Open innovation ecosystems: toward low-cost wind energy startups

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Abstract

Purpose – The purpose of this paper is to demonstrate how an open innovation strategy of public management in the energy sector enables the creation of innovation ecosystems and how it reduces the cost of wind energy projects in energy-poor countries.

Design/methodology/approach – This research study reflects on seven wind energy startups (WESs) in Pakistan using quantitative and qualitative data following a sequential mixed-methods approach. First, it draws from growing literature on innovation and renewable energy management to conceptualize an open innovation ecosystem model around WESs. It then tests this model using cost analyses of wind projects and identifies possible cost-saving strategies. Finally, follow-up interviews with managers in investigated projects cross check study findings and validate the model.

Findings – Three noteworthy findings can help policymakers in developing countries to effectively meet the future energy challenges and get benefit from international funding opportunities: by protecting lenders on approved terms rather than offering sovereign guarantee to operating firms; by letting the government take control of the initial development phase; and by giving off-take guarantees to the manufacturers.

Practical implications – It offers policy recommendations to energy sector managers about guarantees, financing, regulators, governmental control, tariffs and transfer of technology that can significantly curtail outlays.

Originality/value – Results suggest that adopting an open innovation ecosystem model can potentially save around 6 per cent ($4-$7m) in the overall cost of a 50 MW wind energy project.

Keywords Openness, Public management, Ecosystem, Wind energy, Mixed-methods

Paper type Research paper

1. Introduction

Energy poverty is a major issue for half of the world's population and will likely worsen, as population growth forecasts exceed connection rates (World Economic Forum, 2019). World Bank statistics show that despite significant progress in recent years, energy sector is falling short of sustainable energy goals. About 1.06 billion people (80 per cent of this from developing regions of South Asia and sub-Saharan Africa) currently live without access to electricity (The World Bank, 2019). This daunting challenge has led authorities, policymakers and practitioners to source energy from sustainable, renewable resources such as wind power. The dynamic and innovative wind energy sector currently serves a huge market and is expected to cover 18 per cent of the world's energy requirements by 2050 (Adami *et al.*, 2017). Recent management literature concerned with renewables increasingly recommends an open innovation model, which speaks to interconnectedness among firms to access valuable resources through collaborations (Bogers *et al.*, 2018; Hartley, 2014;

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Kuik *et al.*, 2019; Odabashian *et al.*, 2019). At the core of open innovation is to engender an innovation ecosystem (Bogers *et al.*, 2018; Fasnacht, 2018). Defined as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017), the innovation ecosystem underpins a constellation of cross-sector collaboration among public, private and social segments which together develop and commercialize coherent solutions (Jacobides *et al.*, 2018; Dattée *et al.*, 2018). An innovation ecosystem allows energy firms (original developer) to materialize complex value propositions by getting input from multiple complement providers (Carbajo and Cabeza, 2018; Brorström *et al.*, 2018; Adami *et al.*, 2017; Kuik *et al.*, 2019; Greco *et al.*, 2017b, Brink, 2017). A growing number of energy researchers argue that the effectiveness of this innovation architecture hinges on supportive public management because it holds the potential to seed an open innovation ecology (Leyden, 2016; Bogers *et al.*, 2018; Diamond and Vangen, 2017; Odabashian *et al.*, 2019).

On the obverse, studies in public management find that open innovation gets the least priority in development budgets and public policy (Serrat, 2017; Demircioglu and Audretsch, 2017; Diamond and Vangen, 2017). Synonymous to the jargons of business management, working "smarter," not "harder," public management can also deliver more for less by adopting an open innovation model and enabling the creation of ecosystems around energy projects that allow multiple players to complement each other's knowledge, R&D capabilities and resources (Albury, 2005; Diamond and Vangen, 2017; Leyden, 2016; Kuik *et al.*, 2019). Researchers argue that public management should build innovation ecosystems around requirements, instead of making requirements fit the existing arrangement (Serrat, 2017; Kankanhalli *et al.*, 2017; Demircioglu and Audretsch, 2017). Despite fast advancement in innovation literature demonstrating that innovation ecosystems facilitate cross-sector and cross-national collaborations (Jacobides *et al.*, 2018; Adner, 2017; Bogers *et al.*, 2018; Teece, 2018; Dattée *et al.*, 2018; Odabashian *et al.*, 2019), public management in the energy sector still lags to adopt the model. Although a handful of studies in energy sector management have recently started to investigate factors leading to public sector' resistance to adopting open innovation, they mostly analyze objective and structural antecedents (Scherhaufer *et al.*, 2017; Adami *et al.*, 2017; Greco *et al.*, 2017b; Brink, 2017).

