How to keep your ESS flexible in times of changing market conditions

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Content

1. Why be flexible?
2. Three recommendations to stay flexible
3. Key points for implementation
4. Design Options

What are the main challenges in doing business with energy storage systems today ?

TECHNICAL

BUSINESS

FINANCIAL

ENVIRONMENTAL

REGULATORY

WHAT'S DRIVING THE NEED FOR FLEXIBLE ESS ?

- MICHAEL LIPPERT

Changing markets

Merchant Business

- …with short contract duration replacing long term contracts
- …needs service stacking when markets saturate

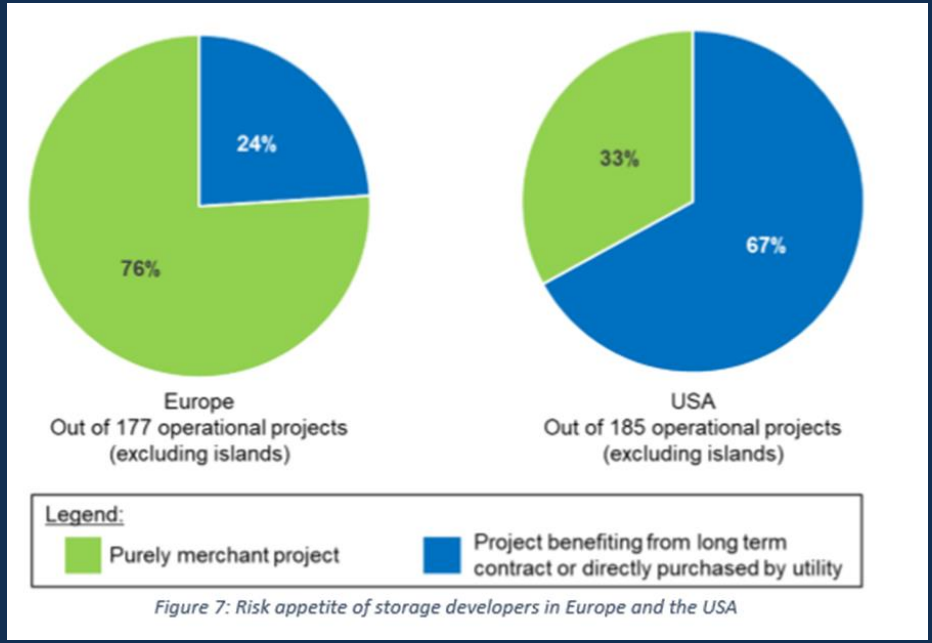

Figure 7: Risk appetite of storage developers in Europe and the USA

Changing markets

Merchant Business

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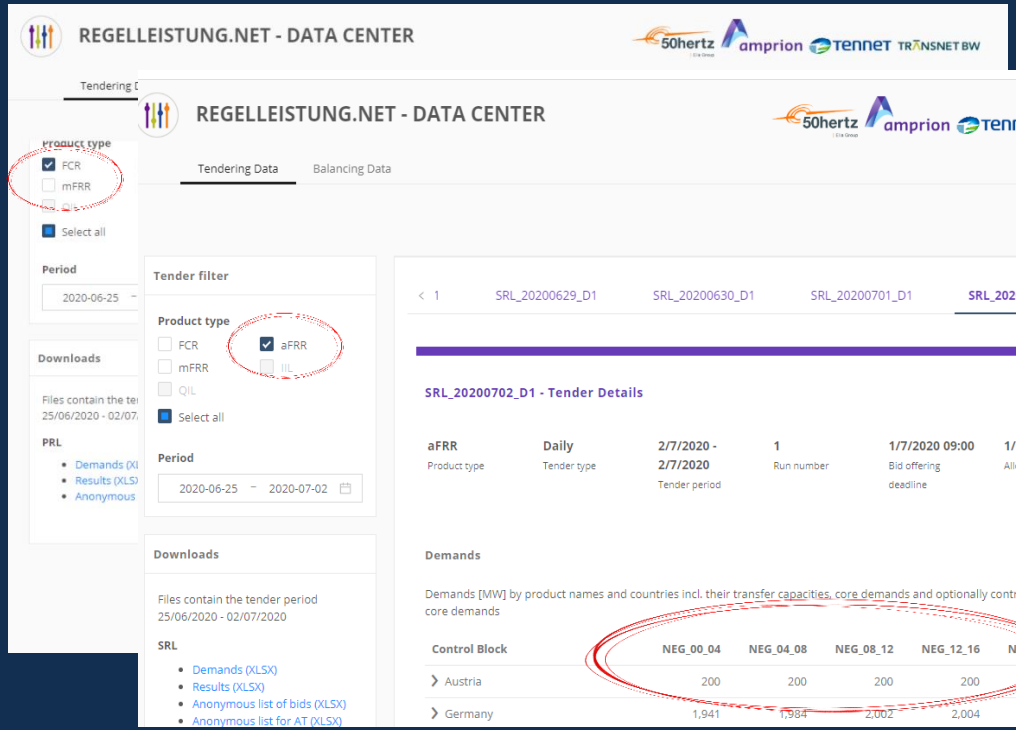
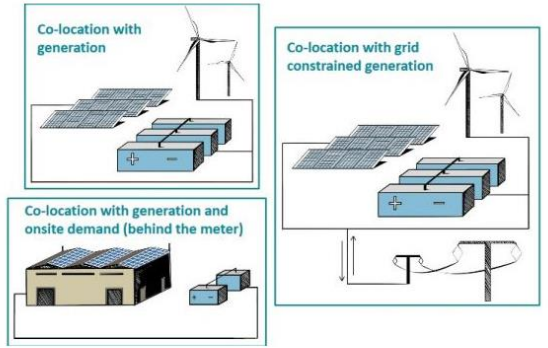


Changing markets

Merchant Business

- …with short contract duration replacing long term contracts
- …needs service stacking when markets saturate

National Grid: 'Don't put all your eggs in the frequency response basket'



The different business cases for co-location energy storage with generation. Image: Regen.

A representative of National Grid, the UK's transmission system operator (TSO), has said that energy storage will be "integral" to the network's flexibility strategy – while urging developers not to rely solely on early frequency regulation contracts.

