ENERGY RELIABILITY THROUGH SOLAR PUBLIC-PRIVATE PARTNERSHIPS IN INDIA AND BANGLADESH FOR SUSTAINABLE COMMUNITY DEVELOPMENT

by
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Executive Summary

As rapidly growing economies, India and Bangladesh's energy needs have become stressed due to availability and reliability constraints, especially in rural regions of the country. Renewable energy is an important resource to harness; aiding in mitigating energy and health issues, particularly in a developing nation struggling with increased energy demand as well as health concerns such as air pollution and water quality from conventional electricity generation affecting community development. Distributed and Central solar power programs in are being more and more popular in India and Bangladesh to provide electricity to its citizens. This paper denotes how Public-Private Partnerships (PPPs), are flexible frameworks the governments can use to empower private investment into major infrastructure, in this case for solar energy and compares examples from India and Bangladesh. With constrained funding resources, private sector funding can help fill the gap through public-private partnerships for solar capital cost, expertise and technology as well as maintenance while leveraging public sector resources such as tax incentives, land acquisition requirement and guaranteed customer base. Federal and state governments within India and Bangladesh are working and should continue to work with the private sector through Public-private partnerships to invest in solar renewable energy development, aiding to reduce greenhouse gas emissions as well as expand the renewable energy market. The paper also notes the need to improve on legal frameworks and language, resource distribution and best practice sharing, as well as technician and implementor training for PPPs to help to ensure the balance and success for both parties. Examples are provided of PPPs in India and Bangladesh specifically for centralized and decentralized solar in different geographic locations, providing leverage for the effectiveness of PPPs as a tool to deploy solar within the two nations.

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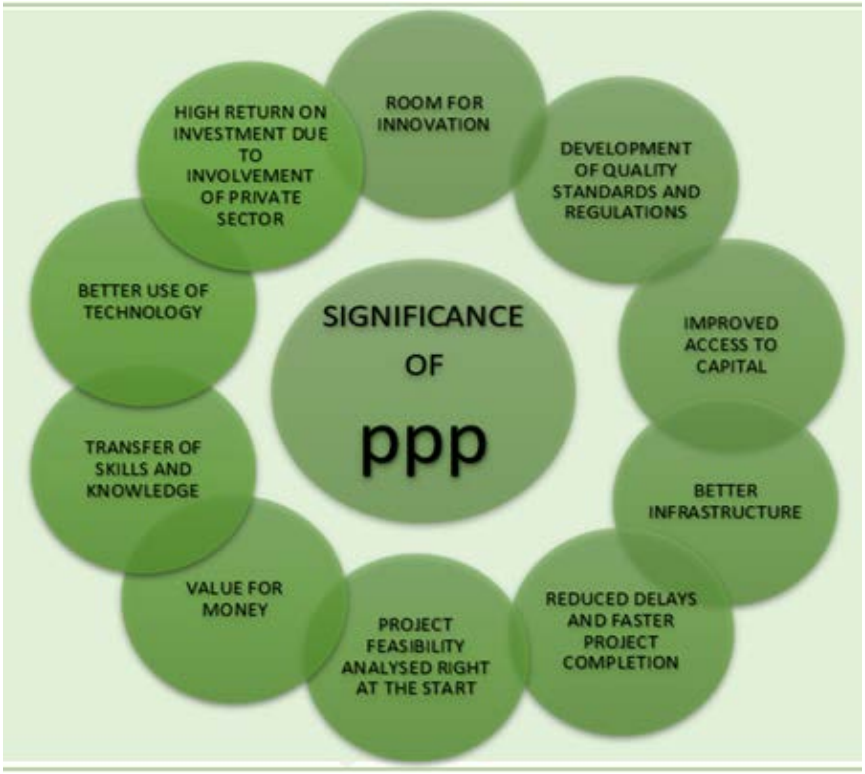
Introduction

Temperatures are rising, floods are increasing, drought is abundant, and the Intergovernmental Panel on Climate Change has connected a portion of global warming to human activities which increase greenhouse gas emissions (GHGs). The Environmental Protection Agency, states that 79% of U.S. GHGs are due to the energy production from fossil fuels, including coal, oil and natural gas. Renewable energy solutions can catalyze a community's ability to become self-sustaining via reliable energy sources and provide a landscape for economic stability through mobilizing income-generating activities (Waray, Patnaik, & Jain, 2018). With an ever-growing global population creating an increased demand on resources, energy resources will be heavily utilized to compensate. Both countries have climate change and greenhouse gas reduction targets they need to reach by a certain timeframe, making it more important to deploy cleaner energy to support their growing economies. Energy availability and transmission are major factors in supporting economic and developmental growth in communities sustainably.

India and Bangladesh's rapidly growing economies are straining their energy needs in some areas due to availability and reliability constraints, while needing new energy infrastructure in others, especially in rural regions of the countries. Renewable energy is an important resource to harness; aiding in mitigating energy and health issues, particularly in a developing nation struggling with increased energy demand as well as health concerns such as air pollution and water quality affecting community development. Moreover, the need to increase penetration of energy infrastructure within communities, specifically solar energy will allow for access to



(Public Private Partnership, 2019)

electricity and opportunity for technology and market development within communities. Federal and state governments within India and Bangladesh are working and should continue to work with the private sector through Public-private partnerships to invest in solar renewable energy development, aiding to reduce greenhouse gas emissions as well as expand the renewable energy market. *This paper denotes how Public-Private Partnerships (PPPs), are flexible frameworks the governments can use to empower private investment into major infrastructure, in this case for solar energy and compares examples from India and Bangladesh. With constrained funding resources, private sector funding can help fill the gap through public-private partnerships for solar capital cost, expertise and technology as well as maintenance while leveraging public sector resources such as tax incentives, land acquisition requirements and guaranteed customer base.*

Background

Significance of Public-Private Partnerships

Financing required for new water, healthcare, and energy infrastructure amounts for trillions of dollars per annum globally (Heathcote, 2017). Additionally, with constrained government resources, private sector funding can help fill the gap through public-private partnerships (PPPs). PPPs are a device to attract private resources to aid in improving access and quality of a service to the community it is meant to serve. Research has revealed that PPPs are suited for economic infrastructure, for instance transport and energy vs. healthcare and schools because of the steady demand and the investment positively impacting service quality, ease of access while also reducing operational costs (Ter-Minassian, 2006). A study from the United Nations Department of Economic and Social Affairs states that PPPs can become a viable tool for financing key economic infrastructure ventures, but it requires countries to have the institutional capacity to create, manage, and evaluate them. Establishing an institutional framework for PPPs would allow countries the capability in ensuring an enhancement in the cost and quality efficiency of the infrastructure service (KS, Chowdhury, Sharma, & Platz, 2016). PPP projects leverage private-sector efficiencies to allow governments to provide essential and improved infrastructure and services at a better rate and value to the impacted society.

