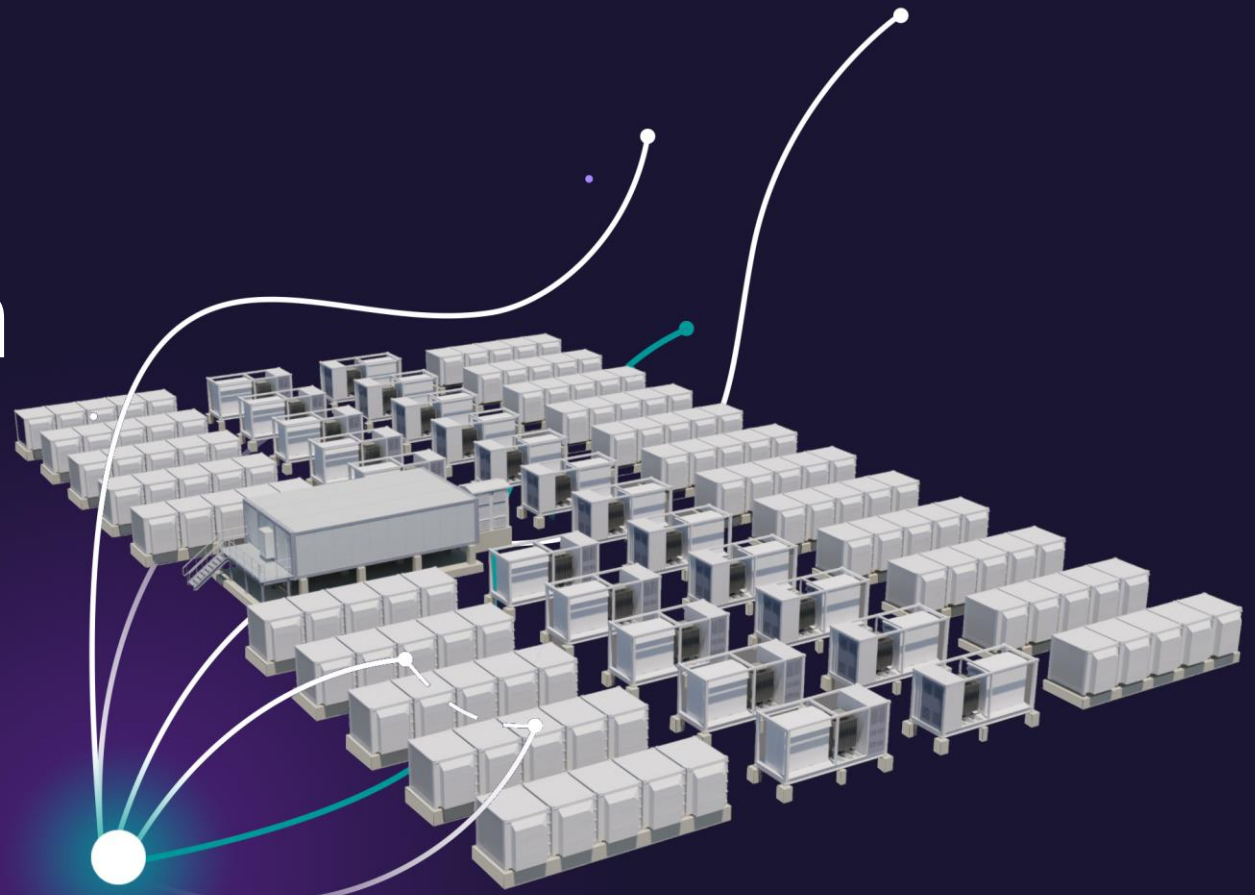
Battery Storage Systems in an urban environment