Changing markets

New opportunities

– …for additional revenue can arise from new grid services and system needs

Existing

Arbitrage / Solar time shifting

Emerging

Reactive Power Compensation

Future

Synthetic Inertia

Existing - Emerging - Future ESS applications

Source: EASE

Generation / System Support	Existing Ancillary Services	New Ancillary Services	Transmission Infrastructure	Distribution Infrastructure	Customer Energy Management
Arbitrage	Frequency Containment Reserve (FCR)	Enhanced Frequency Response (EFR)	Transmission Grid Upgrade Deferral	Distribution Grid Upgrade Deferral	End-User Peak Shaving
Electricity Supply Capacity	Frequency Restoration Reserve - Automatic (aFRR) - Manual (mFRR)	Synchronous Inertial Response (SIR)	Contingency Grid Support	Contingency Grid Support	Time-of-use Energy Cost Management
Support to Conventional Generation	Replacement Reserve (RR)	Synthetic Inertia (SI)	Transmission Support	Dynamic Local Voltage Control	Particular Requirements in Power-Quality
Ancillary Services RES Support	Load Following	Dynamic Reactive Response (DRR)	Angular Stability	Intentional Islanding	Maximising self-production and self-consumption
Capacity Firming	Frequency Stability of Weak Grids	Fast Frequency Response (FFR)	Reactive Power Compensation	Reactive Power Compensation	Continuity of Energy Supply
RES Curtailment Minimisation	Black Start	Fast Post-Fault Active Power Recovery	Cross Sectoral Storage	Cross Sectoral Storage	Limitation of Upstream Disturbances
Seasonal Arbitrage	Voltage Support	Ramping Margin	Power Oscillation Damping	EV charging infrastructure	Compensation of the Reactive Power

Existing	remuneration schemes operational
Emerging	remuneration schemes planned or operational in only few Member States
Future	no clear monetization/ tendering framework existing or expected in near future

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Changing markets

Technical Rules

– …can change

GRID SCALE
BUSINESS
MARKET WATCH
POLICY
TECHNOLOGY

PJM's frequency regulation rule changes causing 'significant and detrimental harm'

Published: 18 Apr 2017, 15:38

By:
Andy Colthorpe

RES' Jake and Ellwood energy storage projects, among the 265MW of such resources deployed in PJM's service area. Image: RES.

Energy storage companies "have suffered significant and detrimental harm" from changes to rules governing the frequency

GRID SCALE
BUSINESS
POLICY

Battery storage will be hit by UK's proposed Capacity Market derating changes

Image: Anesco.

The UK government Department for Business, Energy and Industrial Strategy (BEIS) has incurred the wrath of battery storage asset owners by proposing significant changes to how their generation

Changing markets

Regulation

– …can evolve

Changing markets

Merchant Business

- …with short contract duration replacing long term contracts
- …needs service stacking when markets saturate

Technical Rules

- …can change

New opportunities

- …for additional revenue can arise from new grid services and system needs

Regulation

- …can evolve

A REAL CASE : TOTAL DUNKIRK

- DANIEL LACOMBE

Case Study: Dunkirk I

Battery storage solution to supply the French grid operator with FCR services

Project requirements

15 YEAR PROJECT

25MW
25MWh

Grid service to RTE (French TSO) at 90kV connection point

Initial service: FCR at 25MW/25MWh capacity

Follow market evolutions for new services as and when required

Case Study: Dunkirk I

Battery storage solution to supply the French grid operator with FCR services

Structure

Customer

TOTAL SOLAR INTERNATIONAL

BESS supply

Intensium® Max High Energy 1000 V

Civil works + cabling + AC supply + PMS+ SCADA

OMEXOM

Case Study: Dunkirk I

Battery storage solution to supply the French grid operator with FCR services

Clients' focus

- Enhanced safety
- Competitiveness
- Sustained capacity
- Reliability of system and of revenues
- 1st project before repeat deals up to **130MW**

FLEXIBLE
Energy Storage System

THREE RECOMMENDATIONS TO STAY FLEXIBLE

- MICHAEL LIPPERT

Three recommendations to stay flexible

Enable multiple operation patterns

- ESS solution versatile enough to fulfill multiple operation profiles

Enable adjustment of power and energy over time

- Increase energy of a given ESS as needed

Enable implementation of flexible guarantees

- Performance parameters are flexible enough to cover evolving operation patterns
- Implement adequate controls and data management

Three recommendations to stay flexible

Enable multiple operation patterns

Parameters

- Power bol / eol
  - Peak power
  - Power density
- Thermal behavior
- Energy throughput

Benefits

1. Avoid re-designing solution for each single project
2. Be able to adapt when market rules change

Three recommendations to stay flexible

Enable adjustment of power and energy over time

Parameters

- Stability of operation profile
- KPI to optimize: LCOE, NPV, Capex, …

Benefits

1. Ability to seize additional revenue streams
2. Augment when and only when it is needed
3. Shift Capex to Opex and benefit from decreasing prices

