Saft Energy Storage System

Which application? Which storage?

saft

ADB - Manila, Januray 2018

Who is Saft today?

GROUP PROFILE

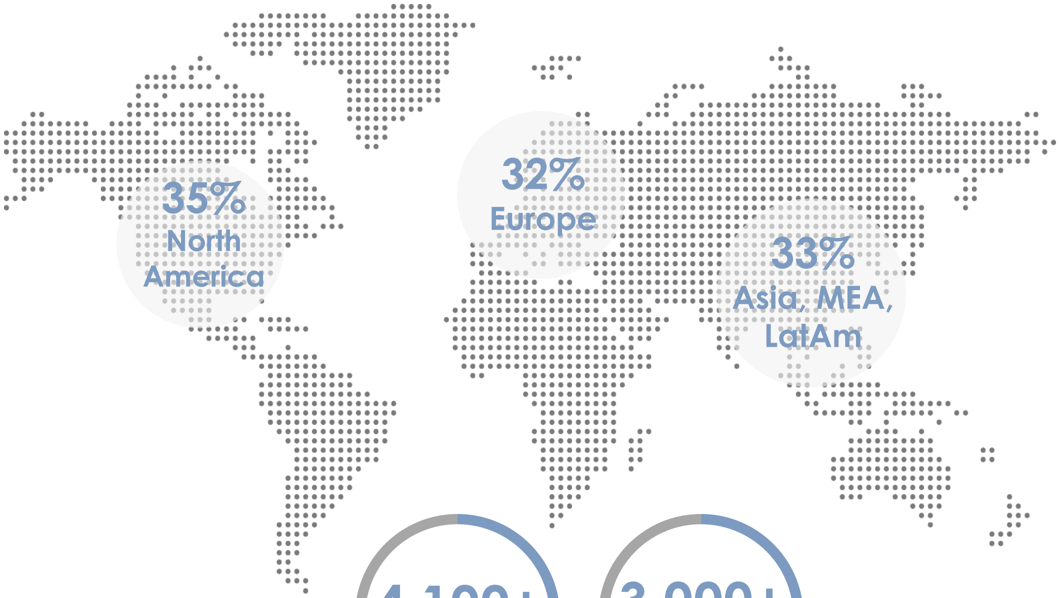
~100 years of history

Leadership position on 75-80% of revenue base

9% invested in **R&D** with **3** main technologies

€738m revenue FY 2016

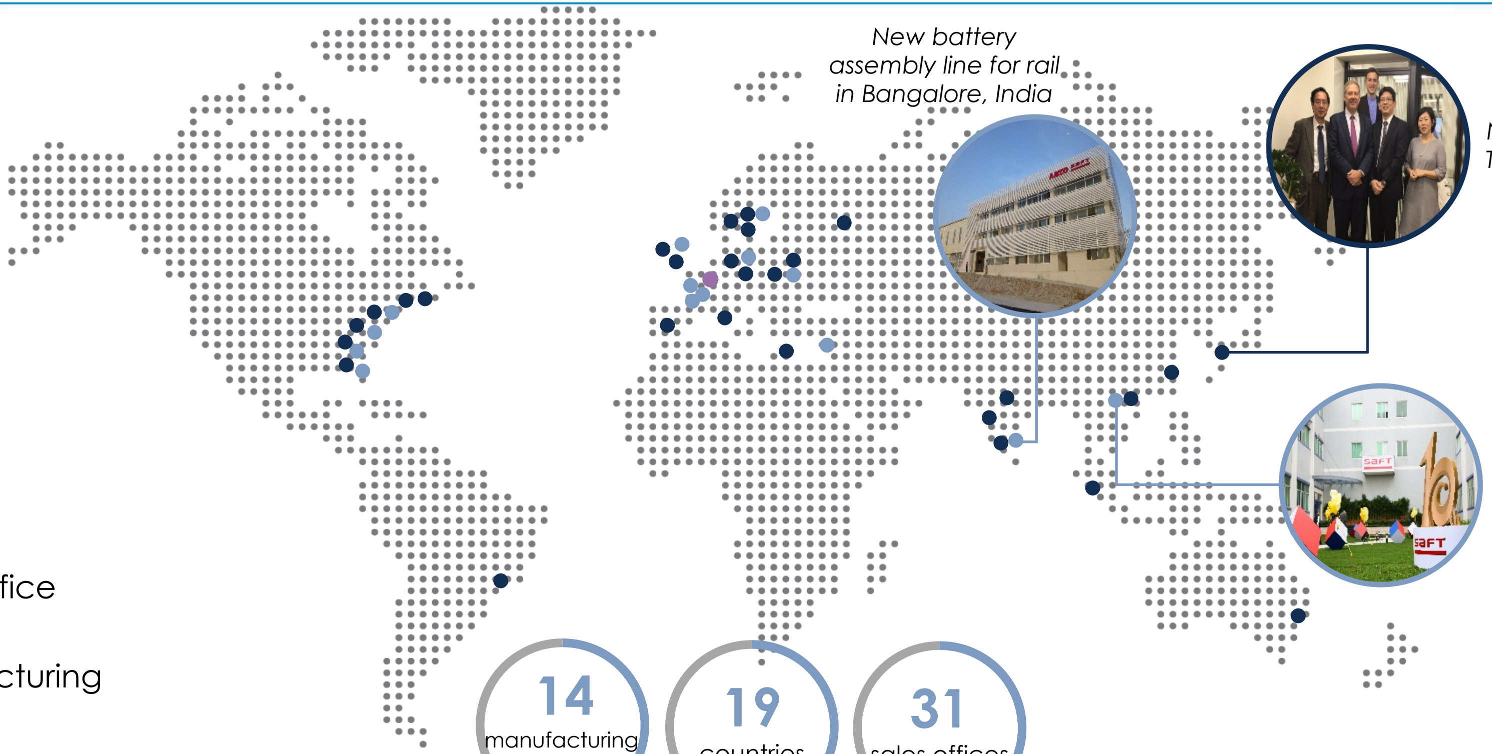
INTERNATIONAL PRESENCE



4,100+ people

3,000+ customers

Global presence



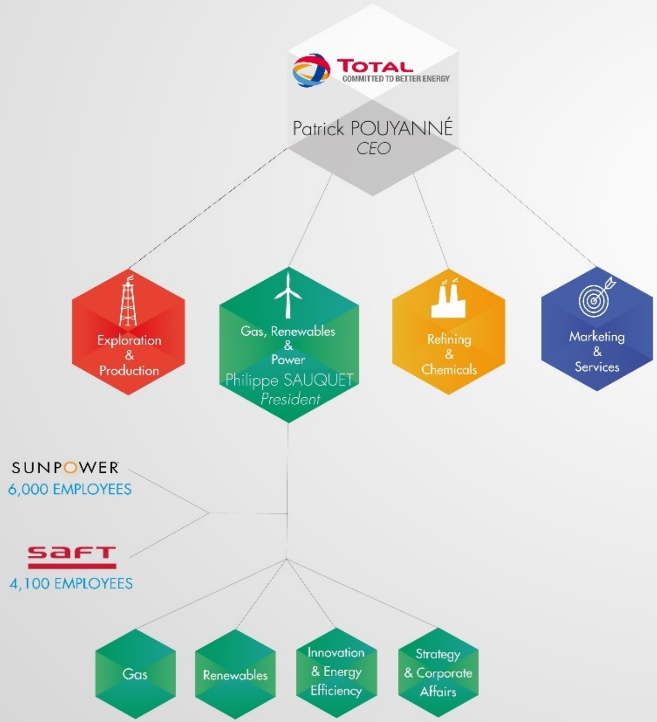
- Head office
- Manufacturing sites
- Sales offices

14 manufacturing sites

19 countries

31 sales offices

Where we fit in Total

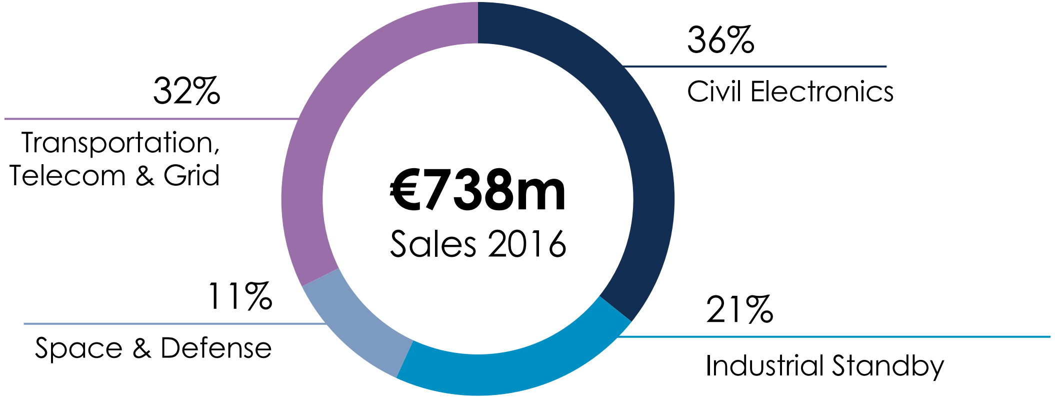


4[TH] LARGEST OIL & GAS COMPANY

100,000 EMPLOYEES

130 COUNTRIES

2016 sales by division



€238m
Transportation, Telecom & Grid

€264m
Civil Electronics

€80m
Space & Defense

€156m
Industrial Standby

We serve multiple customer segments for specific applications

Aviation
Airbus, Boeing

Defense
DCNS, GE

Grid
Enedis, Kaua'i Island Utility Cooperative

IoT
Libelium, World Sensing

Marine
Rolls-Royce, Benetti

Medical
Cardiac Science, Berlin Heart

Metering
Landis+Gyr (manage energy better), Itron

Mobility
Linde, Kalmar

Oil & Gas
Total, Shell

Rail
Alstom, Bombardier

Space
Airbus, Lockheed Martin

Telecom
Reliance Jio Infocomm

Utilities
dewa, एनटीपीसी NTPC

Energy Storage Systems (ESS)