In addition, PPPs are a symbiotic relationship between the public and private sector to take advantage of the joint innovation, resources, and knowledge both sectors have to offer to reach common goals for both. There are a lot of different rules and practices on how PPPs could work with different institutions promoting different strategies for success and nations using a different set of laws and policies, which makes it hard for these partnerships to be replicable within cities, states, and nations. Although, there are common fundamentals, there is different language and characteristics used to define and build out a PPP. The table below represents the

vast type definitions and characteristics of different PPPs (KS, Chowdhury, Sharma, & Platz, 2016).

Furthermore, PPPs are essential to the incubation of public good industries including energy, specifically clean, renewable energy. The cooperation between the governmental and private sector in organizing, developing, financing, constructing, and operating energy infrastructure assets address significant human and environmental needs at a local, national and international level in a timely manner neither alone would attain. The public sector has the ability to provide structured policy frameworks and financing incentives, mandating changes providing the incentive for PPPs, while the private sector fills the gap of funding and managing the energy infrastructure to serve the public good. For example, the government can provide financial incentives such as tax credits and power purchase agreements, which are fixed term contract between private solar developer and public buyer based on solar sales rather than up-front capital for a solar entire system providing financial certainty to both parties, to encourage private investment in solar within communities (Importance of Public-Private Partnerships in the Solar Industry, 2008). PPPs work in the favor of the public communities as public entities can capitalize on the early stages of market development when alone the scale would not be economically feasible. Private partners provide the additional knowledge, capital, technology and expertise to develop and establish the new energy infrastructure, which when has reached a self-supporting ability can allow the market to flourish on its own. The government also benefits as PPPs bring in more business and market access, providing supporting income within the public sector through corporate taxes and personal income taxes (Importance of Public-Private Partnerships in the Solar Industry, 2008).

Solar Infrastructure Suited for PPPs

Public-private partnerships can be used to set up 2 main types of solar infrastructure,

distributed or centralized. Distributed generation is usually in the form of Photovoltaic (PV) panels at scattered locations close to the load centers. Centralized plants are classically located where the resource is best utilized and available and can be in the form of Photovoltaics or Concentrated solar power /solar thermal technology (Stanford Woods Institute of the Environment, 2010). Centralized Power Generation and distributed PV both have strengths and weaknesses depending on geography, location of suppliers and customers, climate, terrain, and other variabilities.

Centralized solar power is more common for larger commercial and utility-scale projects due to its first-cost efficiencies and growing necessities for utility interactive controls generally available in central inverters. Distributed solar power, on the other hand, is a concept that is just gaining more momentum and used mainly for small to medium commercial or residential projects including rooftops, community centers, carports, and other multiple-angled projects due to its ability to use string inverters which optimize energy production in photovoltaic systems with flexible array design parameters (Zipp , 2013).

Distributed PV provides smaller entities with reliable and consistent power during peak demand time, usually around noon, therefore eliminating transmission loss from a central system to individual homes, community centers, schools, etc. Nevertheless, the challenge is directly managing the intermittency of the panel output as well as the uncertainty of how much distributed PV the electrical grid may be able to sustenance. Alternatively, centralized PV "follows the current electrical power management model," and can be situated at areas where the solar resource is most prominent and then supplied to customers. These stations also have their challenges including requiring vast capital investments as well as needing additional new transmission lines to transference power from the station to the

load hubs (Stanford Woods Institute of the Environment, 2010).

Moreover, using PPPs for energy infrastructure, specifically solar energy will allow for access to electricity and opportunity for technology and market development within communities. With climate-change being on the forefront of many environmental and clean energy minded advocates, increasing access to solar electricity for communities is essential to reducing greenhouse gas emissions and reaching clean energy goals. India and Bangladesh are both rapidly developing nations looking for a way to expand their economies while also acknowledging the need to sustainably undertake as much industrialization as possible. Solar energy is key in meeting greenhouse gas reduction targets for both nations and PPPs can bring in the scalable support to reach their renewable energy goals (Importance of Public-Private Partnerships in the Solar Industry, 2008).

Solar PPPs in Bangladesh and India

Bangladesh

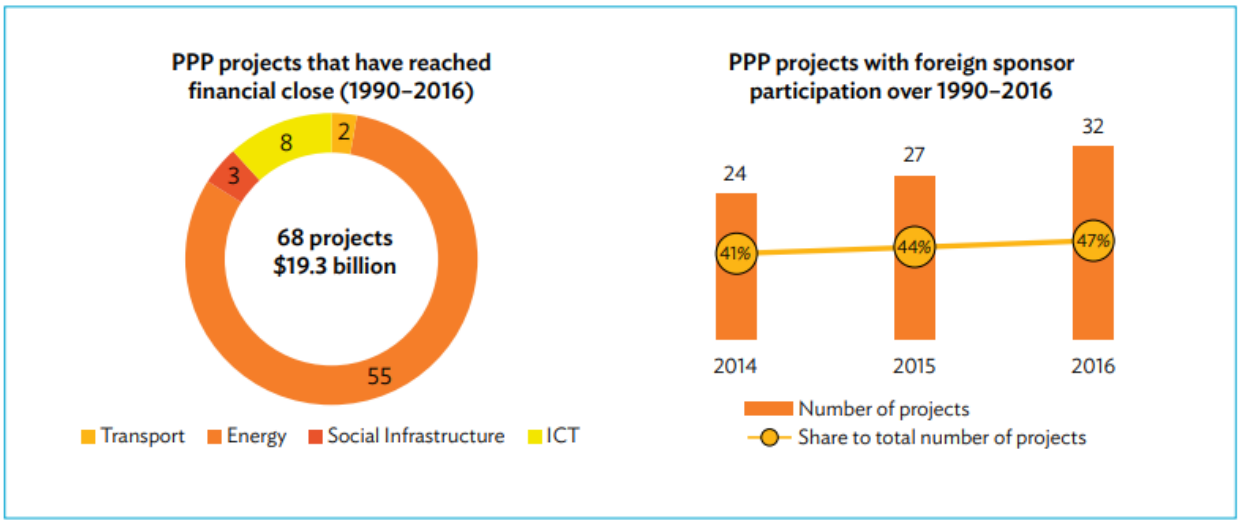
Bangladesh has the highest population density in the world amid large countries having a population of over 160 million with a high vulnerability to climate change and natural disasters due to its low-lying geography. Approximately 65 percent of Bangladesh is in rural areas and the county's continued growth has created a demand and market for electricity, transport, and telecommunication infrastructure and services. With the population growing and energy demand skyrocketing, the infrastructure needs have surpassed the investments in that field. In Bangladesh, public investment in hard infrastructure is around than 2 percent of the GDP (Bangladesh Country Snapshot, 2015), below countries like Thailand, Vietnam and China that invest around 7% of their GDP, ranking 105th (India ranks 68th), on the 2019 World Economic Forum's Global Competitiveness Report (Schwab, 2019), which is a benchmarking of the drivers of long-term competitiveness for 141 countries (Juma , Werner, Dominguez , & Barbour , 2016).