Three recommendations to stay flexible

Enable implementation of flexible guarantees

Parameters

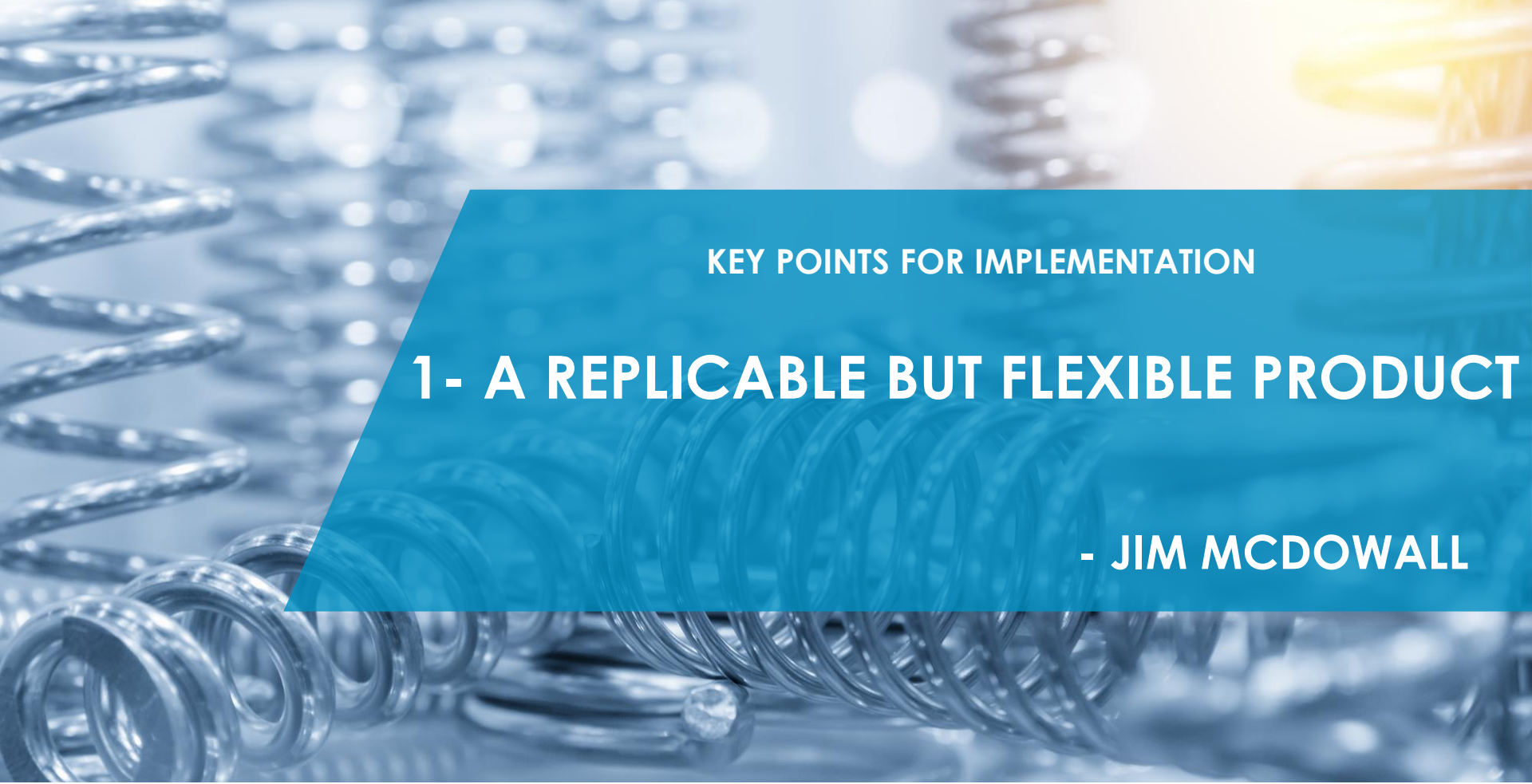
- Uptime
- Capacity
- Energy efficiency
- Remote monitoring of key KPI's

Benefits

1. Secure ESS ability to generate revenue
2. Continuous KPI monitoring, enabling early corrective measures in case of deviations

KEY POINTS FOR IMPLEMENTATION

- JIM MCDOWALL, YANN LAOT

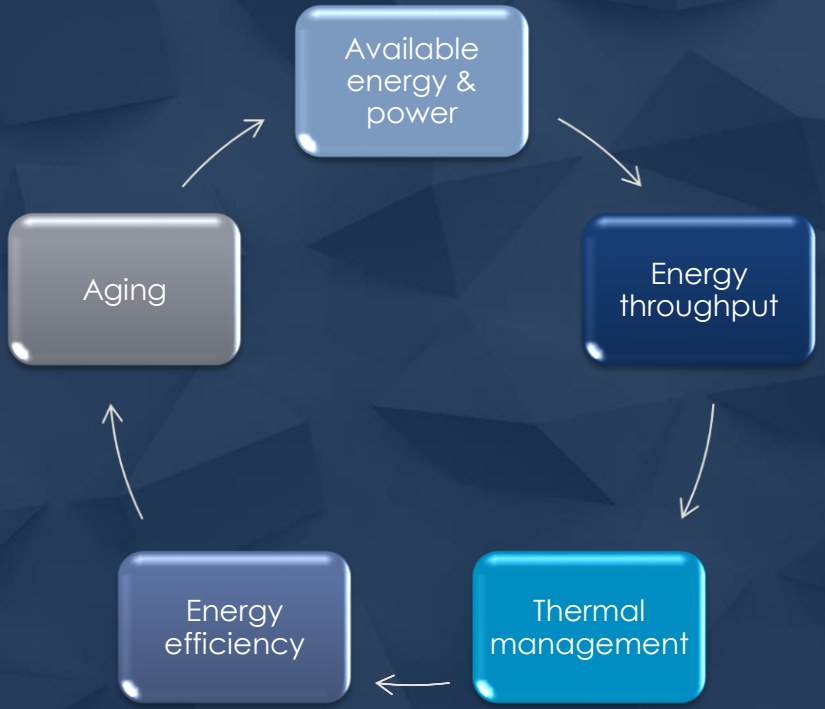


KEY POINTS FOR IMPLEMENTATION

1- A REPLICABLE BUT FLEXIBLE PRODUCT

- JIM MCDOWALL

Addressing flexibility



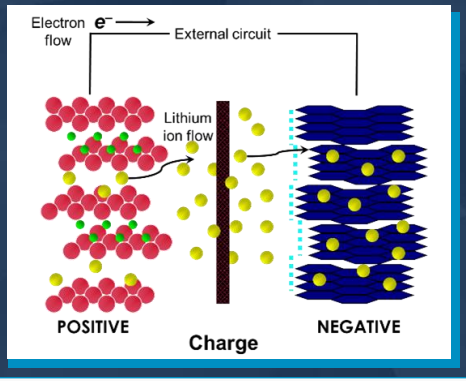
Aging

CALENDAR AGING

- **Driven by thermodynamic stability**
- **Dependent on:**

CYCLING AGING

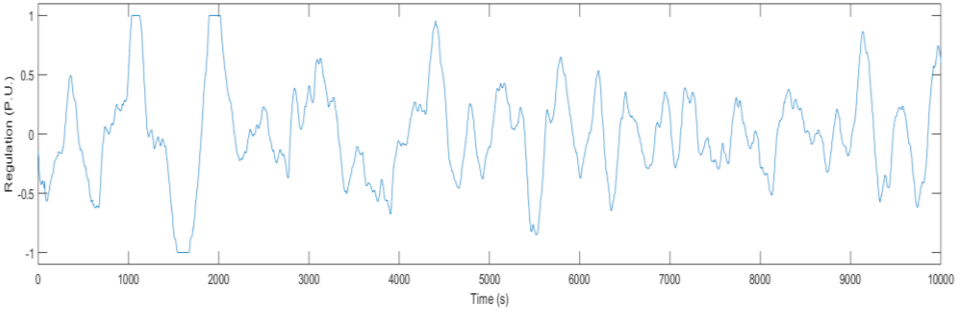
- **Driven by reaction kinetics**
- **Dependent on:**
  - Number and depth of cycles
  - Charge rate (continuous)
  - Charge duration (pulses)