Saft Energy Storage Systems,
January 2018

1 OVERVIEW

Evolution of the electricity grid

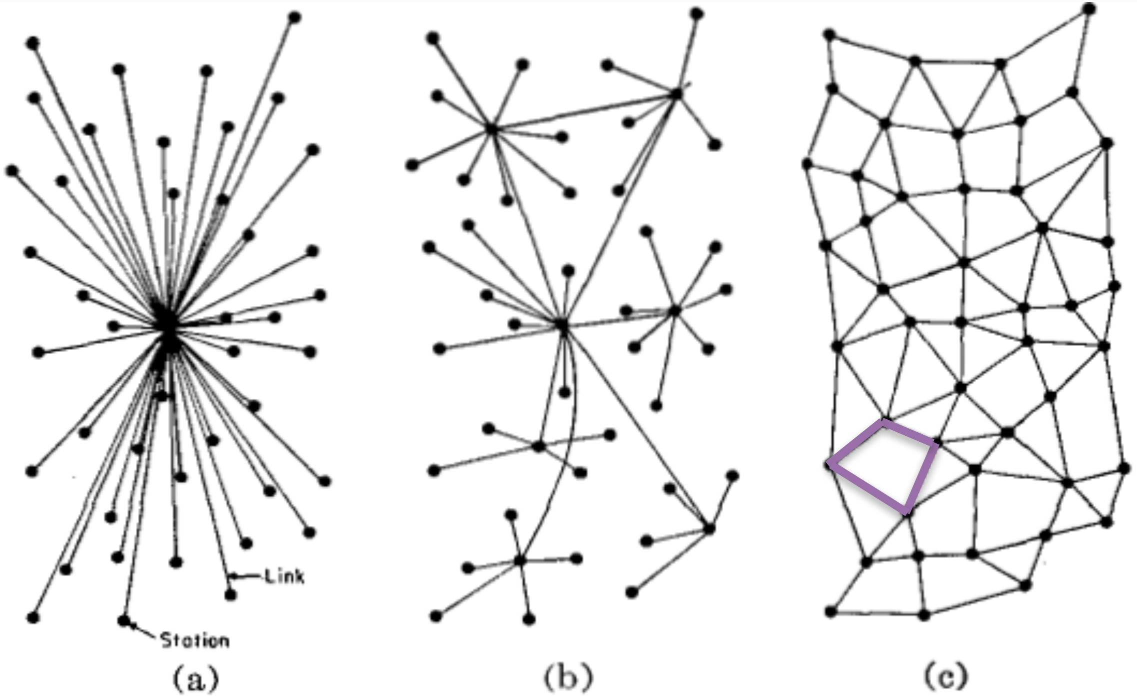


Fig. 1—(a) Centralized. (b) Decentralized. (c) Distributed networks.

ESS Applications: cycling and C-rates

Cycling / Power	Heavy Cycling 5Capa/day @1-40%DOD	Medium Cycling 1-2Capa/day @10-70%DOD	Low Cycling 1 cycle/day @ 50-80%DOD
2C to 4C	Ancillary Services		
1C to 2C		Renewables Integration	
0,5 C to 1C			Grid Peak Management

Saft Li-ion end-to-end capability

1

Techno-
logy

- NCA, NMC, LFP
- More than 20 years experience
- NCA chosen for majority of Saft ESS applications.
- Criteria : performance, life time

- Process control key for life and reliability
- Cell manufacturing and System assembly
- 5 production sites (F, US)

Manu-
facturing

2

3

System
capability

- System Design, development, qualification mechanics, electronics, testing
- Pre-project & project management

State-of-the-art manufacturing in Jacksonville, Florida

- Construction of complete battery systems, automated cell manufacture through module production to assembly into ISO containers
- 235,000ft2 under roof, with annual production capability of around 400 MWh
- Expansion capability to double production

From cells to battery

VL Cells

Modules

Saft Battery System

- VL 30P
- VL 41M
- VL 45E

- Synerion®
- Modul'ion®

- Intensium® Smart
- Intensium® Max

Saft's Energy Storage Projects Worldwide

saft

2 ENERGY STORAGE USE & BENEFITS

Applications On-Grid

Large power plants

Grid compatibility

Photovoltaic Power Plants
Wind Power Plants

Grids

Demand-supply flexibility

Transmission Grids
Distribution / Smart Grids
Micrograids
Private Grids (e.g. railways)

Behind the Meter
Residential, Commercial, Industrial

Self-consumption

Smart Buildings
Industrial / Commercial

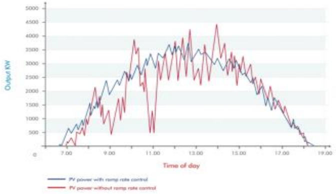
Applications	Saft focus ■ (red)		
	Large power plants	Grids	Behind the Meter
Energy Shifting	■	■	■
Smoothing / ramp control	■ (red)		
Frequency regulation	■ (red)	■ (red)	
Peak Shaving		■	■
Hybrid Systems		■ (red)	■ (red)
Energy Management		■	■

