

GHG Methodological Note

This report provides the detailed methodological framework for quantifying avoided Greenhouse Gas (GHG) emissions associated with four high-impact mitigation projects under the Africa Sovereign Climate Fund (ASCF). The analysis employs technical standards derived from the Clean Development Mechanism (CDM) methodologies, adapted for use in feasibility-stage assessments and structured for rigorous reporting under International Financial Institution (IFI) guidelines.

I. Foundational Principles and Portfolio Context

I.A. Preamble and Alignment with International Standards

The objective of this methodological note is to establish a transparent, reproducible, and methodologically conservative basis for estimating the long-term climate mitigation impact of ASCF investments. The quantification framework is rooted in a project-based accounting approach, which compares a “without-project” baseline scenario against a “with-project” intervention scenario for each investment.

This approach is globally consistent, adhering to the GHG Protocol for Project Accounting and the WBCSD Guidance on Avoided Emissions (2023). Specifically, the mitigation activities deploy relevant CDM methodologies as rigorous technical standards: ACM0002 for Angola and Nigeria Lafia, AM0019 for Benin, AMS-11.A for Nigeria T&D Efficiency.

The project portfolio covers diverse mitigation areas: grid-connected renewable electricity generation (Angola and Nigeria Lafia), captive renewable electricity for an industrial mini-grid (Benin), and supply-side energy-efficiency improvements in transmission and distribution (Nigeria).

Acknowledging that these projects are at an early feasibility or conceptual stage, the data necessary for full CDM registration (such as detailed design parameters, load flow models, or ex-post surveys) are often unavailable. Consequently, the methodology relies on specific, carefully justified simplifications and conservative proxies, as explicitly permitted by climate finance facilities like the Green Climate Fund (GCF) for early-stage infrastructure projects. These approximations ensure that the final calculation of emission reductions does not risk overestimation, maintaining the principle of conservation throughout the assessment.

All four mitigation case studies are illustrative. Full application of the underlying CDM methodologies—including baseline validation, detailed additionality demonstration using CDM Tool 01/Tool 02 or equivalent, and updated activity data and country-specific emission factors—will be undertaken at Funding Proposal stage and may refine the ex-ante results presented here.

I.B. Temporal Boundaries and Reporting Horizons

Avoided emissions are quantified across fixed time horizons to align with ASCF portfolio monitoring and GCF reporting requirements.

The reporting timeline encompasses three critical points:

1. **Year 2 (Mid-term):** Reflects anticipated partial commissioning or initial operational ramp-up phase. The total attributed GHG reduction across the indicative pipeline for Year 2 is 25,084 tCO₂e.

2. **Year 4 (Final Term 1):** Represents the stage of full commissioning or stable, steady-state operation. The total attributed GHG reduction for Year 4 is 104,474 tCO₂e.
3. **Long-term Horizon (Y20–Y40):** Aligned with the expected physical and technical operational lifetime of the assets. The total projected lifetime GHG reduction is 3,415,433 tCO₂e.

Specific asset lifetimes utilized for the calculation are defined by industry standards and GCF guidance:

- **Angola Hydropower:** 25-year operating life.
- **Benin Solar PV:** 25-year asset life (consistent with GCF default guidance for crystalline silicon PV systems).
- **Nigeria T&D Efficiency:** 30-year horizon (consistent with typical lifetimes of transmission and distribution assets).
- **Nigeria Lafia Solar PV Power Plant :** 25-year operating life.

I.C. Core Accounting Equation and Data Sources

The net emission reductions (ER_y) in any given year y are calculated as the difference between the emissions that would occur in the baseline scenario (BE_y), the actual emissions occurring in the project scenario (PE_y), and any quantified indirect emissions (leakage, LE_y).

$$ER_y = BE_y - PE_y - LE_y$$

Data Sources and Emission Factors

The assessment relies on primary data from project feasibility studies, complemented by internationally recognized reference datasets for emission factors and grid characteristics.

1. **Grid Emission Factors (EFs):** Drawn from the UNFCCC–IFI joint grid emission factor dataset (2022) and the EIB Project Carbon Footprint Methodology (2023). These sources provide Combined Margin (CM) factors consistent with CDM methodology TOOL07. Crucially, time-varying adjustments are applied using regional NGFS Net Zero 2050 decarbonization trajectories for Africa, dynamically forecasting the future power mix to ensure baseline EFs decline over time.
2. **Life Cycle Assessment (LCA) Factors:** Project-specific factors for renewable generation technologies (hydropower and solar PV), as well as construction-phase embodied emissions, are sourced from the Ecoinvent 3.11 “supply-only” datasets.

Treatment of Construction Emissions

In adherence to traditional CDM and IFI practice, operational project emissions (PE_y) explicitly exclude emissions resulting from the manufacturing and construction phases. These embodied emissions, such as the estimated 845,300 tCO₂e for the 50 MW Angola hydropower project, are quantified separately within the overall GCF assessment to ensure a complete life-cycle perspective, but they do not diminish the calculation of annual operational emission reductions (ER_y) under the adopted CDM methodologies.

II. Project Methodology 1: Angola Chicomba Hydropower (ACM0002)

II.A. Methodology, Applicability, and Project Boundary

The Chicomba Water Dam project is quantified using the **Large-scale Consolidated Methodology ACM0002: Grid-connected electricity generation from renewable sources**. The project, located in Huíla Province, is a reservoir-based hydropower plant designed to store and regulate seasonal water flow, distinguishing it from a run-of-river project. It is classified as a Greenfield renewable electricity generation activity exporting power to the grid (ACM0002, paragraph 5(a)), assumed to have an installed capacity of 50 MW, consistent with international definitions of medium hydro.

The project boundary includes the hydropower plant and reservoir, and all power plants physically connected to the Angolan electricity system that would be affected by the displacement of generation.

II.B. Baseline Emissions (BE_y): Dynamic Grid Factor Calculation

Angola's power system is **hydro-dominated**, with hydropower supplying around 71.5% of total generation and fossil units (oil and gas) providing the remainder. While hydropower accounts for the bulk of energy, fossil plants still set part of the marginal supply, particularly during dry seasons, peak demand and regional imports. In line with ACM0002, the baseline scenario is therefore defined as the continued operation and expansion of the existing Angolan grid mix, where the 175,200 MWh/year of clean electricity supplied by Chicomba would otherwise be generated by this evolving combination of hydro and fossil capacity.

The Challenge of Full CDM Tool Implementation

A formal CDM quantification requires calculation of the Combined Margin ($EF_{CM,y}$) using TOOL07, which mandates detailed proprietary data, including plant-level fuel consumption, hourly dispatch orders for the Operating Margin (OM), and technology-specific efficiencies for the Build Margin (BM). Because this granular information is currently undisclosed by the Angolan national utility (ENDE), a full TOOL07 calculation is infeasible.