Oct. 2024

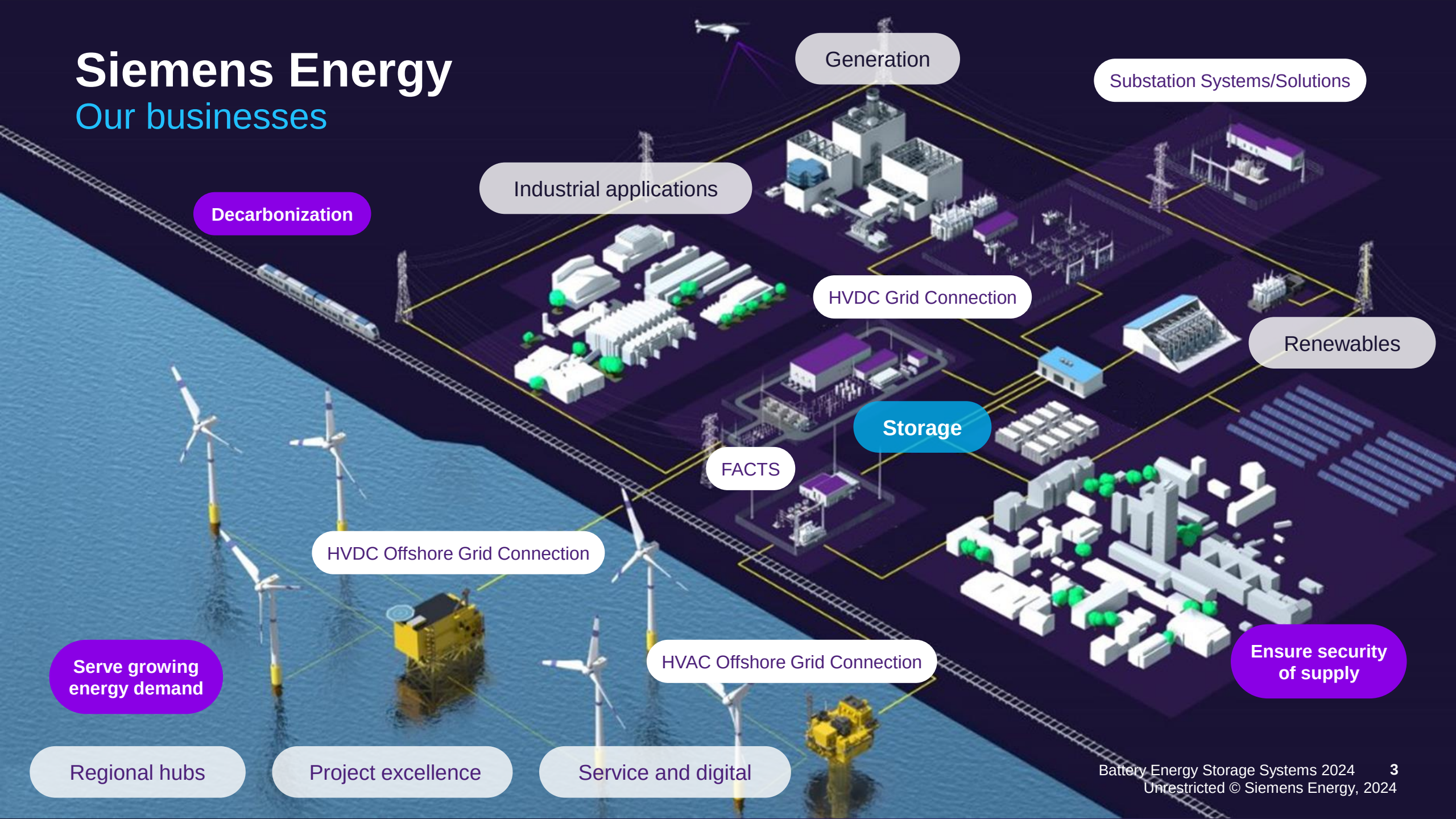
Dr. Thorsten Krol

We energize society

by supporting our customers in transitioning to a more sustainable world, based on our innovative technologies and our ability to turn ideas into reality.

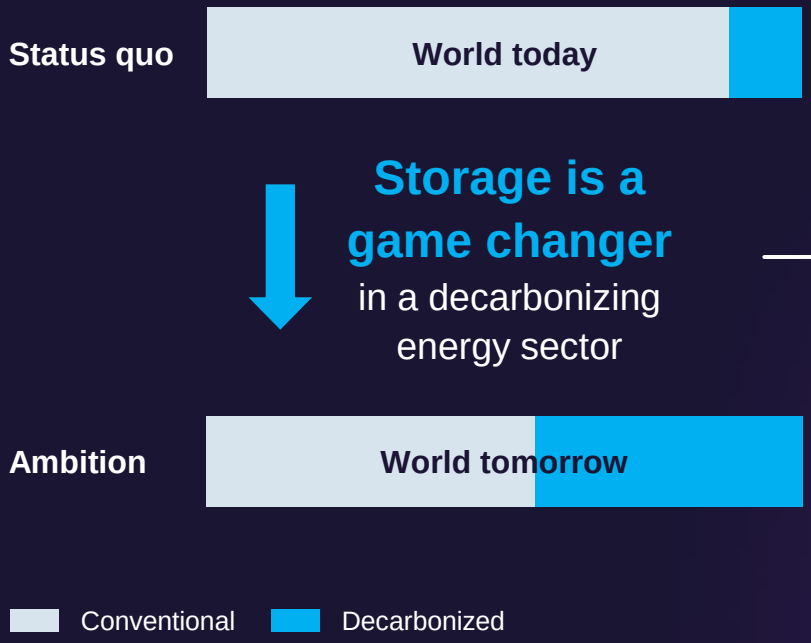
Siemens Energy

Our businesses



Energy storage technologies are essential for the deep decarbonization of energy systems

Change of energy sector worldwide



Storage enables **24/7 availability** of fluctuating renewables

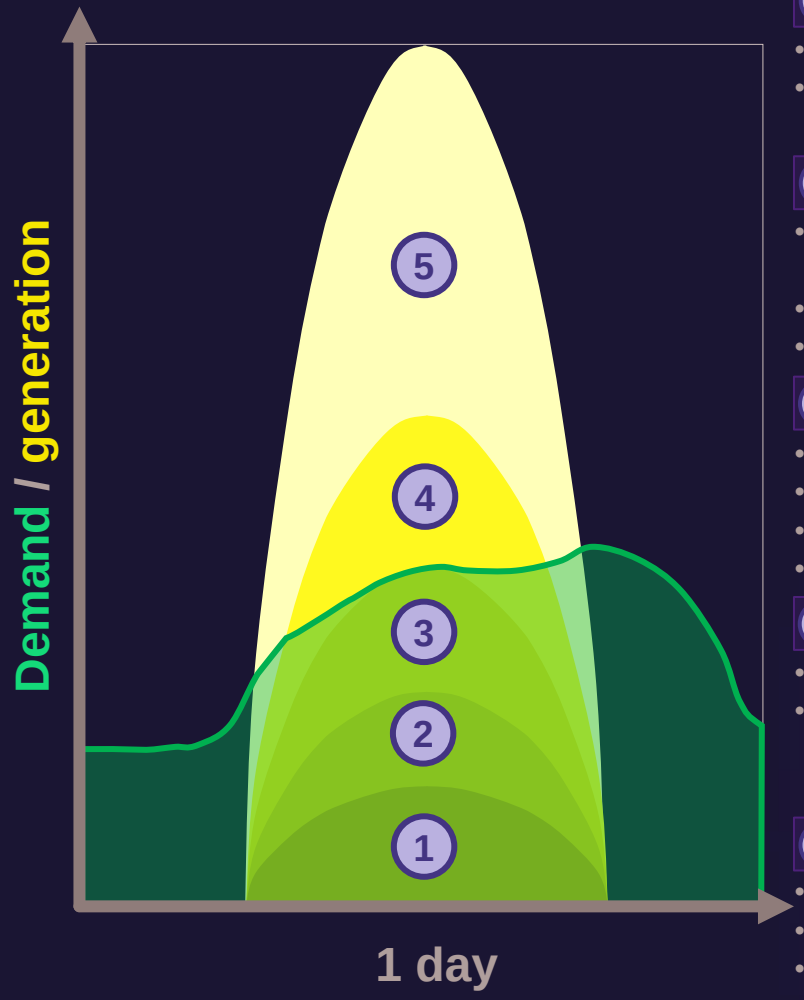
Storage systems cost decrease is challenging parts of gas turbine business already today

