How close are mines to 100% renewable energy?

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Courtesy of B2Gold, Fekola Solar Plant Phase 1 & 2, Mali, 11/2024

Dornier Suntrace GmbH

Toronto November 12, 2024

Dornier Suntrace covers all main bankable renewable energy technologies

- Solar photovoltaic, floating photovoltaic
- Concentrating solar power, solar thermal
- Wind
- Battery electric storage system (BESS)
- Other storage options: molten salt, pumped hydro
- Grid & transmission

Dornier Suntrace is the engineering team of Dornier Renewables, we optimise & design projects and manage implementation

OUR APPROACH

CLIENT NEEDS ANALYSIS
- energy requirements,
- generation cost
- grid conditions

RENEWABLE RESOURCES
solar, wind, hydro etc.
(on-site, off site)

FINANCIAL REQUIREMENTS
on-balance (EPC)
off-balance (IPP)
rental/lease

RENEWABLE TECHNOLOGY OPTIONS
PV, wind, other
energy storage
grid connection

OPTIMIZED CONCEPT
technical concept & sizing /
economics / timeline

COMPETITIVE SELECTION
procurement of
RE plant or PPA

IMPLEMENTING
building of the RE Project

How close are mines to achieve 100% renewable energy?

Energy use covers mainly:

- Electricity consumption of operations
- Fuel consumption of fleet
- Renewable energy to supply both => larger capacity

100% decarbonized: Offset all carbon emissions

- Implement energy efficiency improvements
- Acquire renewable energy for all uses
- Green energy supply for operations (fleet / vehicles)

Focus on solutions at mine level

- 24-7 renewable supply for every asset
- Electricity generation and consumption synchronized
- Within the mine and the connected grid / infrastructure
- Implement site specific solutions based on a roadmap

Solutions are different for on-grid & off-grid / specific for each mine

Grid connected mines

1. Baseline is primary energy factor of the grid
2. Reliablility of grid supply (load shedding, ...)
3. Option for private green PPA (Hydro, PV, Wind)
4. Option for on-site generation and/or storage

