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# Institutional Analysis of the Implementation of Utility-Scale Solar Projects in Ghana

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# Ghana

# Ghana Green Growth PASA

# Institutional Analysis of the Implementation of Utility-Scale Solar Projects in Ghana

June 2022

Environment, Natural Resources, and the Blue Economy Global Practice

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# Acronyms

| | |
|---|---|
| AT&C | Aggregate Technical and Commercial |
| ATC&C | Aggregate Technical, Commercial, and Collection |
| BGT | Bulk Generation Tariff |
| BPA | Bui Power Authority |
| BSP | Bulk Supply Point |
| CAGR | Compound Annual Growth Rate |
| CAPEX | Capital Expenditures |
| CBGT | Composite Bulk Generation Tariff |
| CR | Current Ratio |
| DFI | Development Finance Institution |
| DSC | Distribution Service Charge |
| DSCR | Debt Service Coverage Ratio |
| EC | Energy Commission |
| ECG | Electricity Company of Ghana |
| EOI | Expression of Interest |
| EPC | Engineering, Procurement, and Construction |
| ETU | Electricity Transmission Utility |
| GoG | Government of Ghana |
| GR | Gearing Ratio |
| GRIDCo | Ghana Grid Company |
| IPP | Independent Power Producer |
| IPSMP | Integrated Power System Master Plan |
| IRRP | Integrated Resource and Resilience Planning |
| KfW | *Kreditanstalt für Wiederaufbau* |
| LCOE | Levelized Cost of Energy |
| MoEn | Ministry of Energy |
| NDC | Nationally Determined Contribution |
| NEDCo | Northern Electricity Distribution Company |
| NITS | National Interconnected Transmission System |
| NorFund | Norwegian Investment Fund for Developing Countries |
| NREL | National Renewable Energy Laboratory |
| PGCPES | Policy Guidelines for Competitive Procurement of Energy Supply and Services Contracts |
| PPA | Power Purchase Agreement |
| PURC | Public Utilities' Regulatory Commission |
| PV | Photovoltaic |
| RE | Renewable Energy |
| REFiT | Renewable Energy Feed-In Tariff |
| REMP | Renewable Energy Master Plan |
| RFP | Request for Proposal |
| ROAE | Return on Average Equity |
| RONFA | Return on Net Fixed Assets |
| SNEP | Strategic National Energy Plan |
| SOE | State-Owned Entity |
| STATCOM | Static Synchronous Compensator |
| USAID | United States Agency for International Development |

| | |
|---|---|
| USSE | Utility-Scale Solar Energy |
| VRA | Volta River Authority |
| WEM | Wholesale Electricity Market |

# 1 Introduction

## 1.1 Background of the Assignment

The World Bank is exploring opportunities to accelerate climate action and low-carbon resilient development pathways by supporting Ghana in enhancing and implementing its nationally determined contribution (NDC).

One of the areas identified under the NDC is the support to increase utility-scale solar energy (USSE) generation in the country which is in line with the policy action to increase the share of renewable energy (RE) generation in Ghana's energy mix. In preparation for this, the World Bank has commissioned this consultancy assignment titled 'Institutional Analysis of the Implementation of Utility-Scale Solar Projects in Ghana.'

## 1.2 Objective of the Assignment

The overall goal of this consultancy services assignment, in the context above, was to

- Analyze the implementation structures of existing utility-scale solar projects and future solar projects in the country and
- Assess the most appropriate project finance and institutional arrangement to scale up solar projects in Ghana as a first step in the process.

## 1.3 Consultant's Scope of Work

The consultant's scope of work focused on the execution of the following:

- Review the project finance structures of existing solar projects executed by three utilities in Ghana, namely, Electricity Company of Ghana (ECG), Volta River Authority (VRA), and Bui Power Authority (BPA).
- Review the plans of these utilities to scale up in the next five years.
- Review the mandates of these three utilities to procure additional power capacity for the regulated and nonregulated markets and how these would comply with the 2019 Competitive Procurement Policy of the Ministry of Energy (MoEn).
- Perform an economic and options analysis describing the financial options and the project finance structure of new solar power projects under each utility.

## 1.4 Approach and Methodology

The consultant executed the assignment by completing four primary tasks:

- Task 1: Project finance structure review
- Task 2: Utility generation and procurement plan review
- Task 3: Organizational mandate and procurement policy review
- Task 4: Economic, financial, and impact analysis.

The assignment was executed in three phases of activity covering aspects that enabled the consultant to address each of the four tasks:

- Phase 1: Information gathering and review
- Phase 2: Analysis
- Phase 3: Reporting.

## Phase 1. Information Gathering and Review

During this phase of activity, the consultant contacted the relevant power sector institutions to gather key information which provided a basis for the analysis phase of activity (Activity 2). The information sought included the following:

- Information on cost of generation, project structure, financing, and cost modeling was gathered from BPA and the VRA.
- Key financial performance details typically contained in audited accounts were gathered from each of the target utilities for the assignment—ECG, BPA, and VRA.
- Demand-Supply Projection Documents for the Ghanaian Power System through 2030 were gathered from the regulators (Energy Commission [EC] and Public Utilities' Regulatory Commission [PURC]) and Ghana Grid Company (GRIDCo).
- Transmission-related assessment information was gathered from GRIDCo.
- Market lending rates were gathered from a selection of development finance and commercial project finance lenders.

## Activity 2. Analysis

First, the consultant utilized the documents and information gathered during Activity 1 to summarize the utilities and power sector plans to identify and price the solar power projects and electricity generated from solar power projects planned for execution or procurement by the utilities during the planning period. During this activity, the consultant provided contextual information regarding the mandates of the utilities and the compliance of their power project and electricity procurement plans with the MoEn's Competitive Procurement Policy. These covered the utilities' participation in both regulated and deregulated markets of Ghana's power sector.

Second, the consultant summarized the project finance structures and relevant financial performance indicators of existing solar projects executed by the utilities. The summaries of these structures were used to inform the analysis of the economic and financial options toward addressing the requirements for Task 4.

Third, the consultant dispatched the identified solar power projects alongside the power sector's demand-supply projections to determine the impact of the addition of these solar projects on the achievement of Ghana's RE targets. Additionally, the consultant completed the economic, financial, and impact analysis drawing on threshold analysis to assess the financial impact of the target utilities' solar project

implementation and electricity procurement plans on generation costs during the planning period based on assessed tariff or levelized cost of energy (LCOE) ranges.

Finally, the consultant analyzed the financial position of each utility to determine its capacity to leverage various funding options including equity, balance sheet, and other funding and project structuring options to establish projects.

### Activity 3. Reporting

The consultant prepared and submitted three documents during the execution of this assignment.

- An 'Inception Presentation' summarized the consultant's initial findings and work plan for completion of the subsequent activities.
- A 'Draft Report on Analysis and Recommendations' summarized the consultant's analyses, findings, conclusions, and recommendations from the execution of the assignment.
- The 'Final Report' was submitted following receipt, satisfactory address, and incorporation of the comments and suggestions from the client.

# 2 Ghana's Renewable Energy Targets and Requirements

## 2.1 Definition of Ghana's Renewable Energy Targets

In recent years, Ghana's RE targets/commitments have been mentioned in several policy statements and reports. But they interpret Ghana's RE targets/commitments differently.

Some of the major national policy documents or statements of Ghana's commitments on RE targets are as follows:

- The Integrated Power System Master Plan (IPSMP) Volumes 1 to 4, published between 2017 and 2019 by ICF and the EC under USAID's Integrated Resource and Resilience Planning (IRRP) Project, offered analyses of RE targets under a methodology which focused on the percentage penetration of RE as a proportion of Ghana's off-peak capacity demand (in MW).
- The EC's Strategic National Energy Plan (SNEP) 2030, which was published in July 2019, had a stated goal of "achieving 10% renewable energy in the total national energy supply mix by 2030."
- The Renewable Energy Master Plan (REMP) aims to scale up RE penetration in the electricity grid by 10 percent and increase total renewable energy to 1,363 MW by 2030.

For this assignment, the consultant and client have agreed to adopt the definition of Ghana's RE target/commitment as the goal of achieving 10 percent supply of annual electricity consumption (in GWh) with 2030 as the target year.

## 2.2 Ghana's Electricity Demand Forecast through 2030

The most recent electricity demand forecast for the Ghanaian power system, which the consultant could access, was contained in the 2021 Electricity Supply Plan. This electricity forecast is presented in Table 1. The 2021 Electricity Supply Plan's projection ran from 2022 through 2026 and tracked an approximately 5.8 percent compound annual growth rate (CAGR) which increased the peak capacity demand from 3,539 MW in 2022 to 4,460 MW in 2026. The corresponding projected electricity system energy demand was forecasted to grow from 22,799 GWh in 2022 to 28,550 GWh in 2026.

Table 1: Electricity Demand Forecast (2022–2026)

| Item | 2022 | 2023 | 2024 | 2025 | 2026 |
|---|---|---|---|---|---|
| Peak Capacity Demand (MW) | 3,539 | 3,739 | 3,964 | 4,171 | 4,460 |
| Energy Demand (GWh) | 22,799 | 24,177 | 25,572 | 27,069 | 28,550 |

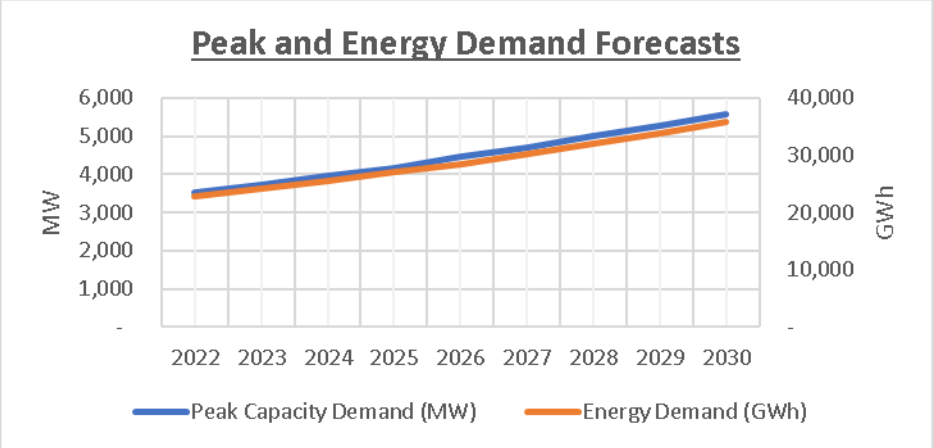
*Source*: 2021 Electricity Supply Plan.

The consultant utilized the 5.8 percent CAGR from the 2021 Electricity Supply Plan to extrapolate both the system peak capacity demand and energy demand through 2030. The resulting forecast (as shown in Table 2 and illustrated in Figure 1) shows that, by 2030, the system peak demand and energy demand are expected to grow to 5,588 MW and 35,772 GWh, respectively.

Table 2: Ghana Power System Electricity Demand Forecast (2022–2030)

| Item | 2022 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|
| Peak Capacity Demand (MW) | 3,539 | 4,719 | 4,992 | 5,282 | 5,588 |
| Energy Demand (GWh) | 22,799 | 30,206 | 31,958 | 33,811 | 35,772 |
| Compound Annual Growth Rate (CAGR) | 5.8% | | | | |

Figure 1: Ghana Power System Electricity Demand Forecast (2022–2030)




## 2.3 Renewable Energy Target and Generation Gap

### RE Generation Projection

The consultant has assessed the RE landscape and developed an RE generation projection. From the information gathered from power sector stakeholders, there are seven RE projects, of which six are already operational. VRA's Lawra project is under construction. The seven RE plants are projected to produce a total of 162 GWh annually, as shown in Table 3.

Table 3: RE Project Generation Forecast (2022–2030)

| RE Projects | Projected Annual Generation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
| VRA Solar 1 - Navrongo | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| VRA Solar 2 - Kaleo | 26.6 | 26.6 | 26.6 | 26.6 | 26.6 | 26.6 | 26.6 | 26.6 | 26.6 |
| VRA Solar 3 - Lawra | | | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| BXC | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 |
| Meinergy | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 |
| Safisana | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Bui Solar Farm 1 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| **Total RE Energy Generated (GWh)** | **152** | **152** | **162** | **162** | **162** | **162** | **162** | **162** | **162** |

Of the seven projects, four are owned/hosted by state-owned entities (SOEs) (that is, VRA and BPA) while three (that is, Safisana, BXC, and Meinergy) are privately owned. Safisana also happens to be the only non-solar project among the seven projects.