Storage has the potential of further **revenue streams** for the customer

Storage is a central part of any future energy scenario and Siemens Energy has an answer

Source: SE Generation Strategy – SE GP G LRE STO, IHS Markit – Energy outlook to 2050 (autonomy scenario)

Challenges in markets integrating high shares of renewables



Operational challenges

Possible solution

1 Low share of renewables within the grid:

- More load cycles in residual load operation
- Grid connection or RES

- Flexible part load operation of existing thermal generators
- Increased demand on adjustable re-active power

2 Moderate share of renewables within the grid:

- Residual load operation requires shut down or MEL operation
- Lack of static and adjustable re-active power
- Load management

- Increased re-dispatch necessary
- Flexible part load operation of existing thermal generators

3 Significant share of renewables within the grid:

- Reliable generators taken off the grid
- Missing inertia and short circuit power
- Lack of static and adjustable re-active power
- No functional market design

- Some thermal generator on MEL
- Clutch between GT and Gen allows multi-use of thermal equipment
- Flexible thermal units or BESS in RES-chasing operation

4 Excess renewables within the grid:

- Excess RES power stored in BESS for load shifting
- Very limited ancillary services

- Power / load management
- Special equipment provides all ancillary services for active, re-active and short circuit power
- Integration of FACTS and BESS for fast responding

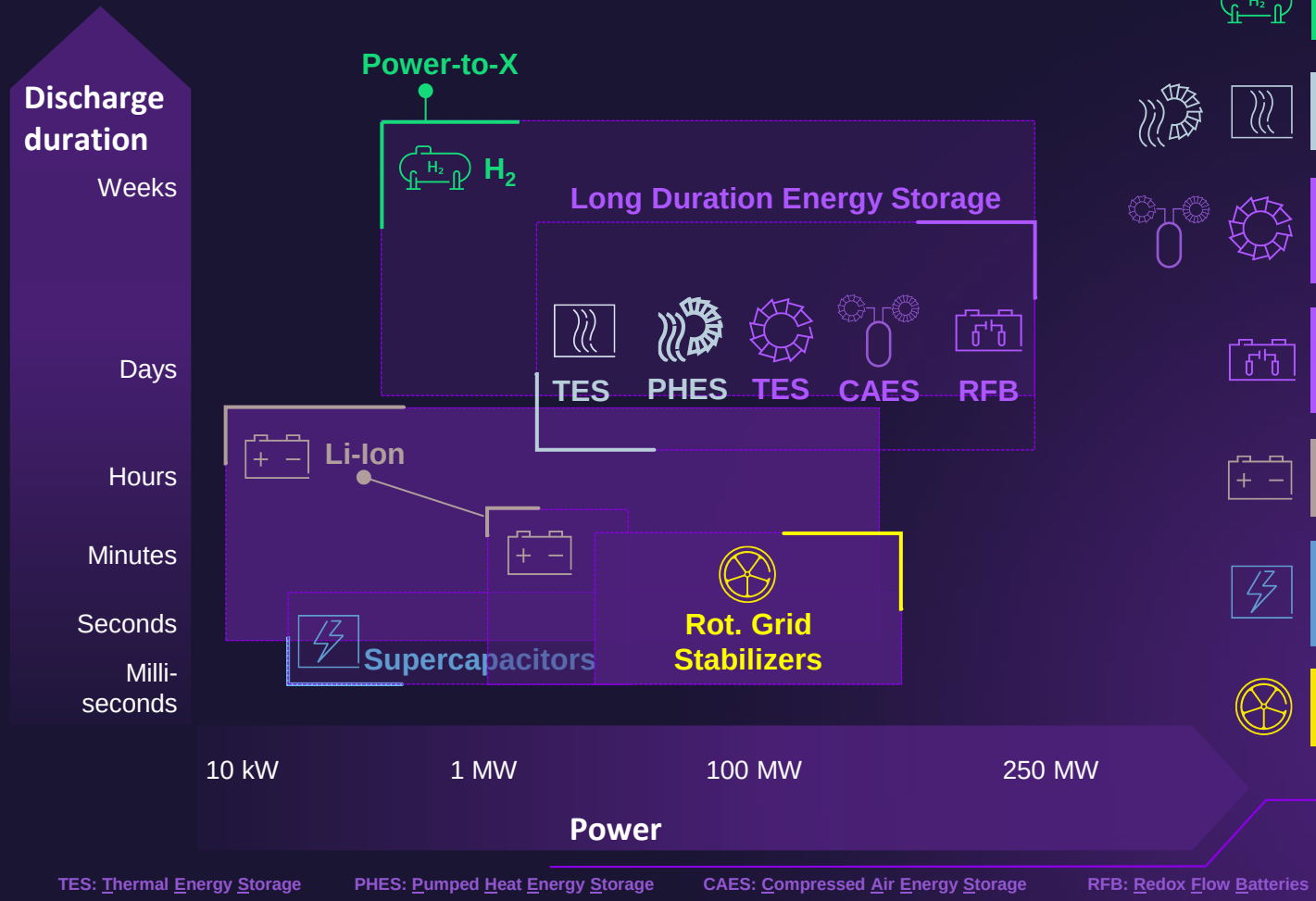
5 Deep decarbonization:

- Massive excess RES power available
- Mainly inverter connected equipment connected to grid
- No dynamic stabilization within grid
- Green seasonal power required

- Long term storage for over night load shifting and seasonal storage technologies
- Ancillary services and re-dispatch via special equipment
- Multi use of equipment keep costs limited

MEL: minimum environmental load

Both short and medium duration energy storage are key elements for the transformation of energy systems



TES: Thermal Energy Storage PHES: Pumped Heat Energy Storage CAES: Compressed Air Energy Storage RFB: Redox Flow Batteries

Long-term storage based on **hydrogen** and Synfuels enables the coupling of all sectors of the economy.

Thermal Energy Storage - TES / PHES enables also decarbonization of industrial heat e.g., by providing high-quality process steam.

(Thermo-) Mechanical Storage - (T)MES / CAES stores energy when demand is low and reuses it when demand is high. It also enables renewable-firming and long-term storage.

Redox Flow Battery (RFB) stores energy when demand is low and reuses it when demand is high. It also enables renewable-firming and long-term storage.

Batteries support fast and zero-carbon energy supply, enable shifting to renewable energy and avoid curtailment.

Supercapacitors store electric charges with a high-power density, thus delivering quickly high energy.

Rotating Grid Stabilizers enable the grid to handle fluctuating renewable infeed.

Charging

- Off-shore wind
  - Connected to HV or MV grid
- Local on-shore wind
  - Local via MV

- Large scale PV
  - Local via MV or LV grid
- Roof top PV
  - Local within district in LV grid
- Mixture
  - Local via MV or LV grid

The BESS decouples intermittent renewable generation and demand.

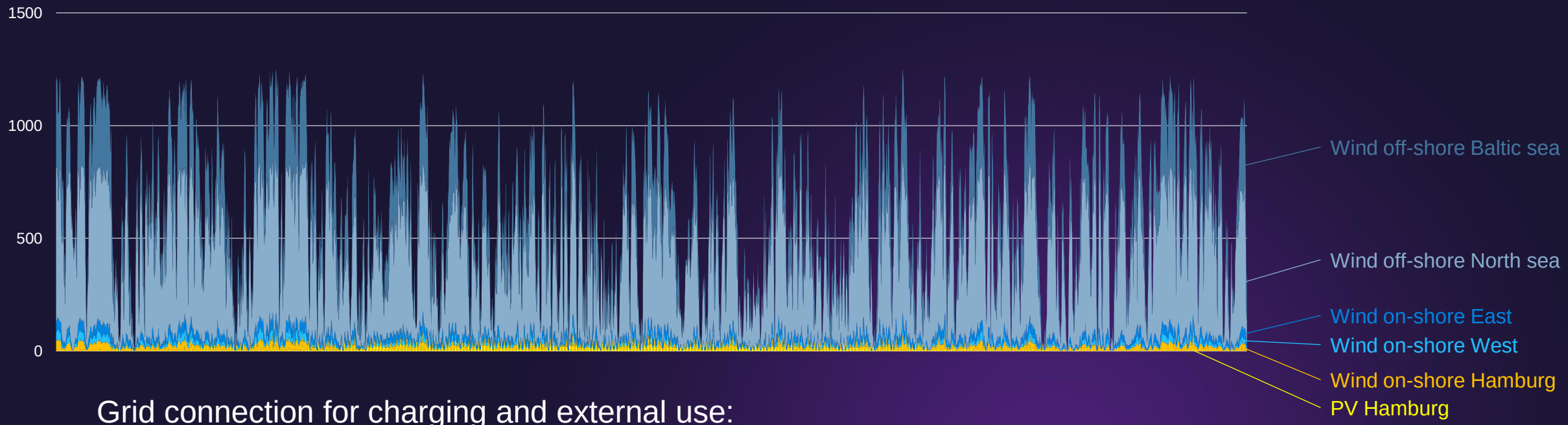
Dis-charging

- Districts
  - Decarbonized security of supply
  - Cost reduction by arbitrage
  - Back-up for EV charging
  - …

- Industries
  - Secured shut down of critical processes
  - Cost reduction by arbitrage
  - DC supply with lower losses
  - Re-active power compensation
  - …

Value of “large scale” storage in an urban environment

Sizing and charging of the storage system



Grid connection for charging and external use:

- High voltage
- Medium voltage
- Low voltage

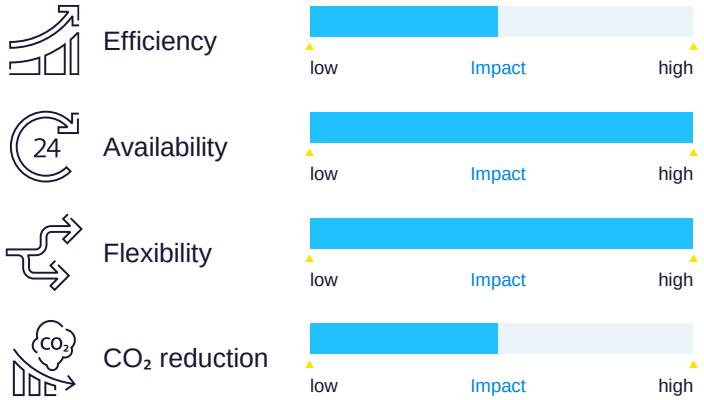
Depending on the source and consumers, different applications and use cases for storage are possible.

