

Mita, Kaori; Iizuka, Michiko

Working Paper

Building CoPS capability for catching up during transitions: The case of ACWA Power in Saudi Arabia

UNU-MERIT Working Papers, No. 2024-015

Provided in Cooperation with:

Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT),
United Nations University (UNU)

Suggested Citation: Mita, Kaori; Iizuka, Michiko (2024) : Building CoPS capability for catching up during transitions: The case of ACWA Power in Saudi Arabia, UNU-MERIT Working Papers, No. 2024-015, United Nations University (UNU), Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), Maastricht

This Version is available at:

<https://hdl.handle.net/10419/326911>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-sa/4.0/>

Working Paper Series

#2024-015

Building CoPS Capability for Catching Up During Transitions: The Case of ACWA Power in Saudi Arabia

Kaori Mita and Michiko Iizuka

Published 12 July 2024

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: info@merit.unu.edu | website: <http://www.merit.unu.edu>

Boschstraat 24, 6211 AX Maastricht, The Netherlands
Tel: (31) (43) 388 44 00

UNU-MERIT Working Papers

ISSN 1871-9872

**Maastricht Economic and social Research Institute on Innovation and Technology
UNU-MERIT**

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT to stimulate discussion on the issues raised.



Building CoPS Capability for Catching Up During Transitions: The Case of ACWA Power in Saudi Arabia

Kaori Mita, Ph.D. candidate, Graduate Institute for Policy Studies

Michiko Iizuka, Professor, Graduate Institute for Policy Studies

Abstract

The energy transition is said to create emerging “green windows of opportunity (GWO)” in developing countries. On the other hand, many latecomer countries remain importers and users of renewables and clean energy technologies. Renewable energy deployment projects are considered complex systems and products (CoPS) that are capital-intensive, client-driven, and complex economic activities. Previous research on catching up in CoPS has concentrated on large engineering projects, focusing on technological aspects and the role of government interventions at different developmental stages, especially the creation of domestic markets. As many latecomer countries are users of emerging renewable energy technologies, the creation of domestic markets through government interventions is considered essential for successful transitions and capability upgrading to take place. However, capability upgrading and the transition to renewable energy can also occur without the initial presence of a domestic market and strong governmental support, as demonstrated by the case of ACWA Power, a project developer in a latecomer country, in Saudi Arabia. This case shows that upgrading of organizational capabilities took place as the firm engaged in projects in the external market to deploy renewable energy, taking advantage of the GWO. The case suggests that the CoPS can be a viable pathway for catching up in the emerging renewable energy sector, enabling firms to transition and build their organizational capabilities from project-based learning when GWOs are effectively leveraged.

Keywords: Complex products and systems (CoPS), Catching-up, Green Windows of Opportunity (GWO), Renewable energy, Saudi Arabia

JEL CODE: O310, O320, O330

1. Introduction

Renewables and clean energy technologies are transforming the landscape of the conventional energy market. The energy transition is creating emerging “green windows of opportunity” (Lema, Fu and Rabellotti, 2020) in developing economies, allowing them to catch up on building technological capability in renewable energy. This can be seen in the large emerging countries with strong policy interventions, such as the development of solar PV and wind in China and India. On the other hand, many latecomer countries remain importers and users of renewables and clean energy technologies. However, the deployment of renewable energy and delivery of renewable energy projects requires a combination of knowledge and skills in depth and breadth (Safdari Ranjbar et al., 2018). It is a project-based, client-driven, capital-intensive economic activity, and is considered complex products and systems (CoPS)(Davies and Brady, 2000; Hobday, 2000). CoPS literature offers interesting possibilities to latecomer countries—that is, taking

advantage of exogenous green windows of opportunity (EGWOs) through “learn[ing] from importing” and using and deploying renewable technologies (Andersen and Lema, 2022).

The oil-producing Arab Gulf countries are latecomers in renewable energy development. This is due to the abundance of hydrocarbons in the region and heavy energy subsidies given to the local population, making it impossible for renewable energy to compete in the market. As a result, the domestic market for renewables remained negligible until recently. Despite challenging market conditions in the region, in 2015, a consortium led by ACWA Power, a Saudi-based firm, surprised the world by winning a solar photovoltaic (PV) project in Dubai against international competitors by achieving the lowest tariff in the world for renewables at that time (Frroukhi *et al.*, 2016; Poudineh, Fattouh & Sen, 2018; IRENA, 2019; Krupa, Poudineh and Harvey, 2019). The achievement of ACWA Power is noteworthy as this took place before a domestic market for renewable energy was created through a Saudi government initiative in 2016. In other words, ACWA Power was able to develop and acquire the capabilities to deploy renewable energy at the lowest cost without the strong presence of a domestic market or government initiatives to support nascent industries, both considered *sine qua non* for emerging industries and especially large infrastructure projects such as complex products and systems (CoPS).

The catching up process in CoPS has shown characteristics that are intrinsic to the domestic market setting: the first mover advantage, large infrastructure (network effects), and government involvement through public procurement to facilitate technological upgrading and secure the market (Davies & Brady, 2000; Mike Hobday, 2000). Early literature on CoPS catching up primarily focused on the technological aspects of catching up to understand the process of capability building, using the domestic market and strong government support as a springboard. These studies cover cases of significant engineering systems (e.g., infrastructure, aviation) (Park, 2012; Naghizadeh *et al.*, 2017), technical systems (e.g., traffic congestion control systems)(Trivellato, Martini & Cavenago, 2021), and IT (e.g., software) systems (Park and Kim, 2014) that require technological and engineering capabilities. By contrast, the deployment of renewable energy places a stronger emphasis on organizational capability—the ability to configure resources needed to meet each client’s unique demands and conditions—rather than solely on technological capability. This emphasis on organizational capability can potentially be considered an entry point for emerging countries into renewable energy activities. Yet, the existing CoPS catching up literature has paid scant attention to organizational capability in understanding the development of renewable energy.

Previous studies on CoPS address large-scale public infrastructure concerning energy, mobility, and digital sectors, which overlap with the main focus of the sociotechnical transition approach (Geels, 2004; Bergek *et al.*, 2008; Schot and Geels, 2008). Similarly, sociotechnical transition, like CoPS, places importance on the government’s role in market creation. The literature suggests that with the necessary capabilities,

latecomers can leverage the exogenous green market to offer tailor-made solutions and further enhance their capability and presence (Bento and Fontes, 2015; Iizuka, 2015; Sawulski, Gałczyński and Zajdler, 2019; Lema, Fu and Rabellotti, 2020).

This paper aims to understand the process of building CoPS capabilities and catching up in the transition process by a latecomer country firm in the absence of state support and a domestic market. This paper aims to answer the following research question:

How can a firm in latecomer countries take advantage of EGWO and catch up by building CoPS capability without strong support from the state?

To answer the above question, the paper specifically examines the case of ACWA Power, a firm in Saudi Arabia, and asks the following questions in a resource-rich country context:

- *How did ACWA Power acquire the capabilities needed for the deployment of renewable energy (CoPS) without domestic policy support or markets to accumulate experience?*
- *What kind of capabilities were needed, and how were these capabilities systematically gained by ACWA Power to enable catching up in CoPS capability in new renewable energy?*

This paper is structured as follows: Section 2 expands on the characteristics of CoPS, CoPS catching up, and adds insights from the sociotechnical transition approach in the context of latecomer countries. Section 3 provides the analytical framework and methodology of our research. It organizes and introduces CoPS capabilities specific to renewable energy deployment. Section 4 presents the case study of ACWA Power to describe the firm's path to building CoPS capabilities for catching up. The discussion in Section 5 comprises an analysis of our findings. Finally, we draw on the policy implications and set out an agenda for future research in Section 6.

2. Literature Review

2.1 CoPS and catching up by the latecomer firms/countries

(1) Characteristics of CoPS in general

CoPS refers to economic activities involving the production of sophisticated, high-value, and engineering-intensive capital goods in the form of projects (Davies & Brady, 2000; Hobday, 2000). These projects can be established either temporarily or permanently to achieve various objectives, ranging from the construction of large infrastructures to their ongoing operations and maintenance (Denicol and Davies, 2022). Each CoPS project is distinct and designed to be adaptable to changing client needs. The successful operation of CoPS requires the management of numerous customized components, necessitating a combination of knowledge and skills spanning both the breadth and depth of the project (Safdari Ranjbar

et al., 2018). Literature on CoPS emphasizes the criticality of capabilities in integrating different types of knowledge and skills, collaborating with diverse actors and subsystems while adeptly managing project risks and uncertainties in a dynamic manner (Hobday, 2000, and others). As CoPS delivers unique products, their learning externalities do not arise from the scale of activities (mass production) but rather from the scope of experiences (diversity).

Existing literature on CoPS identified organizational capabilities in several ways, as follows: project-based (Davies & Brady, 2000; Hobday, 2000; Safdari Ranjbar et al., 2004; Park, 2012), dynamic (Su and Lin, 2014; Choung & Huwang, 2007), and complex (Ren & Yeo, 2006). Organizational capabilities associated with CoPS differ from scalability-dependent economic activities, as these are project-based. Hence, capabilities are built from learning acquired during non-repeatable and one-off projects (Gann & Salter, 2000; Ren & Yeo, 2006). Project-based capabilities include the ability to manage suppliers and construction, risk, data, and information. The learning takes place both internally and externally in the firm when engaging in activities with clients (Gann & Salter, 2000; Davies & Brady, 2000; Hobday et al., 2005). In other words, the dynamic capability to integrate, build, and reconfigure resources to address external environmental changes (Teece, Pisano and Shuen, 2009) is also part of organizational innovation capacity. This capacity can produce optimal solutions through multi-level collaboration in delivering complex projects (Trivellato et al., 2021). These five areas—business, process, organization, external environment, and technology—need to be addressed simultaneously to achieve successful CoPS (Ren & Yeo, 2006); however, different areas may be emphasized during the evolutive phase of CoPS.

(2) CoPS and catching up

Many existing studies on CoPS and the catching up process have primarily focused on the technological aspects. Examples of CoPS in these studies concentrate on sectors that involve government projects: aircraft (Lee and Yoon, 2015; Naghizadeh et al., 2017; Vértesy, 2017), power systems (Kiammehr et al., 2015; Kwak & Yoon, 2020; Majidpour, 2016), telecom systems (Park, 2012), large IT systems (Park & Kim, 2014), and various transport systems, such as airports, roads, urban transportation (Ren & Yeo, 2006).

These studies illustrate the importance of policy interventions designed to promote CoPS capability at different stages. For example, investing in R&D to develop technologically intensive subsystems can involve establishing knowledge networks, as seen in the Iranian case, where different universities acted as subsystems to complement the CoPS in designing aircraft (Naghizadeh et al., 2017). Other countries established international standards and accreditations for compatibility in system integrations (Park and Kim, 2014). In Korean telecommunication systems, for example, the government played the key role as a

large-scale user, with a public research institution supporting technological development and the integration of networks to install the systems (Choung & Hwang, 2007). Some research has also demonstrated activities related to the creation of collaborative networks among domestic and external stakeholders to support the delivery of CoPS services. The government oversight involved private initiatives in networking and leveraging policies to acquire external knowledge from foreign partners through technological licensing, joint research and development agreements (Park, 2012). The specific areas of intervention vary by the nature of the sector, following the sectoral systems of innovation (Malerba, 2002). For example, these may include significant R&D investments in high-tech industries, such as aircraft and military jets; large upfront investments in physical infrastructures, such as power plants and public transport systems; and the setting of standards and preparation of certifications for network infrastructure, like IT and telecommunications (Ren & Yao, 2006).