Fixed Baseline Adaptation

To maintain methodological rigor under the ACM0002 framework, the assessment utilizes a proxy grid emission factor ($EF_{CM,y}$) that uses the Initial EF: Sourced from the UNFCCC-IFI grid emission factor dataset for Angola for 2026 0.62096 tCO₂/MWh.

The formula for baseline emissions is:

$$BE_y = EG_{proj,y} \times EF_{CM,y}$$

II.C. Project Emissions (PE_y): Conservative Reservoir LCA Factor

ACM0002 requires project emissions to account for potential reservoir-related greenhouse gases (CH₄ and N₂O), primarily determined by the **Power Density (PD)** of the plant. The PD threshold must be calculated using the reservoir surface area at full storage level.

Data Gap and Conservative Proxy

The detailed reservoir design information required for the PD calculation is not yet available for Chicomba. Without this data, the assessment cannot definitively apply the ACM0002 defaults (0 tCO₂/MWh for high-PD projects ≥ 10 W/m², or 0.09 tCO₂/MWh for medium-PD projects).

To ensure robust conservation in the emission reduction claim, the analysis adopts a conservative LCA-based emission factor for reservoir hydropower in tropical regions: 0.07183 tCO₂/MWh.

The technical rationale for this choice is based on risk mitigation. By applying a non-zero, mid-range factor (between 0 and 0.09 tCO₂/MWh), the calculation incorporates expected emissions typical of tropical water retention bodies, even in the absence of exact reservoir measurements. This effectively reduces the calculated net emission reduction (ER_y), proactively mitigating the possibility of overstatement should the dam's eventual power density prove lower than the optimal 10 W/m² benchmark, a relevant consideration given Huíla's semi-arid context.

The formula for project emissions is:

$$PE_y = EF_{hydro} \times EG_{proj,y}$$

Where $EF_{hydro} = 0.07183 \text{ tCO}_2/\text{MWh}$.

Leakage (LE_y) is assumed to be zero (no equipment transfer or biomass use). Emission reductions are therefore: $ER_y = BE_y - PE_y$.

Additionality

Table 1: Additionality for Project Methodology Angola Chicomba Hydropower (ACM0002)

CDM Additionality Step	Assessment and Justification
Step 1: Identification of Alternatives (Tool 02)	Credible Alternatives: Realistic alternatives to the 50 MW reservoir-based hydropower plant include: (A1) The project activity not undertaken; (A2) Continued operation and expansion of the fossil fuel-fired grid mix and imports to meet rising demand; and (A3) Development of alternative renewable capacity (e.g., solar farms). Regulatory Compliance: The project is not mandated by any national law or regulation, satisfying the initial ACM0002 applicability condition.
Step 2/3: Barrier or Investment Analysis (Tool 01)	Structural Barriers (Qualitative): A full quantitative investment analysis (IRR vs. WACC) cannot be performed at this stage due to missing proprietary data on tariffs, costs, and the precise financing structure for the hydropower component. However, Chicomba faces significant barriers typical of large multipurpose hydropower in a low-income, high-risk context: (i) high upfront CAPEX for civil works, electromechanical equipment and reservoir infrastructure; (ii) limited access to long-tenor local-currency finance and reliance on hard-currency debt subject to exchange-rate and sovereign risk premia; (iii) hydrological and political risk, including climate-related variability, which raises the cost of capital relative to more flexible thermal generation and deters purely commercial investors; and (iv) offtake and payment risk, given the financial position and creditworthiness challenges of the national utility (ENDE), with no robust cost-reflective tariff framework to secure cashflows. These barriers are specific, persistent and directly affect the project's bankability. In line with CDM Tool 01 and IAT guidance, they indicate that the project is unlikely to proceed at scale on purely commercial terms without concessional climate finance. Additionality is therefore considered plausible, with a detailed Tool 01 analysis to be undertaken at Funding Proposal stage once cost and tariff data are available.
Step 4: Common Practice Analysis	Large hydropower already represents a significant share of Angola's installed capacity and is therefore not uncommon in absolute terms. However, the combination of multipurpose water storage (for drought-resilient irrigation, water supply and flood management) with grid-connected hydropower in a semi-arid

	region remains limited and typically requires international public support. Recent investments have focused on large flagship schemes with substantial concessional involvement. Chicomba's medium scale, water-storage function and explicit climate-resilience role distinguish it from routine generation-only investments and provide potential demonstration effects for similar projects in Angola and neighboring countries.
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III. Project Methodology 2: Benin GDIZ Solar PV (AM0019)

III.A. Methodology and Applicability

The Benin Solar PV farm, intended to supply the Glo-Djigbé Industrial Zone (GDIZ) internal distribution network, is analyzed using the large-scale methodology AM0019: “Renewable energy projects replacing electricity from fossil fuel fired power plants.”

The project meets the functional criteria of AM0019: GDIZ currently relies on a dedicated 143 MW dual-fuel (gas/diesel) thermal plant, with supplementary supply from the national grid (SBEE) as needed. The thermal plant is an identifiable fossil-fuel power plant that either stands alone or supplies to a grid; the solar PV farm is designed to replace a share of its electricity output for a clearly defined consumer (the industrial zone).

The projected operational lifetime is assumed to be 25 years, corresponding to standard technical design life for utility-scale solar PV systems. Annual generation is set at 183,960 MWh/year, based on a 15% capacity factor consistent with regional benchmarks.

III.B. Baseline Scenario Selection and Conservative Factor

Under AM0019, the baseline is the continued operation of the identified fossil fuel plant supplying electricity to GDIZ in the absence of the renewable project. The baseline electricity generation ($EG_{BL,y}$) is assumed equal to the project generation ($EG_{proj,y}$), reflecting one-to-one replacement of thermal electricity by solar generation within the captive industrial network.

Where plant-specific efficiency and fuel data are not available, the emission factor of the GDIZ dual-fuel plant is approximated using CDM defaults for gas/diesel plants (TOOL03/TOOL33). Given the reliance on diesel and the desire to avoid overstating reductions, the analysis applies a conservative default fossil EF, consistent with AM0019 guidance.

The factors evaluated are:

- **Grid Emission Factor (EF_{grid}):** Starting at 0.5026 tCO₂/MWh (in 2025) and declining dynamically.
- **Diesel Generator Emission Factor (EF_{diesel}):** A fixed value of 0.8 tCO₂/MWh (sourced from TOOL33 default tables).

Given that the grid emission factor is lower than the diesel factor and also dynamically declines over the project life, the **dynamic grid emission factor is conservatively applied** as the displacement baseline. This mathematical floor prevents overstating emission reductions by avoiding the use of the higher-carbon diesel factor, even though diesel generation is a guaranteed part of the baseline mix during unstable grid periods.

The formula for baseline emissions is:

$$BE_y = EG_{proj,y} \times \text{MIN}(EF_{grid}, EF_{diesel})$$

Where $EG_{proj,y}$ is 183,960 MWh/year.

