Stockages massifs en Li-ion: exemples de réalisations et perspectives

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Saft aujourd'hui

GROUP PROFILE

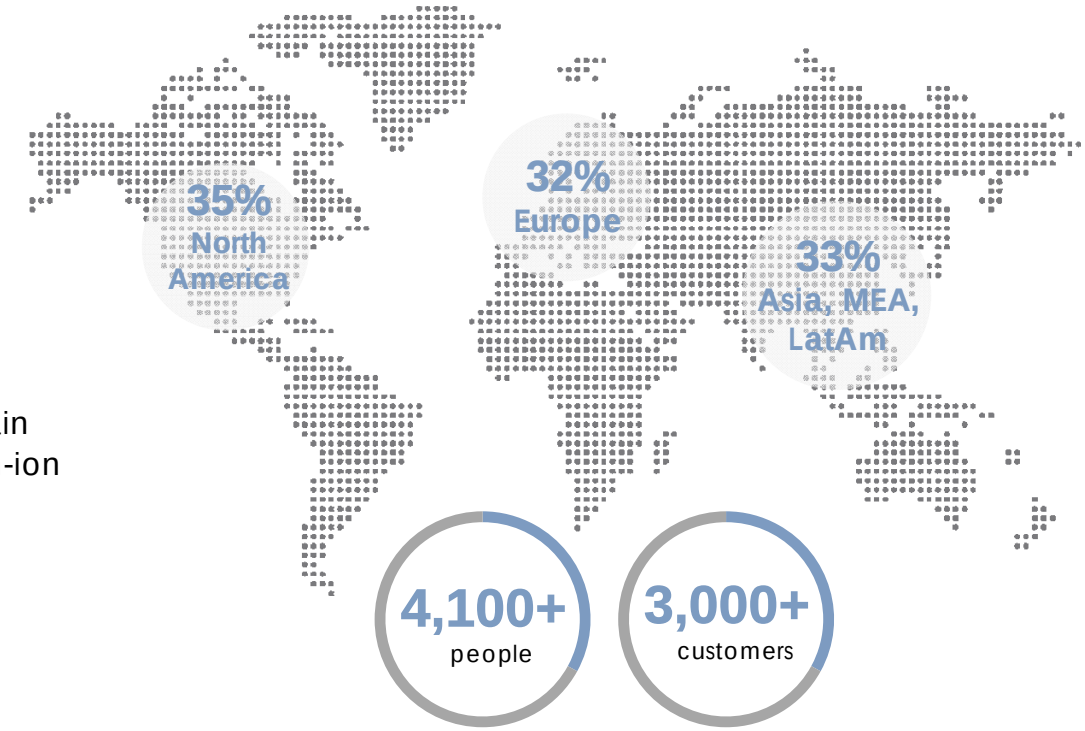
100 years of history

Leadership position on 75-80% of revenue base

9.7% invested in **R&D** with **3** main technologies; primary lithium, lithium-ion & nickel-cadmium,

€744m revenue FY 2017

GLOBAL PRESENCE - SALES

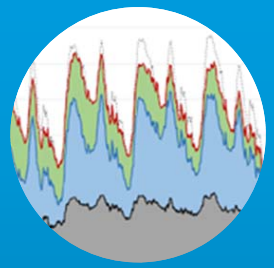


Stockage d'Energie: une vision à court terme

The 4th pillar

of the electricity system

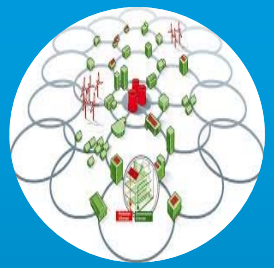
integrated all along the value chain and across the system



Flexibility provider

- @ electricity production
  - supply/demand balance,
  - capactiy
- @ transmission and distribution
  - Grid capacity
  - Grid stability
- @ electricity consumption
  - Self consumption
  - Energy to non connected sites

Short term to long term



Distributed & digital

- Multiple units are aggregated to provide services
- One storage asset provides multiple services to different stakeholders

& sector coupled

- Integrated with gaz, heat networks
- Integrated with electric mobility

Value generator

- Energy markets
- Grid services
- Customer services
- Asset services

Les fonctions du stockage d'énergie

Large power plants

Grid compatibility

Photovoltaic Power Plants
Wind Power Plants

Grids

Demand-supply flexibility

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

Behind the Meter

Residential, Commercial, Industrial

Self-consumption

Smart Buildings
Industrial / Commercial

Applications			
Energy Shifting	■		■
Smoothing / ramp control	■		
Frequency regulation	■	■	□
Peak Shaving		■	■
Hybrid Power Generation	■	■	■

Les fonctions du stockage d'énergie

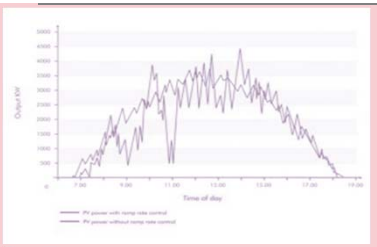
Generation | **Grid** | **Behind the meter/off-grid**

