Picture Courtesy by B2Gold

Renewable Energy for West African Mines – Challenges & Solutions

DORNIER Group

HAW Workshop Energiezukunft Westafrika.Menschen. Kompetenzen. Technologien

Boris Westphal, Dornier Suntrace GmbH, Hamburg, October 11th, 2023

Dornier Group provides sustainable infrastructure solutions

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Dornier Power & Heat
The energy experts

Dornier Construction and Service GmbH
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RENEWABLES
Tolga Özkarakas

Dornier Construction and Service GmbH
Construction and operation services for offshore wind power and solar plants

Dornier Suntrace GmbH
Independent experts for renewable energies

WATER
U. Schott

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Independent experts for solar energy solutions

- Established 2009 in Hamburg, Germany
- International team of 30 FTE professionals with experienced engineers & managers from Germany, Spain, Brazil, Colombia, Honduras, Kenya, Thailand and partners in Chile, Morocco, Mexico, Southern Africa
- Covering photovoltaic (PV), solar process heat, concentrating solar power (CSP), solar research,
  independent power producers (IPP) & utilities
- Expertise: >17000 MW solar, > 150 projects, > 50 countries
- Solutions for all steps of the project development chain from feasibility, project development, finance and investment to construction and operation

Mining Decarbonization: Drivers and Approach

RE Value drivers for the mining industry lowest cost energy

- hedging operating cost
- increase profitability
- extend economic reach
- Reduce carbon footprint
- Compliance with ESG commitments

Phased Approach: from “economic now” to “economic next”:

- Lowest hanging fruit: renewable energy generation
- Second lowest: energy efficiency, electrification of transport
- Quick pay-off investments first, slow pay-off investments at a later stage
- Off-grid minigrids show best economics for renewables
- On-grid solutions: in fair cost environments, renewables do pay off

Namibia, Oshikoto Gold Mine, 2013

Today, Renewables have become the *new normal* for remote mines

Hybrid plants worldwide

B2Gold, Fekola Mine, Mali

- 36 MWp PV, 17MW/15MWh Battery
- Status: In operation

Barrick Gold, Loulu Gold Mine, Mali

- 24MWp off-grid solar hybrid, 63MW thermal power station
- Announced: Second phase solar-battery plant

Centamin, Sukari Gold Mine, Egypt

- 36 MWp PV, 7.5MW BESS hybrid system will be integrated to existing off-grid network
- Status: Expected commission in 2022

Gold Fields, South Deep Gold Mine, South Africa

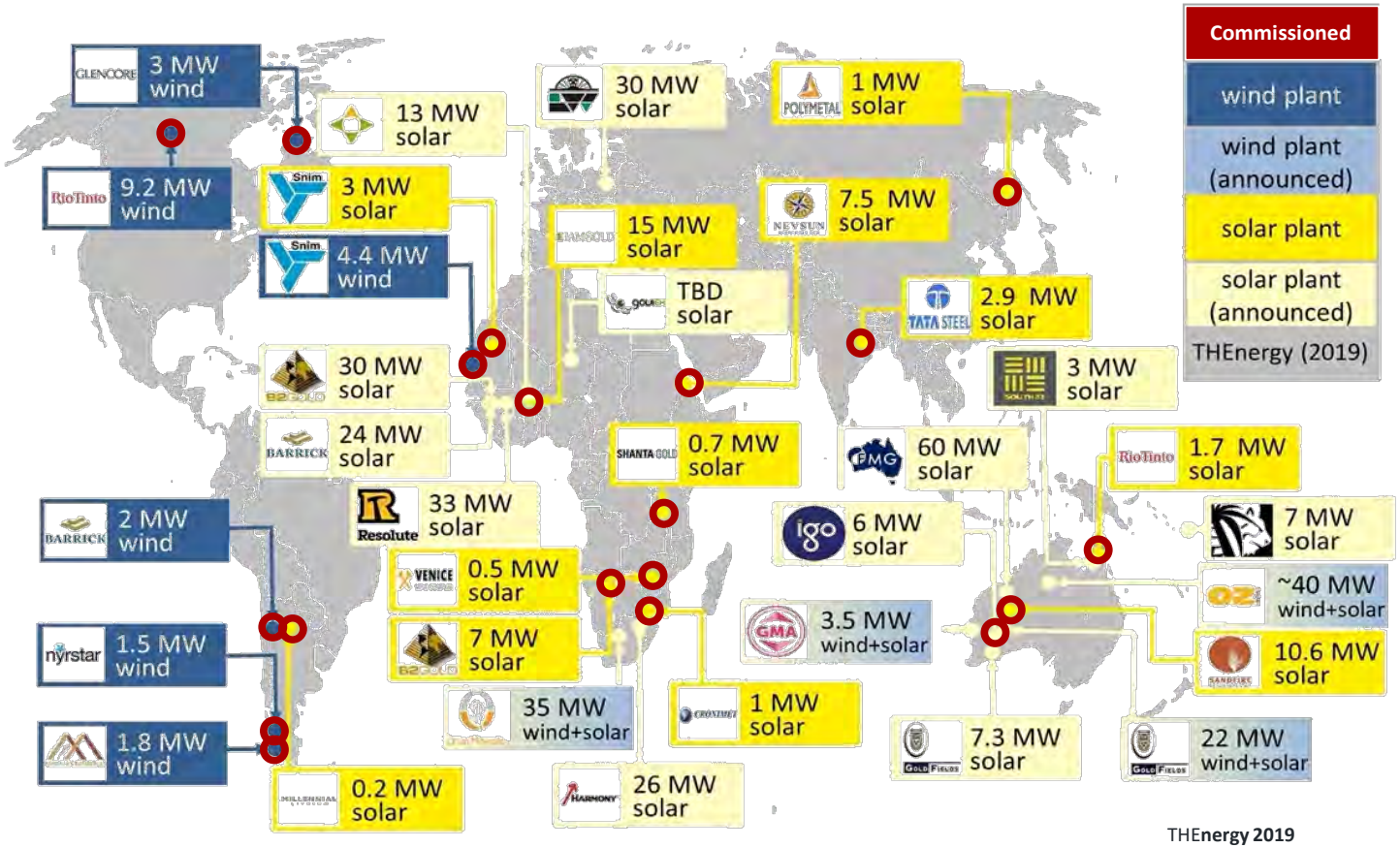
- 50 MWp off-grid PV
- Status: Expected commission in 2022

