

Battery Energy Storage System applications including the trends in the market and technology



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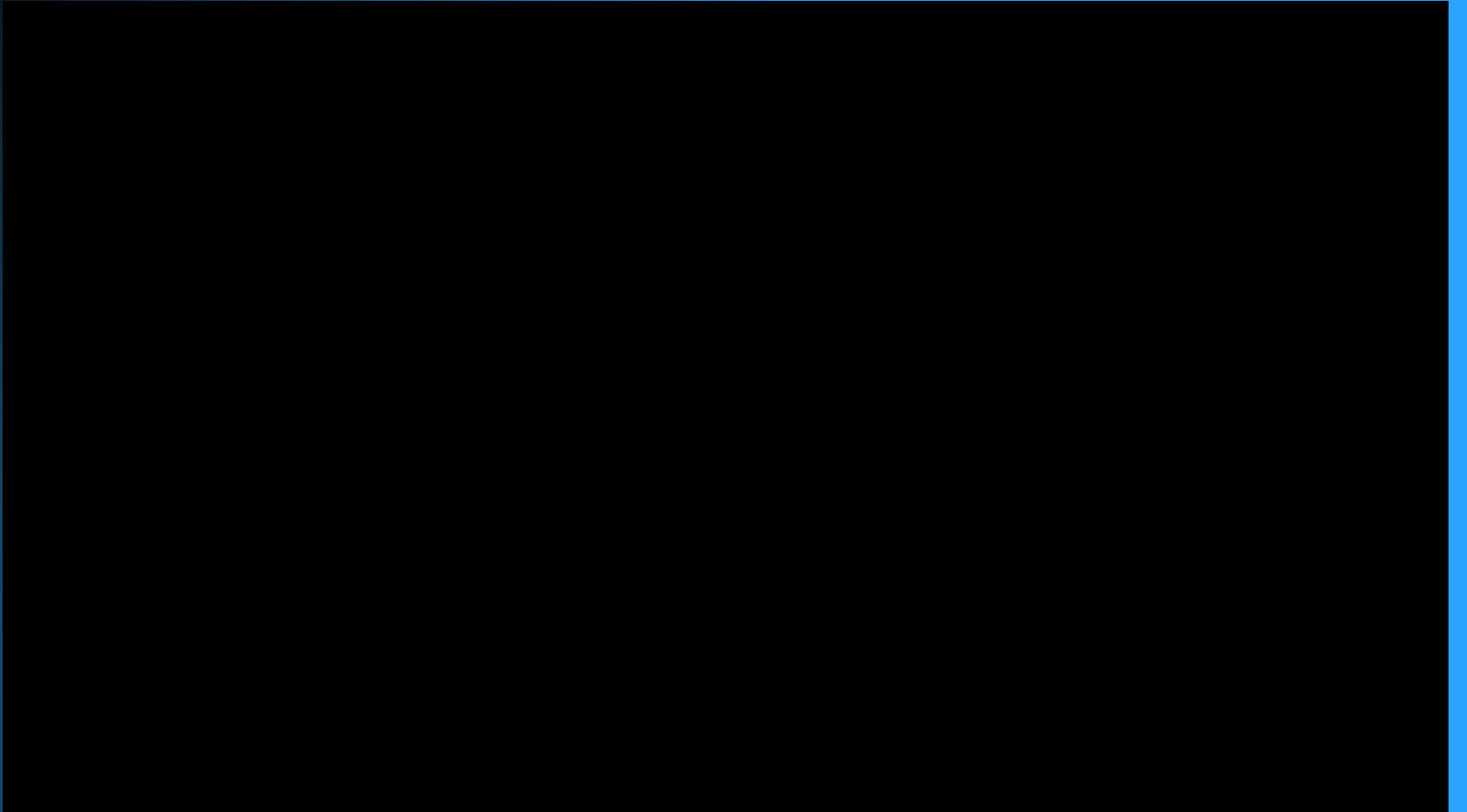
ALFEN
POWER TO ADAPT

Battery Energy Storage System applications including the trends in the market and technology







Subjects
About Alfen, including company video
Energy transition and Energy markets trends
Battery Energy Storage Systems technology and trends
Battery Energy Storage Systems applications and trends
Q&A session



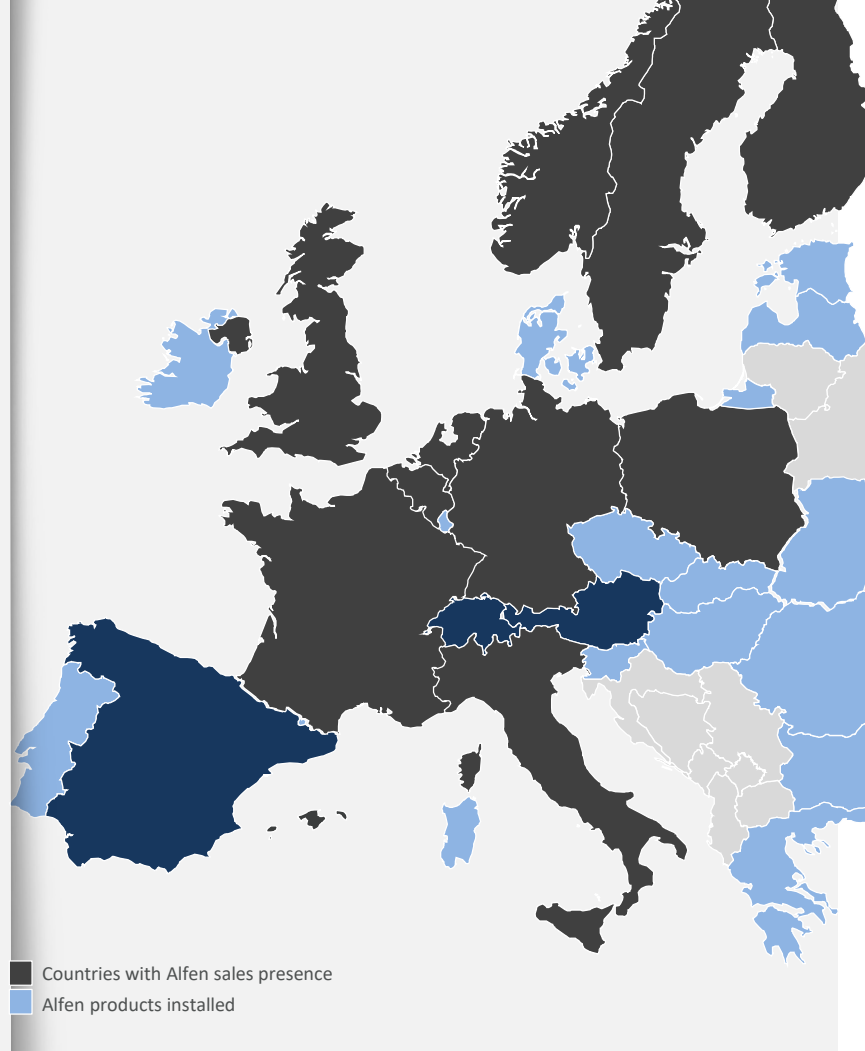


Alfen offers its clients smart energy solutions across Europe

Alfen provides B2B solutions across three business lines

Smart Grid Solutions	EV Charging Solutions	Energy Storage Solutions
<p>Public & infra leasing</p>  <p>Private networks</p> 		
Alfen Connect		
Service & Maintenance		

← Integrated solutions →



Energy market trends



International and national governmental sustainability ambitions drive energy transition

European Green Deal

'The European Green Deal is on the one hand our vision for a [climate neutral continent in 2050](#) and it is on the other hand a very [dedicated roadmap](#) to this goal'

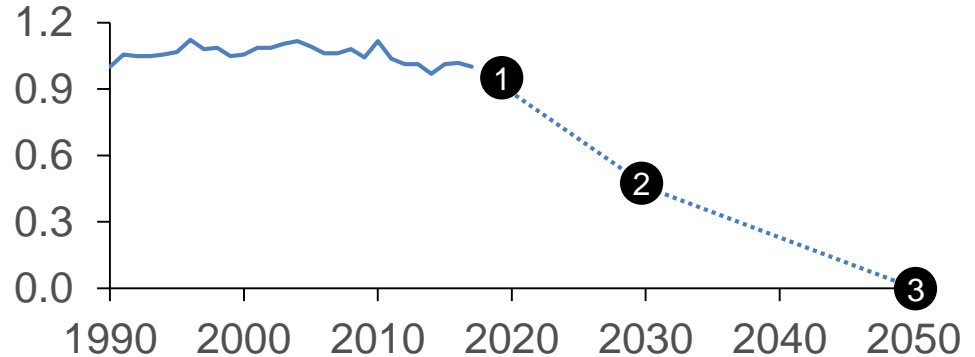
Ursula von der Leyen
President of the European Commission