Battery systems for grid support

Typical properties

Power range	2 – 100+ MW_{el}
Discharge time	1 – 4 hours
Reaction time	300 – 1.000 ms
Storage size	2 – 400+ MWh_{el}
Storage period	seconds – weeks

Benefits



Your challenges

- Having to stabilize grid due to fluctuating renewables
- Power generation by conventional power plants is required in the event of local grid overload (so-called redispatch)
- Regulatory framework demands measures for stabilizing the grid
- Grid extension is required to meet energy demand where it's needed

Our storage systems enable

- Participation in Frequency response markets for grid stabilization due to reliable and plannable input / output
- Redispatch with stored renewable electricity, thus avoiding ramping up conventional power plants, which in turn supports decarbonization
- Batteries that reduce the pressure on grid extension by storing energy close to its use
- Energy arbitrage

Our offerings

- Full integration of batteries including HV grid connection
- Battery Management System enabling automated and fully autonomous operation
- Continuous monitoring and one-stop diagnostics to ensure battery health

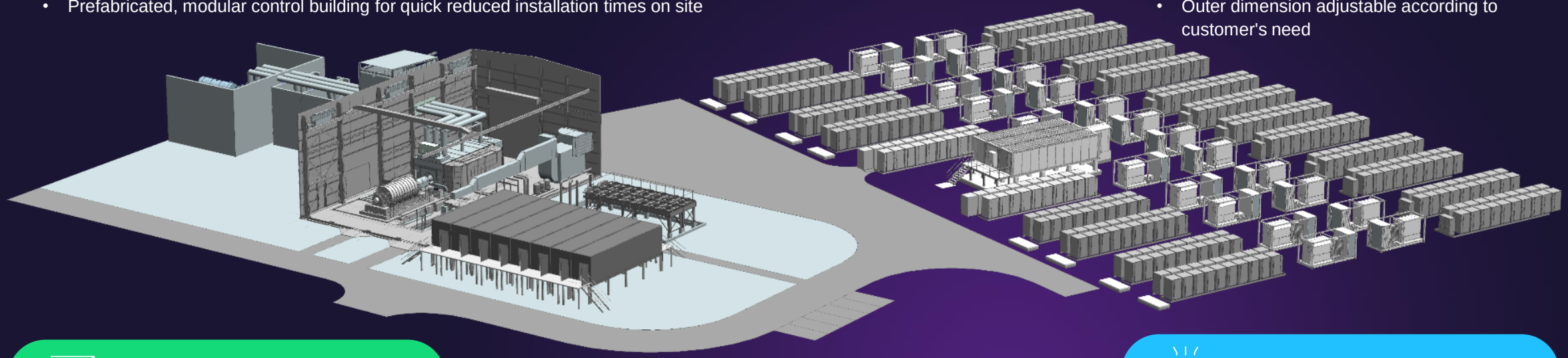
Hybrid project overview

Synchronous Condenser & Flywheel - 4000 MWs

- Proven design for max. provision of short circuit power and kinetic energy to the power grid
- Prefabricated, modular control building for quick reduced installation times on site

Outdoor battery units

- Durable design suitable for outdoor installation
- Outer dimension adjustable according to customer's need



Var controller

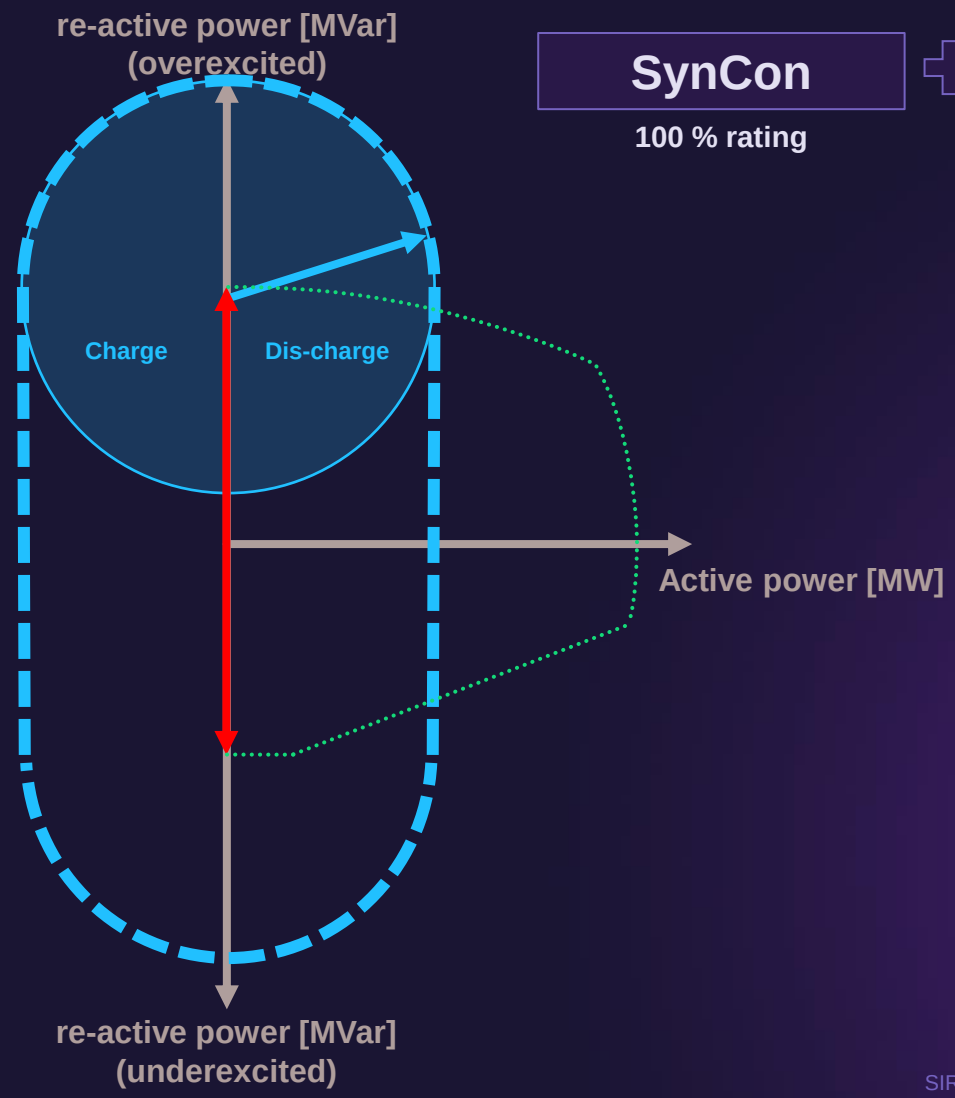
- Common control system between SynCon and BESS for reactive power contribution