Gold Fields, Agnew Gold Mine, Australia

- 4 MWp PV, 18 MW Wind, BESS - 13MW/4MWh Diesel Power Plant - 21 MW Microgrid Project
- Status: Completed 2020

IGO, Nova nickel-copper-cobalt operation, Australia

- 6.7 + 10 MWp PV and 10MWh BESS
- Zenith is the builder, owner, and operator of the power station at the Nova mine
- The Nova project aims to achieve partially 100% power from renewables. LFO based zero engine operation with 9 hours battery storage was announced.



B2Gold Mali: 1st Phase implemented; 2nd Phase ongoing

Phase 1: Largest PV-Battery-HFO Hybrid Plant in Operation

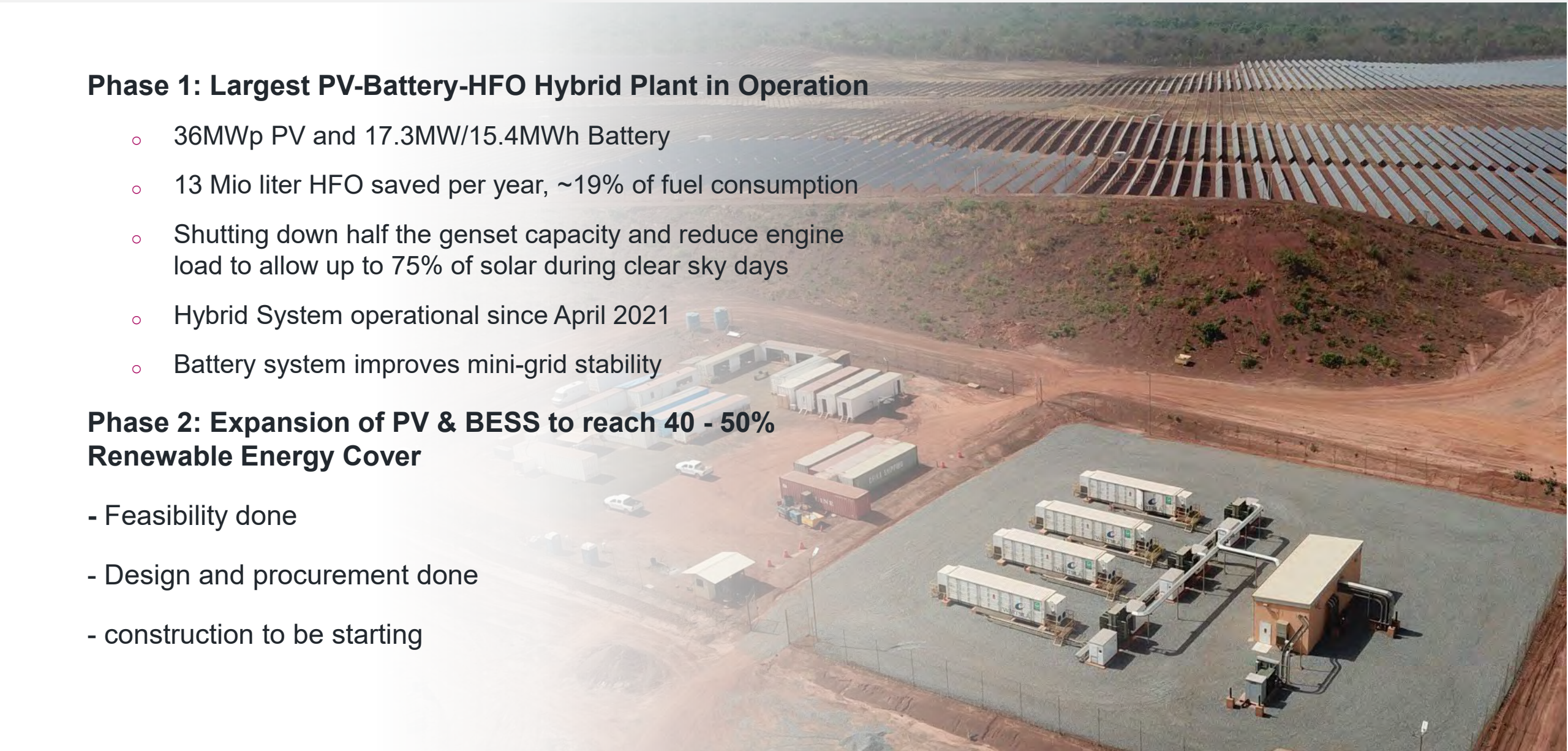
- 36MWp PV and 17.3MW/15.4MWh Battery
- 13 Mio liter HFO saved per year, ~19% of fuel consumption
- Shutting down half the genset capacity and reduce engine load to allow up to 75% of solar during clear sky days
- Hybrid System operational since April 2021
- Battery system improves mini-grid stability

Phase 2: Expansion of PV & BESS to reach 40 - 50% Renewable Energy Cover

- Feasibility done

- Design and procurement done

- construction to be starting



Endeavour Mining – Sabodala Solar Project, Senegal

Engineering & Procurement, Construction Supervision

Sabodala solar plant:

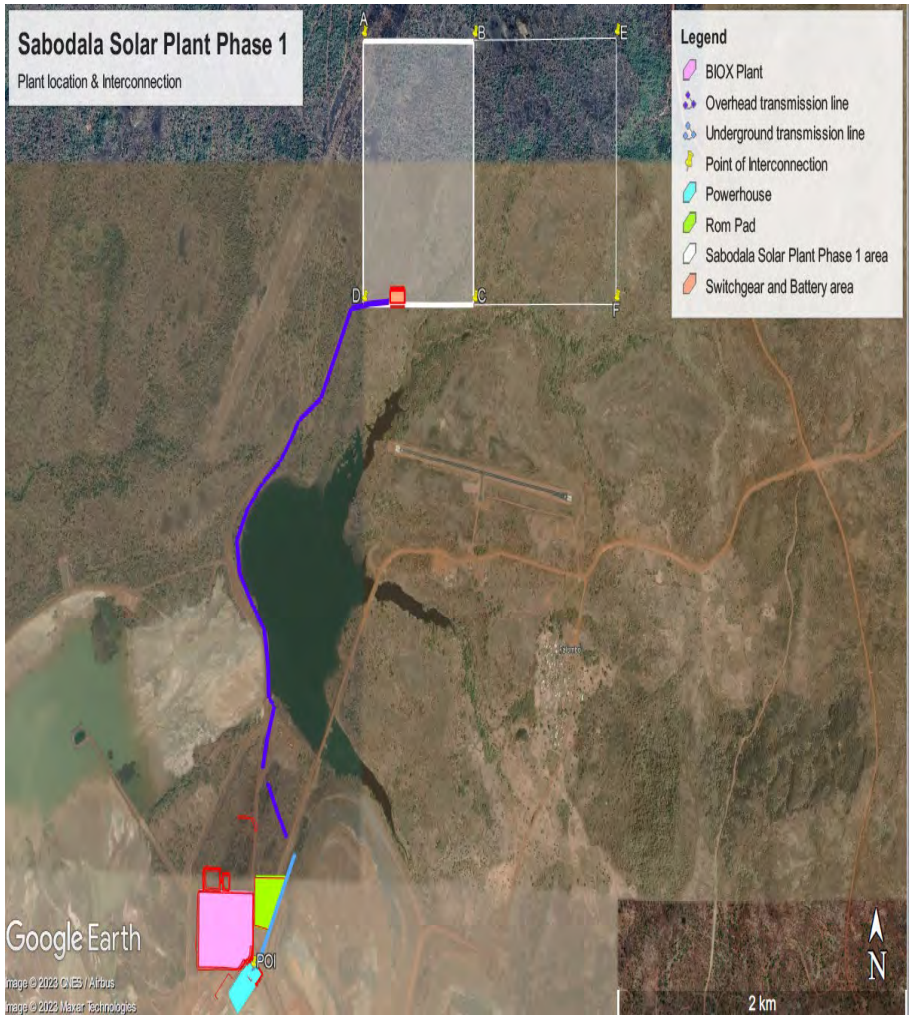
- 37MWp PV and 16 MW / 8 MWh Battery
- Achieve 23% fuel savings
- Design for a 1 engine operation during high solar hours, Battery for spinning reserve
- FEED phase on-going almost completed, construction works start Q1/2023 and targeted completion in Q1/2025

Implementation (2022 – on going)

- **Dornier Suntrace** conducted the PreFS and DFS, and has been mandated as Contractor for Engineering, Procurement, Construction and Commissioning Supervision,
- FEED phase completed
- Detailed engineering & procurement on-going
- Construction and commissioning supervision

Picture courtesy by B2Gold

Sabodala mining site



Multiple Criteria analysis to optimize the solution

NEEDS ANALYSIS

Mine's energy requirements, generation cost, grid stability

FINANCIAL REQUIREMENTS

On-balance EPC
Off-balance IPP
Rental/Lease

OPTIMIZED CONCEPT

Technical Concept & Sizing / Economics / Timeline

IMPLEMENTING

Building of the RE Project

RENEWABLE RESOURCES

Solar, Wind, Hydro etc.
(on-site, off site)

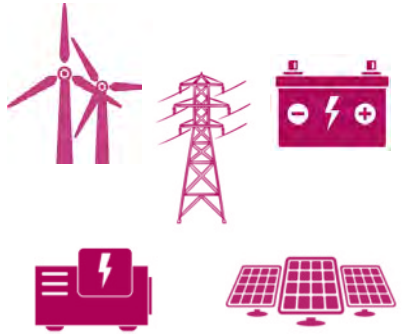
RENEWABLE TECHNOLOGY OPTIONS

PV, Wind, Other Energy Storage Grid Connection

COMPETITIVE SELECTION

Procurement of RE Plant or PPA

Sophisticated tools help to find the optimum design



- Simulation tool for **grid connected and off grid** hybrid systems.
- **Wind, solar PV, battery,**
- Gensets and turbines or grid connection can be modelled.

- **Simulation in up to 1 minute time resolution.**
- Multi year simulations for whole project lifetime.
- **Tailored system sizing to meet load requirements**
- **Customizable** and user defined dispatch strategies.