Major Functions of Storage

Wind & Solar generation

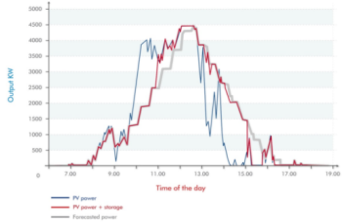
Ramp control

Limit up & down ramp rates



Smoothing

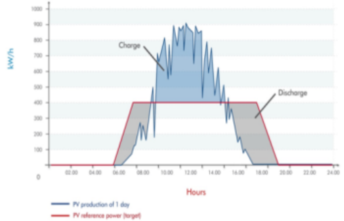
Keep production in forecast window



Shaping

Stable power output

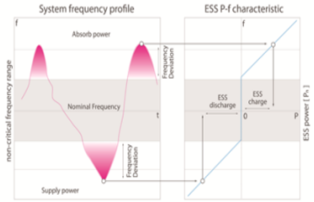
Controlled ramp up/down



Grid

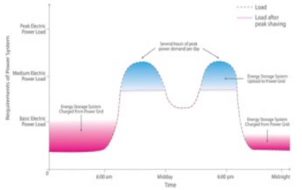
Frequency Regulation

Injection/Absorption of active power



Peak Shaving

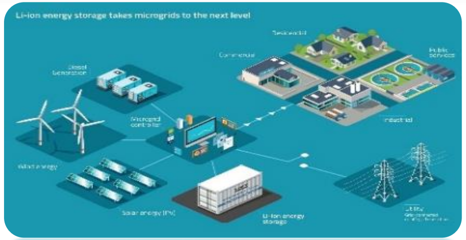
- of consumption peaks
- of generation peaks



Saft positioning

Integration of PV & Wind farms
Ramp control & frequency support & other grid services

Reference projects:
Puerto Rico, Feroe Islands



Microgrids
Diesel & Renewables

Reference projects:
Cobija Bolivia, NTPC Canada

Frequency regulation
associated with other grid services

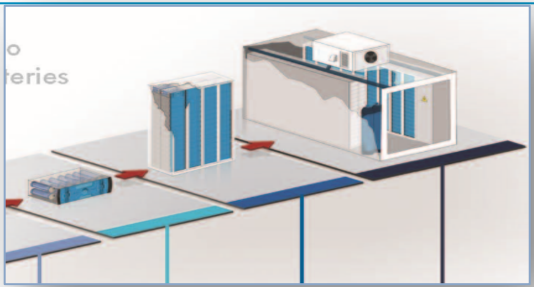
Reference projects:
Venteea, SEPTA

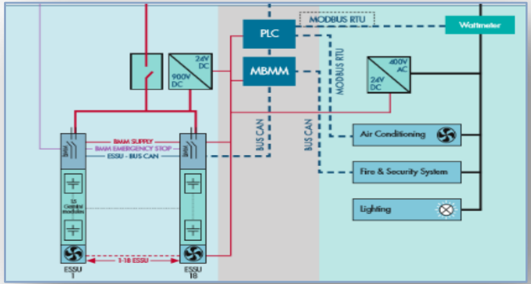
Focus utility scale, power oriented applications for high value generating services

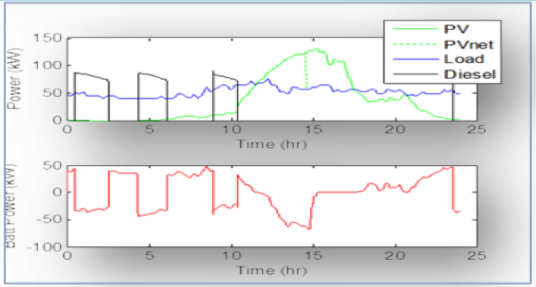
1. High power
2. Long calendar life at high temperature
3. Complex use cases with **multi-application stacking**
4. Microgrids with variable, multi-generation sources and loads

➔ **Requiring high level of application and technology mastering**

Strengths







Scalable Li-ion systems In racks and containers Consistent design from cell to system	**Leading-edge expertise** in system integration Management of • Parallel strings • FSS, aux., alarms, temp. • PCS interfaces	**Advanced Modelling** of battery & electronics Precise, high resolution modelling of battery behavior and ageing
➔ One-stop responsibility ➔ Fast & de-risked field implementation	➔ Failure-free and effective operation in all situations ➔ Low energy consumption ➔ Availability, maintainability	➔ Optimium battery size ➔ Optimum system operation ➔ Certainty on life time

3

LI-ION CELL TECHNOLOGY

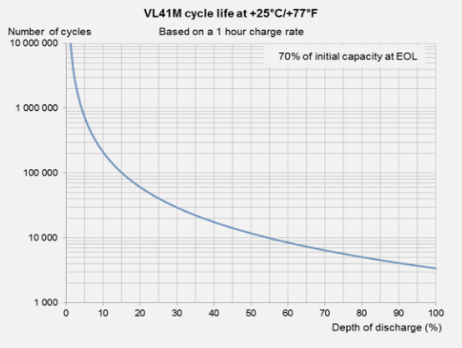
Saft VL cells Gen 3

NMC / NCA technology - main features

- High charge acceptance
- Enhanced cycle life
- High energy throughput
- Lower impedance
- Best calendar life on market

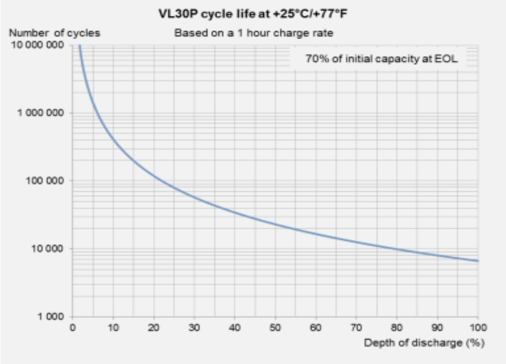
VL 41M

- End Of Life @ 30% capacity loss
- 5,000 cycles @ 80%DOD , 1C
- 100,000 cycles @ 15%DOD, 1C