We supplement this lens by suggesting that prior research in energy sector management may have unnoticed the important role of open innovation ecosystems in cutting costs, enhancing efficiency and ensuring the stability of wind energy startups (WES). Given that innovation ecosystems offer a new approach to deal with austerity in a turbulent environment (Diamond and Vangen, 2017), it is timely to test the model in the energy sector, particularly in energy-poor countries looking for renewables. We believe this inquiry is essential for two reasons. First, to enhance our understanding of how openness embodied in public management enables innovation ecosystems that might create entirely new complementarities around WES previously overlooked in the energy sector. And second, to extend the practical application of innovation ecosystem model to energy sector management in energy-poor countries.

To further these ends, we investigated the energy sector in Pakistan where a recent \$62bn mega-project, the China Pakistan Economic Corridor (CPEC), has allocated \$33bn for energy infrastructure to alleviate a growing issue in energy poverty (Malik, 2015). Using a mixed-method approach, we demonstrate how openness embodied in public management can benefit energy projects by limiting their startup costs. We began with the cost analysis of seven WESs followed by in-depth interviews with 15 executives from these projects. We reflect on whether and where an innovation ecosystem could create value for energy firms by lowering startup costs and capture value from funding opportunities such as CPEC. We conclude by offering policy recommendations and practical implications for other developing economies in the region. Our findings allow us to make two noteworthy contributions to energy sector management literature. First, far as we know, this is the first comprehensive attempt to untangle how public management openness drives ecosystem creation. And second, how ecosystems create a low-cost advantage for WES in energy-poor countries.

2. Theoretical foundation

2.1 Resource dependence

Our theoretical exposition is underpinned by resource dependence theory (Pfeffer and Salancik, 1978), which says that scarcity of resources gives rise to resource dependence and social engagement. In an open innovation context (Kankanhalli *et al.*, 2017; Bogers *et al.*, 2018), the dependence of energy firms may lead to more cooperation and social exchange with external players. This theme is spurred by convergence among research domains ranging from open innovation (Chesbrough, 2003; West *et al.*, 2014), to open strategy (Whittington *et al.*, 2011) and collaborative networks (Vanhaverbeke *et al.*, 2017; Bogers *et al.*, 2017; Bogers *et al.*, 2018). All these studies repeatedly and eloquently argue for participatory modes of value creation by suggesting a social architecture of innovation networks (Rooney *et al.*, 2013; Perry-Smith and Mannucci, 2017). An overwhelming majority of studies in this purview subscribe to "innovation ecosystems" as important vehicles to capture and create value from complex value propositions. Innovation ecosystems add value by allowing multiple actors to coordinate multilateral dependence (Adner, 2017; Jacobides *et al.*, 2018). The more open energy sector management becomes, the more inclusive innovation ecosystems it creates and the more value it derives for WES in the shape of low-cost advantage (Adami *et al.*, 2017). Moving to this innovation approach needs supportive public management (Leyden, 2016; Greco *et al.*, 2017b). According to Adami *et al.* (2017), public sector carries the potential to influence the bargaining power of buyers and suppliers, threats of new entrants, substitutes and industry dynamics thus can worsen or improve national and regional advantage in the energy sector. Below, we discuss the salient features of our theoretical underpinnings in further detail.

2.2 Open innovation

A good deal of extant literature suggests that innovation is embedded in social networks (Perry-Smith and Mannucci, 2017; Carbajo and Cabeza, 2018; Kumar and Zaheer, 2019). A social approach to innovation is leading a major change in policymaking to evolve from "closed" to "open" innovation models (Bogers *et al.*, 2018; Vanhaverbeke *et al.*, 2017; Greco *et al.*, 2017b). According to Chesbrough and Bogers (2014), open innovation is "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries." It is worth recalling the social resource perspective (Gulati, 2007; Rooney *et al.*, 2010; Kumar and Zaheer, 2019), which underscores that advantage emanates from the quality of networks that allow access to valuable resources in an ecosystem. Because openness determines the quality of innovation networks (Rooney *et al.*, 2003); in this regard, it potentially serves as a sustainable source of advantage for firms in innovation ecosystems.

Recent empirical research views openness at the intersection of policy, research and practice (Bogers *et al.*, 2018; Jacobides *et al.*, 2018). Management researchers in wind energy sector (Scherhaufer *et al.*, 2017; Adami *et al.*, 2017; Carbajo and Cabeza, 2018) increasingly recommend public management to adopt an open innovation model for increasing technological capability, cost-cutting, reducing development time, knowledge creation, market growth and improved efficiency in R&D. A supportive policy framework can enable the creation of inclusive innovation ecosystems (Greco *et al.*, 2017b; Leyden, 2016) that stimulate collaboration among internal and external actors within the public, private and social sectors (Brorström *et al.*, 2018; Bogers *et al.*, 2018).

