HOMER MICROGRID AND HYBRID POWER

9TH ANNUAL | INTERNATIONAL

ELUM ENERGY

Energy Storage Microgrids

How microgrids controls can increase renewable energy penetration?

AGENDA

1. Elum Energy overview
2. What is a Microgrid?
3. Values of Energy Storage in Microgrids : use-cases
4. How to design an ESS-based Microgrid from A to Z?

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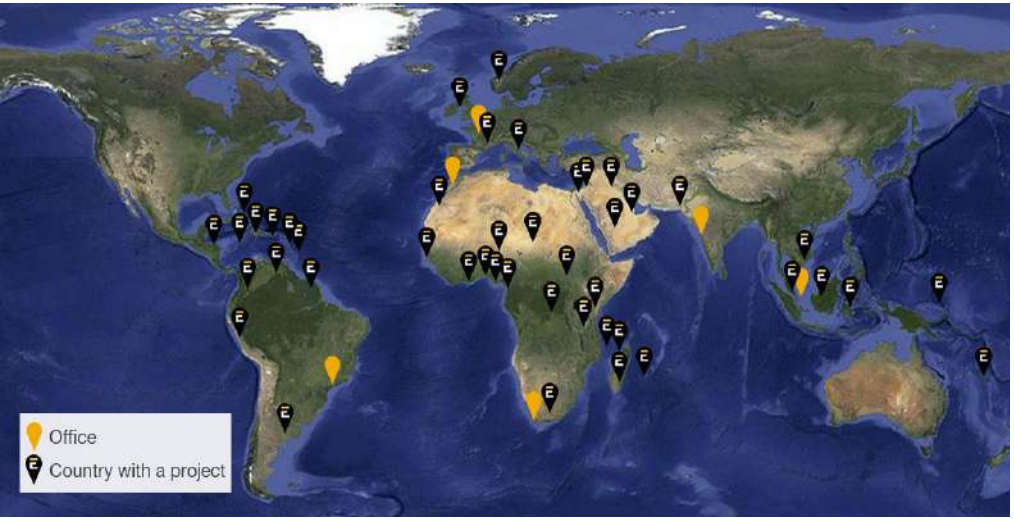
Elum Energy - Company overview

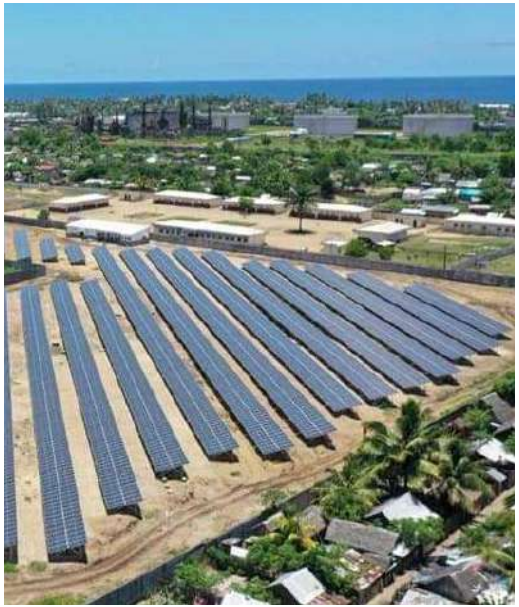


- Offices in **Paris**, **Casablanca, Cape Town** and soon **Sao Paulo, Singapore** and **Mumbai.**
- Expertise in **Monitoring & Control systems for microgrids**, with over **500 sites** equipped in more than **40 countries**
- High-end hardware integration & reliable software development from **energy control experts** in France
- Strong clients & partners

TOTAL ENGIE Masdar A MUBADALA COMPANY greenyellow Scatec solarcentury Sunzil GROUPES TOTAL & EDF

Elum Energy - EMS / Datalogging / SCADA for solar farms

Reliable & simple energy monitoring & control solutions for solar / hybrid power plants.