(2) Importance of the domestic market and state intervention for catching up on CoPS

The existing literature has identified that, in order to catch up on CoPS, it is essential to leverage: 1) first mover advantage, 2) network effect, 3) government support, especially in finance, and 4) the domestic market via public procurement to facilitate building technological capability (Majidpour, 2016; Ren & Yeo, 2006; Safdari Ranjbar et al., 2018). Looking at each of these in turn, the presence of a strong first-mover advantage is clearly recognized. Since CoPS projects often involve large infrastructure that is established in limited numbers and serves as a platform, they can generate network and lock-in effects (Unruh, 2000). Hence, by being the first mover, firms can leverage significant entry barriers in terms of technology, market regulation, and branding (Park & Kim, 2014; Park, 2012). Second, for many latecomer countries, coordinating actors to produce the complex capital goods necessary for CoPS is difficult due to the lack of domestic supplier networks and other complementary services. For this reason, government interventions become necessary to provide the substantial upfront investments typically required for CoPS projects, as well as other interventions to facilitate market entry, especially by creating markets through public procurement. Existing studies have noted that sizable public finance was mobilized for R&D because some of the areas of technology have limited scale merit or applicability in the private sector (Majidpour, 2016). Some case studies have focused on interventions to improve organizational capability, such as establishing supplier subsystems to mobilize knowledge and technology from suppliers and other partners (Trivellato et al., 2021; Freeman, 1987; Kiamehr et al., 2015; Majidpour, 2016; Ren & Yeo, 2006; Safdari Ranjbar et al., 2018; Arocena & Sutz, 2000).

The existing examples of catching up in CoPS suggest that firms start capacity building by leveraging the domestic market, facilitated by public procurement. The literature indicates that firms engage in the exploration of external markets after building capability, suppliers, and reputations in the domestic market

through state support (Kiammehr et al., 2015; Kwak & Yoon, 2020; Safdari Ranjbar et al., 2018). In other words, the domestic market and government procurement play critical roles in the learning and capability-building process for firms in CoPS.

2.2. CoPS and Sociotechnical Transition

(1) Overlapping areas of CoPS and sociotechnical transitions

CoPS are often found in large-scale public infrastructures related to energy (power plants, hydro, renewables), mobility (urban transport, airports, roads), and digital services (e-government, telecommunications). These sectors overlap with the main focus of the sociotechnical transitions approach (Bergek et al., 2008; Geels, 2002, 2004, among others). The sociotechnical transition focuses on the process of systemic change by examining the functions of innovation systems. It is an analytical framework used to identify the key drivers that bring about technological transitions (Hekkert et al., 2007; Bergek et al., 2008). The framework consists of seven key functions—knowledge development, market formation, resource mobilization, influence on the direction of search, legitimation, entrepreneurial experimentation, and development of external economies—whose virtuous interactions are said to enable the acceptance of new technologies by society. The framework also identifies systemic bottlenecks and helps formulate policy implementations necessary to allow better policy mixes (Bergek et al., 2008; Smith, Voß and Grin, 2010; Alkemade, Bakkenes and Eickhout, 2011; Weber and Rohracher, 2012; Wieczorek and Hekkert, 2012; Jacobsson and Karltorp, 2013). While CoPS focuses on delivering complex products, it does not necessarily establish a transition process. However, as the energy sector is undergoing a transformation process due to climate change, and its transformative aspects have become a central concern for latecomers implementing CoPS.

(2) Market creation via government interventions

Many government interventions are targeted at low-carbon and green sector innovations, creating so-called “green windows of opportunity” (GWO) (Lema et al., 2022). Some latecomer countries have employed these green market opportunities in advanced countries to enhance their manufacturing and technological capabilities. For instance, China’s solar PV industry was developed as the result of arbitration exercised by Chinese PV companies. Initially, these companies exported low-cost solar PVs to the green markets in advanced countries. When these advanced markets became closed to Chinese solar PVs, the Chinese government created a domestic market via subsidies to absorb the surplus PVs (Iizuka, 2015).

There are several other examples of latecomer countries arbitrating domestic government policy and green windows of the market opportunity in advanced countries. Lema et al. (2022) identified that in the absence of or a weak domestic green/low-carbon market in latecomer countries, advanced markets can offer

latecomer producers a place to learn about and develop products with high growth and value potential (legitimacy of green products). Kwak and Yoon (2020) called this an “exogenous window of opportunity” (EWO) to distinguish it from the domestic public procurement-led “green windows of opportunity” (Kwak and Yoon, 2020). The examples suggest that, with sufficient capabilities, latecomer CoPS can leverage “exogenous green windows of opportunities” (EGWO) by offering tailor-made solutions on time and at the requested cost to enhance its presence in the international market.

(3) Critical functions of government for enabling emerging CoPS firms to take advantage of EGWO

For the latecomer CoPS firms to fully utilize the EGWO, government interventions may need to focus on the functions of innovation systems as identified in the socio-technical transition approach. The literature of catching up in CoPS revealed that government interventions were made in the following areas:

- Subsidies, tax incentives and public procurement to shape the domestic market (market formation);
- Incentives for R&D to promote technological capability (knowledge development);
- Enhanced networks to complement missing knowledge, skills, and supplier networks (development of externalities);
- Regulatory institutions and policy incentives to provide market incentives (legitimations and influencing direction of search, market formation);
- Significant public funds made available for infrastructure development (resource mobilizations);
- Integrated systems to facilitate network development for both private and public stakeholders (legitimation, development of externalities);

As this shows, the functions of innovation system overlaps significantly with the range of activities and policy interventions to promote CoPS in latecomer countries.

3. Analytical Framework and Methodology

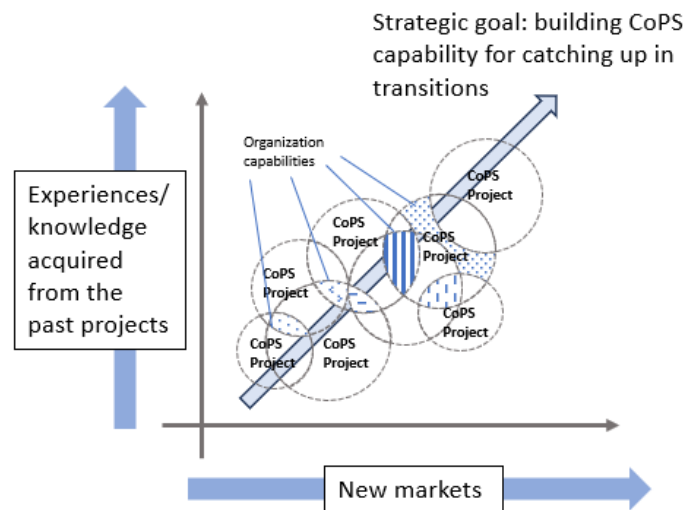
3.1 Analytical framework

The review of the literature indicates the importance of government interventions, especially during the formative stages of catching up for CoPS firms. Government interventions are needed to facilitate networking among stakeholders, knowledge development, and market creation via government procurement. In case the domestic market is absent or too weak to provide a market with sufficient demand, exogenous green markets provide an important opportunity for latecomer firms to explore and enhance their capabilities. As demonstrated in the literature, prior to entering to the EGWO, policy support is still required. In other words, these capabilities need to be nurtured in domestic settings in order to exploring external markets. If the above is true:

- *How did ACWA Power in Saudi Arabia acquire the capabilities needed for the deployment of renewable energy (CoPS) without domestic policy support or markets to accumulate experience?*
- *What kinds of capabilities were needed for COPS, and how were they systematically developed by ACWA Power to enable catching up in new renewable energy?*

Renewable energy deployment is a project-based activity—a relatively new area for latecomer firms that require tailor-made solutions for different geographical settings. In the process of building firm-level CoPS capabilities, there is a tension between utilizing existing skills, experiences, and knowledge learned from the past and developing the knowledge required to enter new markets. Firms need to systematically accumulate and utilize past know-how and experiences while exercising leadership in identifying new strategic markets and technologies through forming new projects (Davies & Brady, 2000). In other words,

the project is the learning platform for testing competence and strategic learning capacity by building organizational capabilities, ultimately leading to the acquisition of CoPS capability (Denicol & Davies, 2022). In fact, Davies and Brady (2016) described a project “as a vehicle for the implanting strategy for innovation and diversification,” as shown in Fig.1.

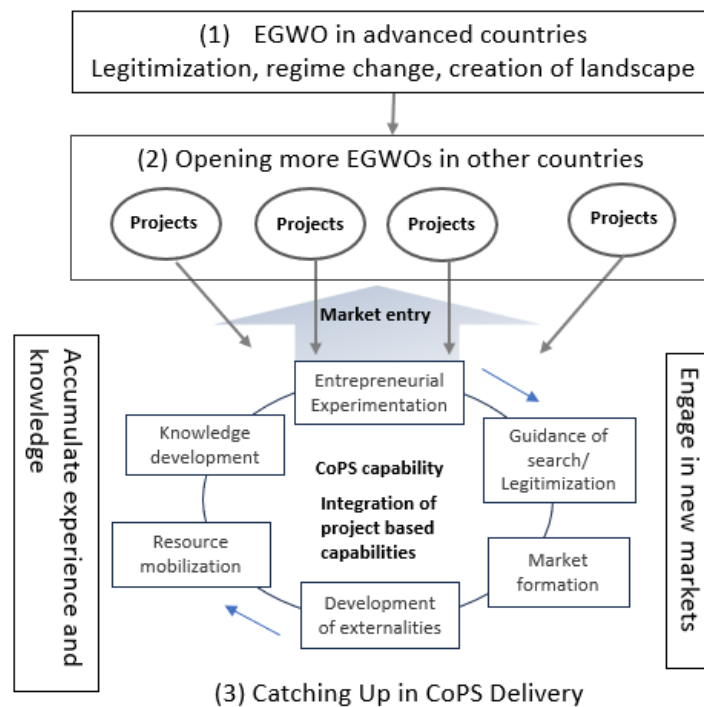


Source: Authors, based on Davies and Brady (2016)

The analytical framework is constructed based on the following assumptions obtained from the literature: (1) the exogenous market in advanced countries was shaped, then legitimized by future growth and value potential, thus causing (2) regime change in the landscape of advanced markets and promoting other countries to follow suit (via more projects in EGWO). Thus (3), this allowed latecomer firms to enter the

market through project-based activities, and (4), through these projects, firms were able to explore new markets and technologies while exploiting existing knowledge to build CoPS capability and strategically develop organizational capabilities to catch up to the frontrunners. The energy transition began in advanced countries, shaping green markets with the support of government policies and initiatives. The GWO provides markets for firms in emerging economies to catch up, resulting in changes in the landscape of the energy regime. With the background described in points (1) and (2), changes in advanced markets prompted firms in emerging and developing economies to adopt renewable energy power generation in the form of projects, and consequently, more EGWOs can be created (Fig.2). By executing different projects, the firms in latecomer countries learn to build CoPS capabilities for transition, using organizational capabilities prior to having the technological capabilities of their own.

Figure. 2 Catching Up during CoPS Delivery



Source: Authors

Next, the six functions of CoPS catching up and the technological innovation system (TIS) function approach of sociotechnical transition are examined in Fig. 2. This examination is done to identify the necessary capabilities in each function of TIS. The functions identified from TIS are: 1) guidance of search and legitimization, 2) market formation, 3) knowledge development, 4) development of externalities, 5) resource mobilization, and 6) entrepreneurial experimentation (Table 1). In practice, government

interventions observed in the cases of latecomer CoPS firms to promote catching up include building knowledge networks, providing incentives, investing in R&D, and creating domestic demand.

These interventions in CoPS were solely implemented in domestic markets under the strong leadership of governments, and firms did not explore external markets prior to building their capabilities domestically. On the other hand, renewable energy TIS cases have been observed worldwide, with some firms already providing renewable energy deployment to the EGWO. Given that renewable energy deployment is carried out through project-based activities, latecomer firms may be able to navigate the challenges by using the project as a means to build their capabilities as part of the renewable energy transition process. In other words, CoPS projects can also be applied to EGWO in the same way as TIS cases when certain conditions are met.

Table 1 integrates functions of innovation systems relevant to the organizational capabilities needed for upgrading in CoPS. Functions of the systems have been divided into two organizational capabilities: 1) the capabilities needed to explore new markets, and 2) the capabilities for systematically accumulating learnings from past experiences (Davies & Brady, 2016).