2.3 Innovation ecosystems in the energy sector

In the energy sector, an ecosystem refers to a bundle of relationships where interaction between government, vendors, investors and project developers facilitates decision-making, idea generation, value creation and commercialization (Greco *et al.*, 2017b; Scherhaufer *et al.*, 2017). Innovation ecosystems typically reside upon openness (Bogers *et al.*, 2018). It draws on resources, knowledge and capabilities from all sectors of the community (Jacobides *et al.*, 2018). By counting on multiple sources in the ecosystem, organizations are not only able to extract new insights for technological progress but also identify new areas for strategic development (Dattée *et al.*, 2018; Vanhaverbeke *et al.*, 2017). Strategies for financing new projects, identifying assets, allocating resources, public space management and evaluating progress are all better implemented in an ecosystem context (Adner, 2017; Bogers *et al.*, 2018; Jacobides *et al.*, 2018).

The benefits of creating open innovation ecosystems can manifest in the form of reduced engineering procurement and construction (EPC) cost, lesser non-EPC outlays lower project development expense and a decrease in tariffs. Further, owing to social networking and collaborations (Kumar and Zaheer, 2019; Dattée *et al.*, 2018), ecosystems help curtail operation and management cost and thus the total operating cost of the project. These cost cuttings significantly reduce the overall cost of a WES, thereby creating a low-cost advantage for energy firms (Adami *et al.*, 2017; Greco *et al.*, 2017b; Kuik *et al.*, 2019).

3. Method

3.1 Research context

Pakistan, like other energy-poor nations in the Asian and African region, has suffered an acute energy shortage for decades (Hayat *et al.*, 2019). Despite having a high potential for wind power (346 GW), fossil fuel dominates its energy mix (85 per cent). One-third of Pakistan's population is not connected to the national power grid and chronic circular debt, the high cost of electricity generation and a mismatch between supply and demand that increasingly force utilities to load shed further complicate the challenges faced by government (Ullah *et al.*, 2017; Zameer and Wang, 2018; Hayat *et al.*, 2019). Pakistan policymakers give priority to renewable resources, such as wind, and 13 wind power projects (591 megawatts) are currently operating and many others are in the development phase (Reuters, 2017; Times of Islamabad, 2019). Although the recent $62bn of mega-project funding associated with the CPEC is an excellent opportunity to finance WESs, there are underlying challenges for policymakers. For example, Chinese funding stipulates using the "Sinosure" – Chinese credit insurance agency to insure the funding and to cover the commercial risk. A substantial portion of the loaned money goes into Sinosure fees as part of the EPC contracting agreements, adding to the overall cost of the project. With the above-alluded opportunities and challenges, we examine the extent to which adopting an open innovation ecosystem model in energy sector management curtails the start-up costs of WESs in Pakistan.

3.2 Data and procedure

Our sequential mixed-method approach draws on both quantitative and qualitative data (Guba and Lincoln, 2005; Teddlie and Tashakkori, 2009). This methodology not only provides a better contextual understanding and descriptive illustration of a complex phenomenon under study but also allows for data triangulation (Jick, 1979). First, we used a quantitative method to analyze WES costs, followed by confirmatory qualitative interviews. The goal of conducting first, quantitative study (cost analysis of WES) was to identify the potential accounts and ways in which startup costs of the projects can be reduced and to develop an interview guide for the follow-up qualitative study. That is, the first phase of the research, the quantitative phase, was conducted to inform the second confirmatory, qualitative phase (Creswell, 2009; Hair *et al.*, 2010; Teddlie and Tashakkori, 2009).

3.2.1 Quantitative data. Quantitative data about startup costs incurred during the development phase of wind projects in Pakistan was collected from archival sources such as public records of tariff determinations (where available), reports and government websites. The population frame comprised 13 wind projects in Pakistan. However, we purposively sampled seven cases that presented the most reliable data of their startup development phase. Adopting a multiple case study design helped us identify patterns of relationships within and across cases (Eisenhardt and Graebner, 2007). The seven chosen cases comprise Fauji Fertilizer Company Energy Limited, Sachal Energy Development (Pvt) Limited, China Three Gorges, Metro Power Company Limited, Zorlu Enerji Pakistan Limited, Foundation Wind Energy-I Limited and Foundation Wind Energy-II Limited. To keep their data anonymous, we assigned random alphabets (A, B, C, D, E, F and G) to these cases.

3.2.2 Qualitative data. To explain, interpret and confirm the results of our quantitative phase, we conducted a qualitative study (Creswell and Creswell, 2017). Multiple valid sources were used for qualitative data collection (Eisenhardt, 1989), including semi-structured interviews with 15 executives (five CEOs, six CFOs and four Directors) from the investigated projects, user Web pages, observations, blogs and social network profiles. Before the main interviews that lasted between 35 and 50 min, a pilot study was conducted to assess the comprehensiveness of the interview guide and identify any difficulties with the interview process. The interview participants were reminded of the purpose, format and need to record their views and consent for participation was obtained. To ensure data accuracy, we interviewed no less than two participants from each selected project. All interviewees were directly involved in the development phase of the wind projects. We undertook data cleaning and remove identifiers to kept participants anonymous and maintain confidentiality. Attention was paid to maintain depth and accuracy during data collection about all cases (Eisenhardt and Graebner, 2007). The reliability and validity of results were ensured through data triangulation using multiple sources of information and data collection techniques (Kirk and Miller, 1986; Jick, 1979). The interviews conducted were recorded using a voice recorder and later transcribed to facilitate thematic analysis (Braun and Clarke, 2006; Creswell, 2009).