## Renewable Energy Target

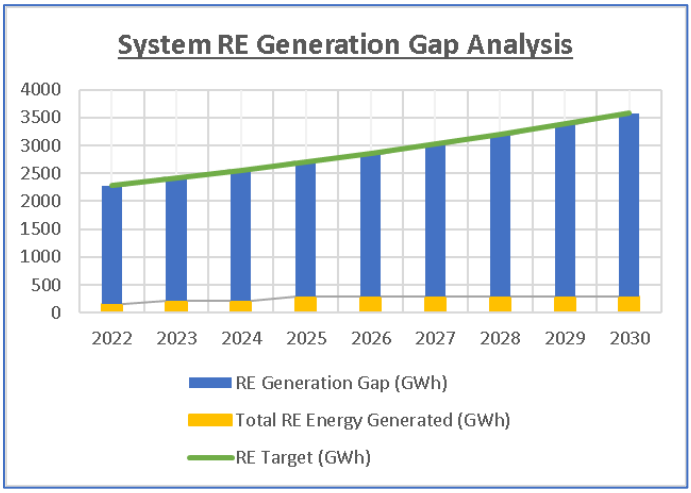
As identified in Section 0 above, the RE target adopted for this assignment is defined as 10 percent of the Ghanaian electricity system's annual energy demand or consumption (in GWh). Based on this definition, the computed RE target for 2030 is 3,577 GWh (see Table 4).

Table 4: Renewable Energy Target Analysis Results

| Item | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| Energy Demand (GWh) | 22,799 | 24,177 | 25,572 | 27,069 | 28,550 | 30,206 | 31,958 | 33,811 | 35,772 |
| RE Target/Commitment | 10% | | | | | | | | |
| RE Target (GWh) | 2,280 | 2,418 | 2,557 | 2,707 | 2,855 | 3,021 | 3,196 | 3,381 | 3,577 |
| RE Penetration (GWh) | 152 | 152 | 162 | 162 | 162 | 162 | 162 | 162 | 162 |
| RE Penetration (%) | 0.7% | 0.6% | 0.6% | 0.6% | 0.6% | 0.5% | 0.5% | 0.5% | 0.5% |
| RE Generation Gap (GWh) | 2,128 | 2,265 | 2,395 | 2,544 | 2,693 | 2,858 | 3,033 | 3,219 | 3,415 |

The seven forecasted RE projects generate approximately 162 GWh of electricity, leaving an RE generation gap of 3,415 GWh, which means the RE penetration is only 0.5 percent against the target of 10 percent of total supply. This implies that the seven plants together can only achieve the equivalent of 4.5 percent of the RE target, leaving a substantial RE generation gap (as illustrated in Figure 2).

Figure 2: System RE Generation Gap Analysis (2022–2030)




## 2.4 Solar Project Requirement to address the Renewable Energy Generation Gap

Based on the expected performance of the solar projects, the consultant has determined the solar project capacity required to generate sufficient electricity to address the RE generation gap. The results of this analysis (presented in Table 5) show that the Ghanaian system requires over 2,500 MW of new solar projects to be implemented by 2030 to reach the RE target/commitment.

Table 5: Solar Project Capacity Requirement to Address RE Generation Gap

| Item | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| RE Generation Gap (GWh) | 2,128 | 2,265 | 2,395 | 2,544 | 2,693 | 2,858 | 3,033 | 3,219 | 3,415 |
| Solar Project Capacity to Fill RE Generation Gap (MW) | 1,564 | 1,666 | 1,761 | 1,871 | 1,980 | 2,102 | 2,230 | 2,367 | 2,511 |

## 2.5 Transmission Considerations for Solar PV Project Implementation

Ideally, the implementation of solar photovoltaic (PV) plants should not contribute negatively to the operation of the National Interconnected Transmission System (NITS). As stipulated under Ghana's Grid Code, GRIDCo is to operate the NITS within specified operating criteria for various NITS components and indicators including the following:

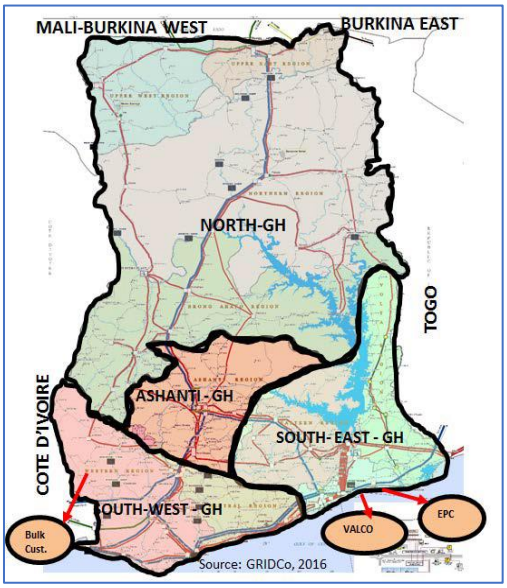
- **Transmission lines.** GRIDCo requires lines to operate within their normal thermal ratings and up to 110 percent under normal and short duration contingencies, respectively.
- **Transformers.** GRIDCo requires transformers to operate up to 100 percent and 120 percent of their ratings under normal and contingency conditions, respectively.
- **Substations**. GRIDCo requires substations to operate within 5 percent and 10 percent bands of the nominal system voltages and power factors under normal and contingency conditions, respectively.

The consultant held discussions with GRIDCo staff regarding the constraints relating to the NITS for large-scale solar project implementation. Many of the opinions expressed by GRIDCo with respect to the viability of large-scale solar PV injection into the NITS were corroborated by the IPSMP's Solar Photovoltaic Penetration Study. Ideally, the implementation of solar PV plants should not contribute negatively to the operation of the NITS but rather support the NITS to remain within acceptable operating limits.

### Zonal NITS Capacity Considerations

The load patterns and geographic coverage of Ghana's NITS are key determinants of the conditions under which solar PV can be implemented to feed into the NITS. The Ghanaian NITS, which consists primarily of 161 and 330 kV transmission systems, has four primary operating zones, as shown in Figure 3.

Figure 3: Ghana NITS Zonal Configuration




*Source*: IPSMP,2019

A Solar PV Penetration Study carried out as part of the IPSMP had investigated the steady-state and transient stability performance of the NITS under various scenarios which included the implementation of solar PV projects at capacity levels of 310, 490, and 790 MW in the various NITS zones, as shown in Table 7.

The study results were that the NITS can handle a combined peak injection of approximately 3,400 MW of solar PV. The views of GRIDCo on the maximum possible solar PV capacity which can be injected across nodes in each of the four zones were corroborated by the IPSMP (see Table 6).

### Operating Requirements and Limits

In helping to complete the IPSMP, GRIDCo worked with ICF to provide high-level assessments of the impact of various levels of solar PV penetration on the NITS. These assessments prioritized consideration of the NITS' system stability and operating requirements under areas including steady-state and transient system conditions or contingencies.

The study results illustrated in Table 6 and Table 7 indicated that the implementation of up to 790 MW of solar PV generation in the North Zone caused no major issues with steady-state voltage violations, line or transformer overloads. However, the assessment showed that the implementation of more than 310 MW of solar PV generation begins to affect the NITS' transient stability under loss of major generator, three-phase fault, and loss of major transmission line contingency scenarios. The effect of solar PV generation on the NITS under transient stability scenarios shows that additional investments will be required to reinforce or enhance the NITS to facilitate the injection of more than 310 MW without negative impacts on grid performance.

Table 6: NITS Solar PV Generation Injection by Zone

| Configuration | NITS Model Zone | Maximum Capacity (MW) |
|---|---|---|
| **Solar PV** | North | 1,440 |
| | Ashanti | 218 |
| | SouthEast | 960 |
| | SouthWest | 845 |
| **Total Max PV Capacity without Storage** | | **3,463** |

Table 7: NITS System Condition/Contingency Analysis

| System Condition/ Contingency | | Solar PV Capacity (MW) | | |
|---|---|---|---|---|
| | | 310 | 490 | 790 |
| **Steady State** | Voltage Violations | | | |
| | Line or Transformer Overloads | | | |
| **Transient Stability** | Loss of Major Generator | | | |
| | Three-Phase Fault | | | |
| | Loss of Major Transmission Line | | | |

*Source*: IPSMP.

## 2.6 Implementation Scenarios for Solar PV Projects

An additional 2,511 MW of solar PV projects, as shown in Table 5, must be completed for the Ghanaian power system to reach its RE target in 2030 using solar PV. The maximum solar PV capacity that can be accepted by the NITS is approximately 3,400 MW, which, as shown in Table 6, exceeds the 2030 projected solar PV project requirement of 2,511 MW. Therefore, under steady-state conditions, assuming solar PV was used to fill the entire RE generation gap, the NITS should be able to absorb the electricity generated from these projects. It should also be noted that the Ghanaian power system gets the greatest benefits in terms of transmission losses and voltage support from solar PV plants sited in the North Zone of the transmission network.

The distribution of solar PV generation under six scenarios, where solar PV is utilized to address the RE generation gap, is as presented in Table 8. The three scenarios representing 100 percent, 75 percent, and 50 percent solar penetration within the RE generation gap were chosen by the consultant for further consideration. The three scenarios equivalent to 31 percent, 20 percent, and 12 percent solar penetration within the RE generation gap were intended to provide comparable assessment points covering the three primary solar penetration assessments previously analyzed in the IPSMP.

As concluded by the IPSMP study, the North Zone of the NITS is capable of absorbing approximately 1,440 MW, which is equivalent to 59 percent of the solar PV capacity of 2,511 MW required to meet the RE generation gap. Of the scenarios considered in Table 11, the Ashanti and SouthEast Zones of the NITS are required to have solar PV injection only when RE penetration is to be higher than 75 percent and 100 percent of the target, respectively.

Table 8: Solar PV Penetration Scenarios by NITS Zone

| | Solar Penetration Scenarios | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Solar Penetration Levels for RE Generation Gap** | **100%** | **75%** | **50%** | **31%** | **20%** | **12%** |
| **Project Configuration** | **Solar PV Generation (GWh)** | **3,415** | **2,561** | **1,707** | **1,074** | **666** | **422** |
| | **Solar PV Capacity (MW)** | **2,511** | **1,883** | **1,255** | **790** | **490** | **310** |
| **Solar PV** | North | 1,440 | 1,440 | 1,255 | 790 | 490 | 310 |
| | Ashanti | 218 | 218 | - | - | - | - |
| | SouthEast | 853 | 226 | - | - | - | - |
| | SouthWest | - | - | - | - | - | - |
| | **Total Implemented** | **2,511** | **1,883** | **1,255** | **790** | **490** | **310** |
| | **PV Capacity Outstanding** | **-** | **-** | **-** | **-** | **-** | **-** |

## 2.7 Plans of Utilities to Scale-Up RE in the Next Five Years

In the next five years, the utilities (BPA and VRA) will be working toward the following notable solar PV project plans:

- BPA has signed contracts and is actively seeking funding to implement two solar PV projects totaling 150 MW.

- VRA is developing a 60 MW solar PV plant to be located at Bongo, near Bolgatanga.

Both the BPA and VRA are working to secure offtakers and obtain financing for the projects.

ECG has no immediate plans for any additional power procurement, including RE, and is focused on addressing issues related to the prevailing overcapacity. ECG is mandated as a distribution utility only and therefore has no mandate for power generation. This means ECG is not mandated to implement RE and/or solar PV generation projects.

The prevailing generation overcapacity in the Ghanaian power sector has made the preparation of new solar PV projects and related power procurement, especially for the regulated market, a fairly challenging activity for the utilities to justify, especially without apparent visibility of the end of the overcapacity situation.

# 3 Investment Requirements to address RE Gap

## 3.1 Solar PV Project Estimates and Investment Requirements

Based on the sizes of recently implemented and planned projects encountered during the assignment, the consultant identified that future solar PV projects are likely to be implemented as modules of 20, 50, or 100 MW. To obtain prices for solar PV plants at 20, 50, and 100 MW, the consultant contacted solar PV developers and engineering, procurement, and construction (EPC) service providers for pricing data. A summary of the typical prices obtained by the consultant for various components of a fully functional solar PV project is presented in Table 9.