Fossile | Solar/wind | Transmission | Distribution | Industrial and commercial | Residential

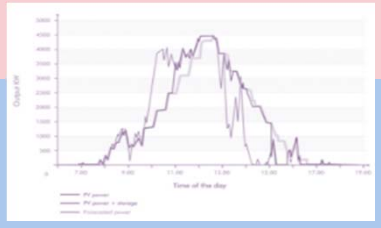
POWER

ENERGY

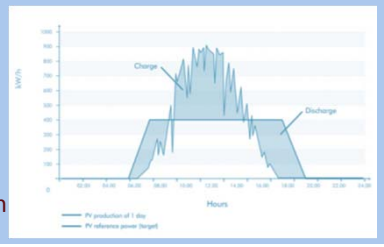
Ramp control
Limit speed of ramping up & down



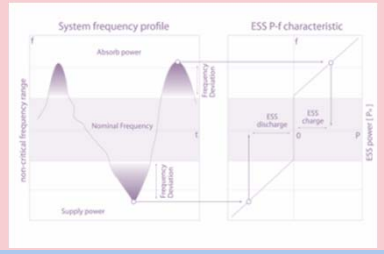
Smoothing
Keep production in forecast window



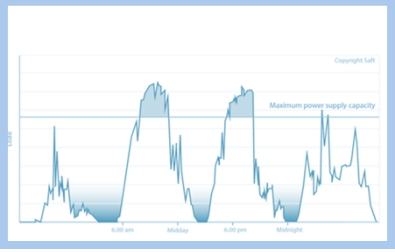
Shifting
Stable power Output & Controlled ramp up/down



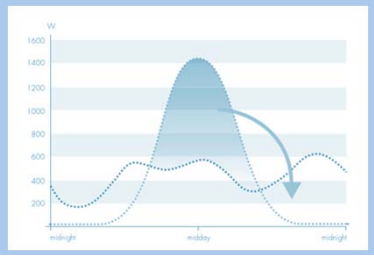
Frequency Regulation
Injection / absorption of active power



Peak Shaving
- of consumption peaks
- of generation peaks



Energy Management
- Self consumption
- Arbitrage
- Load management



Saft Intensium® Max & Mini footprint

Exemples de valorisation: EnR

Large power plants

Grid compatibility

- Higher Value / kWh for high quality RES generation
- Curtailment avoidance
- Peak Capacity

Husahagi 12 MW wind farm Faroe islands
+
2MW/20mn Li-ion ESS

Application = ramp rate control

Additional benefit = curtailment reduction (>60%)

Battery additional impact over wind

Capex	20%
Fuel savings	1000t/year
CO2 savings	3500t/year

Estimated ROI : 5 years

Le projet Feroë

SEV: vertically integrated utility

- Target 2020: 75% renewables with hydro & wind
  - 60% reached in 2015

New 12MW wind farm with ESS in 2015

- Total wind capacity 18MW
- 30% of total generation capacity
- 18% of yearly energy consumption
  - 42% hydroenergy, 40% thermal generation

Long term vision

- Two-fold increase of energy consumption by 2030
- Target: 100% renewables

18 islands - 50 000 inhabitants,
300 GWh/year

Le projet Feroë: le besoin

- Volatility of wind generation
  - Impact on voltage and frequency
  - Stress on diesel generation to compensate short term fluctuation
- Lack of inertia
- Substitution of synchronous generation by inverter based generation