Power Plant

Microgrid

Rooftop Solar

ePowerControl - Plug & play, reliable and compatible controllers

From PV integration to Power plants control, a **tailored solution for each application**

A **cost-effective technology**, saving engineering time from design to operation

High-end hardware integration & **reliable software** development from energy control experts

Universal compatibility with main PV inverters, genset inverters, bess brands

SUNGROW HUAWEI TESLA SMA CAT

1. Elum Energy overview
2. **What is a Microgrid?**
3. Values of Energy Storage in Microgrids : use-cases
4. How to design an ESS-based Microgrid from A to Z?

What is a Microgrid and what is it made of ?

A Microgrid is an **energy distribution network** which :

- Relies on local means of producing electricity (suited for isolated or remote areas / resiliency)
- Is designed to operate independently or in synchronization with the national network, within a defined area
- Is increasingly composed of **renewable energy resources**

A Microgrid is typically composed of the following **distributed energy resources (DERs)** :

- Renewable energy sources (solar, wind, hydro)
- Energy storage solutions (batteries generally Lithium or Lead Acid)
- Fuel generators or gensets
- Power Grid (if available)
- Loads

How all DERs work together on a Microgrid ?

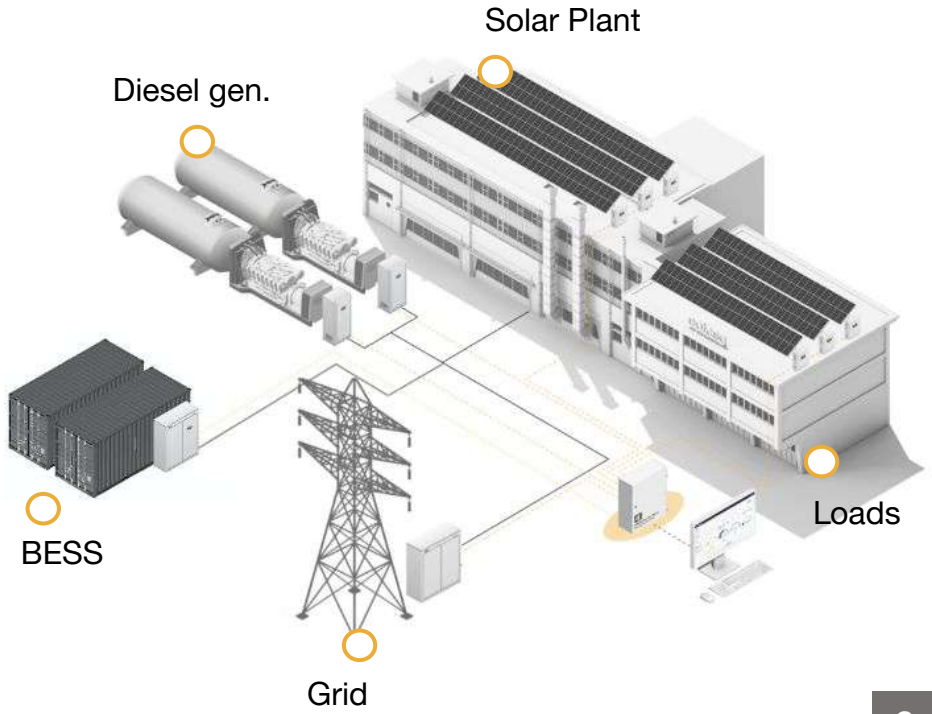
Grid-forming unit - a DER unit which is able to create a grid by regulating a certain electricity network voltage (U) and frequency (f), **this DER is the bandmaster of the Microgrid** :

- National grid
- Diesel generators
- Battery Energy Storage System (BESS)

Grid-following unit - a DER unit which is only able to provide active (P) and reactive (Q) power following the Electricity Network voltage & frequency :

- Solar Inverters

In a Microgrid **there will be at a given time one Grid-forming unit, all the other DERs will be Grid-following**



What can bring Energy Storage to Microgrids ?

Battery Energy Storage Systems are the **only cost effective power system available today able to both inject & store power**.