Table 9: Solar Project Pricing Summary

| Cost Category | Item | 20 MW | 50 MW | 100 MW |
|---|---|---|---|---|
| **Engineering, Procurement, & Construction (A)** | Solar PV Module | $ 5,800,000 | $ 14,500,000 | $ 29,000,000 |
| | Inverter | $ 800,000 | $ 2,000,000 | $ 4,000,000 |
| | Mounting Structure | $ 1,800,000 | $ 4,500,000 | $ 9,000,000 |
| | Electrical Balance of Plant | $ 1,600,000 | $ 4,000,000 | $ 8,000,000 |
| | Installation & Labour | $ 2,000,000 | $ 5,000,000 | $ 10,000,000 |
| | Power Evacuation Transformer | $ 2,319,885 | $ 2,319,885 | $ 4,319,885 |
| | **Total Cost** | **$ 14,319,885** | **$ 32,319,885** | **$ 64,319,885** |
| **Project Preparation (B)** | Feasibility Study | $ 170,000 | $ 170,000 | $ 170,000 |
| | Environmental & Social Impact Assessment (ESIA) | $ 100,000 | $ 100,000 | $ 100,000 |
| | Grid Impact/ Interconnection Study | $ 100,000 | $ 100,000 | $ 100,000 |
| | Land Acquisition ($15,000/Acre) | $ 2,779,935 | $ 5,559,870 | $ 11,119,740 |
| | **Total Cost** | **$ 3,149,935** | **$ 5,929,870** | **$ 11,489,740** |
| **Statutory Approvals (Permitting & Licensing) (C )** | Energy Commission Licenses | $ 30,000 | $ 30,000 | $ 30,000 |
| | Environmental Permit | $ 5,000 | $ 5,000 | $ 5,000 |
| | Local Development Authority Permit | $ 5,000 | $ 5,000 | $ 5,000 |
| | **Total Cost** | **$ 40,000** | **$ 40,000** | **$ 40,000** |
| **Solar Plant Costs** | Basic Solar Plant Costs (A) | $ 14,319,885 | $ 32,319,885 | $ 64,319,885 |
| | Comparable Solar Plant Costs (A + B + C) | $ 17,509,820 | $ 38,289,755 | $ 75,849,625 |
| **Calculated Benchmarks** | Basic Solar Plant Costs ($/kW) | $ 716 | $ 646 | $ 643 |
| | Comparable Solar Plant Costs ($/kW) | $ 875 | $ 766 | $ 758 |

The solar project pricing obtained has been categorized between basic and comparable solar plant configurations for each of the project implementation modules (20, 50, and 100 MW). The basic solar plant includes only EPC costs. The comparable solar plant includes all project cost components comprising EPC, project preparation, and statutory approval costs. The comparable solar plant costs are intended to provide a cost summary similar to the real total cost of implementing solar projects.

The data gathered and presented in Table 9 yield calculated cost benchmarks of US$716, US$646, and US$643/kW for the 20, 50, and 100 MW basic solar plants, respectively. The same data also yield calculated cost benchmarks of US$875, US$766, and US$758/kW for the 20, 50, and 100 MW comparable solar plants, respectively.

The number of projects required for each module, if the RE generation gap was to be filled entirely using the aforementioned modules for solar PV plants (that is, 20, 50, and 100 MW), is as presented in Table 10.

Table 10: Solar Project Modules Required to Fill RE Generation Gap

| | RE Generation Fulfillment Gap Scenarios | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Solar Penetration Levels for RE Generation Gap | 100% | 75% | 50% | 25% | 31% | 20% | 12% |
| | Solar PV Generation (GWh) | 3,415 | 2,561 | 1,707 | 854 | 1,074 | 666 | 422 |
| | Solar PV Capacity (MW) | 2,511 | 1,883 | 1,255 | 628 | 790 | 490 | 310 |
| **Solar Project Modules** | 20 | 126 | 95 | 63 | 32 | 40 | 25 | 16 |
| | 50 | 51 | 38 | 26 | 13 | 16 | 10 | 7 |
| | 100 | 26 | 19 | 13 | 7 | 8 | 5 | 4 |

Table 11: Investment Requirement for Solar PV Plants to Fill RE Generation Gap

| | RE Generation Fulfillment Gap Scenarios | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Solar Penetration Levels for RE Generation Gap | 100% | 75% | 50% | 25% | 31% | 20% | 12% |
| | Solar PV Generation (GWh) | 3,415 | 2,561 | 1,707 | 854 | 1,074 | 666 | 422 |
| | Solar PV Capacity (MW) | 2,511 | 1,883 | 1,255 | 628 | 790 | 490 | 310 |
| **Implementation Configuration & Cost ($' millions)** | 20 Basic | $ 1,843 | $ 1,382 | $ 921 | $ 461 | $ 580 | $ 360 | $ 228 |
| | 20 Comparable | $ 2,243 | $ 1,682 | $ 1,122 | $ 561 | $ 706 | $ 438 | $ 277 |
| | 50 Basic | $ 1,623 | $ 1,217 | $ 812 | $ 406 | $ 511 | $ 317 | $ 200 |
| | 50 Comparable | $ 1,923 | $ 1,442 | $ 961 | $ 481 | $ 605 | $ 375 | $ 237 |
| | 100 Basic | $ 1,615 | $ 1,211 | $ 807 | $ 404 | $ 508 | $ 315 | $ 199 |
| | 100 Comparable | $ 1,904 | $ 1,428 | $ 952 | $ 476 | $ 599 | $ 372 | $ 235 |

The corresponding estimates of the capital investments required for establishing solar PV plants that enable the attainment of various penetration levels of the RE generation gap based on basic and comparable project pricing at various modular project sizes (20, 50, and 100 MW) have been determined and presented in Table 11. Of the project configurations presented toward filling the RE generation gap of 2,511 MW in full, the 20 MW comparable module presents the highest investment cost of US$2,243 million while the 100 MW basic module presents the lowest investment cost of US$1,615 million.

## 3.2 Transmission Requirements to Support New Solar PV Generation

### Planned NITS Investments and Reinforcement Activities

GRIDCo recognizes the need to reinforce the NITS to support electricity supply quality across Ghana. This year, GRIDCo expects to commence several critical projects intended to improve the NITS' performance

in critical ways including transfer capacity, system efficiency or losses, reliability, and quality of supply (primarily focused on voltage stability). The projects include

- Reconstruction and upgrade of the 161 kV Aboadze-Takoradi-Tarkwa-Prestea and 161 kV Bogoso-Dunkwa-New Obuasi transmission lines;
- Construction of a 330/161 kV substation at Dunkwa-on-Offin;
- Construction of a third bulk supply point (BSP) in Kumasi;
- Reconstruction and upgrade of the 161 kV A3BSP-Achimota transmission line; and
- Installation of a 60 MVAr static synchronous compensator (STATCOM) in Kumasi.

GRIDCo is considering the implementation of a second double-circuit 330 kV line from Dunkwa-on-Ofin through Bui, Kintampo, and Tamale and on to Bolgatanga.

GRIDCo's listed priority projects for 2022 should increase the NITS' transfer capacity and grid performance primarily between and within the SouthWest, SouthEast, and Ashanti Zones. Considering that the NITS improvements are to be gained from GRIDCo's listed priority projects, the largest proportion of solar PV projects to be implemented to address the RE generation gap should be in the North Zone. The additional NITS improvement projects will have the primary purpose of improving grid resilience and transfer capacity within and between the North Zone and Ghana's primary load centers in the Ashanti, SouthEast, and SouthWest Zones.

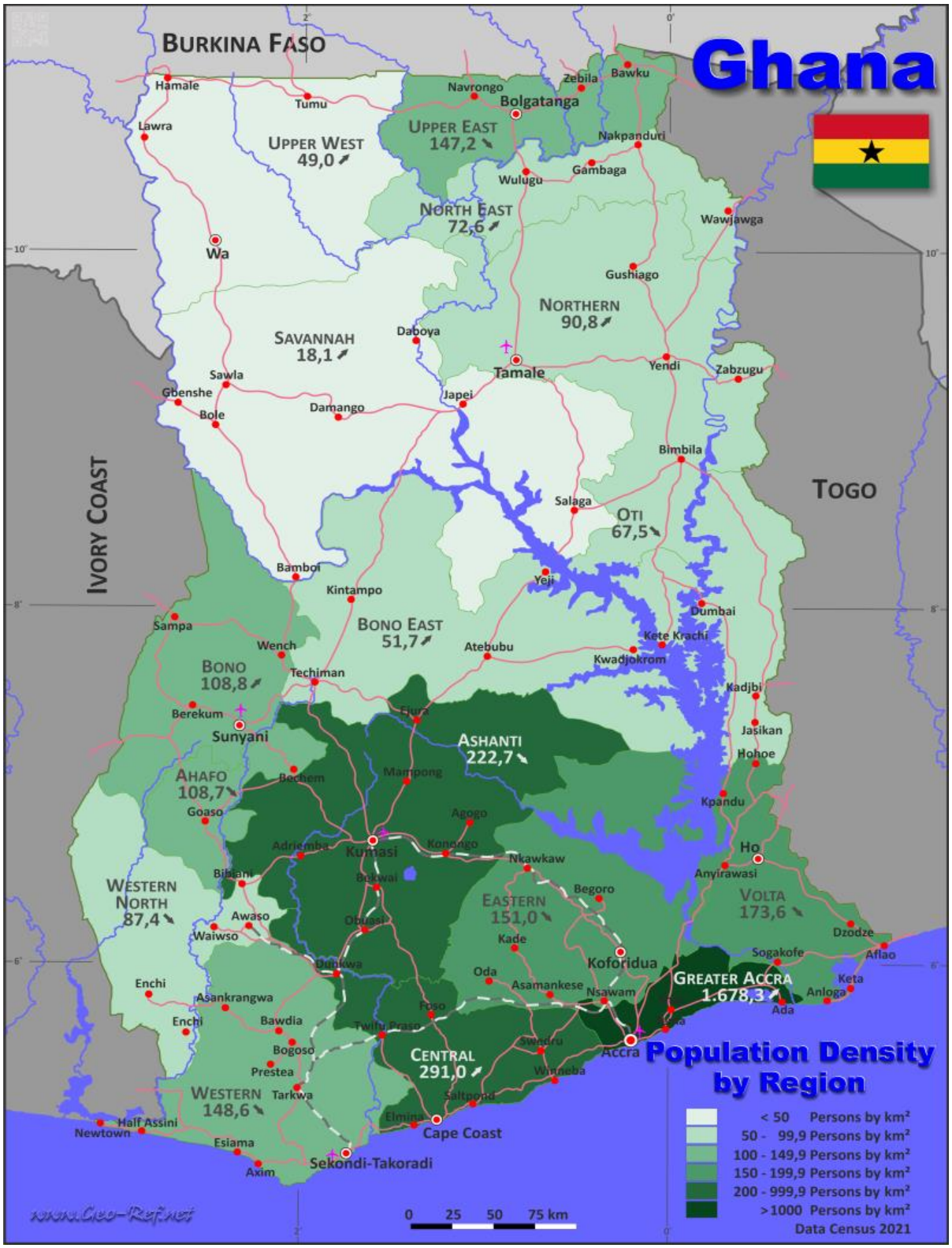
### Distribution and Placement of Solar Projects

To facilitate the assessment of the NITS' project and investment requirements to support solar PV projects, the consultant adopted a methodology which involved the consideration of solar PV projects in groupings totaling 400 to 650 MW each for injection in various geographic areas and their associated transmission lines across the NITS. In selecting the placement of these grouped projects, the consultant considered several factors including

- Ghana's population and its distribution, as shown on Ghana's population density maps in Figure 4, and
- GRIDCo's NITS operational priorities around loss reduction and system performance enhancements.

First, the population distribution is an important consideration; given that the solar PV projects will take up significant land areas, it is preferred for the targeted project areas to be sparsely populated to facilitate the acquisition and use of large tracts of, at least, reasonably contiguous land. Second, the implementation of these solar PV projects should be in areas of the grid where the projects can contribute to reduced NITS losses because of long power transport distances from generation plants to load centers. The long power transport distances also contribute to 'quality of supply' issues, especially in the northernmost parts of the NITS. At present, the least generation dense portion of the NITS is in the areas selected.