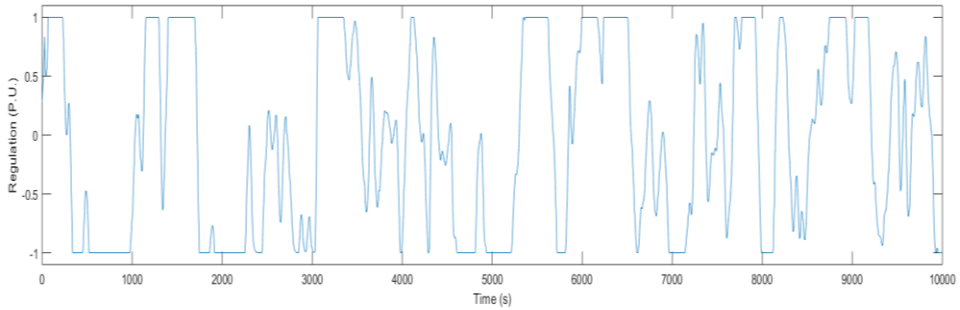
Energy throughput

- Chemistry limits
- Thermal limits
- Application flexibility limited more by rate than aging

OLD PJM

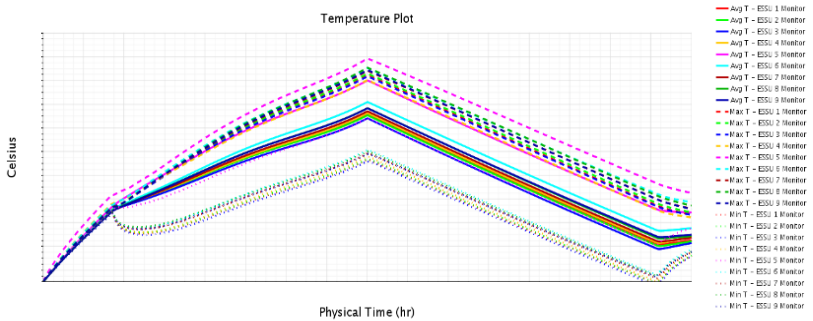


NEW PJM



Thermal management

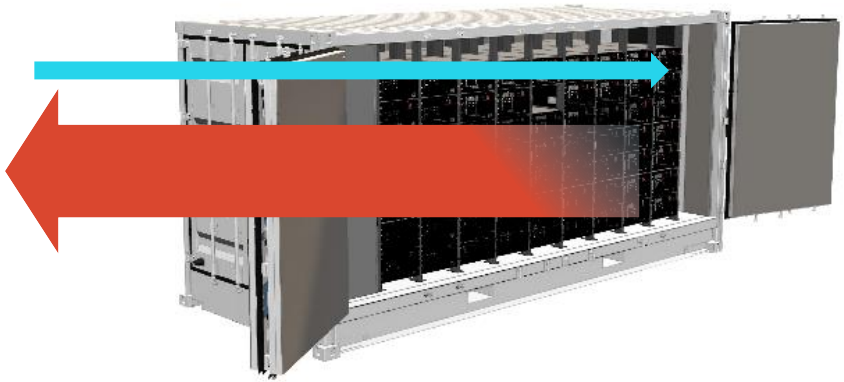
OPERATION PROFILE | BATTERY | DESIGN CHOICES | AIMS



Temperature modeling under high solar load and full charge/discharge cycle

Energy efficiency

- **Battery energy efficiency**
- **Energy for cooling and heating**
  - HVAC efficiency
  - Fan management
  - Set points
- **Auxiliary consumption**

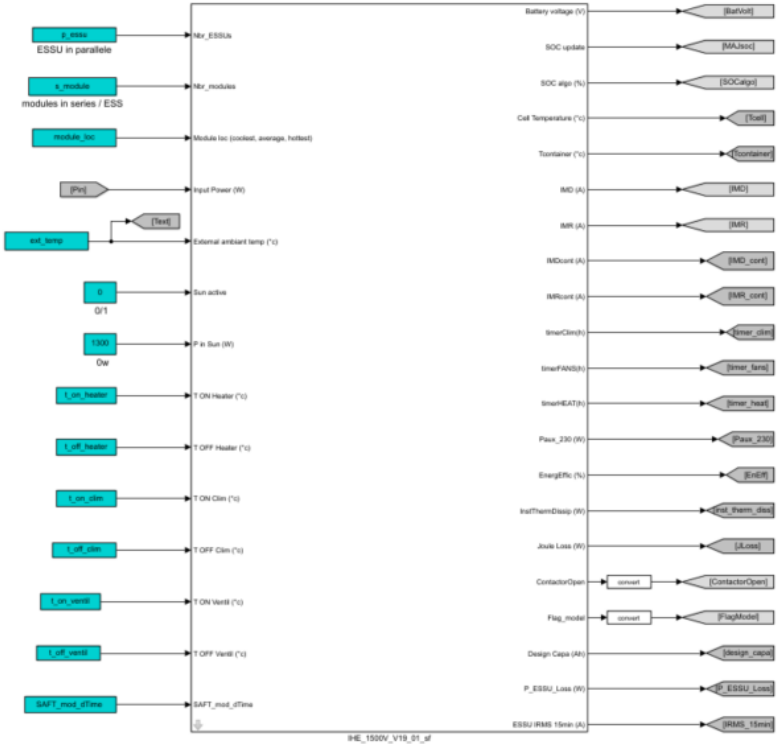


Available Power & Energy

- **Usable SOC range depends on rate**
  - Constant power required in discharge and charge?
- **100% SOC can be reached at reduced power**
- **Changes from BOL to EOL must be considered**
- **Power may be limited by non-chemistry components**
  - Cables
  - Connectors
  - Protective devices