- **Amortization**: Inbuilt cash flow based financial model to calculate financial KPIs like LCOE, IRR, NPV, ROI etc.
- **Optimization engine finds the best configuration based on financials.**

- System performance visualization.
- **Visualization of various system scenarios.**

Outlook: A staged approach can ensure economics on all phases until reaching Net Zero 100% renewable coverage

Stage 1: SPV & Small Battery: Re share > 32%

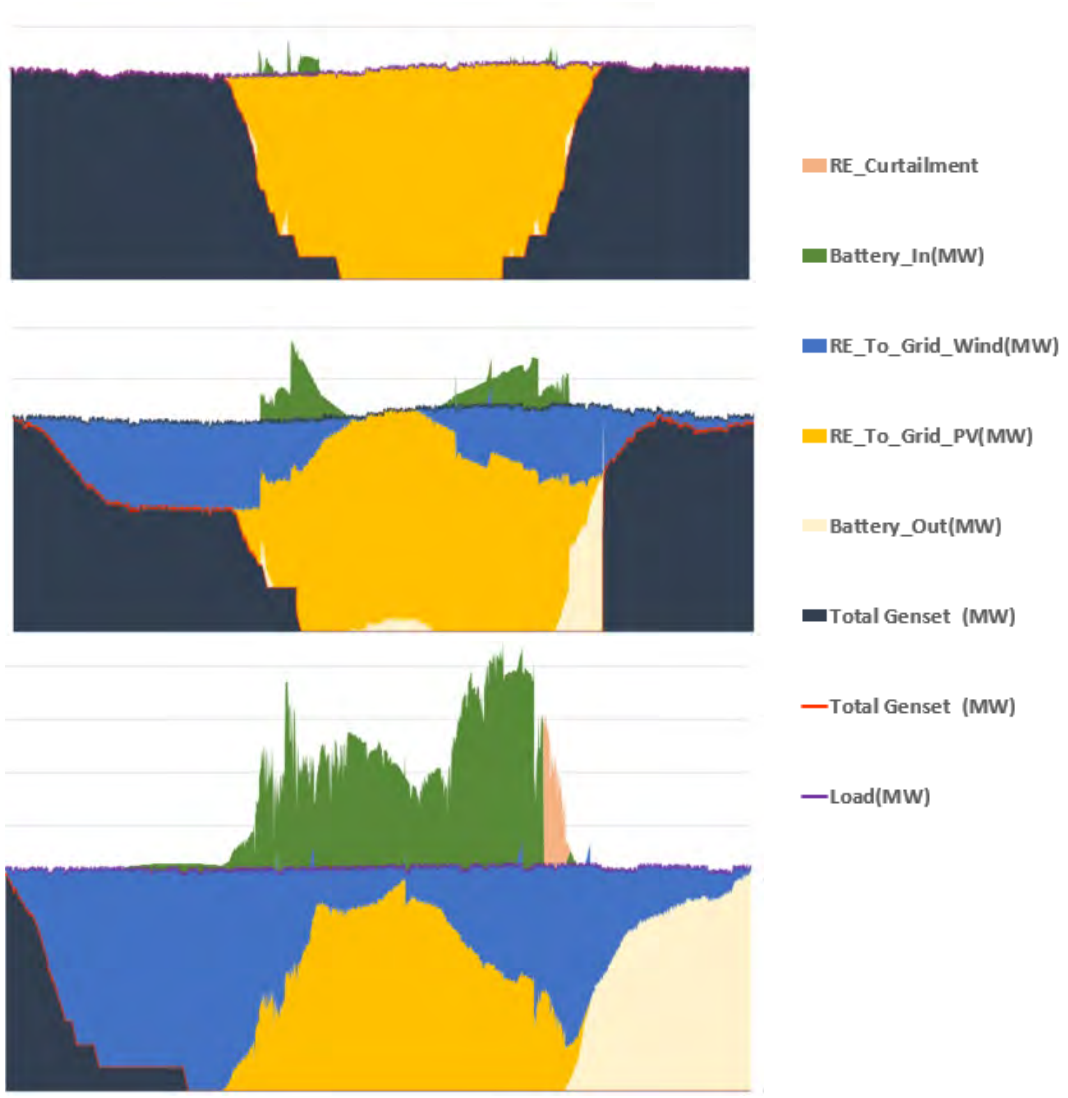
- Solar is lowest cost RE option
- Fastest implementation, most competitive

Stage 2: Add Wind & Expand Battery RE share > 44%

- Wind is second best RE option
- Increase RE share
- Expand Battery (reduce curtailment, stability)

Stage 3: Expand Wind, Solar & Battery RE share > 80%

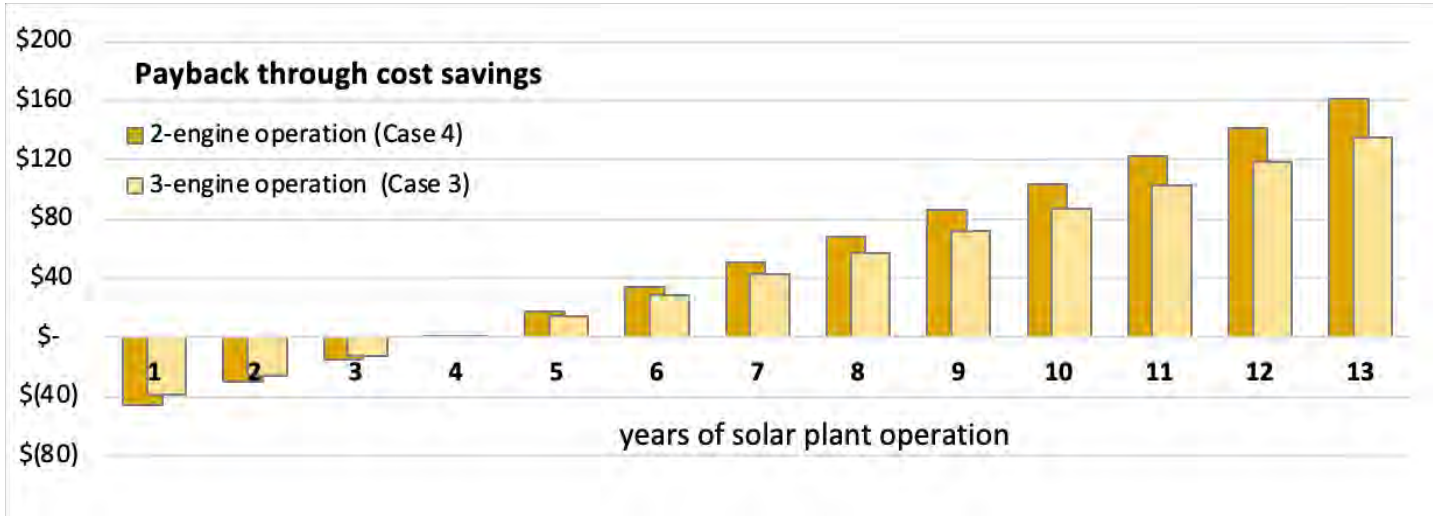
- Expand RE share,
- Competitiveness is criteria (RE cost development)
- Electrify Mining Operations (Vehicles)