Figure 4: Ghana Population Density Map by Region




*Source*: Geo-Ref.net.

Table 12: Population and Land Area of Ghana's Administrative Regions

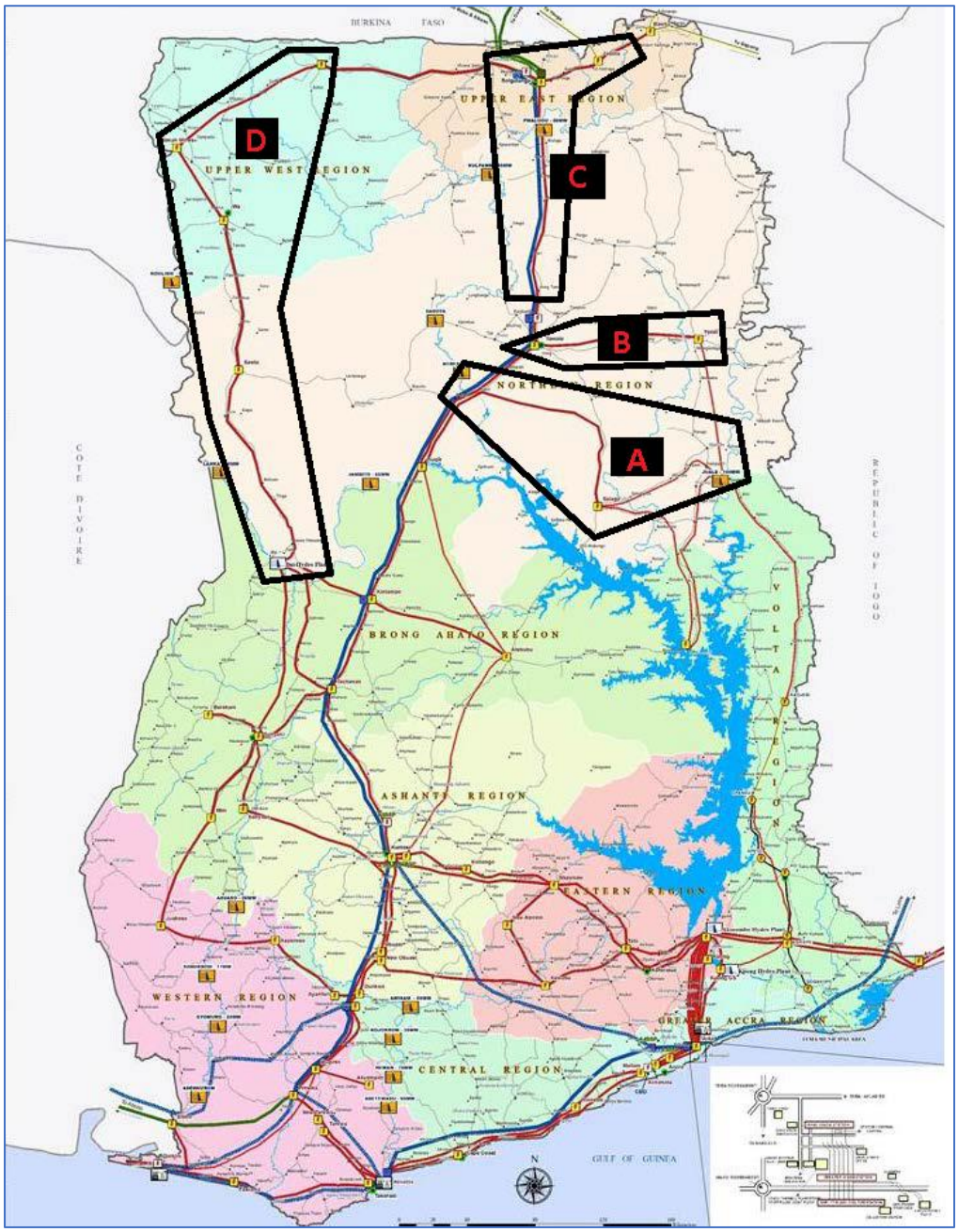
| Region | ISO | Capital | Area (km²) | Population | Density (pers/km²) |
|---|---|---|---|---|---|
| Greater Accra | GH-AA | Accra | 3,245 | 5,446,237 | 1,678.3 |
| Central | GH-CP | Cape Coast | 9,826 | 2,859,821 | 291.0 |
| Ashanti | GH-AH | Kumasi | 24,389 | 5,432,485 | 222.7 |
| Volta | GH-TV | Ho | 9,504 | 1,649,523 | 173.6 |
| Eastern | GH-EP | Koforidua | 19,323 | 2,917,039 | 151.0 |
| Western | GH-WP | Sekondi-Takoradi | 13,847 | 2,057,225 | 148.6 |
| Upper East | GH-UE | Bolgatanga | 8,842 | 1,301,221 | 147.2 |
| Bono | GH-BO | Sunyani | 11,107 | 1,208,965 | 108.8 |
| Ahafo | GH-AF | Goaso | 5,193 | 564,536 | 108.7 |
| Northern | GH-NP | Tamale | 25,448 | 2,310,943 | 90.8 |
| Western North | GH-WN | Wiawso | 10,074 | 880,855 | 87.4 |
| North East | GH-NE | Nalerigu | 9,074 | 658,903 | 72.6 |
| Oti | GH-OT | Dambai | 11,066 | 747,227 | 67.5 |
| Bono East | GH-BE | Techiman | 23,257 | 1,203,306 | 51.7 |
| Upper West | GH-UW | Wa | 18,476 | 904,695 | 49.0 |
| Savannah | GH-SV | Damongo | 35,862 | 649,627 | 18.1 |
| **Total** | | | **238,533** | **30,792,608** | **129.1** |

Based on the factors of NITS operational priorities and population distribution, the consultant concluded that a grouping of solar projects in the northern third of Ghana would have the best chance of being feasibly implemented to meet Ghana's RE target while contributing to enhanced NITS performance. The proposed distribution of the solar PV projects is illustrated in Figure 5.

The four 400–650 MW groupings of solar PV projects have been distributed and placed as follows:

- Group A - 650 MW grouping along the Yapei-Salaga-Kpandai stretch of the NITS
- Group B - 650 MW grouping along the Yendi-Tamale stretch of the NITS
- Group C - 650 MW grouping along the Tamale-Bolgatanga stretch of the NITS
- Group D - 650 MW grouping along the Bui-Sawla-Wa stretch of the NITS.

Figure 5: Solar PV Project Distribution and Placement Map




## Transmission Grid Projects to support Solar PV Projects

To appropriately support the implementation of new solar PV projects without diminishing the NITS' performance and assuming the distribution and placement of solar PV projects are as shown in Figure 5, from discussions with GRIDCo staff, the following grid enhancement projects and related investments (as shown in Table 13) will be required for the reasons indicated.

- An additional 330 kV double-circuit line from Dunkwa-on-Ofin through Bui-Tamale-Bolgatanga which will support power evacuation from Groups C and D. This line will be required to help

improve overall grid stability, reliability in contingency scenarios, and transfer the power generated in the North Zone, especially during the day, to large load centers such as Kumasi and Dunkwa-Obuasi areas.

- An upgrade of the 161 kV Kadjebi-Nkwanta-Salaga line to support power evacuation from Group A. The current line is operated at 69 kV and requires some enhancements to function fully at its rated voltage and provide sufficient power transfer capacity.
- An upgrade of the 161 kV Yendi-Tamale line to a double-circuit line to support power evacuation from Group B. The current line is a single circuit line and requires upgrading to provide sufficient power transfer capacity for Group B. Additionally, this upgrade would help reinforce overall power transfer from both Group A and Group B by forming a ring circuit through Tamale-Yapei.
- At least one 60 MVAr STATCOM per 650 MW project grouping to help improve grid voltage stability and power factor performance in each region where the project groupings are deployed.

Table 13: Financial Estimates of Transmission Reinforcement Projects

| No. | Description | Quantity (km or units) | Unit Price ($/km or $/unit) | Sub-Total |
|---|---|---|---|---|
| 1 | Additional 330kV Double Circuit Line from Dunkwa-on-Ofin-Bui-Tamale-Bolgatanga | 600 | $ 400,000 | $ 240,000,000 |
| 2 | Upgrade 161kV Kadjebi-Nkwanta-Salaga | 500 | $ 360,000 | $ 180,000,000 |
| 3 | Upgrade161kV Yendi-Tamale to Double Circuit | 100 | $ 360,000 | $ 36,000,000 |
| 4 | One (1) 60 MVAr STATCOM per 650 MW Project Grouping | 4 | $ 4,200,000 | $ 16,800,000 |
| **Total** | | | | **$ 472,800,000** |

## 3.3 Total Investment Requirements to Achieve RE Target

The combination of solar PV project and transmission investments yields the total budgetary requirements for Ghana to reach its RE target in 2030. Table 14 shows that it will take US$2,088–2,716 million to complete the solar PV and transmission projects required to achieve the RE target while, at least, maintaining the NITS' performance levels.

Table 14: Total Investment Requirements to Reach RE Generation Target in 2030

| Solar PV Project Configuration | Investment Requirements (in $' millions) | | |
|---|---|---|---|
| | Project | Transmission | Total |
| 20 Basic | $ 1,843 | $ 473 | **$ 2,316** |
| 20 Comp | $ 2,243 | | **$ 2,716** |
| 50 Basic | $ 1,623 | | **$ 2,096** |
| 50 Comp | $ 1,923 | | **$ 2,396** |
| 100 Basic | $ 1,615 | | **$ 2,088** |
| 100 Comp | $ 1,904 | | **$ 2,377** |

# 4 Legal and Regulatory Assessment

## 4.1 Utility Mandates for Regulated and Deregulated Markets

This section discusses the policies and institutional and regulatory framework for utility-scale solar PV plants as well as the evolution of the legal mandates of the target institutions, EGC, VRA, and BPA.

### Electricity Company of Ghana

ECG, the state-owned distribution service provider in Southern Ghana, was transformed in 1997 from a statutory corporation into a company registered under the Companies Act of Ghana 1963 (Act 179) with the Government of Ghana (GoG) as the sole shareholder. The company, per its constitution, was established to

- Acquire the entirety of the business including the assets and liabilities of the predecessor corporation;
- Construct, operate, and maintain its distribution facilities or sub-transmission systems, defined under the Electricity Distribution Code as facilities and equipment operated below 34.5 kV;
- Purchase electricity from VRA or other suppliers for distribution; and
- Transmit, supply, and distribute electricity.

As a distribution utility and a participant in the regulated market as part of Ghana's wholesale electricity market (WEM), ECG falls under the regulatory purview of the EC and PURC. In accordance with the provisions of Act 541 (EC Act), ECG is subject to licensing and technical regulation mandates of the EC (Sections 24 and 27 of Act 541).

Like all distribution utilities, its rates and charges are subject to the approval of the PURC (Section 26(1)(a) of Act 541). The PURC also oversees the customer services matters of these entities. The company operates under a distribution license granted by the EC under the EC Act and the Commission's Licensing Guidelines.

### Volta River Authority

The Volta River Development Act 1961 (Act 46), which established VRA in 1961, has since been amended a few times. As a result of the amendments, the current mandates enable VRA to undertake the functions of generating electricity by means of water power of the Volta River and any other means and supplying electricity through the transmission system, including constructing a dam and power station near Akosombo.

VRA was also granted powers for management of the water resources of the lake and the administration of certain adjoining lands. VRA was also granted power to purchase electricity to meet its contractual and other obligations (Section 10 of the Volta River Development Act, as amended).

With regard to power generation, VRA is mandated to supply electricity to

- The regulated market's distribution companies including ECG, Northern Electricity Distribution Company (NEDCo), and Enclave Power Company;

- The deregulated market's bulk consumers;
- The Akosombo and Kpong townships; and
- Any other customer under an arrangement agreed upon by the government and BPA.