Priority for ramp control

maximum

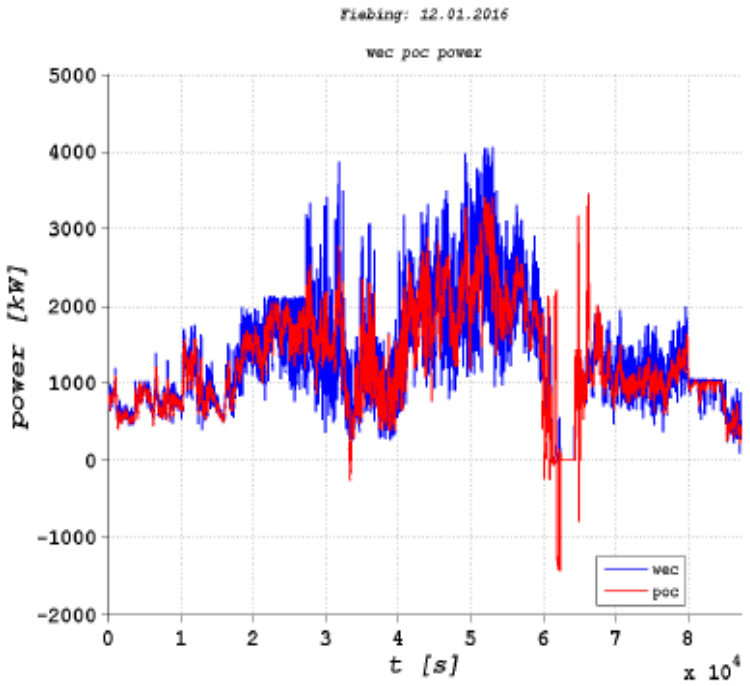
1MW / minute

upramp

downramp

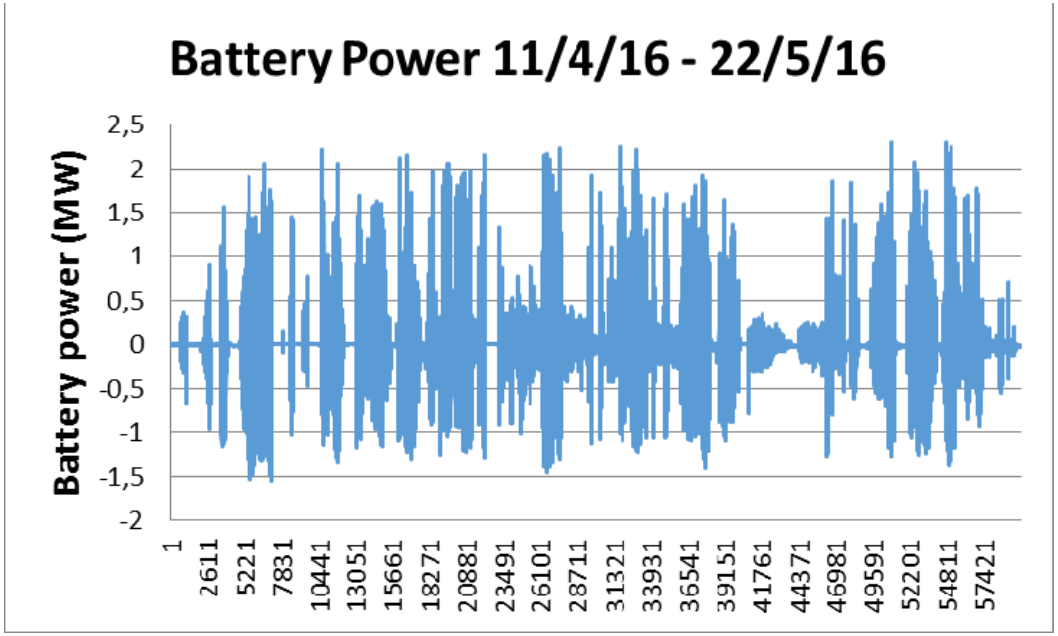
Le projet Feroë : simulation

- Compliance of 1MW /min ramp rate > 99%
- DC roundtrip efficiency 97.6%
- AC roundtrip efficiency including PCS & auxiliaries 86.2%
- Total efficiency losses of wind energy generated 0,22%
- Avge daily energy throughput of BESS 261%
- Capacity loss after 20 years operation 20,9%
- Impedance increase after 20 years 83%



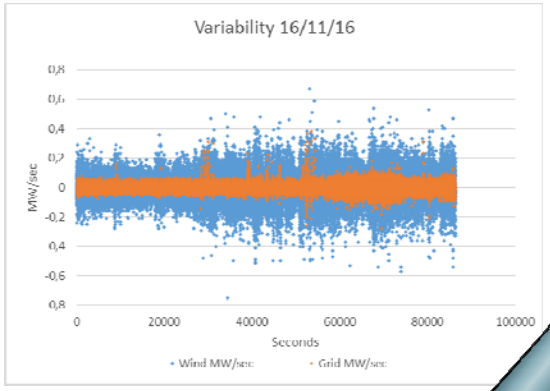

saft
Intensium Max

Le projet Feroë : résultats (1)

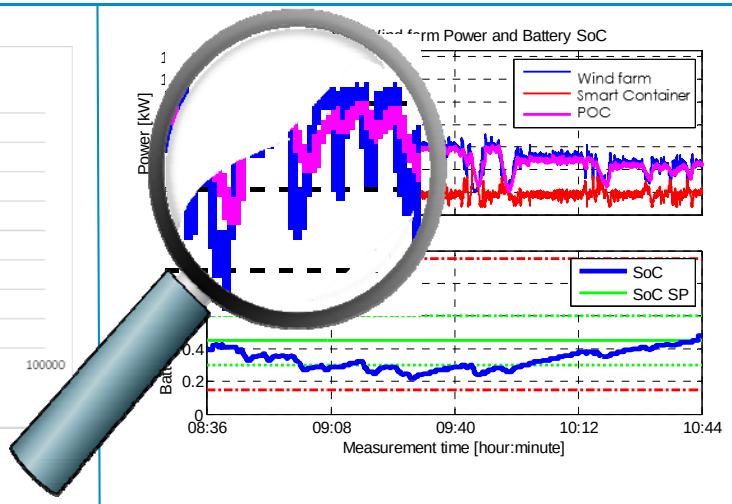


- About 80MWh charged during 40 days
- represents **300% daily throughput** (2 MWh per day / 700kWh battery)
- Maximum battery power frequently required

Le projet Feroë : résultats (2)