Thematic analysis is an appropriate analytical strategy to analyze the interview transcripts because it facilitates the identification of patterns that capture important concepts within a data set (Ayres, 2008). In keeping with Braun and Clarke (2006), initially, the researchers read through transcripts and notes (observations), impressions and ideas were jotted down, coded and categorized. Transcripts were re-read along the finalized list of categories to make sure that the codes comprehensively cover all relevant aspects of the interviews. Once all the interview transcripts were coded, collated and reviewed, overarching themes were identified from the overall data corpus. This recursive process allowed the researchers to sort, focus, discard and better organize interview data in a way that meaningful conclusions could be drawn and verified (Miles and Huberman, 1994).

4. Results

The documented cost breakdown of all seven WESs is presented in Table I. Our data suggest that an overall startup cost of approximately 50 MW WES is about $125-$133m. Most of the overall cost was incurred in three main areas, i.e. the EPC cost, Sinosure and project development. First, the EPC – a prominent form of contracting agreement in which the EPC contractor is responsible for the complete engineering design, procuring all necessary materials and equipment and then constructing the project to deliver a working facility to the developer. The EPC contractor must provide the asset by a specific date, for a guaranteed price and assures that the facility performs to the specified level. As presented in Table I, the EPC contract represented 82-85 per cent of the total cost of wind energy projects.

Second, the "Sinosure" costs for the Chinese financed projects to insure against political, commercial and credit risks, including investment insurance and export credit insurance (short, medium and long term). The National Electric Power Regulatory Authority of Pakistan has approved Sinosure fee of 6.53 per cent on Chinese loans (NEPRA, 2015). Anecdotal evidence, however, suggests that because of circular debt the actual payment amounts to about 9 per cent costing a substantial amount of loaned capital. Table I shows that two of the investigated projects, B and D, paid about $5.6m and $6.7m to Sinosure to cover the commercial risk. Further, considerable variation is seen in interest paid. Project A paid the most interest ($13.7m), whereas D paid the least ($3.7m) during construction. This variation is a function of the total debt carried. Given that future wind power projects in Pakistan are likely to be financed by China (CPEC), Chinese loans will continue to influence capital structures and cash flows of energy firms in Pakistan.

Third, the project development cost also forms a significant portion of the overall cost. It includes the expanse of feasibility studies, permits, travelling and technical/financial/legal consultancy charges. Table I shows that project D (56 MW) spent about $4.0m during project development, whereas all others spent around $2.2-$2.9m. Table I also shows other costs, i.e. financial cost (an average of $3m paid by each project) and non-EPC outlays (including the cost of fixed assets, administration office, employee residence, optical fiber communication). In what follows, we elaborate on how public management can help minimize these variable costs by adopting an open innovation ecosystem approach.

5. Data analysis and discussion

With the above figures in hand, we carried out semi-structured interviews to capture the views of executives regarding how public management might benefit WESs. Study participants emphasized problems within and across wind energy industry, such as financial constraints, practical difficulties, functional mimicry, achieving contextual fit, inherent indecision in the public sector, tensions around EPC cost, Sinosure fees, technology transfer and limited capacity of the energy grid. From our interviewees' comments, we identified at least three main reasons for an overall positive effect of openness in public management that, we argue, can enable, generate and support inclusive ecosystems and facilitate the revival of energy sector in developing countries. This section stipulates the central themes that emerged from the triangulation of qualitative and quantitative data and outlines policy solutions:

5.1 First: protect lenders on approved terms instead of giving sovereign guarantees to the company operating the plant

Much of the discussion regarding cost savings converged on a lack of appropriate public policy for WESs and, most importantly, the EPC contract (Table I). All of the study participants were unequivocal about the financing problems regarding EPC contracts

Table I. Cost break down of wind energy projects (US$000)

	Project	EPC contract cost Onshore	Offshore	Total	Non-EPC cost	Project development	Financial charges	Sinosure fee	Interest	Overall cost
1	A	25,068.0	86,131.0	111,199.0	1,020.0	2,536.0	3,077.0	–	13,675.0	133,770.0
2	B	25,900.0	84,200.0	110,100.0	1,855.0	2,195.0	2,822.0	5,597.0	7,931.0	133,919.0
3	C	20,594.0	88,248.0	108.842.0	1,320.0	2,596.0	2,611.0	–	6,589.0	125,236.0
4	D	31,942.0	78,038.0	109,980.0	1,100.0	2,930.0	2,780.0	6,745.0	3,742.0	129,114.0
5	E	45,093.0	71,780.0	116,873.0	500.0	4,088.0	3,103.0	–	4,805.0	130,342.0
6	F	27,605.0	82,666.0	110,271.0	1,000.0	2,750.0	2,604.0	–	7,119.0	125,473.0
7	G	25,989.0	82,673.0	108,662.0	820.0	2,929.0	2,466.0	–	6,849.0	123,495.0