### Bui Power Authority

The Bui Power Authority Act 2007 (Act 740) established BPA to develop the hydroelectric power project on the Black Volta River at Bui and any other potential hydroelectric power sites on the Black Volta River. Specifically, BPA was to plan, execute, and manage the Bui hydroelectric power project which comprised

- The generation of electrical power for general industrial and domestic use;
- The construction of the transmission system to evacuate the power generated into the national grid; and
- The supply of electricity generated at the dam to licensed distribution and transmission utilities, the township of Bui and its environs, and other consumers in Ghana or elsewhere under arrangements agreed on between the government, BPA, and the consumer.

BPA was also given the responsibility of managing the water resources and providing the facilities for developing the lake for multipurpose use (Section 11 of Act 740).

The functions of BPA were expanded under the BPA Amendment Act 2020 (Act 1046). By the amendment, BPA is to perform, in accordance with the Renewable Energy Act on behalf of the state, RE functions as assigned by the Minister for Energy. These functions include

- Execution of RE projects,
- Management of RE assets, and
- Undertaking of RE activities for generating electric power (Section 2(b) and (c)).

## 4.2 Ghana's Competitive Electricity Procurement Policies

### History of Ghana's Renewable Energy Policies

The legal and regulatory framework for RE development in Ghana has evolved over three distinct phases. The first phase was pre-2011 when RE projects were developed under the existing traditional regulatory regime unintentionally skewed in favor of the predominant conventional energy sources.

The second phase was the Renewable Energy Act 2011 (Act 832) period when legislation dedicated to the promotion of renewables was first enacted introducing, among others, the RE purchase obligation and as well as the renewable energy feed-in tariff (REFiT) mechanism.

The third phase and current regime commenced in 2020 with the passage of the Renewable Energy (Amendment) Act 2020 (Act 1045). Important innovations of Act 1045 include the discontinuance of the REFiT scheme and adoption of the competitive procurement method through competitive bidding or auctions for public utilities, operators in the regulated market, extension of purchase obligation to generators employing fossil fuels, and renewed focus on the development of solar rooftop systems.

## 2019 Competitive Procurement Policy

In May 2019, the MoEn issued the Policy Guidelines for Competitive Procurement of Energy Supply and Services Contracts (PGCPES). The objective of the policy was to ensure that Ghana procures energy in a sustainable and least-cost manner to meet demand based on principles of transparency and open competition underpinned by regulator-approved, regularly updated demand projections determined through a comprehensive planning process. The PGCPES gave the sector regulators the responsibility of ensuring that energy supply, including RE power, is procured through the rigorous master planning and competitive procurement process.

The 2019 Competitive Procurement Policy consists of two primary steps:

- Supply deficit assessment
- Electricity supply procurement

First, the EC's procurement procedure for the entire WEM commences from the indicative planning stage aimed at establishing the source and magnitude of any current or forecasted supply deficits. New power plants may only be procured in accordance with the requirements of the indicative plan.

Second, the distribution utilities and electricity transmission utilities (ETUs) must complete a seven-stage process. Bulk consumers are also encouraged but not obliged to procure electricity supplies through a six-stage competitive bidding process.

## Electricity Procurement Process

The procurement process to be followed by the distribution utilities and ETUs for the regulated market is as follows:

(a) Request for expression of interest (EOI)

(b) Short-listing of bidders

(c) Request for proposals (RFP) based on best practices requesting separate

  (i) Technical proposal and

  (ii) Financial proposal

(d) Evaluation of bids and selection of successful bidder

(e) Execution of the Power Purchase Agreement (PPA)—which is to be done in consultation with the PURC

(f) EC licensing and siting approvals

(g) Construction and operation.

The distribution utilities and ETUs are required to employ World Bank Procurement Guidelines as well as comply with the requirements of the Public Procurement Act.

## 4.3 Assessment of Compliance with Utility Mandates

The following were the key takeaways from the consultant's review of the mandates of the target utilities:

- By Ghana's power sector regulations, ECG is not permitted to supply electricity to participants in the deregulated market.
- ECG, in conjunction with the regulatory and approval processes of the PURC and EC, is responsible for purchasing electricity supplies for customers in its operational areas.
- Both BPA and VRA are permitted to supply electricity to any regulated or deregulated market participants. Neither entity is obliged to provide electricity supplies to customers in either electricity market segments unless otherwise contractually obligated.

## 4.4 Assessment of Compliance with 2019 Competitive Procurement Policy

The following were the key takeaways from the consultant's review of the target utilities' compliance with the 2019 Competitive Procurement Policy:

- Since the initiation of the 2019 Competitive Procurement Policy, three solar PV projects have been concluded—VRA's 17 MW Kaleo Solar Project, BPA's 50 MW Solar Project, and VRA's 6.5 MW Lawra Solar Project which is under construction.
- Of these three projects, BPA's 50 MW and VRA's 6.5 MW solar PV projects have regulated market offtakers (ECG and NEDCo). Because of the offtake by regulated market participants, these projects were supposed to be subject to the 2019 Competitive Procurement Policy.
- The consultant was unable to establish that the actions recommended in the 2019 Competitive Procurement Policy had been followed as part of the establishment of the projects completed before 2019.
- In the case of the post-policy implementation of BPA's 50 MW and VRA's 6.5 MW solar PV projects, the consultant found no evidence that the policy-recommended step had been initiated toward the procurement of either project.
- While the embargo on new utility-scale generation projects has been in place, state-owned generation companies (VRA and BPA) have been aggressively pushing forward with new solar projects by leveraging their existing competitive advantages in the form of access to land, in-house ancillary support (that is, backup power), existing power evacuation infrastructure, and other support services.

# 5 Ghana's Solar PV Projects and Finance Structures

Several solar PV projects in the Ghanaian power system are either operational or in the final stages of development:

- The 2.5 MW VRA Solar PV Plant located near Navrongo
- The 20 MW BXC Solar PV Plant located at Gomoa Onyandze near Winneba
- The 20 MW Meinergy Solar PV Plant located at Gomoa Onyandze near Winneba
- The 17 MW VRA Solar PV Plant located near Kaleo
- The 6.5 MW VRA Solar PV Plant located near Lawra
- The 50 MW Bui Solar PV Plant 1 located near the Bui Dam.

A summary of key commercial and performance information on each of these projects is provided in Table 15.

Table 15: Forecast of Commercial and Performance Information of Solar PV Projects

| RE Projects | Capacity (MW) | Expected Energy (GWh) | Tariffs (US$/kWh) | First Year of Operation |
|---|---|---|---|---|
| VRA Solar 1 - Navrongo | 2.5 | 3 | 0.1725 | 2013 |
| VRA Solar 2 - Kaleo | 17 | 26.6 | 0.0950 | 2020 |
| VRA Solar 3 - Lawra | 6.5 | 10 | 0.0900 | 2023 |
| BXC | 20 | 27 | 0.2014 | 2016 |
| Meinergy | 20 | 27 | 0.1825 | 2018 |
| Bui Solar Farm 1 | 50 | 68 | 0.1024 | 2021 |

## 5.1 Description of Solar PV Projects

### The 2.5 MW Navrongo Solar PV Plant

The 2.5 MW Navrongo Solar PV Plant is a VRA plant located near Navrongo in the Upper East Region of Ghana. This plant is operational and was financed entirely by VRA equity. The electricity generated from the plant is entirely committed to NEDCo as its offtaker at a tariff of US$0.1725/kWh. The plant evacuates its generation through an embedded distribution network connection to NEDCo.

### The 20 MW BXC Solar PV Plant

The 20 MW BXC Solar PV Plant is an independent power producer (IPP) located near Winneba in the Central Region of Ghana. This plant is operational. The stakeholders have not been forthcoming with the source of financing and the terms, but the consultant believes that the plant may have been financed by an export credit facility from China. The electricity generated from the plant is entirely contracted to ECG as its offtaker at a tariff of US$0.2014/kWh. The plant evacuates its power through ECG's local medium-voltage network.

### The 20 MW Meinergy Solar PV Plant

The 20 MW Meinergy Solar PV Plant is an IPP located near Winneba in the Central Region of Ghana. This plant is operational. The participants in this project have not been forthcoming with information on the source of financing and the terms, but the plant is believed to have been financed by an export credit facility from China. The electricity generated from the plant is entirely contracted to ECG as its offtaker at a tariff of US$0.1825/kWh. The plant evacuates its power through ECG's local medium-voltage network.

### The 17 MW Kaleo Solar PV Plant

The 17 MW Kaleo Solar PV Plant is a VRA plant located near Kaleo in the Upper West Region of Ghana. This plant is operational and was financed by concessional loans from *Kreditanstalt für Wiederaufbau* (KfW), a German state-owned investment and development bank, covering 80 percent of the project's cost at an interest rate of 1 percent, with a repayment term of 40 years and a grace period of seven years. The electricity generated from the plant is entirely committed to Newmont Ahafo as its offtaker at a tariff of US$0.095/kWh. The plant evacuates its generation through an embedded distribution network connection to NEDCo.

### The 50 MW Bui Solar PV Plant 1

The 50 MW Bui Solar PV Plant 1 is located near the Bui Dam in the Bono Region of Ghana. This plant is operational. The plant has been developed through an arrangement with the developers of the Meinergy project and is also believed to have been financed by an export credit facility from China. The electricity generated from the plant is entirely supplied to ECG under BPA's existing PPA at a tariff of US$0.1024/kWh. The plant evacuates its generation through the existing 161 kV substation that is connected to the NITS.

### The 6.5 MW Lawra Solar PV Project

The 6.5 MW Lawra Solar PV Project is a VRA project located near Lawra in the Upper East Region of Ghana. This plant is under construction. Like VRA's Kaleo Solar PV Plant, this project is financed by concessional loans from KfW covering 80 percent of the project's cost at an interest rate of 1 percent, with a repayment term of 40 years and a grace period of 7 years. The electricity generated from the plant is entirely committed to NEDCo as its offtaker at a tariff of US$0.09/kWh. The plant evacuates its generation through an embedded distribution network connection to NEDCo.

### Other Solar PV Plant Projects

The BPA is understood to be at various stages of implementing multiple solar PV projects. First, a 1 MW Floating Solar Plant has been completed and is operational. Second, the BPA is also understood to have signed a development contract for an additional 100 MW of solar PV with the developers of the Meinergy project, who also implemented the BPA's 50 MW Solar PV Project 1. Finally, it is understood that the BPA is in discussions with KfW about potentially procuring for this project a concessionary loan similar to those provided for VRA's Kaleo and Lawra solar projects.

## 5.2 Comparison of Solar PV Projects

This section presents the consultant's comparison of Ghana's existing solar PV projects.

### Comparison of Offtake Arrangements

It is noted that outside of the VRA's Lawra project, which is contracted to Newmont Ahafo, the offtakes of the remaining parastatal-owned solar PV projects are all contracted to the regulated market (primarily ECG and NEDCo) under existing wholesale supply arrangements.

Regarding the offtakes of the projects contracted for supplies to the regulated market (ECG and NEDCo), it is recognized that none of the projects were competitively procured. The two IPP projects, BXC and Meinergy, are contracted to ECG as its regulated market offtaker.

### Comparison of Financing and Tariffs

As far as the consultant understands, none of the solar PV projects implemented so far have been project financed. Outside of the Navrongo project that was funded entirely with equity, VRA's other solar PV projects have been implemented with concessional loans from KfW.

It has been observed that tariffs for solar PV projects have generally dropped from above US¢10/kWh to less than US¢6/kWh . The most recent projects with tariffs less than 10 US Cents/kWh have been implemented by BPA and VRA. These projects benefit from varying forms and levels of statutory leverage and, in some cases, concessional loans, without any comparable private sector PV projects implemented in the same timeline. It is therefore difficult to assess whether these tariffs are because of the statutory advantages or they reflect a new and improved price point that can be indicative for future tariffs for all solar PV projects including private-led ones.