Source: Energieopwek.nl

Dutch CO2 emission reduction ambitions

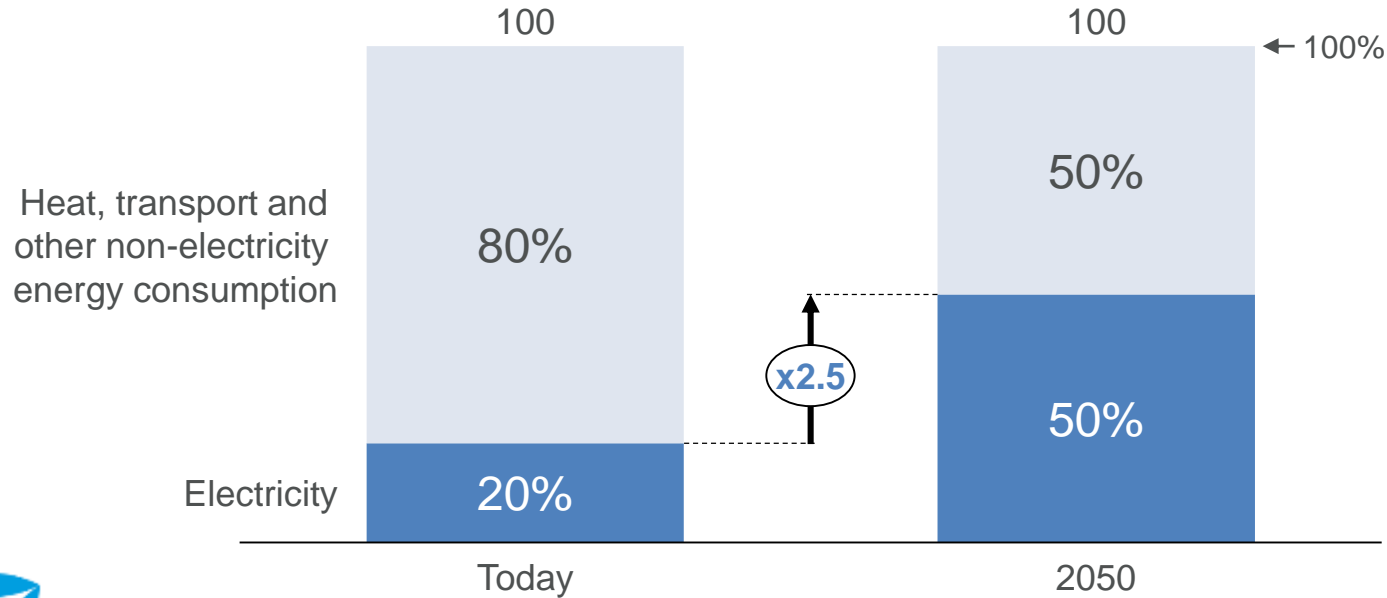
CO2 emissions index



- 1 Dutch goal of 14% renewable power in 2020 unmet with 9% renewable energy consumption in 2019
- 2 -49% CO2 emissions by 2030 (vs 1990) ambition of climate accord, generating as much as possible from solar and wind
- 3 -95% CO2 emissions in 2050 (vs 1990)

Energy consumption is expected to shift to c.50% electricity by 2050, driving companies like Alfen long-term growth

Energy consumption



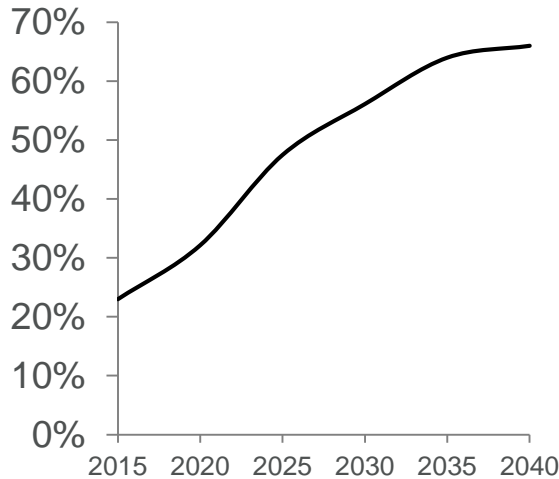
Source: IEA



Three long term trends embody energy transition

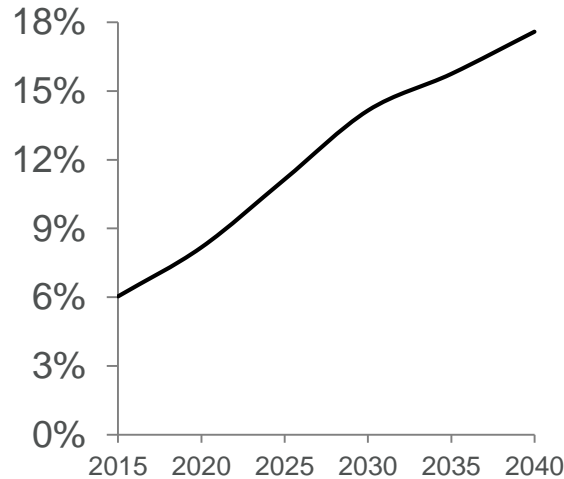
- **Increase in renewables**

European wind and solar PV capacity as % of total generation capacity¹



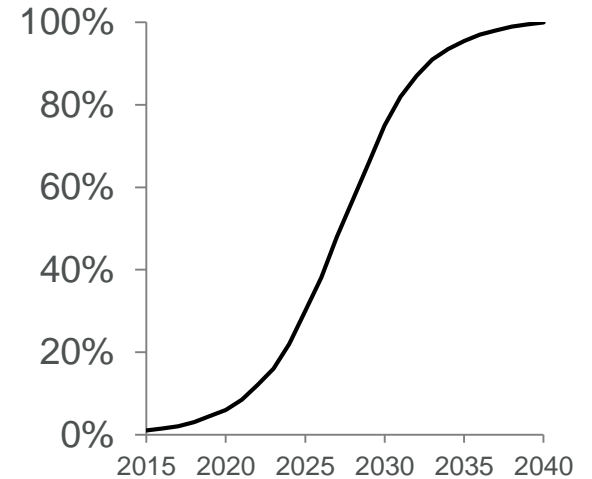
- **Decentralisation of energy**

Decentralisation ratio of electricity production in Europe^{1,2}



- **Growth of electric vehicles**

Market share of EVs in Europe³



1. Source: Bloomberg New Energy Finance. 2. Decentralisation ratio is the ratio of residential decentralised solar PV and storage to total installed generation capacity.

3. Chart reflecting new light vehicle sales, source: DNV-GL Energy Transition Outlook.

Energy transition



More uncontrollable generation



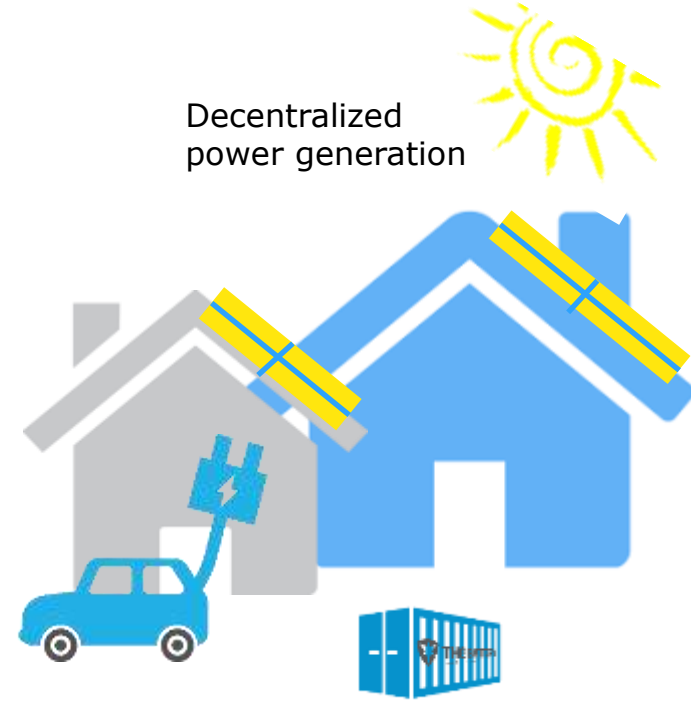
Energy transition Grid balancing is needed



