

المبادرة العربية للتعليم البيئي "تمكين بيئي مستدام"



Battery Energy Storage System BESS

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- جاري تنفيذ مشروعات طاقة رياح بقدره ٣٤٥٠ ميجاوات
- جاري تنفيذ مشروعات طاقة شمسية بقدره ٣٧٠٠ ميجاوات مع انظمه تخزين بطاريات بسعة ٢٨٤٠ ميجاوات ساعة للاستفادة من الطاقة المولدة في أوقات الذروة وتحسين أداء واستقرار الشبكة. المجلس الأعلى للطاقة – ٢٦ أغسطس ٢٠٢٤

Reference: <https://cabinet.gov.eg/News/Details/76794>

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Egypt, 2023-2024

- Egypt signed a letter of intent to join the Battery Energy Storage Systems Alliance (BESS), which is one of the main initiatives of the Global Energy Alliance for People and Planet (GEAPP) during COP28 in Dubai.
- The alliance aims to enhance joint work to secure 5 GWs of stored energy by 2024.
- The first agreement was signed between the Norwegian company **SCATEC** and the Ministry of Electricity in Egypt, to develop **1 GW of solar energy with BESS** battery energy storage solution, with the participation the Norwegian government, the AfDB, British International Investment (BII), and the American Finance Corporation (DFC).
- NREA launched a **20MWp/35Mwh** project at Hurghada, financed by the Japanese JICA.
- July2024, H.E. Prime Minister announced the agreement on 500Mw BESS, to come in-service by 2025.

Reference: <https://cabinet.gov.eg/News/Details/76794>

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“Why BESS” Grid, Nature and Operation

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الطاقة في مصر - المصدر تقرير الشركة القابضة للكهرباء 2022-2023

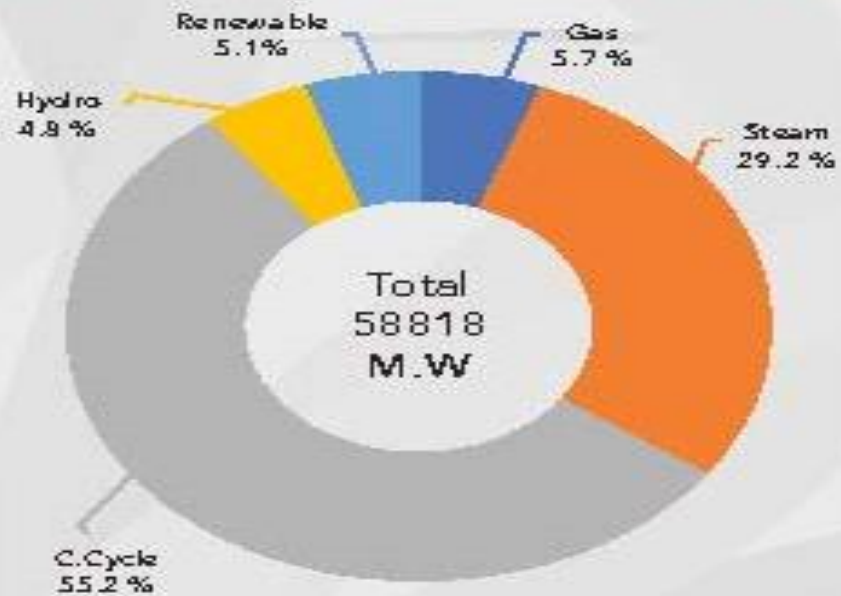
		2021/2022	2022/2023	Y/Y	وزارة البيئة mic nal
Total Installed Capacity	MW	59866	59445	99%	
Hydro	MW	2832	2832	100%	
Thermal (Affiliated Companies & EEHC Plants)	MW	52405	52622.5	100%	
New and Renewable Energy (Wind & Solar)	MW	3264	3308	101%	
Private Sector BOOT (Thermal)	MW	1365	682.5	50%	
Peak Load	MW	33800	34200	101%	
Total Energy Generated (on country level)	GWh	214220	216252	101%	
Hydro	GWh	14646	15458	106%	
Thermal	GWh	179977	184578	103%	
New and Renewable Energy	GWh	10537	10642	101%	
Private Sector (BOOT)	GWh	8890	5399	61%	
Power Generated from Isolated Plants - unconnected plants and reserve	GWh	147	163	111%	
Energy Purchased From (IPPs) - industrial companies surplus	GWh	23	12	52%	
Total Fuel Consumption	K toe	34149	33500	98%	
Production Companies (including EEHCs plants)	K toe	32275	32350	100%	
Private Sector (BOOT)	K toe	1874	1150	61%	
Fuel Consumption Rate at Production Companies	gm/kWh gen.	179.3	175.26	98%	
Fuel Consumption Rate , including BOOT	gm/kWh gen.	180.8	176.3	98%	
Thermal Efficiency (including Private Sector BOOT)	%	48.54	49.77	103%	
No. of Customers at Distribution Companies	M. Customer	39.1	40.7	104%	

EETC Annual Report, 2020-2021.

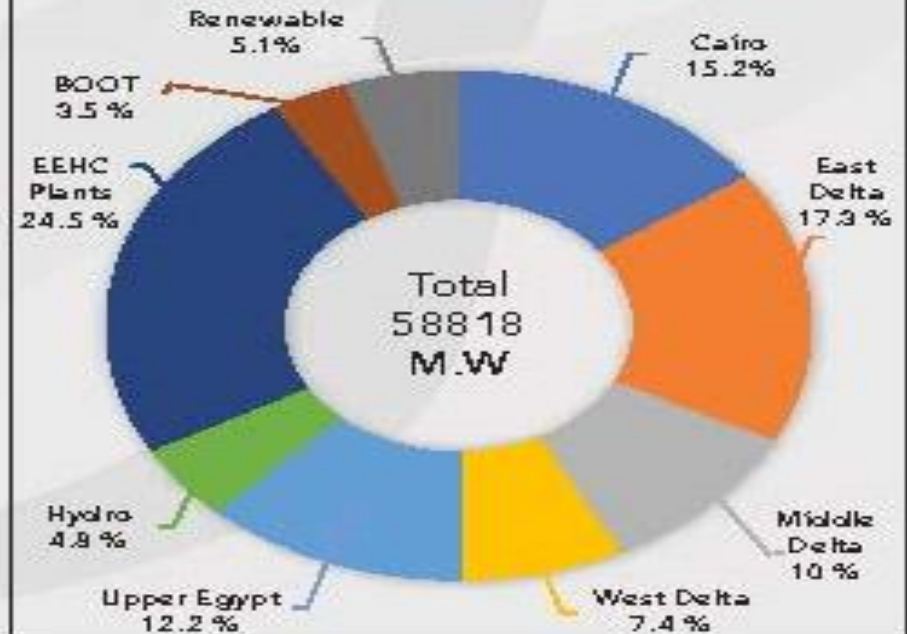
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Type Co.	Cairo	East Delta	Middle Delta	West Delta	Upper Egypt	Hydro Power	EEHC Plants	Private Sector	Renewables	Total
Gas	785	1848	336	24	350	0	0	0	0	3343
Steam	3320	4156	420	3431	3804	0	0	2048	0	17179
Combined Cycle	4834	4200	5107	907	3000	0	14400	0	0	32448
Hydro	0	0	0	0	0	2832	0	0	0	2832
Renewables	0	0	0	0	0	0	0	0	3016	3016
Total (MW)	8939	10204	5863	4352	7154	2832	14400	2048	3016	58818

Installed Capacity by Generation Type (%)



Installed Capacity by Company (%)

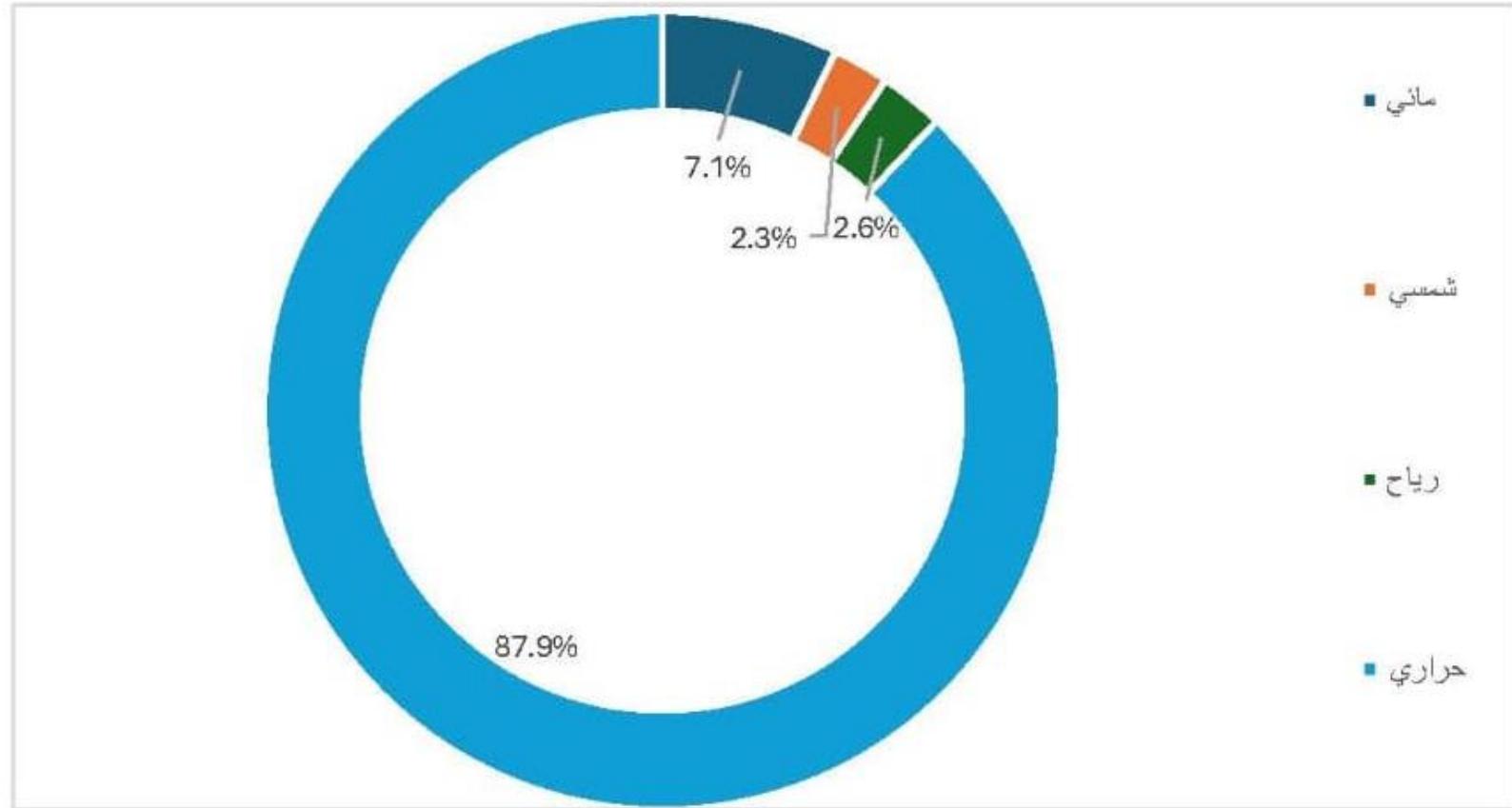


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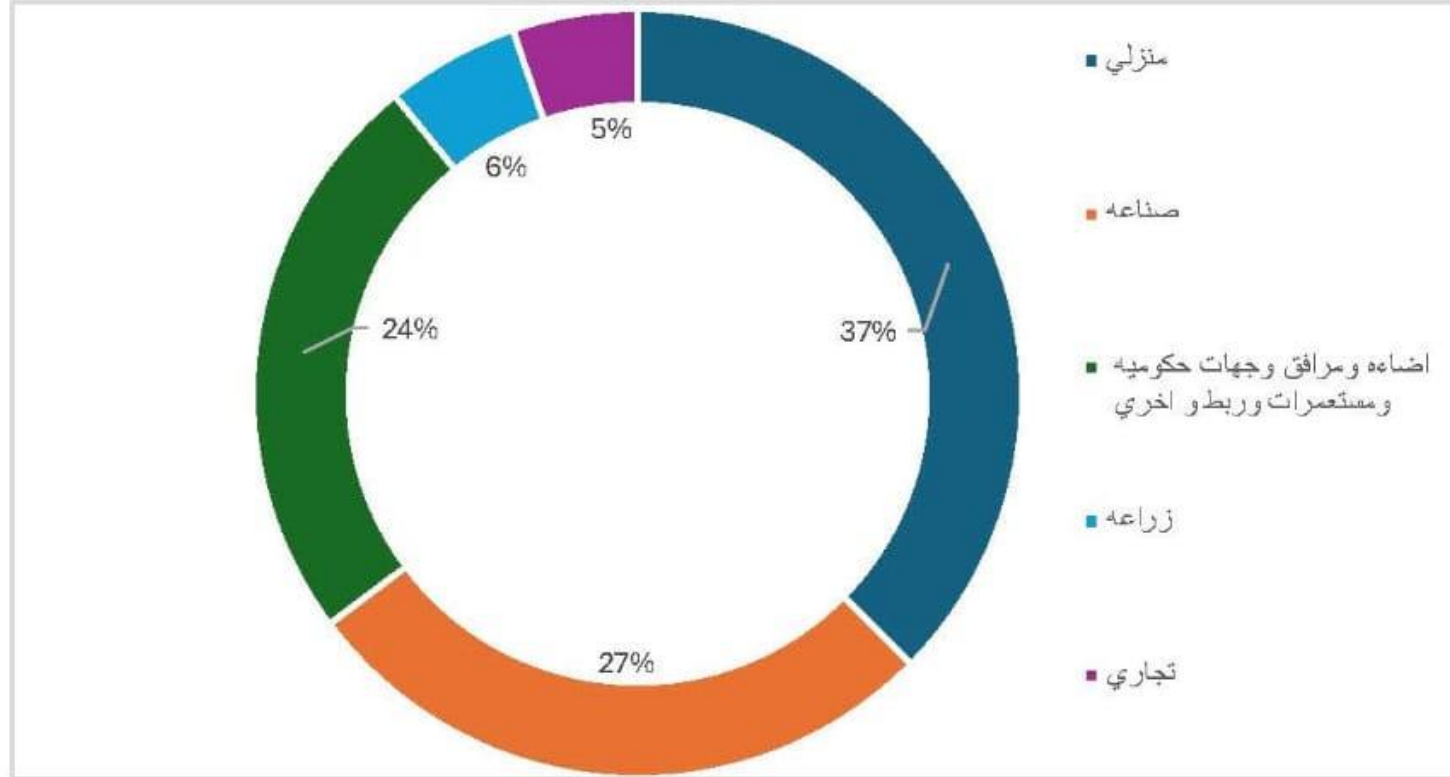