However, despite many bottlenecks in Bangladesh, the country has grown its power sector rapidly over the last decade, increasing its maximum generation capacity to 9,400 MW in 2017. Access to electricity has also seen growth since a decade ago when less than 50 percent of citizens had access to electricity to now about 80 percent have access to grid electricity. In the last 10 years Bangladesh's growth in capacity addition has been from around 4.5 GW in 2007–08 to 12.8 GW in 2016–17 with private sector involvement accounting for about 60% of the overall installed capacity (Halim, 2018). Additionally, the country hosts an off-grid access program managed by the Infrastructure Development Company Limited (IDCOL) called the solar home systems program. This program reaches outwards of 4 million households and businesses within isolated/rural areas in Bangladesh, which sets them on the track for attaining universal access to electricity ahead of the Sustainable Energy for All 2030 target (Bangladesh CPF Consultations, 2015).

Although, Bangladesh has been on an upward trajectory for increasing electricity access, the connections to clean energy still have a long way to go. The total connected renewable energy generation capacity is only about 461 MW with renewable energy on grid being 1.5 percent. A majority of their renewable energy generation is coming from the 230 MW Kaptai Hydropower Project developed in the 1960s. additionally, another 175 MW off-grid solar households in rural areas, 31 MW from two other PV plants, and 15 MW from rooftop solar, with minor amounts from biogas and biomass. A majority of the solar rooftop photovoltaics systems are in main cities vs. rural areas, due to the requirement for a proportion of lighting loads are to come from solar as a pre-requisite for a new grid connection. (Bangladesh Scaling-up Renewable Energy Project, 2018). Because of the rapid need for energy access and pre-

requisite conditions as well as a lack of industry experts undertaking quality control, a lot of these installations produce limited energy (Bangladesh CPF Consultations, 2015).

Bangladesh, similar to India has a big potential when it comes to renewable energy generation. The Bangladesh Climate Investment Funds Scaling Up Renewable Energy Program (CIF-SREP) investment plan published assessments that indicated the country could realize around 3,666 MW of renewable energy capacity with 2600 MW coming from ground-mounted solar and rooftop solar (Bangladesh CPF Consultations, 2015). Bangladesh's government has set up numerous plans and targets for renewable energy development, including updating their yearly renewable energy development plan from 2017 to 2021 calling for 2,458 MW of renewable energy capacity to be newly installed of which 52-54% will be from solar. They also set a Power System Master Plan in 2016 with goals for fuel diversification with an emphasis on increasing the role of renewable energy in the power generation mix and developed its Nationally Determined Contribution (NDC) to the Paris Climate Agreement for adding 1,000 MW of solar PV and 400 MW of wind power generation by 2030 (Bangladesh CPF Consultations, 2015). Additionally, the Sustainable and Renewable Energy Development Agency (SREDA) promotes and oversees renewable energy, acting as the state nodal branch for all clean energy programs and projects in Bangladesh. The agency is accountable for encouraging and approving renewable energy projects as well as developing energy audits and administrate activities related to conservation and energy efficiency (Asian Development Bank, 2017).



(Asian Development Bank, 2017)

With many energy expansions goals and targets, the government of Bangladesh is gearing up for the toughest and most essential challenges of financing these advancements. Bangladesh has also used public-private partnerships for a long time for technology development, infrastructure advancements and other mutually beneficial developments. A detached, independent office under the Prime Minister's Office was created to monitor, identify and promote PPPs to international standards. Moreover, the PPP unit is also under the Ministry of Finance in hopes to foster an atmosphere of fiscal accountability and sustainability in PPP projects (Public Private Partnership Authority, 2019). The unit has put out direction on training for PPPs for state owned enterprises, a joint PPP platform with Dubai for idea sharing, workshops on financing PPPs, technical assistance on PPPs, a procurement and viability gap financing guide as well as many other resources to enhance the PPP platform within the country as a viable mechanism for infrastructure improvements, especially renewable energy and solar (Public Private Partnership Authority, 2019).

Currently, there are about 68 PPPs that have reached financial closing since 1990 in Bangladesh. Over 19.3 billion dollars have been invested for transport, energy, social and other

infrastructure through PPPs in Bangladesh (Asian Development Bank, 2017). In addition, there are about 25 projects (largely solar power plants) under several stages of procurement and negotiation with the buyers (Asian Development Bank, 2017).

PPP Pipeline of Energy Projects

No.	Project Name
1	Construction of LPG Import, Storage and Bottling Plant at Kumira
2	Solar Park at Gaibandha, 200 MW
3	Grid-Tied Solar Power Project at Sylhet, 10 MW
4	Solar Park at Moulvibazar, 10 MW
5	Solar Park at Panchagarh, 30 MW
6	Solar Park at Lalmonirhat, 5 MW
7	Solar Park at Sylhet, 10 MW
8	Solar Park at Narayanganj, 100 MW
9	Solar Park at Bagerhat, 100 MW
10	Solar Park at Manikganj, 35 MW
11	Solar Park at Panchagarh, 70 MW
12	Solar Park at Bhola, 50 MW
13	Solar Park at Tangail, 50 MW
14	Solar Park at Lalmonirhat, 100 MW
15	Solar Park at Panchagarh, 8 MW
16	Wind Power Project at Cox's Bazar, 60 MW
17	Solar–Wind Hybrid Power Plant in Feni, 18 MW
18	Solar Park at Cox's Bazar, 200 MW
19	Solar Park at Mymensingh, 50 MW
20	Solar Park at Sunamganj, 32 MW
21	Wind Power Project at Parky Beach area, Anawara in Chittagong, 50–200 MW
22	Grid Wind–Solar Hybrid System, 7.5 MW
23	Wind Power Plant across the coastal regions of Bangladesh, 15 MW
24	Solar Park at Rangpur, 30 MW
25	Solar Park at Cox's Bazar, 20 MW

(Asian Development Bank, 2017)