Notes: EPC price – engineering, procurement, construction; non-EPC price – the cost of fixed assets, office, employee residence, security for expatriates and optical fiber. Project development cost is estimated on a pro-rata basis. It includes feasibility studies, permits, traveling and consultancy. Sinosure fee – A Chinese credit agency that ensures and backups the loan from China during the initial stage of project development. Interview participants made it clear that although the EPC contract satisfies the lenders' requirements for bankability, EPC contractors were not ready to respond to WES in Pakistan due to uncertainty. Therefore, the initial phase was met with delays and lost time. One respondent (Director) stated that "we issued the request for quotation but did not get any reply for more than a year." One of the CEOs stated that "locally [in Pakistan], the banks have their capital limits, and internationally, it was tough to get financing," also adding, "ultimately, the rescue came from foreign institutions such as the United States-OPIC [Overseas Private Investment Corporation] and CPEC from China." Another CEO responded that:

> We ventured to get financing for our wind project from various markets including the Middle East and others [. . .][. . .]ultimately Chinese banks backed by Sinosure came in and provided the financing.

It is clear that without collaboration with external partners, many of these projects would not take place. One of the CEOs of Chinese funded project responded that:

> China provided much-required breathing space for the power sector in the shape of financing and supply of equipment[. . .][. . .] we had to look out to international suppliers and contractors for the reply to our RFQ [request for quotation], but eventually, it was Chinese who started responding and the work started.

Although a majority of participants believed that CPEC is a breakthrough, they indicated specific challenges associated with Chinese funding such as the Sinosure fee (Table I). For example, one participant said:

> [. . .] while Sinosure backed loans solved the financing problem, the flipside was a near-monopolistic condition [. . .] Sinosure has been placing an unreasonable burden on the project financial structures because of their high fee and lack of flexibility in policies.

Likewise, another participant (CFO) stated, "When we got a loan of about $100 M, we had to pay around $9 M to Sinosure to cover the commercial risk." One theme that repeatedly emerged in the interviews was myopic public policy. The government provides a sovereign guarantee for revenues to the seller, i.e. the firm operating the plant. This security is not extended to the lenders to cover the debt repayment. According to our study participants, if security is to benefit the local firm operating the plant, protecting the lender [Chinese firm] will be more beneficial for the startups. As one of the CEOs of a Chinese funded project said:

> I firmly believe that the government of Pakistan must take this scenario wholistically at their policy level [. . .] it will be a game changer if they develop a pool and shift the sovereign guarantee to lenders at the approved terms to finance the project in Pakistan [. . .] the government may impose some limit on the tariff though.

Participants affirmed that "wind projects would not have to pay 9 per cent insurance fee to Sinosure." Instead, the local government could use some portion of it to develop "a capital fund for an umbrella financing structure" and to "underwrite any payment shortfalls." Our qualitative findings suggest that this 9 per cent could be negotiated, and the savings would eventually translate into tariffs going to the government. Because most developing countries (like Pakistan) are capital constrained and are unable to provide adequate funds to finance energy startups, public management can facilitate future wind energy initiatives by adopting an open innovation model. Our data shows that adopting an open approach to incentivize and protect lenders will improve the trust of international financers, which can attract the participation of diverse actors during the various stages of development, thus making the wind energy ecosystem more inclusive (Greco *et al.*, 2017b). We, therefore, recommend public management to make the best of innovation ecosystems by protecting lenders, thereby creating an advantage for local energy firms (Adami *et al.*, 2017).

5.2 Second: governmental control of the development phase

Of the 15 participants, 12 pointed out procedural delays in the development phase. Interviewees believe that the government should take administrative control of the initial development phase. One participant stated:

> [. . .] traditionally, the timeline of development phase extends due to lack of understanding of various stakeholders, especially the regulators [. . .]. the timeline increases because the regulators are not fully conversant with the wind projects.

One of the directors responded that:

> The developers in Pakistan and mostly everywhere, have to negotiate at least energy purchase agreement, implementation agreement, and tariff. Apart from this, we have to undertake a host of studies and get them approved by the regulators in the government [. . .].we have documentary evidence of time lost due to delays attributable to the government and the time lost is over 12 months, this means financial loss, management time lost, erosion of confidence of the investors and suppliers.

Similarly, some participants also described the crucial role of regulators and suggested that initial governmental control can help minimize delays related to administrative bottlenecks. As another CEO stated that:

> [. . .] government should control the early stage of the startup, let's say until 500MW and then sell it or transfer it to the sponsors [. . .] so that the regulators come up to the speed and the regulations are reorganized [. . .]. The risk premium which investors like to build on in the projects could be reduced significantly if a major part of the public approvals [development phase] is taken over by the government. Thus investors will take on the project from where issues related to red-tape and accessibility [departments] are over.