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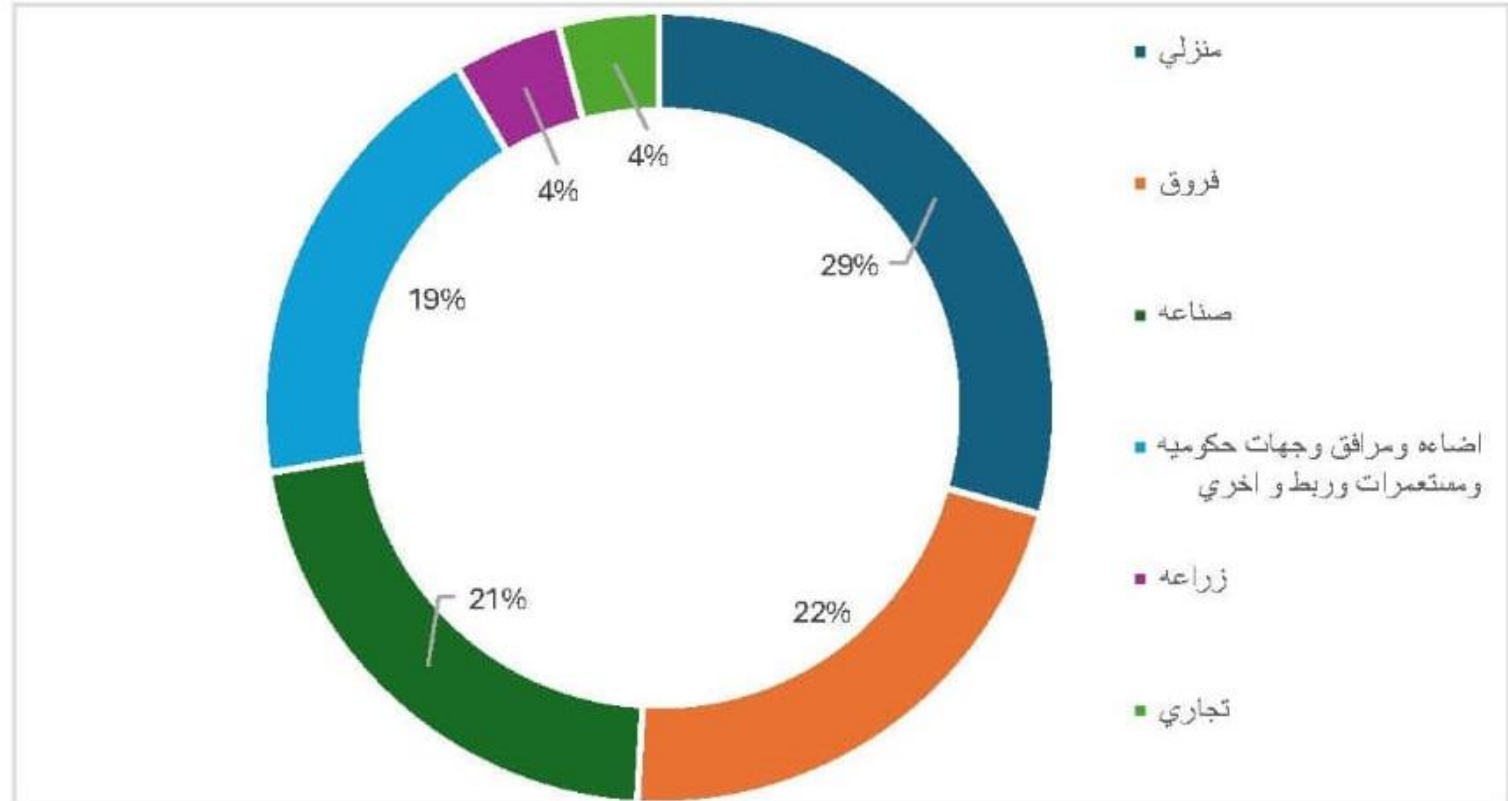
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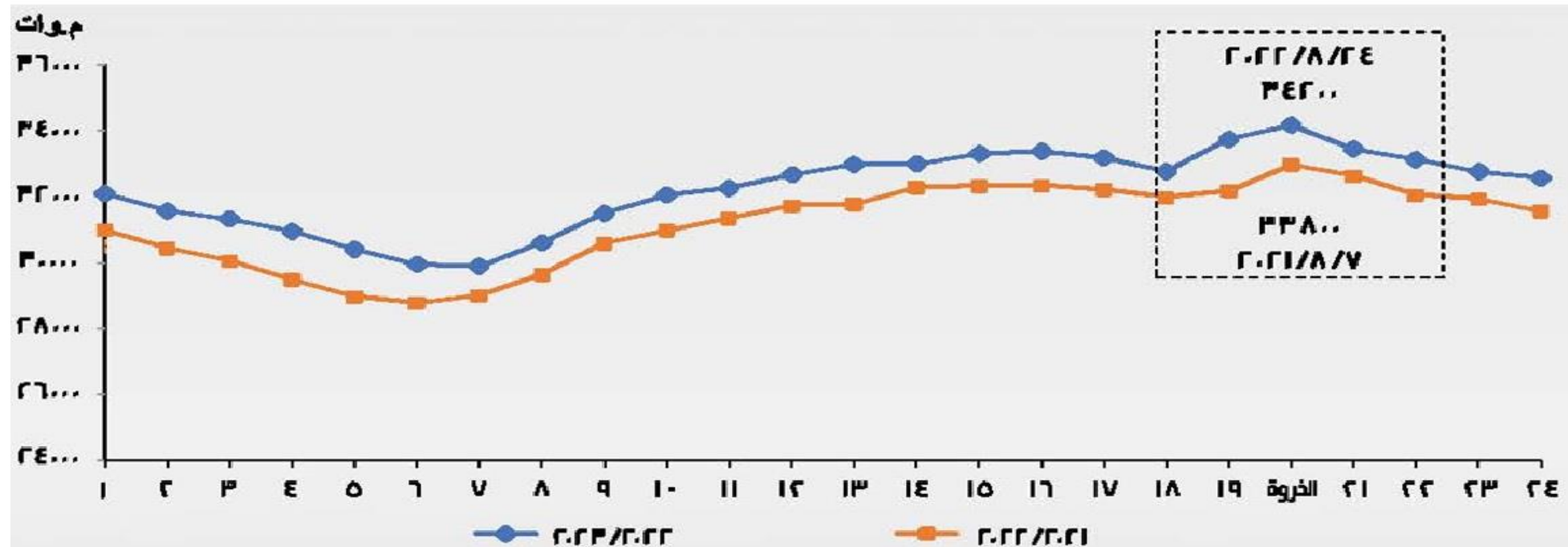
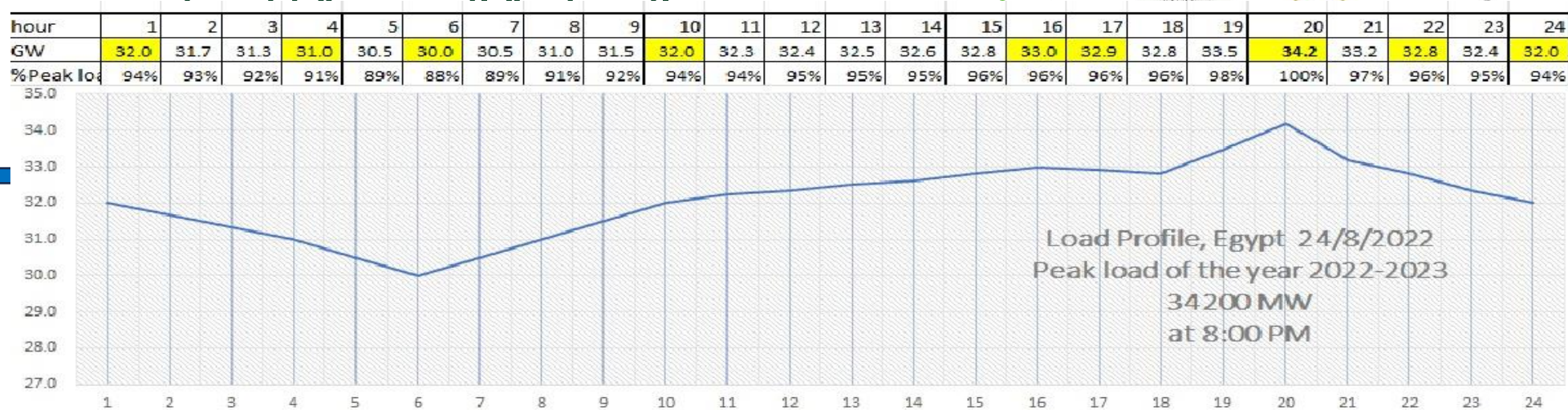
216.2 TWh
169.6 TWh

اجمالي الطاقة المنتجة والمشتراة
اجمالي الطاقة المباعة



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Simulation, based on EETC Annual Report, 2020-2021.

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System load
(MW)

2500

2000

1500

1000

500

0

Potential for
grid instability*



6am



9am



12pm



3pm



6pm



9pm

2018

2020

2022

2024

Duck Curve – Typical Daily load

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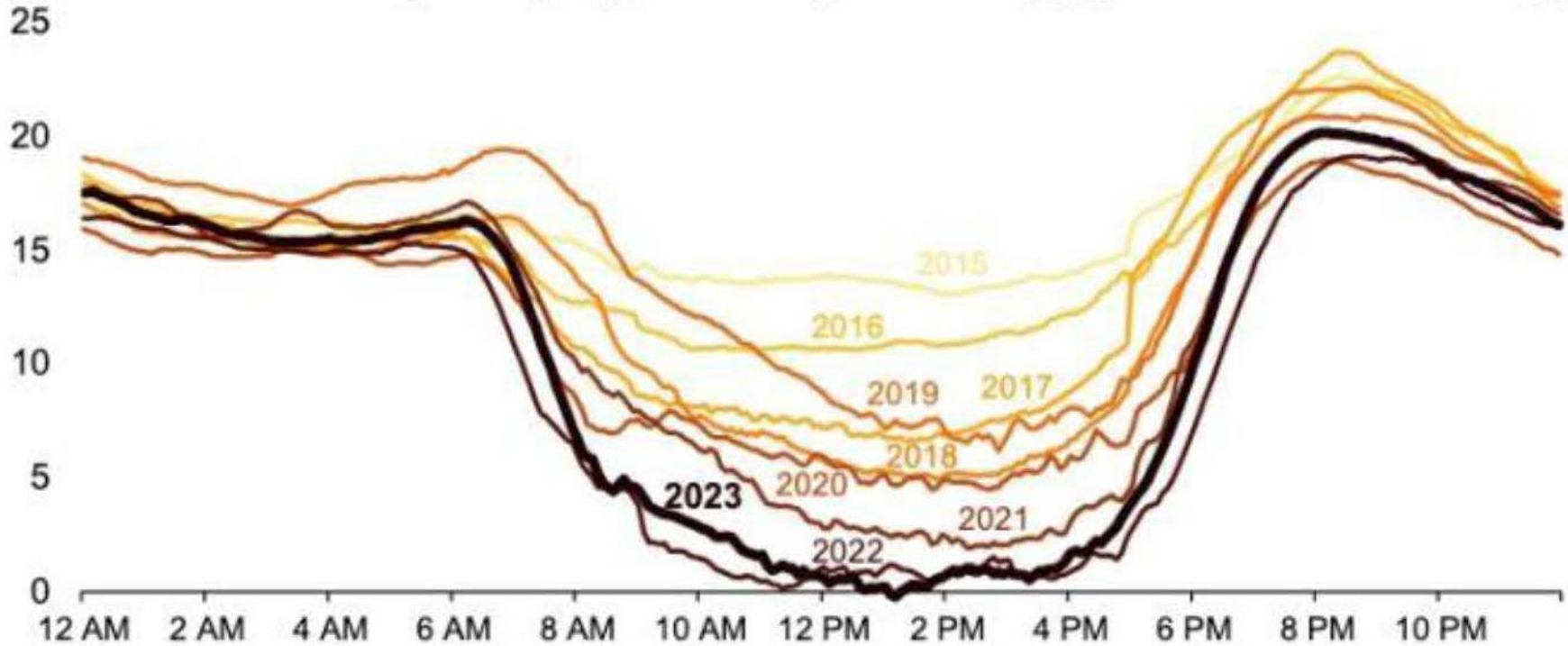
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California's duck curve is getting deeper

CAISO lowest net load day each spring (March–May, 2015–2023), gigawatts



California's Duck Curve is Getting Deeper Credit: [Energy Information Administration\(link is external\)](https://www.eia.gov) (EIA.gov)

Duck Curve – Typical Daily load

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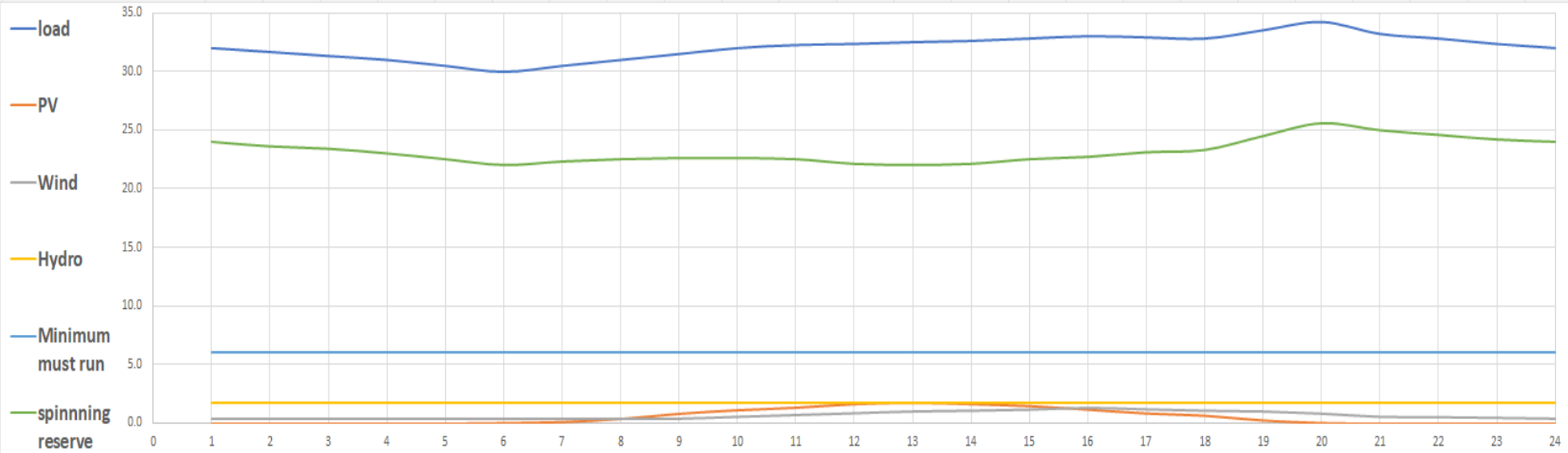
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Hourly Simulation of Demand and supply, 24/8/2023.

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
load	32.0	31.7	31.3	31.0	30.5	30.0	30.5	31.0	31.5	32.0	32.3	32.4	32.5	32.6	32.8	33.0	32.9	32.8	33.5	34.2	33.2	32.8	32.4	32.0
PV	-	-	-	-	-	0.1	0.1	0.4	0.8	1.1	1.4	1.7	1.8	1.7	1.5	1.2	0.9	0.7	0.3	0.1	-	-	-	-
Wind	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.7	0.8	1.0	1.1	1.2	1.3	1.2	1.1	1.0	0.8	0.5	0.5	0.4	0.3
Hydro	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Minimum must run	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
spinning reserve	24	24	23	23	23	22	22	23	23	23	23	22	22	22	23	23	23	23	25	26	25	25	24	24



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50.0

البيئي

— load

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— PV

— Wind

— Hydro

— Minimum
must run

— spinnning
reserve

5.0

0.5

0

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24



وزارة التخطيط والتنمية الاقتصادية
والتعاون الدولي
Ministry of Planning, Economic
Development & International
Cooperation

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Why is Energy Storage needed?

Most energy systems have a varying demand with some short-term but significant peak power requirements, which results in a capacity requirement which might only be used for a fraction of the time. Energy storage enables energy to be saved for later use.

Energy storage creates capabilities and efficiencies low cost energy for the electric grid and assists in mitigating climate change.

Renewable energies are intermittent in nature, i.e., their capacities to produce energy vary with time. Energy storage from renewable energies can avoid any curtailment of renewable energies during favorable weather conditions when excess wind or solar energy gets generated.



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BESS functions Peak Shaving and load shifting

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Role of BESS in Peak Shaving

Peak shaving is the practice of reducing peak demand during periods of high electricity use.

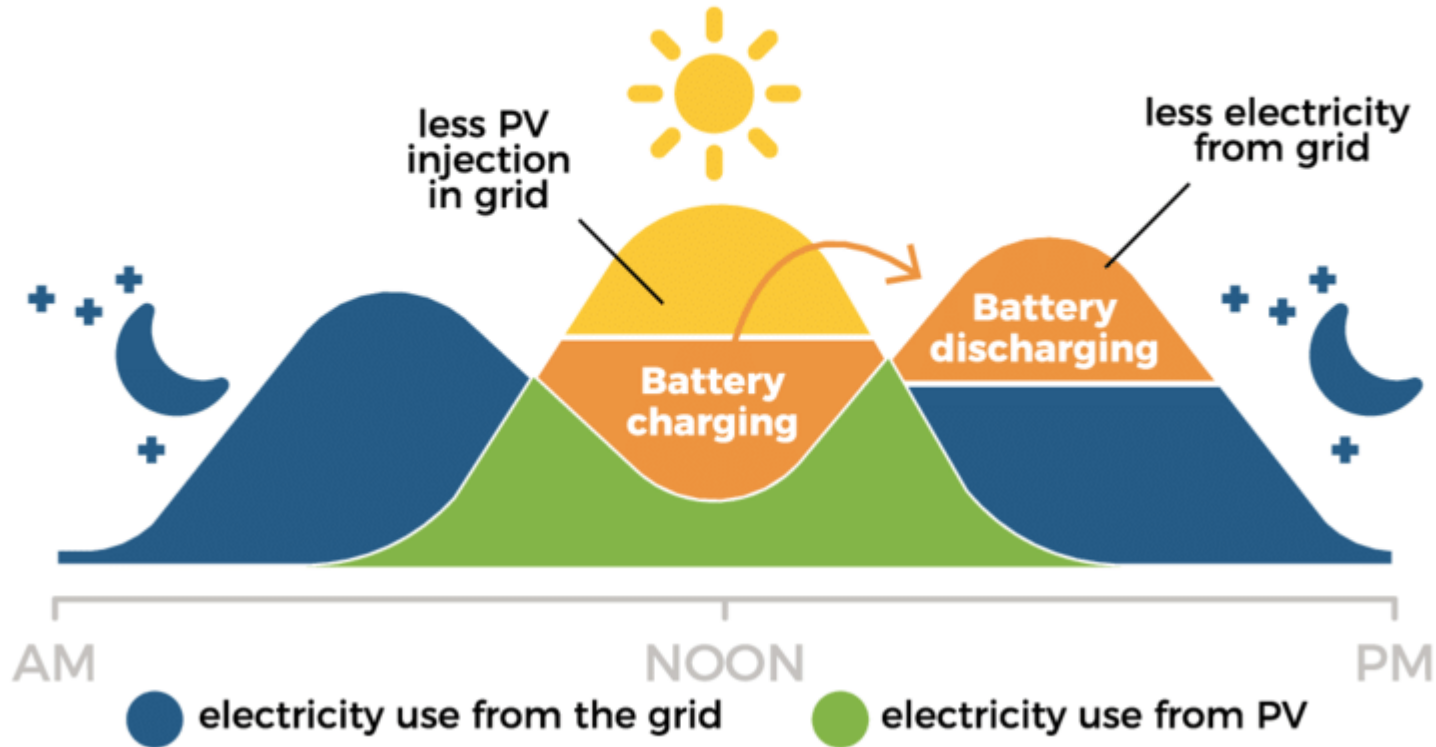
BESS can discharge stored energy during peak hours, reducing strain on the grid and preventing the need for costly generation during peak demand.