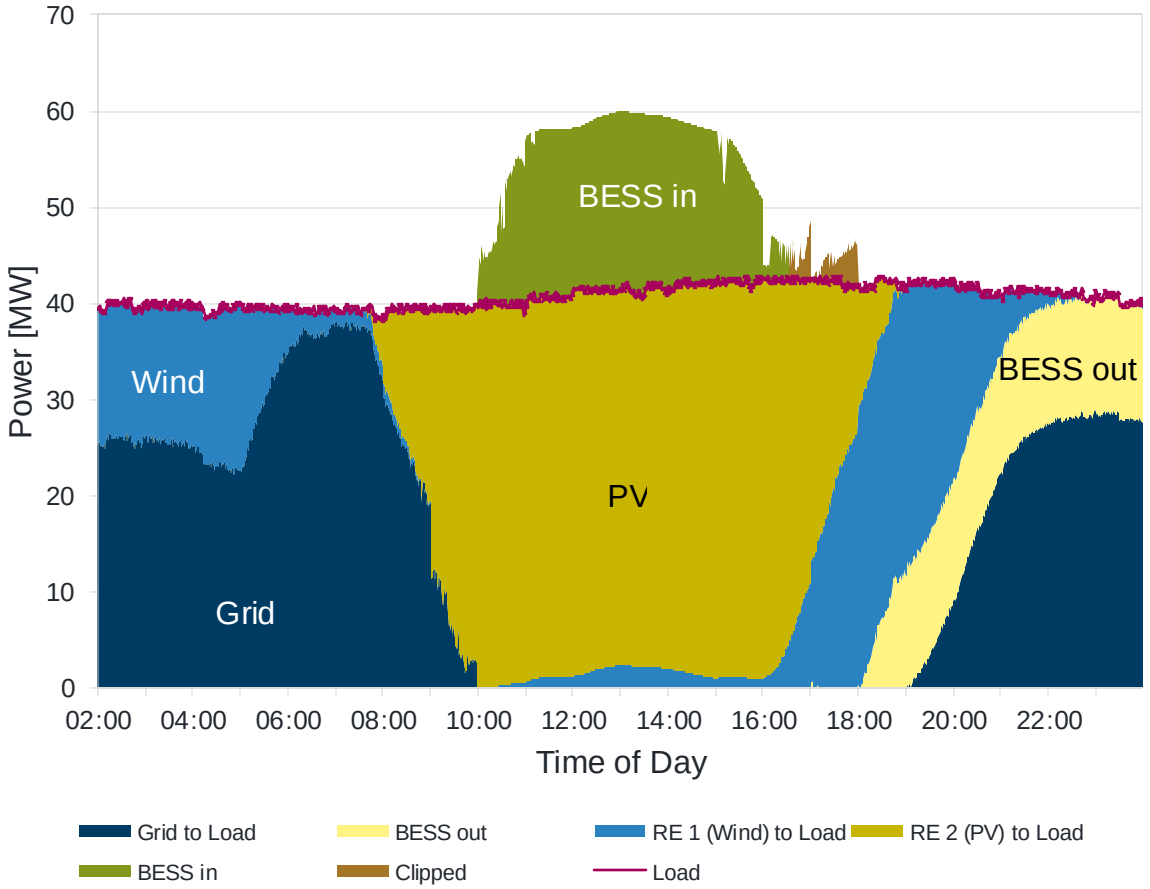
Off-grid mines

1. Baseline is fossil fired power generation
2. Add on-site generation and storage (site specific)
   - Solar (15-50% RE share)
   - Wind (50-65% RE share)
   - Energy storage (intra-day fluctuations)
   - Keep fossil generation as back-up

Technical and economic feasibility

1. Every mine requires a tailored solution