Future situation



Decentralized
power generation



Energy Storage

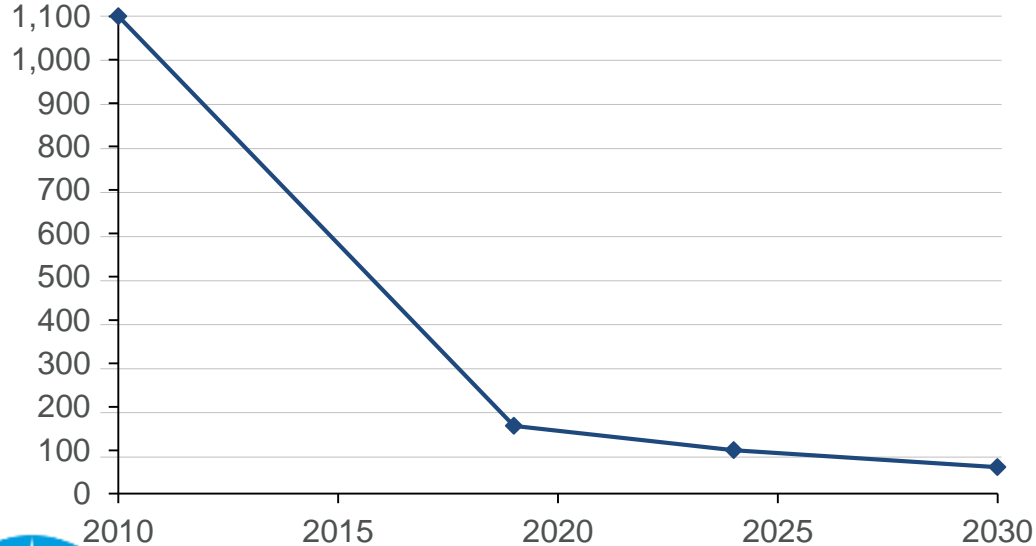
Energy Storage

- Energy storage
- Controllable loads (e.g. EV charging)

Lithium Ion battery prices per kWh are expected to drop by -8% to -9% per annum towards 2030

Battery costs keep on declining

Battery costs in real terms (\$/kWh)



Source: BloombergNEF Dec 2019

Reduced cycle costs → more potential business cases:

- BESS prices are reducing
- Battery guaranteed cycle life is improving
- Battery depreciation can be down to few 0.01 Euro/kWh
- Facilitating new business cases and opportunities !

Battery Energy Storage Systems technology and trends

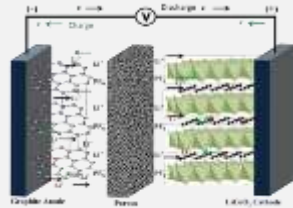


Three main technologies for battery energy storage today

Li-ion batteries

Li-ion batteries are the leading technology for new storage projects. They have gained this position not only because of their flexibility, but also largely because they are already available in mass production and are further down the experience curve than many other newer technologies.

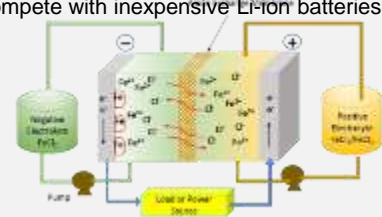
Li-ion batteries use the flow of Li-ions between the cathode and anode of the battery to charge and discharge. These batteries excel in short term durations of less than 6 hours, but the technology is less economical for longer applications.



Flow batteries

Flow batteries have advanced considerably in recent years and is suitable for storage applications requiring longer duration discharge and more than 15 years of operation with minimal maintenance. They generate electricity by pumping a liquid anolyte (negative electrolyte) and catholyte (positive electrolyte) across a membrane.

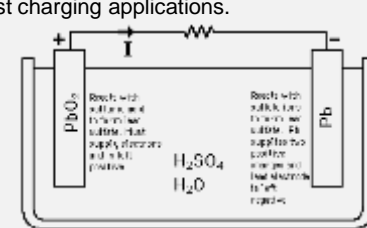
Flow batteries are flexible and expandable by design and can store energy for extended periods by adding extra tanks of electrolyte. However, this is only efficient when designing large systems for economies of scale. Flow batteries have struggled to compete with inexpensive Li-ion batteries.



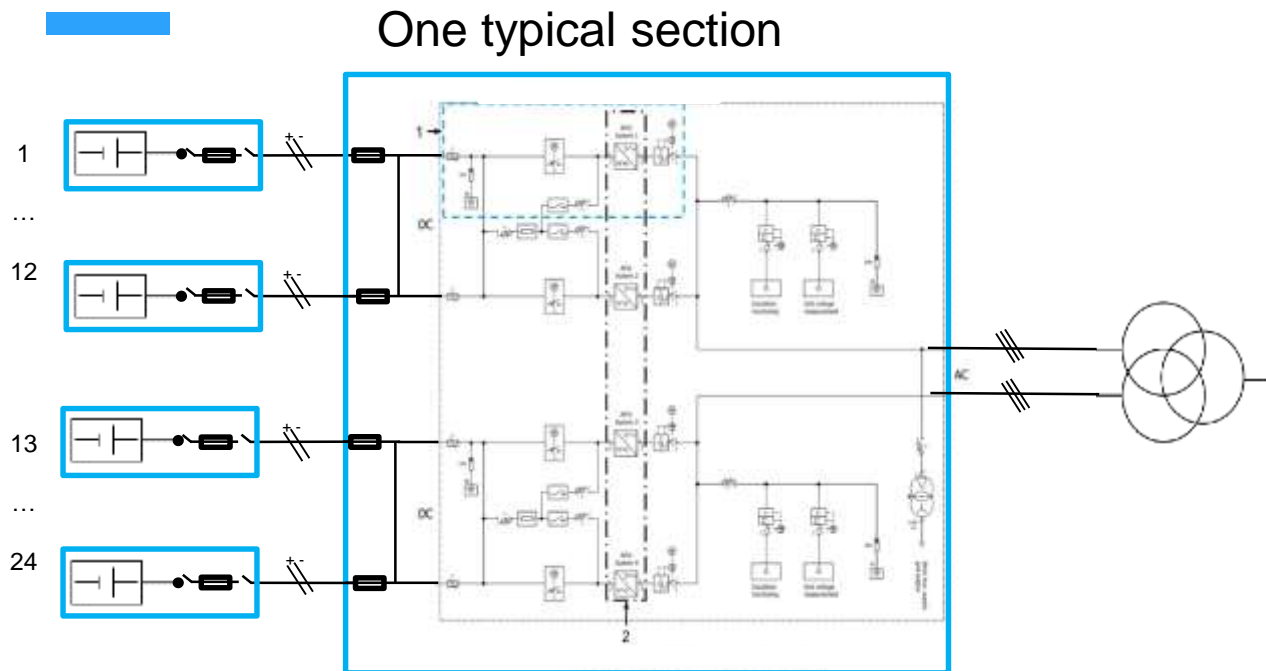
Advanced lead-acid batteries

Lead-acid batteries are among the most ubiquitous energy technologies. However, they are best used for applications that require infrequent use, which make them unsuitable for emerging grid applications that require frequent cycling. They have struggled to compete with the rise of Li-ion batteries in recent years.

Advanced lead-acid batteries are less efficient, have a limited capacity and life cycle, require more maintenance, and pose a greater risk of overheating than Li-ion competitors. Most advanced lead-acid batteries are also unsuitable for fast charging applications.