Furthermore, peak shaving not only benefits the grid but also consumers. It can help reduce peak electricity prices, providing cost savings to households and businesses.

BESS can reduce the intensity of load shedding events.

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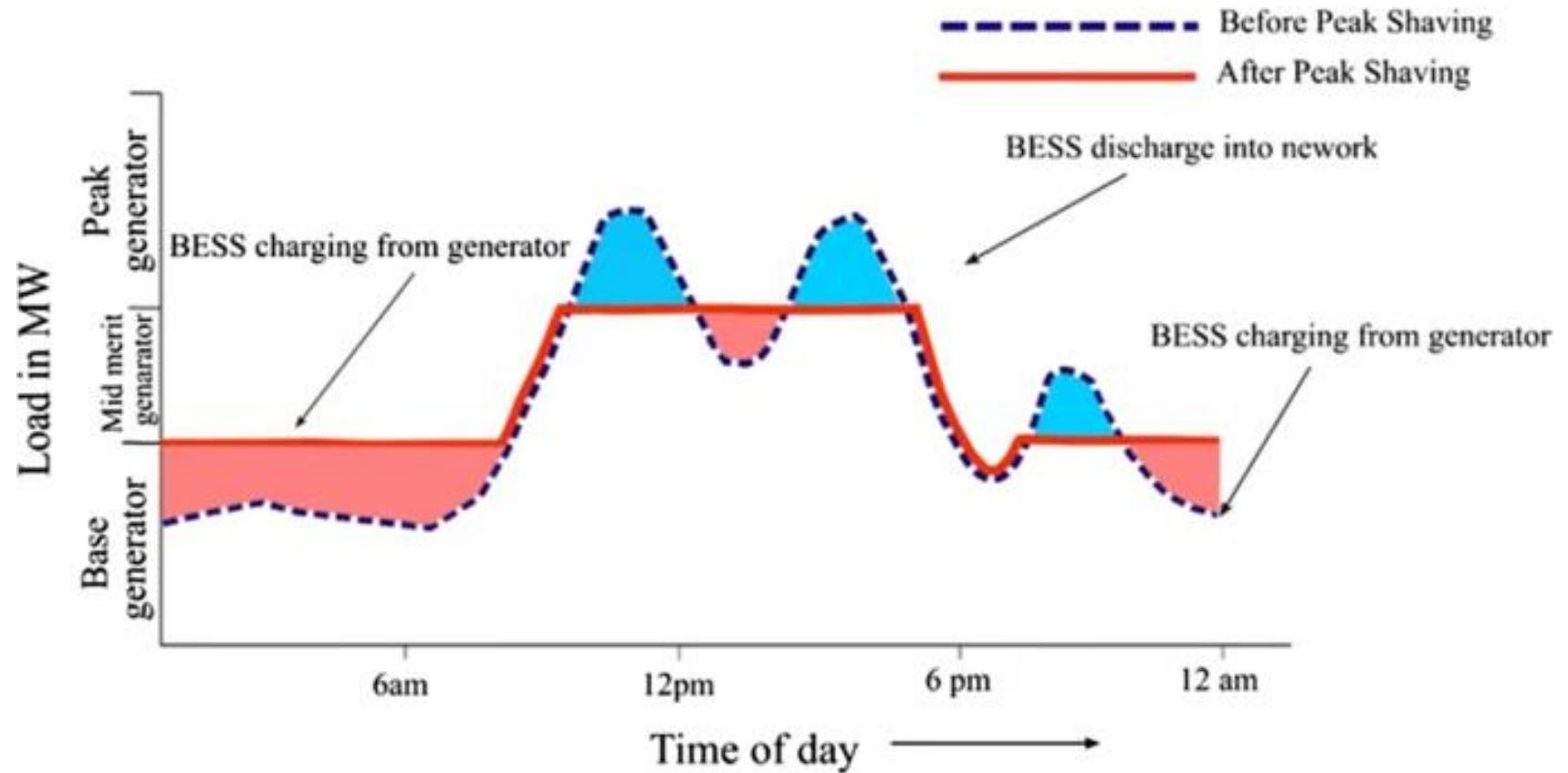
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Reference: <https://openenergi.com/articles/batteries-in-the-balancing-mechanism>
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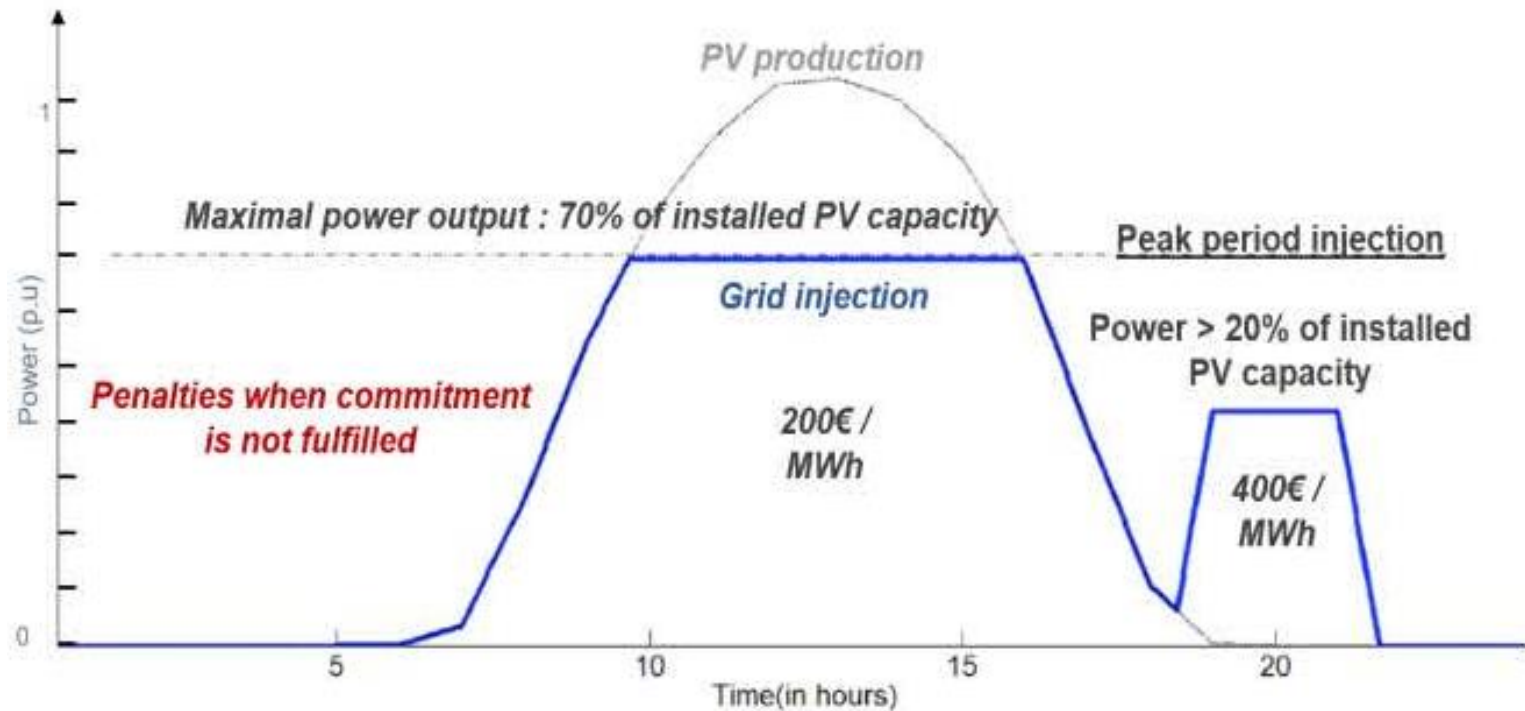


Reference: <https://openenergi.com/articles/batteries-in-the-balancing-mechanism>

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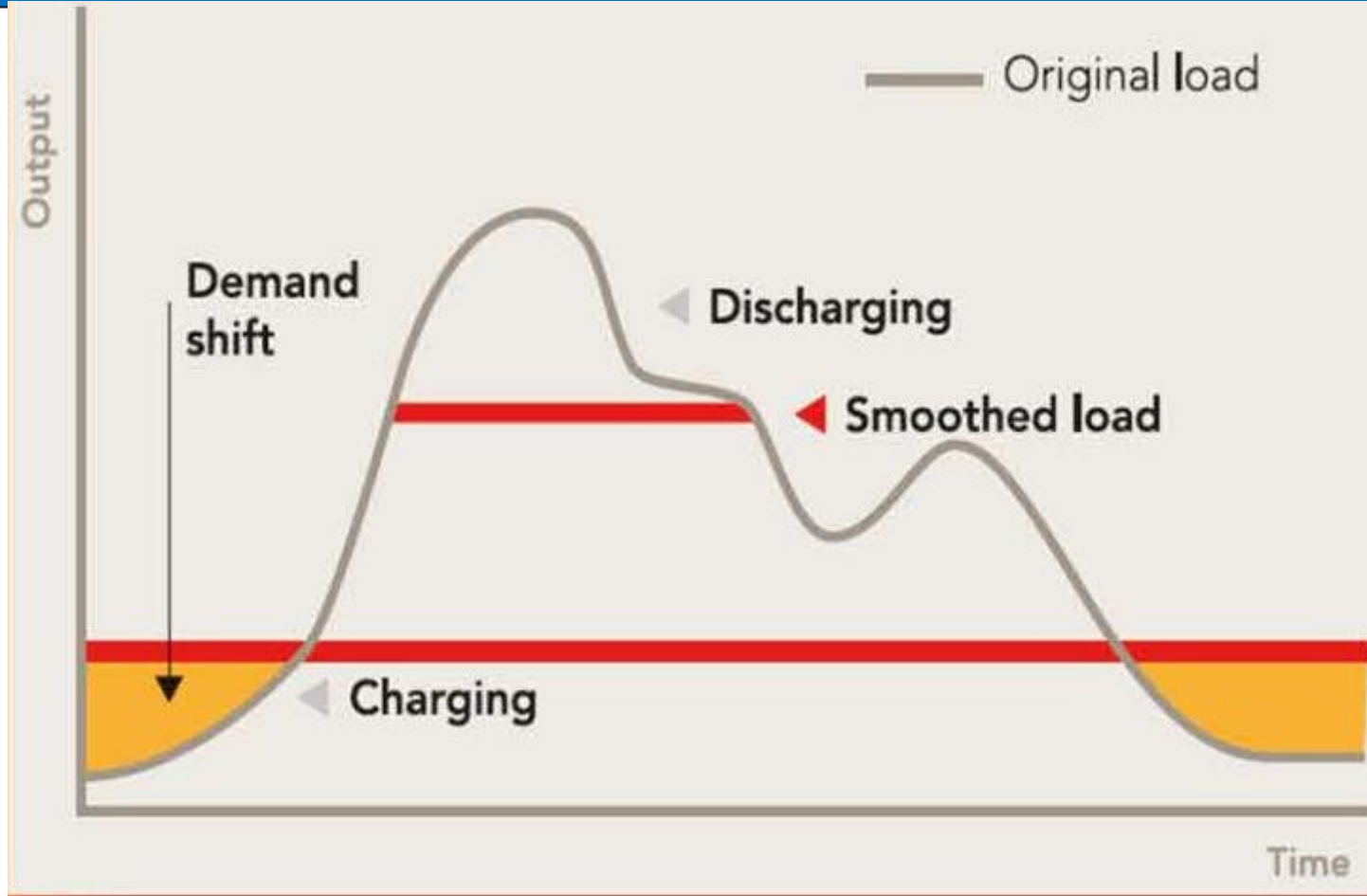


Source: Optimal BESS sizing, Uni Grenoble, Alpes.

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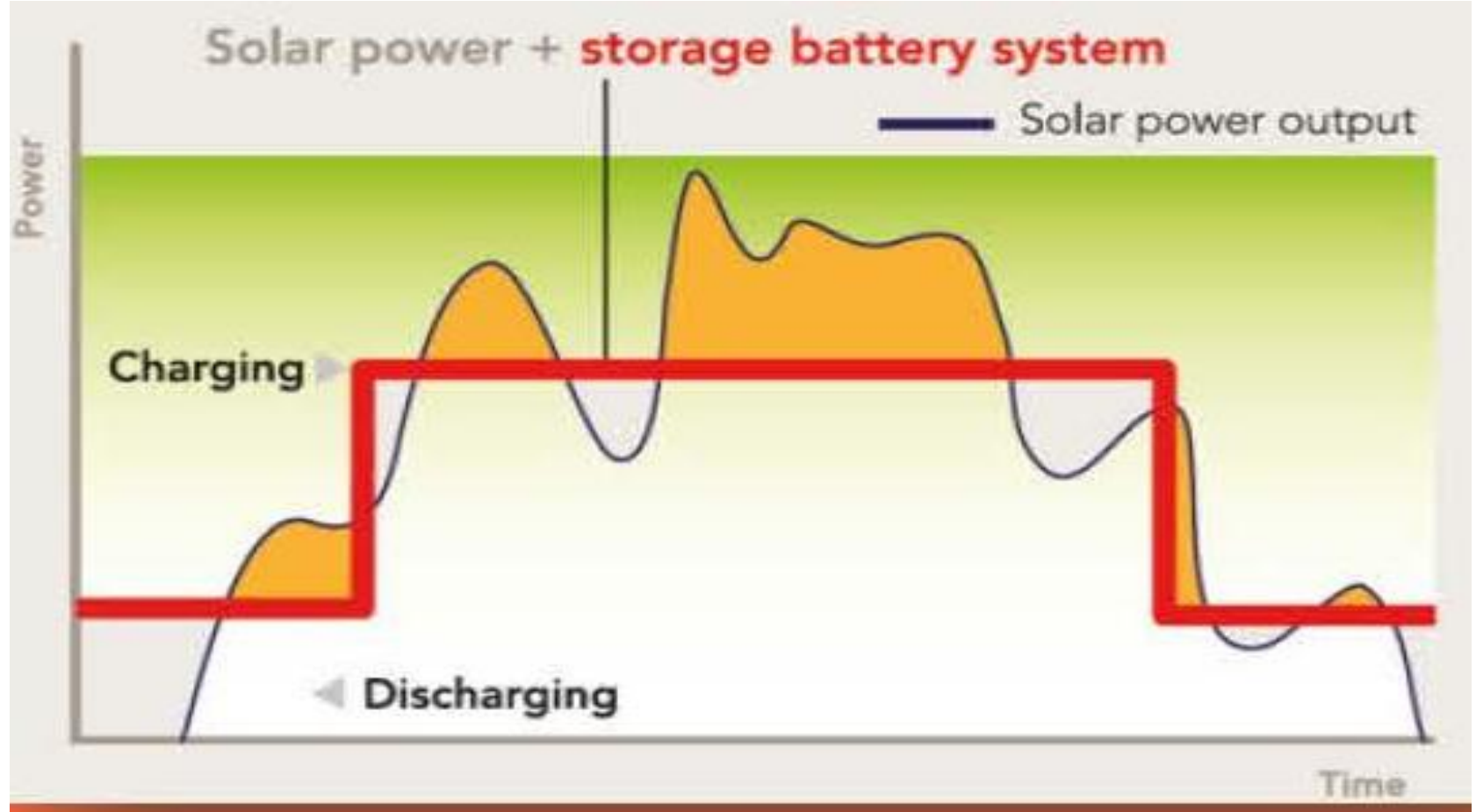


Clemson Uni, Energy storage study, 2010.