2. Determine mine and fleet decarbonization options
3. Based on feasibility and budget implement in stages

Example: Load distribution of a multi-technology renewable solution (Hybrid System)



Tailored solution: Define needs and develop concept

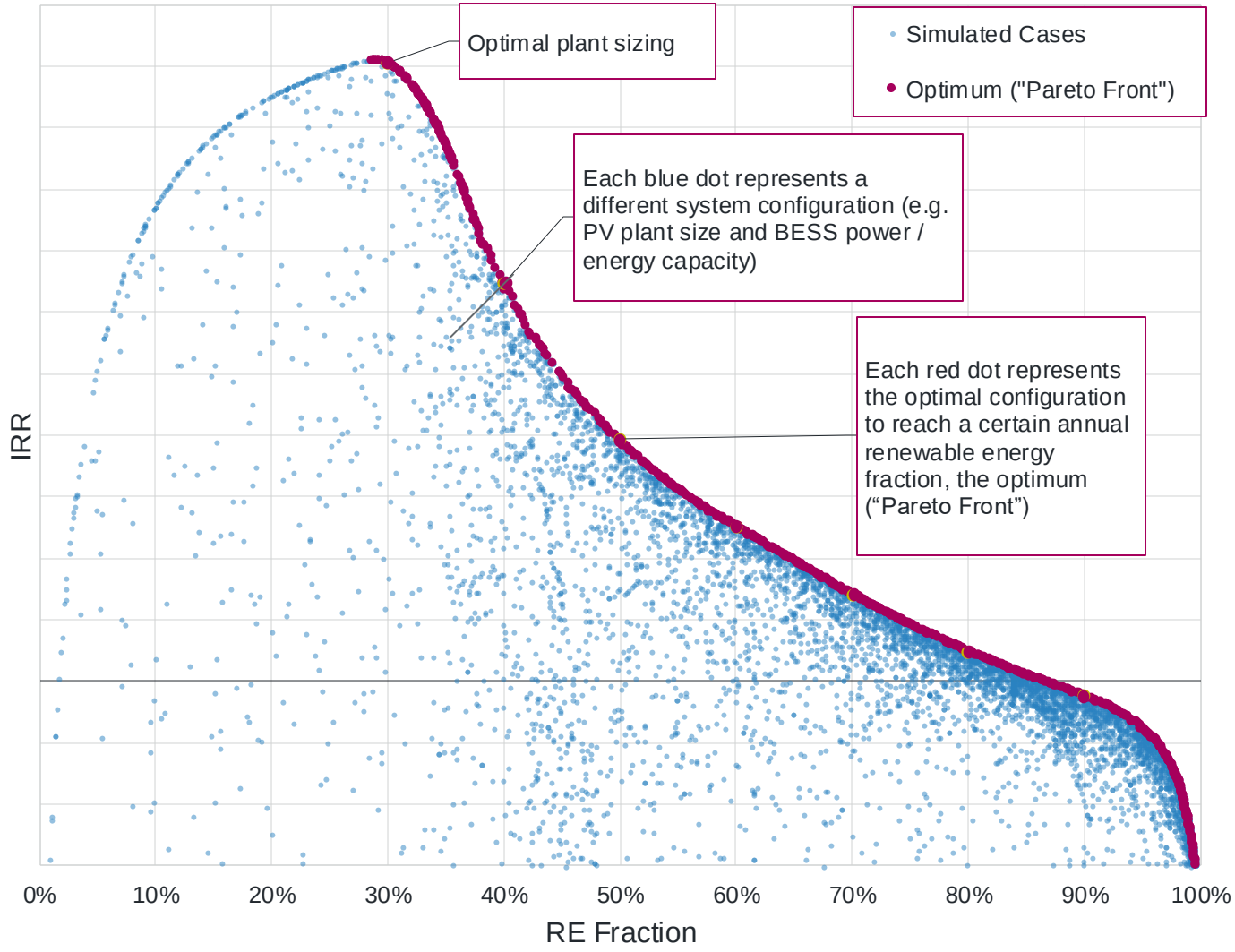
Challenge sizing assumptions, find optimum solution