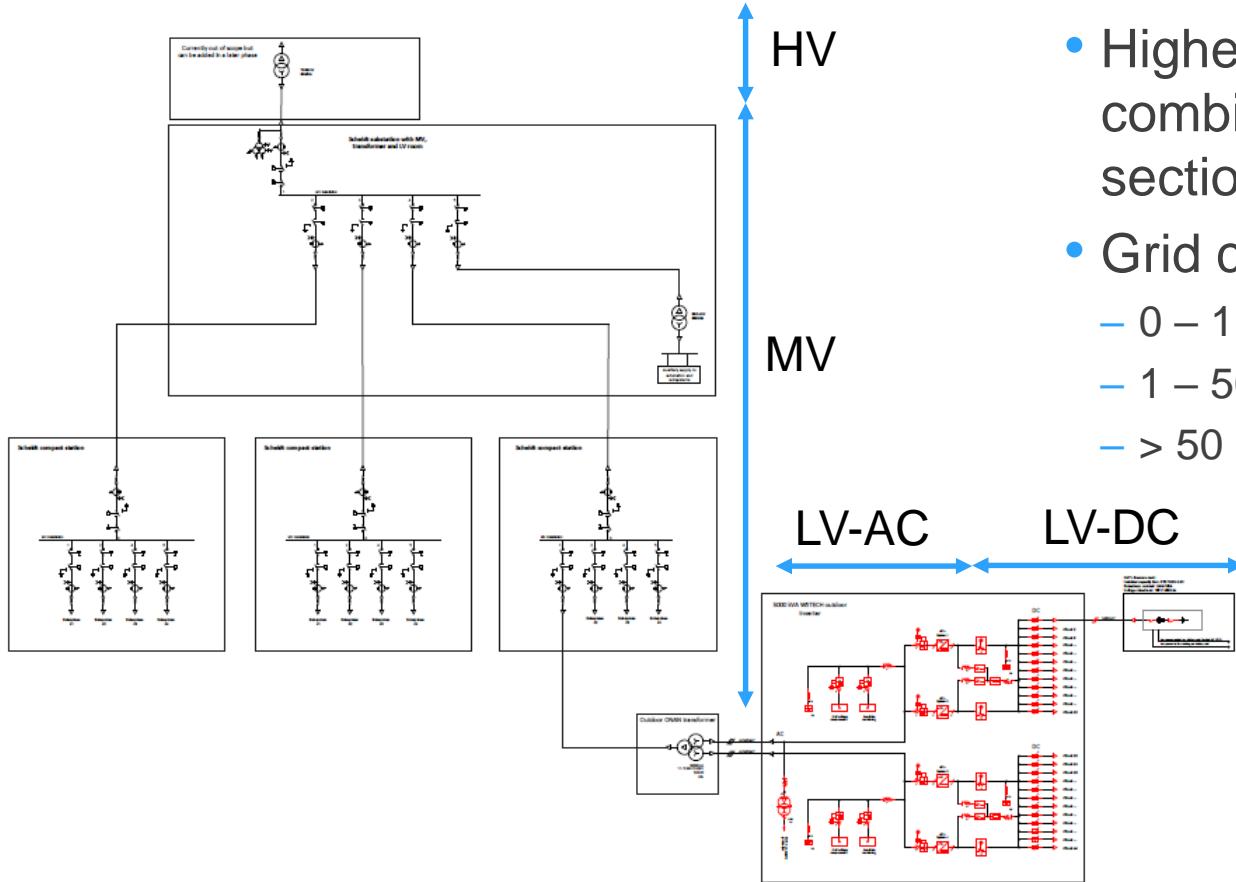
State of the art BESS technology



- Typical power level per section:
 - 1 – 5 MW
 - 1 MWh – 20 MWh
- Combination of 1 – n sections
- Grid coupling: MV AC
- Battery technology:
 - Li-ion : NMC & LFP
 - 2-3% losses at 1C
 - Trend from air to liquid cooled systems
- Inverter technology:
 - IGBT 3 level, 1500 Vdc, 690 Vac
 - Losses: 1.2 %
 - Grid connected and grid forming
 - Trend from air to liquid cooled systems
- MV transformer:
 - Eco design Tier 2
 - Losses : 0.7%
- Response time grid connected P/Q commands:
 - 50-100 msec



1 MW – 100 MW++ BESS solutions



- Higher power levels by combining multiple sections
- Grid connection:
 - 0 – 1 MW: LV level
 - 1 – 50 MW: MV level
 - > 50 MW: HV level (TSO)



Evolution of solutions

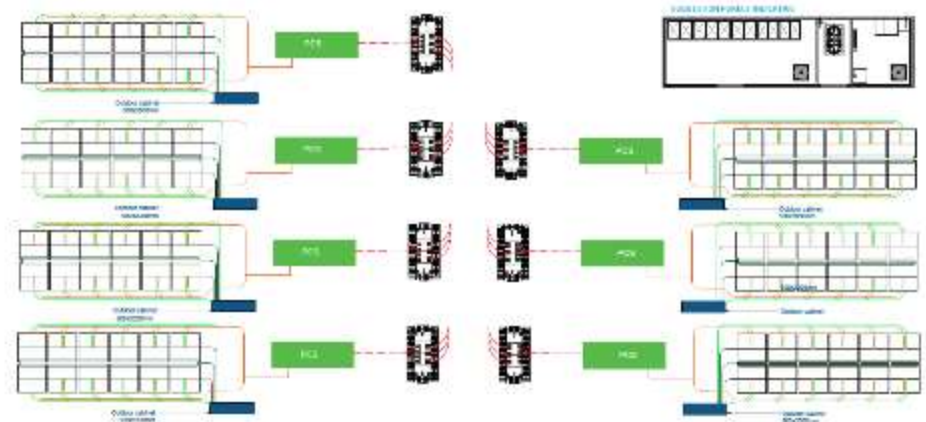
Single container → multi container

→ outdoor cabinets (batteries/inverters)

n x 100 kW

→ n x 1 MW

→ 1 – 200 MW++

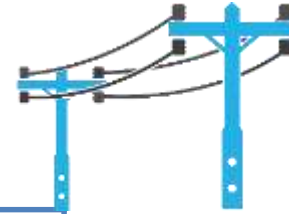
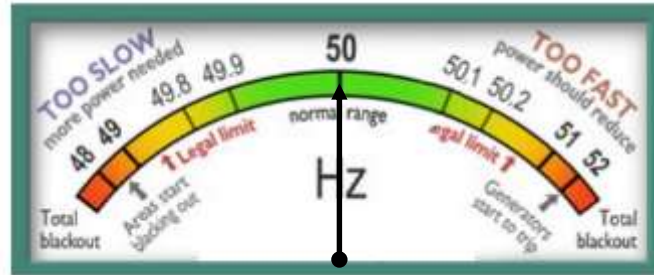


BESS applications and trends

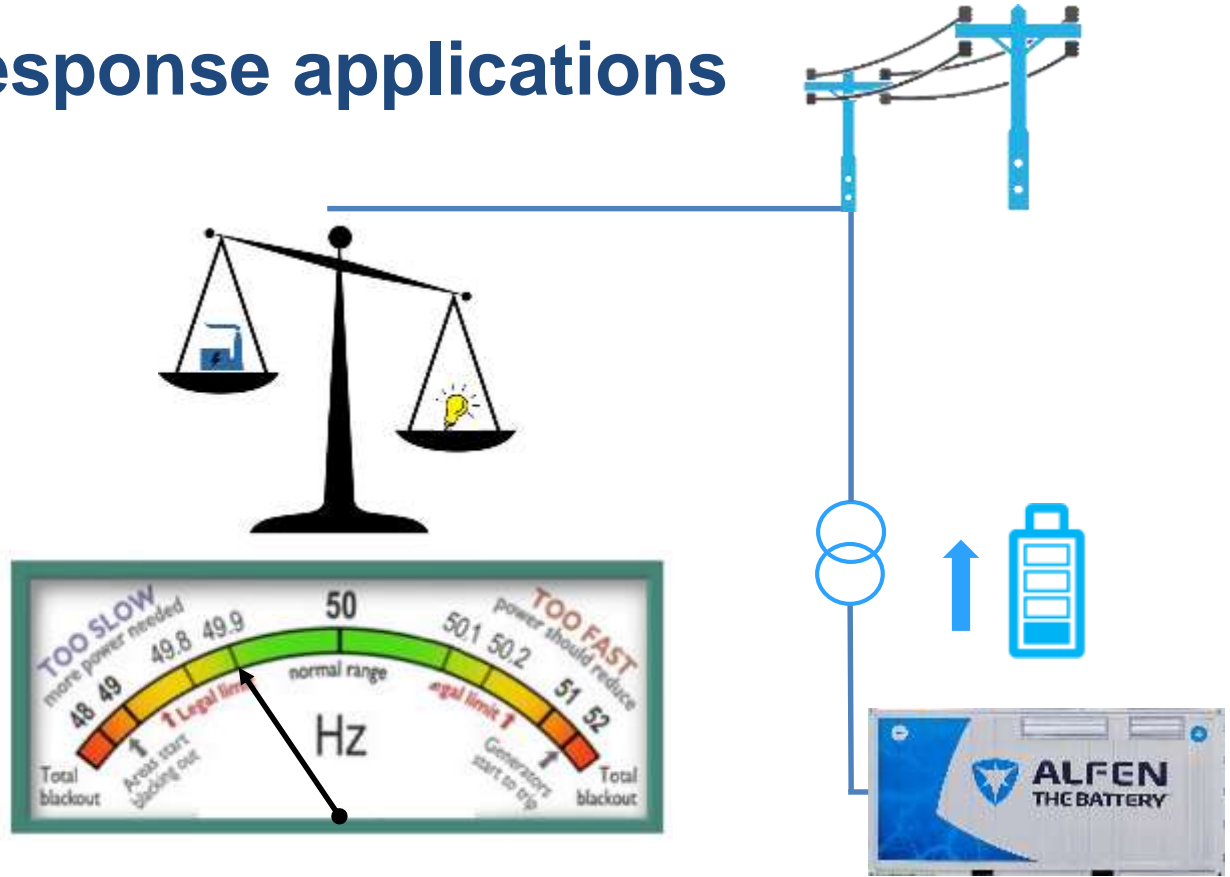
- Frequency response applications
- Synthetic Inertia
- Lower c-rates (more stored energy)
- BESS solutions to reduce congestion
- Backup power
- Mobile applications reducing diesel
- Increasing market interest to replace DG with BESS & PV
- Solutions for datacenters