III.C. Project Emissions and Leakage

Consistent with AM0019 and standard CDM treatment of solar PV, project emissions (PE_y) are set to zero, as solar PV has no operational fuel use.

Leakage (LE_y) is set to zero, because the thermal plant remains within the same system and the project does not involve relocating generation capacity to other locations where it could increase emissions. Any structural reduction in thermal dispatch due to solar generation is captured within the baseline displacement.

Annual emission reductions are therefore: $ER_y = BE_y$.

Additionality

Table 2: Additionality for Project Methodology 2: Benin GDIZ Solar PV (AM0019)

CDM Additionality Step	Assessment and Justification
Step 1: Identification of alternatives (Tool 02)	Credible alternatives include: (B1) continuation of the existing GDIZ supply mix (dedicated dual-fuel plant plus grid imports); (B2) incremental expansion or repowering of the dual-fuel thermal plant; and (B3) smaller-scale rooftop PV on individual facilities without a coordinated 140 MW system. None of these alternatives involve a utility-scale solar farm of the planned capacity dedicated to the industrial zone. No regulation requires installation of the PV plant, and there is no mandatory renewable-share requirement specific to GDIZ.
Step 2/3: Investment and barrier analysis (Tool 01)	A full investment analysis is not feasible at this stage due to incomplete data on tariffs, financing terms and cost allocation between the zone developer and tenants. Nonetheless, AM0019 allows demonstration of additionality through sector- and project-specific barriers. The GDIZ solar project faces: (i) high upfront CAPEX for a 140 MW PV plant dedicated to a single industrial zone, with limited ability to recover costs through regulated tariffs; (ii) limited access to long-tenor finance for large captive renewables, particularly for industrial consumers whose creditworthiness is tied to a relatively new zone with evolving occupancy; (iii) perceived reliability risk, as zone operators are reluctant to rely predominantly on intermittent solar in a context of broader grid instability; and (iv) opportunity cost of capital, as available financing is more likely to be directed toward conventional infrastructure or thermal power with established contracts and predictable cashflows. These barriers are specific and significant, and they materially constrain the likelihood that the PV plant would be developed at the planned scale without concessional climate finance.
Regulatory and institutional barriers	Benin lacks a mature regulatory framework and incentive regime for large-scale captive renewable generation for industrial users. There is no established competitive procurement, feed-in tariff, or dedicated support scheme that would systematically favor investments like the GDIZ PV plant. The project requires coordination between the zone developer, the national utility and government entities, which is complex in a nascent industrial zone context. This regulatory and institutional uncertainty increases perceived risk and raises the effective WACC, reinforcing the need for concessional finance.

Step 4: Common practice analysis	Utility-scale solar plants are emerging in West Africa, but large captive PV systems of this magnitude dedicated to industrial zones remain rare. Existing plants tend to be grid-connected IPPs under structured procurement with sovereign guarantees. By contrast, a 140 MW captive PV plant integrated into an industrial mini-grid is not common practice in Benin. The project therefore departs from prevailing investment patterns and can reasonably be considered additional under AM0019, subject to a more detailed Tool 01 assessment at Funding Proposal stage.
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IV. Project Methodology 3: Nigeria T&D Efficiency (**AMS-II.A**)

IV.A. Methodology and Applicability

The Nigeria Transmission and Distribution (T&D) Efficiency Upgrade Project is quantified using the small-scale methodology **AMS-II.A: “Supply side energy efficiency improvements – transmission and distribution”**, which covers projects that reduce technical losses in electricity networks through physical interventions such as transformer replacement, reconductoring, expansion of an existing system and voltage-upgrade measures. AMS-II.A is for small scale projects where expected loss reduction does not exceed 60 GWh/year, which is unlikely to be the case in this large project. However, this method was still retained as the alternatives AM0067 covers only energy efficient transformers and AM0097 focuses on high voltage transmission lines, whereas this project focuses on distribution lines as well as transformers which are both covered within AMS-II.A. Because the project is still under conceptual definition and feeder-specific engineering design is ongoing, AMS-II.A is used as a structuring framework for estimating GHG impacts, consistent with GCF guidance for early-stage grid projects. The current assessment is not intended to provide a full CDM assessment.

The project focuses on reducing technical losses through transformer replacement with high-efficiency units, reconductoring, line profiling and LV/MV distribution upgrades and extensions within Lot 3 of the Presidential Power Initiative (PPI). The project boundary is restricted to the specific physical T&D segments (distribution lines 0.4–33 kV and associated substations) in which the upgrades are implemented, ensuring that only technical losses (and not commercial or collection losses) are included in the accounting.

IV.B. Baseline Scenario Reconstruction

The baseline scenario is the perpetuation of technical energy losses in the existing T&D system in the absence of the efficiency upgrades.

Proxy Data and Baseline Energy

The baseline scenario is the perpetuation of technical energy losses in the existing T&D system in the absence of the efficiency upgrades. As is common for early-stage grid interventions in decentralized environments, detailed feeder-level data (SCADA logs, geospatial data, loss metering) required for a full bottom-up baseline are not available. Therefore, the quantification relies on a proxy approach AMS-II.A’s allowance for conservative use of aggregated data:

The baseline energy losses ($EL_{BL,y}$) are approximated by the total electricity delivered to the 4.1 million direct beneficiaries (specified in the Feasibility Study for the project) multiplied by 0,138 MWh/person/year (electricity delivered in Nigeria according to IEA Data Services), quantified as 567,180 MWh/year.

Baseline Emission Factor (EF_{BL})

In line with AMS-II.A paragraphs 4–8, the baseline corresponds to the technical energy losses that would continue to occur in the existing Nigerian transmission and distribution system in the absence of the project. At this stage, feeder-level measurements and historical technical loss data are not available, which is common for early-stage grid-efficiency interventions. Consistent with the flexibility provided in AMS-II.A Option 2, the baseline is therefore constructed using a conservative, system-level representation of the electricity supply mix on the affected feeders.

Because CDM-compliant technical loss measurements are unavailable, the baseline emission factor is computed using the an estimated proxy of technical losses across the entire Nigerian national grid applied to the electricity delivered to beneficiaries of this project.

- Technical Loss Factor T&D losses as % of output at 14.08% for Nigeria for 2022 (<https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS> based on IEA data)
- $EL_{BL,y}$: Electricity delivered to beneficiaries: 567, 180 MWh
- $EF_{BL,y}$: A Nigerian grid combined margin emission factor of 0.312 tCO₂/MWh (2025 UNFCCC-IFI dataset, recognised as an ex-ante proxy for the 30-year period).

Baseline emissions are calculated using: $BE_y = EL_{BL,y} \times EF_{BL,y} \times \text{Technical Loss Factor}$

This approach is permitted under AMS-II.A Option 2 for projects without available loss-metering data.

