 2011. The winning bids were in the range of Rs. 10–12 ($0.22 to $0.27) per kWh.[7] As NSM added greater capacities, solar bids fell dramatically starting later in 2015 (Fig. 2).[8] Overall, tariffs have fallen 73% since 2010 (Prabhu, 2017).

Net solar capacity in India at the end of 2017 stood at 19.6 GW, with Andhra Pradesh, Rajasthan, and Tamil Nadu the leading states in generation and Karnataka seeing a major ramp-up (Business Standard News, 2017). About half this figure was added in 2017 alone. India added 14.14 GW in renewables capacity in FY 2016–17, nearly 40% of which was solar, while it added only 6.99 GW in coal (Mahapatra, 2017).[9] While there have been major plans for expansion of coal power for several years, we have recently seen a number of project cancellations, suggesting a preference for non-coal based sources of electricity generally and solar specifically (Hill, 2017).

Conventional explanations for large solar capacity additions in India since 2014 have emphasized techno-economic drivers (Bridge to India, 2016; Upadhyay, 2017; Gopal, 2017). The consultancy Bridge to India cited "falling costs" as being instrumental in boosting demand, and cited aggressive bidding, mergers and acquisitions activity, and the Paris climate agreement. Bloomberg cited "plummeting panel prices" and "competition among developers" (Upadhyay, 2017). The International Renewable Energy Agency (IRENA) cited "dramatic cost reduction" as the "primary driver for the solar revolution" worldwide, including in India (IRENA, 2016). Policy factors figured in some of these analyses (chiefly solar parks, innovative financing, and competitive bidding) (Chandrasekaran, 2017), but there has been little exploration of the deeper causal factors that drove the Indian government's prioritization of solar.

5. Adverse techno-economic factors for solar electricity

The rapid increase of installed solar capacity in India in the 2014–17 period took place under adverse techno-economic circumstances. While major module price reductions brought down the cost of solar electricity late in this period to make solar cost competitive with new coal plants, solar electricity remained more expensive than use of existing domestic coal-fired electricity, particularly for Indian states located near domestic coal pitheads.

Electricity from coal-fired power remained considerably cheaper than solar electricity. The Average Power Purchase Cost (APPC), or average wholesale price, of electricity from non-renewable sources (i.e predominantly coal) was Rs. 3.40 ($0.05) per kWh in December 2015 (Central Electricity Regulatory Commission, 2015). All solar bids in this time period were well above this value, except a bid at Rs 3.30 ($0.049) per kWh at the very end of this time period (Ghoshal, 2017).

However, even the comparison with the APPC is misleading as India's coal plants were running at well below capacity during the 2014–17 period (Fig. 3), as indicated by a falling plant load factor (PLF).[10] Thus an equivalent amount of electricity could have been generated simply by running existing coal plants at their normal, rated capacities. This in turn boils down mainly to the average cost of additional fuel, in the range of Rs. 1.75–2.0 ($0.026–0.030) per kWh which is well below all solar bids seen thus far in India (Financial Express, 2016).[11]

The fall in coal plant PLFs was due to an overcapacity in supply. India's electricity capacity additions (mostly coal) averaged about 10% growth annually, while demand growth has averaged only around 4% (Bridge to India, 2017b). PLFs under healthy operating conditions are typically in the range of 75–85%. Thus about a fifth of existing coal capacity is under-utilized. This works out to the equivalent of approximately 38 GW of unutilized generation capacity at the marginal cost[12] – which, if utilized fully, would generate more electricity than the entire 100 GW solar target slated to be achieved by 2022. Thus the generation from this unused coal capacity would have been cheaper and much greater than that from solar (and wind) deployments in the 2014–17 period. However, India chose not to ramp up its coal plant utilization and focused on adding solar (and wind) power instead. Moreover, bid prices do not reflect the true cost of solar electricity, the variable nature of which imposes an additional requirement of grid integration. This is a "hidden" cost, currently not reflected in the solar bids.

To be sure, coal prices do not include their negative externalities such as impacts on the health and the environment, but Indian policymakers have not considered these social costs formally, except for a modest coal "cess" (or tax) already priced into the APPC (Tongia and Gross, 2018, 5). In short, as Tongia and Gross argue: "The political economy of RE [renewables] development matters because the market, left to itself, would likely continue to focus on coal-fired power" (Tongia and Gross, 2018, 12).

6. Explaining the solar push

Despite its dramatic cost declines, solar energy was not cost competitive with electricity produced from domestic coal in the period 2014–17. Yet, the Indian government made a concerted effort to bring about a dramatic growth in solar energy. This suggests that while techno-economic factors certainly facilitated the solar scale-up, they do not fully explain it. This also implies that political drivers were important. As we suggested in Section 2, there was no clamor for solar from below by interest groups as a pluralist model would suggest. Rather, a top-down decision was taken by the Indian government to rapidly scale-up solar, conforming more to theories of an autonomous state. The question is why?

It could be argued that an anticipation of major cost reductions drove India to front-load its solar push in 2014. After all, module prices had been dropping since 2010. Could expectations of quickly reaching "grid parity" (i.e. the same wholesale cost as conventional sources) driven the rush to solar target expansions? Practically all of our interviewees said that the government in 2014 anticipated continuing falls in solar costs. However, the interviewees were split on whether grid parity was anticipated in the near future (*Not fully anticipated: Interview #20 senior executive in energy consulting firm, Interview #9 senior energy analyst in Indian think-tank, Interview #3 senior former Indian government official; Anticipated: Interview #14 senior energy analyst in international*

[7] About 25 cents per kWh at the then prevailing exchange rates.

[8] Prices continued to fall reaching Rs. 4.63 ($0.07) in the state of Andhra Pradesh in November 2015, Rs. 4.34 ($0.066) in January 2016 in Rajasthan, Rs. 3.3 ($0.05) in Madhya Pradesh and then in May 2017 Rs. 2.44 ($0.036) in Rajasthan.

[9] Note that India's fiscal year (FY) runs from April 1 to March 31.

[10] PLF is the fraction of energy actually generated from a plant as compared to its theoretical maximum. Since shutdowns for maintenance etc. are inevitable, the practical maximum PLFs are around 85% in India.

[11] The average cost of fuel is calculated using a representative energy charge number from late 2015 (the approximate mid-point of the 2014–17 time period) from the National Thermal Power Corporation, India's largest thermal generator.

[12] Calculated as 20% of nationwide coal-fired capacity of 189 GW as of February 28, 2017.

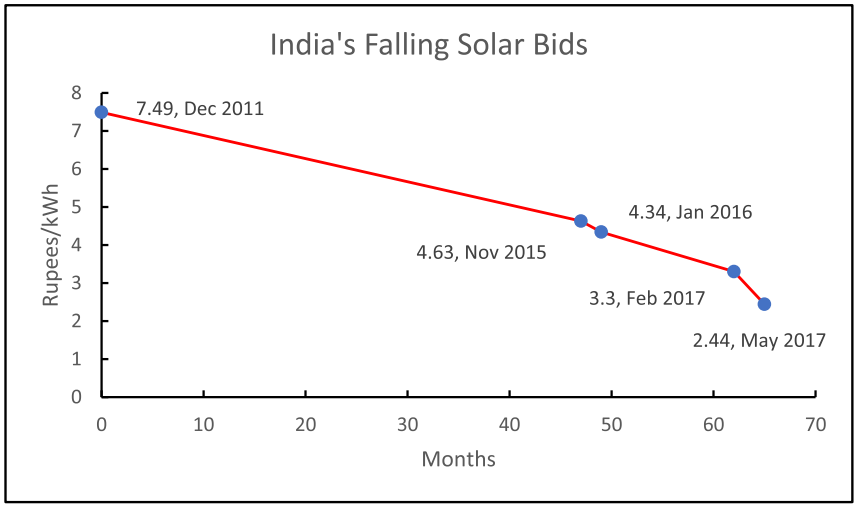

Fig. 2. Indian solar bids have dropped substantially source: (Ramesh, 2017; Ministry of New and Renewable Energy, 2017a).