In a similar vein, study participants noted that alongside other factors, the future of wind energy greatly depends on the "strength of the national energy grid." The intermittent nature of wind-sourced energy poses a challenge for an energy grid to sustain and manage the variable load. One participant indicated that:

> Currently, there is a bottleneck in the energy sector owing to the dawdling response from the government towards strengthening the energy network [. . .] they [government authorities] need to strengthen the energy grid first before looking to further wind projects.

A majority of study participants had reservations and concerns about being connected to the national power grid. A recurrent issue pointed out that:

> [. . .] government provides the letter of intent but getting connected to the energy grid is a lot troublesome' due mainly to a stringent procedure and limited capacity of the grid. This causes "excessive delays, "uncertainty," and "cost overruns" putting the project viability at risk. These comments seem to mirror the findings of prior energy sector management researchers (Callegari *et al.*, 2018; MacDougall, 2015) that uncertainty inevitably imposes a significant financial risk to developers and discourages investment in new startups.

Participants' views and cost analysis presented in Table II, suggest that government intervention can reduce several expenditures, such as the feasibility study cost, permit/licensing/company formation fees, project consultation costs, project administration costs, HR costs and traveling expense. Overall, we anticipate that early-stage government ownership potentially accounts for about 0.66 per cent savings in the overall cost.

Table II.
Cost savings if the project development cycle is shortened and local human resource is available

Description	Current cost[a] (%)	Proposed cost[b] (%)	Justifications for cost savings owing to an ecosystem	Assumptions and additional information
Feasibility study cost	0.13	0.06	Based on the review of tariff petitions filed by the investigated firms and interviews with experts	1. Project A spend approx. $1m in this head. Other projects mostly relied on local and international services.
Permit/ license fee	0.13	0.13	It will remain the same unless the government gives exemptions	Availability of local services can reduce feasibility study and consultancy costs
Consultation cost	0.46	0.28	At present, the development cycle is four years. Experts suggest that an open innovation policy shall reduce it by 75%. This reduction in development time, however, cannot be precisely reflected in the cost. Usually, consultants charge the project on an hourly basis which also includes overhead, deployment charges, consultancy services and salaries. Fixed cost would not vary, only variable costs would be impacted. Analysis of available information and careful estimates reveal that an innovation ecosystem can reduce variable cost in this head by 50%	2. Almost, each project mentioned in Sheet 1 has gone through 4-5 years' development cycle. In some cases, it took 8-10 years from the time the Letter of Intent was issued 3. Construction period of one and half year remains the same. Some projects were slightly delayed due to unavailable grid interconnection system. Its impact, however, has been ignored 4. Training of local staff is important to achieve indigenization, which might add overheads
0.27	0.14	During	Administration cost development (75% reduction in time) During construction (No change) , based on experts' opinion, the overall project administration cost reduces by 50%	
Human resource cost	0.48	0.24	During development (75% reduction in time), during construction (no change), based on the experts' opinion, the overall HR cost reduces by 50%	
Traveling expenses	0.14	0.12	Considering 75% reduction in the development cycle, traveling expense shall reduce. Based on the experts' opinion, it may decrease by 50%	
Other	0.04	0.02	During development (75% reduction in time), during construction (No change), based on the experts' opinion, the overall cost reduces by 50%	
Total	1.65	0.99	(a-b) Overall, 0.66% saving in the project cost	

Although there is no lack of evidence from prior research to point out the lethargy of the public sector being inhospitable to innovation, management and strategy (Serrat, 2017; Kankanhalli *et al.*, 2017; Demircioglu and Audretsch, 2017), we, however, found that the development time of WES is reduced if the government intervenes and takes control of the development phase. Through open strategy, public management supports ecosystem creation (Diamond and Vangen, 2017), which expedites the development phase by eliminating red-tapism, procedural delays and functional silos (Leyden, 2016). The summary of cost savings presented in Table IV indicates that on average, governmental control of the development phase can help WES save approximately $0.8m.

5.3 Third: giving off-take guarantees to the manufacturers for transfer of technology

Interviewees strongly recommended that indigenization of manufacturing capability can significantly reduce the startup cost (Table III). In common was the notion that public authorities must see a big picture. Given a vast potential of wind energy in Pakistan (Hayat *et al.*, 2019) and a large amount of foreign capital ($33bn) available for the energy sector under CPEC, the government should engage with large international manufacturing firms to establish subsidiaries in the local market. The manufacturer initially requires up-take guarantees for the first several years. Public management can adopt an open approach

Table III. Cost saving with indigenous production/transfer of technology (expenditures as a percentage of offshore agreement price)