This provides a conservative and transparent estimate of baseline losses and emissions, consistent with AMS-II.A Option 2(i) and the data constraints typical of early-stage T&D efficiency projects in Nigeria.

IV.C. Project Emissions and Conservatism

Under AMS-II.A, project emissions correspond exclusively to the technical losses of the upgraded transmission and distribution equipment during the crediting period (paragraph 9). The methodology does not assign emissions to the electricity delivered through the grid, nor to the consumers supplied by the upgraded system. Only technical energy losses within the project boundary are eligible sources of PE_y.

In the absence of feeder-level transformer specifications at this stage, PE_y is estimated by taking into account:

- Reduced Technical Loss Factor : The lower technical loss factor taken into account of 2% is considered to be conservatively high, and it is based on a study of technical loss factors on a new distribution network in Nigeria.¹ Also, this factor is conservative when considering two CDM project registered in 2012 for two Indian distribution networks upgrade under AMS-II.A ("Energy efficiency programme in electricity distribution network in Chittoor and Madanapalle operational division of Andhra Pradesh" and "Energy efficiency programme in electricity distribution network in Tirupati and Puttur operational division of Andhra Pradesh"), which both assumed a factor of 1% (also seen as conservative based on the PDDs) - lower than the 2% considered here.

- $EL_{PE,y}$: Electricity delivered to beneficiaries: 567, 180 MWh

- $EF_{PE,y}$: Applying the Nigerian grid combined margin emission factor of 0.312 tCO₂/MWh as per the Baseline Project emissions are calculated using:

$$PE_y = EL_{PE,y} \times EF_{PE,y} \times \text{Reduced Technical Loss Factor}$$

$$PE_y \approx 3,544 \text{ tCO}_2/\text{year}$$

This approach ensures methodological consistency with AMS-II.A while maintaining conservativeness due to limited data on reduced losses.

¹ Evaluation of Technical Losses in Enugu 33kV/11kV Metropolis Networks

IV.C. Leakage

In accordance with AMS-II.A paragraph 10, leakage must be considered only if the project uses equipment transferred from another activity.

For the project, the transformers that will be replaced for high capacity versions will be reused resulting in leakage (although some will be stored and reused later). Project documentation does not mention the number of transformers hence an assumption of 0.2 per km of line (typical ratio for semi-urban/rural MV distribution networks) for the 4798 km of reconducted lines resulting in around 959 reused transformers.

Since no detailed project data are available, to calculate leakage emissions associated with the re-use of existing transformers we have considered no-load losses (in W) for inefficient transformers from a project registered under methodology AM0067 in Kenya ("Installation of Energy Efficient Transformers (IET)", PoA), in which the no-load losses are estimated at 200 W/unit. We recognize this value is specific for the Kenyan project, but we consider it to be a reasonable proxy to estimate LE in our situation, considering the lack of project specific data.

This value is then multiplied by the assumed operating hours and Nigeria's grid emission factor (0.312 tCO₂/MWh). Applying the leakage formula results in approximately 0.54 tCO₂/unit/year. Scaling to an assumed 959 replaced transformers yields: LE_{n,g} ≈ 525 tCO₂/year.

Under AMS-II.A, emission reductions are calculated as: $ER_{\gamma} = BE_{\gamma} - PE_{\gamma} - LE_{\gamma}$

Where: BE_γ = baseline emissions (technical losses in absence of the project), PE_γ = project emissions from residual no-load losses of efficient transformers and upgraded and extended distribution networks, LE_γ = leakage from continued operation of displaced inefficient transformers.

Using the proxy parameters applied to Nigeria: BE_γ ≈ 24,948; PE_γ ≈ 3255 tCO₂/year and LE_γ ≈ 525 tCO₂/year. Therefore, ER_γ = 24,948 - 3,255 - 525 tCO₂/year.

Additionality

Table 3: Additionality for Project Methodology 3: Nigeria T&D Efficiency (AMS-II.A)

CDM Additionality Step	Assessment and Justification
Step 1: Identification of alternatives (Tool 02)	Alternatives include: (N1) continuation of current T&D practices with incremental, ad-hoc repairs but no systematic efficiency programme; (N2) partial upgrades financed solely by DisCos/TCN out of tariffs and limited internal cashflows; and (N3) alternative supply-side investments (e.g. new generation capacity) without targeted network loss reduction. No regulation mandates the specific package of interventions envisaged under PPI Lot 3, nor is there an existing national programme systematically renewing distribution transformers at scale to compliant efficiency levels.
Step 2/3: Investment and barrier analysis (Tool 01)	A full quantitative investment analysis is not feasible at this early stage due to lack of detailed cost recovery projections, tariff trajectories and contractual arrangements. However, the sector exhibits persistent, well-documented barriers: (i) chronic financial distress of Nigeria's Distribution Companies (DisCos), characterized by high Aggregate Technical, Commercial and Collection (ATC&C) losses, low cost-recovery and limited access to affordable

	debt; (ii) misaligned incentives, as investments in T&D efficiency require high upfront CAPEX while near-term financial gains are modest and often uncertain relative to generation-side projects; (iii) the structural inability of TCN/DisCos to finance large-scale transformer replacement and reconductoring from internal resources or local commercial banks; and (iv) persistent grid unreliability, which discourages private and public investment in the network and locks in reliance on diesel self-generation. These barriers directly affect the project's feasibility and are consistent with the types of obstacles recognized in AM0067 and IAT guidance for energy-efficiency programmes.
Regulatory and institutional barriers	Regulatory and institutional constraints reinforce these financial barriers: tariff-setting frameworks do not reliably remunerate efficiency investments; performance-based regulation remains nascent; and there is no mandatory programme for replacing inefficient transformers with high-efficiency models. The PPI, supported by concessional climate finance, is one of the few vehicles available to implement a coordinated, large-scale loss-reduction programme in the Nigerian grid.
Step 4: Common practice analysis	While isolated transformer replacements and limited feeder upgrades occur, there is no established practice of implementing grid-wide energy-efficiency programmes at scale without substantial development-partner support. The combination of high-efficiency transformers, systematic reconductoring and targeted LV/MV improvements under a national initiative remains non-standard. Historical underinvestment and the persistent high level of technical and non-technical losses indicate that the project activity is not business-as-usual.

V. Project Methodology 4: Lafia Nasarawa State Utility-Scale Solar Project

The analysis utilizes the Clean Development Mechanism (CDM) framework, specifically ACM0002 (“Large-scale consolidated methodology for grid-connected electricity generation from renewable sources”), which is applicable to large-scale solar PV projects displacing grid electricity.

1. Project Boundary and Description

The project activity involves the installation of a 350 MWdc (276 MWac) solar photovoltaic power plant in Lafia, Nasarawa State, connected to the Nigerian national grid.