Hybrid control unit

Power conversion skids

- Cutting-edge technology for maximum efficiency
- Consisting of MV switchgears, inverters, transformers and communication device

Use Cases and benefits for Grid Stabilizing Packages



SynCon + **Battery**

100 % rating | 50 % rating

Possible services in active power

Dynamic:

- G* SIR
- ** FFR

Frequency containment reserve:

- G* PFR
- G SFR

Planned services:

- G Re-dispatch (optional)
- G Dispatch Peak Shaving (optional)
- G Arbitrage (optional)

Active and passive re-active power compensation G

Static and dynamic

Safety / Security of supply:

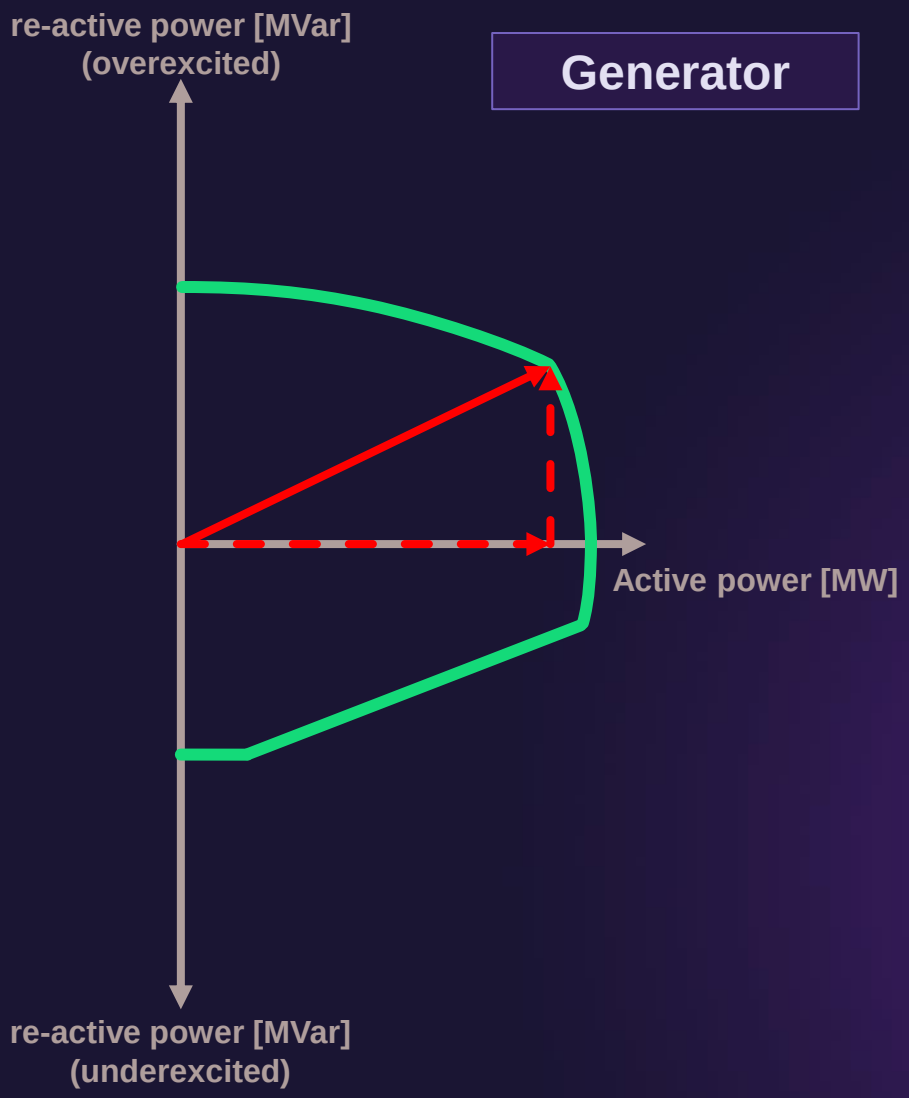
- G Back-up Power
- G* Short Circuit Power
- G Island Hybrid Operation
- G Reserve Margin Reduction
- Grid restoration