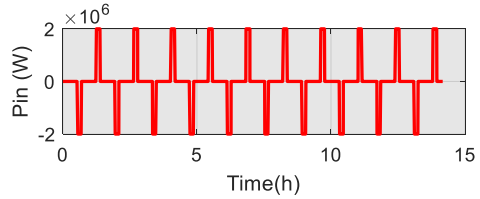
Advanced modeling enables flexibility

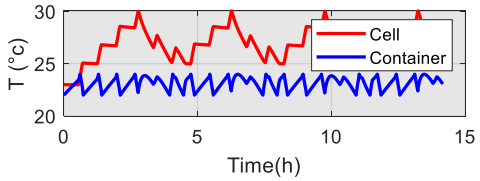
- **Saft has developed and refined advanced modeling capability in Matlab-Simulink**
- **Modeling electrical and thermal characteristics of containerized systems**
  - Modeling at any stage of life
  - Aging analysis
  - Auxiliary power consumption

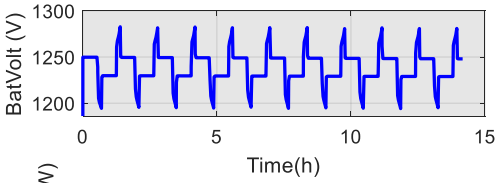


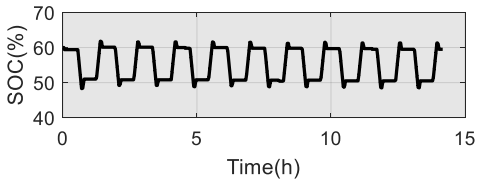
Exploring flexibility solutions

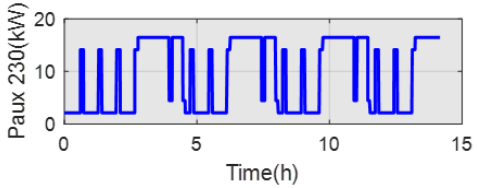
2 MW cycles

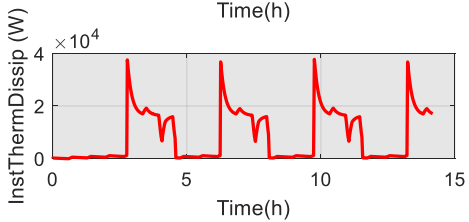




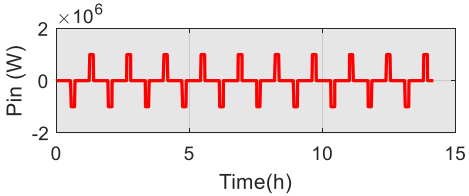


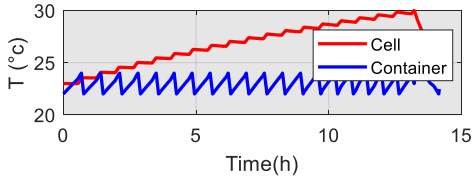


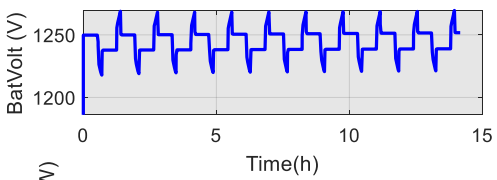


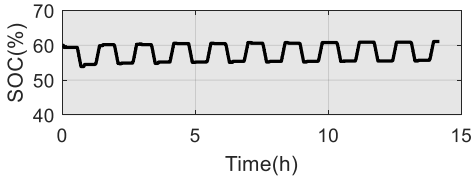


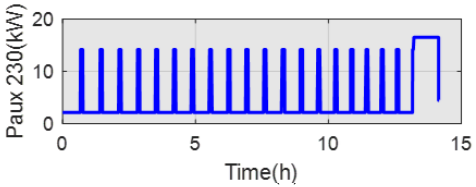
1 MW cycles

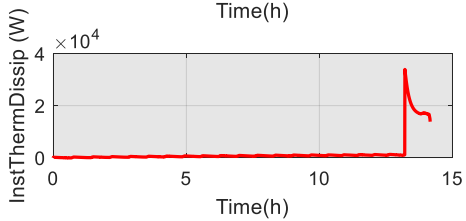


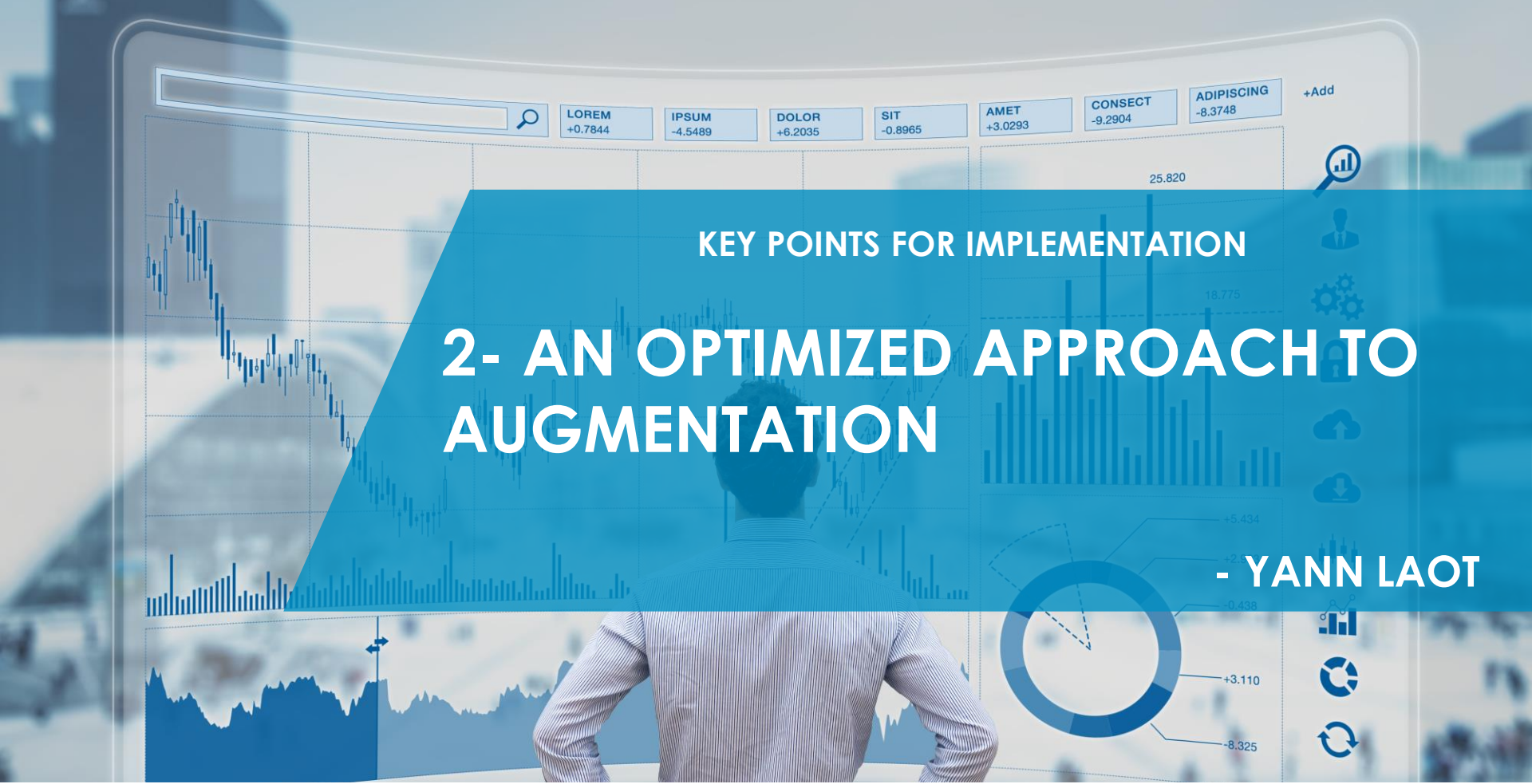












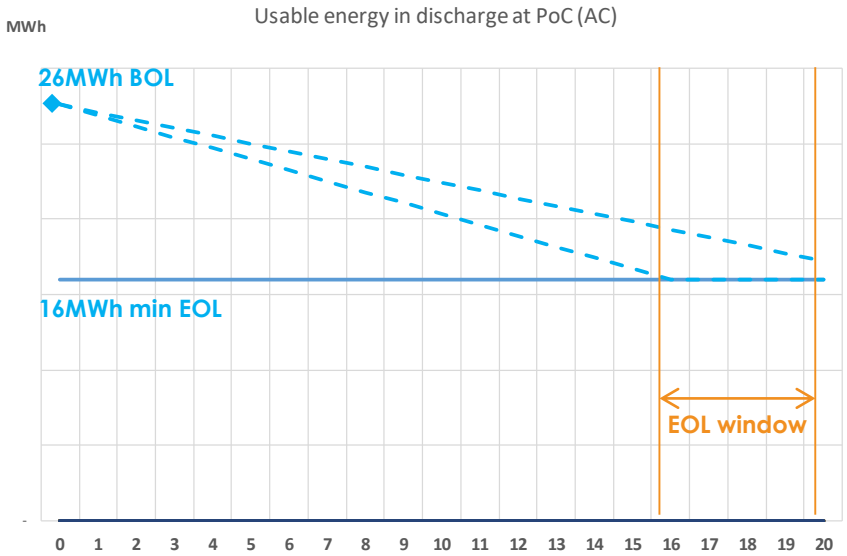
KEY POINTS FOR IMPLEMENTATION