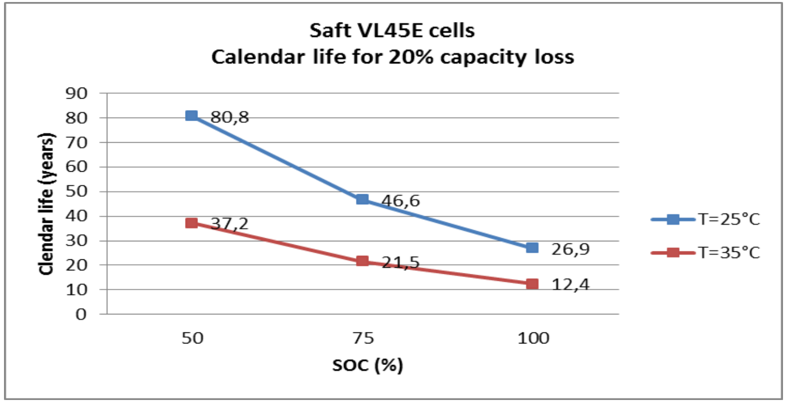
VL 30P

- End Of Life @ 30% capacity
- 9,000 cycles @ 80%DOD , 1C
- 200,000 cycles @ 15%DOD, 1C



Saft VL cells Gen3 - Calendar life

- Best calendar life of Li-Ion technology due to NCA
- Loss below 0.5%/ year in majority of ESS applications:
  - Cell average temperature < 35°C
  - SOC average ≈ 50%



Application example Hybrid ESS & Thermal

average: DOD 40% / power rate 1.5 C / throughput 800%/24h / temp 35°C

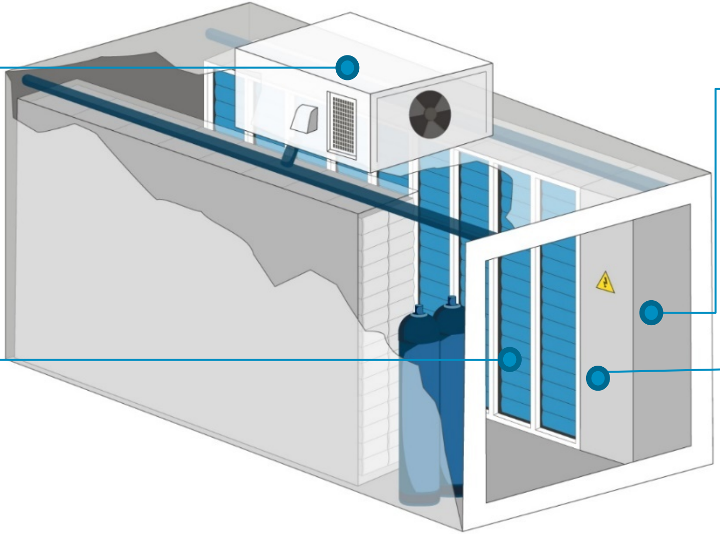
➔Degradation due to calendar : 6% ➔ Degradation due to cycling : 29%

4 PRODUCT OFFERING

Generation 3: Container Improvement

Improved thermal management
- Energy efficiency
- High energy throughput
- Long calendar life

NMC/NCA cell technology
- High charge power
- Enhanced cycle life
- High energy throughput



Smart PLC interface & remote monitoring
- Advanced operation control
- Asset management
- Predictive maintenance

One or two power distribution cabinets
- Optimum PCS interface and system architecture
- Up to 3MW power

High performance to enable most demanding operation profiles

POWER	ENERGY	THROUGHTPUT	EFFICIENCY	LIFE
up to 3 MW	up to 1.2 MWh	up to 800% per day	85% roundtrip incl auxiliaries	up to 20 years

Intensium ® Max + 20 range (700-1200kWh)

	Intensium Max+ 20E	Intensium Max+ 20M	Intensium Max+ 20P	Intensium Max+ 20P 2 dist cab
Energy (kWh)	1 180	1 090	780	700
Continuous discharge power (kW)	2 500	2 500	2 500	2 800
Continuous charge power (kW)	850	2 200	2 600	2 900
Nominal voltage (V)	771			
Voltage range (V)	630 – 867			
Dimensions L x W x H (m)	6,1 x 2,5 x 2,9 (3,8 incl HVAC)			
Weight (t)	19,5			