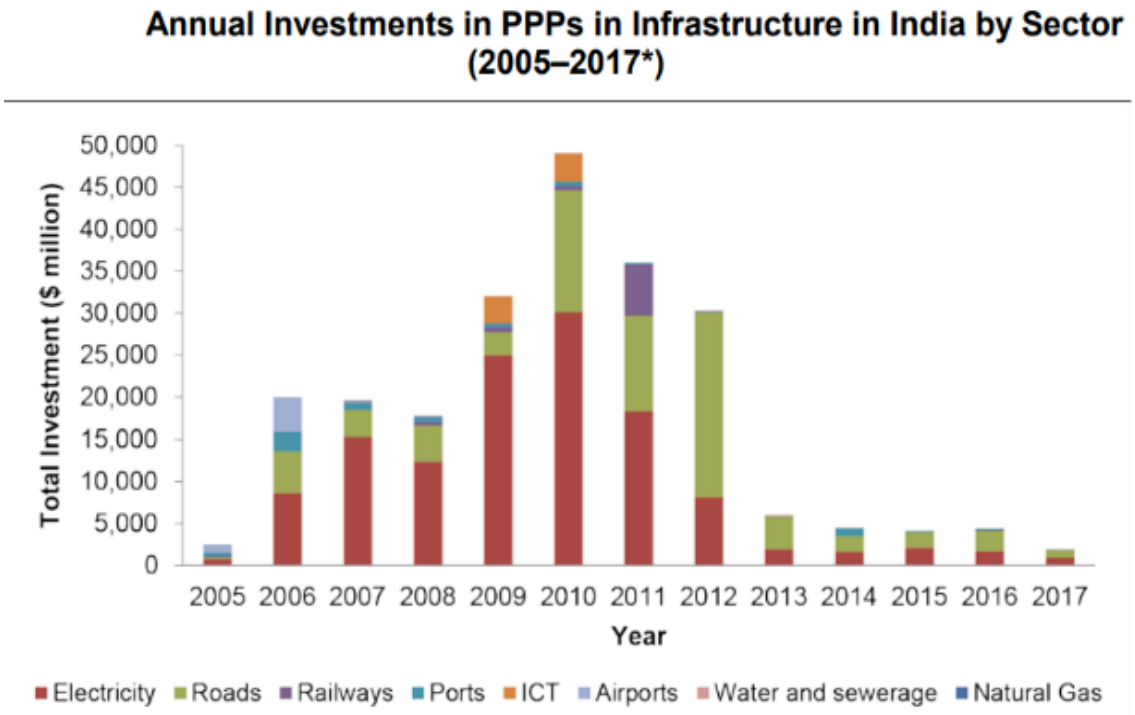
India

Wrestling the challenge of bankrolling renewable energy for sustainable development, specifically solar, India is connecting with private companies to auction out parcels of land and/or instigate participation schemes for renewable solar installations. The public-private partnership model allows for progressing India's energy infrastructure by encouraging investment from renewable energy companies that would otherwise have a hard time finding land, customers, and support, in turn, benefitting developing communities using the energy (David, 2018). These public-private partnerships are long-term arrangements with the Government and a

private company. The private company comes in and likely will provide financing, infrastructure construction, operations and maintenance of a project or multiple projects for different communities. Public-private partnerships are most appropriate for projects of the large and multifaceted nature that can "justify the associated transaction and monitoring costs and thus provide value for money considering the project's life-cycle cost to the Government (David, 2018)."

Public-Private Partnership collaborations are modernized and flexible frameworks the governments can use to empower private investment into major infrastructure, in this case for energy. Additionally, the concept of foreign direct investment, (foreign firms investing in India for energy or other), helps to take advantage of relatively lower salaries and unique investment privileges including tax exemptions in India. This investment strategy is a key basis of non-debt financial resources for India's economic development and can be utilized through public-private partnerships to encourage competition between domestic and foreign companies. Overall, strengthening India's community and its citizen's ability to access clean energy.

India has been utilizing public-private partnerships for many years now since 1990s, particularly on the transportation sector. From 2004 – 2012, the government laid more policy foundation for a mature framework through guidelines and standardization thus increasing awards throughout that time period, as seen in the image to the left. The country has established a committee called the Public Private Partnership Appraisal Committee, which standardized auction and bidding documents, dramatically streamlining the evaluation and approval of infrastructure projects (David, 2018).



(David, 2018)

In 2013, India hit major challenges in infrastructure investment, mainly due to the global economic slowdown as well as delays in land attainment and clearances, utility changes, right of way issues, inadequate due diligence by project developers etc. (David, 2018). India has been making wonderful use of the private sector capacity and interest in renewables as seen on the image to the right. Solar and wind infrastructure investments have seen much larger flow of private capital especially through public-private partnerships, however still need streamlined policies to increase the sustainability of this model (David, 2018). India's definition of PPP includes "An arrangement between a government or statutory entity or government owned entity on one side and a private sector entity on the other, for the provision of public assets and/ or related services for public benefit, through investments being made by and/ or management undertaken by the private sector entity for a specified time period, where there is a substantial risk sharing with the private sector and the private sector receives performance linked payments

that conform (or are benchmarked) to specified, pre-determined and measurable performance standards (Overview of PPP in Infrastructure, 2011).” Defining the partnership is the first step in initiating groundwork for sustainable and streamlined policy frameworks for the nation to follow.

Public-private partnerships including foreign direct investment address investment gaps for projects with enormous upfront capital costs, in addition to gaps rising from lending costs being high or limited source of public capital. India’s policy status is currently advantageous towards a robust business environment involving foreign capital and has taken initiatives in relaxing some foreign direct investment norms across the defense, oil, telecom, power, and stock sectors (About FDI in India, 2019). However, India also has initiatives to encourage more domestic business investments and needs to determine the ongoing balance of these two investment opportunities. Competitive Renewable Energy Auctions for Solar is a leading way the government is utilizing these public private partnerships. Under these tenders or auctions, a renewable energy purchaser, whether a government or utility, publicizes interest in buying a quantity of electricity from renewable energy source(s). Then, the renewable energy venders such as project developers compete in person or online to meet predefined technical and economic criteria. This encourages competition as they all submit price bids to the renewable energy purchaser, who then selects the lowest, most cost-effective bit. This is a great mechanism for supporting renewable energy in a cost-effective path to achieving India’s aggressive renewable energy targets (Designing renewable energy auctions for India: Managing risks to maximize deployment and cost-effectiveness, 2016).

Furthermore, the National Solar Mission is a key initiative of India’s Government in promoting environmentally maintainable growth as well as addressing the challenges of a

county's energy security and energy availability. Launching the National Action Plan on Climate Change in 2008, India has aimed to establish itself as a global leader in solar energy, by implementing a 3-phase approach to install and evaluate solar projects based on emerging cost and technology trends. The mission aims to also set up enabling policy environment for solar technology penetration at a centralized and decentralized level. This initiative is organized ideally as a private-public partnership model (Jawaharlal Nehru National Solar Mission Towards Building SOLAR INDIA, 2018).