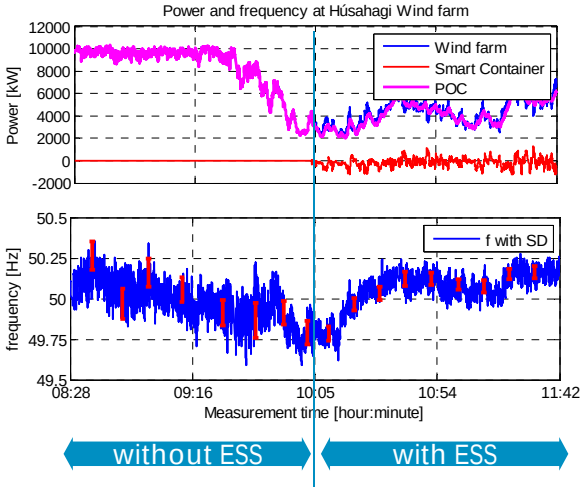


Reduced variability at point of connection (POC)



Evolution of power flows

State of charge Control



Reduced standard deviation ( ) of frequency

Curtailment decreased from ~30% below 10% ➔ lower diesel consumption
Stable system operation with up to 85% wind penetration

La Réunion – Appel d'Offres CRE

9 MW PV PV plant

9 MWh Li-ion Energy Storage System

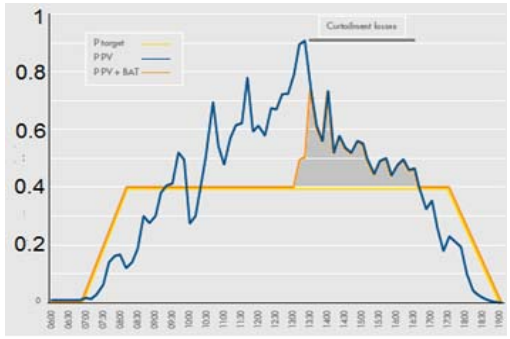
- Consortium Saft, Ingeteam, Corex
- 9 containers Intensium Max 20+E
- 5,6 MVA converters in 4 containers

Specification

- Constant power injection @ 40% Pmax
- Primary reserve : 10% Pmax / 15 minutes
- Voltage support by PCS reactive power

Battery Optimization

Energy capacity	Losses	Average DOD	Lifetime
9 MWh	11.3%	69.8%	>12 years
14 MWh	3.5%	56.3%	>17 years
21 MWh	0.7%	44.9%	>20 years



Exemples de valorization: réseaux

Large power plants

Grid compatibility

- Higher Value / kWh for high quality RES generation
- Curtailment avoidance
- Peak Capacity

Grids

Demand-supply flexibility

- Grid Services Frequency Control / Balancing
- Investment Deferral
- Microgrids: minimize genset fuel consumption

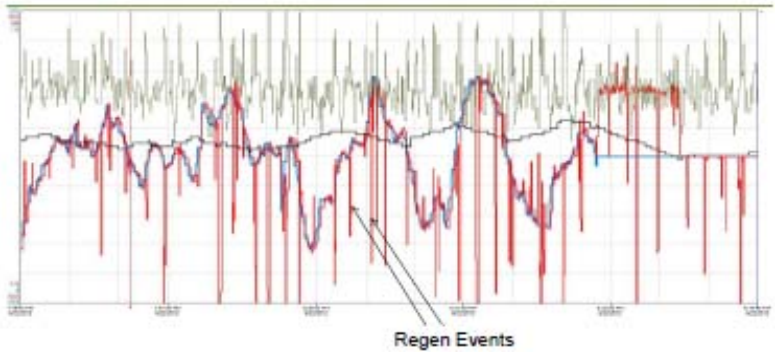
SEPTA
Brake recovery
&
Frequency regulation

1.5 MW ESS

Energy savings	1 – 2 GWh / year
	90 – 190 k$ / year
PJM market revenue	75 – 250 k$ / year
CO2 savings	1000 t /year

Viridity / SEPTA
recuperation de freinage & reglage de fréquence

- **Store energy from decelerating trains and use it for accelerating trains**
  - Analogous to PV smoothing
- **Participation in the PJM frequency regulation market**



- **1 Intensium Max 20P – 420 kWh / 1.6 MW**

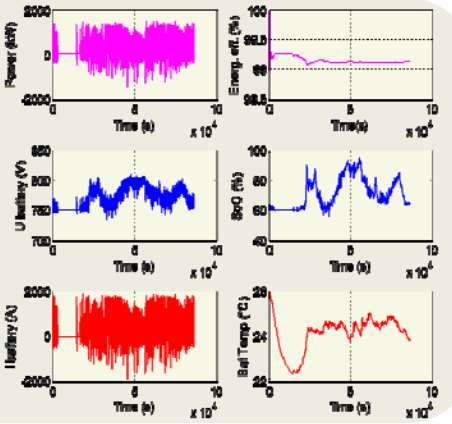
  Commissioned Feb 2012 at substation in Philly