Table 1. CoPS organizational capabilities for catching up

	TIS Functions	Organizational Capability in CoPS*
Engage in new markets	Guidance of Search Legitimization	E1: Strong leadership/Business strategy (search for new technology and market) E2: Connections (with relevant actors, political and industrial)
	Market Formation	E3: Stakeholders relationship management (external and internal) E4: Client satisfaction management
	Entrepreneurial Experimentation	E5: Investment capability
Accumulate experience and knowledge	Knowledge Development	A1: Experience (non-repeatable, individual and unique projects) A2: Technical capability (operation and management)
	Resource Mobilization	A3: Data and information management A4: Communication (external and internal stakeholders) A5: Investment capability
	Development of Externalities	A6: Supplier network, warehouse capability A7: Project leadership A8: Project management

Source: Authors, based on the literature review in Section 2.1

For latecomers to catch up through the transformation of CoPS, they need to identify the guidance of search, seek market formation, and experiment with new markets and new technologies. They also need to develop knowledge from the delivery of projects while mobilizing resources and developing externalities through their activities (Davies and Brady, 2016). For latecomer firms aiming for EGWO, since the market is exogenous, the guidance of search/legitimization and market formation often overlap because these are usually led by governments. Entrepreneurial experimentation occurs while the firm is engaging with new markets. Naturally, strong leadership is required to navigate through TIS and manage CoPS catching up.

Moreover, knowledge development and resource mobilization occur simultaneously using existing experiences, networks, and connections to realize CoPS projects. Knowledge development in TIS and emerging technologies entails developing technological and engineering knowledge through networking with others or learning by doing and searching. By contrast, for CoPS, knowledge is developed and applied through non-repeated processes deriving from the past experiences of individual unique projects.

3.2 Methodology

(1) Methodology and data

The study chose a single in-depth case study of ACWA Power, a Saudi Arabian desalination and power generation firm. Although it is a single-firm case study, the firm has implemented several projects of varying sizes, diverse technologies, and differing locations worldwide, offering rich insights into its experiences over the two decades from its establishment in 2004 to 2023. Despite its late entry into power generation, the installed power generation capacity of ACWA Power is reaching levels similar to its peers in other regions of the world that are actively expanding their IPP operations overseas (see Appendix 2). The case study is organized around each CoPS TIS function, allowing an understanding of the capability-building process during transitions (Table 1). The case study uses primary information consisting of 11 interviews with industry personnel (see Appendix 3). Secondary information on the firm used in the analysis was comprised of company annual reports (2009–2022), company sustainability reports (2014–2020), investor reports, financial results, and monthly newsletters. A total of 72 project reports were also examined, including inactive, stalled, and sold projects, as well as information collected from the company’s website. This was supplemented with information extracted from government websites, industry association reports (2010–2022), and international organization data, allowing cross-referencing of sources. In addition, interviews with ACWA Power management personnel conducted by various sectoral organizations (27) and industry-focused webinars (2) between 2013 and 2023, available on social media (Appendix 4), were also used. These interviews were transcribed using Otter.ai software for analysis.

(2) Renewable energy deployment project cycle: Identifying the important factors at each phase

Delivering CoPS in areas such as renewable energy deployment requires an understanding of key project cycle components: planning, execution, and operations (Roehrich et al., 2019). This section organizes the tasks performed by a firm engaged in renewable energy projects, allocating them under each phase. These tasks are then tied to CoPS organizational capabilities for catching up (Table 2) to show the process of the firm moving from project to project to accumulate experience and knowledge while searching for new

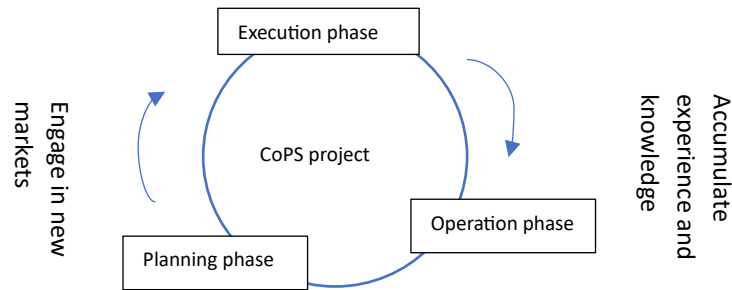
markets. As the cycle recurs, the firm accumulates the experience and knowledge necessary to engage in new markets (Fig. 3).

Table 2. Renewable energy project cycle, tasks, and CoPS capability

(Refer to Table 1 for a description of A–E)

Planning Phase Tasks	Execution Phase Tasks	Operation Phase Tasks
E1: Identify environmental factors E2: Communicate with relevant actors E3: Maintain and develop stakeholders' relations E5, A6: Optimization (EPC and financial strategy)	A7, A4: Place project leaders A8, A4: Manage projects A8: Early detection of risks A3: Manage data and information A2, A1: Compute and analyze data	A1: Learn and develop knowledge A2: Performance prediction (Data analytics, cloud computing) A3: Accumulate data A6, A4: Develop supplier network (warehouse capability) A2: Mobilize experience and skilled human capital

Figure 3. Project cycle and CoPS capability building process



Source: Authors, based on the literature review in Section 3.2, (2)

a. Planning phase

During the planning phase, tasks primarily associated with engaging in new markets are performed. First, the firm must identify environmental factors such as the legal and political conditions of the market (E1, E5¹). Deploying renewables as power generation infrastructure is a capital-intensive and long-term commitment to the government, requiring long-term planning and regulatory changes (Komendantova et al., 2012; Goh et al., 2014; Ong, Chin and Yap, 2016). The firm needs to access possible project information from relevant actors (E2, E3). It requires the firm to have a strong investment capability and financial strategy, be politically well-connected and have access to renewable project information from relevant actors (Vidican, 2012).

The client of the projects is usually a government or governmental agency. Thus, maintaining client and project relations and the ability to cooperate with both external and internal stakeholders can ensure client

¹ E5 is the Optimization of finance strategy, because the country's condition, such as political risks, determines the availability of investors and financial options.

satisfaction, leading to successful projects in any country of operation (Maqbool et al., 2022). Next, the firm develops project plans based on the knowledge of operations and maintenance, and optimizes engineering, procurement, and construction (E5, A6). In order to develop competitive projects, knowledge of operations and maintenance is required (Goh et al., 2014).

To deliver the client's order—i.e., meeting the government's requirements and conditions, as well as securing a return on investment—the plant needs to run for the period of the contract with the least amount of service interruptions while maintaining the performance of the plant. This is difficult to achieve in a project without a detailed operations and maintenance plan and cost estimate (National Renewable Energy Laboratory, 2018) because the plan helps to eliminate certain levels of uncertainty in project development. Therefore, experience and knowledge of operations and maintenance greatly contribute to the planning phase.

b. Execution phase

When the project moves on to the execution phase, tasks that contribute to building experience and developing knowledge are performed. During this phase, project leaders must effectively manage the workflow, monitor progress, and handle uncertainty. Managing big data and the information generated from the daily operation of building the physical plant becomes crucial for meeting deadlines and budgets (A3, A4, A7, A8). The sheer size of large infrastructure construction requires the involvement of multiple suppliers and construction teams, necessitating project management capabilities to ensure early detection of potential risks, promote cooperation, facilitate top-down decision-making, and utilize diverse resources (Abe & Takano, 2017).

With recent technological advances in the construction field, data management is becoming increasingly important (A3). Recently, project ecologies that involve collaborating with other firms have become digitalized, and the co-creation process is managed and governed through a digital platform (Lobo & Whyte, 2017). Thus, computational and data analytic capabilities are essential for the execution phase (A2, A1). These capabilities continue to be important in the operation phase as they create digital twin information systems to ensure a seamless transition to the next phase and effective plant operation (Sacks et al., 2020).

c. Operations phase

The tasks performed during the operation phase are related to knowledge development, development of externalities, and resource mobilization. The firm learns and develops knowledge through the operations and maintenance of the plant, including data accumulation, analytics, cloud computing, and cybersecurity (A1, A2, A3). First, the firm gains a technical understanding of the power system and grid of the location

(Boulakhbar et al., 2020). Extensive knowledge of renewable power technology itself determines the quality of operations (Ong et al., 2016). This knowledge of operations allows continuous power generation from renewable sources, requiring management of intermittent production and power usage dispersal (Boulakhbar et al., 2020).

Electricity demand fluctuates during the day, while renewable power generation is affected by the natural environment. By operating the plant daily, engineers accumulate the plant performance data needed to maintain the plant's performance. This directly affects the investors' rate of investment return and the ability to manage intermittent production time effectively (National Renewable Energy Laboratory, 2018). The data collected from operations and maintenance activities (e.g., sensor feedback, energy usage patterns, predictive performance) are highly classified and contribute to the warehouse capability (A6, A4). Therefore, they require proper protection against outside threats (Olabi et al., 2023). Next, the firm needs to place experienced and skilled human resources, as they are essential to successful maintenance (A2). Skilled technicians and engineers can analyze and solve the problems the plant may face, enabling the plant to run smoothly without interruptions (Goh et al., 2014). Finally, the combination of knowledge development, development of externalities, and resource mobilization enables the firm to accumulate experience and knowledge through the project—and then to engage in new markets.

The case study illustrates the firm's pathway toward building CoPS capabilities and the process of catching up during transitions by observing the changes in key functions of CoPS over time. Each phase focused on answering how the firm identified these key functions (Guidance of search/legitimization, market formation, entrepreneurial experimentation, development of externalities, knowledge development, and resource mobilization) and obtained the necessary capabilities to move the projects into new markets and technologies while utilizing and accumulating the knowledge and experiences.

4. Case Study: Renewable Energy Deployment, ACWA Power, Saudi Arabia

4.1 ACWA power and its evolutionary pathway

ACWA Power started as a desalination and power generation company in Saudi Arabia. ACWA Power Project was established in 2004 as a joint venture between ACWA Holding² and MADA Group for Industrial and Commercial Development to capture opportunities from the Saudi government's

² ACWA Holding was represented by the well-established private firms, Abunayyan Trading Company and Abdulkadir Al Muhaidib & Sons Co. The Abunayyan Trading Company was founded in Riyadh in 1960 and specializes in construction, operation and maintenance, and contracting. Abdulkadir Al Muhaidib & Sons Co. was established in Dammam in the 1940s and specializes in food, manufacturing, building materials, real estate, construction, and other activities. MADA Group is an investment company owned by the Al-Rajhi Group to invest in a specific targeted area.

privatization program in the desalination and wastewater management sector, becoming ACWA Power in 2008. ACWA Power's business model is to develop, invest, operate, and optimize. The company's history (from 2004 to the present) can be divided into four phases; 1) The formation period (2004–2007), 2) expansion within the regional market (2008–2011), 3) building capability for the next business domain (2012–2015), and 4) opening up to the domestic market and beyond (2016 onwards).

In the formation period (2004–2007), ACWA Power developed large independent water and power plants (IWPPs) in Saudi Arabia. During this period, ACWA Power learned about the IWPP business from a forerunner firm from Malaysia by closely working with them and successfully mobilizing investment to finance sizable projects. ACWA Power then expanded its desalination and power generation operations to Oman and Jordan (2008–2011). This first expansion period gave the firm the time and means to build capabilities for new business domains by accumulating experience in regional markets and increasing its technical capabilities through projects that needed rehabilitation and maintenance due to the lack of uniformed procurement over time, such as wind farms in Jordan. The firm further built its capabilities through its next business domain in 2012–2015 by seeking new markets and testing new technologies at a smaller-sized renewable plant in Bulgaria before moving on to larger projects in more distant markets in South Africa and Morocco. These experiences and knowledge from the building capability phase enabled ACWA Power to return to the domestic market in 2016 and accelerate renewable energy deployment in the Kingdom. Saudi Vision 2030 was launched in 2016 with the aim of diversifying the national energy mix to increase power generation from renewable energy sources to approximately 50% by 2030. With the launch of the vision, the government started five stages of energy subsidy reform in 2016. We organized the case study using the framework established in the previous section and the organizational capabilities of CoPS discussed in Section 3.