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BESS functions Grid Support

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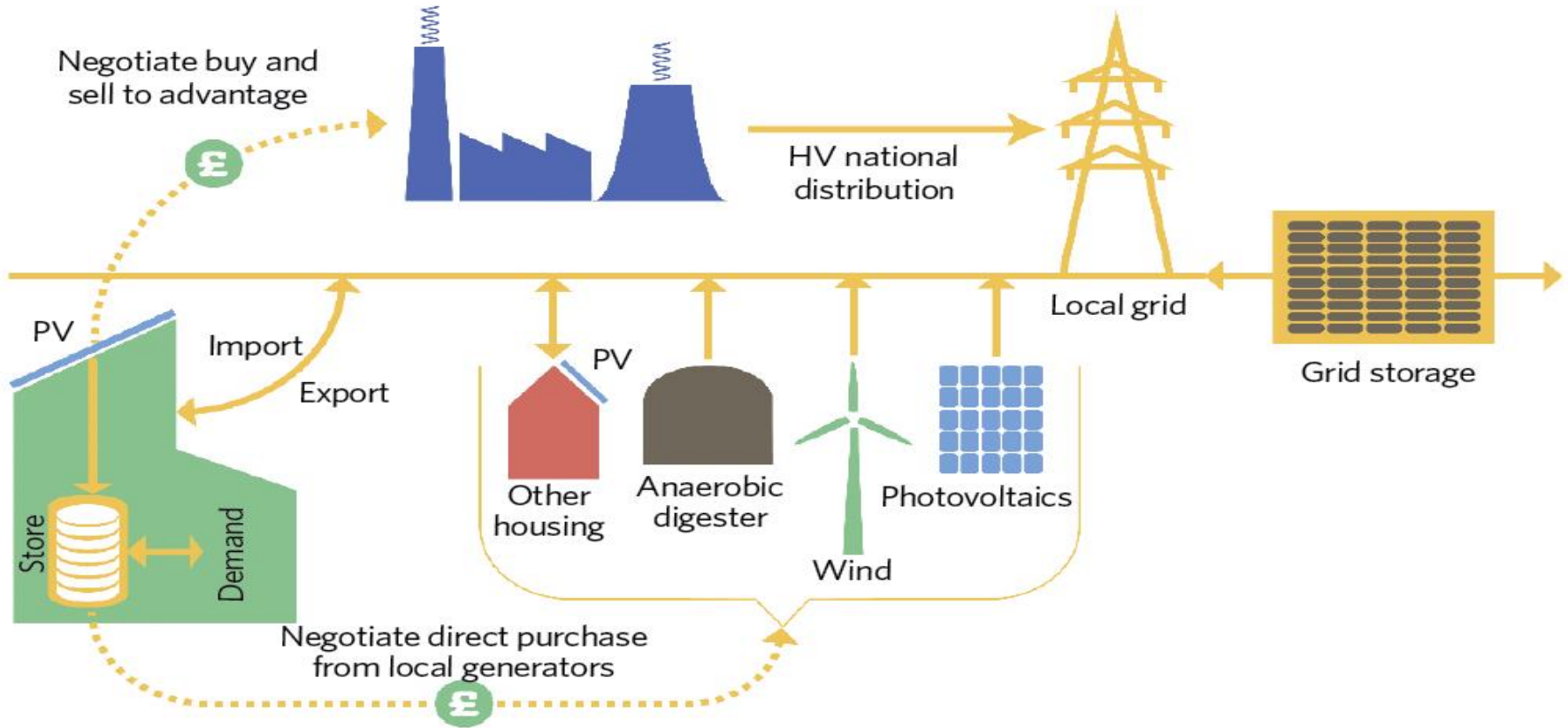
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Conventional large-scale supply



New local supply possibilities

Reference: <https://www.cibsejournal.com/general/staying-power-demand-response-market/>

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BESS and Grid Support

They provide grid operators with greater flexibility, reliability, and stability.

With the increasing integration of renewable energy sources, such as solar and wind, BESS becomes more essential in managing the intermittency and variability of these sources.

BESS also contribute to energy independence and security. They can be strategically located to ensure a continuous power supply during natural disasters.



Category 1 - Electric Supply	Category 4 - End User / Utility customer
1 Electric Time-Shifting	11 Time of Use (ToU) Energy Cost Management
2 Electric Capacity Supply	12 Demand Charge Management
	13 Electric Service Reliability
Category 2 - Ancillary Services	14 Electric Service Power Quality
3 Load following	Category 5 - Renewables Integration
4 Area regulation	15 Renewables Energy Time-Shift
5 Electric Supply Reserve Capacity	16 Renewables Capacity Firming
6 Voltage Support	17 Wind Generation Grid Integration
Category 3 - Grid System	Category 6 - BESS mandatory responses
7 Transmission Support	18 VSG
8 Transmission Congestion Relief	19 LRT
9 Transmission & Distribution Upgrade Deferral	20 HRT
10 Substation On-Site Power	21 V-F control
	22 Grid forming
	23 Grid following

Source: Collection from various regulators.

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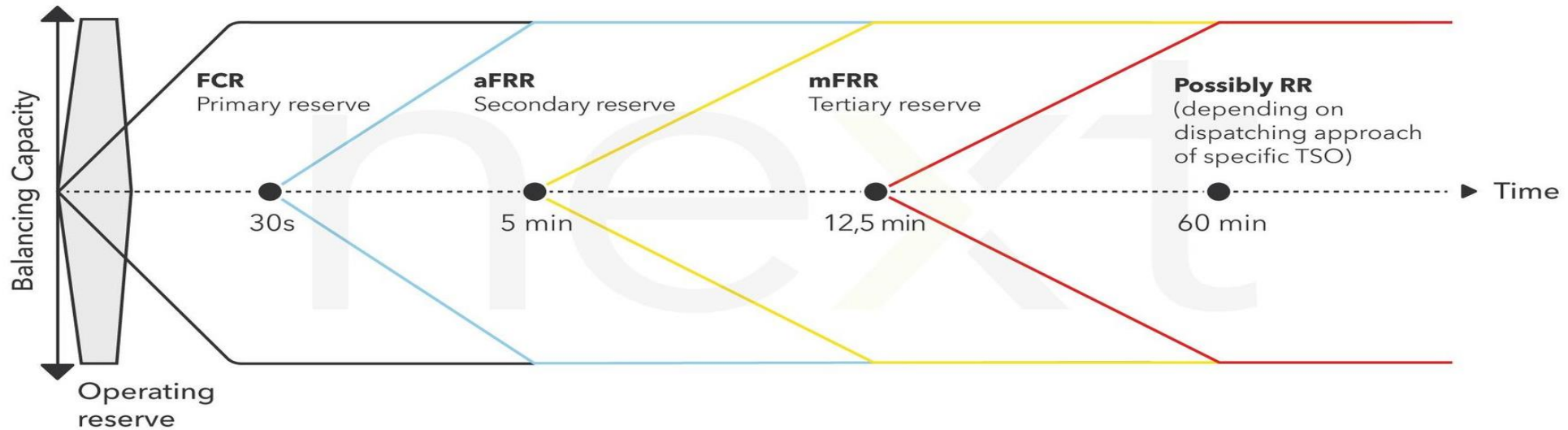
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Frequency Response

- A BESS has a frequency response which allows it to provide active power output when there is a change in the electrical grid's frequency.
- A deviation from the nominal frequency indicates a mismatch between power supply and demand, which can destabilize the grid, causing outages or blackouts.
- To restore balance quickly, the BESS can adjust its active power output by reacting to deliver sub-second frequency response to stabilize and balance supply and demand within the network.
- The growing share of renewable generation and decentralized power plants connected to the network, means battery storage will continue to play a critical role in our energy transition.

Balancing Services According to the System Envisaged by ENTSO-E



Balancing energy is divided into:

- Frequency Containment Reserve ([FCR](#))
- [Primary](#) control reserve,
- Automatic Frequency Restoration Reserve (aFRR, or secondary control reserve),
- Manual Frequency Restoration Reserve ([mFRR](#), or tertiary control reserve), and
- Replacement Reserve (RR).

Reference: next-kraftwerke.com/knowledge/balancing-services

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How BESS Improves Grid Stability

BESS can enhance grid stability by rapidly responding to fluctuations in supply and demand. They can provide quick injections of power when needed, preventing voltage sags and blackouts.

BESS can act as frequency regulators, maintaining the grid's frequency within acceptable limits.

BESS can help utility reduce operational costs, enhance grid reliability, and defer expensive infrastructure investments.

BESS can serve as backup power sources during outages.

BESS can enable utility to manage demand response programs, i.e.: manage electricity consumption during peak hours, which can be cost-effective for both the utility and the consumer.

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BESS and Renewable Energy Integration;

BESS can also smooth out the variability of renewable sources. For instance, they can store excess energy and discharge it during low production time and/or high demand time, hence, ensuring a more consistent power supply.

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Challenges and Concerns

While BESS offer numerous benefits, there are also challenges and concerns to address, including:

- cost,
- recycling of batteries, and
- environmental impacts associated with battery production.

Moreover, safety is a critical concern in the BESS industry. Ensuring that batteries are handled and disposed of safely is essential to prevent accidents and environmental damage.

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- Battery energy storage can be beneficial due to the flexibility of co-locating with other renewable energy sources or non-renewable sources.
- Battery energy storage also requires a relatively small footprint and is not constrained by geographical location.
- BESS can improve grid stability by responding rapidly to fluctuations in supply and demand, preventing voltage sags, load shedding and blackouts.
- They also act as frequency regulators, maintaining a consistent power supply.

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Energy Time Shifting / Arbitrage

- Energy time shifting or arbitrage allows users with BESS solutions to store their purchased power during off-peak times to use on-site when the imported power price is high.
- Alternatively, users can trade their stored electricity via the flexibility markets (Energy Markets, Ancillary Services, and Capacity Market) for income generation.

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Energy Resilience

- Battery energy storage can supply fast response backup power in the event of a mains failure to ensure infrastructure is operational and downtime is minimal.
- Using these battery energy storage systems alongside power generation technologies such as gas-fired [Combined Heat and Power \(CHP\)](#), [standby diesel generation](#), and UPS systems will provide increased resilience mitigating a potential loss of operational costs.

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Grid Connected

- In Front-of-the-Meter (FtM) applications battery storage systems are typically referred to as utility or grid-scale battery storage and can be connected to transmission or distribution networks.
- FtM can reduce congestion management whilst also controlling voltage and providing reserve and ancillary services.

A BESS can also support power generation assets.



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Commercial and Industrial

BESS are typically Behind-the-Meter (BtM):

- avoiding electricity network charges,
- benefiting from tariff differences,
- delivering value-added balancing services,
- or enhancing on-site resilience and energy consumption when paired with on-site solar PV.



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Co-location

- BESS can be paired with renewable and non-renewable technologies to form a Hybrid power solution.
- Hybrid systems can enhance the performance of new and existing gas engine installations.
- Combining a battery storage system with gas generation and solar power will go a long way to making cheaper, cleaner and more reliable power more accessible.



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Sources of Revenue - BESS

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BESS projects can be attractive by obtaining 'stacked' revenue streams. These include:

Capacity Markets

Participants may earn revenue for entering into commitments under a statutory contract called a 'Capacity Agreement' with the Government. These Capacity Agreements provide a backup electricity supply to meet peak demand during system stress. The agreements may have a duration of up to 15 years.

Offtake Agreements

These agreements are with the consumers for a negotiated price. The contracts are known as Power Purchase Agreements or PPA. PPAs may have a duration of up to 15 years.

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Dynamic Frequency Response

Dynamic Frequency Response provides an extremely valuable source of income. However, contracts with the National Grid typically have two years. Under the dynamic frequency response contracts, the operator responds to fluctuations in demand on the network by reducing or increasing its energy consumption. This is organized through the Dynamic Containment Service.

Energy Arbitrage

Users with BESS assets can optimize their energy usage to lower costs, improve sustainability or reduce costs. Electricity can be purchased and stored when prices are cheap and discharged during peak times to offset energy costs.



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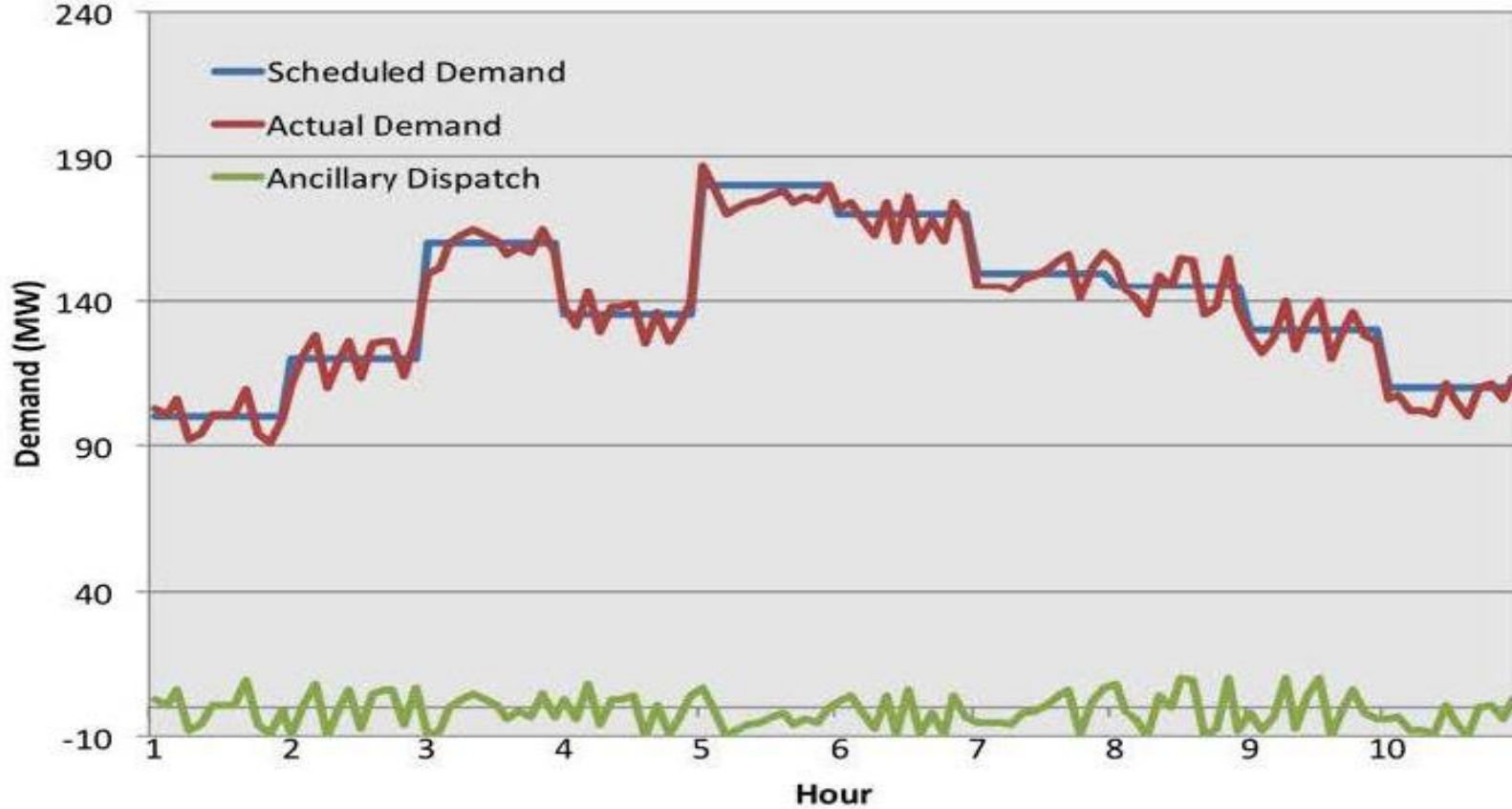


Figure 12.7: Dispatch of ancillary services in response to unscheduled fluctuations in electricity demand

Credit: S. Blumsack © Penn State is licensed under CC BY-NC-SA 4.0

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BESS Overview

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World largest BESS,
California, The Edwards & Sanborn
PV+BESS
energy-storage.news - January 24, 2024

- 875MWdc of solar PV, 1.9 million PV modules (First Solar),
- 3,287MWh BESS, (LG Chem, Samsung and BYD),
- interconnection capacity of 1,300MW,
- 18.6 Square kilometer,
- EPC contractor Mortenson, two phases, three years.

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Vistra's 750MW/3,000MWh in California.

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Bird's view, What is BESS?

A form of energy storage technology that uses batteries to store electrical energy. These systems are designed to store energy during periods of low demand and release it when demand is high, effectively balancing the grid's load.

BESS can be categorized into various types:

- lithium-ion batteries;
- flow batteries; and
- compressed air energy storage.

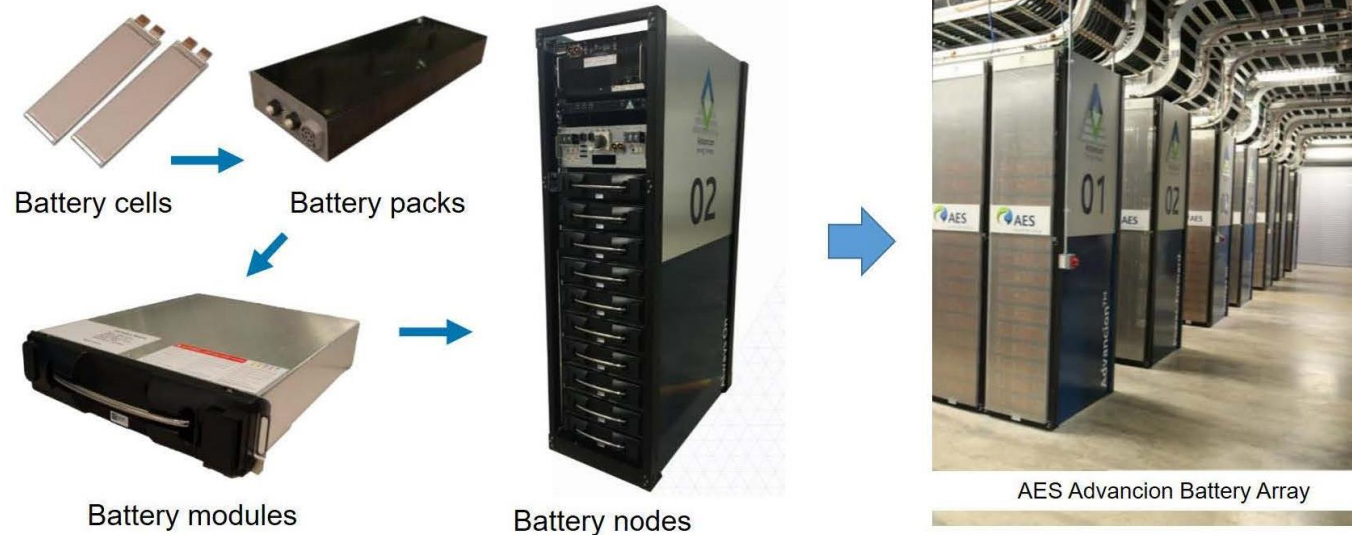


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Bird's view, What is BESS?