  End 2016: > 10MW of Saft ESS in multiple SEPTA substations

- **Modeling used to optimize operation and minimize aging**

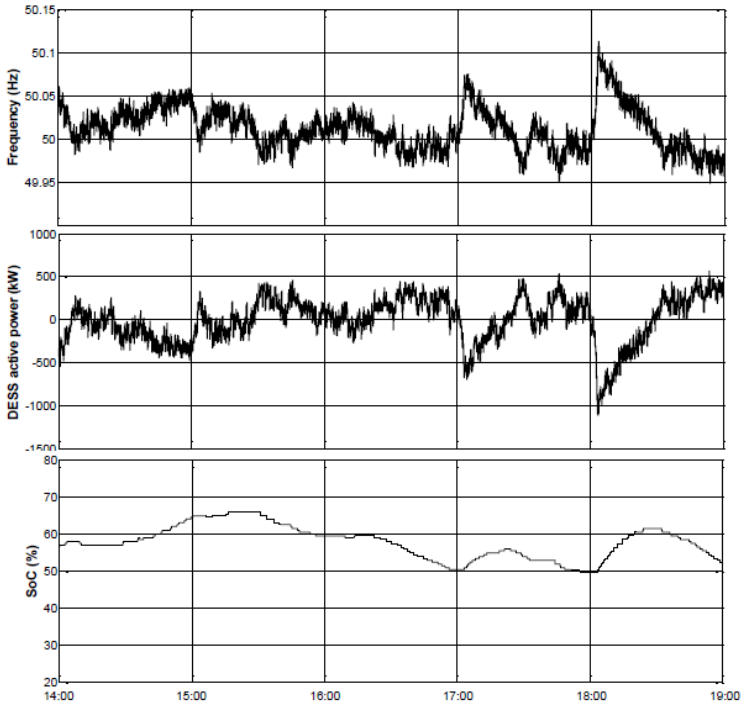
1 day operation (11/2012)

- Daily Energy turnover 2.2 MWh (520%)
- Average DOD 4%
- SOC management implemented
- Ageing 0.0055% per day ~ 2% / year



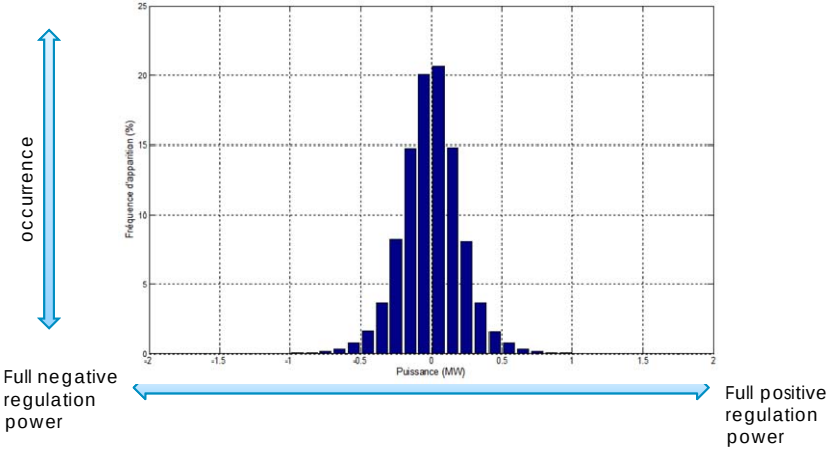
Du signal de fréquence à l'operation batterie

Frequency Profile



Storage Operation

Occurrence of charge / discharge cycles vs power level



Power and Energy per 1MW regulation power

Battery Energy installed	640 kWh
Average Power	170 kW
Average DOD	3-4%
Energy throughput / 24h	1,4 MWh = 2.2 C

Exemples de valorization: microgrids

Large power plants

Grid compatibility

- Higher Value / kWh for high quality RES generation
- Curtailment avoidance
- Peak Capacity

Grids

Demand-supply flexibility

- Grid Services Frequency Control / Balancing
- Investment Deferral
- Microgrids: minimize genset fuel consumption

EXAMPLE

Cobija
8 MW Microgrid
Bolivia

5 MW PV
2.2 MW ESS
16 MW diesel

ESS additional impact over PV :

Capex	+50%
Fuel Savings	+ 100%
	2mio l/yr

Bolivia Hybrid Plant PV + Diesel + ESS

Microgrid in Bolivia's remote area (Cobija, Pando Dpt.)

- Sizing: 2 x IM20M 2.2MW / 1.2 MWh
  4 x 690 kVA inverters Sunny Central Storage
- PV penetration 40% in 2015 with new 5MW PV plant
- The 5MW PV + 2MW ESS plant will increase electricity coverage from 65% to 80%
- Applications: fuel saving (2 millions liters/year) + grid stability (PV ramp control + spinning reserves)

Multi-Services dans la pratique

venteea

ADEME

Agence de l'Environnement et de la Maîtrise de l'Energie

Transporteur

- ST1 – Réglage de fréquence
- ST1i – Soutien dynamique
- ST2 – Réglage de tension
- ST3 – Réduction des pertes
- ST4 – Résolution congestions
- ST5 – Stabilité angulaire

Stockage

- ARB – « Arbitrage » marché

Distributeur

- SD0 – Secours poste source
- SD1 – Lissage de la pointe
- SD2 – Réglage de tension
- SD3 – Soutien régime dégradé
- SD4 – Renvoi local de tension
- SD5 – Compensation de réactif
- SD6 – Réduction des pertes
- SD7 – Qualité/continuité
- SD8 – Perturbations HTB
- SD9 – Facture d'acheminement