Methodology

This paper denotes how Public-Private Partnerships (PPPs), are flexible frameworks the governments can use to empower private investment into major infrastructure, in this case for solar energy and compares examples from India and Bangladesh. With constrained funding resources, private sector funding can help fill the gap through public-private partnerships for solar capital cost, expertise and technology as well as maintenance while leveraging public sector resources such as tax incentives, land acquisition requirements and guaranteed customer base. Various resources were utilized within the research paper for a comprehensive overview of the current state and importance of public-private partnerships for solar energy in India and Bangladesh, with regards to the examples of different types of PPPs for solar and their significance, as well as for the future policy recommendations for the proficient use to PPPs for solar in South Asia. These two countries were the focus of this report as they are 2 rapidly growing countries aiming to sustainably continue their economic growth by providing basic energy to its communities. Determining the current state of both their solar energy and public private partnership landscape and then showcasing successful projects and policy recommendation for continued growth in this sector was provided. The report takes

geographically and categorically diverse examples of public private partnerships in India and Bangladesh to portray how PPPs are a sustainable methodology for solar energy reliability.

First, online research was completed from May 2019 to December 2019 on how India and Bangladesh are doing in the renewable energy space and what their current state of PPPs includes. Digital libraries, academic journals, online media, and articles from various sources were searched and organized into educational and public mediums. Second, the reference sections for select sources were searched for additional information on the examples of PPPs in India and Bangladesh as well as their current state, challenges, and policy recommendations. Third, the examples were categorized into central and decentralized solar PPPs within different regions in India and Bangladesh to represent that PPPs are able to be utilized in different structures in different areas. Fourth, the examples were described in methodology and challenges were recorded from each project. Fifth, policy recommendations were based on the examples of successful results as well as addressing opportunities in the mythology of PPPs in solar in India and Bangladesh. This paper aggregates examples of decentralized and centralized solar public-private partnerships in India and Bangladesh to provide support on how Public-Private Partnerships (PPPs), are flexible frameworks that can be used to empower private investment into solar infrastructure.

Solar PPP Examples in India and Bangladesh

Examples of PPPs in India and Bangladesh for solar that are provided in this paper include India's Rewa Solar Park project, Gandhinagar's Solar Photovoltaic Rooftop Program, and Odisha's Rooftop Solar Initiative as well as Bangladesh's Tefnaf solar project and the Dakha SOLshare project. These examples were chosen based on geographic variability within both India and Bangladesh, seen by the maps provided with each example. The examples were further

chosen to provide samples of successful distributed solar and centralized solar projects withing the nations as well.

1: India - Madhya Pradesh - Rewa Solar Park

Installing solar, whether it be on a decentralized home or on a centralized site, will have capital costs associated with infrastructure, technology, and labor. Solar projects involve identifying and acquiring land for the project, obtaining essential statutory clearances from local and state governments, arranging supplementary infrastructure facilities including roads and telecommunications, and constructing the transmission infrastructure that connects the produced solar to grid substations. All these steps take time and money, and with a partnership with public sector regulators, developers have more direct access and flexibility to streamline as much of the process as possible (Nigam, 2019).

Centralized solar projects have their advantages, of course depending on site insolation, logistics, solar technology pricing etc., including reducing project costs per megawatt and decreasing transmission losses. Thus, solar parks, have the ability to overcome bottlenecks some independent power producers of solar PV projects face otherwise such as land availability, evacuation infrastructure development as well as financial changes (Nigam, 2019). Solar parks have advantages in this case as they are a large connecting stretch of land with high insolation levels while giving the developer proper infrastructure and access to amenities with minimal project risk. Furthermore, they can also guarantee land availability and transmission infrastructure compared to decentralized solar, reducing the individual approvals required. Solar parks may also aid in minimizing the planning stage timeframe, thus establishing more incentive for economy of scale and cost reduction for solar energy, while achieving greenhouse gas reduction goals (Nigam, 2019).

Implementing projects such as the Rewa Solar Park project, commissioned in 2016, in Madhya Pradesh through a public private partnership, the Government of India and private solar developers mobilized private investment in the state and renewable power sector. This project was a 750MW solar capacity installment invested in by the International Finance Corporation to support a public-private partnership between Mahindra Renewables, Acme Solar, and Sprng Energy for investment in three 250MW solar ventures within the Rewa Solar Park. Since this project was also supported by the government, the project was able to leverage a World Bank loan for public evacuation infrastructure (India's Solar-Energy Policies and Projects Fast-Track Results, 2017).

(Madhya Pradesh Location Map, n.d.)

An online auction was set up to enable bids from any interested and capable solar developer, domestic or international allowing for unique flexibility for variable developers to participate as well as ensuring thorough competition. Over 20 bids came in from all over the world including Japan, France, Singapore. Mahindra Renewables, Acme Solar, and Sprng Energy won the bids signed project agreements in 2017 for 4.4 cents a kWh, realizing the lowest

tariff ever given for a solar project in India without viability gap funding (subsidies) bringing the price on par with coal, making the project cost effective and sustainable (India's Solar-Energy Policies and Projects Fast-Track Results, 2017).

The Rewa project was one of many firsts for India and the state itself, including the 1st project to receive funds from the Clean Technology Fund in India, 1st to have a 3-tier payment safety mechanism for the purchaser to reduce economic risk, and was the largest solar power tender(auction) led by a State (India's Solar-Energy Policies and Projects Fast-Track Results, 2017). The energy produced will be supporting the Madhya Pradesh Power Management Corporation for state utilities and about ¼ will be supporting the Delhi Metro Rail Corporation, which has permission to bypass the local power supplier and run its trains using open access regulation, thus using the power directly from the Rewa Ultra Mega Solar park. This project marks a great achievement for the country as well as the state because it may not have been achievable or as economically feasible without the public-private partnership model that was implemented. As for of this project impacts, it will generate $575 million in private investment and avoid 15.4 hundred thousand tons of CO_2 every year, bringing India closer to their renewable energy and sustainability targets of 2022 (India's Solar-Energy Policies and Projects Fast-Track Results, 2017).

2: Bangladesh – Teknaf – Solar Power Plant

Sun Edison Energy Holding (Singapore) Pte Ltd built a 28-megawatt solar power plant in Cox's Bazar District of Bangladesh. This massive solar installment in Teknaf sub-district, the southernmost point in mainland Bangladesh will provide cheaper electricity for the community then from conventional power stations. This PPP has allowed the community to have a fixed rate tariff of 2/3 the price of electricity generated by oil-fueled plants. The solar park is 116-acres and will support the energy needs of 80% of power demand in the Teknaf sub-district in Cox's

Bazar. The community itself has about 300,000 power users, with mainly residential and small commercial users and a few industrial or large commercial users, allowing the community to really ramp up their economic means with additional energy (Islam, 2015).