(1) Formation period: 2004–2007

Engagement in the new market (Guidance of search, entrepreneurial experimentation): ACWA Power was formed as a project in 2004 to capture the opportunity in the newly privatized IWPP sector. The firm developed and learned from working with forerunner firms from Asia. In 2002, the government of Saudi Arabia announced a privatization program in the desalination and wastewater management sector. ACWA Project was initially formed in 2002 to capture new opportunities in the domestic desalination and power generation sector and expand into new markets in emerging countries.

Establishment of NOMAC (Knowledge development, development of externalities, guidance of search, resource mobilization): Through working with experienced firms, ACWA Power identified the importance

of having its own operations and management function. ACWA Power established an operations and maintenance company and started to mobilize resources to expand its activities further. ACWA Power established the First National Operation and Maintenance Company (NOMAC) with SOGEX-Oman in 2005, marking a vertical integration—a key to successful CoPS (Davies & Hobday, 2005). Since its establishment, NOMAC has been operating and maintaining most of ACWA Power’s projects both domestically and internationally. The industry personnel we interviewed specifically drew attention to this as one of the main factors behind the firm’s breakthrough in this sector, as well as the firm’s approach to vertical integration in this early phase and its commitment to the market (Appendix.3, 2-B). The experience and knowledge in the operations and maintenance of the plants enabled the firm to learn the technology and accumulate data from its operations.

Collaboration with Malaysian and Japanese firms (Knowledge development): ACWA Power quickly learned project development through collaboration with experienced international firms. Large IPP/IWPP projects are often developed by a consortium of international firms, providing a learning opportunity for younger firms in the sector. The Independent Power Producer model was developed in the early 1990s in Pakistan and then spread through other Asian countries, such as Indonesia and Malaysia. ACWA Power’s first big project was with a Malaysian firm, Khazanah (Malaysian SWF), and TNB (Tenaga Nasional Berhad – SOE under Khazanah). According to industry personnel (Appendix. 3, 6-E), the ACWA Power leadership learned directly from those Malaysian firms about the IPP business. The early IWPP projects in Saudi Arabia were also led by a Japanese firm (Petro-Rabigh IWPP). At that time, the newly formed ACWA Power lacked experience and track record in project development (Appendix. 3, 2-B); therefore, in those projects, a Japanese firm coordinated the engineering and procurement, and ACWA Power took on overseeing the financing aspects of these large projects.

Cooperation with Islamic banks and involvement of ECAs (Resource mobilization): During this time, ACWA Power developed its capability to mobilize investments for financing projects by utilizing Islamic tranche financing. With the strong backing of the Saudi government for its first IWPP project, Shuaibah IWPP, the firm executed a pioneering transaction that united Export Credit Agency (ECA) facilities and Islamic banks in a single transaction (ACWA, 2009). The significance of this achievement was that the project’s legal documentation instilled sufficient confidence for ECAs to invest and for local banks to provide longer-term loans, facilitated through ECA involvement (McLeod-Roberts, 2006). Furthermore, the Marafiq IWPP project was developed in partnership with multiple stakeholders, including Power and Water Utility Co. for Jubail and Yanbu, Saudi Arabia’s Sovereign Wealth Public Investment Fund, and Saudi Electric Company, along with a consortium of Suez, GIC, and ACWA Power. The project involved several

international banks utilizing equity bridge loans (EBL) to offset risks and won several industry awards for the deal of the year (ACWA, 2009).

Underdevelopment of the domestic renewable market (Guidance of search): At this time, ACWA Power had not yet gained policy support or applied for government initiatives to explore renewable energy

deployment in the domestic market. ACWA Power's leadership perceived an opportunity for solar PV deployment in the Kingdom, as the cost of solar PV was dropping rapidly. They contacted the Saudi Electric Company and government officials in 2007 but were told that the government had other priorities at the time. The domestic market for renewable energy was nearly nonexistent at that time (Appendix.4-25). The biggest barriers to renewable energy deployment were energy subsidies due to the abundant supply of hydrocarbons and high domestic energy consumption. Since the energy subsidies drove energy prices to the lowest in the world, it was not economically viable to deploy renewable energy sources at the utility or residential scale (Elshurafa & Matar, 2020).

	TIS Functions	CoPS Capabilities: Formation period
Engage in new markets	Guidance of Search	Privatization program in desalination and wastewater management, Saudi Arabia Leadership's strong commitment to IWPP/IPP business is shown in its early engagement to the O&M function (NOMAC) (Management interests in solar PV, however, could not gain government backing or policy support in Saudi Arabia)
	Legitimization	
	Market Formation	
	Entrepreneurial Experimentation	
Accumulate experience and knowledge	Knowledge Development	-Collaborated with a Malaysian firm to learn IPP business -Collaborated with a Japanese firm
	Resource Mobilization	-Mobilized Islamic financing, local banks, and ECAs to finance large IWPPs -Gained Networks with international firms to develop projects in Saudi Arabia
	Development of Externalities	-Gained experience in operation and management, and started to accumulate data and information from O&M (NOMAC)

(2) First expansion 2008–2011

Strategy development for future growth (Guidance of search, market formation): ACWA Power targeted markets based on a projection using annual population growth, country demographics, credit ratings, social infrastructure, and available human resources (Project Finance International, 2012). Participants in several interviews with management highlighted the following criteria for the project selection: country demographics to determine future energy consumption and demand, credit conditions to ensure financing, localization capability, human capital, industrialization capability, construction platform to minimize costs, geographical location for land and future expansion to the European market (green hydrogen), and government policies, rules, and regulations, including commitment to energy policy (Appendix.4-3,15,16, ACWA, 2014, 2015).

Entering the market in Oman (Market formation, resource mobilization): Based on the capabilities and connections established through its domestic IWPP projects, ACWA Power expanded into regional markets. Privatization programs outside the home market can create openings for foreign firms to enter the market. As foreign firms were no longer able to compete with ACWA Power in bidding for projects in the region, they changed their strategy to form consortia with ACWA Power (Appendix.3, 6-E). Utilizing its close relationship with the Omani government—established through their historical collaboration on building its LNG facilities—a Japanese firm partnered with ACWA Power to enter the market in Oman. Together, they developed three projects in Oman, and later, one project in Bahrain (Appendix.3, 6-E).

Learning from rehabilitation projects in Jordan (Knowledge development, resource mobilization): Acquisition and rehabilitation of existing plants provided an opportunity for the firm to develop computing skills and gain experience in operations and maintenance of the plants and new technologies. Jordan also privatized its power sector in 2007, and as this fit the targeted market criteria, ACWA Power had been monitoring this development for some time. In June 2011, ACWA Power acquired the Central Electricity Generation Company (CEGCO) of Jordan. CEGCO comprises eight power plants and generates 52% of Jordan’s power (ACWA, 2011). CEGCO’s portfolio included wind turbines, steam turbines, hydraulic turbines, gas turbines, and thermal—all built in the mid-1980s to the mid-1990s. The operations and maintenance capabilities and human resources that ACWA Power accumulated through prior mega IWPP projects enabled the firm to undertake technical due diligence, research, and site visits to make this transaction possible (Project Finance International, 2012).

Figure 5. CoPS Capabilities: First Expansion

	TIS Functions	CoPS Capabilities: First Expansion Period
Engage in new markets	Guidance of Search/Legitimization	-Evaluated target markets based on criteria and future growth -Privatization program in Oman and Jordan
	Market Formation	-Foreign firm’s support in entering the market in Oman
	Entrepreneurial Experimentation	
Accumulate experience and knowledge	Knowledge Development	-Acquisition of rehab projects, technical learning -Data accumulation from operation and maintenance
	Resource Mobilization	-Gained experience in the operations and maintenance of renewable plants (wind) -Networking with CEGCO and international firms
	Development of Externalities	

(3) Building Capabilities for New Business Domains: 2012–2015

Acquisition of Solar PV plant in Bulgaria (Entrepreneurial experimentation, knowledge development): ACWA Power’s efforts to build technical capabilities through rehabilitation projects and gather experience

in the regional markets enabled the firm to seek out advanced technologies and new markets. In the absence of a domestic market, ACWA Power sought foreign markets to test and learn new technologies to capture future opportunities. In 2012, ACWA Power acquired its first PV plant in Bulgaria, Karadzhhalovo PV IPP, which has a smaller capacity of 60 MW. NOMAC and the US-based Sun Edison operated and managed the plant together. This acquisition helped to increase their computing capacity and develop experience in operations and maintenance (Appendix. 4-2). The plant was sold in September 2020, as ACWA Power sought to focus on larger projects.

Opportunities in external markets (Guidance of search, market formation, knowledge development, development of externalities): Although domestic actors were still not interested in renewable energy deployment at the time, foreign governments were seizing these opportunities. Morocco and South Africa saw value in the long-term fixed cost of renewable energy to meet their growing needs. ACWA Power and the Moroccan government partners worked together to raise international, multilateral, and bilateral donor funds to finance projects in Morocco (Appendix. 4-12). NOORo I CSP IPP in Morocco, with a capacity of 160MW, was ACWA's next renewable project in partnership with the Moroccan Agency for Solar Energy (MASEN). The project introduced the new extended-duration storage technology, enabling power to be stored for up to 9 hours (Appendix. 4-13). Another milestone project was Bokpoort CSP IPP in South Africa. This project marked ACWA Power's first power sector investment in South Africa in 2013. The track records of renewable projects and experience gained from projects in Morocco and South Africa prepared ACWA Power to return to the regional market and explore its new possibilities. The second phase of the famous Mohammed Bin Rashid Al Maktoum Solar Park became a significant turning point in the regional market. In 2015, the ACWA Power and Dubai Electricity and Water Authority-led consortium achieved the world's lowest tariff for renewables—just \$0.05845/kWh, sparking a race to lower prices in the region (IRENA, 2019; Appendix 4. -6, 23).

Gaining support from the government (Resource mobilization): Backing from the government's sovereign wealth fund provided credibility to ACWA Power, enabling it to attract foreign investors. ACWA Power's relationship with the Saudi Arabian Public Investment Fund was established in 2013 when PIF's fully-owned subsidiary, Sanabil Direct Investments Company, began investing in the firm. During this time, ACWA Power was able to expand its business into additional foreign markets in South Africa and Morocco.

Figure 6. CoPS Capabilities: New Business Domain Period

	TIS Functions	CoPS Capabilities: New Business Domain Period
Engage in new markets	Guidance of Search/Legitimization	-Acquisition of Solar PV plant in Bulgaria -EGWO (Morocco, South Africa, UAE)
	Market Formation	-Morocco and South Africa's demand for long-term, fixed-cost, affordable energy -Gained Saudi SWF support
	Entrepreneurial Experimentation	
Accumulate experience and knowledge	Knowledge Development	-Operation and maintenance of a small solar PV plant in Bulgaria -Gained experience and technical capability in the operation and maintenance of renewable plants (Solar PV/CSP, molten salt power storage system) in Morocco, South Africa, UAE
	Resource Mobilization	-Supplier network for renewables from those projects -Gained investment from Saudi PIF-owned investment company
	Development of Externalities	

(4) Opening of the domestic market: 2016 and beyond

Opening of the domestic market (Guidance of search/legitimation, market formation): The experience and knowledge gathered over the past decade allowed ACWA Power to have a smooth entry into the domestic market, accelerating the firm's growth. In January 2016, Mohammed bin Salman, then Deputy Crown Prince of Saudi Arabia, launched a long-term national vision, Saudi Vision 2030. Vision 2030 focuses on renewables development and, subsequently, value chain development (Kingdom of Saudi Arabia, n.d.). Supported by the PIF, the National Renewable Energy Program (NREP) was established, along with the Renewable Energy Project Development Office (REPDO), to implement the programs simultaneously. The government started subsidy reforms in the water and power sectors in 2016. Energy subsidy reforms were passed in January 2016 and January 2018 (Krane, 2021, p. 152), and new tariffs were implemented for water and wastewater services for government, industry, and commercial-sector consumers (US-Saudi Business Council, 2021). Domestic market conditions improved as power generation from renewables and supply chain creation were incorporated into the long-term national vision.