Producteur EnR

- SPd1 – Appui services système
- SPd2 – Lissage court-terme
- SPd3 – Valorisation effacements
- SPd4 – Report d'injection
- SPd5 – Production garantie
- SPd6 – Systèmes isolés

- Non faisable dans la situation
- Non chiffré pour l'heure
- Départ dédié (ferme de 12 MW)
- Départ mixte (ferme de 6 MW)

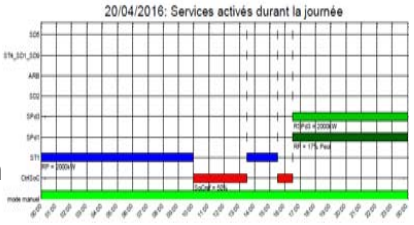
Wind farm **12 MW**

Battery **2 MW / 1,3 MWh**

Operation **2015/2016**

Results:

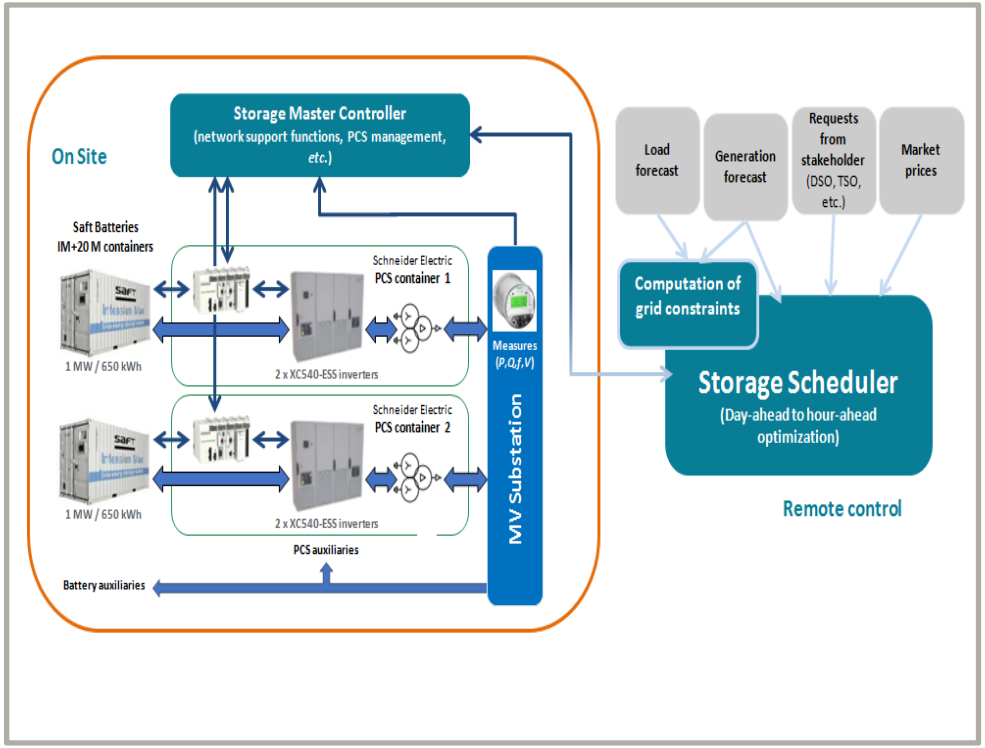
- 12 services demonstrated
- Sequential and parallel operation of services, technico - economic optimization of sequence by merit order