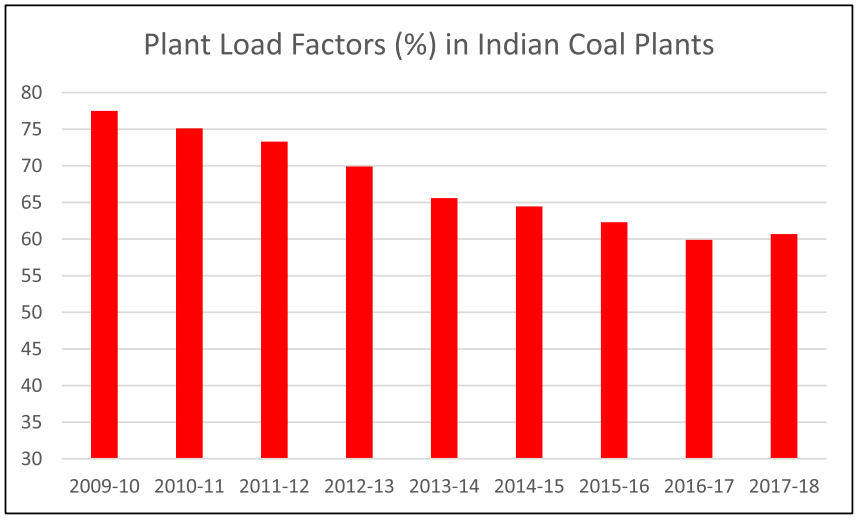

Fig. 3. Plant Load Factors are falling in Indian coal plants Source: (Government of India, Ministry of Power, 2018).

think-tank, Interview #1 senior Indian government official).

Perhaps the strongest indicator that rapid emergence of grid parity did not drive Modi and his team in 2014 was Modi's approach to solar in Gujarat well before 2014, when solar was far more expensive and cost reductions were even less expected. He was the earliest among all Indian politicians to embrace solar, by unveiling an ambitious feed-in-tariff scheme with a rate of about Rs. 16/kWh in 2009 before the NSM was launched nationally. Among his initiatives were solar projects atop irrigation canals, which he routinely pitched as one of his achievements (Carrington, 2014) which were even more expensive at more than Rs. 20/kWh *(Interview #10 former senior official in international institution)*. By the end of his tenure in 2014, Gujarat was responsible for 900 MW of solar generating capacity, about 1/3 of the country's total (Ramesh, 2014), but this had been achieved at a cost many times greater than electricity from conventional sources. Clearly, these moves were not primarily driven by techno-economic considerations.

By all accounts, the 100 GW decision came from the Prime Minister's office and built upon his prior experience with solar in Gujarat *(Interview # 10 former senior official in international organization, Interview #11 senior Indian government official)*. Our interviews however yielded some differing details on the genesis of the 100 GW target. The decision caught many observers by surprise (*Interview #14 senior energy analyst in international think-tank)*. A government official said though the Ministry of New and Renewable Energy was consulted, the prime minister was personally involved and critical to the decision *(Interview #11 senior Indian government official)*.

One Indian solar analyst said the 100 GW number was pulled from the air without much study or analysis *(Interview #20 senior executive in energy consulting firm)*. Another observer from an Indian think-tank argued, by contrast, that an analytical process was commissioned and began in September 2014, but the target ultimately adopted was substantially above what the analytical process yielded *(Interview #8 senior energy analyst in Indian think-tank)*.

Four major drivers emerged from our analysis of interviews and policy trends – namely *domestic politics, global pressure and partnerships, attracting investment, and energy sovereignty*. In addition to these four potential causal factors, we considered a wider set of possible explanations including air pollution, climate change, energy access, energy security, and generation costs and assessed whether government actions supported any of these arguments (we found they did not).

Fig. 4 lists how each interviewee mentioned the drivers under consideration as primary or secondary in importance; blank fields indicate the driver was not seen as important by that interviewee. The total number of mentions is also listed in the right-most column but only serves to highlight the top four drivers (which stood out from the rest) and not to indicate any particular ranking within this subset.

Drivers Tabulation

Mentioned as Primary Driver																							
Interviewee #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**Mentions**
Global Pressure and Partnerships	1	1	1	1			1	1	1		1		1	1		1	1	1	1	1	1	1	1	18
Domestic Politics			1	1	1	1	1	1	1	1										1	1			10
Attracting Investment		1	1		1	1			1	1			1	1	1		1					1	1	12
Energy Sovereignty/CAD		1		1									1					1	1	1		1		7
Energy Security												1												1
Energy Access																						1		1
Air Pollution																								0
Climate Change															1									1
Generation Costs												1		1										2
Mentioned as Secondary Driver																								
Global Pressure and Partnerships					1	1						1			1									4
Domestic Politics		1													1									2
Attracting Investment	1							1										1		1				4
Energy Sovereignty/CAD	1			1	1	1	1				1					1								7
Energy Security																				1				1
Energy Access		1														1				1				3
Air Pollution																				1				1
Climate Change				1																				1
Generation Costs				1													1							2

Fig. 4. Interviewee citations of drivers for India's solar push.

6.1. Domestic politics

Domestic politics implies factors that enhance the political power of the ruling party and the Prime Minister. In their most general form, such factors can be classified as material (winning support by providing enhanced material benefits to voters) or ideational (defining and projecting an idea or image of the government for electoral gain).

10 of our interviewees placed domestic politics as a primary driver, while 2 ranked it as a secondary driver. According to these interviewees, Modi saw solar as a way to project an image of a future-oriented modern reformer *(Interview #7 senior energy analyst in international aid organization, Interview #5 senior energy analyst in international think-tank, Interview #3 senior former Indian government official)*. Embracing solar also allowed Modi to showcase leadership by being a first mover *(Interview #10 former senior official in international institution)* and demonstrate vision and ambition *(Interview #6 senior energy analyst in international think-tank, Interview #20 senior executive in energy consulting firm, Interview #9 senior energy analyst in Indian think-tank)*.

Prior to becoming Prime Minister, Modi was Chief Minister (highest elected official) of Gujarat, where he developed a reputation for efficient, if highly centralized, governance. This helped burnish Modi's image as a modern leader who could deliver the nation's development goals. Modi's emphasis on promoting solar power in Gujarat has already been detailed.

The BJP led the national election campaign of 2014 projecting Modi as a can-do modernizer. The “Gujarat development model” was held up as a standard that the country would achieve under his leadership. The model emphasized a build-up of modern infrastructure and industry through state-facilitated private investment (Pathak, 2014).[13] This pitch was strongly linked to technology. For example, Modi's campaign speeches were projected as holograms to many Indian small towns and villages (Nelson, 2014) and had a major impact on rural, less educated voters. Solar energy was thus a part of the general message of modernization and development.