Accessing to new markets (Market formation): With a strategy aimed at high-growth offtake markets, ACWA Power selected Egypt and other MENAT countries, Southeast Asia, Southern Africa, and the rest of the Gulf Cooperation Council (GCC) states, including Bahrain (ACWA, 2015). In 2015, ACWA Power signed a memorandum of understanding (MOU) with Masdar of UAE and the Egyptian Electricity Holding Company, and another MOU with the Silk Road Fund Co. from China in 2016, to explore the market in Egypt (ACWA, 2016). In 2019, the firm further expanded its target to Azerbaijan and Uzbekistan (ACWA, 2019). ACWA Power entered the Uzbekistan market just a few months after the new Ministry of Energy was established, allowing it to engage with the government at an early stage of its power sector development (Appendix.4-22).

Stronger relationship with PIF (Guidance of search, resource mobilization): Based on ACWA Power’s achievements in renewable power project development, REPDO awarded the firm a large portion of the planned renewable energy project deployment in Saudi Arabia. ACWA Power started to align with Vision 2030 goals and objectives. Despite its relatively small size compared to the other traditional tycoons of Saudi Arabia, ACWA Power had become the “national champion” in the renewable energy sector, bringing the government and the firm closer (Appendix.3, 6-E). Increased backing from the government has allowed the firm to grow stronger. In 2021, PIF increased its share in ACWA Power from 33.6 percent to 44.16 percent during the company’s initial public offering (IPO). PIF’s extensive networks and relationships enabled the firm to further explore foreign markets, improving its credit capacity as well as connecting it to financial and technical providers (Appendix.4-19).

Large projects and local content requirements (Development of externalities, knowledge development): ACWA Power undertook two major solar PV projects in 2018 and 2021: Sakaka PV IPP and Sudair PV IPP. Sakaka PV IPP, located in Al Jouf, Saudi Arabia, is the first utility-scale PV project in Saudi Arabia where the power station is connected to the national grid. The plant’s capacity is 300 MW, which is expected to provide electricity to 75,000 households. Sakaka PV achieved another record-low tariff of 0.0234/kWh, comparable to, if not lower than, conventional power generation in Saudi Arabia. The project is subject to a local content policy, and a supply chain readiness study found that the Sakaka project’s local content ratio exceeded 30% (Alghamdi et al., 2022). In 2019, ACWA Power announced its new business unit, ACWA Industrial Investment Company (AIICO), to work on local content development and industrialization. Subsequently, the ACWA-led consortium, including Saudi Aramco-owned SAPCO and PIF-owned Badeel, reached financial closure for the Sudair PV project in 2021. The plant will be located in Sudair Industrial City, home to several industrial activities such as fabricated metal products, non-metallic mineral products, rubber and plastic products, food products, chemicals, and chemical products.

Towards new power generation (Entrepreneurial experimentation, knowledge development, resource mobilization, development of externalities): ACWA Power’s experience in transitioning from desalination and power generation to renewable energy power generation equipped them with the project capability to venture into newer sources of power generation by integrating various technologies. Jazan IGCC, located in Jazan Economic City, is a joint venture among Saudi Aramco Power Co, Air Products ME, Gas Industry Co, and ACWA Power. Feedstock produced by the refinery will be fed into the plant, and then the combined cycle power plant will generate power for the national grid. The project contract utilizes an own-operate-transfer model. The Red Sea Project is a tourism project supported by renewable energy generation from solar PV (340 MW) with a battery energy storage system (BESS). This mega project is expected to generate

1,648 MW and produce 18,315 m3/day of desalinated water for the facility. Finally, the NEOM Green Hydrogen Project, a joint venture with Air Products, is expected to produce green hydrogen from solar and wind energy generation and convert it to liquid ammonia for export.

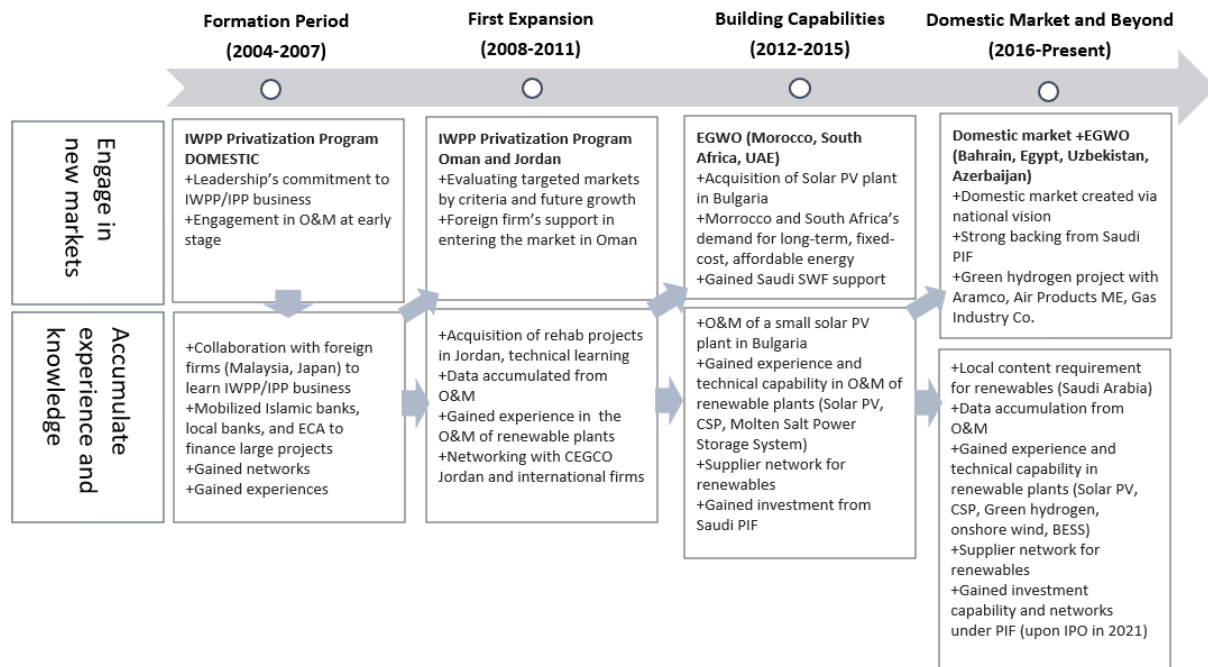
Figure 7. CoPS Capabilities: Domestic market and beyond

Engage in new markets	TIS Functions	CoPS Capabilities: Domestic market and beyond
	Guidance of Search/Legitimization	-Domestic market created via national vision -EGWO (Egypt, Bahrain, Uzbekistan, Azerbaijan)
	Market Formation	-Strong backing from Saudi PIF -Green hydrogen project with Aramco, Air Products ME, Gas Industry Co.
	Entrepreneurial Experimentation	
Accumulate experience and knowledge	Knowledge Development	-Local content requirement for renewables (Saudi Arabia) -Data accumulation from O&M -Gained experience and technical capability in the operation and maintenance of renewable plants (Solar PV, CSP, Green hydrogen project, onshore wind, BESS)
	Resource Mobilization	-Supplier network for renewables
	Development of Externalities	-Gained investment capability and networks under PIF (upon IPO in 2021)

5. Results and Discussion

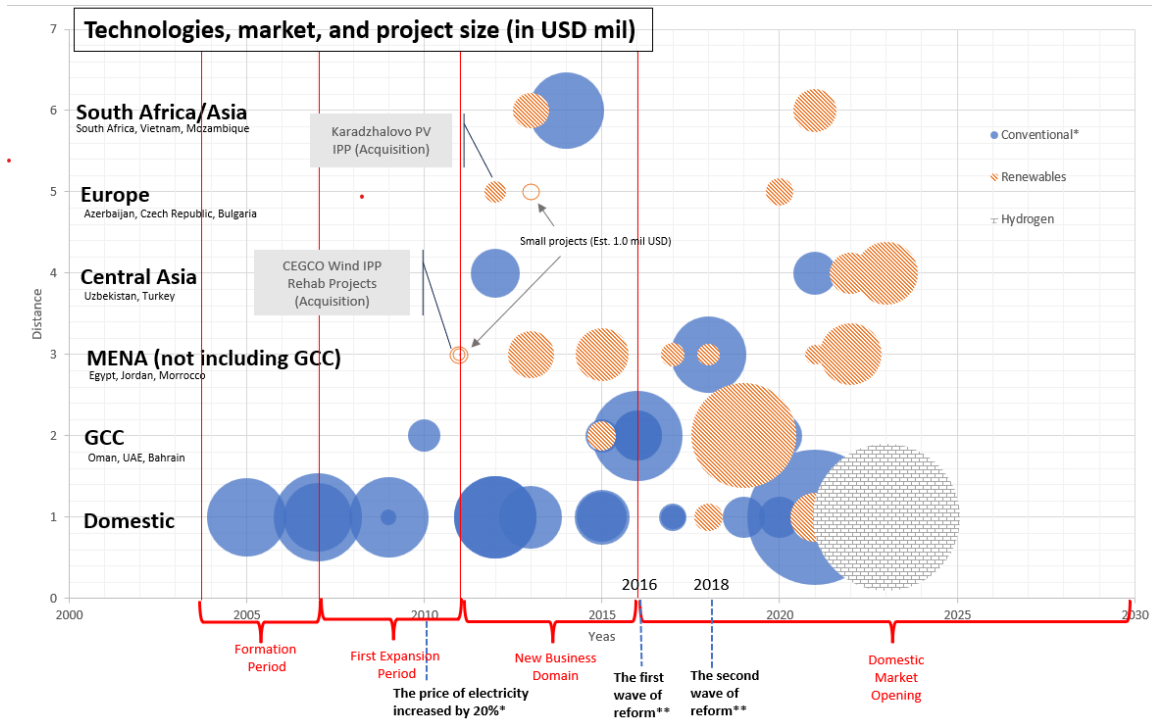
In the absence of a domestic market to develop the CoPS capabilities required for renewable energy development, ACWA Power sought opportunities presented by the changes in the direction of search in foreign markets. The firm was able to build CoPS capability outside its home country until the green windows of opportunity opened in the domestic market. In the case study, the legitimacy created by advanced countries changed the direction of developing countries (e.g., Morocco and South Africa saw opportunities in renewable power generation). The firm took advantage of these waves of change in developing countries and built CoPS capabilities for renewable energy deployment. To catch the changing tide, ACWA Power built its initial capabilities by acquiring projects in Jordan and rehabilitating plants that were built while ago, learning from operating and maintaining wind farms, and acquiring a solar PV project in Bulgaria with a US firm to gain data management skills. This enabled the firm to enter foreign markets. Before the start of energy subsidy reforms and the government's renewable policy measures in the home market, ACWA Power gained experience and built organizational capabilities by undertaking projects in Jordan, Bulgaria, South Africa, and Morocco before returning to a closer and more similar market in Dubai (UAE). Since then, the firm's renewable portfolio has been increasing steadily while also diversifying into green hydrogen projects in NEOM. In consortium with Air Products, ACWA Power's role is to generate power from solar PV.

Figure 8. ACWA Power's pathway to developing CoPS capability during transitions



Finally, the firm was able to accumulate experience and knowledge through past project development experiences, effectively utilizing them to discover the next market opportunities as they built CoPS capabilities in transition (Fig. 8). The decisions to explore new markets and search for new technologies to accommodate clients required strong leadership and a solid business strategy. During the interviews, several industry personnel pointed to the leadership of ACWA Power, with one noting that it was “always forward-looking, trying something new, and taking risks when other firms are reluctant to take them,” which was evident in their decision to undertake the CSP plant with molten salt heat storage in Morocco (Appendix 3, 6-E). According to the interviewee, not many firms were willing to attempt the use of heat storage due to the uncertainties associated with this new technology (Appendix 3, 6-E). Another interviewee highlighted the leadership’s strong commitment to human capital development in the early phase when the leadership decided to engage in the operation and maintenance function of the business through the establishment of NOMAC (Appendix.3, 5-B). In addition to leadership, upon returning to the domestic market, the firm gained strong support from PIF and aligned its strategy with the Kingdom’s economic development strategy (Appendix.3, 11-Q). This process of accumulating knowledge and experience while moving from project to project and engaging in new markets aligns with the depiction in Fig. 1: the process of building CoPS capability for catching up during transitions.