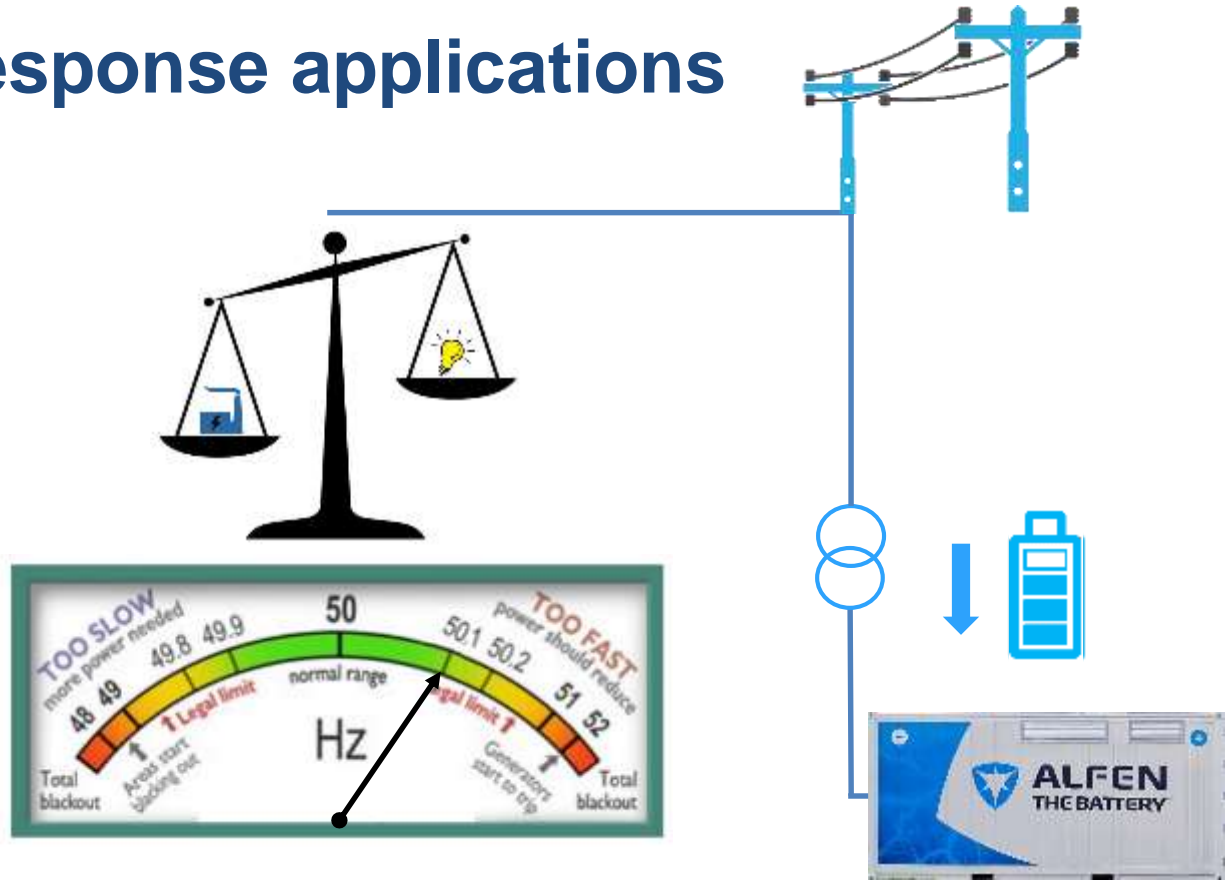
Frequency response applications



Frequency response applications



Frequency response applications



Typical reaction times 1-30 seconds

HARTEL WIND FARM PROJECT



10 MW Battery Energy Storage System in the Port of Rotterdam



Customer: [Green Choice](#)

Location: [Port of Rotterdam](#)

Project: [Hartel wind farm \(24 MW\)](#)

Power output: [10 MW](#)

Battery capacity: [10 MWh](#)

Scope: [End-to-End BESS project with integrated transformer solution and connection on MV-level.](#)

Applications: [Frequency response / Renewables](#)

Operational since: [April 2019](#)

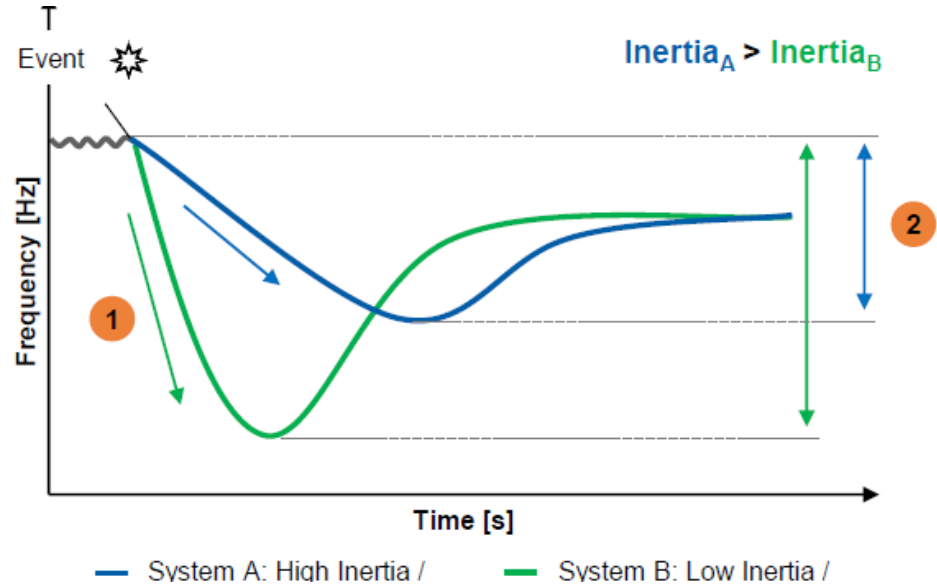
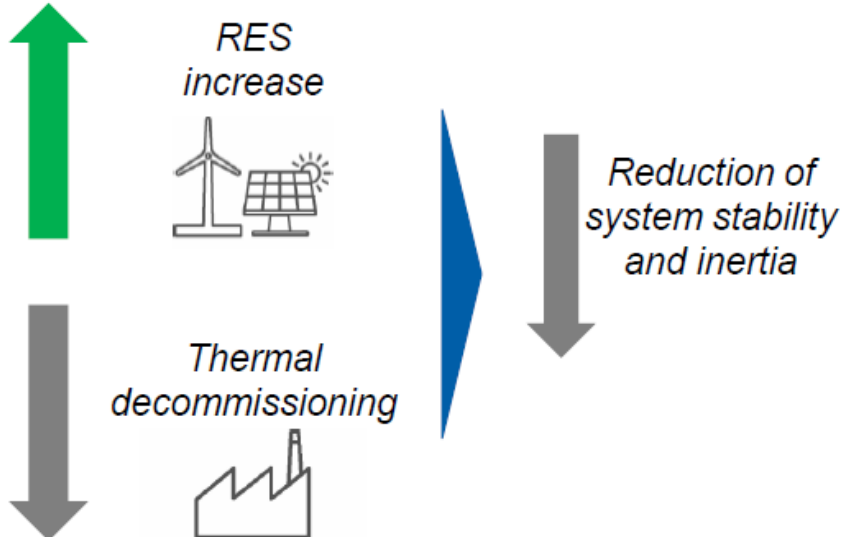
Press release: <https://alfen.com/en/news/alfen-selected-supply-10mw-energy-storage-system-greenchoice-hartel-windfarm>