Hence, adding a BESS to a Microgrid can bring multiple values based on Microgrid type and services available, leading to :

- **Added revenues for the plant owner**
  - From more effective use of renewables onsite
  - From to grid services
  - From reduced fuel consumption
- **Added resiliency for the facility owner**

BESS values

- **Increase Solar Penetration** (for non synchronized prod/load curves)
- **Power supply resiliency** (grid outages, extreme events)
- **Fossil fuel avoidance** (genset running hours savings)
- **Behind-the-meter services** (Peak-shaving / load-shifting)
- **Front-of-the-meter services** (U,f, P, Q regulation)

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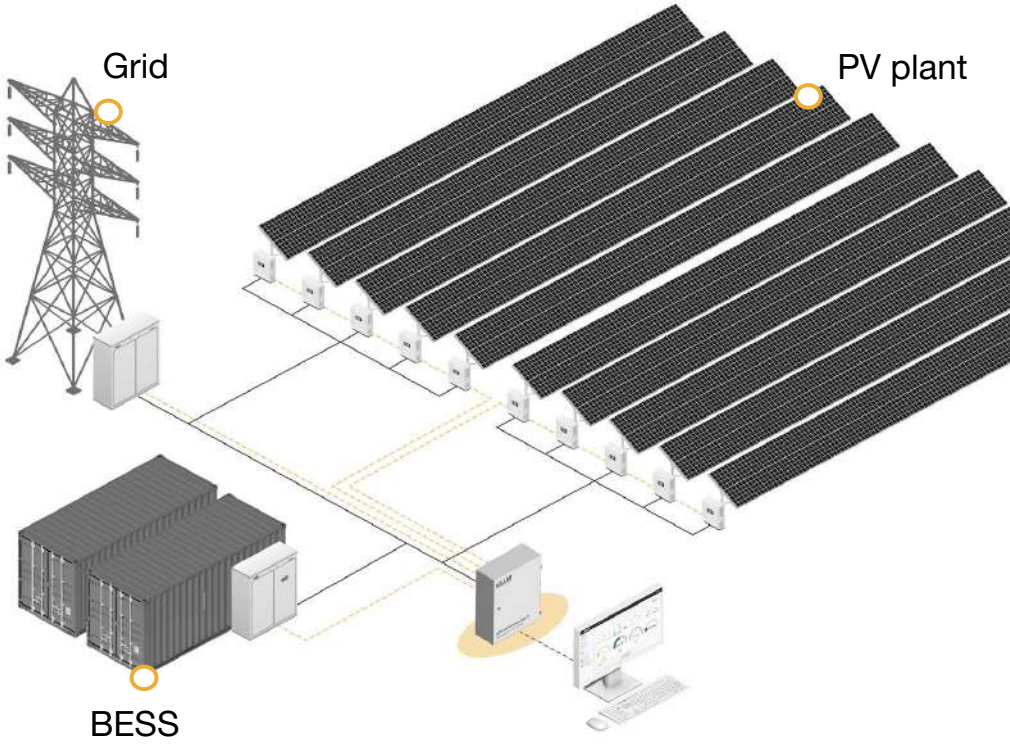
Values of Energy Storage for grid-tied solar / hybrid plants

Energy Storage systems on grid-tied injecting Solar plants can :

- Provide in front of the meter services (Voltage, Frequency services)
- Increase plant solar penetration
- Reduce fuel consumption from diesel plant if applicable