Assembly principle of single battery cells into larger scale storage units. Source: AES Energy Storage

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What is a Battery Energy Storage System?

A battery energy storage system (BESS) captures energy from renewable and non-renewable sources and stores it in rechargeable batteries (storage devices) for later use.

A battery is a Direct Current (DC) device and when needed, the electrochemical energy is discharged from the battery to meet electrical demand to reduce any imbalance between energy demand and energy generation.

The increase in renewable energy sources and drive to achieve net zero carbon make BESS an essential technology for commercial and industrial organizations. By adopting BESS.



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How does a battery storage system work?

A BESS collects energy from renewable energy sources, such as wind and or solar panels or from the electricity network and stores the energy using battery storage technology. The batteries discharge to release energy when necessary, such as during peak demands, power outages, or grid balancing. In addition to the batteries, BESS requires additional components that allow the system to be connected to an electrical network.

A bidirectional inverter or power conversion system (PCS) is the main device that converts power between the DC battery terminals and the AC line voltage and allows for power to flow both ways to charge and discharge the battery. The other primary element of a BESS is an energy management system (EMS) to coordinate the control and operation of all components in the system.



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Power Conversion unit (PCS)

<https://www.edina.eu/power/battery-energy-storage-system-bess>

Inverter or a Power Conversion System (PCS) – the battery cell produces direct current (DC), which the PCS converts into alternating current (AC) used for the power grid, commercial or industrial applications. Bidirectional inverters allow for the charging and discharging of the battery cell.



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Battery System or Battery modules

containing individual low voltage battery cells arranged in racks within either a module or container enclosure. The battery cell converts chemical energy into electrical energy. The batteries are connected in series and parallel for the required capacity.



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Energy Management System (EMS)

controls and monitors the energy flow of the BESS and systems. The EMS coordinates the BMS, inverters and other components of the battery energy system by collecting and analyze data used to manage and optimize the overall system performance.



Battery Management System (BMS)

which ensures the battery cell's safe working operation, ensuring it operates within the correct charging and discharging parameters. In doing so, the BMS monitors the battery cell's current, voltage, and temperature and estimates its state of charge (SoC) and State-of-Health (SoH) to prevent safety risks and ensure reliable operation and performance.

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BESS

High Level Design – “The What”.

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Sizing and selection Parameters (example of figures)

- 1) Number of Equivalent Cycle/Years: 730 cycles per year.
- 2) Charge P Rate and Discharge P Rate: 0.25C / 0.25C.
- 3) Battery Depth of Discharge (DOD): 96.51%.
- 4) Battery grouping efficiency: 98.43%
- 5) Battery Operating Temperature: $25 \pm 5^{\circ}\text{C}$. (The cooling system's design, the responsibility of the Supplier, must maintain the temperature within this range throughout the system's lifetime).
- 6) Site Ambient Conditions: Maximum temperature 45°C outdoor, and minimum temperature -10°C .
- 7) Power Factor: 1.0

BESS Container

5,015 MWh

Liquid-cooled battery storage system



Preliminary

Liquid-cooled battery storage system based on HiTHIUM prismatic LFP BESS Cells 314 Ah with highest cyclic lifetime.

Improved safety characteristics and specially optimised for the highest requirements on safety, reliability and performance. Suitable e.g. for industrial, utility, and grid serving applications.

- Product certifications:
IEC 62619, IEC 62477, IEC 63056, IEC 61000, UL 1973, UL 9540A, UN 38.3
- Company certifications:
ISO 9001, ISO 14001, ISO 45001
- Environmental Compliance:
RoHS, REACH

High safety

- High thermal stability thanks to liquid cooling
- Multi-stage, active fire protection system, compliance to NFPA 855
- Use of highly safe prismatic HiTHIUM LFP cells
- Dedicated cell monitoring and protection system

Low LCOS (Levelised Cost of Storage)

- Excellent thermal management improves energy throughput by ensuring optimal operating temperature
- Highly integrated: including thermal management system, fire protection system, BMS, etc.
- Very high energy density using dual channel compact module technology (DCCM)
- Supports back to back and side by side installations

BESS Container

5,015 MWh

Liquid-cooled battery storage system based on prismatic LFP cells with very high cyclic lifetime



GENERAL

Battery Type	HITHIUM LFP314-2P52S
No. of Battery Modules	48 (6 x 8) with DCCM Technology
Configuration	12P416S
Cooling Method	Liquid Cooling
BMS Communication	CAN, RS485, Ethernet
Gravimetric	> 111 Wh/kg
Volumetric	> 117 Wh/l
Application Altitude	≤ 4.000 m

ELECTRICAL

Nominal Voltage Container	1.331,2 V
Operating Voltage Container	1.040 ... 1.497,6 V
Nominal Energy Container	5.015,96 kWh ^{1,2}
Nominal SOC at delivery	27 % ²
Nominal Charge/Discharge Rate	0,5 P / 0,5 P
Round Trip Efficiency	> 94 %

MECHANICAL

Dimensions (L x W x H)	6.058 x 2.438 x 2.896 mm
Weight Container (20 ft.)	< 45.000 kg
Protection Level	IP 55

TEMPERATURE RANGE

Operating	-30 °C ... 55 °C ³
Storing (recommended)	-20 °C ... 35 °C ³

PRODUCT CERTIFICATIONS

Certificates and Reports	IEC 62619, IEC 62477, IEC 63056, IEC 61000, UL 1973, UL 9540A, NFPA 855, UN 38.3
---------------------------------	---

ENVIRONMENTAL

Compliance	ROHS, REACH
	Cobalt free

COMPANY CERTIFICATIONS

ISO 9001, ISO 14001, ISO 45001

¹ 0,5 P / 0,5 P

² 25°C +/- 20

³ ambient temperature

BESS Cell 314 Ah

Prismatic LFP cell optimised for use in stationary BESS



GENERAL

Nominal Capacity	314 Ah ^{1,2}
Nominal Energy	1.004,8 Wh ^{1,2}
Cell Chemistry	LiFePo4 (LFP)
Nominal Cycles	> 11.000 ^{1,2,3}
Gravimetric	> 175 Wh/kg
Volumetric	> 385 Wh/l
Industry Standard (Type)	LFP71173207

ELECTRICAL

Nominal Voltage	3,2 V ^{1,2}
Operating Voltage	T > 0 °C 2,50 ... 3,65 V T ≤ 0 °C 2,00 ... 3,65 V
AC Resistance (1 kHz)	0,20 mΩ +/- 0,05 ⁴
Max. self discharge rate	3 % / month ^{2,4}
Nominal SOC at delivery	27 % ²
Max. continuous charge rate	1 P
Max. continuous discharge rate	1 P

¹ Q5P/Q5P

² 25 °C +/- 2,0

³ 70 % SoH

⁴ 27 % SOC

⁵ Ambient temperature

MECHANICAL

Dimensions (L x W x H)	174,7 x 71,70 x 207,11 mm
Type	prismatic
Weight	5,65 kg +/- 0,2
Volume	2,59 l

TEMPERATURE RANGE

Charging	0 °C ... 60 °C ⁵
Discharging	-30 °C ... 60 °C ⁵
Storing (recommended)	-20 °C ... 35 °C (+5 °C ... 35 °C) ⁵

PRODUCT CERTIFICATIONS

Certificates and Reports	UN 38.3, UL 9540A, UL 1973, IEC 62619
--------------------------	---------------------------------------

ENVIRONMENTAL

Compliance	ROHS, REACH
	Cobalt free

COMPANY CERTIFICATIONS

ISO 9001, ISO 14001, ISO 45001

BESS Module 46 kWh

Liquid-cooled BESS module based on prismatic LFP cells with high cyclic lifetime



GENERAL

Cell Type	HITHIUM LFP71173207
Cell Capacity	300 Ah ^{1,2}
Battery Configuration	1P48S
Cooling Method	Liquid Cooling
Coolant	50 % Water / 50 % Glycol
Gravimetric	> 139 Wh/kg
Volumetric	> 210 Wh/l
Type	LFP300-1P48S
Application Altitude	≤ 4.000 m

ELECTRICAL

Nominal Voltage	153,6 V
Operating Voltage	T > 0 °C 120 ... 175,2 V T ≤ 0 °C 96 ... 175,2 V
Nominal Energy	46,1 kWh ^{1,2}
Nominal SOC at delivery	27 % ²
Nom. Charge / Discharge Rate	0,5 P / 0,5 P ²

MECHANICAL

Dimensions (L x W x H)	820 x 1.150 x 245 mm
Weight	340 kg
Protection Level	IP 67

TEMPERATURE RANGE

Operating	-30 °C ... 50 °C ³
Storing (recommended)	-20 °C ... 35 °C ³

PRODUCT CERTIFICATIONS

Certificates and Reports	IEC 62619 (cell level), UL 1973, UL 9540A, UN 38.3
--------------------------	---

ENVIRONMENTAL

Compliance	ROHS, REACH Cobalt free
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COMPANY CERTIFICATIONS

ISO 9001, ISO 14001, ISO 45001

بيئي مستدام"

Connection point and voltage	132 kV side of Grid substation
Elevation	Assumed >1000 m
Ambient temperature	-2.4 °C to 35 °C
Initial Installed Capacity	361.08 MWh @BOL/ 99 MVA, Configured as:
	72 ESS (Energy Storage System) containers, each container: 5015 kWh, Contents of each container: the battery racks, the MC cabinet, the battery management system (BMS), the thermal management system, the fire protection system and the ventilation system.
	18 MV Skid, each 5.5MVA Each skid: 4 units of PCS (PCS capacity 5 MW) and 1 MV transformer.
First Augmentation at the end of Year 2	40.1 MWh @BOL 08 ESS containers with an initial rated capacity of 5015 kWh each.
Second Augmentation at the end of Year 6	80 MWh @BOL 16 ESS containers with an initial rated capacity of 5015 kWh each.

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Configuration list of the system

Item	Quantity	Specification
ESS container	72	5.015 MWh, Refer to ESS Container Configuration List
PCS	72	1.25MW PCS, Refer to PCS datasheet
MV Skid	18	17 Qty of 5500 kVA in 40 ft container 1 Qty of 27500 kVA in 20 ft container Refer to MV skid datasheet
EMS	1	Suitable to integrate ESS container, PCS, BESS command center
Battery System Augmentation-1 @ year 2	08 2	5.015 MWh, ESS Container MV Skid
Battery System Augmentation-2 @ year 6	16 4	5.015 MWh, ESS Container MV Skid

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Configuration list of each ESS Container

Item	Quantity	Specification
Enclosure	1	1) 20ft Container: 6058*2438*2896mm (W*D*H) 2) Protection Class: IP55, C4
Battery Rack	6	1) Cooling: Liquid cooling 2) Configuration: 2P416S 3) Cell Information: LFP 314Ah 3.2V 4) Nominal Energy 835.9936kWh 5) Protection: • Fuse in each module • Fuse in each rack
Thermal Management System	1	1) Battery Cooling & Heating function 2) Coolant: 50% water & 50% glycol.
Fire Protection System	1	1) Each Fire protection system mainly consists of: • 1 FACP (Fire alarm control panel) Automatic alarm system: 2 heat detectors, 2 smoke detectors, 1 alarm bell, 1 horn/strobe, 1 emergency button and 1 manual release button. • Ventilation system: 2 gas detectors (hydrogen), 1 air inlet device and 1 air exhaust device. • Aerosol fire extinguishing system: 4 aerosols • Water sprinkle system (Optional)
Aux. Power Supply	1	1) Supply voltage: • 3-phase, 400Vac (IEC standard) 2) Total Loads: 40kW for each container 3) UPS: • Capacity: 2 hours; Loads: 0.5kW
Battery Management System (BMS)	1	1) Including 48 MBMU, 6 CBMU, 1 SBMU in each container
Accessories	1	1) Communication & power cables between equipment inside the container etc.

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15 years, without Augmentation

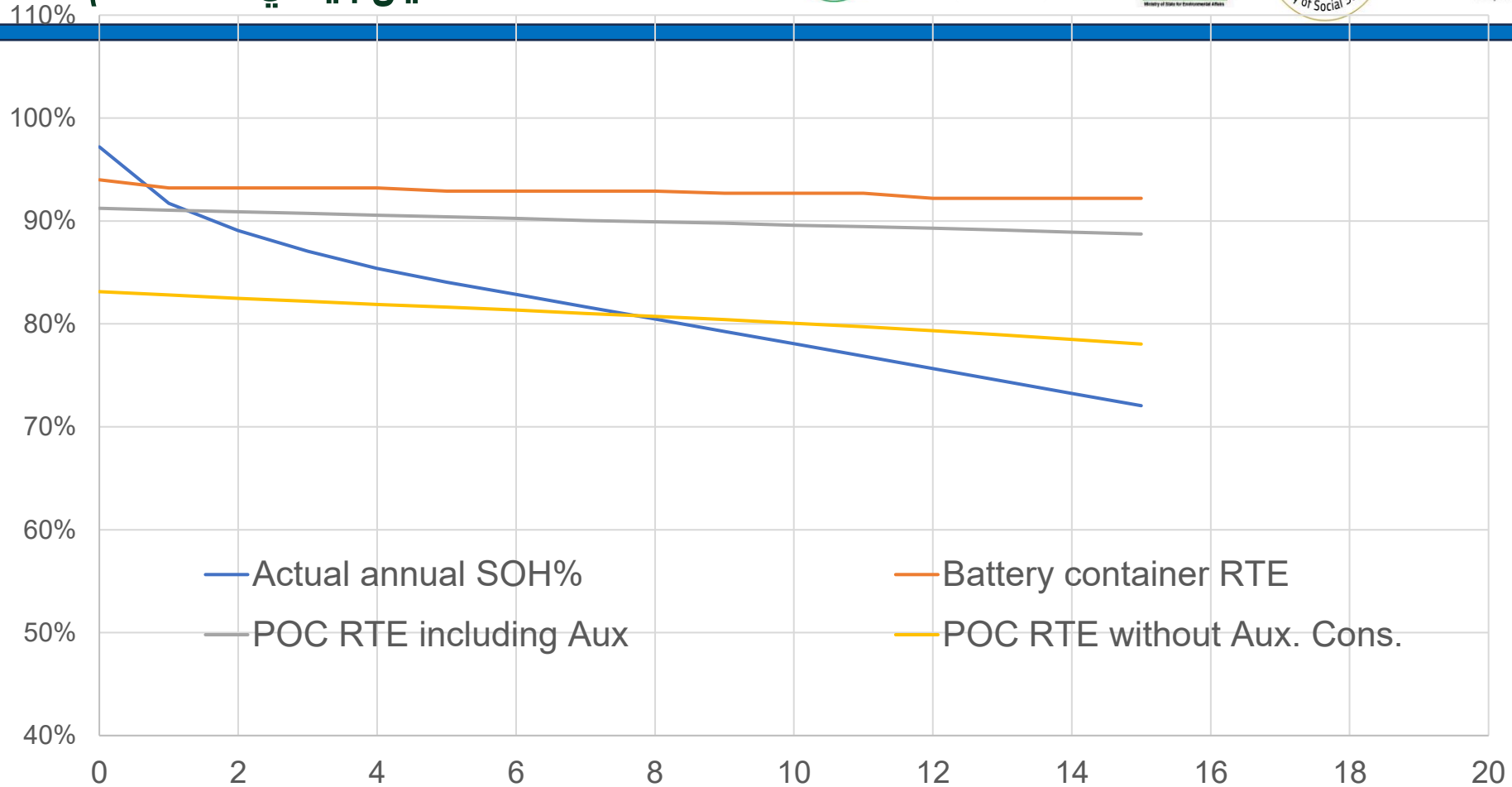
Years	Actual annual SOH%	Battery container RTE	POC RTE without Aux. Cons.	POC RTE including Aux	Years	Guranteed capacity @POI	Aux cons. MWh
0	97.2%	94.0%	83.13%	91.23%	0	319.92	9.94
1	91.7%	93.2%	82.81%	91.04%	1	309.47	9.94
2	89.1%	93.2%	82.48%	90.88%	2	297.42	9.94
3	87.1%	93.2%	82.19%	90.74%	3	287.91	9.94
4	85.4%	93.2%	81.89%	90.55%	4	279.96	9.94
5	84.1%	92.9%	81.62%	90.41%	5	272.71	9.94
6	82.9%	92.9%	81.34%	90.25%	6	265.28	9.94
7	81.7%	92.9%	81.02%	90.05%	7	258.02	9.94
8	80.5%	92.9%	80.72%	89.91%	8	249.87	9.94
9	79.3%	92.7%	80.42%	89.78%	9	241.63	9.94
10	78.1%	92.7%	80.06%	89.58%	10	234.11	9.94
11	76.9%	92.7%	79.72%	89.45%	11	225.38	9.94
12	75.7%	92.2%	79.34%	89.29%	12	216.68	9.94
13	74.5%	92.2%	78.93%	89.12%	13	208.01	9.94
14	73.3%	92.2%	78.49%	88.92%	14	199.31	9.94
15	72.1%	92.2%	78.04%	88.73%	15	190.96	9.94