(Jahangir, 2013)

The solar park is built to produce up to 28MW of solar electricity at peak capacity as mentioned above, however is contracted to deliver 20MW to the government grid (Bangladesh PPP Framework, 2017). The partnership between the public government and the Sun Edison builders provides a limited risk investment for the private sector, similar to the other projects mentioned in this paper, as well as benefits the public community in Teknaf in providing stable energy for homes, businesses, and schools (Bangladesh PPP Framework, 2017).

Teknaf is one of the many large-scale solar projects in the pipeline for Bangladesh in terms of attaining their goal of having 10% or around 2,000 MW of their overall energy capacity, produced from renewable energy sources. The Teknaf solar power plant project emits 20,000 fewer tons of CO_2 each year when compared to similar sized diesel-run plants, further allowing the community and nation to reach its climate change and greenhouse gas emissions reduction goals. This solar project showcases, that yes solar plants need a substantial amount of initial financing to get set up, but with their limited operational costs benefit not only the community through technology training but also the investor through less maintenance costs compared to

coal or other fossil fuels. By leveraging public-private partnerships in Bangladesh for solar projects like this, hundreds of factories would be able to meet their own electricity needs and even contribute surplus power to the national grid if possible (Jahangir, 2013).

3: India - Gandhinagar - Photovoltaic Rooftop Program

In addition, the Gandhinagar (Solar) Photovoltaic Rooftop Program was also designed as a public-private partnership through a competitive bidding process. The project was set up to allow for 2 developers, 2.5 MW each, where the Gujarat government would offer access to about 25 state government building rooftops and encourage about 250 households to participate. This project encouraged only generation-based incentive (GBI) with no capital subsidy as well as launched a standard for large-scale rooftop PV programs in the state. A GBI of Rs. 12.41 per kWh is provided to state utilities to subsidize small solar power projects (100 kW to 2 MW each) by the Indian Renewable Energy Development Agency (IREDA) when they directly acquire solar power through the project developers (Generation Based Incentive Scheme, 2011).

This type of auction is based on a tariff-based competitive bidding procedure, requiring the buyers to quote a tariff for a 25-year contract from the commercial operation date. This reduces the risk for the buyer and customer through limiting upfront cost to the Government and Utility which creating a generation-based incentive for long-standing operation. Over 40 companies expressed interest in perusing this project, but SunEdison and Azure Power were the companies selected and awarded 2.5 MW each supplying solar power to Torrent Power, the mandatory Distribution Licensee for Gandhinagar (Omkar, 2016). The striking feed-in-tariff until grid equivalence is achieved, renewable purchase obligations increasing, and incentives offered to individual rooftop owners attracts third party ownership as well as encourages participation from homeowners (Omkar, 2016).

(Gujarat - India Map Slide, 2019)

This inimitable public-private partnership served as a catalyst for developers in the sector who found it challenging to acquire land for solar projects. The partnership also reduces risk by ensuring some amount of capacity addition inside Gandhinagar's limits, easing the burden of creating smaller transmission infrastructure needed to wheel electricity generated from farther locations to demand centers (Omkar, 2016)." The Gandhinagar (Solar) Photovoltaic Rooftop Program was the 1st roof top solar project in India modeled through a public-private partnership. The project will reduce around 6000 tons of CO_2 every year. The structured public-private partnership establishes technical, commercial and regulatory viability and sustainability of this model in the solar industry and has been applied and scaled up in 5 other cities Gujarat including Mehsana, Vadodara, Surat, Rajkot, Bhavnagar totaling a capacity of about 25MW (Omkar, 2016). Additionally, other cities outside Gujarat, such as Delhi, are also eyeing this model and planning to implement solar on their rooftops. The state of Gujrat itself, is helping cities as well such as Odisha with its own rooftop solar initiatives, which is where sharing the lessons learned from each project is important to continue success of these projects (The World Bank, 2014). Gujarat has its own sustainability goals and plans of exemplifying the state through solar power, feeding into the overall renewable energy goals of India (The World Bank, 2014).

4: India - Odisha - Rooftop Solar

Moreover, the Odisha Rooftop Solar public-private partnership is a pilot rooftop solar project on the west coast of the country (opposite of Gujarat) which also followed some of the lessons learned from the Gujrat solar project mentioned above. More than 40% of the energy reaching the state would be lost due to transmission and inadequate infrastructure. With a rising population and unstable energy, the state wanted to utilize solar energy to provide reliable and sustainable energy to their residents. In 2016, put out a similar competitive tendered (auction) for a 25-year project of 4MWs of rooftop solar in the state of Odisha. Azure Power Mercury Private Limited ended up winning the bid and is developing the country's 1st MW scale, grid connected rooftop solar project based on net metering basis that is modeled on a public-private partnership. The International Finance Corporation facilitated the state in developing the pilot rooftop solar project, permitting the least amount of state subsidies to be used (International Finance Corporation, 2018).

The state is using a net-metering model in a way that rooftop systems provide power largely to the building owner with any excess then feeding into the grid. The excess that goes into the grid is metered and then credited into the building owners account as well as is adjusted against usage from the grid over a distinct settlement timeframe. This is done mainly in yearly periods to account for seasonal disparities in solar irradiance and energy generation (Gupta, 2019). Best practices and lessons learned from the Gujarat model helped model this public-private partnership, strengthen the success of this is other potential rooftop solar projects in the state.

(About Odisha, 2019)

The Odisha Rooftop Solar public-private partnership was well modeled and created a well replicable and bankable business model by incentivizing buildings or private rooftop owners by allowing for making income from selling energy back to the grid. The project attracted over $7 million in private investment, stimulating the solar energy sector in the region as well as local home and rooftop owners. The 4MW project will result in savings of over 5,000 tons of greenhouse gas emission annually and improved energy reliability to over 8000 people in the state. The International Finance Corporation plans to scale up this type of public-private partnership across 10 other cities in Odisha, replicating this model to help reach the aggressive renewable energy targets of country (International Finance Corporation, 2018).

5: Bangladesh - Dhaka - SOLshare

In Addition, a peer-to-peer electricity trading network, based in Dhaka, Bangladesh has provided the rural city of Shariatpur as means of access to energy that would otherwise not be accessible. SOLshare, similar to a microgrid platform, is in a public-private partnership with the German consulting company MicroEnergy International GmbH, provides a platform for peer-to-peer solar electricity trading as well as a pay-as-you-go solution for low-income communities in parts of Bangladesh (IIX, 2019). With over 29 million households in Bangladesh and only 41% electrified, 17 million households are not offered the means of basic energy. These off-grid

households are mainly concentrated in rural Bangladesh where the electrification rate dips even lower to 28% (United Nations Climate Change, 2019). Bangladesh has initiated and participated in solar programs such as the Solar Home Systems Initiative with the Infrastructure Development Company and the Scaling-up Renewable Energy Project with the World Bank to expand the reach of electricity throughout the country.