Figure 9. Project timeline of technologies and markets over time based on annual reports



Source: Created by the authors. Data was collected from the annual reports (from 2002 to 2023) and the company website. Domestic events based on Aldubyan & Gasim (2021); Krane & Monaldi (2017).

Figure 9 provides a visual illustration of the firm's project history based on the data acquired from the annual reports from 2002 to 2023. It illustrates the CoPS projects (represented by circles) from the formation period to the present. The circles (projects) initially appear in the domestic market before gradually moving to external markets and emerging renewable technologies (as indicated by different colors). The size of the bubbles illustrates the size of the projects (in USD million). The project size gradually grew as time progressed, with the firm learning from small-scale projects (such as wind farm rehabilitation in Jordan and the small solar PV plant in Bulgaria) to explore and experiment with new technologies in various environments. The firm then returned to the domestic market and started mobilizing resources and experimenting with newer technologies at a large scale. This demonstrates and triangulates the understandings from the analysis based on interviews and secondary sources in Fig. 8, using the framework described in Fig.1. This demonstrates the pathway towards the gradual building of CoPS capability in transition by the external market and experimenting with new technologies.

The next challenge for the firm is to gain competitiveness beyond organizational capability. The international competitors have several different business functions, ranging from transmitting and distributing power to developing their own technologies for renewables and beyond. To catch up with these competing firms, the firm must consider whether it needs to develop its own engineering capabilities, or if

engineering capability is overrated for the renewable deployment model. If engineering can be outsourced, uncertainty can be eliminated through data utilization and optimization becomes their strength, making market targeting sufficient. With the Saudi Arabian government aiming to create a supply chain (Alghamdi, Bahaj and James, 2022), ACWA Power is expected to play a significant role in this development. This will potentially provide new opportunities to build engineering capabilities.

6. Conclusion

Taking the case of ACWA Power from Saudi Arabia, this paper aimed to answer the question of *how a firm in latecomer countries can take advantage of EGWO and catch up through building CoPS capability without the strong support of the state*. The study found that ACWA Power built CoPS capability by developing several projects (IWPP, conventional power generation) domestically and internationally. The firm sought external markets to test new technologies (renewables), gaining experience and knowledge through operations and maintenance from the formation period. ACWA Power was led by strong and forward-looking leadership that managed the tension between building organizational capabilities through project-based activities and searching for new markets to explore. Having operations and maintenance functions as the outcome of cumulative capability upgrading helped the firm eliminate uncertainty in operating renewable energy plants. This contributed to improving performance predictions and enabled the firm to develop competitive project proposals. Furthermore, the accumulation of data and experience allowed the firm to explore distant markets in various environmental conditions.

The case of ACWA Power illustrates how firms can accumulate the capabilities required for the deployment of renewable energy (CoPS) in a resource-rich country, even in the absence of the domestic market. This research used an analytical framework based on the CoPS delivery model in renewable energy deployment and sociotechnical transition functions to explore how a firm uses project-based learning while accessing emerging green market opportunities and building capabilities to enable transitions. The case study demonstrates that firms can build CoPS capabilities by balancing the tensions between acquired knowledge and experiences from past projects, running the project cycle, strategic planning, learning from the execution of various projects, and developing the necessary experience from operations to explore new markets. These factors contributed to leveraging exogenous markets created by the landscape changes driven by developed economies.

The conceptual contribution of this paper is the creation of a framework that integrates TIS (used for emerging technology) and CoPS (products and services) to illustrate the overlapping areas of the transition process for latecomers deploying large-scale infrastructure for CoPS. The second contribution is that the study covers the CoPS delivery model (the Build-Own-Operate model), thereby addressing the entire

project cycle—from planning and delivery of the project, through to maintenance. Previous research into CoPS has mostly focused on the planning and execution phases, rarely extending to the operations phases (Davies, MacAulay and Brady, 2019; Trivellato, Martini & Cavenago, 2021; Denicol and Davies, 2022). There are still only a few studies covering the entire project cycle in the CoPS literature, and this study is expected to address this gap. The policy implication of this study is to support firms seeking to enter new technology markets in latecomer countries that lack a domestic market for the technology. The study also deals with the Middle East Gulf region, a resource-rich area. Case studies from this region, especially Saudi Arabia, remain limited due to the difficulty of access to data.

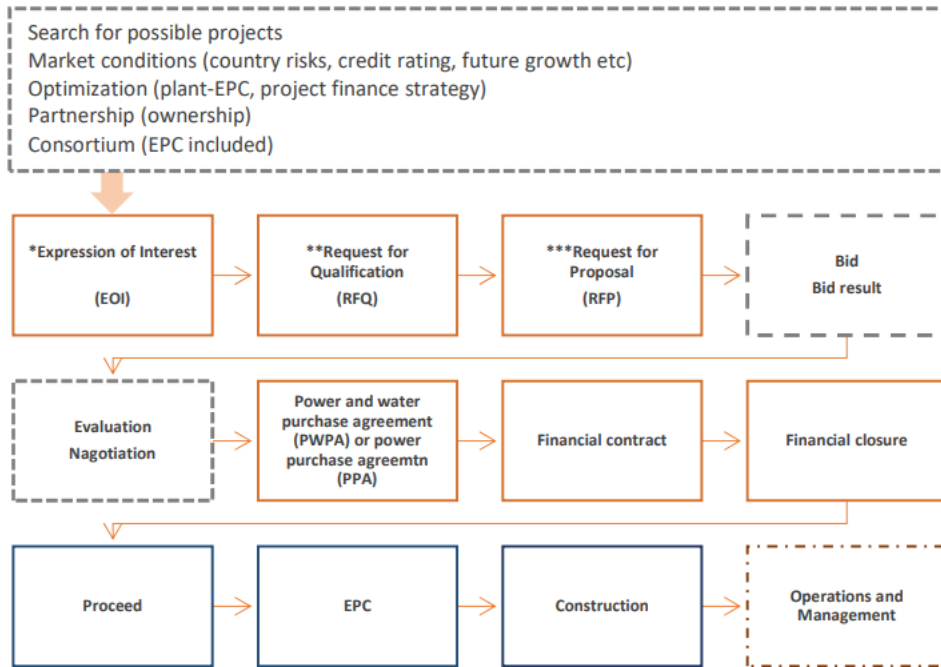
A limitation of the study is that it is based on a single case study of one firm. Moreover, the findings are based on a limited number of primary interviews. This issue was complemented by incorporating several secondary interviews with key financial and technical management personnel from ACWA Power available in the public domain and on social media (see list in Appendix 4). Furthermore, the evidence obtained from the interviews was triangulated with the information obtained from annual reports, as demonstrated in Figure 9.

Finally, given the similar opening of exogenous markets observed in the region (e.g., the port system in UAE) and developing economies (e.g., the high-end automobile industry in Vietnam), there is the possibility of exploring different cases of CoPS in future studies. Future research could also explore new development pathways for the renewable energy industry after the firm returns to the domestic market and works with the government's initiative to develop domestic supply chains. This circles back to the earlier question posed in the discussion: the importance of gaining competitiveness beyond organizational capability for latecomers.

Appendices

Appendix 1. IPP Project Cycle

IPP/IWPP Project Cycle



*General project information by offtaker is circulated.

**In the case of Saudi Arabia, there is a separation between management and technical contracts. Management contractors are developers and allowed enter the bid alone. Technical contractors can only enter the bid with a developer. Some developers are qualified for both management and technical contracts.

***In the Middle East, invitations are only extended to firms that have prequalified.

Created by author based on International Project Business (2001) and interviews to industry personnel.

----- Planning Phase — Execution Phase - . - Operation Phase

Appendix 2. International Competitors

Firm	Country	Activities***	Technologies	Scale	International projects
Iberdrola (1840)*	Spain	Power generation, transmission, distribution, and supply of electricity in Spain and overseas.	Renewables, onshore and offshore wind, hydro, solar PV, CCGT, nuclear, and biomass.	Installed capacity: 61,142 total (29,171 domestic, 31,971 overseas)	U.S., Brazil, Mexico, Australia, Germany, Greece, Hungary, France, Portugal, Poland, Romania, Cyprus, Italy,
Enel (1962)**	Italy	Power generation, transmission, distribution, purchases, transports, and sells electricity.	Mainly LNG, also wind, thermal, hydro, nuclear, solar OV, geothermal.	Installed capacity: 82,667 total (34,359 domestic, 48,308 overseas)*	Argentina, Brazil, Chile, Colombia, Peru, Panama, Guatemala, Costa Rica, Romania, Greece, Germany, Mexico, Canada, U.S., Australia, South Africa, India, Zambia
Orsted/Dong Energy* (2017/1972)	Denmark	Develops, constructs, own and operate renewables.	Offshore and onshore wind farms, solar farms, energy storage facilities, and bioenergy plants.	Installed capacity: 15,478 total (4,440 domestic, 11,038 overseas)*	UK, Germany, Denmark, the Netherlands, Poland, Belgium, Sweden, Norway, Iberia, Baltic State, US, Taiwan, Japan, Korea.
Engie/GDF Suez/GDF** (2015/2008/1880)	France	Power generation, natural gas, energy services, financing, constructing, operation, and maintenance. Project development, transporting, and distribution.	Hydroelectric, onshore wind, solar PV, biomass, offshore wind, and geothermal.	Installed capacity: 24,900 total	North America, South America, MENA, Europe, South Pacific
ACWA Power/ACWA Power Project (2008/2002)	Saudi Arabia	Power generation and desalination, natural gas, conventional energy, project development, operation and management.	Solar PV, CSP, CCGT(natural gas), desalination (steam and membrane), conventional energy generation, hydrogen	Operational capacity: 25,182 total*	KSA, UAE, Oman, Uzbekistan, Bahrain, Egypt, Jordan, Turkey, Morocco, Azerbaijan, South Africa, Indonesia
China Yangtze Power Co, Ltd. (2002)	China	Hydropower generation, investment and financing, power distribution and sales, integration of smart energy, pumped storage, new energy.	Hydropower generation.	Installed capacity: 45,495	Peru, Brazil, and Pakistan
EDF (1946)	France	Power generation, regulated activities, optimization and trading, customer solutions, energy services	Nuclear, hydropower, renewables, gas, coal, fuel oil	Installed capacity: 116,900 (overseas; 18,300)	UK, Italy, Brazil, Asia and other
NTPC Ltd. (1975)	India	Power generation and others.	Coal, gas, liquid fuel, hydro, solar, nuclear, wind, thermal, renewable energy sources.	Installed capacity: 73,824 (includes 15,986 thru JV).	Domestic market only - recently entering bids in Saudi Arabia

*Firms expanding their business from conventional energy to renewable energy

** IPP/Utility firms operates overseas, activities similar to ACWA Power

*** S&P Global Commodity Insights

MEMO

EU liberalization of gas and electricity markets in 1996, 2003, 2009.