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320MWh BESS - 2 cycles per day without augmentation



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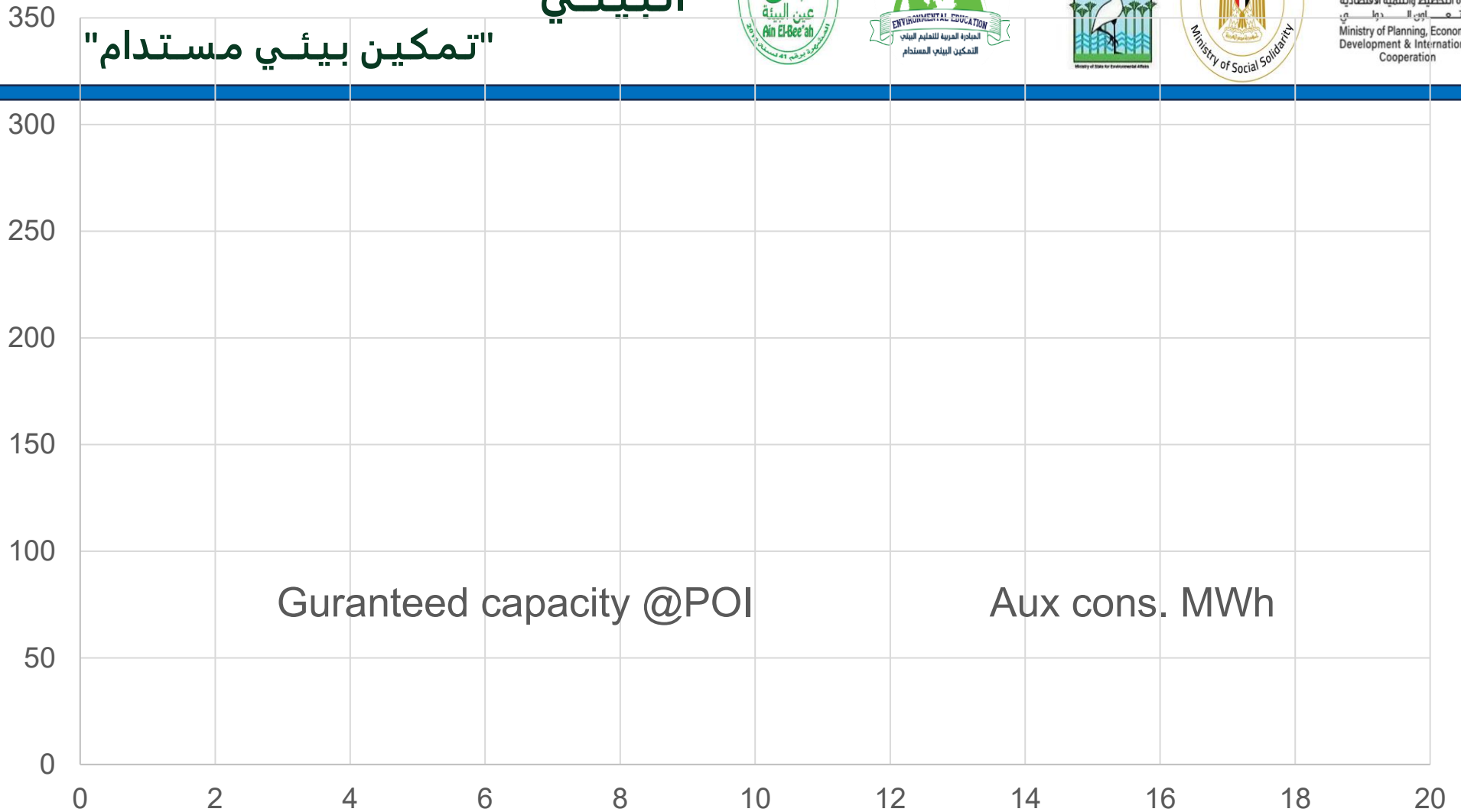
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320MWh BESS - 2 cycles per day without augmentation

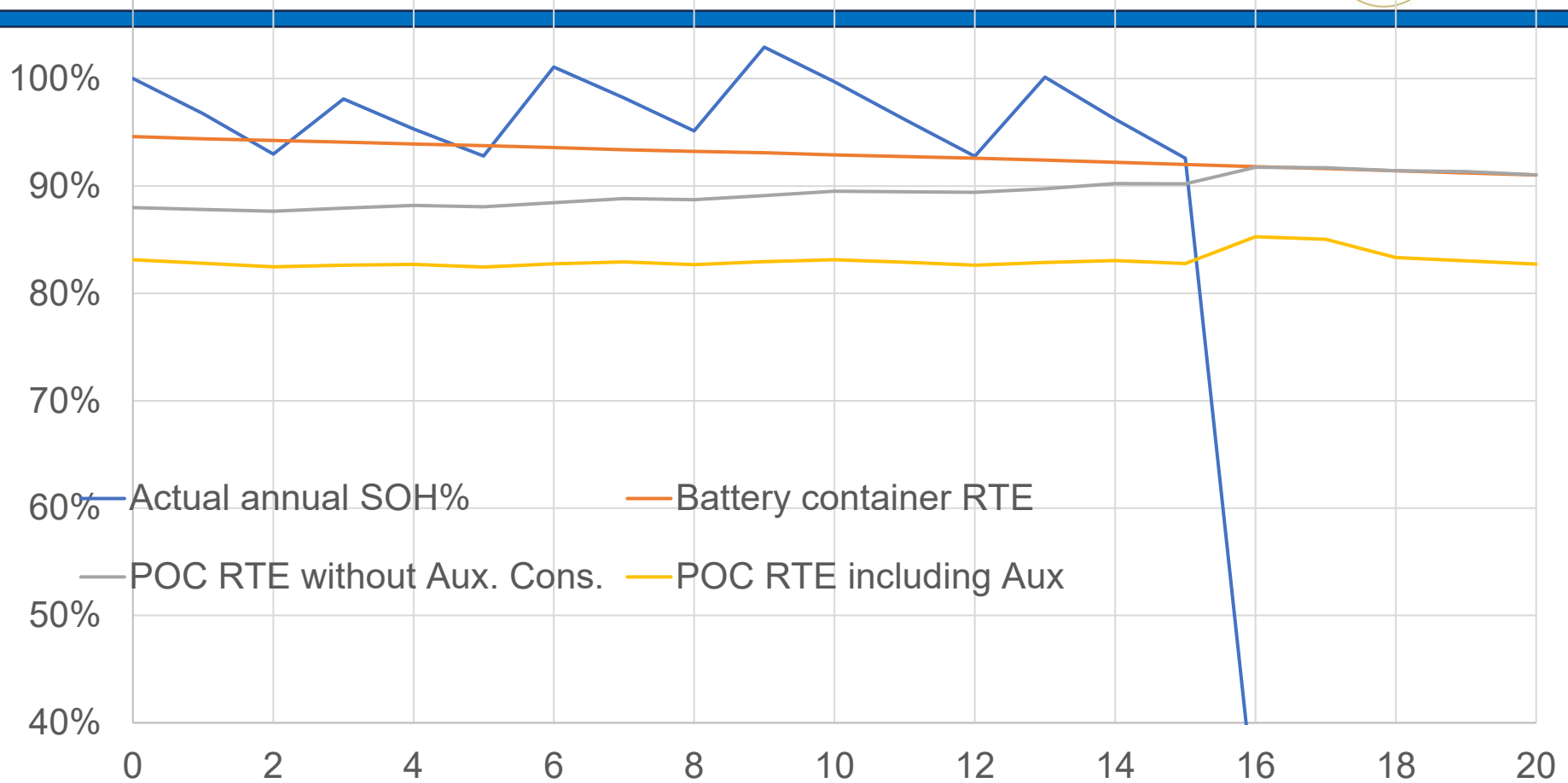


20 years, with Augmentation									
Years	Actual annual SOH%	Battery container RTE	POC RTE		Years	Guranteed capacity @POI	Aux cons. MWh	Augmentation	
			without Aux. Cons.	POC RTE including Aux					
0	100.00%	94.60%	87.98%	83.13%	0	319.92	9.94	MWh	%Y0
1	96.73%	94.40%	87.80%	82.80%	1	309.47	9.94		0.0%
2	92.97%	94.24%	87.65%	82.48%	2	297.42	9.94		0.0%
3	98.10%	94.09%	87.94%	82.62%	3	313.85	10.7451	16.43	5.5%
4	95.30%	93.90%	88.18%	82.69%	4	304.88	10.7451		0.0%
5	92.79%	93.75%	88.06%	82.45%	5	296.85	10.7451		0.0%
6	101.08%	93.58%	88.44%	82.74%	6	323.38	11.8196	26.53	8.9%
7	98.20%	93.38%	88.82%	82.93%	7	314.16	11.8196		0.0%
8	95.14%	93.23%	88.73%	82.67%	8	304.39	11.8196		0.0%
9	102.93%	93.10%	89.10%	82.95%	9	329.28	12.8941	24.89	8.2%
10	99.70%	92.89%	89.51%	83.14%	10	318.96	12.8941		0.0%
11	96.19%	92.75%	89.47%	82.89%	11	307.73	12.8941		0.0%
12	92.77%	92.59%	89.42%	82.62%	12	296.78	12.8941		0.0%
13	100.13%	92.41%	89.73%	82.88%	13	320.32	13.9687	23.54	7.9%
14	96.23%	92.21%	90.23%	83.06%	14	307.87	13.9687		0.0%
15	92.58%	92.01%	90.20%	82.77%	15	296.18	13.9687		0.0%
16	31.83%	91.81%	91.74%	85.27%	16	101.83	4.0294		0.0%
17	30.80%	91.61%	91.70%	85.03%	17	98.54	4.0294		0.0%
18	24.91%	91.41%	91.41%	83.34%	18	79.7	4.0294		0.0%
19	24.08%	91.22%	91.35%	83.04%	19	77.03	4.0294		0.0%
20	23.23%	91.02%	91.03%	82.72%	20	74.31	4.0294		0.0%

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320MWh BESS 2 cycles per day with augmentation

"تمكين بيئي مستدام" 110%



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Factors for POC Energy and RTE Calculation:

Item	Data	Comments
DC Cables efficiency	99.85%	EPC Scope
PCS efficiency	98.20%	
LV AC efficiency	99.95%	
MV transformer efficiency	99.10%	
MV AC cable efficiency	99.50%	EPC Scope
Measurement Accuracy at POC	99.80%	EPC Scope

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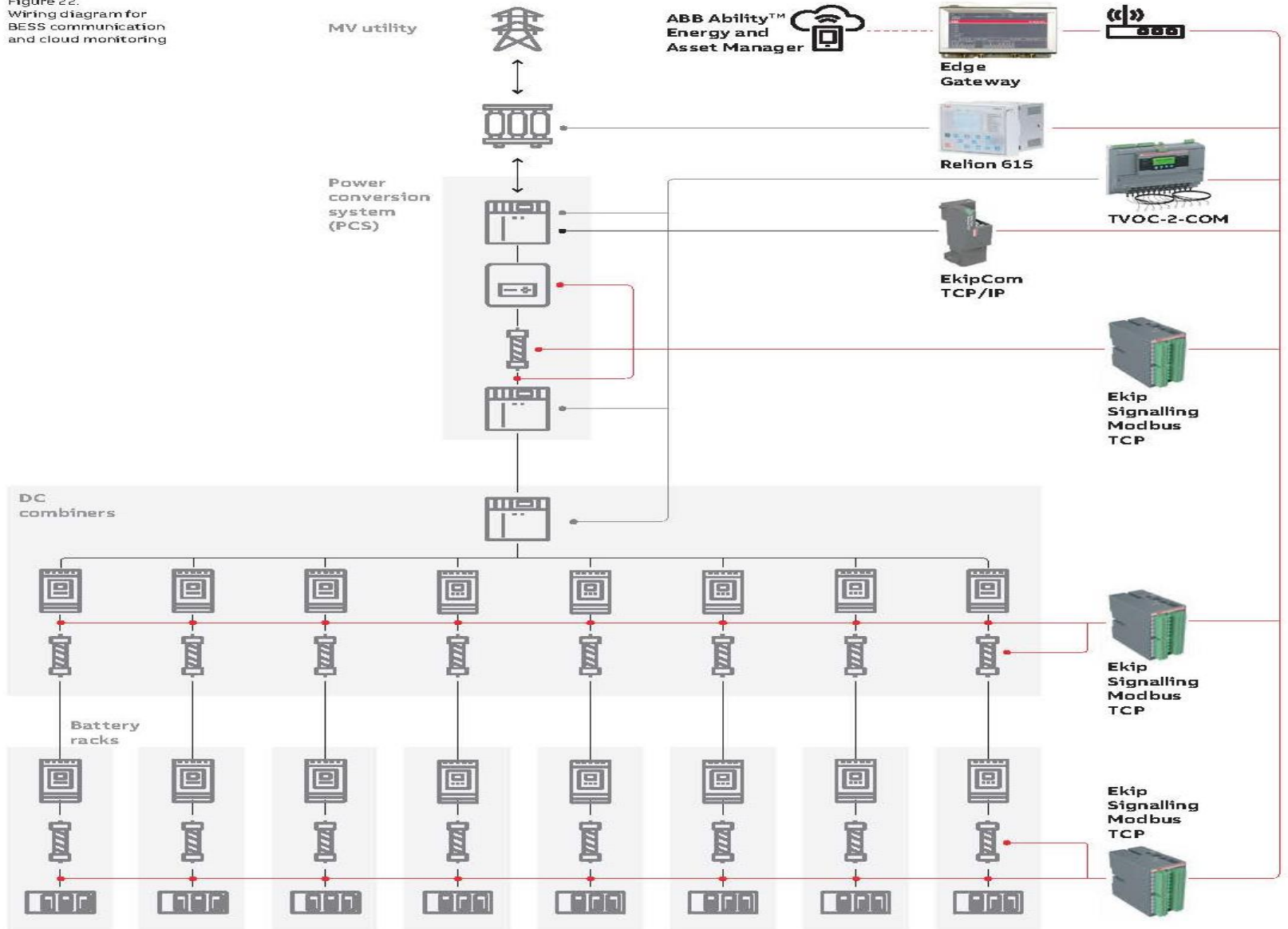
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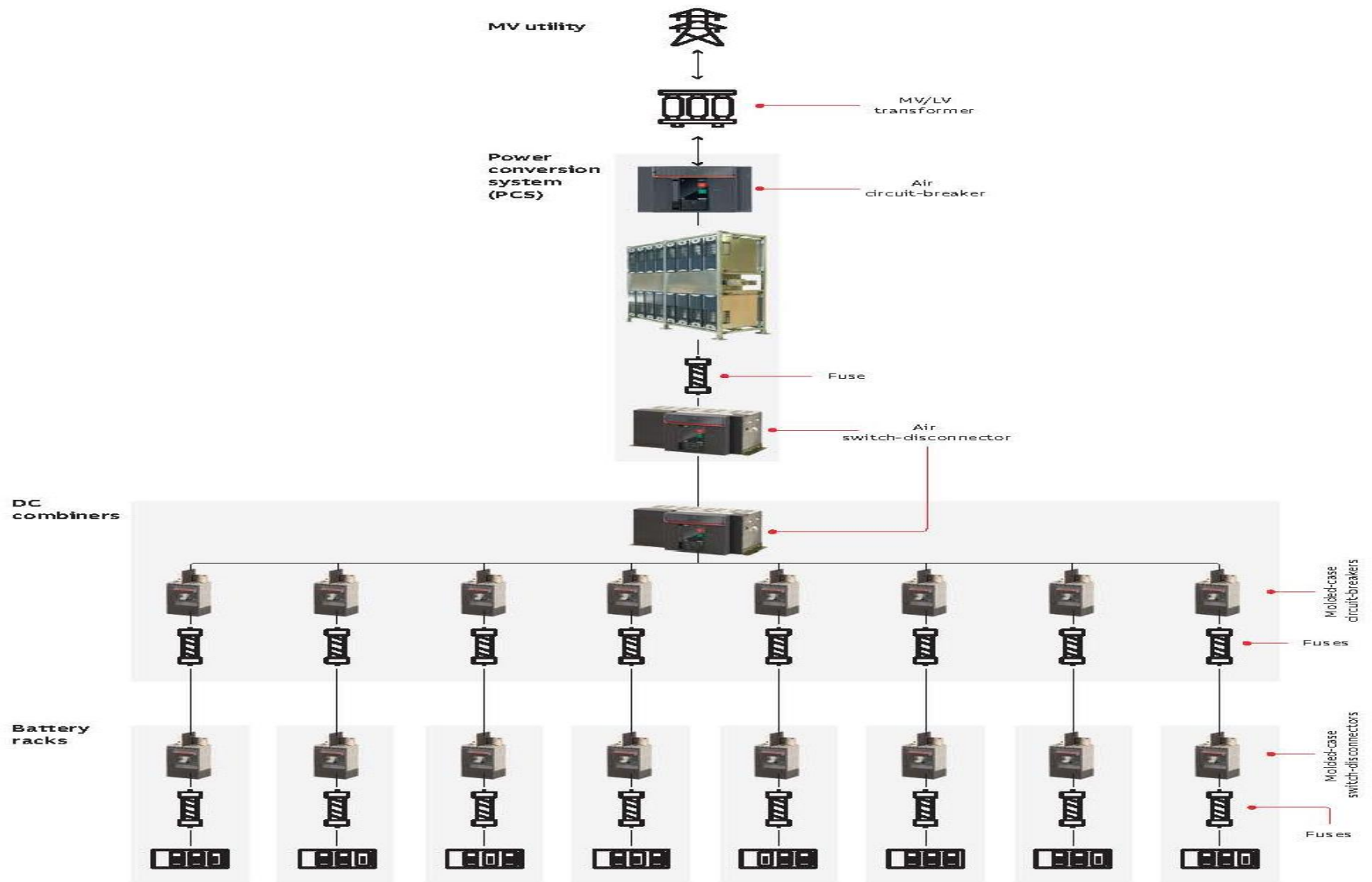