Configuration : 18 or 16 ESSU with 15 Synerion-Gemini each - gen3 NMC/NCA cells

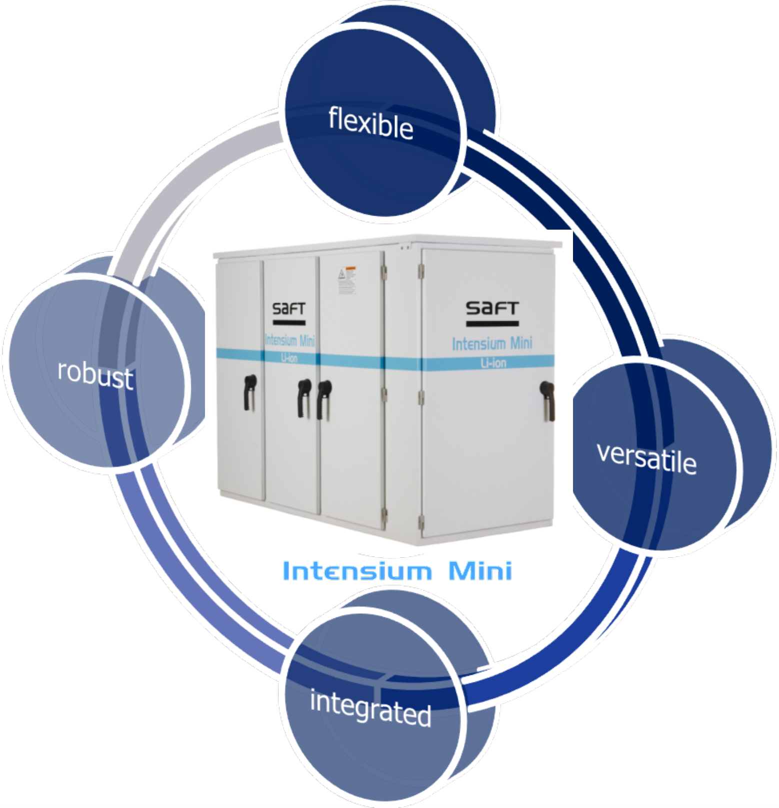
Saft's Intensium Mini (120-480kWh)

From 80 to 480 kWh,
Energy, Medium Power,
High Power

Utility, Renewables, Industrial and Commercial Applications

Optimised integration of system functions
incl. FSS & HVAC

Solid IP55 outdoor construction for all environments



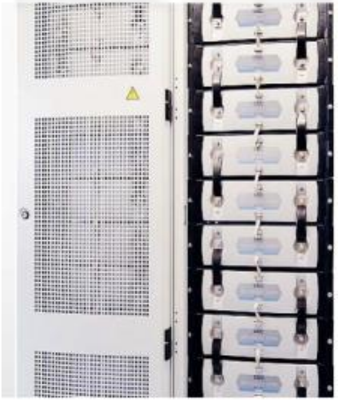
Intensium® Mini - outdoor

	Intensium Mini - E	Intensium Mini - M	Intensium Mini – P
Energy (kWh)	120	110	80
Continuous discharge power(kW)	280	280	280
Peak discharge power (kW)	420	420	420
Continuous charge power (kW)	80	115	170
Voltage range (V)	588 - 790	588 - 790	588 – 790
Dimensions L x W x H (m)		2,45 x 1,03 x 1,58	
Weight (t)		1,95	

Configuration : 2 ESSU with 28 Synerion each - gen 2 NCA cells

Field Service

– Skilled workers, comprehensive services
  - Installation
  - Commissioning
  - Training
  - Testing
  - Trouble Shooting
  - Maintenance & Repair
  - Warranty Extension
  - Condition Monitoring
  - Refurbishment



Technical Performance driving low TCO

	Feature	Customer Benefit
Energy Efficiency	- Low energy consumption for cooling - Stability across all SOC/temp/C rates	Lower energy cost – higher revenue Lower CO2 footprint
Calendar life	No capacity oversizing Can operate at high temp ➔ less cooling	Low / no replacement cost Low opex
Availability	99% PLC & monitoring to reduce downtime	Grid asset compatible High revenue – low maintenance
Design Flexibility	Multiple PCS interfaces (2 / container) Adaptation to harsh environements Daisy chain of 2 containers equiv. 40 ft	Optimum power / energy rating for each project
BMS performance	Accurate cell & string balancing SOC accuracy	Full utilization of energy ➔ Optimal revenue generation
Maintenance & Services	PLC enables: Capability matrix Predictive maintenance Realtime DTP, data valorization & reporting	Optimum asset utilization Minimum maintenance cost

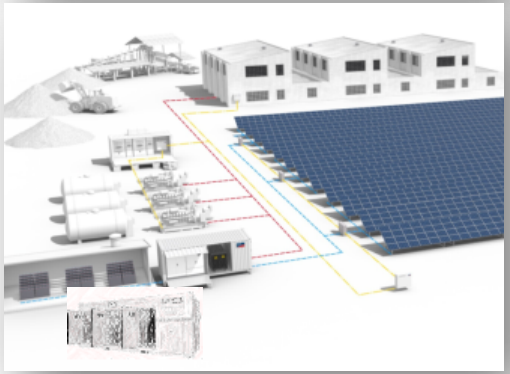
5 REFERENCES

Cobija PV diesel hybrid power plant

- Pando province, northern Bolivia
  - Not connected to national grid
  - 65% electricity coverage
- World's largest PV-diesel hybrid
  - 16MW diesel generation – 8MW max load
  - 5MW PV
  - 2.2 MW Li-ion storage system
  - 50% of Cobija power needs (37 GWh/yr)

The storage solution

- 2.2 MW – 1.2 MWh
  - 2 containers Intensium Max 20 M
  - 4 Sunny Central Storage 630 – SMA
  - ➔ compensation of PV fluctuations
- Fuel Save Controller – SMA
  - Calculates maximum PV injection to grid
  - Smooth operation of gensets