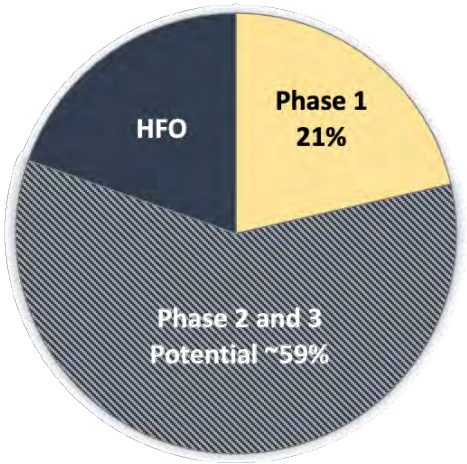
Selected Cases/Scenarios

Benefits of solar for mining operations

- Fuel savings and CO2 reduction increase with solar
- Payback period ~4 years
- Total of 21.4% of electricity from Solar Plant, generated at US$ cents ~1.3 per kWh
- Hedging of future fuel cost
- Every additional year LOM shows significant improvement



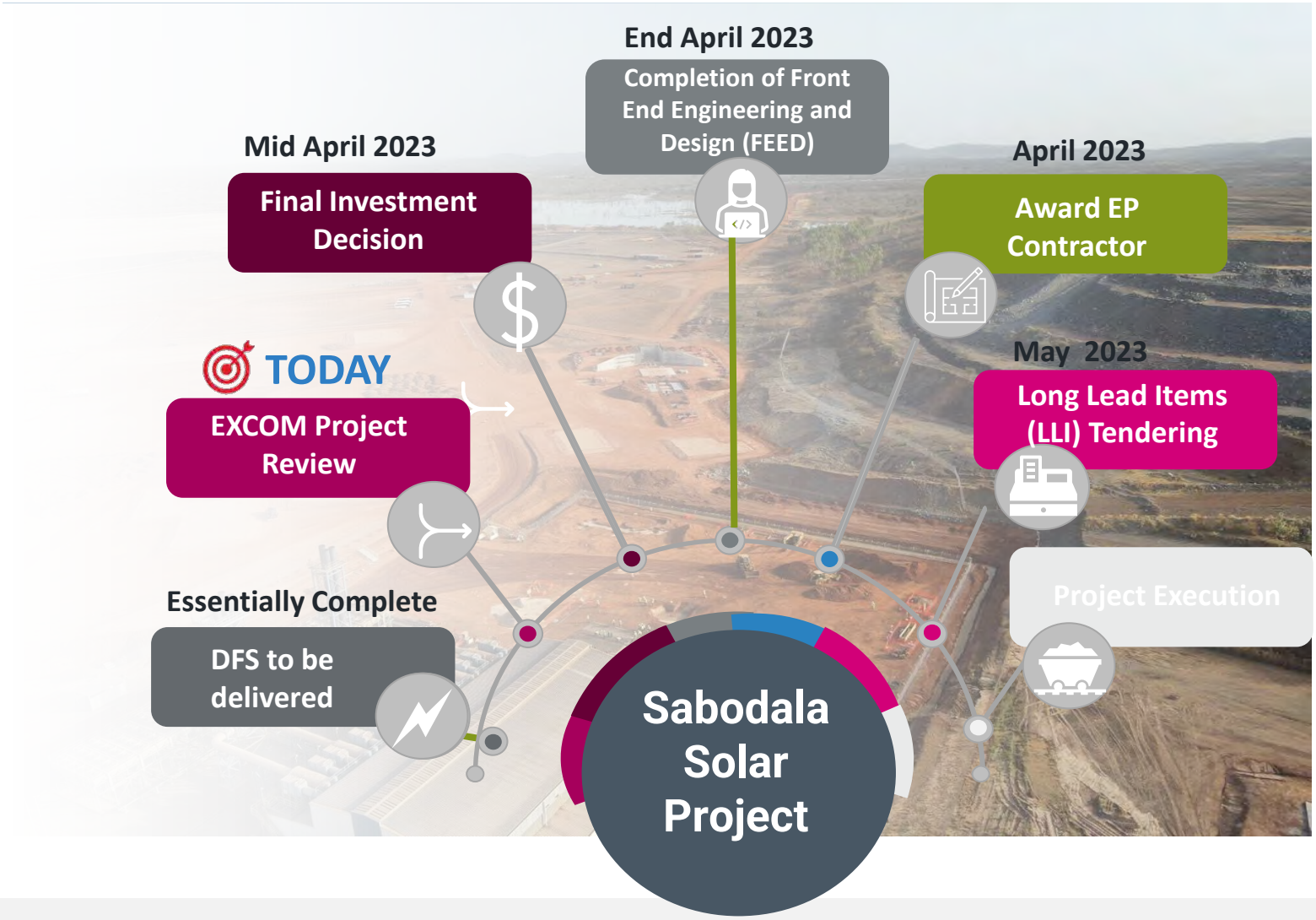
Reduce CO2 emissions by > 21%



Base Cases (Phase 1)	2-engine operation	3-engine operation
PV (MW_p) [1]	37	31
Battery (MW / MWh) [2]	25	20
IRR (%)	25.1	24.9
NPV (M. US$)	127.4	106.8
Fuel savings (M liters HFO / year)	15.4	12.9
CO2 reduction (year 1)	**21.4 %**	**18.0 %**