However, most mass voters want reliable electricity supply - the specific source of electricity is not so significant for them. Thus, it is unclear that the solar targets themselves were all that politically attractive to the wider public.

Nevertheless, what we heard from interviewees is that more environmentally-conscious urban elites do and did respond to whether the added capacity is renewable. Modi's political payoffs in pushing solar were in creating a favorable impression among the elite, with intended trickle-down effects, as elites have a disproportionate influence in shaping the national political discourse *(Interview #4 senior energy analyst in Indian think-tank, Interview #15 senior official at national energy exchange)*. Since his election victory, Modi continued to position solar as being synonymous with a future modernity to both elite and mass audiences (Firstpost, 2015; Mohan, 2015). He has also showcased other symbolic projects that burnish his image as a modernizer, such as the Mumbai-Ahmedabad “bullet train” (BBC, 2017).

While we found strong support for the symbolic value of solar for elite audiences, we did not hear or read about strong evidence of political favoritism for key regions, voter segments or entities in solar projects as might have been expected from a domestic politics explanation.

6.2. Global pressure and partnerships

A second leading driver that emerged from our interviews was a reorientation in India's approach to the outside world. The Modi government brought significant changes in Indian foreign policy. One of the new government's goals was to position India as a global leader. Building a closer relationship with the US was seen as a primary pathway to achieving this goal. India and the US had grown steadily closer since the late 1990s. However, the two sides remained apart on some issues such as trade, burden-sharing for Asian maritime security, and climate action.

After Modi took charge in May 2014, he announced in June that he would expand the National Solar Mission (E. King, 2014). In July, the Fifth India-U.S. Strategic Dialogue featured a climate change working group for the first time. Among other things, the July working group helped move discussions forward between the India and the US on efforts to phase out hydrofluorocarbons (HFCs), a refrigerant and important contributor to climate change.

The meeting also put broader climate concerns on the agenda in advance of Prime Minister Modi's visit to the United States in late

[13] Critics pointed to its neglect of basic education, health, and the environment.

September 2014. Modi took part in the UN General Assembly meetings in New York before heading to Washington for his first bilateral meeting with President Obama. In line with our expectations that India would try to generate goodwill for its actions in the lead up to major events, India's minister of power and energy, Piyush Goyal, told the press in August 2014 that the government's solar goals would be more ambitious than the previous government (Ravindran, 2014).

The UN General Assembly was preceded by a high-level summit on climate change. Though Modi did not attend, his environment minister, Prakash Javadekar, did. While Javdekar said India's emissions would not peak in the near future (Davenport, 2014), he signaled that India would do more to scale up renewables (Javadekar, 2014).

In his September 2014 visit to Washington, Modi agreed to engage in formal discussions on HFC phasedown. The meeting also encouraged India's push for renewables (Warrick, 2014). In a joint op-ed in the *Washington Post,* Obama and Modi touted the potential for cooperation on renewables (Modi and Obama, 2014).

Consistent with our expectations, the solar target was announced in November 2014 just prior to global climate negotiations in Lima, Peru (Business Standard India, 2014). In early January 2015, Secretary of State John Kerry traveled to Delhi in advance of a visit by President Obama, with clean energy part of the discussion (Gordon and Harris, 2015). Modi and Obama discussed the upcoming Paris climate negotiations and signed a memorandum of understanding on clean energy cooperation, which opened with praise for the 100 GW solar goal (White House, 2015).

In October 2015, India released its pledge for the Paris summit, a commitment to increase its non-fossil electricity target to 40% by 2030. Though the solar target was not an explicit part of India's pledge or "nationally determined contribution," it implicitly envisaged a large role for solar. At the Paris climate talks in December 2015, India and the US bridged remaining differences, allowing the historic agreement to be signed. Indo-US convergence accelerated on other strategic fronts, including diplomatic and military coordination on the balance of power in Asia and greater defense ties (Joshi, 2015).

Another focus of India's global partnership efforts was France. As the host of the Paris climate talks, France advocated major decarbonization commitments by India. India was already in talks with France on critical defense acquisitions.[14] Additionally, at Paris, India and France together founded the International Solar Alliance (ISA), the first international organization headquartered in India. The ISA has ambitious goals of reducing solar costs for developing countries through financial and technical innovation.

Global pressure and partnerships were validated as a major driver by most of our interviewees. 18 of them saw it as a primary driver, and four as a secondary driver. However, there were differences in how interviewees emphasized this driver. Some focused on a global push for leadership and goodwill specifically on the climate/energy issue, citing India's desire to match the US and France on climate leadership *(Interview #3 senior former Indian government official)*. Others thought supporting solar helped eliminate global criticism on its coal usage and growing emissions *(Interview #1 senior Indian government official, Interview # 4 senior energy analyst in Indian think-tank, Interview #6 senior energy analyst in international think-tank, Interview #18 senior official in industry body, Interview #21 former senior Indian government official, Interview #19 senior executive in renewable energy firm)*. Embracing solar also allowed the prime minister to go on the offensive on climate action in global fora (Interview #3 senior former Indian government official, Interview #4 senior energy analyst in Indian think-tank) and emerge as a global solar leader given its high solar resources (*Interview # 10 former senior official in international organization, Interview # 22 former executive at US think-tank*).

Others highlighted India's desire to bolster its global status and enhance strategic relationships with the US and France *(Interview #8 senior energy analyst in Indian think-tank, Interview #13 senior executive in renewable energy firm, Interview #14 senior energy analyst in international think-tank, Interview #20 senior executive in energy consulting firm, Interview #21 former senior Indian government official, Interview #9 senior analyst in Indian think-tank)*. Reaching a climate deal as one former US diplomat noted would have payoffs in terms of enhancing the broader relationship with both countries *(Interview #23 former senior US government official)*. Thus there are two components to this driver - defensive (India trying to stave off criticism from its partners on doing too little to combat climate change) and offensive (positioning India as a global leader in climate action with partnership payoffs.)

6.3. Attracting investment

Another driver that emerged from our interviews was the importance of attracting investment. All Indian governments have placed a high priority on attracting investment, both domestic and foreign. As a globally rising sector, solar was seen as a key pathway for realizing this objective, In January 2015, the Modi government announced it would seek $100 billion from investors from Germany, the United States, China, and Japan to meet its ambitious solar goals (Das and Gopinath, 2015).

Twelve of our interviewees mentioned attracting investment as a major driver for the solar scale-up. Four others saw it as a secondary driver. Seven specifically mentioned foreign investment, others spoke of it in general terms or saw both domestic and foreign investors as targets.

The push to attract investors through solar began even when Modi was governing Gujarat *(Interview # 10 former senior official in international organization)*. On coming to office, solar was prioritized as investment prospects in many infrastructure sectors such as ports, roads, and coal power had dried up *(Interview #17 senior energy journalist)*. Renewable capital is mostly private internationally, and green investment funds were entering the scene *(Interview #14 senior energy analyst in international think-tank)*.

Consistent with our expectations, the Indian government strongly positioned solar as an opportunity for investors. For example, it initiated a high-profile event in February 2015 called RE-Invest aimed to attract investors into the renewables market (Ministry of New and Renewable Energy, 2014). Major corporations such as Adani Enterprises, SunEdison, and Welspun announced investments, each for more than 10 GW of renewables capacity.[15] Other events showcasing India's potential to investors were also held (KPMG, 2016).