Although these programs were and are paramount in initiating the expansion of solar in these communities, singular home solar is limited by the initial capacity and is not able to connect larger electricity consuming devices or communities together. Microgrids are also great in providing energy for houses and communities, but the capital expenditure causes financial strain on investors. These two options unfortunately had financial and access challenges, thus the Solshare program provided a combined solution as well as the ability for development and within the community (United Nations Climate Change, 2019).

Solshare works to allow households to participate in a solar network that can interconnect homes with and without solar to allow for a local electricity trading network. This allows for a higher usability rate for homes with solar while also providing additional community members with access to cleaner electricity at a lower cost without the costly installations. There is a meter that is placed in each home within the participating community, with and without solar infrastructure, which measures power inflows and outflows in the home allowing for grid accountability, household preferences of buying or sell-only mode and battery optimization. The "SOLshare meters form a SOLshare electricity trading network, enabling peer-to-peer electricity trading in the village (United Nations Climate Change, 2019)."

(Bangladesh Capital Map, n.d.)

SOLshare allows for community members that would otherwise not have access to or be wasting excess solar energy to obtain cleaner energy resources and earn an income to expand the communities and their individual well-being. The program also allows for innovative business possibilities such as reinvesting profits from the programs solar energy trading ability for upgrading the technology efficiency or buying more equipment to produce more electricity (United Nations Climate Change, 2019). Community members are able to have more energy and thus be able to power more equipment, lights etc. leading to an increase in any type of production of goods, services and community welfare. The SOLshare solar trading network is supported by data management and a grid control system, allowing the community users to trade electricity with an integrated mobile money platform for remote payments. This structure enables operational monitoring and lockout with an added benefit of providing high level data analytics and grid optimization functionality. The program's bottom-up approach enables the community to access clean energy technology at a reduced initial capital investment, allowing for a "micro-energy transition lead by the community itself (United Nations Climate Change, 2019)."

In addition to the access to cleaner energy and reducing community greenhouse gas emissions, it spurs community growth through permitting the use of high energy using appliances and products, strategic sustainable business models around the new technologies as well as enabling parts of the agricultural chain to become more local. For instance, clinics, schools, lighting networks can now be powered through the community SOLshare network enabling community members to maximize the saved money to bring in local jobs and improve the overall community economy. New opportunities in expanding to neighboring community is also a possibility to spur rural business, include additional households and continue the growth of green sustainable energy in rural communities. The SOLshare concept is stated to work in "any under-electrified area in the Global South with a minimum of 10 households or small and medium enterprises located close to each other," making the program relevant and scalable for millions of homes internationally. In Bangladesh itself, already 4+ million solar home systems are installed in the field, with SOLshare expecting to activate an additional10,000 nano-grids by the end of 2030, with the ability to support more than 1,000,000 clienteles in the country (United Nations Climate Change, 2019).

Challenges and Opportunities

Both India and Bangladesh are on their way to growing their engagement in PPPs to rapidly increase their solar energy infrastructure, allowing them to reach their renewable energy goals and targets. Cash-strapped public agencies all over the world including India and Bangladesh are showing growing interest in Public-Private Partnerships (PPP) as a technique for acquiring public infrastructure assets and/or services. However, there are still challenges and market barriers that need to be addressed in both nations to successfully create a streamlined process for PPPs to maximize benefit for both parties involved. Their project examples discussed

in this paper as well as others that have been completed provide a window into the needs to create a viable environment for PPPs within India and Bangladesh.

Centralized Framework

Multifaceted issues that still need to be addressed for PPPs within India and Bangladesh include improving standardized and efficient permitting and regulation, technician training, the documentation of best practices and customer awareness (Importance of Public-Private Partnerships in the Solar Industry, 2008). One major opportunity both nations have is to create a well-defined national policy framework for the PPP program. India and Bangladesh have made efforts to create policy and documents around PPPs, but they are not easily accessible to private investors, customers or even citizens due to awareness, online searchability, and document readability. The lack of PPPs framework documentation and lack of clarity within the ones that are publicly available unintendedly deter investors in partnering with the countries. Additionally, the language that is available can also be misinterpreted and abused for negative applications and end up being more expensive than was expected or don't provide the benefit that were supposed to deliver (The Maravi Post, 2017).

Furthermore, language regarding termination, renegotiation, and project purchase-back provisions in PPP project rules are very important and need not to be left for interpretation and negotiation after the contract has been awarded. Educated industry experts and academics strain that classifying and properly assigning risks to partners involved as well as ensuring that private partners genuinely realize the risks, they are taking on are crucial to success of the PPPs for both partners (The Maravi Post, 2017). India and Bangladesh both needs to create and enhance their PPP framework and guidelines, however, for India it may take the shape of multiple frameworks due to the size and diversity of geographic locations and their electric infrastructure within the states. Bangladesh also has much geographic diversity and may need chapter or sections calling

out different direction for them, but a centralized framework would benefit the country in streamlining the PPP process significantly.

Public Incentives

Furthermore, tax credits and governmental incentives such as tax credits need to be established until market penetration and technology financing is stable within the energy sector to not only make sure the proper infrastructure is laid out to continue the solar energy service is consistent for customers but also to ensure the private partner is inclined to partner with India and Bangladesh for solar infrastructure projects. In some cases, the lifespan may be too short to encourage noteworthy industry growth and provide cost reductions, in turn causing the loss of employment and investment opportunities. Longer-term market support is vital to decreasing the cost of solar energy infrastructure in both nations to ensure a stable market climate allowing solar companies to continue to invest confidently and drive down costs through economies of scale. Supporting development projects and solar manufacturing helps to build a strong marketplace base that in consequence will put solar power in a more cost-competitive platform with or over fossil fuels (Importance of Public-Private Partnerships in the Solar Industry, 2008).

Training and Workforce

India and Bangladesh have many talented and experienced workers, however, proper training and education on PPPs and their ins and outs for different types of projects especially solar in this case, is imperative to ensuring the policy and frameworks that were addressed above are enacted correctly. Having transparent and structured legal frameworks and national policies is not the end of the line, the implementors are necessary to make sure all laws and contract terms of the PPP are followed through (Bloomgarden & Blumenfeld, 2015). In some instances, such in Bangladesh, 15 MW of solar rooftop PV systems have been installed in the main cities because of the government requirement of having a percentage of the lighting loads to be met by

solar power. Nevertheless, a majority of the panels installed were hastily installed to comply with the requirement, therefor with inadequate quality control and monitoring to guarantee that quality panels were installed. As a result, many of those PV systems produced no to minimal energy (Asian Development Bank, 2017). Having training there specific to the type so solar that is available and implemented in the community, decentralized and centralized, will allow for the project to ultimately succeed as the maintenance of the solar technology to function optimally is key. Community training on decentralized solar is very important, mainly because there is more community maintenance and individual stake in this type of solar on home or building rooftops.