[1] Ratio MW_p to MW_{AC} is 1.15
[2] Battery size requires more detailed analysis and depend on PV capacity, maximum load and engines online considering PV power drop (up to 75% in 1 min) and trip of highest mine load / engines)

PROJECT EXECUTION AND CONSTRUCTION Steps



DFS Delivery

Technical Committee Project Review
Final Investment Decision (FID)
Completion of FEED:

- Including the solar PV and battery plant design and integration and the general operation philosophy
- Technical specifications for the key equipment ready by end of March 2023 to launch the RFP process.

EP Award

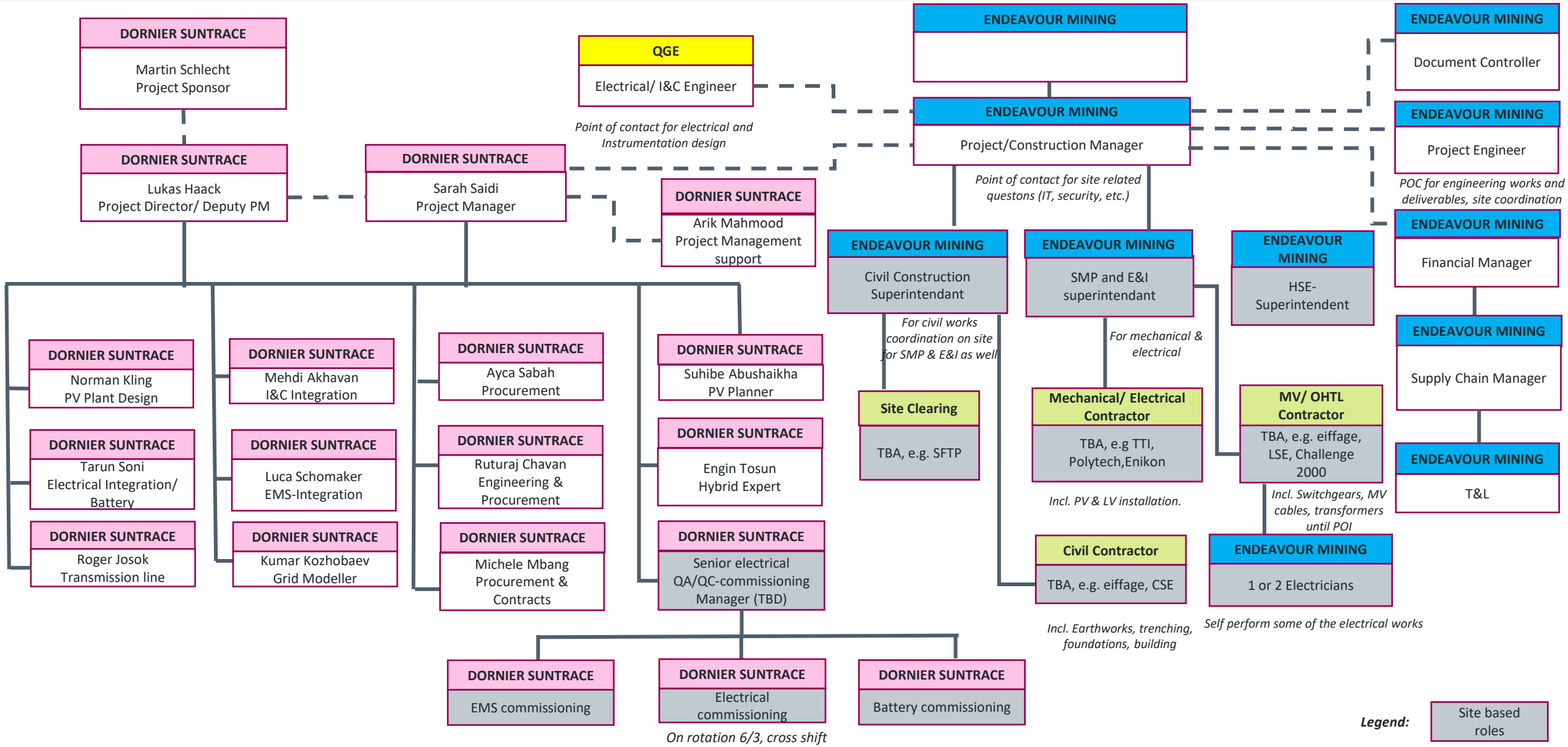
Long Lead Items (LLI) tendering:

- Mainly the battery system, the MV switchgear, the cables, subsequent to the Final Investment decision

Project in execution

- Detailed Engineering and RFP process to start early May 2023
- Construction works to commence early November 2023

Sabodala Solar Project Org-Chart



Local Human Resources: Feedback from project management

- Knowledgeable and organized, good international standard (experience based on mining project)
- Team members mostly from Senegal and other African countries
- Most of Senegalese to do not speak English fluently
- Miner's management positions rather not held by Senegalese, but expats
- Senegalese considered to be very smart and hard working but not seen in technical and management positions
- Almost no women engineers on site, working in administration, HR, etc.
- Working conditions at the mine are difficult over long terms, e.g. 45°C temperature in plain sunlight to supervise local workers ...
- Senegal is a dynamically growing country, in need of foreign investment

➢ **need of young people with civil, electrical, mechanical engineering background to execute projects and foster the development of the country.**

Dornier Suntrace: A diverse, multinational team

Experience and Academic Backgrounds

- Mechanical engineers
- Geophysicists
- Meteorologists
- Environmental engineers
- Electrical engineers
- IT specialist
- MBA‘S
- Economists
- Finance and Accounting

Nationalities:

- Bangladesh
- Barbados
- Brazil
- Cameroon
- Egypt
- Germany
- Honduras
- India
- Iran
- Jordan
- Indonesia
- Maldives
- Morocco
- Pakistan
- Turkey
- Vietnam

International Resources: Remember Compact with Africa ?