Auxiliary Consumption (part of the discharging capacity)

Energy Consumption Category	Value
Maximum Site Aux. Consumption (BESS + PCSs) Power	2,484.81 kW
Total Site Aux. Consumption (BESS + PCSs) During Discharging	9,939.24 kWh
Total Site Aux. Consumption (BESS + PCSs) During Charging	9,718.01 kWh
Total Site Aux. Consumption (BESS + PCSs) During Standby (~16h)	4,915.61 kWh

Figure 22.
Wiring diagram for
BESS communication
and cloud monitoring





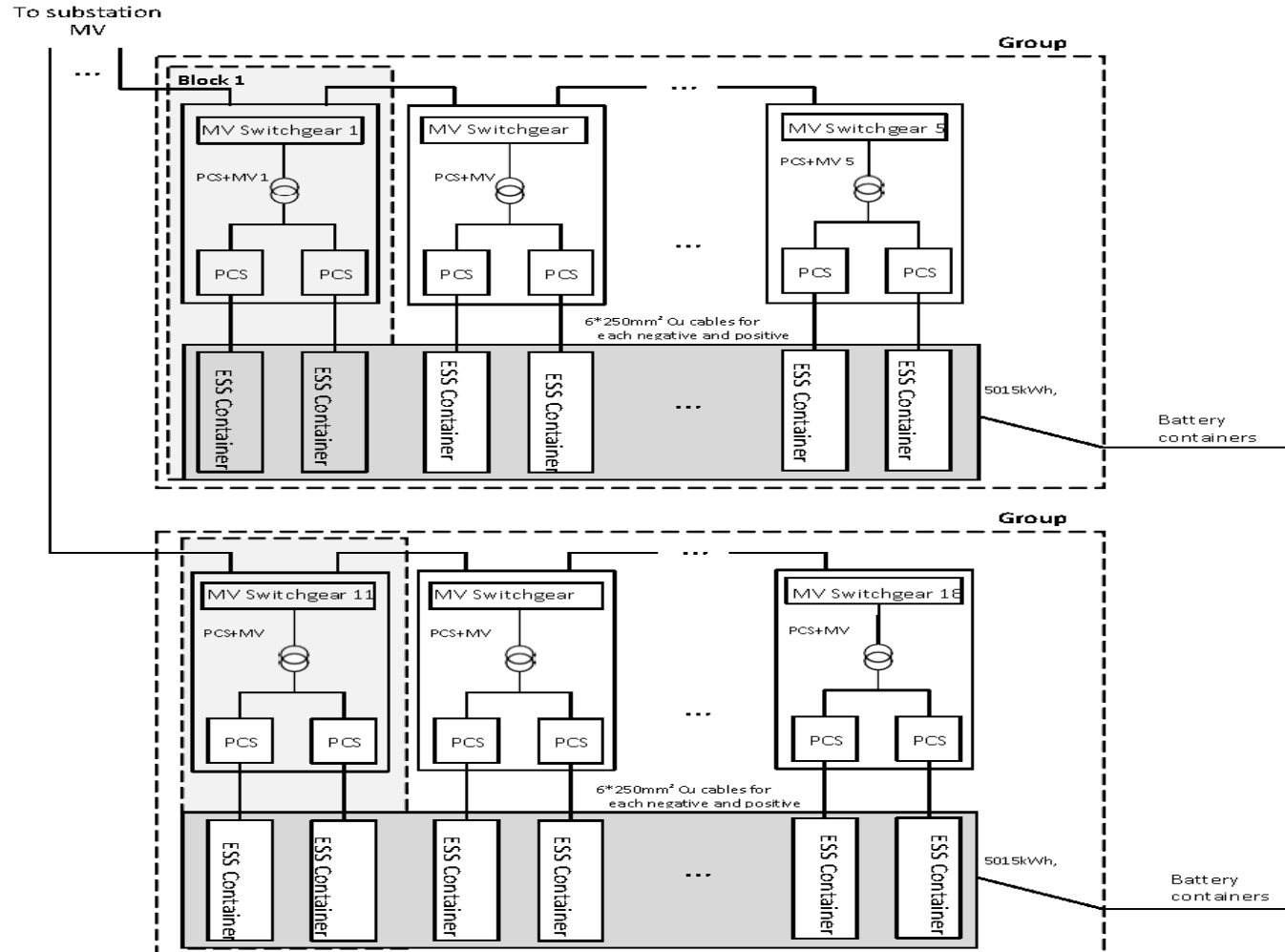
* To provide the complete 4 MWh BESS architecture, two of these modules in parallel are needed, as shown in Fig. 3 on page 7

ABB_WhitePaper_4MWh Utility Scale BESS design.

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Battery Management system (BMS):

Three-level system:

- battery cluster level,
- pack level,
- and system level management.



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Battery Management system (BMS):

The key function of BMS is to manage the charge and discharge process.

Power functions:

- No overcharged,
- No over discharged or
- No overheated,
- Cell balancing,

Data:

- data collection & uploading,
- Statistics,
- fault diagnosing
- and alarm protection.



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Battery Management system (BMS):

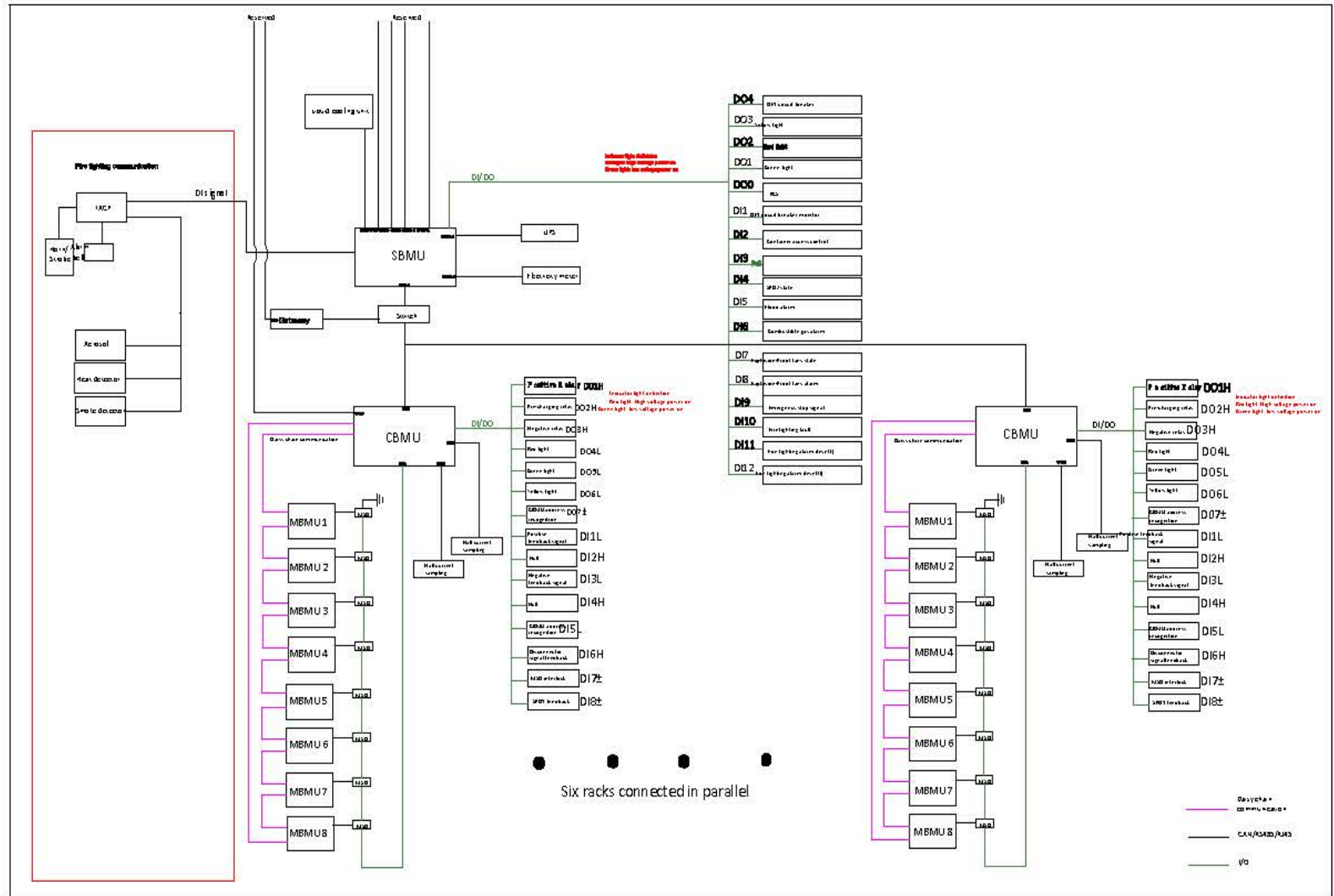
BMS is able to measure real-time electrical and thermal data of batteries, including at least battery cell voltage, battery cell temperature, module voltage, rack current, insulation resistance, and other parameters.

The BMS of the Liquid cooling ESS Container adopts the three-level architecture, which is composed of SBMU (System Battery Management Unit), CBMU (Cluster Battery Management Unit) and MBMU (Module Battery Management Unit).



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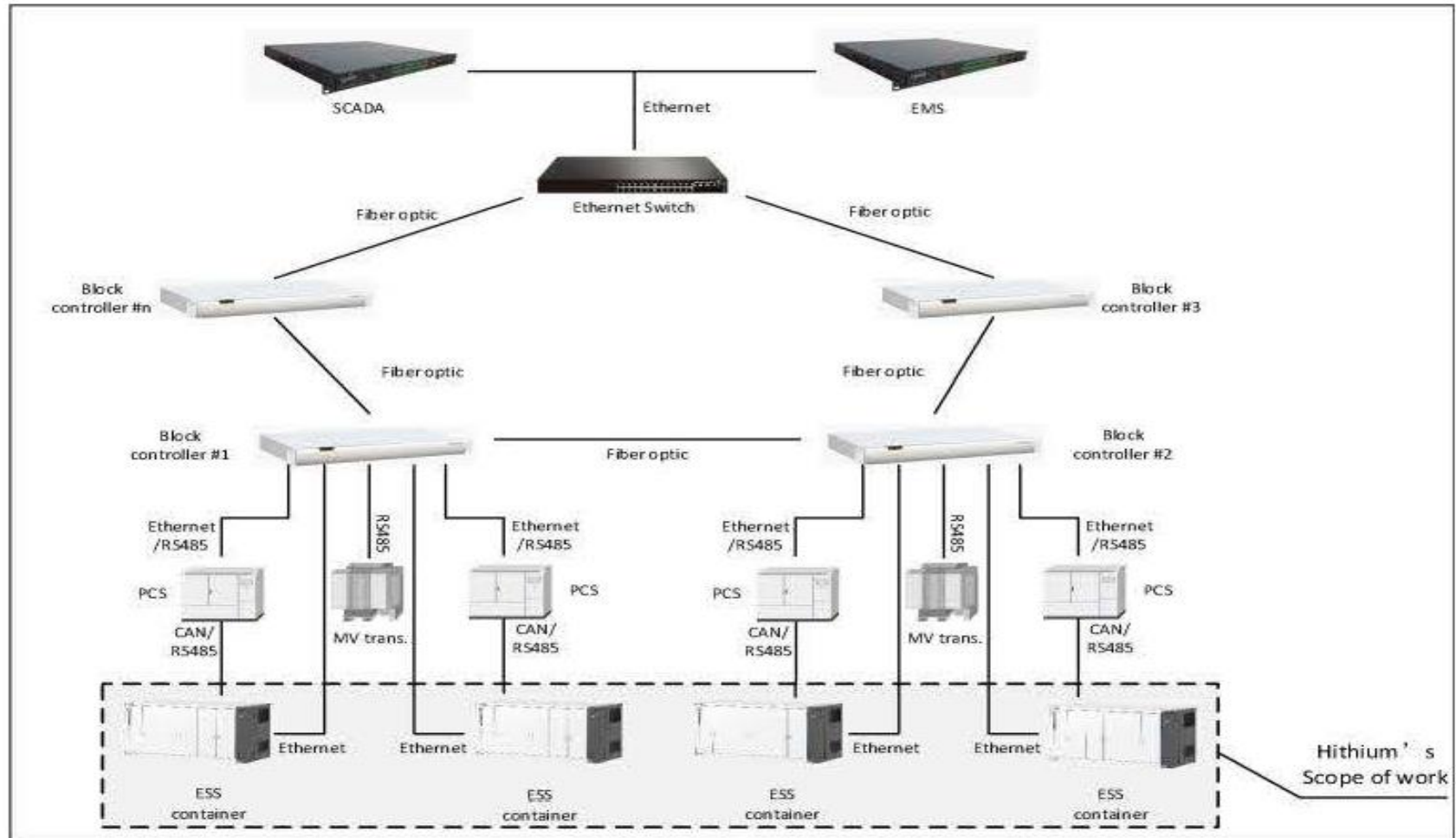


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Communication Diagram



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Thermal Management System

Reduce temperature imbalance between battery cells,
increase battery lifetime, and
prevent potential fire risks.

Thermal management system has four operating modes:
(heating, circulating, cooling and standby).

The liquid cooling plates are integrated in each module, and
connected to the chiller through nylon pipes.

The leakage of the coolant is monitored in real time and an alarm
will be sent if leakage occurs.

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Thermal management system key parameters

Item	Parameter or description
Cooling mode	Liquid cooling
Coolant	50%Water & 50%Glycol
Electric Power	$\leq 38\text{kW}$
Cooling capacity	$\geq 60\text{kW}$ @18°C water temp. & 45°C ambient temp.