Courtesy SMA

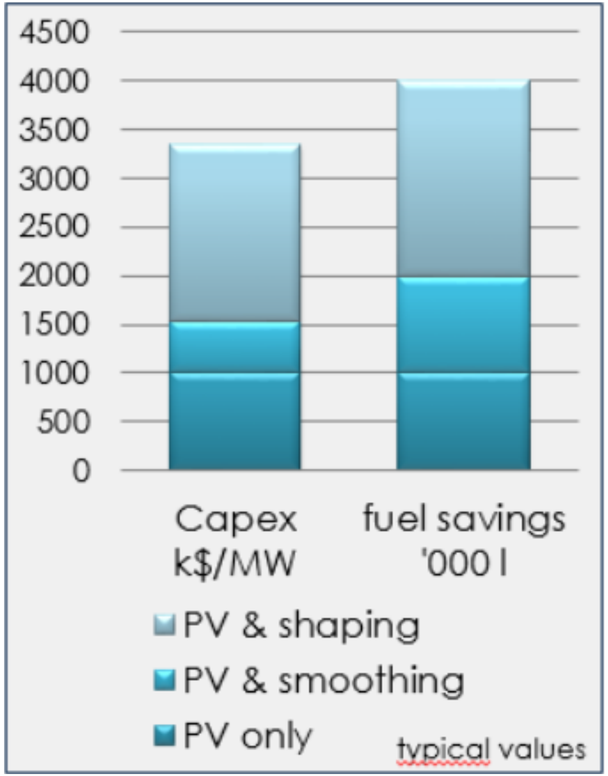
The storage optimum

PV & smoothing

- Optimum for Cobija project
- Replaces 2 gensets running @50%
- 2 mio l fuel saving

PV & shaping

- Significantly higher Capex
- ROI depends on fuel cost



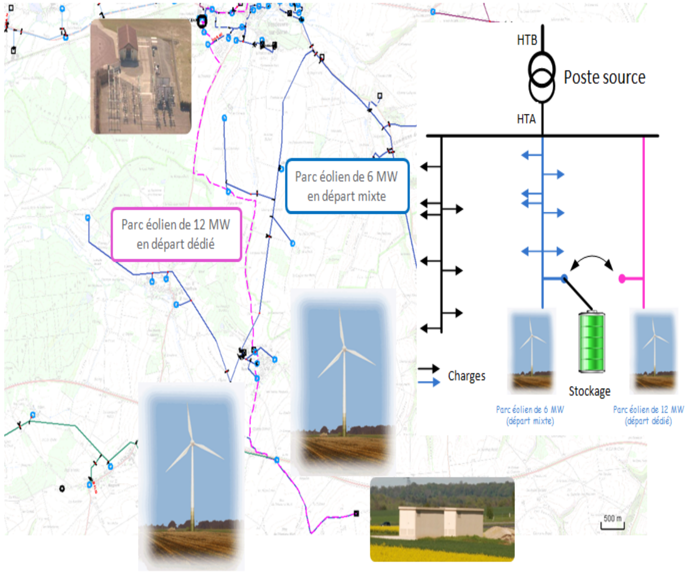
THANK YOU

VENTEEA project

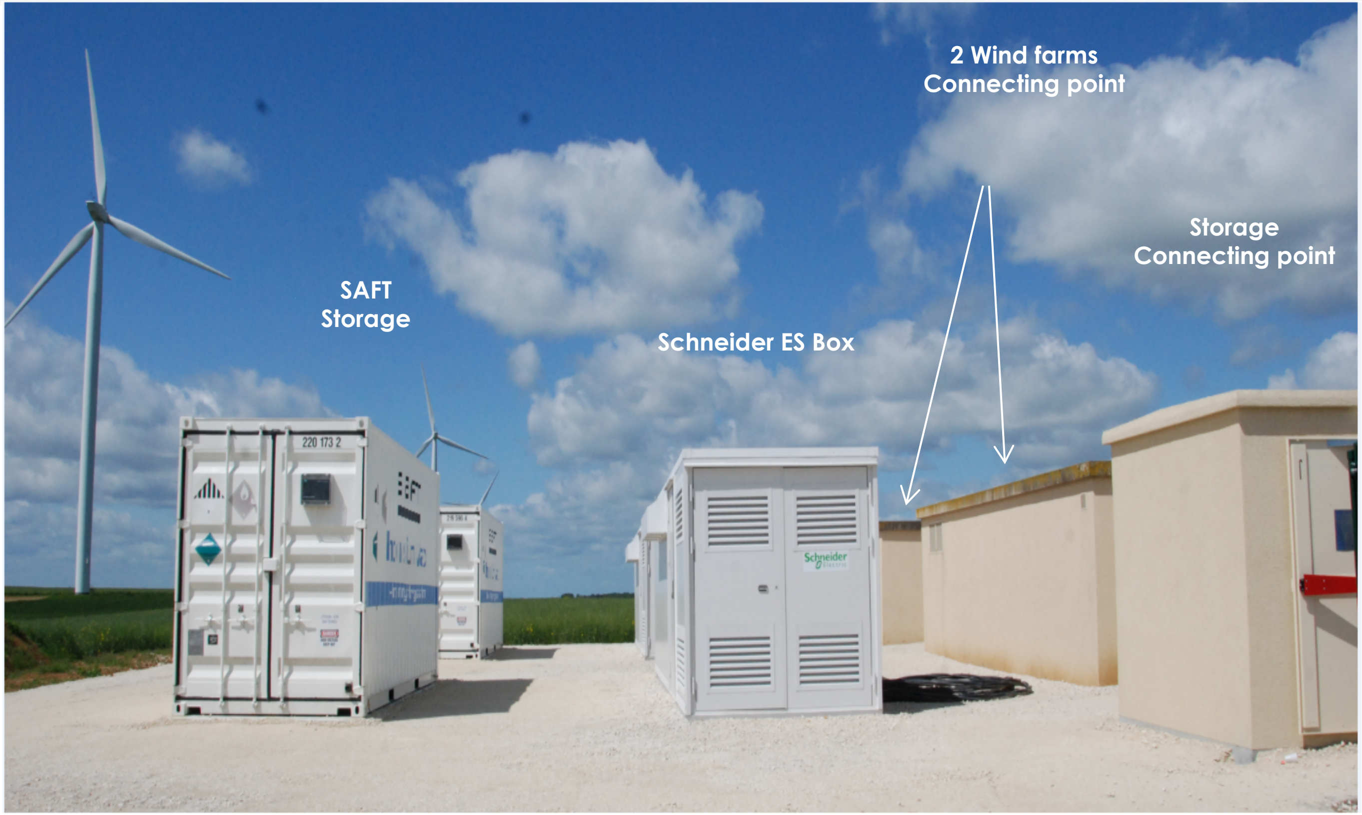
VENTEEA is a project focused on the integration of large wind generation within MV distribution networks.