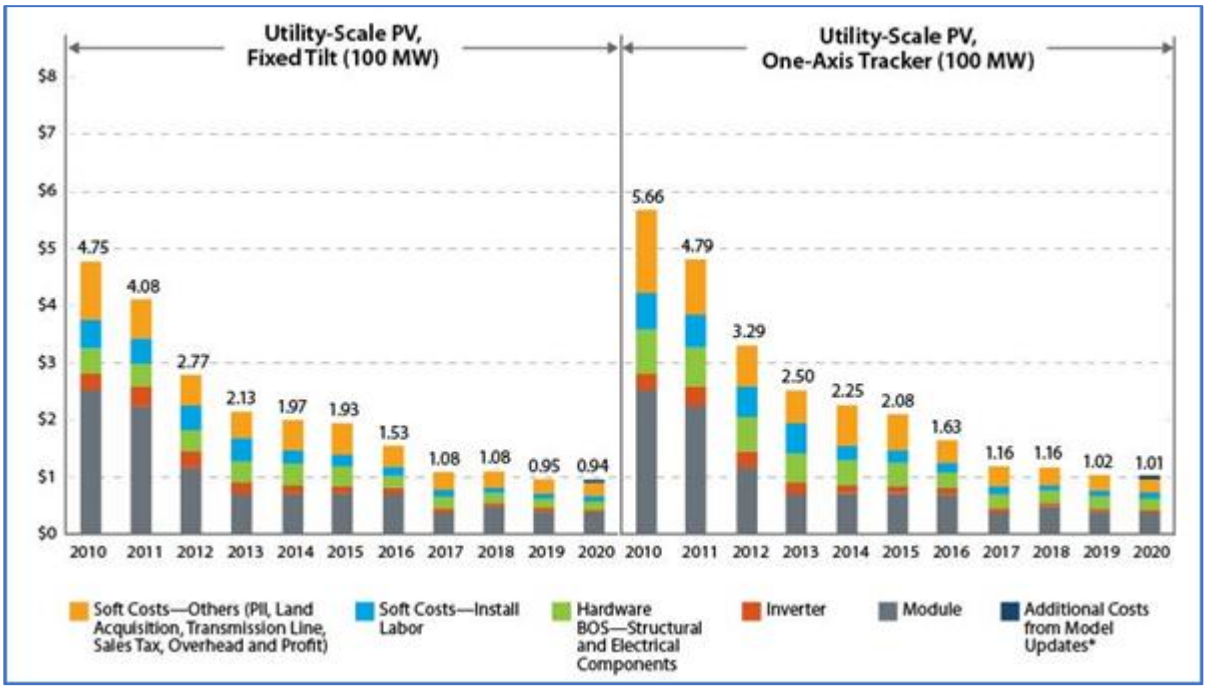
### Comparison of Implementation Costs and Tariffs

The solar PV projects operating in Ghana have been implemented over a decade. During this period, fundamental shifts in the pricing of solar PV facilities have occurred. Also, several significant changes in the policy environment have affected the pricing of solar PV generation, making any direct comparisons of their implementation or unit costs of supply contentious and debatable.

The notable changes that have occurred during this period include

- Change in Ghana's RE pricing regime from REFiT to competitive procurement,
- Varying implementation models,
- Significant differences in their financing arrangements, and
- Global reduction in solar PV implementation costs (as shown in Figure 6).

Figure 6: Benchmark Costs for Solar PV Systems (2010–2020)




*Source*: National Renewable Energy Laboratory (NREL).

The benchmark costs from the NREL (see Figure 6) have been used to derive the adjustment factors that would translate the costs or applicable tariffs for the various plants to prices of the base year 2020 for a more equitable comparison. The computed adjustment factors are as shown in Table 16.

Table 16: Price Adjustment Factors for Utility-Scale Solar PV

| | Benchmark Values for Utility-Scale Solar PV (Source: NREL) | | | | | | | | | | | Assumed | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| Benchmark Prices (Fixed Tilt) | 4.75 | 4.08 | 2.77 | 2.13 | 1.97 | 1.93 | 1.53 | 1.08 | 1.08 | 0.95 | 0.94 | 0.94 | 0.93 | 0.93 |
| Adjustment Factor (BaseYear = 2020) | 20% | 23% | 34% | 44% | 48% | 49% | 61% | 87% | 87% | 99% | 100% | 100% | 101% | 101% |

As noted earlier, the implementation dates for the existing solar PV plants vary. Therefore, recognizing the global rate of fall in solar system prices, the comparable equivalent unit price for each of these plants, as adjusted using the factors from Table 16, are as presented in Table 17.

Table 17: Comparison of Equivalent Prices for Existing Solar PV in Ghana

| Solar Projects | First Year of Operation | Tariffs (US$/kWh) | Equiv. Tariff *(Base Year = 2020)* |
|---|---|---|---|
| VRA Solar 1 - Navrongo | 2013 | 0.1725 | 0.0761 |
| VRA Solar 2 - Kaleo | 2020 | 0.0950 | 0.0950 |
| VRA Solar 3 - Lawra | 2023 | 0.0900 | 0.0910 |
| BXC | 2016 | 0.2014 | 0.1237 |
| Meinergy | 2018 | 0.1825 | 0.1588 |
| Bui Solar Farm 1 | 2021 | 0.1024 | 0.1024 |

The results presented above indicate that the VRA Solar 1 - Navrongo plant has the most competitive unit cost of supply while the Meinergy plant is providing the least competitively priced solar energy. These comparisons, however, do not consider the differences in financing terms, ownership, and risk allocation, especially where the plants are privately owned as against state utility owned.

# 6 Economic and Financial Analysis

This section discusses, among others, the financial performance of ECG, BPA, and VRA. While noting ECG's role as an electricity distribution utility and the roles of BPA and VRA as generators, the context and perspective for discussion of the financial performance, creditworthiness, and ability to raise financing are viewed considering each organization's mandated function in the unbundled energy sector.

In view of the restrictive mandate of ECG which precludes it from obtaining financing for generation projects, there is no consideration of ECG's ability to raise financing for generation projects directly. The discussion of ECG's financial performance therefore focuses entirely on its creditworthiness to continue to secure or purchase electricity from generators or wholesale suppliers.

The discussion of the performance of BPA and VRA focuses on their ability to raise financing for generation projects, including solar PV projects. The current power sector regulations, however, do not permit ECG to raise financing to execute generation projects.

The energy offtake of ECG in 2020, for example, accounted for 40 percent of VRA's production and all of BPA's production. Being Ghana's largest distribution utility, ECG's financial performance has a cascading effect on all other participants in the electricity supply chain. Furthermore, ECG being the primary offtaker for VRA and BPA, its financial performance has a particularly direct and corresponding effect on the financial performance of these two entities.

## 6.1 Indicators of Utility Creditworthiness

To empirically discuss the ability of the utilities to access financing for various projects, the consultant considered the following performance indicators:

- **Current ratio (CR).** This indicator is calculated by dividing current assets by current liabilities. This indicator shows a company's ability to cover its near-term obligations. The minimum recommended CR is 1. From a lending perspective, having a CR less than 1 means a company does not have sufficient assets to cover its liabilities. This tends to be a concern, particularly for collateralized lending.

- **Debt service coverage ratio (DSCR).** This indicator is calculated by dividing earnings before interest and taxes by the current portion of a company's long-term obligations. This ratio is typically utilized as a significant indicator to demonstrate to lenders that a company will have enough future cash flow to cover its debt obligations. Typically, the minimum desired DSCR is approximately 1.2x; the strictest lenders can require a DSCR as high as 1.5x.

- **Gearing ratio (GR).** This ratio is a measurement of an entity's leverage. It shows the extent to which a company's operations are funded by equity funds versus debt financing. A company with higher leverage (higher use of debt finance) could be at higher risk of default should there be a negative change in the business environment, especially when the same company has a low DSCR.

- **Return on average equity (ROAE).** This is a ratio that measures the performance of a company based on its average shareholders' equity and it is calculated by dividing the net income at the end of the fiscal year by the average of shareholders' equity at the beginning and the end of the year. It is one measure of the company's profitability.

- **Return on net fixed assets (RONFA).** This metric is calculated by dividing the net income for the fiscal year by the average of the net fixed assets at the beginning and end of the fiscal year under consideration. This indicator shows the efficiency with which an entity can turn a profit from its fixed assets. The higher the return, the more efficient the operation of the assets and the firm.

### ECG Creditworthiness

From 2017 through 2019, ECG had suboptimal performance in terms of DSCR, CR, and RONFA. In those years, ECG recorded negative DSCR values. This is a troubling sign for lenders because it indicates a lack of income toward meeting-long term liabilities. However, in 2020, it appears that an uptick in payment from the GoG was sufficient to improve ECG's performance on the key indicators.

As far as indicators are concerned, RONFA is especially relevant for ECG's creditworthiness as its earnings are largely based on transactional volume rather than its own productivity. ECG's assets do not, by the company's activities, produce a sellable product as it buys the same product (electricity) from generators that it sells to consumers.

Table 18: Key Financial Indicators for ECG

| Indicator | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Revenue (GHS) | 6,219 | 5,906 | 7,283 | 6,913 |
| Gearing Ratio | | | | |
| DSCR | -0.32 | -1.94 | -2.11 | 1.78 |
| Current Ratio | 0.64 | 0.41 | 0.49 | 0.62 |
| Return on Net Fixed Assets | -4% | -16% | -8% | 4% |

### VRA Creditworthiness

The key indicators for assessing VRA's creditworthiness are summarized in Table 19.

Table 19: Key Financial Indicators for VRA

| Indicator | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|
| Revenue (GHS millions) | 2,562 | 2,633 | 3,001 | 3,891 | 3,793 |
| Gearing Ratio | 26% | 27% | 27% | 9% | 9% |
| DSCR | 0.02 | 0.61 | 0.71 | 0.9 | 0.77 |
| Current Ratio | 0.68 | 0.99 | 1.17 | 1.16 | 1.18 |
| Return on Average Equity | -5% | 16% | 9% | 10% | 10% |
| Return on Net Fixed Assets | -2% | 10% | 8% | 10% | 10% |

The indicators show that between 2016 and 2020, VRA recorded a 9.9 percent ROAE even though there was a slight reduction in revenue for 2020. This illustrates the productivity of VRA's use of its fixed assets. Over the same period, VRA's GR declined from 27 percent in 2017 to less than 9 percent in 2020. This illustrates the improvement in the strength of its balance sheet and its ability to acquire more debt for projects, if required. VRA's CR has also increased during the same period and has been above 1 since 2018. This demonstrates VRA's relatively improved ability to cover its short-term obligations more reliably.

However, VRA's DSCR remains below 1 and might be a cause for concern if there are plans to use VRA's balance sheet to take on more debt as long-term financing for a project. VRA's DSCR would have to rise above 1.2 to 1.5 consistently for the utility to be viewed as able to reliably cover its debt obligations.

### BPA Creditworthiness

The key indicators for assessing BPA's creditworthiness are summarized in Table 20.

Table 20: Key Financial Indicators for BPA

| Indicator | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|
| Revenue (US$ millions) | $ 105.93 | $ 98.96 | $ 58.78 | $ 95.72 |
| Gearing Ratio | 2.01 | 1.96 | 1.84 | 1.72 |
| DSCR | | | 1.62 | 1.84 |
| Current Ratio | 7.72 | 5.39 | 10.57 | 14.73 |
| Return on Average Equity | 19% | 9% | 18% | 14% |
| Return on Net Fixed Assets | 6% | 3% | 6% | 5% |

BPA averaged a RONFA of 5.5 percent between 2018 and 2019. BPA's balance sheet has been steadily improving on key indicators since 2016 with the GR consistently decreasing because of the reduction in BPA's total debt. Similarly, with a steadily improving CR, BPA can cover its short-term obligations relatively reliably. BPA's return on average equity is currently better than that of VRA.

All the indicators point to BPA being in a healthy position to attract financing or contract debt for generation projects.

## 6.2 ECG's Key Risks and Other Considerations

Key risks to ECG's creditworthiness come in the form of internal and external risks. The primary internal risk is ECG's own operational performance, especially as measured through total losses—technical, commercial, and collection. The external risk exposures of ECG include state bill payments, PURC tariff setting, and related currency and fuel price risks.

### Operational Performance

ECG distributes 64 percent or about two-thirds of the energy in Ghana's electricity market, making it the most significant source of revenue for the power system's value chain. This is especially true because Ghana's second largest distribution utility—NEDCo—does not have any formal PPA obligations and operates in the relatively less consumer dense parts of the country. ECG's operational performance, especially as gauged through the lens of total losses (technical, commercial, and collection) is particularly impactful on the financial health of the greater power sector. ECG is reported to be operating with aggregate technical and commercial (AT&C) losses of 24.7 percent and 26.2 percent in 2019 and 2020, respectively, which are generally considered to be excessive. This is a source of concern.