Hybrid utility scale with Solar, BESS and Genset plant

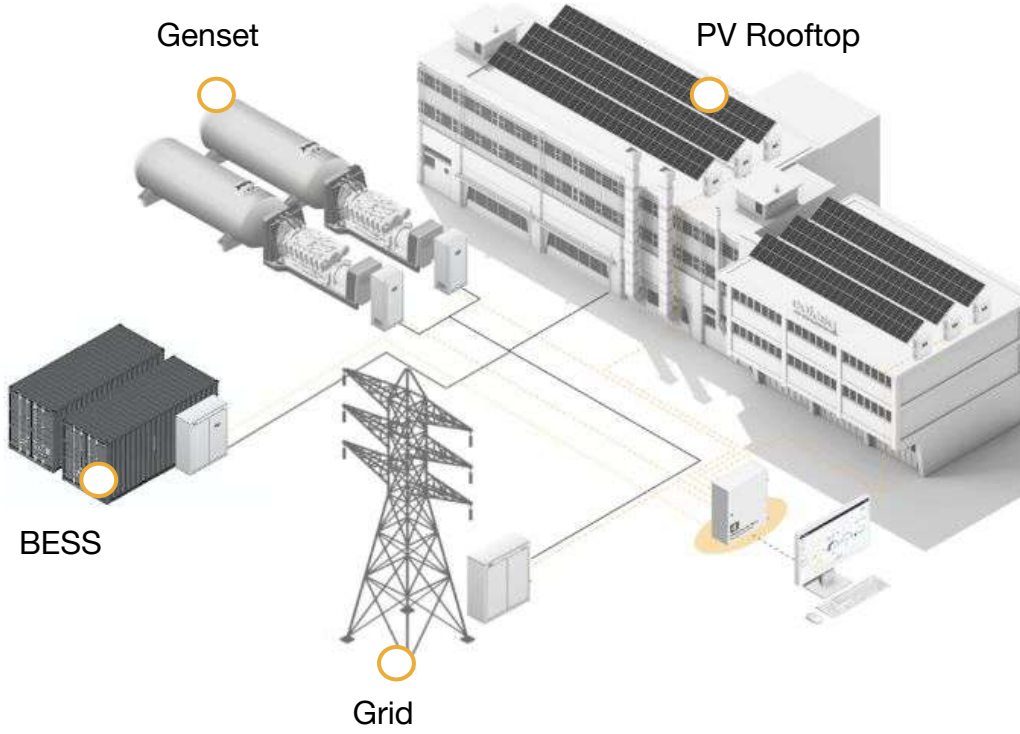
Foumbouni Solar+BESS Plant
Comoros
PV - 3 MWp
BESS - 1 MW / 2 MWh
Genset plant - 6 x 2 MVa

This Solar/BESS plant, is able to handle grid-tied operation, connected to Comoros island genset plants. Depending on the genset plant running, the power will be injected on the island's main grid, or on a small portion of the grid.
The plant is also able to operate in grid-forming mode, completely islanded from the grid, or connected to the local grid.
BESS synchronization and transitions are managed by ePowerControl PPC, which also helps increase solar penetration and deliver in front of the meter services.

Values of Energy Storage for solar powered poor-grid C&I building

Energy Storage systems on self-consumption C&I Solar plants can :

- Reduce Fuel consumption from existing diesel plant if applicable
- increase plant Solar Penetration
- Increase Energy supply resiliency
- Provide behind-the-meter services (Peak-shaving, Load shifting)



BESS integration to increase power reliability

Off-grid / On-grid Clinic
Puerto Rico
PV - 50 kWp
BESS - 170 kWh
Gensets - 300 kVA

Puerto Rico suffers since hurricane Maria from grid outages, making them rely on backup genset to assure reliability.

To reduce its reliance to the grid and the genset plant, a BESS and a rooftop power plant have been installed.

The addition of the BESS increases site reliability.

The Elum Energy ePowerControl Microgrid Controller **eases the solar integration** with the existing infrastructure and maximizes the solar penetration on this site.

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How to design a ESS-based microgrid from A to Z?

The objective is to both optimize system sizing and usage at design stage and consistently implement it at operation stage.

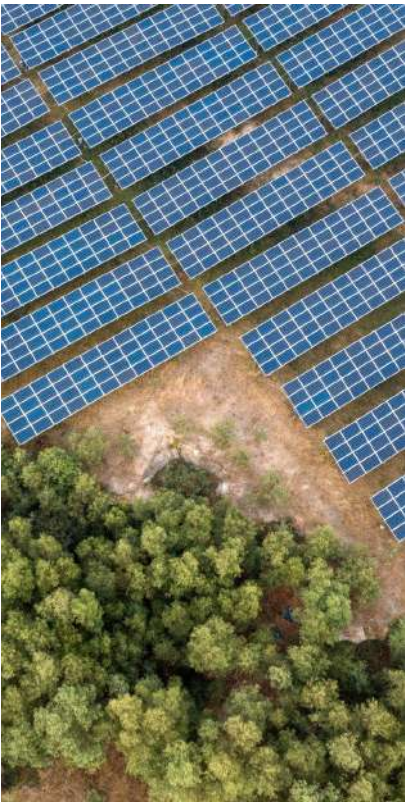
1. **Step #1 : Identify the best values and size the ESS accordingly**

Analyzing the various potential configurations in advance and studying their profitability makes it possible to choose the best value maximizing option for ESS usage and sizing.