Synthetic inertia

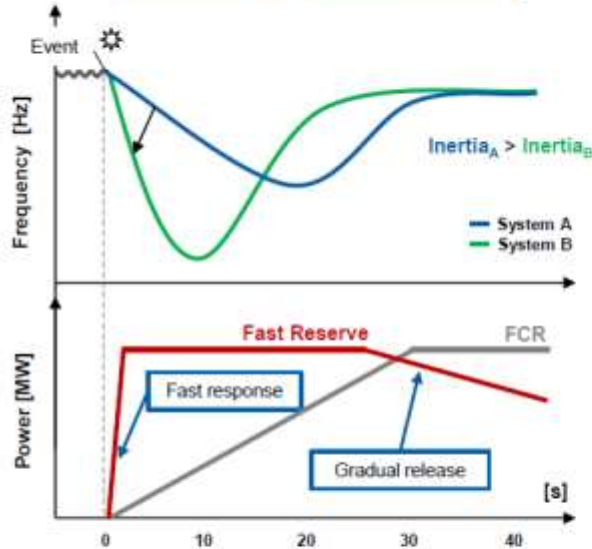


EFFECTS OF INCREASING RENEWABLES ON SYSTEM STABILITY



FAST RESERVE & FREQUENCY CONTROL RESERVE

Key Rational



Objective and main features*

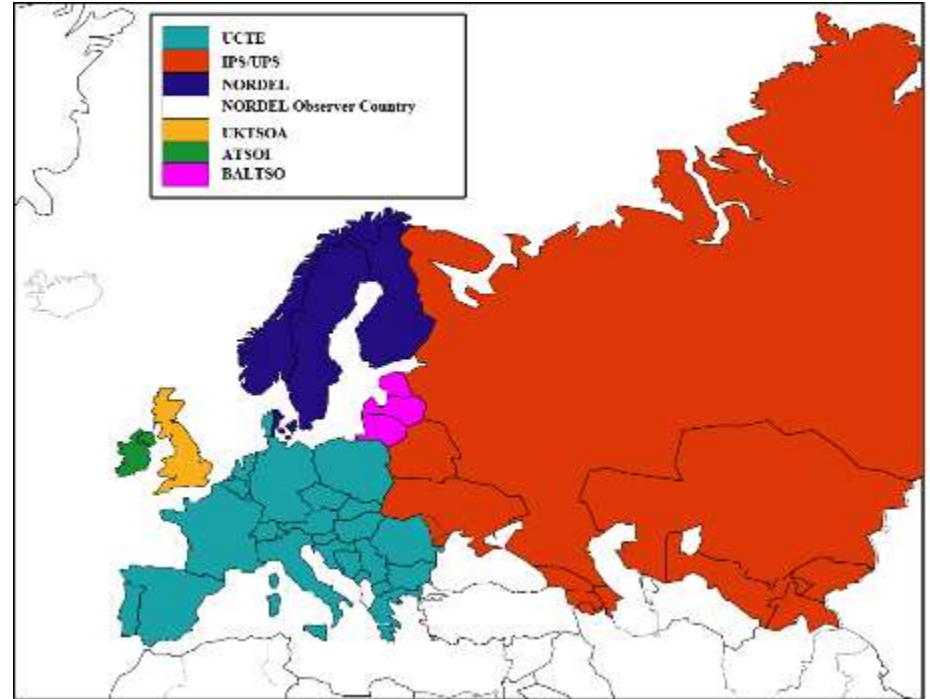
- New service to support system inertia
- Fast activation (< 1 second)
- Proportional response to frequency variations and/or triggered by a setpoint with continuous operation

FCR might be insufficient to assist frequency dynamics in the very first moments after an event



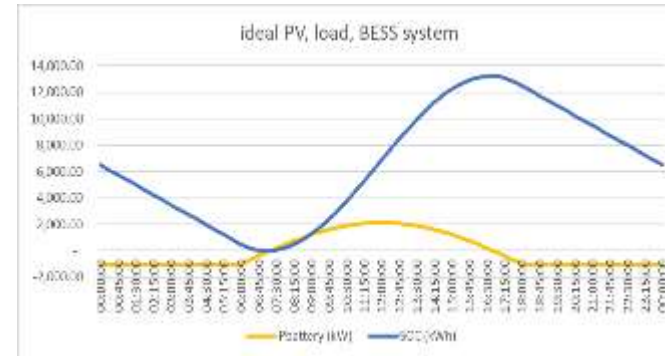
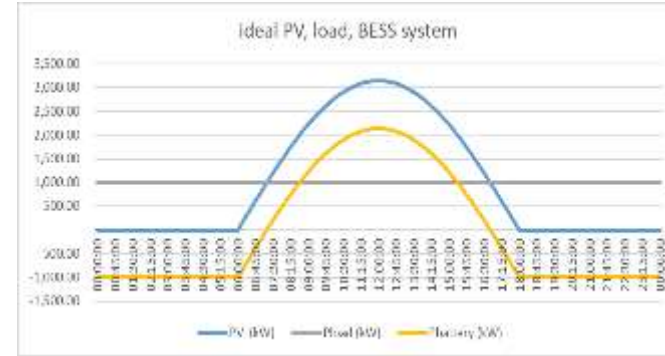
Need for synthetic inertia

- Demand for synthetic inertia: small synchronous grids + high % renewables, like:
 - Ireland (FFR 150 msec)
 - Nordics (FFR), “kick the grid” with “power burst” when frequency drops below certain threshold
 - Baltics
- For UCTE grid also pilots are starting
 - Italy (Fast Reserve)



Lower C-rate trend:

- Currently most systems are 1C
 - Frequency response 2 x 25 min activation time
- Future renewable integration will affect c-rates, hypothetical example:
 - Assume we would use a BESS to fully balance the energy for PV powered load on an average day, how would such system look like:
 - Pload = 1000 kW (constant assumed)
 - Average day PV yield: 2.466 kWh/kWp (900 sunhours/yr)
 - Required PV: 9,733 kWp
 - Required BESS : 2.133 kW / 13.3 MWh → C-rate: 0.16
 - Reduced battery prices support lower C-rate business case



Examples congestion management:



1 MW Battery Energy Storage System for distribution centre LIDL



Customer: LIDL

Location: Nijmegen, the Netherlands

Project: Distribution centre

Power output: 1 MW

Battery capacity: 1.23 MWh

Scope: End-to-End BESS project with connection to the local grid on MV-level.

Applications: Frequency response / Peak shaving

Operational since: August 2018



Alfen selected by Vattenfall to supply a 20 MWh energy storage system in Sweden

07-04-2020

Alfen selected by Vattenfall to supply a 20 MWh energy storage system in Sweden

Mega energy storage system in Swedish university town Uppsala, will contribute to Vattenfall's mission of 'fossil free living within one generation'

Vattenfall has selected Alfen to deliver a battery energy storage system of 20 MWh in the university town Uppsala in Sweden, also the fourth largest city in Sweden. This is the third large-scale energy storage system that Alfen will deliver to Vattenfall. The energy storage system will be connected to the power grid of distribution grid operator Vattenfall Eldistribution. The system will be deployed to address grid congestion challenges and to benefit from trading opportunities on the flexibility market.