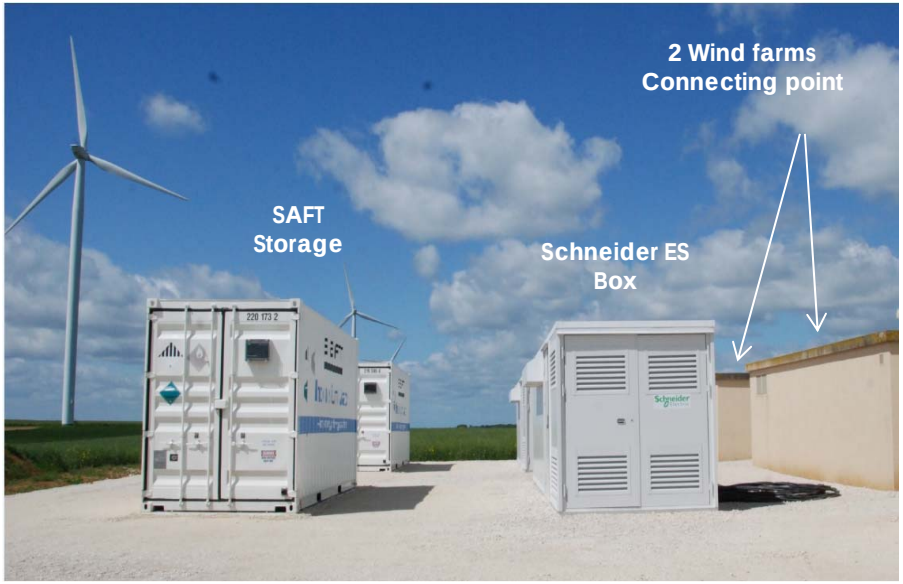


➔ Enhanced hosting capacity for wind energy on the distribution grid

saft

VENTEEA: architecture





Exemples de valorisation: l'aval compteur

Large power plants

Grid compatibility

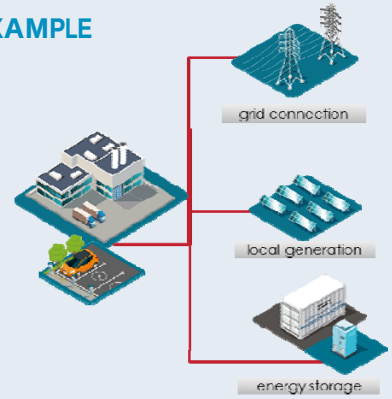
Grids

Demand-supply flexibility

Behind the Meter

Self-consumption

EXAMPLE



Industrial / tertiary site 5–10 MW

Integrated energy management with local generation and storage

Value generation
- Self consumption
- Peak reduction (grid fees)
- Energy efficiency
- Grid services (frequency regulation)

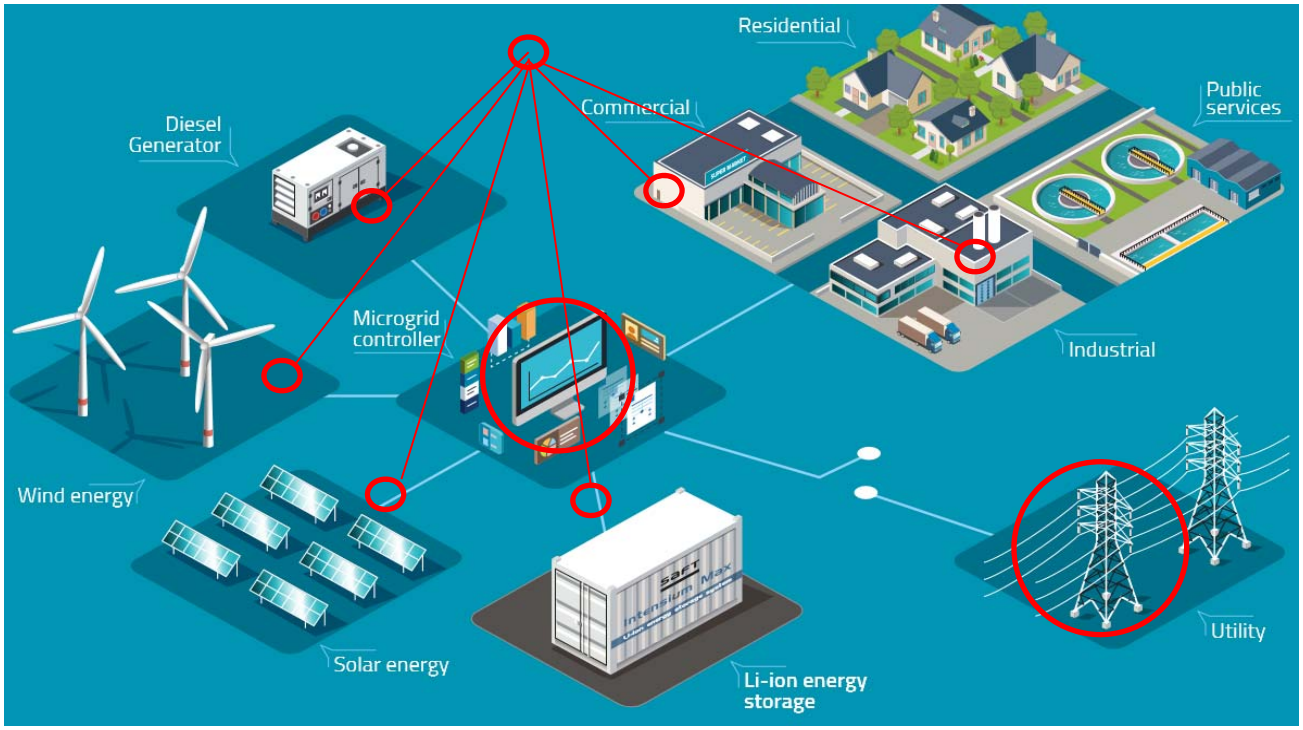
- Grid services
- Increase renewable self-consumption
- Decrease electricity bill / demand charge reduction
- Energy backup