- **Spatial Boundary:** Includes the project power plant (PV modules, inverters, transformers), the site area of 426 hectares, and the interconnection point at the Lafia 330 kV/132 kV substation.
- **Greenhouse Gases (GHGs):** The primary GHG reduced is Carbon Dioxide (CO_2). Methane (CH_4) and Nitrous Oxide (N_2O) from the baseline fossil fuel combustion are also avoided but are often excluded in conservative CDM calculations for grid projects.
- **Timeframe:** The analysis considers the operational lifetime (25 years, based on linear warranty) and the 3-year construction timeline.

2. Baseline Scenario and Methodology

Baseline Scenario: In the absence of the project, electricity would be generated by the operation of existing grid-connected power plants and the addition of new generation sources. Nigeria’s grid is dominated by gas-fired thermal plants (nearly 77%) and hydropower (22%).¹ Furthermore, due to grid unreliability (high frequency of system collapses and load shedding), there is heavy reliance on fossil-fuel backup generators (diesel/gasoline).

Baseline Emission Factor: The analysis adopts ASB0034-2021: Grid emission factor for the West African Power Pool. This standardized baseline covers the interconnected electricity system of nine countries, including Nigeria.

- **Reference:** UNFCCC ASB0034-2021 (Version 01.0).² While the validity period technically ended in Feb 2024, these remain the reference values until the UNFCCC releases the approved update
- **Operating Margin (OM):** $0.578 \text{ tCO}_2/\text{MWh}$
- **Build Margin (BM):** $0.556 \text{ tCO}_2/\text{MWh}$
- **Combined Margin (CM):** For solar PV projects, the CDM methodology assigns a specific weighting ($w_{OM} = 0.75, w_{BM} = 0.25$).
 - Calculation: $(0.578 \times 0.75) + (0.556 \times 0.25) = 0.573 \text{ tCO}_2/\text{MWh}$.

3. GHG Emission Reduction Calculation

A. **Annual Energy Production (AEP):** 653,128 MWh/year (based on project Feasibility study).

B. **Baseline Emissions (BE_y)**

The baseline emissions are the emissions avoided by displacing grid electricity.

$$BE_y = EG_{PJ,y} \times EF_{grid,y}$$

– $EG_{PJ,y}$ (Electricity Generation): 653,128 MWh/year – $EF_{grid,y}$ (Emission Factor): $0.573 \text{ tCO}_2/\text{MWh}$

Annual Baseline Emissions:

¹ <https://www.iea.org/countries/nigeria>

² [ASB0034-2021.pdf](#)

$$653,128 \text{ MWh} \times 0.573 \text{ tCO}_2/\text{MWh} \approx 374,242 \text{ tCO}_2/\text{year}$$

C. Project Emissions (PE_y) - Operational

Under CDM methodology for Solar PV, $PE_y = 0 \text{ tCO}_2$.

D. Net Emission Reductions (ER_y)

$$ER_y = BE_y - PE_y$$

$$ER_y = 374,242 - 0 = 374,242 \text{ tCO}_2e/\text{year}$$

4. Additionality and Common Practice Analysis

A. Investment Barrier Analysis

- **High Capital Cost:** Utility-scale solar requires significant upfront capital. Without this concessional/external financing, the project likely could not compete with established state-subsidized thermal generation or simple cycle peakers.
- **Infrastructure Gaps:** The project requires heavy investment in associated interconnection infrastructure and grid management software (SCADA) to function on the Nigerian grid.

B. Technological Barrier

- **Knowledge Gap:** There is a need for a dedicated “knowledge transfer facility” and training because local expertise in operating 350MW solar plants with single-axis trackers and BESS is currently limited.

C. Common Practice Analysis

- **Dominant Practice:** Nigeria’s energy mix for electricity generation is Natural Gas (approx. 77%) and Hydro (approx. 22%).
- **Backup Practice:** The common practice for reliability is widespread diesel generator usage (estimated 5 million units in Nigeria).
- A 350 MW grid-connected solar plant with BESS represents early-stage technology penetration.

5. Leakage and Construction Timeline Impact

- **Construction Leakage:** Emissions from the transport of 594,054 panels and civil works over the 3-year construction period constitute a one-time release of GHGs.
- **Timeline Impact on Crediting:**
 - **Years 1-3 (Construction):** Negative GHG impact (emissions from diesel trucks, site clearing of 426 Ha, manufacturing).
 - **Year 4+ (Operation):** Net positive GHG reduction of $\sim 374,242 \text{ tCO}_2/\text{year}$.
- **Payback Period:** Based on the lifecycle emissions ratio, the carbon payback period - where the emissions saved exceed the emissions created during construction - is approx. 3 years of operation.

Monitoring plan

The following monitoring plan is designed to track lifecycle emissions in alignment with CDM principles. While standard CDM methodology ACM0002 (Grid-connected electricity generation from renewable sources) primarily focuses on operational emission reductions, it references specific CDM Methodological Tools that can be voluntarily applied to monitor construction and leakage emissions. This plan integrates those tools to provide a rigorous accounting of the project's full carbon footprint.

1. Construction Phase Monitoring Plan

This table utilizes specific CDM Tools to track the carbon debt incurred during the 3-year construction phase.

Lifecycle Stage	Emission Source	Monitoring Parameter	Unit	Frequency	CDM Tool / Method Alignment
Construction (On-Site)	Diesel Generators & Heavy Machinery (Excavators, Cranes)	Quantity of Fuel Consumed ($FC_{i,y}$)	Liters / Tonnes	Monthly (aggregated annually)	CDM TOOL03: "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion". <i>Method:</i> Purchase receipts or flow meters on site tanks.
Construction (On-Site)	Electricity Grid Usage (during civil works)	Electricity Consumed ($EC_{PJ,y}$)	MWh	Monthly	CDM TOOL05: "Baseline, project and/or leakage emissions from electricity consumption". <i>Method:</i> Utility meters or sub-meters at site office/camp.
Upstream Transport	Delivery of Modules, Inverters, & BESS (Port to Site)	Distance Travelled ($D_{f,y}$) & Weight of Freight ($W_{f,y}$)	km & Tonnes	Per Shipment	CDM TOOL12: "Project and leakage emissions from transportation of freight". <i>Method:</i> Bill of Lading (BoL) and GPS logs for truck routes.
Embodied Emissions	Manufacturing of PV Modules & BESS	Global Warming Potential (GWP) per unit	$kgCO_2e$ / kWp	One-time (Pre-install)	Lifecycle Assessment (LCA): Request Environmental Product Declarations (EPDs) from suppliers (e.g., ISO 14025).
Land Use Change	Site Clearance (Vegetation Removal)	Area Cleared	Hectares	One-time	A/R CDM Tools: Estimate biomass loss due to site clearing

2. Operational Phase Monitoring Plan

Once operational, the monitoring shifts to verifying the Emission Reductions (ER_y) generated by the project, which generates the carbon credits (CERs). This strictly follows ACM0002.