Example: IRR vs. Fuel Savings

- Moving down: Less IRR
- Moving right: Higher RE share
- Optimum IRR: Upper right edge
- Blue: Values calculated during optimization process; not included in the output
- Magenta: Output of optimization process (“Pareto front”)

Notes:

- Curve different for each project, depending on specific inputs such as solar resources or financial assumptions
- Highest IRR may not be optimum from a total savings or from CO2 Emission reduction perspective



Competitiveness is key: the metrics of RE shares and cost

Stage 1:
Lowest LCOE @ today‘s CAPEX

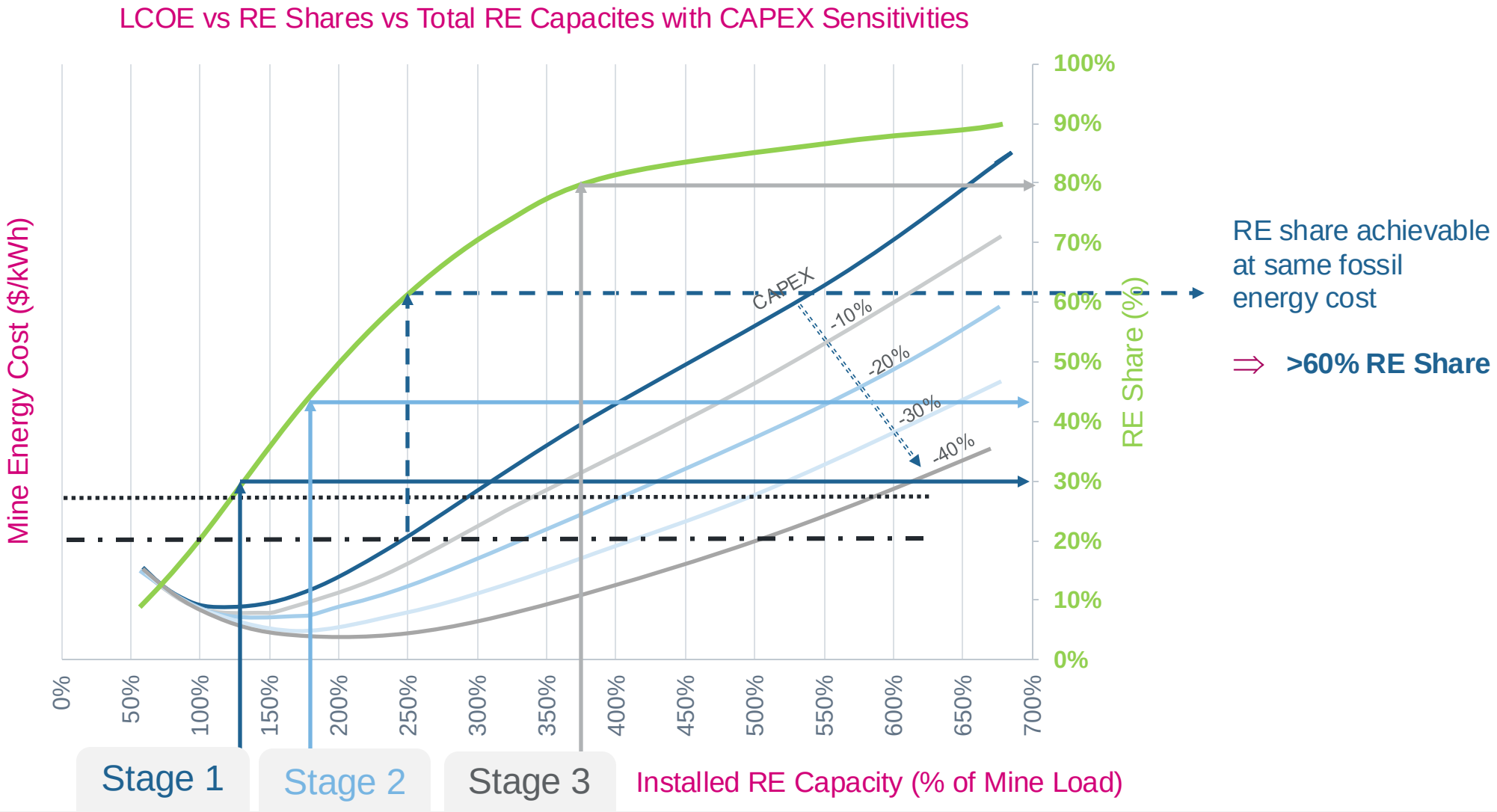
⇒ **30% RE Share**

Stage 2:
Lowest LCOE @ CAPEX -20%

⇒ **44% RE Share**

Stage 3:
High RE @ CAPEX -30%

⇒ **80% RE Share**



RE share achievable at same fossil energy cost

⇒ **>60% RE Share**

B2Gold Fekola Gold Mine, Mali, Solar Plant – Phase 1

Engineering & Procurement, Construction Supervision (in operation 04/2021)

Largest PV-Battery-HFO hybrid plant in operation (2021)

- 36MWp PV and 17.3MW/15.4MWh battery
- 13 Mio litre 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

Implementation (2019 – 2021)

- Dornier Suntrace developed the concept and guided B2Gold in the decision process, and
- Acted as Owner's Engineering and Procurement (EP) Contractor, including supervision of construction and commissioning

Plant performance exceeds expectations (>3y)

Picture courtesy by B2Gold

B2Gold Fekola Gold Mine, Mali, Solar Plant – Phase 2

Engineering & Procurement, Construction Management Contract (Completion end 2024)

Phase 2 solar plant

- Additional 25MW PV and 12.5 MWh battery, to a total of 61 MWp and 28 MWh battery capacity
- Increase annual fuel savings from 19 to 32%
- Implement a zero-engine operation during high solar hours, using the battery for spinning reserve
- Solar powered electric heating for HFO system
- Engineering & procurement phase completed; Construction works ongoing
- Completion date: End of 2024

Implementation (2022 – 2024)

- Dornier Suntrace conducted the study, developed the concept and has been mandated as Engineering & Procurement Contractor by B2Gold.
- FEED, detailed engineering works and procurement phase completed.
- Site management and construction & commissioning supervision ongoing

Picture courtesy by B2Gold

Kinross Tasiast Gold Mine, Mauretania

Owner’s Engineer for Solar & Battery Hybrid Plant (in operation since 04/2024)

Tasiast solar plant

- 34MW (42 MWp) & 18 MWh Battery
- More than 20% of annual fuel savings
- Switching off HFO generators at hours of solar generation
- EPC Contractor: Voltalia awarded in April 2022, Construction works started in 2023, Completion 04/2024

Implementation (2022 – 2024)

- Dornier Suntrace conducted PreFS & FS, supported investment decision
- Nominated Owner’s Engineer to support Kinross
- Prepare technical specs, support Kinross in tendering & procuring a qualified EPC Contractor
- Design review, construction and commissioning supervision

Picture courtesy by B2Gol

Endeavour Mining – Sabodala-Massawa Gold Mine, Senegal

Engineering & Procurement / Construction Supervision (in construction, completion in Q1/2025)

PV-Battery-HFO hybrid plant in construction

- 37MWp PV and 16 MW / 8 MWh battery
- >20% HFO savings per year,
- Shutting down most genset capacity during solar during clear sky days
- Battery system improves mini-grid stability
- Engineering & procurement phase completed; Construction works ongoing
- Completion date: Q1/2025