G20 Compact with Africa (CwA) initiated under the German G20 Presidency to promote

- private investment in Africa, including in infrastructure
- launched in 2017
- objective to increase the attractiveness of private investment through substantial improvements
- macro, business, and financing frameworks…
- Reform minded African countries, international organizations, and bilateral partners from G20 and beyond to coordinate
- country-specific reform agendas, support respective policy measures, and advertise investment
- opportunities to private investors. The initiative is demand-driven and open to all African countries…..

German Human Resources…? October, 2023

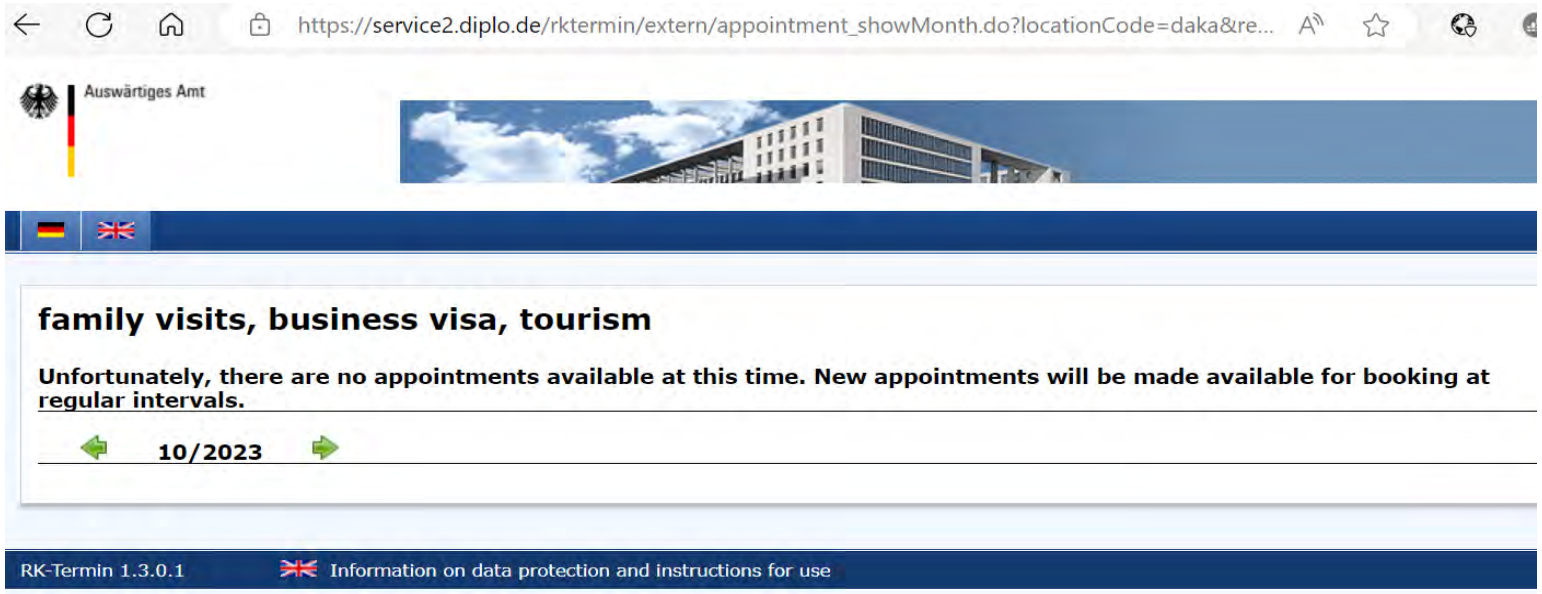
*** EXTERNAL EMAIL ***

Fyi
Regards
Deme

From: Fato[redacted]
Sent: 06 October 2023 12:14
To: Abd[redacted]
Subject: Fwd: Urgent Visa for business trip

Hello gents,
This is reason why I couldn't get any appointment confirmed. Dates are blocked and Re opened only when available again.

Deme, I will call you shortly to explain further.
Cheers



Dornier Suntrace Renewable Projects for Mining (not including studies)

Mining Company	Mine / Country	Ore	PV Capacity	BESS Capacity	Services	Status
Schweck Cement	Ohorongo, Namibia	Cement	6.5 MWp	-	Development Support, OE, O&M support	Completed, In operation since 08/2018
B2Gold	Fekola, Mali	Gold	Phase 1 36MWp	18 MW	Scoping, DFS, EP Contractor	Completed. In operation since 07/2021
B2Gold	Fekola, Mali	Gold	Phase 2: 25MWp	12.5 MW	Scoping, DFS, FEED, EP-Contractor	Under construction (COD Q4/2024)
Endeavour Mining	Sabodala, Senegal	Gold	37 MWp	16 MW	Scoping, DFS, FEED, EPCCM Contractor	Under Construction (COD Q1/2025)
Kinross	Tasiast, Mauretania	Gold	42 MWp	18MW	Scoping, DFS,EPC selection, OE	Under Construction (COD Q!/2024)
Impala Platinum	Zimplats, Zimbabwe	Platinum	40 MWp	-	OE	Under Construction (COD Q2/2024)
Osino Resources	Twin Hills, Namibia	Gold	35 MWp	-	FS, OE for IPP selection	FEED Phase (COD Q2/2026)
Total			**221.5 MWp**	**64,5 MW**		