Parameter	Description	Measurement Method	Recording Freq.
$EG_{facility,y}$	Net electricity generated and supplied to the grid by the solar plant in year y .	Main Bidirectional Energy Meter at the Point of Interconnection (Lafia Substation). <i>Accuracy: 0.2s class or higher.</i>	Continuous (Hourly integration)
$EG_{import,y}$	Electricity imported from the grid by the project (when PV/BESS is offline or charging from grid).	Main Bidirectional Energy Meter (Import register).	Continuous

Parameter	Description	Measurement Method	Recording Freq.
$EF_{grid,y}$	Grid Emission Factor (Combined Margin) for Nigeria.	Calculated annually using the CDM "Tool to calculate the emission factor for an electricity system".	Annually
$T_{ambient}$	Ambient temperature at the site (affects PV efficiency).	Weather Station (SCADA).	Hourly
GHI_{site}	Global Horizontal Irradiance (Solar Resource).	Pyranometers (SCADA).	Hourly

3. QA/QC Procedures for Lifecycle Data

To ensure the "Lifecycle" data is robust enough for audit (e.g., for Gold Standard or ESG reporting):

- **Fuel Cross-Check:** Compare measured fuel consumption ($FC_{i,y}$) with the theoretical consumption based on the operating hours of construction machinery.
- **Leakage Management:** For the BESS, monitor the Round-Trip Efficiency (RTE) annually to ensure energy losses (which represent indirect emissions) do not exceed manufacturer warranties.
- **Supplier Engagement:** Include a requirement in the EPC contract for suppliers to provide Carbon Footprint Verification for the PV modules (Passivated Emitter and Rear Cell - PERC) and Lithium-Ion batteries, as these constitute the bulk of embodied emissions.

Adjustment of AFC investment

The **Lafia Nasarawa State Utility-Scale Solar Project** is not assessed as part of the feasibility report. Public records confirm the financial value of the portfolio to which Lafia belongs:

- **Total Portfolio Value:** The Lafia project is part of a 5-site Phase 1 portfolio valued at approximately \$2.2 billion.
- **Total Capacity:** 961 MW Solar PV + 455 MWh Battery Storage across 5 sites (Gwagwalada, Gombe, Lafia, Geregu, and Ihovbor).
- **Lafia Specifics:** 350 MW Solar PV + 166 MWh Battery Energy Storage System (BESS).
- **Lafia's estimated cost:** Lafia represents approximately **36.4%** of the total portfolio's capacity ($350/961 \approx 0.364$). Applying this percentage to the total budget ($\$2.2 \text{ billion} \times 0.364$) results in an estimated capital expenditure of ~\$801 million for the Lafia site alone.
- AFC's proposed contribution: \$65 million
- AFC's financing share (of the total) = 8.115%
- AFC's attributable share of the total emissions: $374,242 \text{ tCO}_2e \times 0.08115 \approx 30,369 \text{ tCO}_2e/\text{year}$

Lifetime emissions avoided (over 25 year lifespan, with no emission reductions for the construction period in years 1-3): $30,369 \times 22 = 668,123 \text{ tCO}_2e$

VI. Synthesis and Reporting of GHG Impact

VI.A. Consolidated Project Methodological Mapping and Key Parameters

The table below summarizes the technical approaches and the application of conservative measures across the four mitigation projects.

Table 4: Project Methodological Mapping and Key Input Parameters

Project	CDM Methodology	Primary Displacement	Metric	Project Lifetime (Years)	Conservative Project EF	Baseline EF Approach	Status/Assumptions
Angola Hydro	ACM0002	Grid electricity	MWh	25	0.07183 tCO ₂ /MWh (LCA Proxy for PE)	Dynamic CM (IFI + NGFS trajectory)	50 MW capacity; Data gaps force proxy use.
Benin Solar PV	AM0019	Captive thermal/Grid	MWh	25	0 (PE excluded by methodology)	Conservative: Lower of Grid EF (dynamic) vs. Diesel EF (0.8 tCO ₂ /MWh)	140 MW capacity; Applied as reference standard due to size (>15MW).
Nigeria T&D	AMS-11.A	Technical losses (Hybrid supply)	MWh	30	Non-zero PE and leakage based on AMS-11.A Baseline: 24,948 tCO ₂ /year; Project emissions: 3,544 tCO ₂ /year Leakage; ≈525 tCO ₂ /year)	Baseline emissions: 24,948 tCO ₂ /year using 0,312 tCO ₂ /MWh Emission factor - Nigerian grid (Combined Margin equivalent)	Focus on technical loss reduction; Baseline reflects systemic grid technical losses.
Nigeria Lafia solar	ACM0002	Grid electricity	MWh	25	0 (PE excluded by methodology)	Grid emission factor for the West African Power Pool (0.573 tCO ₂ /MWh)	350 MWdc grid-connected solar PV plant.

VII. Detailed Methodological Steps and Formulas (Summary)

This section provides the final summary of the calculation structure for verification and monitoring purposes.

Table 5: Summary of Mitigation Calculation Formulas

Project	Methodology	Baseline Emissions (BE_y)	Project Emissions (PE_y)	Leakage (LE_y)	Emission Reduction (ER_y)
Angola Hydro	ACM0002	$BE_y = EG_{proj,y} \times EF_{CM,y}$	$PE_y = EF_{hydro} \times EG_{proj,y}$ (Using $EF_{hydro} = 0.07183 \text{ tCO}_2/\text{MWh}$)	0	$ER_y = BE_y - PE_y$
Benin Solar PV	AM0019	$BE_y = EG_{proj,y} \times \text{MIN}(EF_{grid,y}, 0.8 \text{ tCO}_2/\text{MWh})$	0	0	$ER_y = BE_y$
Nigeria T&D	AMS-11.A	$BE_y = EL_{BL,y} \times \text{Technical Loss Factor (14.08\%)} \times EF_{grid,y}$	$PE_y = EL_{PE,y} \times \text{Reduced Technical Loss Factor (2\%)} \times EF_{grid,y}$	$LE_y \approx 525 \text{ tCO}_2/\text{year}$	$ER_y = BE_y - PE_y - LE_y$
Nigeria Lafia solar	ACM0002	$BE_y = EG_{PJ,y} \times EF_{grid,y}$	0	0	$ER_y = BE_y$

VII.A. Critical Monitoring Requirements (Ex-Post Verification)

For continuous compliance with CDM principles and robust reporting, subsequent project phases must address the current data limitations through dedicated monitoring and verification protocols:

- **Angola Hydropower (ACM0002):** The feasibility studies must prioritize the quantification of the reservoir surface area at full storage level. This is required to determine the project's Power Density (PD) and formally verify the continued use of the LCA proxy factor or transition to the official ACM0002 thresholds.
- **Benin Solar PV (AM0019):** The primary verification requirement is the mandatory metering of net electricity supplied to the internal distribution network ($EG_{proj,y}$), as this value is directly equated to the baseline energy displaced (BE_y), due to zero project emissions/leakage. Monitoring must also confirm that the dual-fuel GDIZ plant remains the relevant baseline fossil source (i.e. no unexpected low-carbon plant replaces it) and that the project continues to use conservative default fossil emission factors (TOOL03/TOOL33) where plant-specific data are not available.
- **Nigeria T&D Efficiency (AMS-11.A):** To validate efficiency improvements and replace proxy values used ex ante, the project must:
 - Establish **verifiable baseline technical loss data** for the targeted lines and transformers prior to commissioning (energy in vs. energy out, by segment), consistent with **AMS-11.A**;
 - Implement **continuous metering and operational monitoring** (e.g. SCADA / smart meters) to measure technical losses post-upgrade, enabling calculation of project losses and PE_y from efficient transformers using project-specific nameplate data and operating hours;

- Maintain a **complete inventory of replaced transformers** and document their final disposition (scrapped, stored, redeployed) to quantify or eliminate leakage in line with **AMS-11.A**.
- **Nigeria Lafia (ACM0002)**: The primary verification requirement is the mandatory metering of net electricity supplied to the Western Africa Power Pool, and the updating of the grid emission factor to ensure that the baseline reflects changes in the baseline over time. Physical inventory of the PV assets included in the project boundary will also be required to ensure that the production capacity assumptions remain valid.

VII.B. Detailed Monitoring Plan During Implementation

This sub-section expands upon the Critical Monitoring Requirements, outlining the specific parameters and processes required for continuous verification during the operational lifespan of each asset, ensuring adherence to the respective CDM methodological frameworks (ACM0002, AM0019, AMS-11.A and AM0031).

1. Angola Chicomba Hydropower (ACM0002)

Table 6: Detailed monitoring plan during implementation for Angola Chicomba Hydropower (ACM0002)

Parameter	Required Data/M Measurement	Frequency & Method	CDM Requirement Addressed
Project Electricity Generation ($EG_{proj,y}$)	Net electricity delivered to the grid in MWh/year.	Continuous metering at the project boundary substation. Annual calculation.	Primary GHG reduction metric.
Reservoir Surface Area	Surface area of the reservoir at maximum operating level (in m^2 or km^2).	One-time measurement post-construction, via bathymetric or geospatial survey (GIS).	Required to calculate Power Density (PD) for mandatory Project Emissions determination.
Grid Emission Factor ($EF_{CM,y}$)	Annual Combined Margin EF of the Angolan grid (in tCO_2/MWh).	Annual update using national grid data or publicly accepted IFI/UNFCCC factors to maintain the dynamic baseline.	Ensures the baseline reflects grid decarbonization over time.
On-site Fossil Fuel Consumption	Quantity and type of fuel consumed for non-generation activities (e.g., maintenance, administration).	Annual record keeping via invoices or logbooks.	Accounts for any operational Project Emissions not related to the reservoir.

2. Benin GDIZ Solar PV (AM0019)

Table 7: Detailed monitoring plan during implementation for Benin GDIZ Solar PV (AM0019)

Parameter	Required Data/M Measurement	Frequency & Method	CDM Requirement Addressed
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Project Electricity Generation ($EG_{proj,y}$)	Net electricity generated by the PV plant and supplied to GDIZ (MWh/year).	Continuous metering at the point of interconnection to the internal grid. Annual summary.	Core parameter for baseline and project emissions under AM0019.
Fossil Plant Operating Status	Confirmation that the GDIZ dual-fuel plant remains the relevant baseline plant (fuel type, capacity, operating regime).	Annual qualitative review of operator records.	Confirms applicability of AM0019 baseline definition.
Fossil Emission Factor (EF_{fossil})	Default or plant-specific EF for the dual-fuel plant (tCO ₂ /MWh).	Periodic check against TOOL03/TOOL33 and any new plant data.	Used to validate the constant Diesel EF (0.8 tCO ₂ /MWh) assumed for the minimum EF comparison.
Physical Inventory of PV Assets	Installed capacity (MW), module and inverter types, location, O&M records.	Annual verification.	Confirms project boundary and capacity assumptions.

1. *Nigeria T&D Efficiency (AMS-II.A)*

Table 8: Detailed monitoring plan for Nigeria T&D Efficiency (AMS-II.A)

Parameter	Required Data/Measurement	Frequency & Method	CDM Requirement Addressed
Baseline Technical Energy Losses ($EL_{BL,y}$)	Pre-project technical losses in targeted lines/transformers (energy in vs. energy out, MWh/year).	One-off measurement or model validation prior to implementation, using utility data and/or targeted measurements.	Establishes baseline emissions in relevant T&D segments.
Project Technical Energy Losses (PE_y Loss)	Post-upgrade technical losses (MWh/year) in the same segments (and extended segments).	Continuous (e.g. SCADA / smart meters) with annual aggregation.	Enables calculation of actual loss reduction.
Replaced Transformer Inventory & Fate	Number, rating and destination of removed transformers (scrapped, stored, redeployed).	Inventory at decommissioning; follow-up checks where equipment is redeployed.	Required to quantify or rule out leakage (LE_y).
Grid Emission Factor ($EF_{grid,y}$)	Emission factor of grid electricity (tCO ₂ /MWh) used for baseline, PE_y and LE_y .	Annual update using national / IFI/UNFCCC sources.	Ensures consistency with ex-ante assumptions and AMS-II.A.

1. *Nigeria Lafia (ACM0002)*

Table 11: Detailed monitoring plan for Nigeria Lafia (ACM0002)

Parameter	Required Data/M Measurement	Frequency & Method	CDM Requirement Addressed
Project Electricity Generation ($EG_{proj,y}$)	Net electricity generated by the PV plant and supplied to GDIZ (MWh/year).	Continuous metering at the point of interconnection to the grid. Annual summary.	Core parameter for baseline and project emissions under ACM0002.
Grid Emission Factor ($EF_{CM,y}$)	Annual Combined Margin EF of the West African Power Pool (in tCO ₂ /MWh).	Annual update using West African Power Pool data or publicly accepted IFI/UNFCCC factors to maintain the dynamic baseline.	Ensures the baseline reflects grid decarbonization over time.
Physical Inventory of PV Assets	Installed capacity (MW), module and inverter types, location, O&M records.	Annual verification.	Confirms project boundary and capacity assumptions.