After a slow start, solar investment grew rapidly in India (Tripathy, 2017). For instance, 28% of all global project finance in the solar sector went to India in 2017. This amounted to $3.6 billion out of a total solar investment in India of $6.4 billion during that year (Mercom India, 2018).[16] The International Solar Alliance initiative led by India and France aims to mobilize $1 trillion of foreign investment in the solar sector, with India presumably garnering some of this share (Stothard, 2015).

6.4. Energy sovereignty (independence)

Energy sovereignty (or energy independence) aims to achieve domestic self-sufficiency in energy production.[17] In India, increased

[14] An agreement for the sale of 36 Rafale combat aircraft was eventually signed in September 2016 by the two governments.

[15] However, most of these commitments were from domestic companies, and many of these announcements have not translated into actual projects as yet.

[16] UNEP reports $6.7 billion. See (UNEP, Frankfurt School-UNEP Collaborating Centre, and Bloomberg New Energy Finance, 2018).

[17] The concept of energy sovereignty is in some tension with that of energy supply security, which is about sourcing lowest cost energy irrespective of its geographic origin.

energy sovereignty can also reduce import bills, and therefore India's persistent current account deficit (CAD). Though 100% energy independence is not achievable, reducing dependence is possible, as the country does possess coal, hydropower, wind, and sunshine.

Energy independence was a focus of discussions at the central government policy think-tank NITI Aayog *(Interview #2 senior analyst at energy consulting firm)*. The expectation that India's coal stocks will run out in 40–50 years drove the push toward energy sovereignty *(Interview # 11 senior Indian government official, Interview # 15 senior official at national energy exchange)*, as did reducing fuel import bills from coal *(Interview #7 senior energy analyst in international aid organization),* but especially crude oil used to make diesel *(Interview # 13 senior executive in renewable energy firm)*.[18] However, two did not consider this driver to be important, contending that thermal coal is only a small fraction of total fuel imports *(Interview #1 senior Indian government official, Interview #5 senior energy analyst in international think-tank)*.

Indian government officials and Modi himself have repeatedly use the sovereignty argument, both to rely less on other countries and for reducing India's current account deficit (NITI Aayog, 2015; Business Standard, 2015). If India is pursuing energy sovereignty rather than security, we would expect it to manifest itself most clearly in the electricity sector,[19] by stressing domestic fuel sources over imports, which for India are coal, sunshine, wind, rivers, and nuclear.[20] We would also expect it to reduce existing imports of coal and natural gas.

This is indeed what was mostly observed in the 2014–17 time period. On coming to power, the Modi government initiated a major expansion in *both* coal and solar. By ramping up domestic coal production from the state-owned monopoly coal mines, coal shortages in power plants turned into surpluses by the middle of 2015 (Jai, 2015). The government also abandoned the previous Congress-led government's initiatives on allowing massive coal plants designed to be run on higher-quality imported coal, by demanding that such plants blend in domestic coal (ETEnergyworld, 2016).

However, India's high solar imports – 89% sourced from China in 2017–18 – appear to weaken the energy sovereignty argument (Prateek, 2018b), especially as India and China have had difficult relations in recent years (Bridge to India, 2017a). That said, capital imports (such as solar modules) are an upfront, one-time cost while fuel charges are recurring and frequent. Moreover, creating a domestic solar manufacturing industry has been a long-standing Indian goal. India put in place Domestic Content Requirements (DCR) for its early solar auctions.[21] But China emerged as the biggest source of solar modules in India, not by design, but due to the low costs of Chinese modules in a globalized market. In July 2018, the Modi government also sought to reduce its dependence on imported panels (and boost domestic manufacturing) through a new 25% tariff levied on imported solar panels from China and Malaysia (Upadhyay, 2018).

6.5. The drivers that didn't drive

It is helpful to review the drivers that were plausible but for which little evidence was found. Candidates include energy supply security, energy access, environmental threats (air pollution and climate change), and reducing generation costs. However, these were either not cited by interviewees or mentioned as low priorities. Moreover, outside of the interviews and thinking about the observable implications in Appendix B, little to no evidence suggests these were important drivers of policy change.

Supply security reflects concerns about shortages as a result of demand exceeding available supplies. In 2014, forecasts of Indian energy demand projected large increases in demand. However, given the ramp-up of domestic coal production under the Modi government and lower-than-expected demand increases, supply shortages as an incentive for solar scale-up did not loom large in our interviewees' accounts (Shroff, 2017). The supply deficit also decreased steadily after 2014. Nonetheless, India persisted in its scale-up of solar even as supply deficits waned. While this is consistent with an energy sovereignty logic (using domestic resources where possible), this does not support a energy supply security logic (since the supply shortage concerns were decreasing during this period).

Some analysts have suggested energy access, that is extending electricity to the hundreds of millions of Indians lacking it, was an important driver of solar scale-up (Ghosh, 2015). This lack of access is predominantly concentrated in remote, rural areas where the Indian government's solar policy should have emphasized offgrid solar. Instead, the policy has almost exclusively focused on utility scale solar plants. As several interviewees noted, the collective demand of households that lack access to electricity is likely to be small in aggregate. Additional gigawatts of electricity production would more likely serve business customers and manufacturing *(Interview #14 senior energy analyst in international think-tank, Interview #20 senior executive in energy consulting firm)*. Energy access, though ever-present in Indian rhetoric, has never been a high priority for Indian governments, with household electrification far from being universal more than 70 years after independence. This is also reflected in the solar sector, with its minimal budgets and low installed capacity for offgrid solar. Net offgrid and grid-integrated rooftop capacity at the end of 2017 amounted to just above 3% of the total solar capacity, with most of this representing grid-connected rooftop installations by businesses (Ministry of New and Renewable Energy, 2017b).

Two environmental drivers are relevant to this study – air pollution and climate change, but both failed to resonate with our interviewees. Had air pollution been a significant driver of solar scale-up, we should have seen accompanying actions to address other contributors to the problem[22]. Air pollution was not yet a significant electoral or policy issue for the period of study however.

Interviewees did mention climate change as a driver of policy – but almost always as an international *issue*, rather than as a response to the scientific phenomenon itself. Therefore “climate change” is subsumed within the “global pressure and partnerships” driver as detailed above. This is also consistent with the observable implications test – had the actual phenomenon of climate change been a driver of the solar scale-up, there would have been more done on adaptation, on “proofing” agriculture and scaling back coal. But the focus was primarily renewables targets which as we argue above, had other reasons for prioritization. In general, the environmental record of the Modi government has not been stellar, with a prominent environmental monitoring organization labeling it as “mixed” (Center for Science and Environment, 2016).

The last plausible driver, generation costs, is easy to dismiss since as we already discussed, electricity from solar was still more expensive than coal-based power at the time of the 2014/2015 solar scale-up decision and until 2017.

7. Conclusions and policy implications

The solar push has both a domestic facing and international component. Domestically, solar enhanced the Modi and the ruling party

[18] Diesel is often used in residential and commercial electricity generation to make up for supply unreliability.

[19] In the short-to-medium term, there is no alternative to transport fuels other than (mostly imported) oil in India, but India has announced an ambitious electric vehicles target.

[20] Nuclear energy relies on imported fuel, but the technology greatly reduces the frequency and volume of fuel supplies.

[21] These were however struck down by a World Trade Organization (WTO) ruling in September 2016.