Merci beaucoup pour votre attention

CEO Dornier Suntrace GmbH

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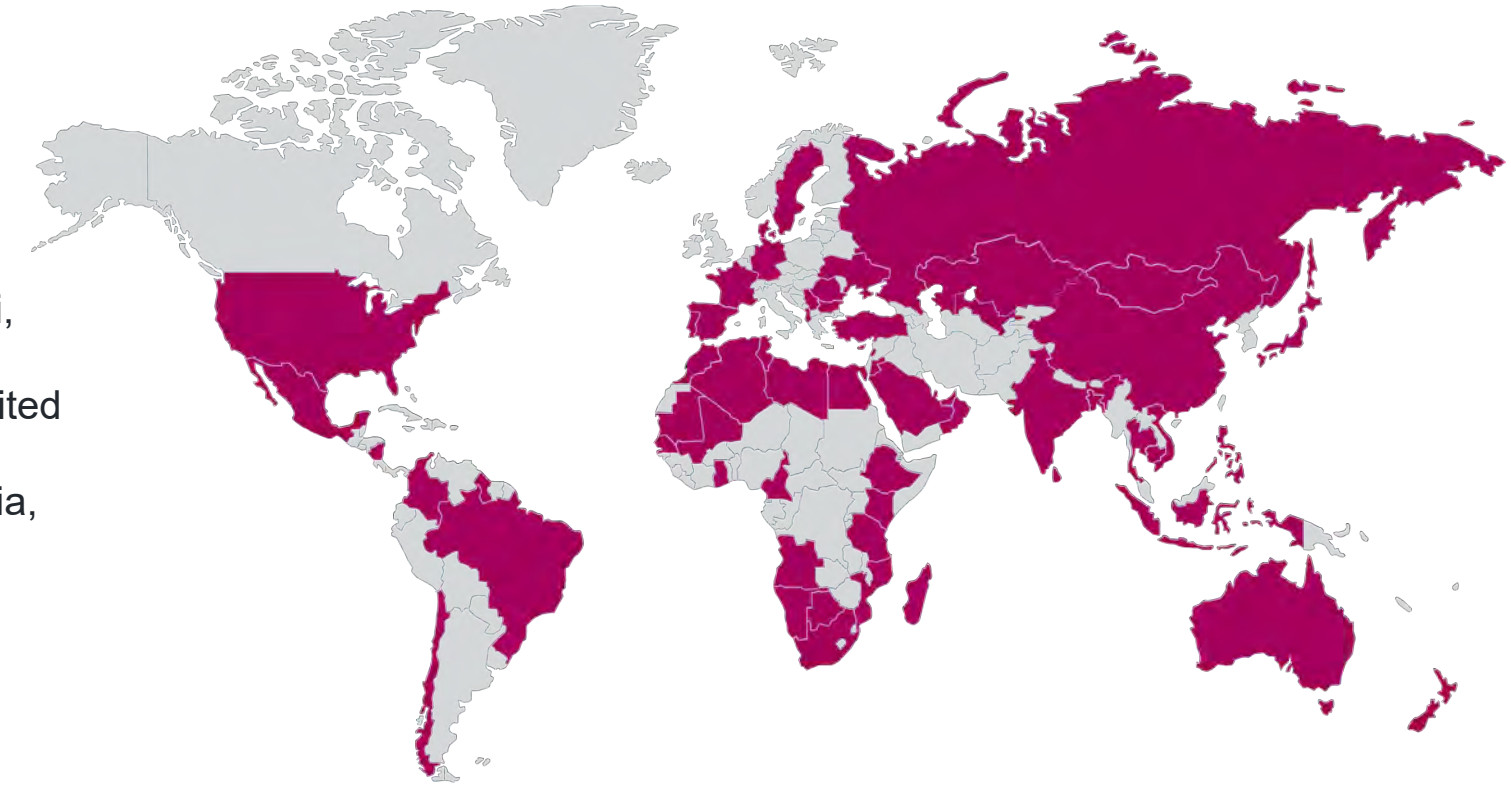
Venture the Impossible to attain the best

Focus on dynamically growing, emerging solar markets

International Project Activities

Australia, Bangladesh, Brazil, Cambodia, Cameroon, Cape Verde, Chile, China, Colombia, Cyprus, Czech Republic, Egypt, Ethiopia, France, Germany, Ghana, Greece, Guadeloupe, India, Indonesia, Italy, Japan, Jordan, Kenya, Kuwait, Libya, Maldives, Mali, Mexico, Mongolia, Morocco, Namibia, Nicaragua, Philippines, Portugal, Russia, United Arab Emirates, Uzbekistan, Saudi Arabia, Slovakia, South Africa, Spain, Sri Lanka, Syria, Tanzania, Tunisia, Turkey and Vietnam



Our Offices

Germany, India, South Africa, Ukraine, Kazakhstan, UAE, Saudi Arabia, Jordan, Serbia, India

Typical Project Development Process for Renewables

Project Development Process

Conceptual Phase
- Setup of SPVs
- Resource Mapping
- Site selection
- Agreement about sites & grid capacity
- Outline business case (PPA..)
- Check permitting requirements

Pre-feasibility & detailed feasibility analysis
- Red-flag & fatal flaw analysis of all relevant project details on high level

Iterative process – from rough to detailed
- Solar/wind assessment/measurement on sites
- Site assessment
- Techno-economic optimisation
- O&M concept
- Energy & financial yield
- EPC market cost monitoring
- Feasibility study report
- Permitting – tasks & timeline
- Financial Concept (PPA offtaker validity)

Project / Site qualification
- Geotechnical and topographic survey
- Environmental impact assessment (EIA)
- Permitting process
- PPA & other contract negotiations
- Land agreement

Procurement

Equity:
- auctioning process, select equity investors into SPVs

Debt:
- negotiating debt financing strategy