Mitigation Activity Table

The table 12 below summarises the indicative mitigation activities that are expected to be supported across participating countries. It describes, for each activity, the applicable methodologies or tools, baseline and additionality justification, results from common practice analysis, GHG boundaries, and the indicative mitigation impact based on the programmatic scenarios outlined above. The table does not represent a finalised project pipeline. Instead, it functions as a programmatic tool that ensures that all potential interventions are assessed in a transparent, consistent, and methodology-based manner in line with GCF and IPCC guidance. As additional subprojects are identified, project-specific data will be incorporated using the same methodological approach, and mitigation estimates will be updated within the programme's monitoring framework. All detailed assumptions, parameter definitions, calculation procedures, and programme-level aggregation rules are provided in the ASCF Programme Mitigation Methodological Note, which governs quantification across the Programme lifecycle

Table 9: Mitigation Activity Table

Country	Mitigation activity	Methodologies / tools	Baseline & additionality	Common practice (if relevant)	Boundaries	Impact (tCO ₂ eq)
Angola	Construction of the Chicomba reservoir-based hydropower plant (assumed to be approx. 50 MW reference case) to supply clean electricity to the Angolan grid, displacing fossil-based marginal generation.	Primary: CDM methodology ACM0002 <i>Grid-connected electricity generation from renewable sources</i> (used as reference standard). Supporting tools/data: GHG Protocol for Project Accounting; UNFCCC-IFI grid emission factor dataset.	The baseline is the continuation of Angola's existing grid mix, where fossil units – despite a high national hydro share – continue to set part of marginal generation, especially during dry periods. In the absence of Chicomba, the same electricity would be supplied by this mix. Additionality is supported by well-documented barriers to medium-scale, reservoir-based hydro in Angola: very high upfront CAPEX, limited availability	Hydropower is widespread in Angola, but integrated reservoir projects that combine hydropower with water-storage and local resilience benefits remain rare, particularly in drought-prone regions.	The boundary includes the Chicomba hydropower plant and reservoir; all grid-connected plants in the Angolan electricity system whose output would be displaced; and reservoir-related CH ₄ /CO ₂ emissions. Construction emissions are excluded under ACM0002 but reported separately in the GCF life-cycle narrative. Due to the absence of reservoir surface-area data, project emissions were quantified using a conservative LCA	2-year avoided emissions: N/A
						4-year avoided emissions: N/A
						20-year avoided emissions: 2,303,000

			of long-tenor finance, exposure to hydrological and sovereign-risk premia, and offtaker credit concerns. Multi-purpose hydropower with drought-resilient storage is not common practice in the semi-arid south and typically requires concessional support.		hydropower emission factor (0.07183 tCO ₂ /MWh).	
Benin	Construction of a 140 MW solar PV facility supplying renewable electricity to the internal captive grid of the Glo-Djigbé Industrial Zone (GDIZ), thereby reducing reliance on fossil-fuel generation.	Primary: CDM methodology AM0019 <i>Renewable energy projects replacing part of the electricity production of one single fossil fuel fired power plant</i> (used as reference standard). Supporting tools/data: GHG Protocol for Project	In the absence of the project, electricity demand within GDIZ would continue to be met mostly by fossil sources, either through dispatch of the existing plant or through additional fossil capacity that the zone developer would install as demand increases.	Large-scale captive solar PV supplying an industrial zone is not established practice in Benin. Industrial users predominantly depend on fossil captive plants and intermittent grid imports.	The project boundary includes the solar PV facility, the GDIZ internal distribution network, industrial users, and the fossil-fuel captive plant whose generation is displaced. Under AM0019, project emissions are zero for solar PV and leakage is excluded unless fossil equipment is relocated, which is not expected.	2-year avoided emissions: 25 116
						4-year avoided emissions: 71 287
						20-year avoided emissions: 397 984

		<i>Accounting; UNFCCC-IFI grid emission factors.</i>	Additionality is supported by structural and financial barriers: the zone lacks access to long-tenor finance for captive renewables; the existing thermal plant is already capitalised and cheaper to operate in the short run; there is no tariff mechanism that would remunerate independent solar investment; and exposure to foreign-exchange volatility makes commercial financing unattractive.			
Nigeria	Development of a 350 MW utility-scale solar PV power plant with 166 MWh BESS in Nasarawa State. The plant will supply clean electricity to the national grid via a 132 kV	Primary methodology ACM0002 – Large-scale grid-connected renewable energy projects. Supporting tools/data: GHG Protocol for Project Accounting; UNFCCC-IFI grid emission	Baseline: Electricity would otherwise be supplied primarily from Nigeria’s fossil-fuel-dominated grid (mainly gas-fired plants) and distributed diesel generators during outages.	Utility-scale solar PV with integrated BESS is not common in Nigeria. Most large PV projects rely on concessional finance or smaller-scale captive systems. Systematic	Includes PV modules, inverters, transformers, 426-hectare site, interconnection at Lafia 330 kV/132 kV substation, and electricity delivered to the grid.	2-year avoided emissions: N/A
						4-year avoided emissions: 30,369

	interconnection, reducing reliance on fossil-fuel generation and private diesel generators.	factors; national grid generation mix data.	Additionality: Barriers include high upfront capital costs, grid unreliability, and limited access to long-term project financing for large-scale solar PV projects in Nigeria.	deployment to replace grid/diesel generation is not established practice.		20-year avoided emissions: 668,123
Nigeria	Utility-scale distribution network rehabilitation and expansion under PPI Phase 1 (Lot 3, Section 1), including reconductoring MV/LV lines,	Primary: AMS-II.A <i>Supply-side energy efficiency improvements – transmission and distribution</i> (used as reference standard). This project is likely larger than the AMS-II.A small scale	Baseline emissions correspond to the continuation of technical losses in the existing distribution network, estimated using national loss factors and the	Nigeria has no precedent for large, self-financed distribution-loss-reduction programmes.	The project boundary for PPI Phase 1 (Lot 3, Section 1) includes the upgraded distribution lines, associated transformers and substations, and the downstream electricity delivered to an estimated ~3.7M direct beneficiaries.	2-year avoided emissions: N/A
						4-year avoided emissions: 2,950

	transformer replacement and substation upgrades to reduce technical losses and improve reliability.	but alternative CDM methods did not encompass distribution lines and transformers. Supporting tools/data: <i>GHG Protocol for Project Accounting; World Bank/IEA national loss statistics; peer-reviewed loss-factor studies for Nigeria, UNFCCC-IFI grid emission factor dataset.</i>	electricity delivered to project beneficiaries. Additionality is supported by structural barriers affecting Nigerian DisCos: severe liquidity constraints, high ATC&C losses, lack of cost-recovery tariffs, inability to raise long-tenor finance, and dependence on concessional or sovereign-backed capital for any large-scale network rehabilitation.	All recent grid modernisation efforts (PPI, World Bank DISREP, previous donor-funded upgrades) have relied on concessional financing. Most efficiency improvements are reactive and occasional, not systematic. Systematic loss-reduction programmes are therefore not common practice.	Only technical losses are included. Leakage reflects continued operation of replaced transformers, resulting in 525 tCO ₂ /year.	20-year avoided emissions: 50,156
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