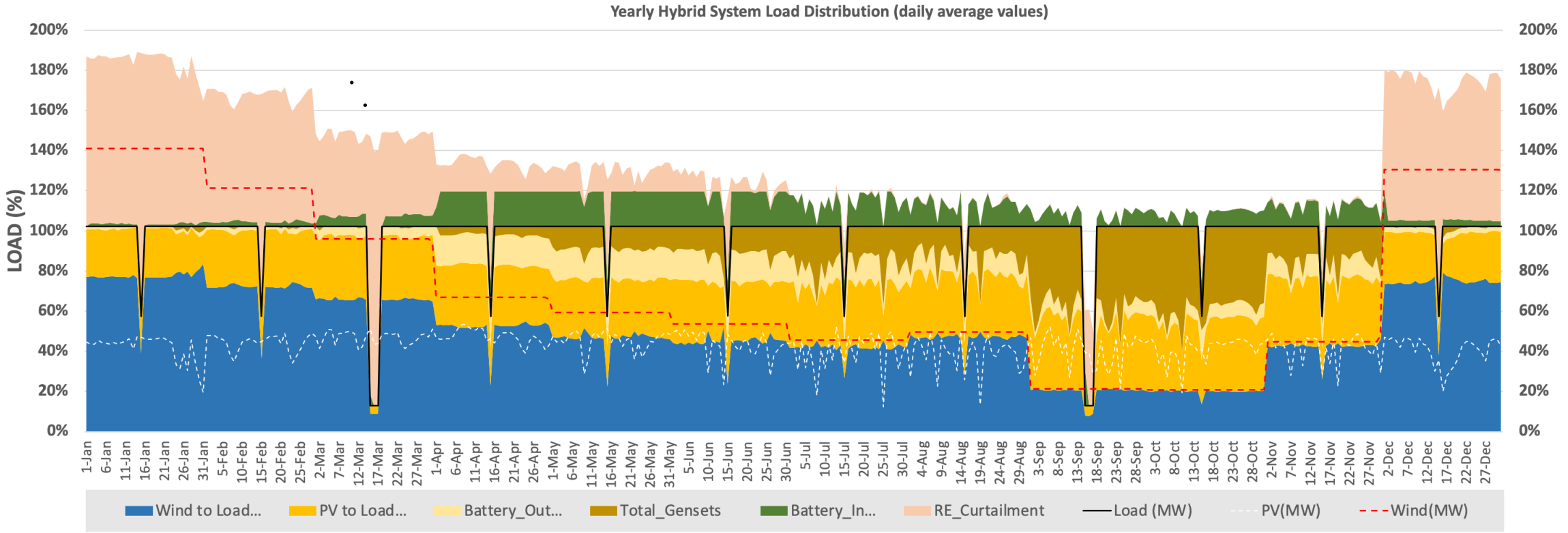
Implementation (2023 – 2025)

- Dornier Suntrace developed the concept and guided Endeavour Mining in the decision process, and is
- Acting as Owner's Engineering, Procurement and Construction Management Contractor, including supervision of construction and commissioning.

Off-grid mine with 85% RE share – payback in 6 years

PV	29%	180% capacity
WIND	49%	203% capacity
BESS	8%	4 hrs x capacity
ENGINES	13%	133% capacity

- Seasonal high RE in winter
- Seasonal low RE in autumn
- BESS does not serve as seasonal storage
- Engines serve as back-up



Market update:
Cost reduction improves business cases with storage

Solar PV market:

- PV module prices have dropped to record low
- PV market increases to > 400GW in 2024

Energy storage market:

- Battery cost dropped significantly, further drop expected
- Manufacturing capacity increased more than demand
- GW scale BESS projects built in USA and Australia

Electrification / Green hydrogen

- Green fuel projects are not progressing in larger scale
- Electrification seems the most competitive option to date

International markets

- China is the dominant manufacturer
- Has 80-90% market share for PV and Battery modules
- Lower cost open up new business cases for renewables

Conclusions and Summary:
100% renewables is a target - phased implementation is key

RE value drivers for the mining industry

- Lowest energy cost
- 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
- Next: energy efficiency, electrification of transport
- Quick pay-off investments first
- Observe market for next stage decision
- Off-grid mini-grids: Best economics for renewables
- On-grid: In fair cost environments, renewables do pay off

VENTURE THE IMPOSSIBLE
TO ATTAIN THE BEST...