Promotion of vertical integration (generation, transmission, distribution) -->A&M

Limitation in domestic market, Spain, Italy --> expansion to oversea market

Appendix. 3 Industry Personnel Interviews

#	Date	ID	Actor	Category
1	8/30/2023	A	Researcher	Private Firm
2	9/6/2023	B	Industry personnel	General incorporated foundation
3	9/6/2023	C	Industry personnel	General incorporated foundation
4	9/13/2023	D	Research Staff	Independent administrative agency
5	9/19/2023	B	Industry personnel	Independent administrative agency
6	11/28/2023	E	Industry personnel	Private Firm
7	11/28/2023	F	Industry personnel	Private Firm
8	11/28/2023	G	Industry personnel	Independent administrative agency
9	11/28/2023	H	Industry personnel	Private Firm
10	11/28/2023	I	Government staff	Government staff
11	11/29/2023	J	Industry personnel	Private Firm

Appendix 4. Management Interviews (Secondary)

#	Date	Channel Name	Interview title	Accessed	Keywords
1	2013.05.03	Acuris	ACWA acquisition strategy to include Africa and Turkey	2023.03.24	Market, Africa, commodity, acquisition strategy, Mozambique, regulatory environment, geographically driven, GCC, Turkey, rising star, acquisition
2	2013.07.31	World Finance Videos	Paddy Padmanathan on solar energy ACWA Power World Finance Videos	2023.03.21	Renewable energy, megawatts, electricity, technology, photovoltaic, tariff, Morocco, Bulgaria, competitively, concentrated solar power
3	2014. 10.02	Engerati	Paddy Padmanathan, CEO, ACWA Power	2023.03.15	Africa, megawatts, Nigeria, tariff, electricity and water plant, coal, desalination, platform, efficiency, resource, governance
4	2014.02.20	World Finance Videos	The privatization of electricity in Saudi Arabia ACWA Power World Finance Videos	2023.03.18	Megawatts, competitive, electricity, MENA region, tariff, storage (energy), business model, Saudi Arabia, power company, deliver, plants
5	2014.02.21	World Finance Videos	Renewable energy in Saudi Arabia ACWA Power World Finance Videos	2023.03.18	Renewable energy, kilowatt/hr., oil price, electricity, energy production, policymakers, young population, sector
6	2015.06.03	Climate Investment Funds	Paddy Padmanathan, CEO ACWA Power	2023.03.15	Renewable energy, Dubai, PV, DEWA project, tariff design, 5.845, 86% debt achieved, policymakers, private sector
7	2015.07.28	Marcopolis Net	Saudi Arabia report: Solar energy future	2023.03.24	Tariff structure, tariff design, supply chain, purchasing power, credit condition, DEWA
8	2015.07.28	Marcopolis Net	Renewable energy projects in Saudi Arabia and the lows feed in tariff for solar in UAE	2023.03.24	K.A. CARE, Late King Abdullah, Aramco and reduce oil dependence, subsidies, future energy mix
9	2015.07.28	Marcopolis Net	ACWA Power strategy for 2015-2016	2023.03.24	Tenders, projects, exploration phase, optimize, operating, footprint, coal fired power generation, gas fired power plants, financing, growth
10	2016.02.26	Marcopolis Net	Fossil fuel vs renewables by Saudi Arabia's Acwa Power	2023.03.24	Coal, projects, Dubai, coal fired power, fact, emissions, plant, fuel, electricity, cost, photovoltaic, Morocco, countries, clean coal, toughest, fired, carbon, best available technology, lowest possible price, submitted
11	2016. 09.29	Bonds & Loans	Bonds & Loans Interview: Pascal Martese, ACWA Power	2023.03.24	Private sector financing, credit rating, contractual structure, construction liabilities , Natural Gas Agreement, Salalah IPP,Oman, international banks, Oman economy and energy sector
12	2016.02.26	Marcopolis Net	ACWA Power strategy for 2016-2017	2023.03.24	Project bid numbers in 2015, 2016-2017 plan, So-called Clean Coal project in Dubai, Morocco, best available technology, lowest possible price
13	2017.04.19	Dolapo Aina	Dolapo Aina's The Interview Series With Paddy Padmanathan President of ACWA Power at COP22	2023.03.24	Morocco's energy mix, 52% renewable by 2030, economical than traditional fuel, investment, steam turbine, CSP
14	2017.06.16	Cleantech Business Club	ACWA Power CEO Paddy Padmanathan - Short Term Goal: US\$ 70 Billion Platform	2023.03.24	Fossil fuel energy, the data and its value, cost, utilization, recognizing the paradigm shift, denial and focus on core business, behavioral data, location data,
15	2019. 04.30	ACWA Power	New Market Investment Criteria: ACWA Power CEO & President Paddy Padmanathan	2023.03.18	Deliver, countries, economic diversity, creditworthy, GCC, value chain, strong, renewable energy, terms, geographies, provide, takers, southeast Asia, technology, middle east, intrinsically, population growth, region, competitive,
16	2019.04.30	ACWA Power	New Market Investment Criteria: Lucas Hautvast, VP Portfolio Management & Strategy	2023.03.15	Power, customer, strongholds, reach, supplier, significant market share, critical, Middle East Africa, solar power plant, counterpart, UAE, water, strategy, Asia region, operate, plants, Oman, years, countries, developing
17	2019.05.22	MEED Middle East Economic Digest	"Ten Minutes into the Future of Energy" with Paddy Padmanathan, ACWA Power International	2023.03.18	Challenge, technology, regulations, consume, electricity, cost, deliver, wastewater, energy, wastewater treatment, water, distributed, today, lowest possible cost, pension fund, private sector, rooftop, solutions, central, top
18	2019.09.19	Regency Global	SA INC EP4 ACWA Power 12minute	2023.03.24	South Africa, community, area, province, power plant, opportunity, support, plants, development, create, project, developing, Northern Cape, construction, mirrors, power, CFB, economically, land, engineers, remote sites
19	2020.02.11	Bloomberg Television	ACWA Power Will Be in 16 Countries by End of Year: CEO	2023.03.15	PIF, IPO, Saudi, Aramco, cents, shareholding, project, Indonesia, dams, Bangladesh, expect, announced, trend, year, credit worthiness, countries, sooner, relationship, grow, biggest
20	2021.04.22	ACWA Power	ACWA Power Transition Talks Reimagining the future of water desalination.	2023.03.15	Desalination, technology, plants, membrane, project, water, chemicals, developer, desalination plant, development, reduce, energy, discharge, important, R&D, big data analysis
21	2021.06.24	Emerald	Paddy Padmanathan, ACWA Power - Is H2 production ready to scale? - Innovation Insights	2023.03.15	Hydrogen, ammonia, produce, project, electricity, electrolyzer, steel, cents, cost, transport, fossil fuels, abate, Europe, Saudi Arabia, plants, coal, entry barriers, fertilizer, vehicles, starts
22	2021.10.23	Ministry of Economy and Finance of Uzbekistan	Tom Teerlynck Interview at the Uzbekistan Economic Forum 2021 mp4	2023.03.24	Renewable power, power plants, sector, country, power, projects, government, renewables, economic forum, energy sector, conventional, happening, extremely, transformation, discussions, increase, target, plants, Uzbekistan, megawatt
23	2022.08.25	Voices of the Future	Paddy Padmanathan, CEO, ACWA Power - Future of Energy Industry - Full Interview	2023.03.21	Famous 5.845, developing project based on future cost of technologies, obsolescence risk
24	2022.09.13	International Desalination Association	Global Water Community at IDA WC 2022 - Mr. Paddy Padmanathan, Vice Chairman and CEO of ACWA Power	2023.03.18	Water, global, cubic meters, congress, innovating, water desalination, lowest possible cost, Saudi, ACWA, technology, desalination, supplying, largest private, peers, proud, sector, reverse osmosis, demand
25	2022.11.14	CleanTech Business Club	ACWA Power by 2030: 130GW+ RE portfolio & championing the green hydrogen growth - Paddy Padmanathan	2023.03.15	2007 renewables prices were coming down, the idea was turned down, government and SEC, ACWA sought opportunities outside, hydrogen, human ingenuity, capacity
26	2022.11.15	Boston Consulting Group	BCG at COP27 A New Era for Energy	2023.03.24	Decarbonization, risk, energy, crisis, private sector, renewable energy, fossil, security, enabling environment, governments, price, continue, short term, companies, technology, challenging aspect, fossil fuel prices, lots, case, efficiency
27	2022.12.20	Ministry of Economy and Finance of Uzbekistan	An interview with Clive Turton, Chief Investment Officer at ACWA Power	2023.03.24	Developing green hydrogen program together, wind and solar power, geographically suited, the country's willingness to cooperate with the private sector.
28	2022.12.20	Arabian Business	AB In Focus: The Middle East's role as an energy transition hub	2023.03.24	Cost of producing green hydrogen is low in the MENA, high resource, vast land, low cost financing, NEOM to European market, possibility of connecting KSA to Europe by building pipeline
29	2023.4.26	MESIA	Saudi Arabia Solar Energy Market Outlook 2023	2023.4.12	Rules and regulations, Commercial and Industry Sector, Utility scale deployment, manufacturing, LCGPA local content authority, 75% percent localization target by 2030.
30	2023.11.29	MESIA	Digitalization and AI Transforming Solar Project Execution and Asset Management	2023.12.05	Digitalization of plants, platforms, remotely managing plants, data analysis, sensors, drones, supply warehouse capability, use of AI in sorting data, garbage in and garbage out.

References

- Abe, Kazuhide and Takano, K. (2017) 'Correlation between the measures of project management and the enhancement of resilience of organization for the success of plant construction projects', *Japan Architecture Planning*, 82(731), pp. 153–162. Available at: https://www.jstage.jst.go.jp/article/aija/82/731/82_153/_article/-char/ja/.
- ACWA Power. (2009). Annual Report
- ACWA Power. (2016). Annual Report
- ACWA Power. (2019). Annual Report
- Aldubyan, M. and Gasim, A. (2021) 'Energy price reform in Saudi Arabia: Modeling the economic and environmental impacts and understanding the demand response', *Energy Policy*, 148(PB), p. 111941. doi: 10.1016/j.enpol.2020.111941.
- Alghamdi, N., Bahaj, A. B. S. and James, P. (2022) 'Supply Chain Readiness for Solar PV Expansion in Saudi Arabia', *Energies*, 15(20). doi: 10.3390/en15207479.
- Alkemade, R., Bakkenes, M. and Eickhout, B. (2011) 'Towards a general relationship between climate change and biodiversity: An example for plant species in Europe', *Regional Environmental Change*, 11(SUPPL. 1), pp. 143–150. doi: 10.1007/s10113-010-0161-1.
- Arocena, R. and Sutz, J. (2000) 'Looking at National Systems of Innovation from the South', *Industry and Innovation*, 7(1), pp. 55–75. doi: 10.1080/713670247.
- Bento, N. and Fontes, M. (2015) 'The construction of a new technological innovation system in a follower country : Wind energy in Portugal', *Technological Forecasting & Social Change*, 99, pp. 197–210. doi: 10.1016/j.techfore.2015.06.037.
- Bergek, A. et al. (2008) 'Analyzing the functional dynamics of technological innovation systems: A scheme of analysis', *Research Policy*, 37(3), pp. 407–429. doi: 10.1016/j.respol.2007.12.003.
- Choung, Jae-Yong & Hwang, Hye Ran. (2007). Developing the complex systems in Korea: The case of TDX and CDMA telecom system. *International Journal of Technological Learning, Innovation and Development*. 1. 204-225. 10.1504/IJTLID.2007.015404.
- David M. Gann and Ammon J. Salter (2000) 'Innovation in project-based, service-enhanced firms: the construction of complex products and systems', *Research Policy*, 29(7–8), pp. 955–972.
- Davies, A. and Brady, T. (2016) 'Explicating the dynamics of project capabilities', *International Journal of Project Management*, 34(2), pp. 314–327. doi: 10.1016/j.ijproman.2015.04.006.
- Davies, A., MacAulay, S. C. and Brady, T. (2019) 'Delivery Model Innovation: Insights From Infrastructure Projects', *Project Management Journal*, 50(2), pp. 119–127. doi: 10.1177/8756972819831145.
- Denicol, J. and Davies, A. (2022) 'The Megaproject-based Firm: Building programme management capability to deliver megaprojects', *International Journal of Project Management*, 40(5), pp. 505–516. doi: 10.1016/j.ijproman.2022.06.002.