2- AN OPTIMIZED APPROACH TO AUGMENTATION

- YANN LAOT

Energy storage value creation driven by four main drivers affecting sizing

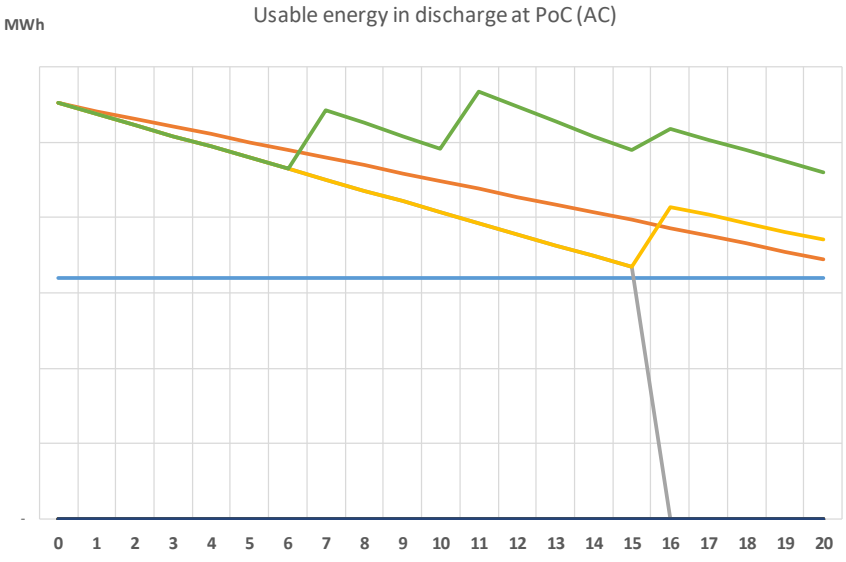
“No ideal solution”, a concrete example of a Saft customer PV + storage power plant



CUSTOMER REQUIREMENT

- Grid-connected energy storage , collocated with a PV plant >45MWp
- Multiple stacked applications
- Uncertain PPA duration
- Technical requirements

“No ideal solution”, augmentation a key choice among multiple options



CUSTOMER REQUIREMENT

OPT A « Baseline – Full usage »

OPT B « Baseline – Limited usage »

OPT C « Replacement »

OPT D « Augmentations for secured performance & max throughput »

	Total CAPEX	Cumulated throughput (GWh)	LCOS $21/MWh	NPV $21
	As a ratio versus option A			
CUSTOMER REQUIREMENT	1	1	1	1
OPT A « Baseline – Full usage »	=	-30%	+60%	-270%
OPT B « Baseline – Limited usage »	+50%	+30%	=	-30%
OPT C « Replacement »	+60%	+50%	=	>+20%
OPT D « Augmentations for secured performance & max throughput »				