[22] Note that urban air pollution in India is driven by causes other than coal plants, including crop burning, transportation, and construction dust.

brand and helped shape elite and mass opinion of Modi as a modern development-oriented leader. Internationally, solar was seen as a way to win plaudits in Washington, connect India to Obama's ambitious climate goals, and an easier area for gains compared to trade, where concessions are harder. Commitments on solar reduced global pressures for more action from India in the lead up to Paris (for a similar view, see Tongia and Gross, 2018).

The solar push served two other goals for the government, to attract investment and to shore up energy sovereignty. The investment drive is one that any Indian government would likely have embraced, given the country's development needs. However, solar, as a new technology with international appeal, served as a good platform to mobilize domestic capital and attract foreign investment. Energy sovereignty has been a perennial concern in India, though the more liberalizing tendencies of previous governments led to an increase in imported coal. In this, the Modi government's energy nationalism is a return to an earlier suspicion of interdependence.

India's solar story provides some insights that may enrich theories of the developmental state. A constitutionally “concurrent” legislative subject – i.e. with legislative powers shared between the central government and states – electricity demonstrates fragmented governance due to the push and pull of federalism as well as the increasing role of private sector interests (Busby and Shidore, 2017). In our own work, we find that incumbent players such as distribution companies (mostly in the hands of federal states) are key influencers of solar scale-up, as they overwhelmingly control the demand side.

However, the national state has also exhibited a strong autonomous instinct that has its origins in the agency of the Prime Minister and India's own distinctive developmental nationalism and desire to rise in the global system. Although interest groups are important barriers in the solar scale-up, the central government has demonstrated significant autonomy from some of these interests in its developmental push for solar in India.

Thus, three of our major drivers (global pressure and partnerships, attracting investment, and energy sovereignty) indicate that, at the level of the central government at least, India's solar policy is developmental, that is aimed to enhance the country's long-run welfare and global standing. However the fourth driver, domestic politics, indicates that this conclusion may only be part of the story. For instance, India has ample history of corruption, including in the electricity space, which would potentially provide one indicator of predatory state behavior – though competitive bidding presumably limits opportunities for rent-seeking. If the political rewards from solar in terms of influencing elite opinion diminish, the government may focus less attention on the scale-up. Further study of the implementation track record of the solar scale-up will be revealing about whether the process is subject to any predatory dynamics.

As suggested above, the central government is conditioned by Indian states in important respects, not just due to federalism but also due to different motivating factors at work. While the central government is driven by factors such as energy security, energy independence, climate change, global factors, and a broad understanding of domestic (national) politics, Indian states have their own distinct concerns such as electricity tariffs, interests of distribution companies, and regional politics centered on local constituencies such as farmers (who tend to organize regionally rather than nationally).

It is at the level of Indian states where we believe pluralist dynamics are more likely operative. In Indian states, incumbent resistance is manifested most clearly, in the form of mostly state-owned Discoms and resistance by state-level regulators to implement tariff reform but also adequately scrutinize high generation costs from fossil-fuel plants. This is because electricity has traditionally been seen in India as a public good, which is to be made available universally as something akin to a right rather than a market good. State governments are the face of electricity supply for the Indian citizen through their ownership of Discoms, which levy tariffs, engage in billing, and supply electricity. Much of the upstream generation and transmission structure is essentially invisible to the voter. Thus paradoxically, sites of entrenched incumbent behavior have often been those institutions that have the most direct contact with citizens, putting in tension the imperatives of democracy with those of clean energy.[23] It is these patterns of differential support for solar among Indian states that we will turn to in our next research project.

As we noted, India's developmental nationalism also has an outward-facing aspect. Since its independence in 1947, India has tried to make a mark as a major global influencer commensurate with its self-image as one of the world's greatest civilizations. In the post-Cold War era, this took the form of global economic integration and partnering with major global powers, particularly the United States. The solar push is a contemporary aspect of this grand strategy. While addressing clear material needs, it furthers the goal of creating a narrative of modernization and development at home and raising the country's global profile abroad. Both are essentially political or ideational aims. The agency of Prime Minister Modi was crucial in centering solar in his push to sharpen and deepen this narrative.

The sustainability of India' solar story will depend on the persistence of favorable techno-economic conditions, but equally if not more, the largely political drivers we have identified. Two remain potent while the other two appear to have weakened. The Trump presidency in the United States implies that furthering India's rise in the global system through climate leadership is no longer as relevant as it was in the Obama era.[24] The symbolic value of solar in the domestic narrative of modernization is also somewhat weaker compared to its novelty in 2014.

The motivations of attracting investment and energy sovereignty, however, remain relevant. Meanwhile, techno-economic factors indicate a mixed picture for solar, with protectionism in the air, limited flexibility for balancing variable renewables generation, and open access (where consumers can purchase electricity from generators outside their states), failing to take off. Distributed generation holds promise, but large centralized projects will remain a key feature of the solar story with a commitment to about 40 large solar parks, making grid integration a continued focus. India's domestic coal production has lagged demand, and the supply security driver could make a comeback. On balance, this indicates a weaker, but still favorable prognosis for solar in the years ahead. It is possible however that escalating detrimental effects of either air pollution or climate change or both could make environmental issues an electoral issue in India and emerge as a major driver for solar within a decade.[25]

Our work suggests a number of future research questions. India is not alone in being an “intermediate” state with elements of autonomy and pluralism. Federalism is not unique to India, nor are challenges associated with development and corruption. How would an analysis of political or ideational drivers in other major developing economies such as Brazil, Mexico, China, and others yield insights on their pathways in embracing renewable energy? How does governance in large federal systems enable or constrain the renewables scale-up? Questions such as these call for further research.

Acknowledgements

This research was supported by the IC^2 Institute.

[23] This tension is declining as clean energy costs are reaching grid parity over time but remains a major factor in the time period of the study (2014–17).

[24] Climate change remains a high priority for France and Europe, and therefore has not gone away entirely.

[25] The IPCC's October 2018 report on the impact of a 1.5 C warming has clearly brought out nearer-term adverse effects of climate change on most countries including India.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2019.02.032.

References

Aklin, Michaël, Urpelainen, Johannes, 2018. Renewables: the Politics of a Global Energy Transition. The MIT Press, Cambridge, MA.

Allen, Robert C., 2012. Backward into the future: the shift to coal and implications for the next energy transition. Energy Pol. 50 (November), 17–23. Special Section: Past and Prospective Energy Transitions - Insights from History. https://doi.org/10.1016/j.enpol.2012.03.020.

BBC, 2017. India Launches First Bullet Train Project. BBC News September 14, 2017, sec. India. https://www.bbc.com/news/world-asia-india-41251210.

Breetz, Hanna, Mildenberger, Matto, Stokes, Leah, 2018. The political logics of clean energy transitions. Bus. Polit. 20 (4), 492–522 (Clean energy transitions in a global economy) December 2018.

Bridge to India, 2016. 2016 Was a Great Year for the Indian Solar Industry but the Best Is yet to Come. Bridge to India (blog) December 19, 2016. http://www.bridgetoindia.com/2016-great-year-indian-solar-industry-best-yet-come/.

Bridge to India, 2017a. India Solar Handbook. Bridge to India. http://www.bridgetoindia.com/wp-content/uploads/2017/05/BRIDGE-TO-INDIA_India-Solar-Handbook_2017-1.pdf.

Bridge to India, 2017b. India's Problems with Coal Sector Continue. Bridge to India (blog) February 20, 2017. http://www.bridgetoindia.com/indias-problems-coal-sector-continue/.