Community Contribution

Additionally, involving the community in projects such as rooftop solar or the SOLshare project, allow members of society to feel a sense of inclusion, ownership and pride. Programs that use the PPP model to not only provide solar access to rural areas but also arm the community members with knowledge of the technology and a structure of business so that the community members themselves can spur the economy or even just run their bread shaving business longer into the evening. From the research done in this paper, it was unclear how the more centralized projects interact with communities in specific, even though they do provide similar benefits, the tangible aspect for the community is not present. However, it depends on land availability, permitting, financial investments, as well as need of the location that determine if a centralized solar plant or a more decentralized approach is most relevant to all parties involved.

Knowledge/ Best Practice Sharing

This being said, another challenge was finding replicable solutions for Indian and Bangladeshi state or local governments to use as a framework for implementing their own PPPs. The examples discussed above were laid out in good detail but through many sources, while

other projects barely were tracked throughout the entire procurement, implementation and measurement and valuation periods. Creating frameworks that balance and hold both parties clearly liable for their part and transparently in sharing the best practices and technicians educated allows PPP to work holistically and provide successful project benefits for both public and private parties as well as the effected community members.

Policy recommendations

India and Bangladesh have been applying public-private partnerships since the 1990s and have been expanding on their programs recently to encourage the PPP methodology to be used in more sectors within their nations. Solar projects in both countries are prominent and, on the rise, as reducing greenhouse gas emissions as well as cleaner energy is in the forefronts of many member of their societies. PPPs are contractual arrangements governed by agreements and the law, therefore, needs to be supported by a fitting enabling environment: a comprehensive legal and institutional framework. Appropriate bookkeeping and reporting measures and established executive rules outlining its expansion and implementation, the steps essential to ensure proper distribution and management of the responsibilities and risks and clarifying the process for conducting such assessments is needed (Krishnan, 2016). A sustainable and effective PPP involves Bangladesh and India putting more efforts into creating a centralized policy framework with guidelines and standards that all the states and cities within the country can utilize. The governing bodies need to ensure that there is flexibility for the different types and geographic location PPPs but also make sure to include monitoring the proper construction, streamlined maintenance, project evaluation of the PPPs so the results can be aggregated at the higher level for nationwide metrics and accounting (Krishnan, 2016). India and Bangladesh now have some sort of Public Private Partnership Committee which can house and disseminate the baseline PPP

requirements and standards to maximize the effectiveness of this strategy, especially for solar investments within the country.

Providing guidelines for a cost-benefit analysis within the framework can reduce overall costs and ensure society's welfare benefits are achievable before starting the project. The bidding process in PPPs seems to be an effective avenue in getting international investment but establishing a comprehensive and transparent accounting and reporting standard for PPPs will permit a disclosure of all risks and liabilities, encouraging all projects to stay on track and budget as well as allow for more replicable solutions to be implemented. Additionally, tariff bids for solar in India have sometimes been too low, seeming competitive at the time, but then are not viable in the long run and are decommissioned (Ghosh & Prasad, 2017). Providing guidelines for a cost-benefit analysis within the framework helps to make sure there is sustainable pricing and quality of service are considered for the broader welfare benefits, including sustainable development within communities and social externalities (Bloomgarden & Blumenfeld, 2015).

A PPP policy alone is not enough. Governments require training and experience to successfully implement the policy. Applying a policy to bring projects to the transaction stage requires practice. As governments go through the process a few times, public institutions deepen their interactions with one another, which gradually eases the process (Bloomgarden & Blumenfeld, 2015).

A sustainable, successful program requires raising awareness and training throughout the entire PPP ecosystem. Often, the launch of a PPP program requires the presence of a champion—a government official or officials who believes in the potential benefits of PPPs for the country's infrastructure. However, the long-term sustainability of the program requires support and understanding throughout government and by other stakeholders, such as local

private businesses and civil society groups (Bloomgarden & Blumenfeld, 2015). Requiring these Public Private Partnership Committees to also provide resources and tools to ensure technical expertise can be developed when it comes to monitoring, measuring, and valuating PPPs in the industry as well as incorporating guidelines on training for community members involved in decentralized solar projects is essential to the success of the PPP. This aids in proper maintenance, utilization of the equipment as well as maximizes investment effectiveness. PPPs are made for risk sharing between both the public and private sector and having competent and educated implementor and community members involved only increase the chances of success for both parties (The Maravi Post, 2017).

For the communities that are connected to the grid, supply lags for peak demand over all for both nations and rural areas get effected the most by demand curtailment (load shedding) (Kumar & Sadeque, 2012). Using PPPs for solar parks or community and rooftop solar are mechanisms to ensure the reliability and access of electricity to homes and businesses to continue operations and decrease the effects of grid energy gaps.

Conclusion

Public-private partnerships are a symbiotic relationship between the public and private sector to take advantage of the joint innovation, resources, and knowledge both sectors have to offer to reach common goals for both. India and Bangladesh's energy needs have become stressed due to availability and reliability constraints, especially in rural regions of the country. Providing high-quality and cost-effective solar energy to its nations is important in aiding in mitigating energy and health issues, particularly in a developing nation struggling with increased energy demand as well as health concerns such as air pollution and water quality affecting community development. Federal and state governments within India and Bangladesh are

working with the private sector through Public-private partnerships to invest in renewable energy development, aiding to reduce greenhouse gas emissions as well as expand the renewable energy market.

The projects in India and Bangladesh discussed in this report portray how PPPs are a viable mechanism within in solar industry to successfully providing reliable solar energy to communities. PPPs have the ability to be flexible and viable in different methods of solar including centralized solar parks and decentralized rooftop solar as discussed in this report. Examples of PPPs in India and Bangladesh for solar that were provided in this paper include India's Rewa Solar Park project, Gandhinagar's Solar Photovoltaic Rooftop Program and Odisha's Rooftop Solar Initiative as well as Bangladesh's Tefnaf solar project and the Dakha SOLshare project. PPPs for solar in India and Bangladesh are modernized and flexible frameworks the governments can use to empower private investment into major infrastructure, in this case for energy, however need to improve on legal frameworks and language, PPP resource distribution and best practice sharing, as well as technician and implementor training helps to ensure the balance and success for both parties. Although, these projects have been established and replicated in some instances, there are additional opportunities for PPPs in the solar industry to improve within those areas.

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