KEY POINTS FOR IMPLEMENTATION

3- FLEXIBLE GUARANTEES

- YANN LAOT

Warranty *versus* Performance guarantees, two different but complementary notions

(Extended) Warranty

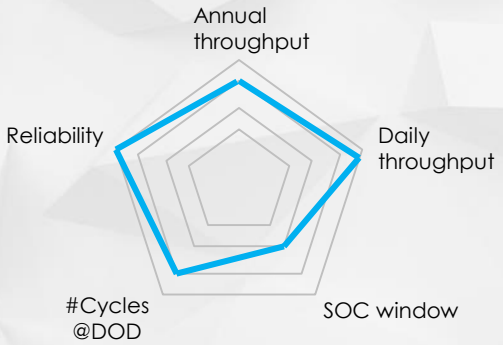
- Covers defects or failures: “free from material defects in materials and workmanship”
- Applies to "materials" components, subsystem or system (hardware or software)

Performance Guarantees

- Ensure a minimum performance and/or its evolution performance overtime
- Applies more often to "immaterial" metrics of a product or of a service

Performance guarantees, a range of possible choices to arbitrate between coverage and complexity

PRODUCT NOMINAL GUARANTEE



Pro & cons

✓ Very simple

✗ Limited – No guarantee outside of nominal point

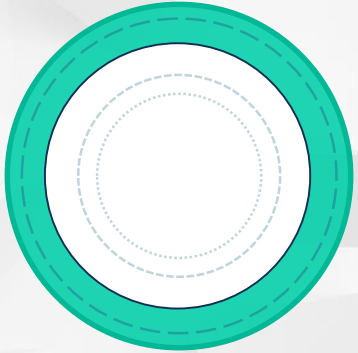
Performance guarantees, a range of possible choices to arbitrate between coverage and complexity

PRODUCT NOMINAL GUARANTEE → **PROJECT-ORIENTED GUARANTEE**

Guaranted ***throughput*** not tied to specific use

Guaranted ***performances*** related to specific cycling

Guaranted ***performances & rules*** related to cycling envelopes



Pro & cons

- ✓ Very simple
- ✗ Limited – No guarantee outside of nominal point

- ✓ Very simple
- ✗ Limited gain versus product-tied guarantee
- ✗ Limited match with complex and very variable use case

- ✓ Large guarantee
- ✗ Complex & specific to modeled use-case
- ✗ Lack of flexibility versus evolving use case

- ✓ Best guarantee
- ✓ Flexible versus evolving use case
- ✗ May be very complex
- ✗ Requires advanced Energy Management System

Saft remote monitoring & cloud CUBE solution, the key enabler to support all kind of performance guarantees

Customer Site

Microsoft Datacenters

Dashboard, Operations

Customer

Firmware (OPSW), Parameters and remote queries

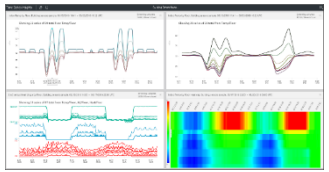
ESS-CUBE

Battery Data
(I,U,T°,Faults..)
Meta Data
(Software version, ID)

Azure

CLOUD
Automatic analytics, Algorithms& big data

Dashboard / Notification / Guarantee management / Maintenance Operation



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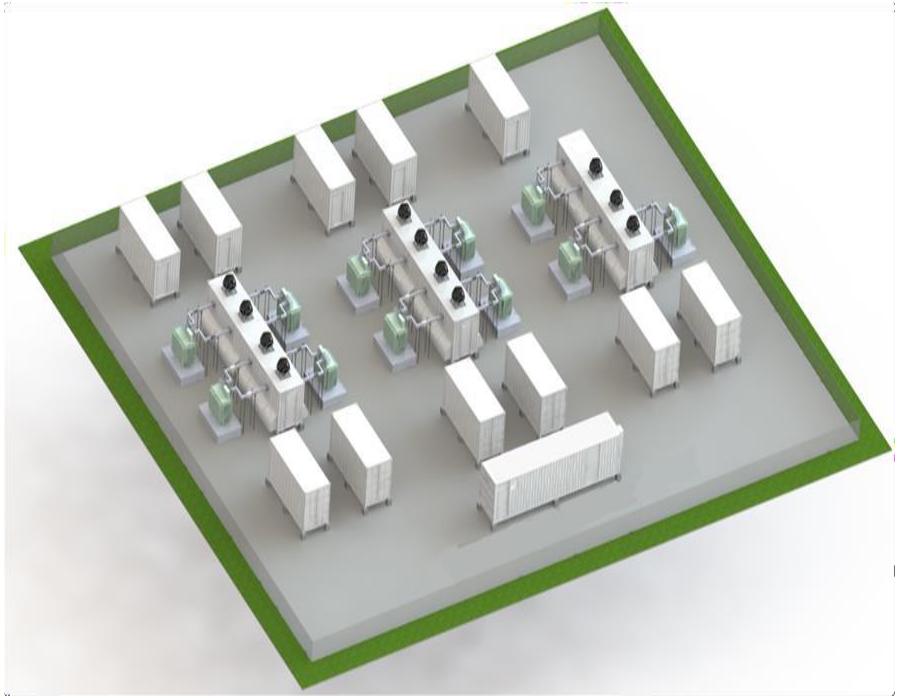
DESIGN OPTIONS

- MICHAEL LIPPERT

Case Study: Dunkirk I

Battery storage solution to supply the French grid operator with FCR services

- **Solution for Dunkirk**
  - 25 MW - 25 MWh
  - 11 Intensium Max High Energy
  - 3 PCS
  - 11 LV/MV transformers
  - Perennial solution to be used for future projects