Bridge to India, 2018. India RE Map. https://bridgetoindia.com/reports/india-re-map-i-september-2018/.

Busby, Joshua W., Shidore, Sarang, 2017. When decarbonization meets development: the sectoral feasibility of greenhouse gas mitigation in India. Energy Res. Soc. Sci. 23 (January), 60–73. https://doi.org/10.1016/j.erss.2016.11.011.

Business Standard, 2015. India Should Be Energy Independent to Serve People's Needs: Modi (Roundup). Business Standard India March 27, 2015. https://www.business-standard.com/article/news-ians/india-should-be-energy-independent-to-serve-people-s-needs-modi-roundup-115032701104_1.html.

Business Standard India, 2014. Government Looking at 100,000 MW Solar Power by 2022. Business Standard India November 17, 2014. https://www.business-standard.com/article/news-ians/government-looking-at-100-000-mw-solar-power-by-2022-114111701373_1.html.

Business Standard News, 2017. Solar Capacity grows over 3 Fold to 10,000 Mw in Three years. Business Standard News May 12, 2017. https://www.business-standard.com/article/pti-stories/solar-capacity-grows-over-3-folds-to-10k-mw-in-three-years-117031200215_1.html.

Carrington, Damian, 2014. Can Narendra Modi Bring the Solar Power Revolution to India? | Environment | the Guardian. The Guardian September 30, 2014. https://www.theguardian.com/environment/2014/sep/30/-sp-narendra-modi-india-solar-renewables-energy.

Center for Science and Environment, 2016. Report Card: Environmental Governance under NDA Government. . https://web.archive.org/web/20161025033653/http://www.downtoearth.org.in/coverage/report-card-environmental-governance-under-nda-government-54359.

Central Electricity Regulatory Commission, 2015. Petition No. 16/SM/2015. http://www.cercind.gov.in/2015/orders/SO16.pdf.

Chandrasekaran, Kaavya, 2017. Solar Power Tariff Drops to Historic Low at Rs 2.44 per Unit. The Economic Times May 13, 2017. https://economictimes.indiatimes.com/industry/energy/power/solar-power-tariff-drops-to-historic-low-at-rs-2-44-per-unit/articleshow/58649942.cms.

Cherp, Aleh, Vinichenko, Vadim, Jewell, Jessica, Brutschin, Elina, Sovacool, Benjamin, 2018. Integrating techno-economic, socio-technical and political perspectives on national energy transitions: a meta-theoretical framework. Energy Res. Soc. Sci. 37 (March), 175–190. https://doi.org/10.1016/j.erss.2017.09.015.

Das, Krishna N., Gopinath, Swetha, 2015. India's Modi Raises Solar Investment Target to $100 Bln by 2022. Reuters January 2, 2015. https://www.reuters.com/article/india-solar/indias-modi-raises-solar-investment-target-to-100-bln-by-2022-idUSL3N0UG13H20150102.

Davenport, Coral, 2014. Emissions from India Will Increase, Official Says. *New York Times* September 24, 2014. https://www.nytimes.com/2014/09/25/world/asia/25climate.html.

Della Bosca, Hannah, Gillespie, Josephine, 2018. The coal story: generational coal mining communities and strategies of energy transition in Australia. Energy Policy 120 (September), 734–740. https://doi.org/10.1016/j.enpol.2018.04.032.

Downs, George, Jones, Michael A., 2002. Reputation, compliance, and international law. J. Leg. Stud. XXXI, S95–S114.

Erickson, Jennifer, 2014. Saving face, looking good, and building international reputation in East and west. In: Bruce, Jentleson, Louis, Pauly (Eds.), Power in a Complex Global System, pp. 180–191.

ETEnergyworld, 2016. BHEL Asked to Modify Power Plants Running on Imported Coal. ETEnergyworld.Com October 2, 2016. http://energy.economictimes.indiatimes.com/news/coal/bhel-asked-to-modify-power-plants-running-on-imported-coal/54642659.

Evans, Peter, 1995. Embedded Autonomy, first ed. Princeton University Press, Princeton, NJ.

Financial Express, 2016. NTPC Cuts Power Cost by Nearly 14% - the Financial Express. Financial Express January 16, 2016. https://www.financialexpress.com/industry/ntpc-cuts-power-cost-by-nearly-14/195727/.

Firstpost, 2015. PM Modi Inaugurates Solar Power System, Pushes for Environment Protection on Gandhi jayanti. Firstpost October 2, 2015. https://www.firstpost.com/politics/pm-modi-inaugurates-solar-power-system-pushes-for-environment-protection-on-gandhi-jayanti-2452982.html.

Fouquet, Roger, 2012. The demand for environmental quality in driving transitions to low-polluting energy sources. Energy Pol. 50 (November), 138–149. Special Section: Past and Prospective Energy Transitions - Insights from History. https://doi.org/10.1016/j.enpol.2012.04.068.

Fouquet, Roger, 2016. Historical energy transitions: speed, prices and system transformation. Energy Res. Soc. Sci. 22 (December), 7–12. https://doi.org/10.1016/j.erss.2016.08.014.

Fouquet, Roger, Pearson, Peter J.G., 2012. Past and prospective energy transitions: insights from history. Energy Pol. 50 (November), 1–7. Special Section: Past and Prospective Energy Transitions - Insights from History. https://doi.org/10.1016/j.enpol.2012.08.014.

Frei, Fanny, Sinsel, Simon R., Ahmed, Hanafy, Hoppmann, Joern, 2018. "Leaders or laggards? The evolution of electric utilities' business portfolios during the energy transition. Energy Policy 120 (September), 655–665. https://doi.org/10.1016/j.enpol.2018.04.043.

Ghosh, Arunabha, 2015. The big push for renewable energy in India: what will drive it? Bull. At. Sci. 71 (4), 31–42. https://doi.org/10.1177/0096340215590791.

Ghoshal, Devjyot, 2017. Solar Is Now Cheaper than Coal-Based Electricity in India, but the Math Makes No Sense. Quartz (blog) May 18, 2017. https://qz.com/984656/solar-power-is-now-cheaper-than-coal-based-electricity-in-india-but-the-math-makes-no-sense/.

Gopal, Sapna, 2017. India's Solar Sector Prepares for Next Phase of Growth. India Climate Dialogue (blog) February 17, 2017. http://indiaclimatedialogue.net/2017/02/17/indias-solar-sector-prepares-next-phase-growth/.

Gordon, Michael R., Harris, Gardiner, 2015. Kerry Lays Groundwork for Obama's Visit to India. The New York Times January 11, 2015, sec. World. https://www.nytimes.com/2015/01/12/world/asia/john-kerry-india-narendra-modi.html.

Government of India, Ministry of Power, 2018. Power sector at a glance ALL India. May 28, 2018. https://powermin.nic.in/en/content/power-sector-glance-all-india.

Grubler, Arnulf, 2012. Energy transitions research: insights and cautionary tales. Energy Pol. 50 (November), 8–16. Special Section: Past and Prospective Energy Transitions - Insights from History. https://doi.org/10.1016/j.enpol.2012.02.070.

Hall, Peter A., 1993. Policy paradigms, social learning, and the state: the case of economic policymaking in britain. Comp. Pol. 25 (3), 275–296. https://doi.org/10.2307/422246.