Key facts and figures:

- 1 existing wind farm 12 MW (dedicated MV feeder)
- 1 existing wind farm 6 MW (non dedicated MV feeder with 1500 customers)
- 1 HV/MV transformer (63/20 kV - 20 MVA)
- 130 secondary substations
- 3 200 customers (6 MV feeders)



VENTEEA: installation



Testing multiple services for different players

TSO

- TSO1: frequency control
- TSO1i : frequency stability
- TSO2: voltage control
- TSO3: loss minimization
- TS04: congestion relief
- TSO5: angular stability

DSO

- DSO0: main substation UPS
- DSO1: capacity support
- DSO2: local voltage control
- DSO3: Contingency grid support
- DSO4: intentional islanding
- DSO5: reactive power support
- DSO6: loss minimization
- DSO7: power quality (users)
- DSO8: power quality (TSO)
- DSO9: TSO fees optimization

DG/RES

- DG1: ancillary services support
- DG2: fluctuation smoothing
- DG3: curtailed energy reduction
- DG4: time shifting
- DG5: capacity firming
- DG6: micro grid balancing

End-Users

- CUS1: peak shaving
- CUS2: time-of-use optimization
- CUS3: unnoticed DR support
- CUS4: power quality (user)
- CUS5: end-user UPS
- CUS6: power quality (DSO)
- CUS7: reactive power support

Storage owner

- ARB: energy arbitrage

Not feasible in VENTEEA

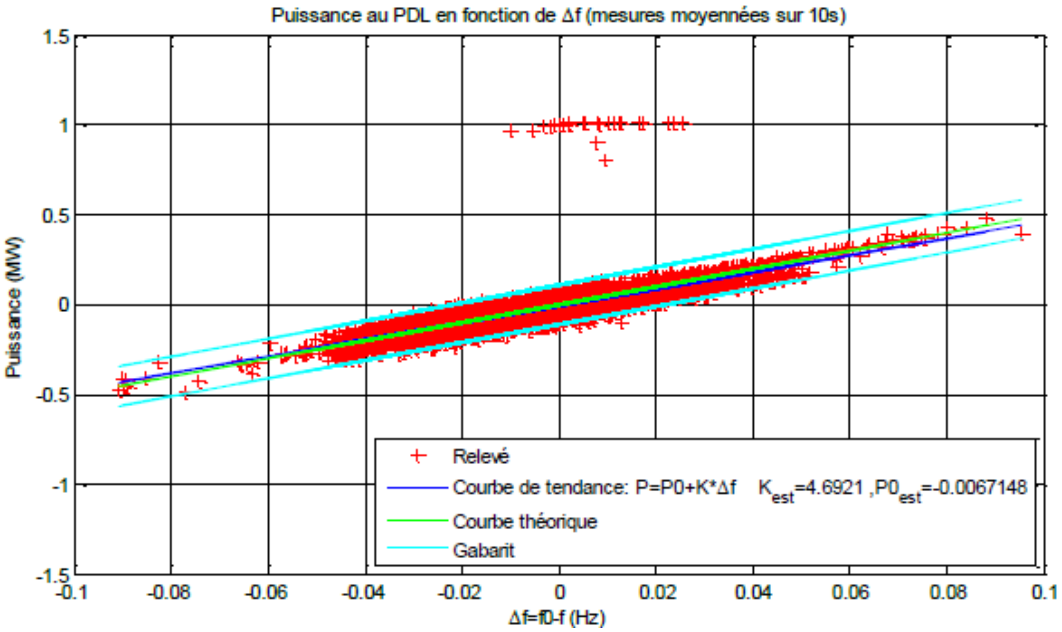
Not considered in VENTEEA

Dedicated feeder mainly

Feeder with customer mainly

ERDF VENTEEA project
2M- 1.3MWh system

Results for 2 days test at TSO level : 99.5% of time service was provided in expected band of power according to Δf



Conclusions of VENTEEA project

- Availability of 94% during 304 days of demonstration
- Up to 400% throughput per day
- Overall energy efficiency of 85%
- 12 services tested succesfully
- Multi-services approach planned day-ahead tested and validated
- Qualification by RTE (Frebch TSO) to participate in frequency regulation market