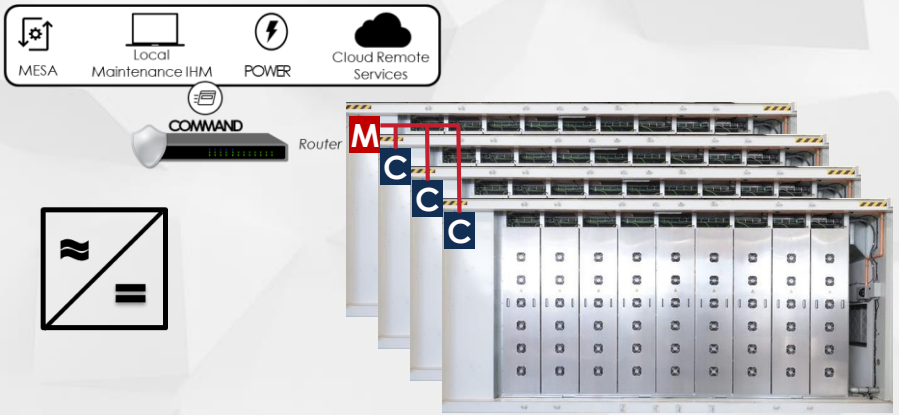
A building block for flexible usages

- **Intensium Max 20 High Energy**
  - 2.5 MWh
  - Up to 2.5 MW

DIFFERENT APPLICATIONS CALL FOR…

✓ **Flexible architectures**

- different / evolving power and energy
- different system sizes



A building block for flexible usages

- **Intensium Max 20 High Energy**
  - 2.5 MWh
  - Up to 2.5 MW

DIFFERENT APPLICATIONS CALL FOR…

✓ **Flexible architectures**

- different / evolving power and energy
- different system sizes

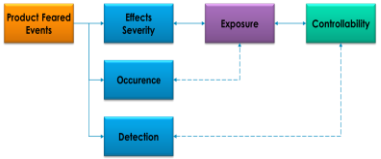
✓ **Different voltages**

✓ **Different environments**

✓ **A consistent safety concept adaptable to local conditions**

… a consistent safety concept adaptable to local conditions

System approach to identify, minimize and mitigate product hazards



Risk analysis at system level

- Capture electrical (U, I) electrochemical & thermal hazards, and combinations
- Effects and occurrence

Design HW and SW safety barriers

- Detect
- Eliminiate
- Mitigate
- Control effects

Extensive component and system abuse testing

- Validate effectiveness of safety barriers
- International certifications EC, UL, …

… replicable solutions

20-foot container concept, factory assembled and tested

One product – 3 sites

- One single design available from 3 industrial Saft sites worldwide
- Locally optimized supply chain and services

Assembled and tested in factory environment

- Specialized Saft personnel
- Test benches for
- high power / high voltage
- Full functional testing

Transportation and quick installation anywhere

- Weight < 30t
- No local assembly
- No climate constraints

Saft turnkey energy storage solutions

Our building blocks for a complete lifecycle solution

Value chain offering	Solutions		Project services		After Sales	
	Technology & know-how	Equipment & systems	Engineering	Project support	Asset services	Guarantees

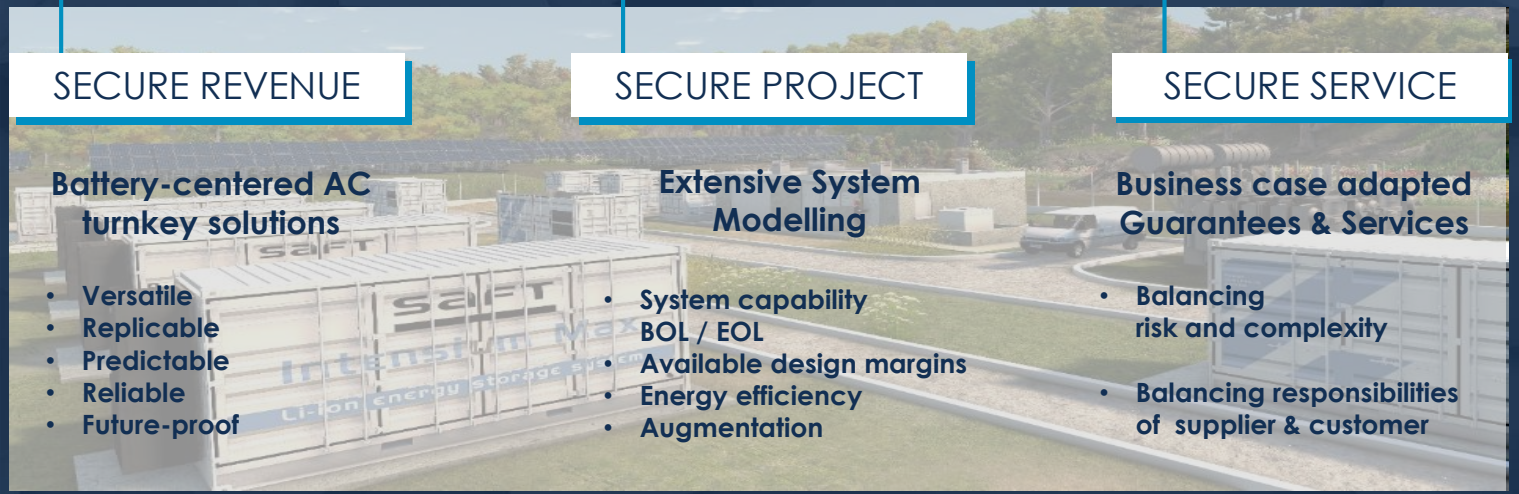
Li-ion Battery Energy Storage Container

Power Conversion System

Power Management

Saft turnkey energy storage solutions
Our value proposition

Value chain offering	Solutions		Project services		After Sales	
	Technology & know-how	Equipment & systems	Engineering	Project support	Asset services	Guarantees



SECURE REVENUE

Battery-centered AC turnkey solutions

- Versatile
- Replicable
- Predictable
- Reliable
- Future-proof

SECURE PROJECT

Extensive System Modelling

- System capability BOL / EOL
- Available design margins
- Energy efficiency
- Augmentation

SECURE SERVICE

Business case adapted Guarantees & Services

- Balancing risk and complexity
- Balancing responsibilities of supplier & customer

Which topics would you be interested in for future webinars?

ESS control systems

Safety deep dive

ESS on islands

Microgrids

Augmentation deep dive

Sustainable Batteries

Saft's common purpose

We energize the world.
On land, at sea, in the air and in space.

Stay tuned!

contact.webinar@saftbatteries.com