Description	Current cost[a] (%)	Proposed cost[b] (%)	Justifications for cost savings owing to an ecosystem	Assumptions and additional information
Transportation cost	10	5	Based on the experts' views and internet search, the transportation cost is 2.6% if the equipment is locally manufactured. In the case of Pakistan, raw material, e.g. steel, etc. shall require transportation cost, which is assumed to be 5%	1. Cost of indigenization is not considered. 2. Pakistan is importing steel and other raw materials. Thus, considering the existing infrastructure, assembling could be achieved 3. Training of local staff is vital to achieving indigenization, which might add overheads 4. Considering imported raw materials and inland transport, the transportation cost is estimated to be 50% lesser 5. Transfer of technology (local production) can provide job opportunities to the local community and flourish many connected businesses. However, the benefits cannot be quantified precisely
Marine cargo insurance and delay in startup	0.50	0	It shall not be required for local production. For imported raw material it is negligible	
Procurement, design, manufacturing, testing and commissioning	89.50	89.50	Indigenization and local human resource can reduce the price. However, it is difficult to assess. Further, Descon (a Pakistani EPC Contractor) in a joint venture with Nordex has been charging approximately the same price	
Total	100	94.5	(a-b) Overall, 5.5% saving in the offshore EPC price	

by providing time-barred off-take guarantees to the manufacturer. For example, in one of the investigated projects, a director stated that:

> In our case, we consulted a renowned Spanish manufacturer [. . .].they [the manufacturer] initially asked for an off-take guarantee of 500MW machinery per annum for the first five years to establish their plant in Pakistan [. . .].they [the manufacturer] even agreed to negotiate it, and later they reduced it by 50 per cent.

About half of the participants mentioned that the government could, indeed, negotiate the off-take guarantee protection with the manufacturer at better terms for a specified period for 200-300MW. One participant (Director) suggested that:

> After the lapse of this limit, whichever is earlier, the government can open the competition [. . .] it [the government] will have an advantage of one indigenous plant working under an international license. It means that the future EPC contractor has to come to better terms.

In the backdrop of participants' comments, we recommend that if policymakers adopt an open innovation strategy, the maker can establish local manufacturing. As one CEO suggested that "after indigenous production has been established, the government can open-up market competition" leading to social, economic and industrial benefits. It can potentially create a future opportunity for China to consider production in the host (developing) country due to the low-wage rate factor – creating an economic advantage (Mercer *et al.*, 2017). One participant (CEO) stated, "the wage rate advantage of China as compared to Pakistan exists no more [. . .] the [wage rate in China] has tremendously increased as compared to Pakistan."

The social benefits include job creation, skill development and employment of local skilled labor in specialized jobs. The economy not only benefits from the establishment of power plants but also from their indigenous production to assure sustainability. For industry, opening up the markets for competition will influence service providers to innovate with better terms to feature superior products. This strategy will allow public management to eradicate drawbacks (if any), in the previous manufacturing setup and replace it by choosing from the top competitors. Making good use of all these strengths entails an innovation ecosystem (Vanhaverbeke *et al.*, 2017; Greco *et al.*, 2017b; Adner, 2017). As one of the participants (CEO) indicated that:

> By now, policymakers have utilized over 1500MW [in peacemeal] providing off-take guarantees negotiating with different manufacturers for the provision of machinery [. . .]. with better planning; it could indigenously manufacture the machines under license for an off-take guarantee of just less than 300MW for few years.

Given the upcoming opportunities of CPEC, this study recommends public management in energy sector to consider the transfer of technology as a policy strategy. This intervention can play a significant role in creating a low-cost advantage for future WES (Adami *et al.*, 2017). Table IV shows that by adopting openness, public management can reduce the EPC cost, Sinosure fee, project development cost and hence the overall start-up cost of a typical WES by about 6 per cent, i.e. approximately $4-$7m.

6. Implications

Evidence from this study emphasizes that by adopting an open innovation strategy, public management in the energy sector can develop an umbrella financing structure, build the capability and ultimately get better deals at reduced costs. Table IV alludes to strong practical implications of the open innovation ecosystem model, indicating that each of the WESs investigated could save a considerable amount of expenditure (minimum $0.48m, maximum $0.719m). As such, creating innovation ecosystems as a policy strategy can benefit all stakeholders of WES in meaningful ways. For the operators, it offers collaborative social networks that translate into a low-cost advantage. As presented in Table II, several outlays can be significantly curtailed as a percentage of the overall cost of WES. For instance, feasibility study cost (reduced from 0.13 to 0.06 per cent), consultation cost (from 0.46 to 0.28 per cent), administration cost (from 0.27 to 0.14 per cent), human resource cost (from 0.48 to 0.24 per cent), traveling expanse (from 0.14 to 0.12 per cent) and other expenses (from 0.04 to 0.02 per cent).

For the government, an open innovation ecosystem model can not only address energy supply issues in the shortest possible time but also promise a platform for the transfer of technology that can play a central role in cost reduction of WES. Table III proposes that it can reduce transportation costs (from 10 to 5 per cent), marine cargo insurance and delay cost (from 0.5-0 per cent) of the overall cost of the WES. For domestic financiers, it provides a sovereign guarantee of debt repayment. As suggested by interviewees, the saved amount (about $0.5m) can be diverted to debt repayment. In a similar vein, for domestic citizens, an open innovation ecosystem builds trust and transparency in the system – an interactive mechanism in which the objections and qualms are seriously considered by adopting a participatory approach through inclusion and engagement.