2. **Step#2 : Choose the right control strategy and maximize profitability**

Integrating into the Microgrid controller the exact strategy defined at step #1 will allow consistent and effective plant operation.

Step#1 : design a Microgrid and choose the best Energy Storage values



“Choosing the right energy storage values through modelling and size your system accordingly is the only way to maximize plant profitability”

To define what service will be required for your microgrid, a technico-economical pre-study will help identify the main value levers based on the specifics of the site: load, weather, grid availability…

Tools like Homer Pro Microgrids provide advanced modelling and analysis of power systems.

This step is critical to define :

- The units capacity (ESS power capacity & duration, PV plant capacity...)
- The control strategy (type, modes and value thresholds)
- The microgrid electrical topology

Energy Storage benefits analysis example with HOMER

Off-grid mine in South Africa

Off-grid Industrial site - Diesel fueled power stations

Power System

- **3 MW** average load
- **5.5 MW** peak load
- **4 x 1 MW** diesel generators

BESS strategy

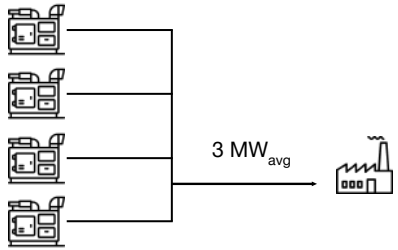
- **Cycle charging**

Business Case

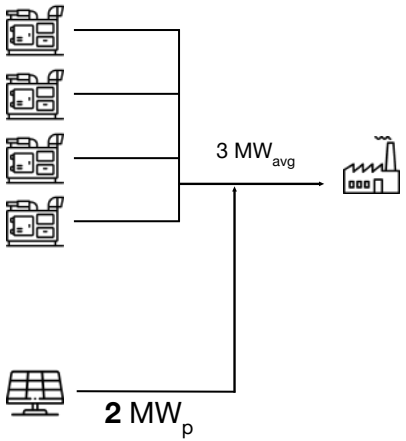
- Delivered Fuel Cost: **$1 US/L**
- Solar installed cost: **$0.8 US/Wp**
- Minimum genset loading: **30%**
- BESS cost: **$500 US/kWh**
- Discount rate: **10%**

Modelling scenarios results showing ESS value added

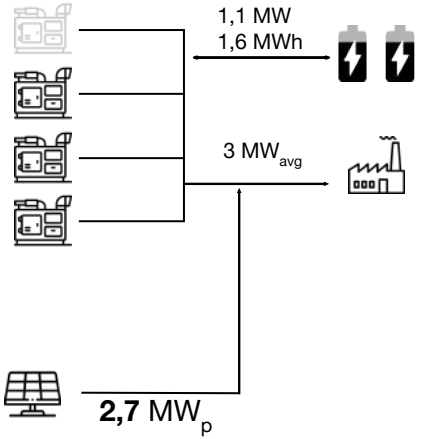
Diesel only



Diesel + Solar



Diesel + Solar + BESS



Fuel cost ($/y)	$2,34M	$1,8M	$1,43M
CAPEX ($)	-	$1,62M	$3,32M
LCOE ($)	**$0.315**	**$0.271**	**$0.235**
IRR (%)	-	34%	32%
Payback (year)	-	2.7	3.2

Genset status: On

Step 2 : a good control system is even more critical on BESS Microgrids

“Choosing the best musical instruments with the wrong bandmaster will lead to a disaster. This is the same in Microgrids”

BESS-based Microgrid are highly versatile :

1. **Energy storage can be used for various use-cases** : choosing the best ones and arbitrate between service is critical to maximise plant profitability

2. **Energy storage can be used in diverse contexts** : off-grid / grid-tied, and corresponding more transitions are critical

Advanced control unlocks :

- **Energy Storage value stacking** to maximise the asset profitability
- **Increased solar penetration** even further (spinning reserve optimisation)
- **Ensured energy supply continuity and resiliency** (mode transitions + asset supervision)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