Healy, Noel, Barry, John, 2017. Politicizing energy justice and energy system transitions: fossil fuel divestment and a 'just transition. Energy Policy 108 (September), 451–459. https://doi.org/10.1016/j.enpol.2017.06.014.

Hess, David J., 2014. Sustainability transitions: a political coalition perspective. Res. Pol. 43 (2), 278–283. https://doi.org/10.1016/j.respol.2013.10.008.

Hill, Joshua S., 2017. India Cancels Nearly 14 Gigawatts of Proposed Coal Plants. Clean Technica May 25, 2017. https://cleantechnica.com/2017/05/25/india-cancels-nearly-14-gw-proposed-coal-plants/.

Horbach, Jens, Rammer, Christian, 2018. Energy transition in Germany and regional spill-overs: the diffusion of renewable energy in firms. Energy Policy 121 (October), 404–414. https://doi.org/10.1016/j.enpol.2018.06.042.

IRENA, 2016. Letting in the Light: How Solar Photovoltaics Will Revolutionise the Electricity System. Publications/2016/Jun/Letting-in-the-Light-How-Solar-Photovoltaics-Will- Revolutionise-the-Electricity-System.June_2016./publications/2016/Jun/Letting-in-the-Light-How-solar-photovoltaics-will-revolutionise-the-electricity-system.

Jai, Shreya, 2015. Coal output on a High but Demand dries Up. Business Standard India September 7, 2015. https://www.business-standard.com/article/economy-policy/coal-output-on-a-high-but-demand-dries-up-115090700035_1.html.

Javadekar, Prakash, 2014. Text of Statement made by MoS for Environment, Forests and Climate Change Shri Prakash Javadekar, at United Nations Climate Summit 2014. September 24, 2014. http://pib.nic.in/newsite/PrintRelease.aspx?relid=109947.

Jenkins, Kirsten, Sovacool, Benjamin K., McCauley, Darren, 2018. Humanizing socio-technical transitions through energy justice: an ethical framework for global transformative change. Energy Policy 117 (June), 66–74. https://doi.org/10.1016/j.enpol.2018.02.036.

Johnson, Chalmers A., 1982. MITI and the Japanese Miracle: the Growth of Industrial Policy, 1925-1975, 1 edition. Stanford University Press, Stanford, Calif.

Joshi, Shashank, 2015. The US-India Convergence. Lowy Institute for International Policy February 13, 2015. https://www.lowyinstitute.org/the-interpreter/us-india-convergence.

Kale, Sunila, 2012. Electrifying India: Regional Political Economies of Development. Stanford University Press, Palo Alto. http://www.sup.org/books/title/?id=22441.

Kapstein, Ethan B., Busby, Joshua W., 2013. AIDS Drugs for All Social Movements and Market Transformations. Cambridge University Press, Cambridge. http://www.cambridge.org/us/academic/subjects/politics-international-relations/political-economy/aids-drugs-all-social-movements-and-market-transformations.

Kern, Florian, Markard, Jochen, 2016. Analysing energy transitions: combining insights from transition studies and international political economy. In: Van de Graaf, Thijs, Sovacool, Benjamin K., Ghosh, Arunabha, Kern, Florian, Klare, Michael T. (Eds.), The Palgrave Handbook of the International Political Economy of Energy, first ed. Palgrave Macmillan, London, pp. 291–318 2016 edition.

"India PM Modi targets 'saffron' revolution for solar energy. In: King (Ed.), Climate Home News, June 9, 2014. http://www.climatechangenews.com/2014/06/09/india-pm-modi-targets-saffron-revolution-for-solar-energy/.