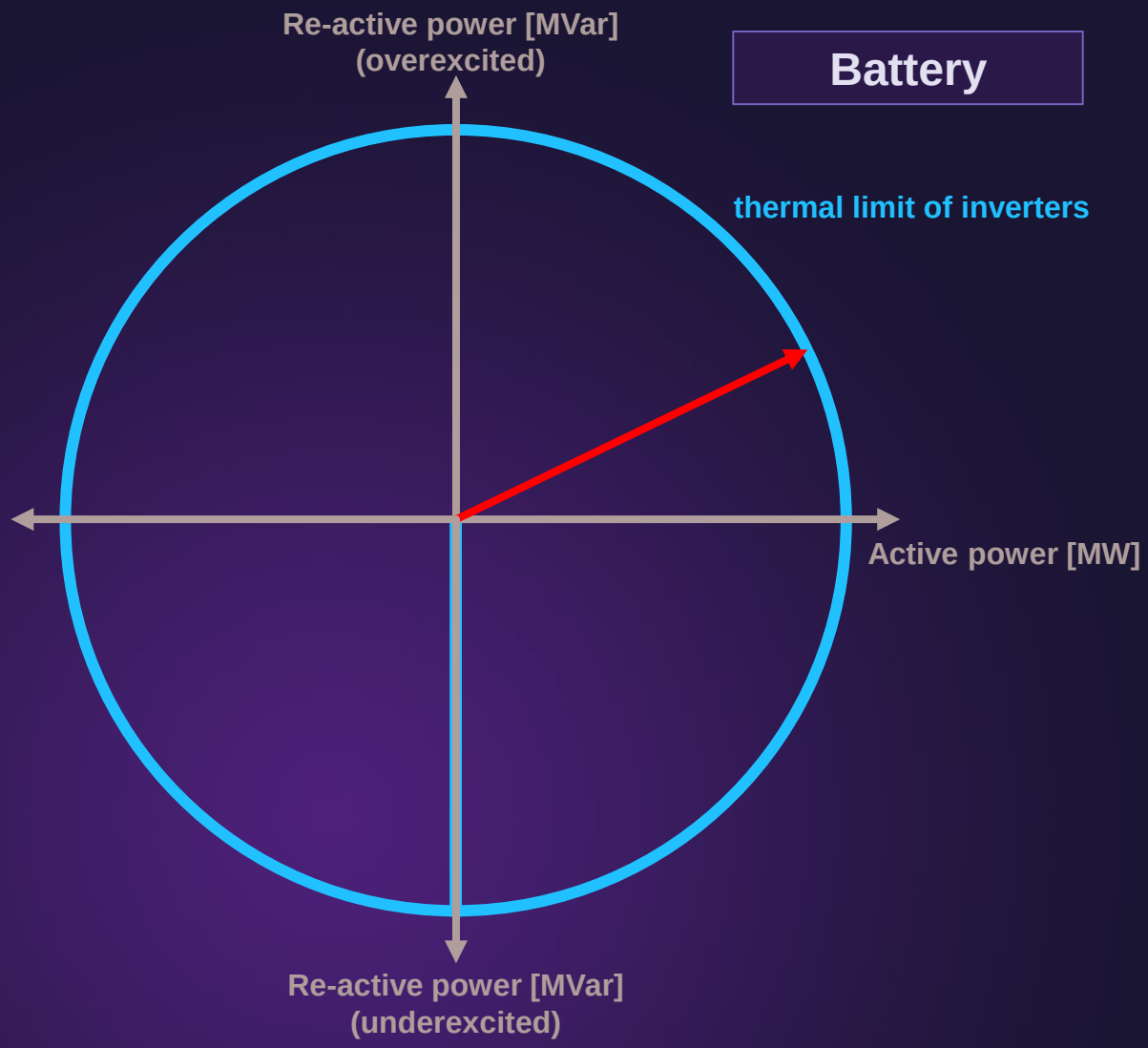
*Only when online

** requires fast acting power cell technologies with special connection

SIR: Synthetic Inertial Response
FFR: Fast Frequency Response
PFR: Primary Frequency Reserve
SFR: Secondary Frequency Reserve
TFR: Tertiary Frequency Reserve