Digitalisation

Aggregation
Virtual connection of power devices

EMS
Dispatch of power flows

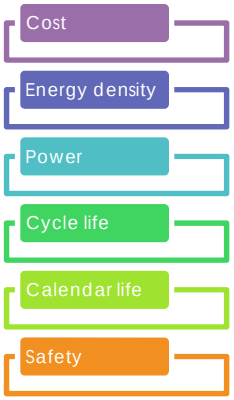
Participation in flexibility markets

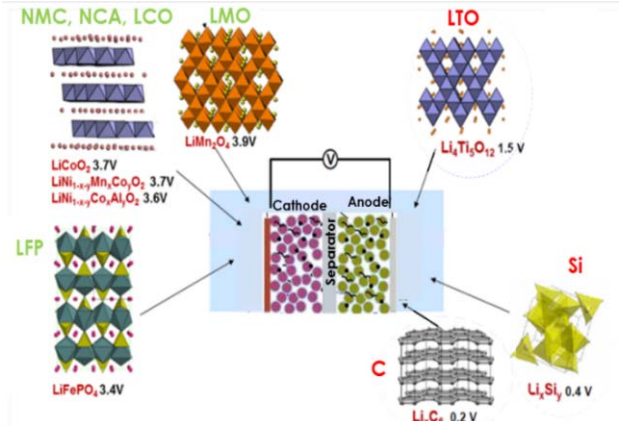


Les technologies Li-ion aujourd'hui et demain

After many decades of screening, very few elected commercial cathode and anode materials

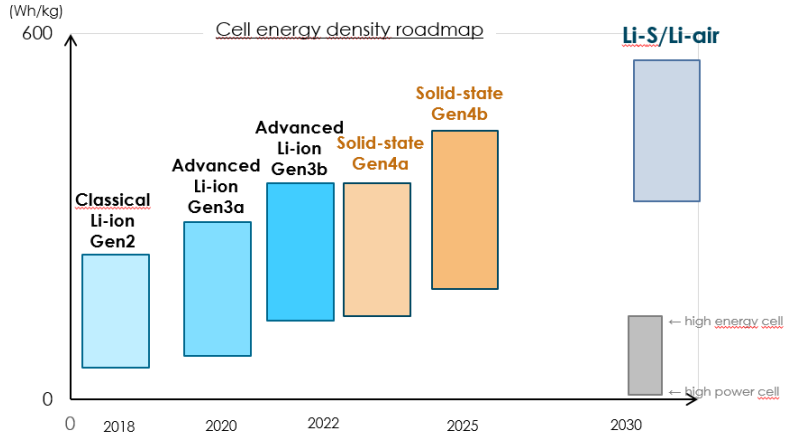
Each with its own domain of excellence





What is the next technology beyond Li-ion?

- ➔ In a 3 year horizon, advanced Li-ion!
- ➔ Beyond: Solid state Li-ion
- ➔ Long term > 2030 post-li-ion technologies

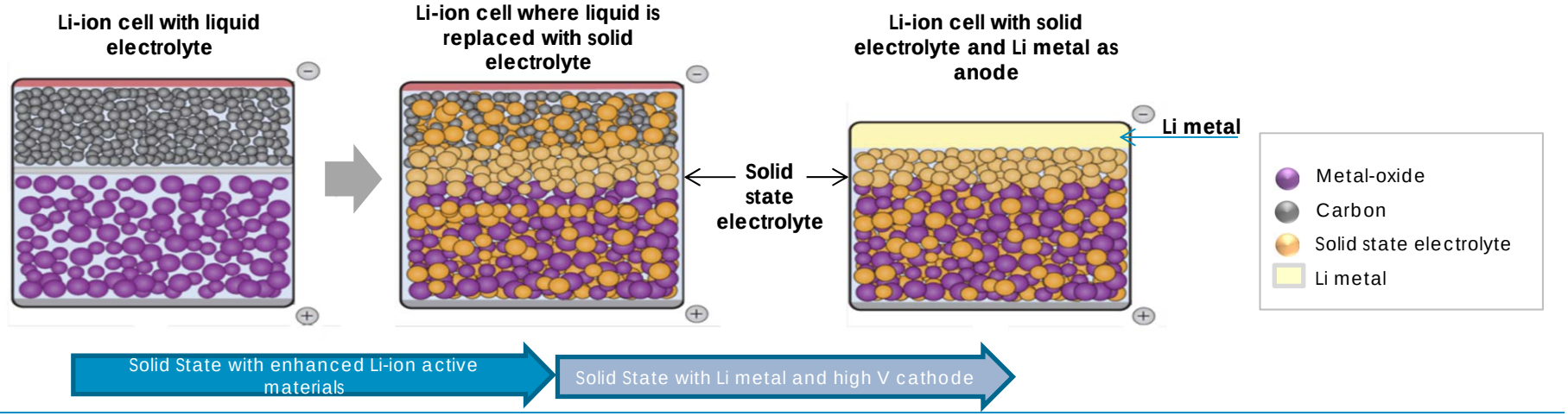


Source: SAFT, based upon internal expertise, EU commission, MIIT, NEDO, German VDA.
Generation names aligned with EU commission roadmap.

La technologie lithium à électrolyte solide

- Major projected improvements:
  - High energy and lower cost / kWh
    due to use of metallic Li in the negative electrode
  - Improved safety due to non-flammable solid electrolyte
  - Longer life due to electrochemical stability of solid electrolytes

- Keys to success:
  - A solid electrolyte material with good ionic conductivity
  - A solid electrolyte membrane
  - Active materials electrochemically stable
  - High speed manufacturing processes



MERCI

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