King, Gary, Keohane, Robert, Verba, Sidney, 1994. Designing Social Inquiry. Princeton University Press, Princeton.
Kohli, Atul, 2004. State-Directed Development: Political Power and Industrialization in the Global Periphery, Later Reprint edition. Cambridge University Press, Cambridge, UK ; New York.
KPMG, 2016. Investing in Solar Projects in India - a huge Opportunity - an investor's Perspective. August 29. KPMG, pp. 2016. https://home.kpmg.com/in/en/home/events/2016/08/investing-solar-projects-india.html.
Madureira, Nuno Luis, 2012. The iron industry energy transition. Energy Pol. 50 (November), 24–34. Special Section: Past and Prospective Energy Transitions - Insights from History. https://doi.org/10.1016/j.enpol.2012.03.003.
Mahapatra, Saurabh, 2017. India Added Twice as Much Renewables Capacity as Coal Capacity in 2016–17. Clean Technica May 1, 2017. https://cleantechnica.com/2017/05/01/india-added-twice-much-renewables-capacity-coal-capacity-2016-17/.
Meadowcroft, James, 2009. What about the politics? Sustainable development, transition management, and long term energy transitions. Pol. Sci. 42 (4), 323. https://doi.org/10.1007/s11077-009-9097-z.
Mercom India, 2018. India Solar Market Update – Q4 2017. Mercom India (blog) 2018. https://mercomindia.com/product/solarinstallations-q4-2017.
Ministry of New and Renewable Energy, 2014. RE-INVEST: Making India the New Investment Destination for Renewable Energy. http://2015.re-invest.in/Document/orginal/4.RE-INVEST_Presentation_Sep30_2014_MNRE.pdf.
Ministry of New and Renewable Energy, 2017a. Twenty-Eighth Report to the Standing Committee of Energy of the Indian Parliament. . http://164.100.47.193/lsscommittee/Energy/16_Energy_28.pdf.
Ministry of New and Renewable Energy, 2017b. Year End Review 2017 –MNRE. http://pib.nic.in/newsite/PrintRelease.aspx?relid=174832.
Ministry of New and Renewable Energy, 2017c. Schemes Launched by the Government to Promote Solar Energy in the Country. Government of India December 28, 2017. pib.nic.in/Pressreleaseshare.aspx?PRID=1514462.
Modi, Narendra, 2015. Let us turn to the sun to power our future: PM Narendra Modi at the launch of international solar alliance in Paris." Narendramodi. November 30, 2015. https://www.narendramodi.in/pm-modi-at-the-launch-of-international-solar-alliance-385253.
Modi, Narendra, Obama, Barack, 2014. A Renewed U.S.-India Partnership for the 21st Century. Washington Post September 30, 2014. https://www.washingtonpost.com/opinions/narendra-modi-and-barack-obama-a-us-india-partnership-for-the-21st-century/2014/09/29/dac66812-4824-11e4-891d-713f052086a0_story.html?utm_term=.ae1d47dbd645.
Mohan, Vishwa, 2015. Prime Minister Modi pitches for Solar Energy as Ultimate solution to India's Energy problem. The Times of India August 19, 2015. https://timesofindia.indiatimes.com/home/environment/developmental-issues/Prime-Minister-Modi-pitches-for-solar-energy-as-ultimate-solution-to-Indias-energy-problem/articleshow/48548062.cms.
Nelson, Dean, 2014. Magic' Modi Uses Hologram to Address Dozens of Rallies at once. Daily Telegraph May 2, 2014. https://www.telegraph.co.uk/news/worldnews/asia/india/10803961/Magic-Modi-uses-hologram-to-address-dozens-of-rallies-at-once.html.
NITI Aayog, 2015. Government of India, Report on India's Renewable Electricity Roadmap 2030: towards Accelerated Renewable Electricity Deployment. . http://cii.in/Publicationform.aspx?enc=+VOmGxIxCxf2n7zt4OXyAPIVd3fgdmCZV7kw5/hjnpuzgK7ClVUXiBcqoTbbOvrf.
Pathak, Maulik, 2014. The Narendra Modi Model of Development. Livemint May 9, 2014. https://www.livemint.com/Politics/jidgEODmTuivukTLuJHSTN/The-Narendra-Modi-model-of-development.html.
Pollitt, Michael G., 2012. The role of policy in energy transitions: lessons from the energy liberalisation era. Energy Pol. 50 (November), 128–137. Special Section: Past and Prospective Energy Transitions - Insights from History. https://doi.org/10.1016/j.enpol.2012.03.004.
Prabhu, Raj, 2017. Mercom Exclusive: Solar Tariffs in India Have Fallen by 73 Percent since 2010. Mercom India (blog) March 14, 2017. https://mercomindia.com/mercom-exclusive-solar-tariffs-india-fallen-73-percent-since-2010/.
Prateek, Saumy, 2018a. Greenko and Adani Named Top Solar Project Developers in India in 2017. Mercom India (blog) May 22, 2018. https://mercomindia.com/greenko-adani-top-developers-2017/.
Prateek, Saumy, 2018b. Indian Solar Imports Were up by 20% in FY 2018. Mercom India (blog) June 21, 2018. https://mercomindia.com/indianolar-imports-up-20-percent-fy-2018/.
Ramesh, M., 2014. Gujarat's Solar Success May Shine on Nation. The Hindu Business Line May 18, 2014. https://www.thehindubusinessline.com/economy/Gujarat%E2%80%99s-solar-success-may-shine-on-nation/article20775280.ece.
Ramesh, M., 2017. How Solar Power Was Made Cheap. The Hindu Business Line February 10, 2017. https://www.thehindubusinessline.com/economy/how-solar-power-was-made-cheap/article9533738.ece.
Ravindran, Shruti, 2014. India's Push for Renewable Energy: Is it Enough? National Geographic News September 20, 2014. https://news.nationalgeographic.com/news/energy/2014/09/140919-india-modi-renewable-energy-science-world-wind-solar/.
Rogge, Karoline S., Kern, Florian, Howlett, Michael, 2017. Conceptual and empirical advances in analysing policy mixes for energy transitions. Energy Res. Soc. Sci. 33 (November), 1–10. Policy mixes for energy transitions. https://doi.org/10.1016/j.erss.2017.09.025.
Safi, Michael, 2016. India Plans Nearly 60% of Electricity Capacity from Non-Fossil Fuels by 2027. The Guardian December 22, 2016, sec. World news. http://www.theguardian.com/world/2016/dec/21/india-renewable-energy-paris-climate-summit-target.
Shroff, Kaushal, 2017. India's Electric Turnaround: Powerless to Power-Surplus. Dna May 2, 2017. http://www.dnaindia.com/india/report-india-s-electric-turnaround-powerless-to-power-surplus-2424556.
Sinha, Aseema, 2003. Rethinking the developmental state model: divided leviathan and subnational comparisons in India. Comp. Pol. 35 (4), 459–476. https://doi.org/10.2307/4150190.
Sivaram, Varun, Shrimali, Gireesh, Reicher, Dan, 2015. Reach for the sun: How India's audacious Solar Ambitions Could Make or break its Climate Commitments. Stanford Law School December 8, 2015. https://law.stanford.edu/reach-for-the-sun-how-indias-audacious-solar-ambitions-could-make-or-break-its-climate-commitments/.
Smil, Vaclav, 2016. Examining energy transitions: a dozen insights based on performance. Energy Res. Soc. Sci. 22 (December), 194–197. https://doi.org/10.1016/j.erss.2016.08.017.
Smil, Vaclav, 2017. Energy Transitions: Global and National Perspectives, second ed. Praeger, Santa Barbara, California. https://www.amazon.com/Energy-Transitions-Global-National-Perspectives/dp/144085324X.
Sovacool, Benjamin K., 2016. How long will it take? Conceptualizing the temporal dynamics of energy transitions. Energy Res. Soc. Sci. 13 (March), 202–215. Energy Transitions in Europe: Emerging Challenges, Innovative Approaches, and Possible Solutions. https://doi.org/10.1016/j.erss.2015.12.020.
Sovacool, Benjamin K., Geels, Frank W., 2016. Further reflections on the temporality of energy transitions: a response to Critics. Energy Res. Soc. Sci. 22 (December), 232–237. https://doi.org/10.1016/j.erss.2016.08.013.
Stothard, Michael, 2015. India and France launch $1tn solar power tie-up. Financial Times November 30, 2015. https://www.ft.com/content/6b781150-978c-11e5-9228-87e603d47bdc.
Tongia, Rahul, Gross, Samantha, 2018. The Politics and Economics of India's Turn to Renewable Power. Brookings Institution (blog) September 18, 2018. https://www.brookings.edu/research/working-to-turn-ambition-into-reality/.
Tripathy, Devidutty, 2017. Global Investors Backing India's Drive to Be Solar Energy Giant. Independent.Ie May 3, 2017. https://www.independent.ie/business/world/global-investors-backing-indias-drive-to-be-solar-energy-giant-35675473.html.
UNEP, Frankfurt School-UNEP Collaborating Centre, and Bloomberg New Energy Finance, 2018. Global Trends in Renewable Energy Investment Report 2018. FS UNEP Centre April 2018. http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-report-2018.
Upadhyay, Anindya, 2017. India Solar Prices Set to Drop on Competition, Costs. *Bloomberg.Com* January 11, 2017. https://www.bloomberg.com/news/articles/2017-01-11/india-s-solar-prices-set-to-drop-amid-competition-lower-costs.
Upadhyay, Anindya, 2018. How Indian Solar Tariffs Delay Modi's Renewable Goals. The Economic Times September 25, 2018. https://economictimes.indiatimes.com/industry/energy/power/how-indian-solar-tariffs-delay-modis-renewable-goals/articleshow/65949564.cms.
Vazquez, Miguel, Hallack, Michelle, 2018. The role of regulatory learning in energy transition: the case of solar PV in Brazil. Energy Policy 114 (March), 465–481. https://doi.org/10.1016/j.enpol.2017.11.066.
Warrick, Joby, 2014. Obama and Modi Announce Agreement on U.S.-India Efforts to Fight Global Warming." Washington Post, September 30, 2014, Sec. Health & Science. https://www.washingtonpost.com/national/health-science/obama-modi-announce-modest-progress-in-joint-efforts-to-fight-global-warming/2014/09/30/c3e7464e-48aa-11e4-b72e-d60a9229cc10_story.html.
White House, 2015. Fact sheet: U.S. and India Climate and Clean Energy Cooperation. Whitehouse.Gov. January 25, 2015. https://obamawhitehouse.archives.gov/the-press-office/2015/01/25/fact-sheet-us-and-india-climate-and-clean-energy-cooperation.
World Resources Institute, 2017. "Achieving India's Ambitious Renewable Energy Goals: A Progress Report. World Resources Institute May 12, 2017. http://www.wri.org/blog/2017/05/achieving-indias-ambitious-renewable-energy-goals-progress-report.
Wu, Xifeng, Xu, Yuechao, Lou, Yuting, Chen, Yu, 2018. Low carbon transition in a distributed energy system regulated by localized energy markets. Energy Policy 122 (November), 474–485. https://doi.org/10.1016/j.enpol.2018.08.008.