### State Bill Payments

The agencies of the GoG are a significant customer group for ECG. Delays or arrears in payment for electricity supplies to state premises have a significant impact on ECG's cash flow and performance. In recent years and as admitted in the Energy Sector Recovery Plan, the GoG has recognized that the state

agencies have been a significant contributor to ECG's arrears and is taking steps toward closing this gap. Until the payment discipline of this group is seen to have improved, this will continue to be perceived as a risk to the financial health of energy sector actors.

### PURC Tariff Setting and Related Risks

Over the years, ECG and other sector actors, including NEDCo, VRA, and GRIDCo, have complained about the PURC's tariff setting. As the only mandated institution responsible for tariff setting for the regulated market, the utilities submit their tariff proposals for consideration by the PURC, which has the final say on tariffs awarded.

In 2021, ECG submitted tariff proposals requesting an increase in their distribution service charges (DSCs) based primarily on increasing costs of operation and exchange rate changes. The PURC granted no increment on ECG's DSCs. If the increase request is truly reflective of full cost recovery as claimed by the utilities, then the failure to grant the increase would represent a significant impact on the financial sustainability of ECG.

Similarly, VRA, NEDCo, and GRIDCo, during the same tariff review period, submitted tariff proposals for increments which were also denied. The level of tariff and tariff setting practices are therefore likely to be considered a risk factor by potential lenders to the sector.

**Related Risks**

The PURC's tariff setting process and decision-making have a knock-on effect on the ability of the utilities to consistently deal with changes in their costs of service delivery. The volatility of currency exchange rates and fuel costs are risks that are typically passed on to the offtakers as part of their contractual obligations toward generators (especially IPPs) and, by association, fuel suppliers. Between October 2021 and April 2022, the Ghanaian cedi to US dollar exchange rate went from 6.05 to 7.5 (peaking above 8 in mid-March) while electricity tariffs remained stagnant in nominal local currency terms. During the same period, the price of crude oil also changed from US$86/bbl to US$104/bbl. With no change in the approved tariffs chargeable by ECG, which are denominated in local currency, the weakening currency, and increasing fuel prices, it understandably becomes more difficult for ECG to meet its obligations to upstream electricity value chain service providers whose costs and payments are largely denominated in foreign currency.

## 6.3 Generators' Key Risks and Other Considerations

This section discusses several key risks (internal and external) and other considerations relevant to the financial positions of VRA and BPA that are key determinants of their financial performance and, therefore, creditworthiness.

### Organizational and Power Generation Portfolio Performance

VRA and BPA are both growing utilities which are increasing their breadth of power generation projects. VRA's current power generation portfolio has a total of 11 power generation facilities: 2 hydropower, 6 thermal, and 3 solar PV. Similarly, BPA's current power generation portfolio includes hydropower and solar PV generation facilities. The two organizations have ambitions to add to their power generation portfolio.

Whereas the PPAs of private IPPs have capacity as well as energy charges, the contractual arrangements of both VRA and BPA with ECG only have energy charge and so these utilities get paid only for electricity generated. The financial performance and fortunes of these utilities are even more closely tied to the dispatch and operation of their power generation portfolio than, for example, private thermal power generators. The underperformance of any of these power generation projects poses a risk to their financial stability and profitability.

It must be noted that, in recent years, some plants in VRA's generation portfolio have experienced some unexpected occurrences whose end result has been a reduction in output and, therefore, underperformance. This is damaging to the utility's finances, especially because some of these underperforming assets have ongoing liabilities associated with them. The Takoradi 1 Thermal Plant (T1), for instance, has experienced operational issues with its second gas turbine. Additionally, the entire Takoradi Thermal Complex had been experiencing issues with cooling systems, which resulted in rationing of operations at the complex. Finally, in 2013, the 132 MW Takoradi 3 Thermal Plant experienced a major incident which has resulted in the cessation of generation from that plant since then.

### ECG Performance and Payments

As noted elsewhere in this report, both VRA and BPA are highly exposed to their primary offtaker ECG. Currently, ECG is BPA's only offtaker. Therefore, any shortfall in ECG's payments to BPA has a major negative effect on BPA's finances. Similarly, ECG consumes more than 40 percent of VRA's annual generation. According to VRA's 2020 Annual Statements, VRA had outstanding receivables of GHS 1,949 million (equivalent to US$322 million) from ECG. Therefore, ECG is a significant source of revenue and a corresponding financial performance risk for VRA as well.

Finally, the consultant understands that after years of discussions, a cash waterfall mechanism was implemented to harmonize the sharing of ECG-gathered revenues with participants in the electricity value chain (including VRA, BPA, GRIDCo, and fuel suppliers).

### PURC Tariff Setting

As discussed previously, the VRA submitted tariff proposals in 2021 seeking an 18 percent increase in their bulk generation tariff (BGT) based primarily on increasing fuel prices and exchange rate changes. The PURC granted no increment on the BGT which is the rate paid for energy supplied by VRA to ECG. If any part of the increase requested was truly reflective of full cost recovery, then the failure to grant the increase would represent a significant impact on the financial sustainability of VRA.

Similarly, ECG, NEDCo, and GRIDCo, during the same tariff review period, submitted tariff proposals for increments which were also denied by the PURC.

The PURC indicated that it had recognized an over-recovery of revenue after reconciliation of data on hydroelectrical generation by VRA. In addition to the approval of 64 percent hydro-allocation by the Electricity Market Oversight Panel to the regulated market, there was, in the view of the PURC, a marginal reduction of cost of procuring power from VRA by the distribution companies. The PURC had, therefore, decided that the distribution companies should be allowed to use this revenue to address revenue shortfall challenges relating to power sales to industrial customers.

### Fuel Costs and Availability

Related to the PURC tariff setting risks affecting VRA, the authority, especially without the necessary adjustments in tariffs, is exposed to variations in fuel costs driven by fuel mix and global price changes. In 2021, VRA generated about 40 percent of its annual electricity output from thermal sources. These thermal generators are fueled primarily by indigenous natural gas and imported liquid fuels. When recent liquid fuel import price changes are paired with Ghana's recent currency depreciation, it can be understood that VRA's financial situation is significantly weakened by the denial of BGT increases.

## 6.4 Other Considerations – GRIDCo Operations

As Ghana's sole ETU, GRIDCo is the bridge between the operations of generators and distributors and/or bulk consumers. GRIDCo's technical performance has a significant bearing on the operations of both generators and the distribution utility. If the NITS is not operational, both generators (especially VRA and BPA) and distributors who rely on the NITS for their operations suffer revenue losses.

Additionally, if GRIDCo's operations are suboptimal, the effect on ECG's operations, especially given previously discussed tariff setting issues, results in reductions in ECG revenues, which further strains payments for the rest of the upstream electricity value chain.

## 6.5 Assessment of Fundraising and Financing Options

### ECG

Of the three utilities considered for this assignment, ECG is the least creditworthy. Within the context of ECG's mandate, ECG's financial strength needs to be reviewed with long-term liabilities as the primary focus. ECG's negative DSCR and often negative RONFA would be a significant cause for concern to lenders. The impact of this relatively poor performance is also evidenced by the approach of multiple project developers to require state guarantees in support of ECG's purchase obligations.

ECG's exposure to currency risk through the PURC tariff setting's potential shortcomings is also likely to provide a cause for concern about erosion of ECG's finances from any depreciation of the local currency against major global currencies.

### VRA

VRA is a relatively creditworthy organization when viewed through the lens of short-term lending indicators such as the CR. Therefore, the VRA should be able to access short-term debt funding for operational costs.

However, VRA performs sub-optimally on the primary long-term lending indicators such as DSCR. As DSCR is a key indicator of the long-term creditworthiness and performance of the offtaker, VRA's ability to obtain funding for power generation projects from financing institutions (on development finance institution [DFI], blended, or commercial finance bases, as discussed in Section 0 below) is hampered by its DSCR indicator levels.

### BPA

BPA is the most creditworthy of the three utilities considered under this assignment. BPA scores well on multiple indicators of creditworthiness for both short- and long-term lending. As noted earlier, however, a related secondary concern is with the creditworthiness of an offtaker such as ECG. So alternative offtakers may be considered a more acceptable proposition for lenders.

## 6.6 Summary of Market Debt Finance Options for Solar PV Projects

Beyond concessional financing such as that provided by KfW for multiple VRA solar PV projects in Ghana, there are three primary types of financing available to fund solar PV projects:

- **Development financing**, which is typically provided by a DFI such as the World Bank, FMO, Norwegian Investment Fund for Developing Countries (Norfund), and so on
- **Commercial financing**, which is typically provided by a commercial bank
- **Blended finance**, a combination of commercial and development financing, as has been offered by Chinese entities of late and typically achieved by obtaining funding from multiple institutions fitting the lending type.

A summary of the typical terms associated with each of these funding types is presented in Table 21.

Table 21: Summary of Debt Financing Options and Terms

| Item | DFI | Blended | Commercial |
|---|---|---|---|
| Debt Proportion | 70% | 70% | 70% |
| Interest Rate | 5% | 8% | 10 |
| Term | 15 | 10 | 5 |
| Grace Period | 1 | 1 | 1 |

For this assignment, the cost of equity was assumed to be 18 percent.

## 6.7 Generation Cost Impact of Achieving the 10 Percent RE Target

To assess the generation cost impact of reaching the 10 percent RE target, the consultant analyzed multiple configurations of project module size and implementation approaches by comparing the resulting LCOE for the various solar PV project simulations against the composite bulk generation tariff (CBGT).

### Composite Bulk Generation Tariff

For this assignment, the consultant used the PURC's gazette CBGT for January 2022. The CBGT published was GHS 44.1224/kWh which is equivalent to US$0.073/kWh, using exchange rate of 6.05 as at the date issued.

### LCOE for New Solar PV Projects

Based on the project module costs shown in Table 9 and the identified debt funding options shown in Table 21, the consultant analyzed the LCOE (in US$/kWh) for each solar PV project implementation scenario in either basic or comparable financial configurations. Table 22 shows the results of this analysis.

Table 22: Solar PV Project LCOE Summary of Results

| Financing Scenario | Implementation Scenario LCOE Results ($/kWh) | | | | | |
|---|---|---|---|---|---|---|
| | 20 Basic | 20 Comp | 50 Basic | 50 Comp | 100 Basic | 100 Comp |
| DFI | 0.0640 | 0.0653 | 0.0590 | 0.0674 | 0.0588 | 0.0669 |
| Blended | 0.0729 | 0.0860 | 0.0670 | 0.0768 | 0.0667 | 0.0762 |
| Commercial | 0.0789 | 0.0935 | 0.0725 | 0.0833 | 0.0722 | 0.0826 |

As expected, the results in Table 22 show that lower-cost financing results in a lower cost of electricity supply; therefore, DFI financing is more capital efficient than blended and commercial financing in that order. Also, as expected, the basic configurations of solar PV projects, which present opportunities for cheaper project capital expenditures (CAPEX), result in lower cost of electricity supply than the comparable configurations. Therefore, depending on the project implementation configuration and module sizes chosen, solar projects deployed under the scenarios discussed will be at LCOE levels between US¢5.88/kWh and US¢9.34/kWh

## Cost Impact of New Solar PV Projects

The LCOE results in Table 22 show that solar projects deployed under the scenarios discussed will be at LCOE levels between US¢5.88/kWh and US¢9.34/kWh. The consultant evaluated the cost impact of new solar PV projects between US¢5.5/kWh and US¢9.5/kWh and at US¢1/kWh intervals.

The results of the cost impact analysis, in Table 23, indicate that the new solar PV plants at price points below US$0.073/kWh generate savings for the Ghanaian power system's generation cost. These results also indicate, as expected, that

1. The new solar PV projects are the least cost when implemented in larger modules and
2. The new solar PV projects generate the greatest savings impact with access to lower-cost, longer-tenure financing such as DFI financing.