Although public sector innovativeness can create superior value for society (Kankanhalli *et al.*, 2017), extant literature hints to myopic public policy lacking entrepreneurial approach (Serrat, 2017; Demircioglu and Audretsch, 2017; Leyden, 2016) toward creating innovation ecosystems (Greco *et al.*, 2017b; Adner, 2017). Energy sector management can particularly benefit from our findings. Particularly, in developing countries, power supply authorities already short of capital are unable to undertake all the upgrading and maintenance, network extension and rehabilitation. Instead, available funds are directed to other visible and prestigious projects like dams and power stations. In this milieu, public management in the energy sector can deliver more for less (Albury, 2005; Diamond and Vangen, 2017; Kuik *et al.*, 2019) by adopting greater openness to enable ecosystem emergence.

7. Future research directions

First, our data come from WES in a developing economy and our findings offer generalizability to energy-poor countries. However, it masks discrepancies that occur due to economic variations. Therefore, one potentially fruitful avenue for future research is to investigate how our findings can help WESs in the developed economies. Second, the recent surge of research and widespread application of open innovation concept, the paradigm of management in the energy sector is shifting toward greater openness (Greco *et al.*, 2017a, 2017b; Adami *et al.*, 2017;

Project		Offshore EPC		Sinosure fee		Project development		Overall cost	
		Expense	Saving[a]	Expense	Saving[b]	Expense	Saving[c]	Expense	Saving
1	A	86,131.0	4,737.2	–	–	2,536.0	882.8	133,770.0	5,620.0
2	B	84,200.0	4,631.0	5,597.0	1,679.1	2,195.0	883.9	133,919.0	7,194.0
3	C	88,248.0	4,853.6	–		2,596.0	826.6	125,236.0	5,680.2
4	D	78,038.0	4,292.1	6,745.0	2,023.5	2,930.0	852.2	129,114.0	7,167.8
5	E	71,780.0	3,947.9	–	–	4,088.0	860.3	130,342.0	4,808.2
6	F	82,666.0	4,546.6	–	–	2,750.0	828.1	125,473.0	5,374.7
7	G	82,673.0	4,547.0	–	–	2,929.0	815.1	123,495.0	5,362.1

Notes: [a]5.5% saving in offshore EPC price. [b]30% saving in Sinosure payment. [c]Currently, it accounts to about 1.51% of the overall cost of the project, which could be reduced to nearly 0.98%

Table IV. Summary of possible cost savings (US$ 000)

Brink, 2017; Odabashian *et al.*, 2019). There is limited research about the process of how firms adopt openness and evolve from ego-system to ecosystems? Without a clear framework explaining the openness process, it is difficult for energy firms to adopt open innovation strategies in a planned manner. Thus, an increasingly important area for research in energy sector management is to explore the process of inter-firm openness.

Third, although inter-firm openness helps create innovation ecosystems, it is not exogenous. Innovation advantages stem from the agency of multiple players such as government, regulators and institutions. Many questions require further research on, for example, the role of institutions, regulators and public policy in creating conducive environment for the creation of ecosystems. Future research in energy sector management might find these aspects worthy of systematic investigation. Last, because firms are mostly resource dependent (Pfeffer and Salancik, 1978), they engage with external actors in possession of needed resources and create ecosystems to gain advantages. The competitive strategy, such as the resource-based view (Barney, 1991), promotes resource inflow (inflow openness) but dissuades outflow (outflow openness), which is believed to harm competitive advantages. But all too often, a critical resource spans a firm's boundaries and lies not at the level of a firm but at the level of an ecosystem in which multiple interdependent firms have residual control over shared resources. This conundrum alludes to the need for further research on the competitive advantage of interdependent firms in open innovation ecosystems.

8. Concluding remarks

To sum up, innovation is not an optional luxury but mandatory for the progress of energy sector management (Albury, 2005; Diamond and Vangen, 2017; Yapp, 2005). Fostering openness in public management helps develop innovation ecosystems by integrating internal and external stakeholders that save resources, reduce expenditures and create a low-cost advantage for energy firms. We proposed three policy reforms. First, besides offering public subsidies for R&D activities to local firms, policymakers might also consider incentivizing foreign collaborators in the ecosystem to realize long-term benefits. Second, delays in WES can be curtailed by adopting a more open strategy of letting the government control the initial development phase to protect the ecosystem. Last, incentivizing the manufacturer through off-take guarantee can help the transfer of technology and later opening the market competition. Consonant with these strategies, public management in developing countries can meet future energy challenges and get benefit from international funding opportunities. Policymakers need to understand and realize the long-term economic benefits of enacting ecosystems. Nonetheless, if management in the energy sector continues with a myopic short-term approach, they will miss bigger opportunities.

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