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Fire Protection System

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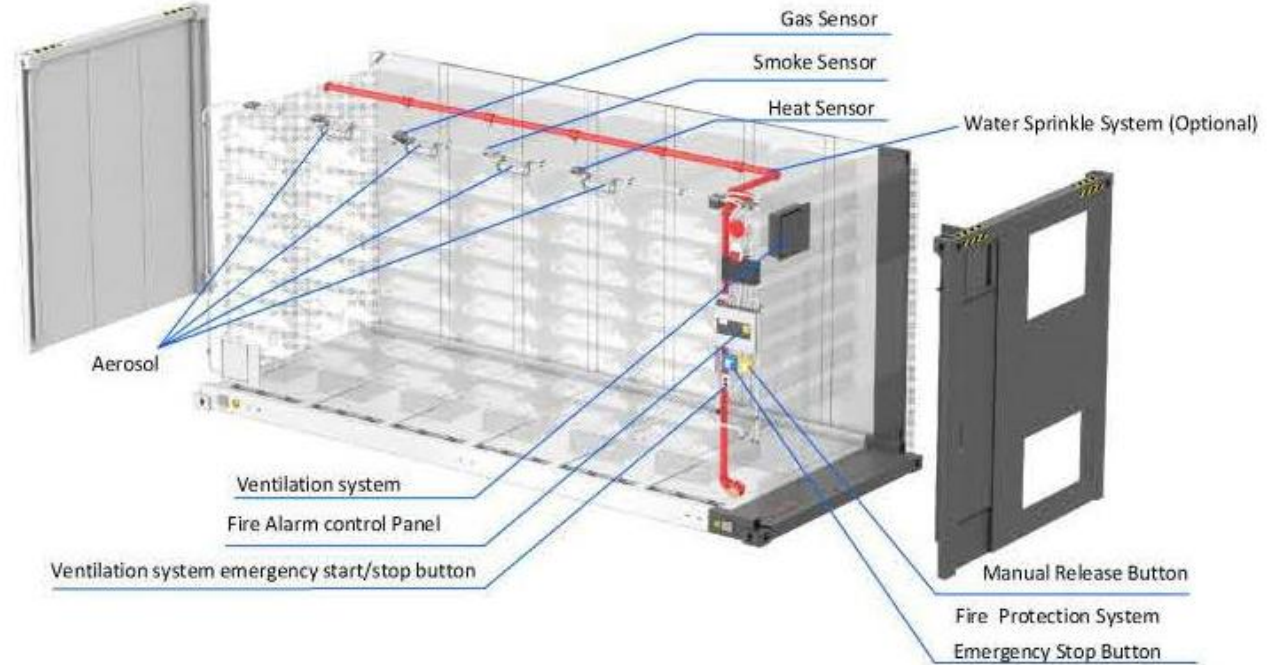


Fire Protection System

Instrument	Compliance
Fire alarm control panel	EN 54-2, EN 54-4, EN 12094-1, EN 12094-3
Battery	EN 61056
Smoke detector	EN 54-7
Heat detector	EN 54-5
Detector base	EN 54
Abort switch (Fire protection emergency stop button)	EN 12094-3
Manual pull station (Manual release button)	EN 12094-3
Horn/Strobe	EN 54-3
Alarm bell	EN 54-3
Aerosol	EN 15276
Combustible gas detector (H ₂)	EN 50270:2015
Electric ventilation louver	EN 55014-1
Exhaust Fan	EN IEC 60079
Ventilation system emergency start/stop button	EN 60947-5-1
Sprinkler	EN 12259-1

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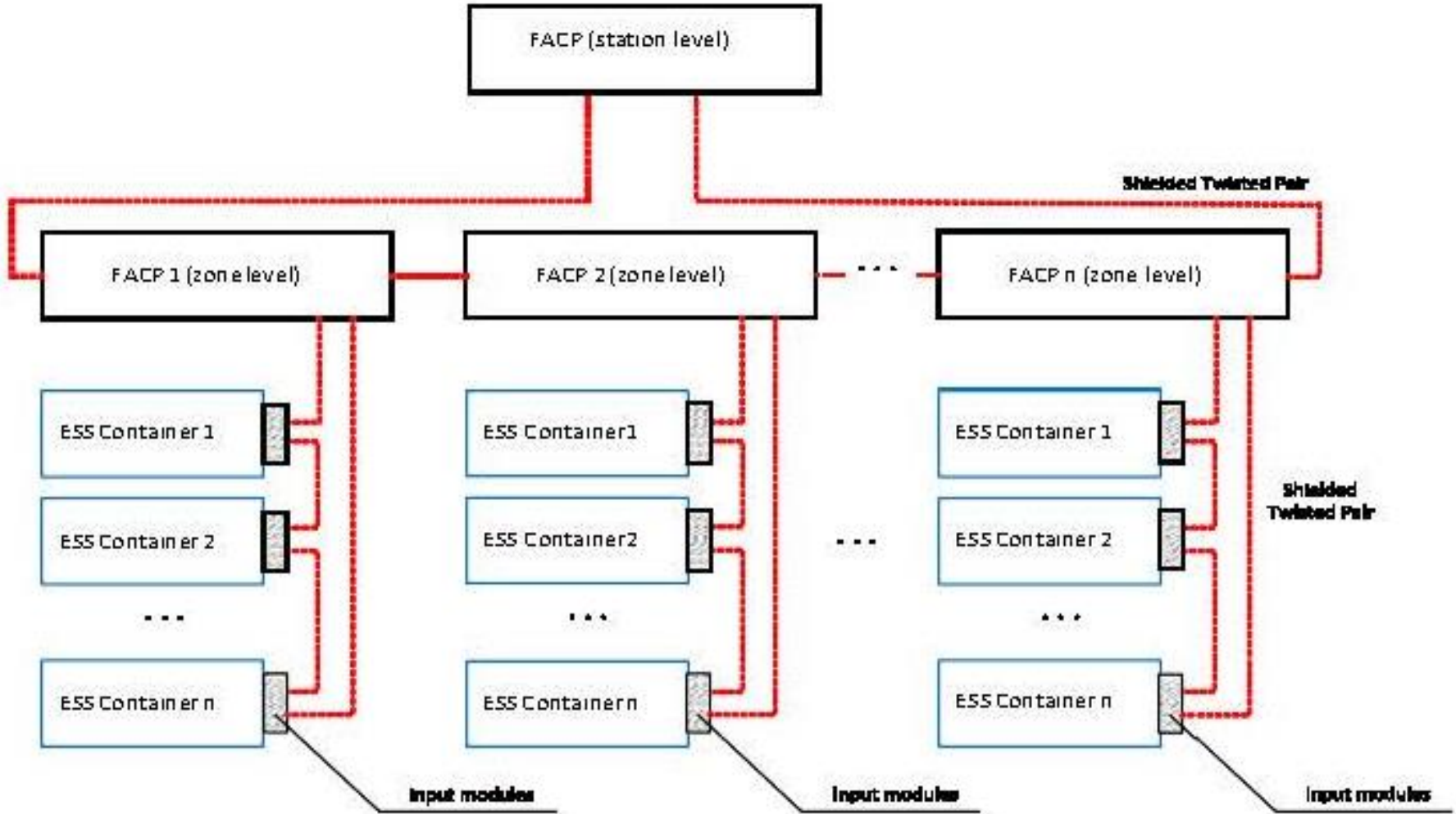


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Station Level Fire Protection System Communication Architecture

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Cost of BEES Storage

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Cost of Storage

A straight forward approach is to calculate the ratio of the total investment cost for a system and the total amount of electric energy [MWh] that this system delivers during its lifetime.

$$\text{LCoS [€/MWh]} = \frac{\text{Capex [€]} + \text{Opex [€]} - \text{Residual value [€]}}{\text{Lifetime [cycles]} * \text{DoD [\%]} * \text{Capacity [MWh]} * \text{Roundtrip efficiency [\%]}}$$

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Average cost, for multi-hundred MWh storage: 0.01
USD/kWh

Source: Average of cost estimates from various OEMs,
2024.

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Rated Capacity MWh - FAT
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319.9MWh

Project years	15Years
Days per year	365Days
Number of cycles per day	2Cycles
Number of cycles of the project	10950Cycles
Capex USD/MWh	90,000 USD
Total Capex USD	28,792,800 USD
Total generation along 15 years one cycle per day	1,363,903 MWh
Total generation along 15 years two cycles per day	2,727,806 MWh
LCOS USD/MWh storage along 15 years two cycles	10.555 USD
LCOS USD/kWh	0.0106 USD

© Sources: Rough-out calculation by the presenter.

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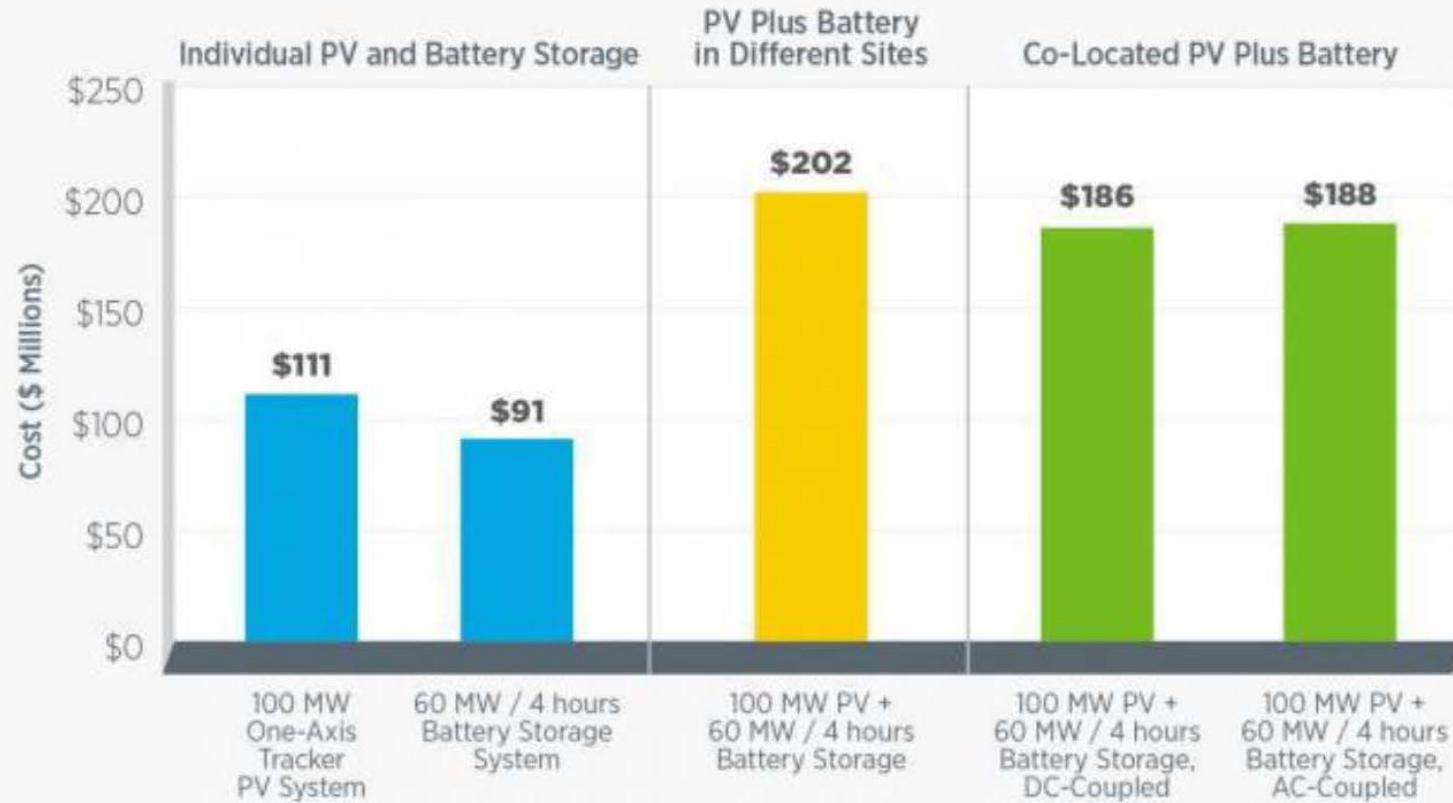
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PV Plus Storage Cost Breakdown



Estimated costs of stand-alone and co-located PV and storage systems. Credit: [Energy.gov](https://www.energy.gov)

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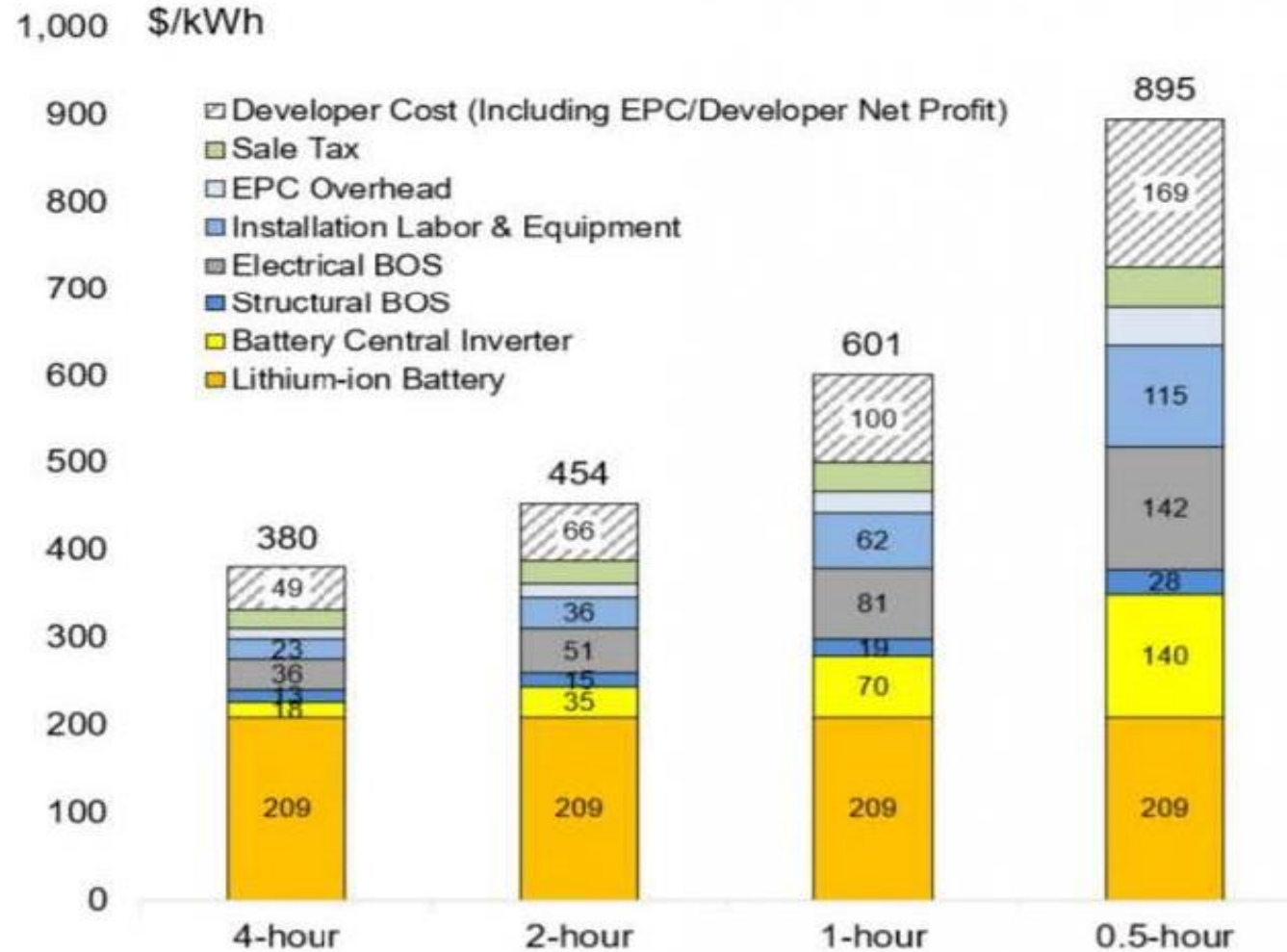
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System costs of Li-ion battery utility scale energy storage for a stand-alone system. Credit: NREL, 2018

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Future challenges

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- Development of solid-state batteries, with higher energy density and improved safety.
- Development of Flow batteries store energy in liquid electrolyte solutions. The vanadium redox battery (VRB) is the most prevalent flow battery type and is suitable for longer durations of up to 8 hours.
- Despite their low energy capacity and charge/discharge rate, flow batteries respond quickly and reduce fire risk due to the non-flammable electrolytes used.



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Codes and standards

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- UL 9540: Standard for Energy Storage Systems and Equipment.
- UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems.
- NFPA 68: Standard on Explosion Protection by Deflagration Venting
- NFPA 69: Standard on Explosion Prevention Systems
- NFPA 855: Standard for the Installation of Stationary Energy Storage Systems.
- UL 1973: Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail (LER) Applications.
- UN 3536: Lithium Batteries Installed in Cargo Transport Unit
- UN 38.3: Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria.
- IEC 62619: Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes - Safety Requirements for Secondary Lithium Cells and Batteries: This standard specifies safety requirements for lithium-based batteries, including electrochemical energy storage systems, to mitigate potential risks during operation and handling.
- IEC 61439-1: Low-voltage switchgear and control gear assemblies - Part 1: General rules.
- IEC 61439-2: Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies.
- IEC 62477: Safety requirements for power electronic converter systems and equipment.
- EMC IEC 61000: Electromagnetic compatibility- Generic standards.

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Thank you

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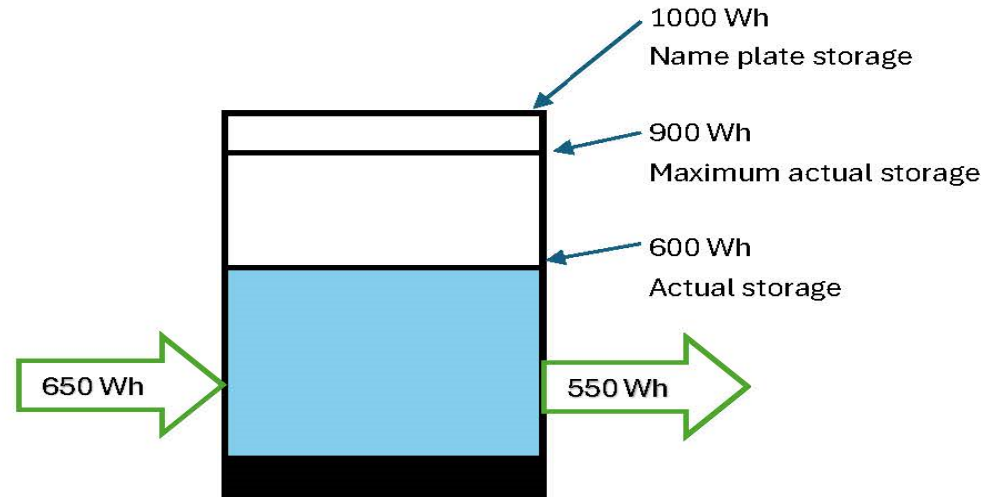


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$$(\text{SoH}) \text{ State of health} = 900/1000 = 90.0\%$$

$$(\text{SoC}) \text{ State of Charge} = 600/900 = 66.7\%$$

$$(\text{RTE}) \text{ Round Trip Efficiency} = 550/650 = 84.6\%$$

$$\text{Depth of Discharge (DOD)} = 1 - ((650 - 550)/900) = 88.9\%$$

Source: Graphic illustration by the presenter.

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PPA price of kWh, Egypt, 2024

- PV: 2.48 USD Cent.
- Wind: 2.4 X USD Cent.

Press releases, Ministry of Electricity and Renewable Energy

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