- Elshurafa, A. M. & Matar, W. (2020). Economics of solar power in the GCC: assessing opportunities at residential and utility scales. In *Economics of renewable energy in the Gulf* (pp. 41–76). essay, Routledge.
- Freeman, C. (1987). *Technology Policy and Economic Performance: Lesson from Japan*. Pinter Publishers, London.
- Frroukhi, R. et al. (2016) ‘Renewable Energy Market Analysis The GCC Region’, Irena, pp. 1–96. Available at: https://www.irena.org/DocumentDownloads/Publications/IRENA_Market_GCC_2016.pdf.
- Geels, F. W. (2002) ‘Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study’, *Research Policy*, 31(8–9), pp. 1257–1274. doi: 10.1016/S0048-7333(02)00062-8.
- Geels, F. W. (2004) ‘From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory’, *Research Policy*, 33(6–7), pp. 897–920. doi: 10.1016/j.respol.2004.01.015.
- Goh, H. H. et al. (2014) ‘Renewable energy project: Project management, challenges and risk’, *Renewable and Sustainable Energy Reviews*, 38(October), pp. 917–932. doi: 10.1016/j.rser.2014.07.078.
- Hekkert, M. P. et al. (2007) ‘Functions of innovation systems: A new approach for analysing technological change’, *Technological Forecasting and Social Change*, 74(4), pp. 413–432. doi: 10.1016/j.techfore.2006.03.002.
- Hobday, M. (2000) ‘The project-based organisation: An ideal form for managing complex products and systems?’, *Research Policy*, 29(7–8), pp. 871–893. doi: 10.1016/s0048-7333(00)00110-4.
- Hobday, M., Davies, A. and Prencipe, A. (2005) ‘Systems integration: A core capability of the modern corporation’, *Industrial and Corporate Change*, 14(6), pp. 1109–1143. doi: 10.1093/icc/dth080.
- Iizuka, M. (2015) ‘Diverse and uneven pathways towards transition to low carbon development : the case of solar PV technology in China’, 9318. doi: 10.1080/2157930X.2015.1049850.
- IRENA (2019) *Renewable Energy Market Analysis: GCC 2019*, Irena. Available at: <https://www.irena.org/publications/2019/Jan/Renewable-Energy-Market-Analysis-GCC-2019>.
- Jacobsson, S. and Karltorp, K. (2013) ‘Mechanisms blocking the dynamics of the European offshore wind energy innovation system - Challenges for policy intervention’, *Energy Policy*, 63(June 2010), pp. 1182–1195. doi: 10.1016/j.enpol.2013.08.077.
- Kiammehr, M., Hobday, M. and Hamed, M. (2015) ‘Latecomer firm strategies in complex product systems (CoPS): The case of Iran’s thermal electricity generation systems’, *Research Policy*, 44(6), pp. 1240–1251. doi: 10.1016/j.respol.2015.02.005.
- Kingdom of Saudi Arabia. Saudi Vision. https://www.vision2030.gov.sa/media/rc0b5oy1/saudi_vision203.pdf
- Komendantova, N. et al. (2012) ‘Perception of risks in renewable energy projects: The case of concentrated solar power in North Africa’, *Energy Policy*, 40(1), pp. 103–109. doi: 10.1016/j.enpol.2009.12.008.
- Krane, J. (2021). *Energy kingdoms: Oil and political survival in the Persian Gulf*. Columbia University Press.

- Krane, J. and Monaldi, F. (2017) 'Oil Prices, Political Instability, and Energy Subsidy Reform in Mena Oil Exporters', Center for Energy Studies, Baker III Institute for Public Policy, Rice University, (June). Available at: https://www.bakerinstitute.org/media/files/files/0660db8a/CES-pub-QLC_Subsidies-042517.pdf.
- Krupa, J., Poudineh, R. and Harvey, L. D. D. (2019) 'Renewable electricity finance in the resource-rich countries of the Middle East and North Africa: A case study on the Gulf Cooperation Council', *Energy*, 166, pp. 1047–1062. doi: 10.1016/j.energy.2018.10.106.
- Kwak, K. and Yoon, H. (David) (2020) 'Unpacking transnational industry legitimacy dynamics, windows of opportunity, and latecomers' catch-up in complex product systems', *Research Policy*, 49(4), p. 103954. doi: 10.1016/j.respol.2020.103954.
- Lee, J. J. and Yoon, H. (2015) 'A comparative study of technological learning and organizational capability development in complex products systems: Distinctive paths of three latecomers in military aircraft industry', *Research Policy*, 44(7), pp. 1296–1313. doi: 10.1016/j.respol.2015.03.007.
- Lema, R., Fu, X. and Rabellotti, R. (2020) 'Green windows of opportunity: Latecomer development in the age of transformation toward sustainability', *Industrial and Corporate Change*, 29(5), pp. 1193–1209. doi: 10.1093/icc/dtaa044.
- Lema, R. et al. (2022) *Building innovation capabilities for sustainable industrialisation renewable electrification in developing economies*. Abingdon: Routledge.
- Lin, H. and Su, J. (2014). A case study on adoptive management innovation in China. *Journal of Organizational Change Management*, Vol. 27 No. 1, pp. 83-114. <https://doi.org/10.1108/JOCM-07-2012-0112>
- Lobo, S. and Whyte, J. (2017) 'Aligning and Reconciling: Building project capabilities for digital delivery', *Research Policy*, 46(1), pp. 93–107. doi: 10.1016/j.respol.2016.10.005.
- Majidpour, M. (2016) 'Technological catch-up in complex product systems¹', *Journal of Engineering and Technology Management - JET-M*, 41(November 2013), pp. 92–105. doi: 10.1016/j.jengtecman.2016.07.003.
- Malerba, F. (2002) 'Sectoral systems of innovation and production', *Research Policy*, 31(2), pp. 247–264. doi: 10.1016/S0048-7333(01)00139-1.
- McLeod-Roberts, L. (2006). Full steam ahead on Saudi IWPPs. *Case Studies, IJGlobal*. <https://www.ijglobal.com/articles/31045/full-steam-ahead-on-saudi-iwpps> (accessed May 6, 2023).
- Naghizadeh, M. et al. (2017) 'Managing integration in complex product systems: The experience of the IR-150 aircraft design program', *Technological Forecasting and Social Change*, 122, pp. 253–261. doi: 10.1016/j.techfore.2016.06.002.
- National Renewable Energy Laboratory (2018) *Best Practices for Operation and Maintenance of Photovoltaic and Energy Storage Systems*, NREL. Available at: <https://www.nrel.gov/research/publications.html>.

- Ong, P. Y., Chin, C. M. M. and Yap, E. H. (2016) 'Reviewing Malaysia's Renewable Energy Policies: A Management Framework Perspective', *Journal of Clean Energy Technologies*, 4(6), pp. 448–452. doi: 10.18178/jocet.2016.4.6.330.
- Park, T. Y. (2012) 'How a latecomer succeeded in a complex product system industry: three case studies in the Korean telecommunication systems', *Industrial and Corporate Change*, 22(2), pp. 363–396. doi: 10.1093/icc/dts014.
- Park, T. Y. and Kim, J. Y. (2014) 'The capabilities required for being successful in complex product systems: case study of Korean e-government', *Asian Journal of Technology Innovation*, 22(2), pp. 268–285. doi: 10.1080/19761597.2014.973166.
- Poudineh, R., Fattouh, B. and Sen, A. (2018) 'Electricity markets in MENA: Adapting for the Transition Era', Oxford Institute for Energy Studies, (May). Available at: <https://www.oxfordenergy.org/publications/electricity-markets-mena-adapting-transition-era/>.
- Project Finance International (2012). CEGCO – The Arabian Oryx. Year Book 2012. https://www.acwapower.com/media/99124/arabian-oryx_cegco.pdf (accessed March 10, 2023).
- Ranjbar, M. S. et al. (2004) 'Dynamism of Iran's Government Policies meantime Formation and Evolution of Gas Turbine Industry as a Complex Product Systems', in *The 14th Asia Pacific conference & the 7th International Conference on Management of Technology and Innovation*.
- Ren, Y. T. and Yeo, K. T. (2006) 'Research challenges on complex product systems (CoPS) innovation', *Journal of the Chinese Institute of Industrial Engineers*, 23(6), pp. 519–529. doi: 10.1080/10170660609509348.
- Roehrich, J. K. et al. (2019) 'Management innovation in complex products and systems: The case of integrated project teams', *Industrial Marketing Management*, pp. 84–93. doi: 10.1016/j.indmarman.2018.10.006.
- Sacks, R. et al. (2020) 'Construction with digital twin information systems', *Data-Centric Engineering*, 1(6). doi: 10.1017/dce.2020.16.
- Safdari Ranjbar, M., Park, T. Y. and Kiamehr, M. (2018) 'What happened to complex product systems literature over the last two decades: progresses so far and path ahead', *Technology Analysis and Strategic Management*, 30(8), pp. 948–966. doi: 10.1080/09537325.2018.1431390.
- Saito, Y. and Hosomaki, Y. (2001) *Kokusai Project Business* (International Project Business). Tokyo: Bunshun-do.
- Sawulski, J., Gałczyński, M. and Zajdler, R. (2019) 'Technological innovation system analysis in a follower country – The case of offshore wind in Poland', *Environmental Innovation and Societal Transitions*, 33(July), pp. 249–267. doi: 10.1016/j.eist.2019.07.002.
- Schot, J. and Geels, F. W. (2008) 'Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy', *Technology Analysis and Strategic Management*, 20(5), pp. 537–554. doi: 10.1080/09537320802292651.
- Smith, A., Voß, J. P. and Grin, J. (2010) 'Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges', *Research Policy*, 39(4), pp. 435–448. doi: 10.1016/j.respol.2010.01.023.

Teece, D. J., Pisano, G. and Shuen, A. (2009) 'Dynamic capabilities and strategic management', *Knowledge and Strategy*, 18(April 1991), pp. 77–116. doi: 10.1093/0199248540.003.0013.

Trivellato, B., Martini, M. and Cavenago, D. (2021) 'How Do Organizational Capabilities Sustain Continuous Innovation in a Public Setting?', *American Review of Public Administration*, 51(1), pp. 57–71. doi: 10.1177/0275074020939263.

Unruh, G. C. (2000) 'Understanding carbon lock-in', *Energy Policy*, 28(4), pp. 817–830. doi: 10.1016/S0301-4215(01)00098-2.

US-Saudi Business Council (2021). Water in Saudi Arabia' Desalination, Wastewater, and Privatization. <https://ussaudi.org/water-in-saudi-arabia-desalination-wastewater-and-privatization/>

The UNU-MERIT WORKING Paper Series

- 2024-01 *The green transformation as a new direction for techno-economic development* by Rasmus Lema and Carlota Perez
- 2024-02 *Evidence on an endogenous growth model with public R&D* by Thomas H.W. Zieseemer
- 2024-03 *Higher Educational Systems and E-resilience* by Mindel van de Laar, Julieta Marotta and Lisa de Graaf
- 2024-04 *Estimating the wage premia of refugee immigrants: Lessons from Sweden* by Christopher F. Baum, Hans Lööf, Andreas Stephan and Klaus F. Zimmermann
- 2024-05 *Green window of opportunity through global value chains of critical minerals: An empirical test for refining copper and lithium industries* By Jorge Valverde-Carbonell and Alejandro Micco A.
- 2024-06 *Migration and Consumption* by Roberta Misuraca and Klaus F. Zimmermann
- 2024-07 *The power of narratives: How framing refugee migration impacts attitudes and political support towards refugees* by Tobias Hillenbrand, Bruno Martorano, Laura Metzger and Melissa Siegel
- 2024-08 *Strategies of search and patenting under different IPR regimes* by Robin Cowan, Nicolas Jonard and Ruth Samson
- 2024-09 *From drains to bridges: The role of internationally mobile PhD students in linking non-mobile with foreign scientists* by Rodrigo Ito, Diego Chavarro, Tommaso Ciarli, Robin Cowan and Fabiana Visentin
- 2024-10 *Expanding horizons: The impact of post-doctoral mobility grants on research diversification* by Yağmur Yıldız, Diego Chavarro, Fabiana Visentin and Tommaso Ciarli
- 2024-11 *Scorching heat and shrinking horizons: The impact of rising temperatures on marriages and migration in rural India* by Manisha Mukherjee, Bruno Martorano and Melissa Siegel
- 2024-12 *Labour market integration for refugees: A social justice framework* by Tamara Kool and Zina Nimeh
- 2024-13 *The evolution of development with trade in global value chains* by Önder Nomaler and Bart Verspagen
- 2024-14 *The impacts of the Microfinance Multiplied approach on seasonal food insecurity: Evidence from a high-frequency panel survey in Uganda* by Ricardo Morel, Franziska Gassmann, Bruno Martorano, Nyasha Tirivayi and John Kamau
- 2024-15 *Building CoPS Capability for Catching Up During Transitions: The Case of ACWA Power in Saudi Arabia* by Kaori Mita and Michiko Iizuka