Alfen's scope consists of the delivery of an energy storage system of 20 MWh (5 MW) based on BMW car batteries, Alfen's 'TheBattery Connect' energy management system and the local grid connection.

<https://alfen.com/en/news/alfen-selected-vattenfall-supply-20mwh-energy-storage-system-sweden>



Use case

All our businesses integrated in one smart solution



ADO Project

Solar PV



Alfen TheBattery system



Smart Charging Network



Alfen Connect™



ADO THE HAGUE PROJECT



Storage with integrated EV charging hub football stadium



Customer: [Scholt Energy Control](#)

Location: [The Hague, the Netherlands](#)

Project: [ADO Football Stadium](#)

Power output: [0.750 MW](#)

Battery capacity: [0.754 MWh](#)

Scope: [End-to-End BESS integrated with renewable energy sources, EV charging equipment and connection with the local grid.](#)

Applications: [Frequency response / Peak-shaving / EV charging equipment](#)

Operational since: [June 2018](#)

Press release: <https://alfen.com/en/news/energy-storage-makes-hague-football-stadium-self-sustainable>

Back up power applications



Amsterdam (17 January 2017)

aslander

- Outage from 4:19 to 6:15



Self healing cellular microgrids

14 November 2017

aslander

- Apache causes blackout for about 50,000 households for 6 hrs

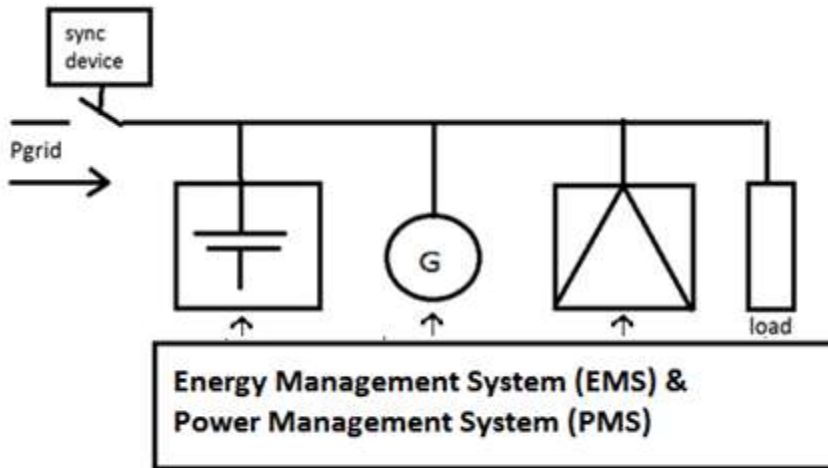


U R HACKED

UKRAINIAN POWER
GRID TAKEN DOWN
BY HACKERS...

THE POWER GRID
CYBER WARS
HAVE BEGUN

HealthRangerReport.com



Normally connected to the main grid

- Storage to reduce imbalance in the main grid (energy trading, frequency response)
- Demand side management (EV, heatpumps, etc)
- Virtual Neighbourhood storage

Self healing and self controlling in case of grid outage

- Battery Storage to generate microgrid
- Local power generation (renewable / conventional)
- Using grid frequency as reliable Demand Side Management control method
- Working together with other cells
- Building main grid back from bottom up

Alfen to deliver 1MW energy storage system to Fortum and Caruna as part of new framework agreement

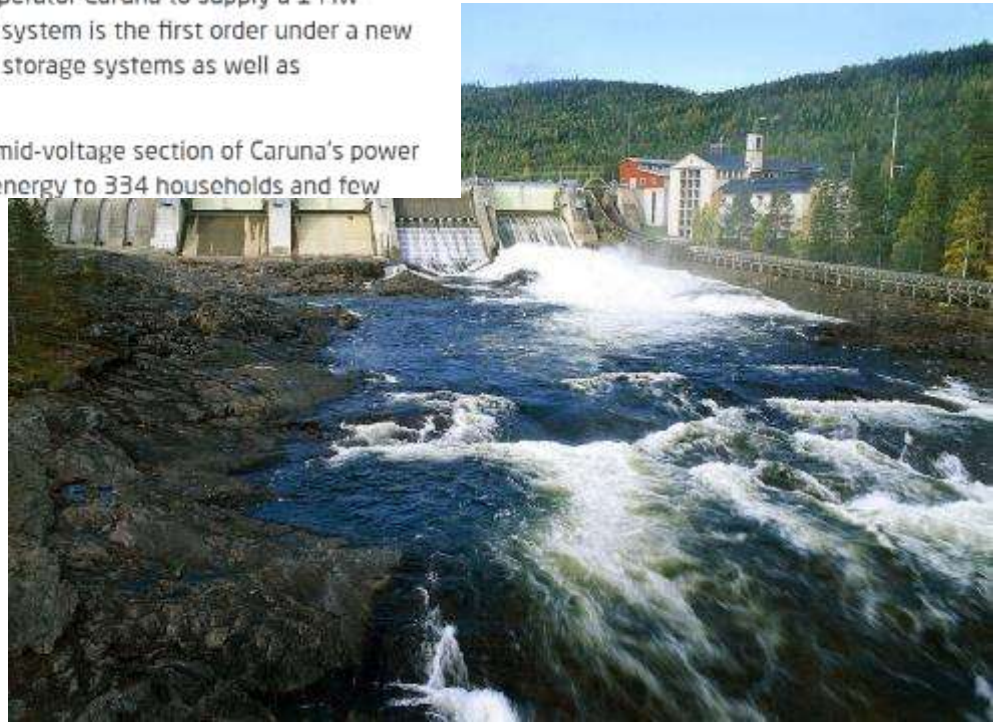
24-10-2019

Alfen to deliver 1MW energy storage system to Fortum and Caruna as part of new framework agreement

Alfen has been selected by Finnish utility Fortum and distribution grid operator Caruna to supply a 1 MW (1MWh) energy storage system in the Helsinki capital area. This storage system is the first order under a new framework agreement between Fortum and Alfen, covering both energy storage systems as well as transformer substations.

The energy storage system will be used to provide back-up power for a mid-voltage section of Caruna's power grid. The section consists of 20 mid-voltage transformers and provides energy to 334 households and few

<https://alfen.com/en/news/alfen-deliver-1mw-energy-storage-system-fortum-and-caruna-part-new-framework-agreement>



Mobile BESS applications



Mobile BESS applications



- Diesel cars are being banned from cities
- What what about diesel generators ?

With 30 new mobile battery energy storage systems from Alfen, Greener is scaling up to become the world's largest emission-free mobile power provider

12-12-2019

With 30 new mobile battery energy storage systems from Alfen, Greener is scaling up to become the world's largest emission-free mobile power provider

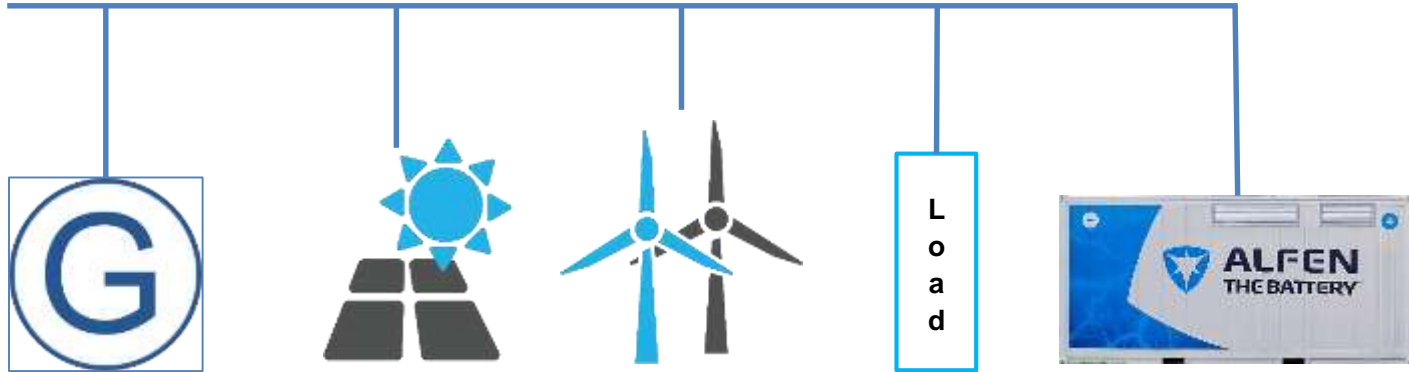
Greener, the clean energy provider for grid-edge and off-grid situations, orders 30 new mobile battery energy storage systems from Alfen, specialist in energy solutions for the future. The mobile storage systems will be deployed to provide a green emission-free alternative for temporary and polluting diesel generators throughout Europe.