PROF. CLAUDE DORNIER

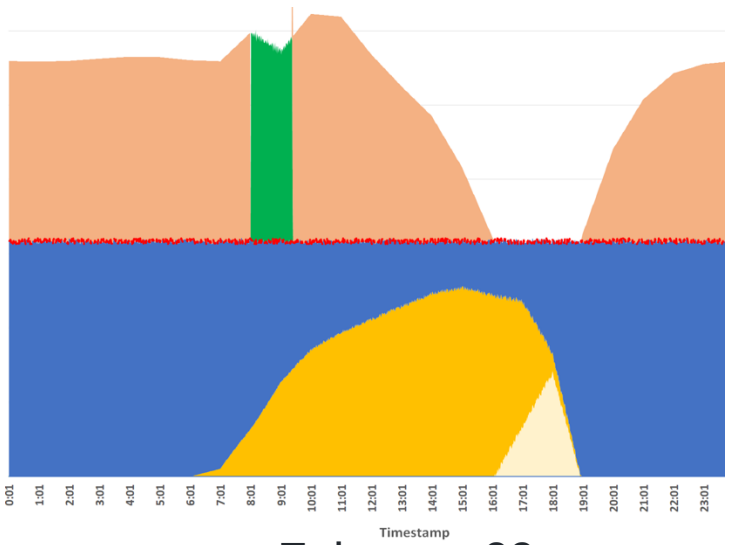
Sample days from annual calculation

The Concept:

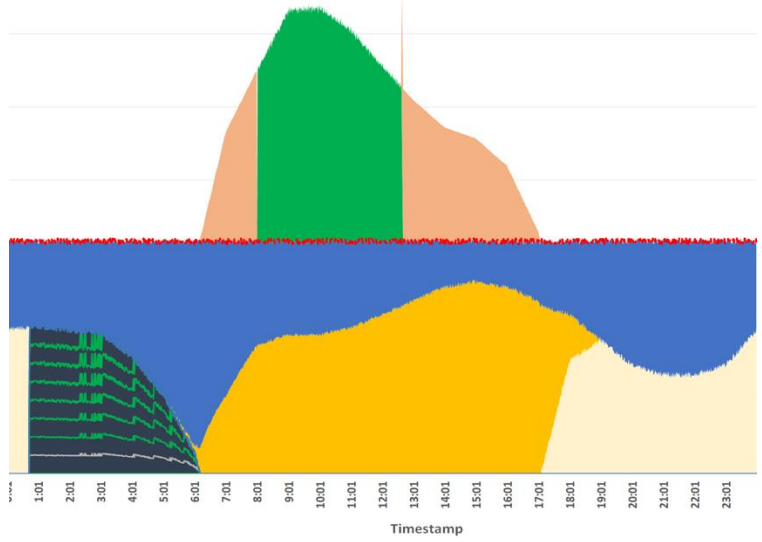
- PV oversized to Mine load by factor of 180%
- Wind sized at 200% of Mine load
- All engines shut off during high solar and wind hours
- 4 hrs BESS for load shifting

Sample days:

- Feb day without engine 24/7,
- June day shows load shifting and engine operation during night
- October days require significant engine operation due to low wind



February 09



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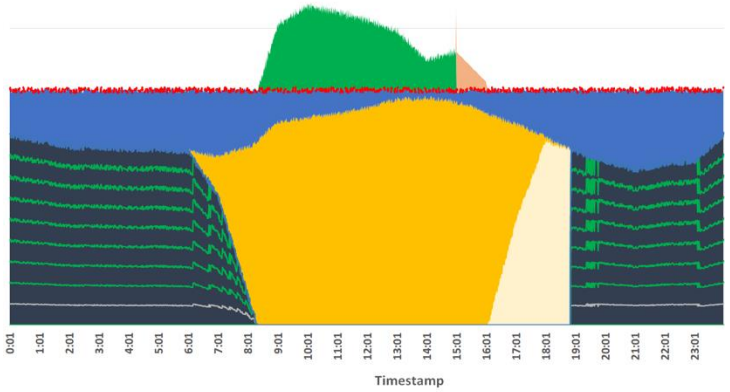

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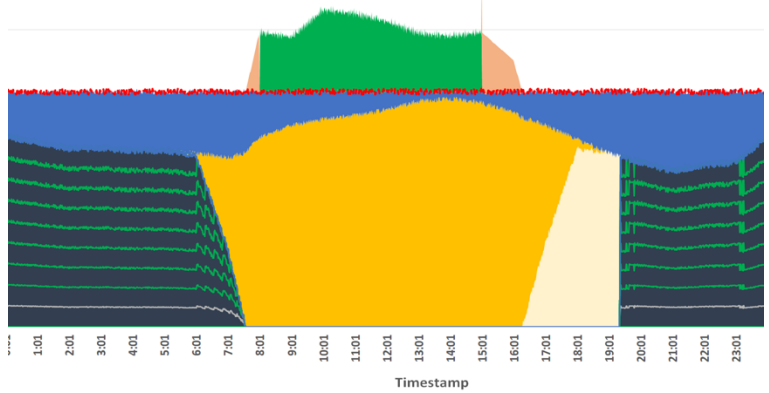

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