Table 23: Cost Impact of New Solar Plants

| | RE LCOE Scenarios ($/kWh) | | | | |
|---|---|---|---|---|---|
| Item | 0.055 | 0.065 | 0.075 | 0.085 | 0.095 |
| Composite Bulk Generation Tariff (GHS/kWh) | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 |
| Total Demand (GWh) | 35,772 | 35,772 | 35,772 | 35,772 | 35,772 |
| Conventional Generation (GWh) | 32,358 | 32,358 | 32,358 | 32,358 | 32,358 |
| Total Cost of Conventional Generation ($' millions) | 2,360 | 2,360 | 2,360 | 2,360 | 2,360 |
| RE Generation Gap Filled | 100% | 100% | 100% | 100% | 100% |
| New RE Generation (GWh) | 3,415 | 3,415 | 3,415 | 3,415 | 3,415 |
| LCOE or RE Tariff ($/kWh) | 0.055 | 0.065 | 0.075 | 0.085 | 0.095 |
| Total Cost of New RE Generation ($' millions) | 188 | 222 | 256 | 290 | 324 |
| Average Generation Tariff ($/kWh) | 0.071 | 0.072 | 0.073 | 0.074 | 0.075 |
| **Change in Average Generation Tariff (%)** | **-2.35%** | **-1.04%** | **0.27%** | **1.58%** | **2.89%** |
| **Annual Savings on Generation ($' millions)** | **61.23** | **27.08** | **(7.07)** | **(41.22)** | **(75.37)** |

# 7 Conclusions and Recommendations

This section presents key takeaways or conclusions from the various subjects considered in the report.

## 7.1 Project Financing Structures of Existing Solar Projects

There are six existing solar projects:

- VRA's 2.5 MW Navrongo Solar Plant
- BXC's 20 MW Solar Plant
- Meinergy's 20 MW Solar Plant
- VRA's 17 MW Kaleo Solar Plant
- BPA's 50 MW Solar Plant
- VRA's 6.5 MW Lawra Solar Plant.

Table 24: Summary of Existing and 'Under-Construction' Solar PV Projects' Financing Information

| RE Projects | First Year of Operation | Funding Agency | Primary Funding Type | Funding Terms |
|---|---|---|---|---|
| VRA Solar 1 - Navrongo | 2013 | VRA | VRA Equity Only | |
| VRA Solar 2 - Kaleo | 2020 | KfW | Concessional Loan | - Interest Rate = 1%<br>- Grace Period = 7 Years<br>- Repayment Term = 40 Years<br>- Debt Ratio = 80% |
| VRA Solar 3 - Lawra | 2023 | | | |
| BXC | 2016 | China Export Credit | N/A | N/A |
| Meinergy | 2018 | | N/A | N/A |
| Bui Solar Farm 1 | 2021 | | N/A | N/A |

Table 25: Summary of Existing and 'nder-Construction' Solar PV Projects' Commercial and Performance Information

| RE Projects | Capacity (MW) | Expected Energy (GWh) | Solar Yield (MWh/MW) | Tariffs (US$/kWh) | First Year of Operation | Tariffs (US$/kWh) | Equiv. Tariff *(Base Year = 2020)* |
|---|---|---|---|---|---|---|---|
| VRA Solar 1 - Navrongo | 2.5 | 3 | 1200 | 0.1725 | 2013 | 0.1725 | 0.0761 |
| VRA Solar 2 - Kaleo | 17 | 26.6 | 1565 | 0.0950 | 2020 | 0.0950 | 0.0950 |
| VRA Solar 3 - Lawra | 6.5 | 10 | 1565 | 0.0900 | 2023 | 0.0900 | 0.0910 |
| BXC | 20 | 27 | 1350 | 0.2014 | 2016 | 0.2014 | 0.1237 |
| Meinergy | 20 | 27 | 1350 | 0.1825 | 2018 | 0.1825 | 0.1588 |
| Bui Solar Farm 1 | 50 | 68 | 1360 | 0.1024 | 2021 | 0.1024 | 0.1024 |
| **Total RE Generation (GWh)** | **116** | **162** | | | | | |

These projects were implemented over 10 years (2013–2022). During this period, the global implementation costs for fixed tilt solar PV projects dropped by over 80 percent (as shown in Figure 6).

Therefore, the LCOEs of the different projects executed do not provide an accurate comparison of the projects' financial efficiency.

VRA's Navrongo Solar Plant was funded by VRA equity only. The BXC, Meinergy, and BPA projects were financed using China Export Credit. The VRA Solar Plants at Kaleo and Lawra were funded by concessional loans from KfW.

The BXC and Meinergy plants were executed during the REFiT regime and at higher tariffs that provide cash flows significant enough to absorb any additional costs to the project, especially from land acquisition.

With the BXC and Meinergy being the only privately owned solar PV plants, the remaining solar projects benefit from nonmarket-based lending structures (in the form of concessional loans) as well as statutory and infrastructure advantages presented by the sponsoring state institutions—VRA and BPA.

## 7.2 Economic and Financial Analysis

### Creditworthiness

As the largest distribution company in Ghana, ECG's performance is a significant determinant of the Ghanaian power sector's overall financial position. As evident from requirements for GoG guarantees for electricity supply projects in the recent past, ECG is not viewed as a creditworthy entity for long-term power supply to be funded using project finance structures.

The creditworthiness of the generators (BPA and VRA) is largely considered on a project-by-project basis and focuses on the viability and creditworthiness of the project's offtaker, rather than the generators themselves, unless they are intermediary offtakers which has been the case for BPA's existing 50 MW Solar Project and the VRA's Takoradi 2 Thermal Project. In cases where these generators act as intermediary offtakers, their creditworthiness is determined through the strength of their own balance sheets as well as those of the eventual offtaker—typically a distribution utility or bulk consumer.

Currently, BPA is a more creditworthy entity than VRA.

### Risks and Other Considerations

The primary risk exposures affecting ECG's creditworthiness in terms of assuring its providers of full and regular payments are

- Its own operational performance especially in terms of aggregate technical, commercial, and collection (ATC&C) losses;
- Volatility of exchange rates and fuel costs;
- GoG payments of electricity bills on behalf of SOEs and facilities;
- GRIDCo's and generators' operations; and
- The PURC's tariff setting processes.

BPA and VRA are both highly exposed to ECG. A summary of their other risks includes

- Organizational and power generation portfolio performance,
- Fuel availability and costs,
- ECG performance and payments,
- PURC tariff setting, and
- GRIDCo operations.

## 7.3 Mandates and Responsibilities for Supply to Regulated and Deregulated Markets

The following were the key conclusions from the report regarding utility mandates:

- None of the utilities (ECG, BPA, and VRA) have any obligations toward the deregulated market.
- ECG is only responsible for electricity procurement for the regulated market customers in those geographic areas for which it holds the distribution concession.
- BPA and VRA have mandates for electricity generation functions but with no explicit obligations to take responsibility for supplying customers in the regulated nor deregulated markets.

Table 26: Summary of Utilities' Mandates and Creditworthiness

| Criteria | Utilities | | | | | |
|---|---|---|---|---|---|---|
| | Electricity Company of Ghana (ECG) | | Volta River Authority (VRA) | | Bui Power Authority (BPA) | |
| | Mandate | Obligation | Mandate | Obligation | Mandate | Obligation |
| Power Generation | No | No | Yes | Voluntary | Yes | Voluntary |
| Electricity Procurement or Supply (Regulated Market) | Yes | Yes | Yes | Voluntary | Yes | Voluntary |
| Electricity Procurement or Supply (Deregulated Market) | No | No | Yes | Voluntary | Yes | Voluntary |
| Solar PV Project Implementation Experience | N/A | | 26 MW | | 50 MW | |
| Future Solar PV Implementation or Procurement Plans | N/A | | 60 MW | | 160 MW | |
| Financial Situation & Trend | Stable & Trending Upward | | Stable & Trending Stable | | Positive & Trending Upwards | |

## 7.4 Solar PV Procurement Plans and Investments to Reach 10 Percent RE Commitment

The following were the key takeaways from the consideration of power sector procurement plans and RE commitments:

- ECG has no explicit power procurement plans for the next five years; the company expects that the current situation of overcapacity will end in 2028–2030.
- In the next five years, the utilities (BPA and VRA) will work toward the following notable solar PV project plans:
    - BPA has signed contracts and is actively seeking funding to implement two solar PV projects totaling 150 MW.
    - VRA is developing the 60 MW Bongo solar PV plant.
- The Ghanaian power system's electricity demand and energy demand are expected to reach over 5,588 MW and 35,772 GWh in 2030.

- To meet a 10 percent RE target with solar PV generation, approximately 2,511 MW of new solar PV generation will be required to generate approximately 3,415 GWh annually.
- Depending on the project module sizes of 20, 50, and 100 MW, the Ghanaian power system will require 122, 49, and 25 MW modules, respectively.
- The general deployment strategy could be to use the 20 MW module when the plant is to be connected to the distributions network and the 50 MW and 100 MW modules for the cases where the generation would be evacuated through a NITS node.
- Depending on the project configurations, the projects are expected to require US$1,615–2,243 million.

Table 27: Summary of Solar PV Project LCOE and Investment Requirements to Reach 10 Percent RE Target

| Cost Category & Item | | 20 MW | | 50 MW | | 100 MW | |
|---|---|---|---|---|---|---|---|
| Engineering, Procurement, & Construction (A) | | $ 14,319,885 | | $ 32,319,885 | | $ 64,319,885 | |
| Project Preparation (B) | | $ 3,149,935 | | $ 5,929,870 | | $ 11,489,740 | |
| Statutory Approvals (Permitting & Licensing) (C ) | | $ 40,000 | | $ 40,000 | | $ 40,000 | |
| Solar Plant Costs | Basic Solar Plant Costs (A) | $ 14,319,885 | | $ 32,319,885 | | $ 64,319,885 | |
| | Comparable Solar Plant Costs (A + B + C) | $ 17,509,820 | | $ 38,289,755 | | $ 75,849,625 | |
| Calculated Benchmarks | Basic Solar Plant Costs ($/kW) | $ 716 | | $ 646 | | $ 643 | |
| | Comparable Solar Plant Costs ($/kW) | $ 875 | | $ 766 | | $ 758 | |
| Project Configuration | | Basic | Comp | Basic | Comp | Basic | Comp |
| LCOE by Financing Scenario | DFI | 0.0640 | 0.0653 | 0.0590 | 0.0674 | 0.0588 | 0.0669 |
| | Blended | 0.0729 | 0.0860 | 0.0670 | 0.0768 | 0.0667 | 0.0762 |
| | Commercial | 0.0789 | 0.0935 | 0.0725 | 0.0833 | 0.0722 | 0.0826 |
| Number of Projects to reach RE Target | | 126 | | 51 | | 26 | |
| Total Solar Project Only Cost (in $ 'millions) | | $ 1,843 | $ 2,244 | $ 1,623 | $ 1,923 | $ 1,615 | $ 1,905 |
| Transmission Upgrade Cost | | $ 473 | | | | | |
| **Total Cost (in $ 'millions)** | | **$2,316** | **$2,716** | **$2,096** | **$2,396** | **$ 2,088** | **$ 2,378** |

- To implement solar PV projects sufficient for reaching the RE target, the NITS will require reinforcement in key spots. The exact scope and extent of the transmission projects depend on project location, project size, system load distribution, and NITS' performance at the time of implementation.
- It is estimated that a total investment of approximately US$473 million will be required for various NITS reinforcement projects intended to help resolve any challenges with transfer capacity and grid stability arising from the implementation of the solar PV projects.

## 7.5 Recommendations

Based on the analyses and observations contained in this report, the following recommendations are made:

- Solar PV projects should be implemented at the largest possible single module scale to improve the cost efficiency and savings to the power system.

- To facilitate improved tariff offers, solar PV projects should be competitively procured with provision of enabling services (such as intermittency mitigation and ancillary services) and land commonly provided to all bidders on the same terms. The procured solar PV project sites should be acquired by state agencies to minimize the cost of land acquisition. GRIDCo should be included as part of the stakeholders to identify suitable sites for large-scale solar PV projects as the cost-efficient evacuation infrastructure will be critical for efficient implementation.
- The solar PV projects should be implemented in the largest possible single module sizes and paired with competitive procurement to achieve the lowest LCOE possible for the particular financing arrangement.
- Regarding project deployment strategy, the smaller project modules, such as the 20 MW module, should be used to feed directly to local distribution networks, where viable. The larger project modules, for example, 50 MW and above, should then be deployed in cases where the generation would be evacuated through the Ghanaian NITS.

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