Each mobile storage system has a capacity of 338kWh and is based on BMW i3 car batteries. The storage systems are equipped with standard power connectors allowing for easy plug-and-play integration at temporary project and remote locations. Greener provides smart batteries and data-driven energy management software services to events, construction sites, transformer substation maintenance, EV charging hubs and grid-boosting & balancing.

<https://alfen.com/en/news/30-new-mobile-battery-energy-storage-systems-alfen-greener-scaling-become-world%E2%80%99s-largest>



Off grid microgrids

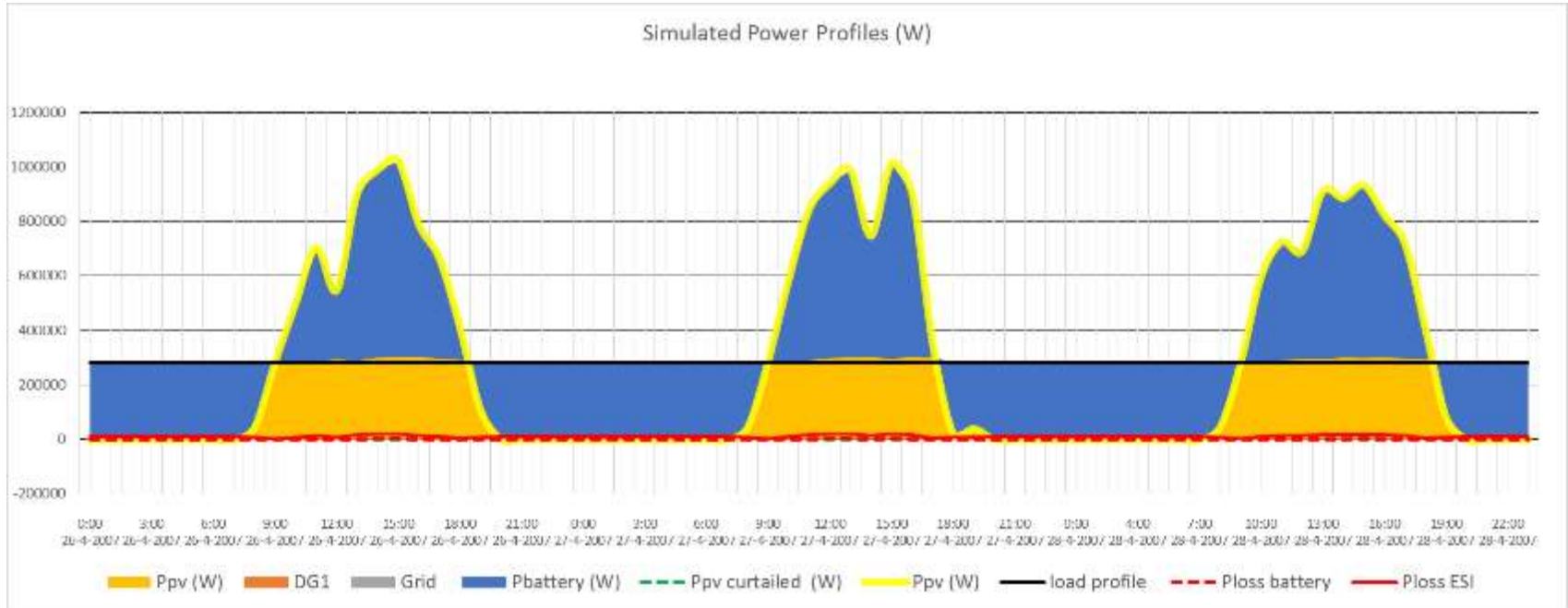


Off grid: example project Nigeria



- Cocoa factory near Lagos Nigeria
- Electricity off for 80% of time
- 15 year ago grid was disconnected => using diesel generators
- disadvantages: high costs of diesel & maintenance, often supply problems diesel, negative CSR
- New solution: Solar PV + battery storage
 - 2,35 MWp PV
 - 2 MWh/2MW (= daily electricity consumption of 200 houses !)

Typical three days of energy flow



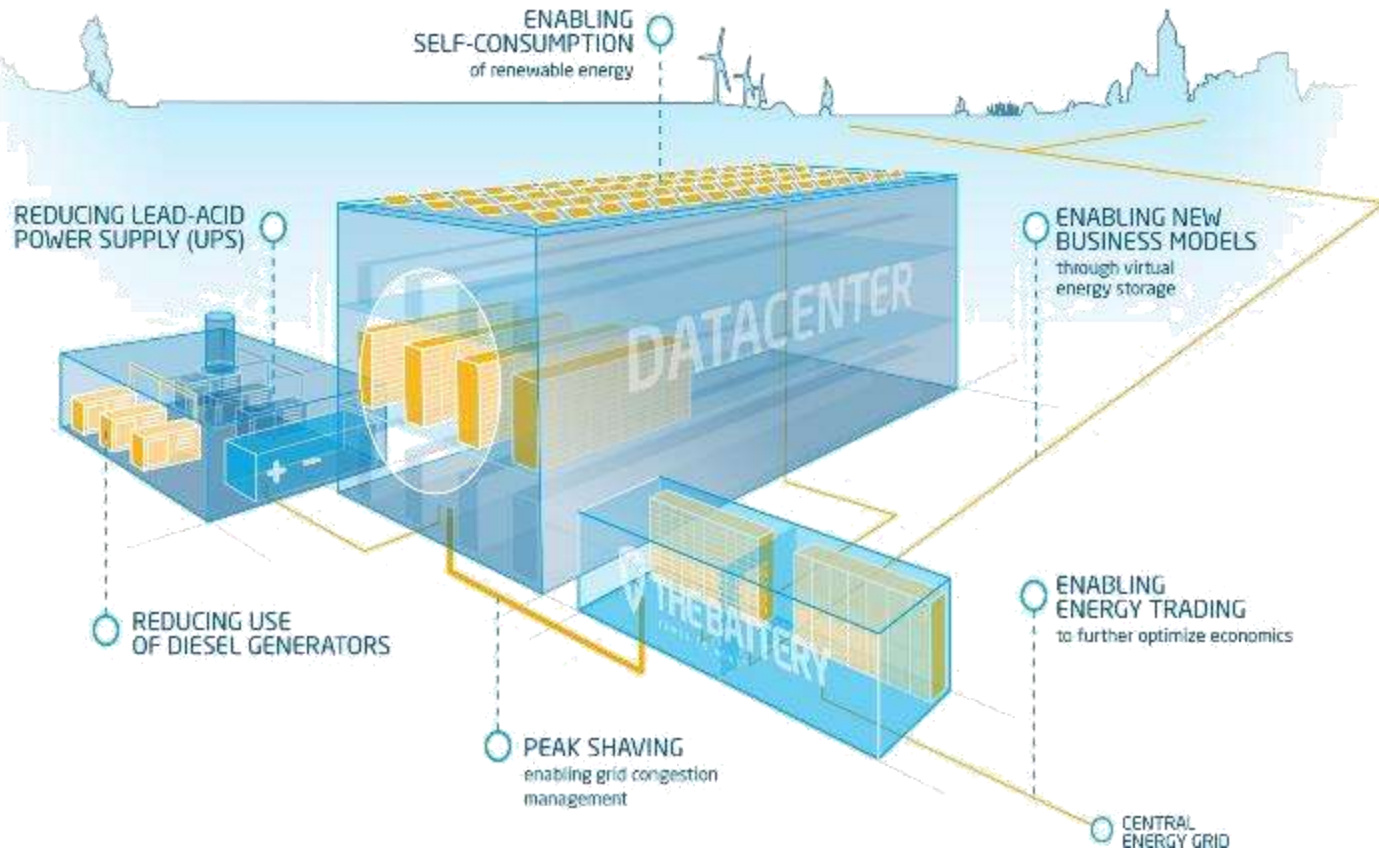
Content workshop



Content workshop



Solutions for datacenters,



Alfen is in the center of the energy transition !


Alfen Connect™





Questions?





Thank you
for
your
attention