Basic Comparison of generator and battery capability curves





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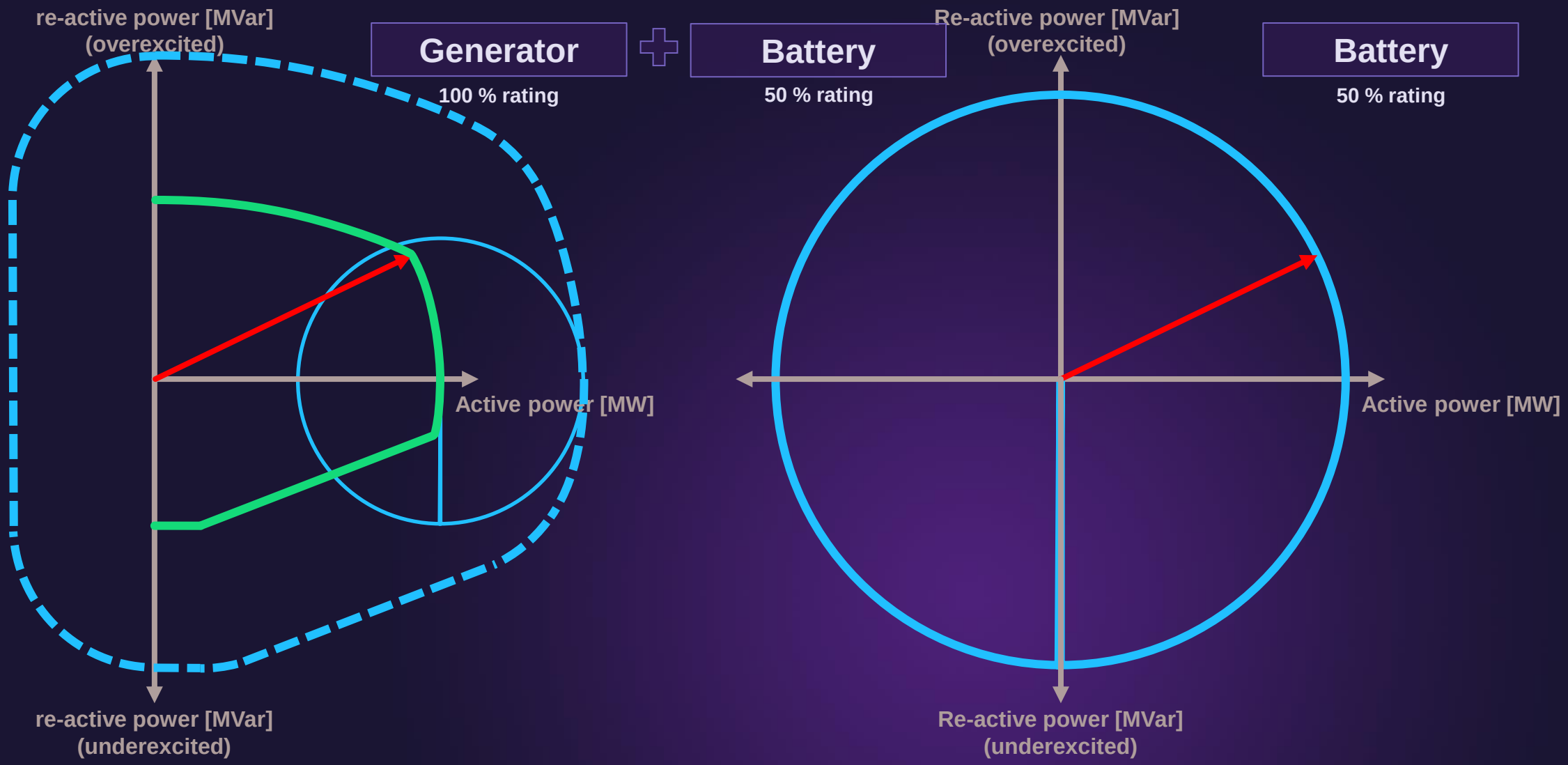

Basic Comparison of generator and battery capability curves

Generator

100 % rating

Battery

50 % rating

Possible services in active power

Dynamic:

- G* SIR
- FFR**

Frequency containment reserve:

- G* PFR
- G SFR
- G TFR

Planned services:

- G Re-dispatch
- G Dispatch Peak Shaving
- G Arbitrage
- G Capacity Firming
- G Seasonal

Active and passive re-active power compensation G

Static and dynamic

Safety / Security of supply:

- G Black Start
- G Back-up Power
- G* Short Circuit Power
- G Island Hybrid Operation
- G Reserve Margin Reduction
- Grid restoration

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SIR: Synthetic Inertial Response
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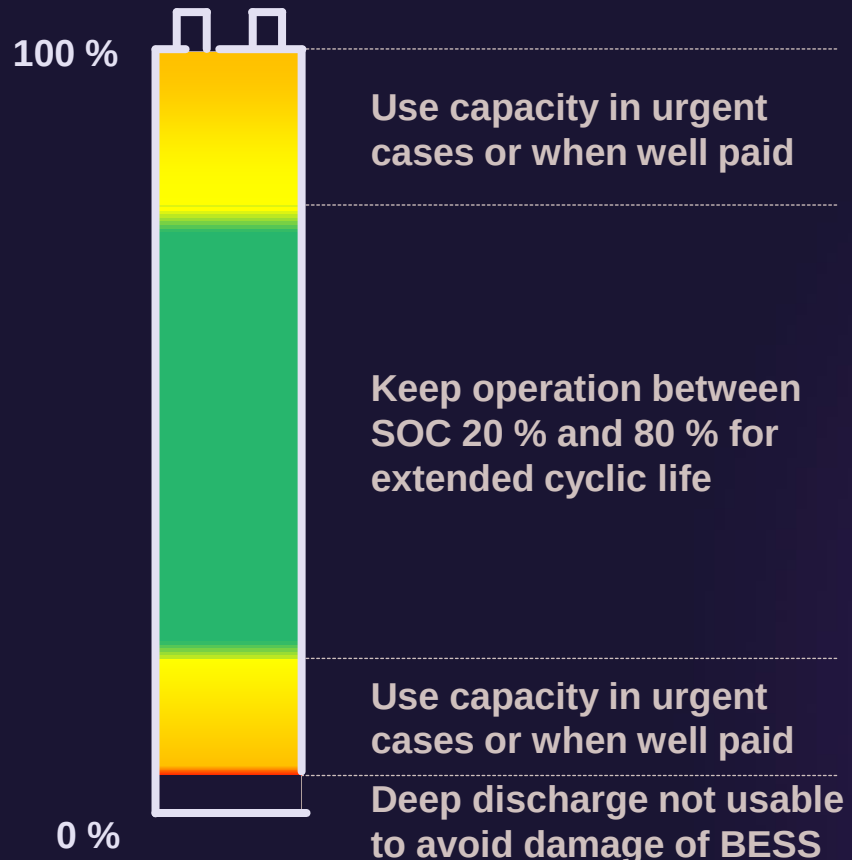
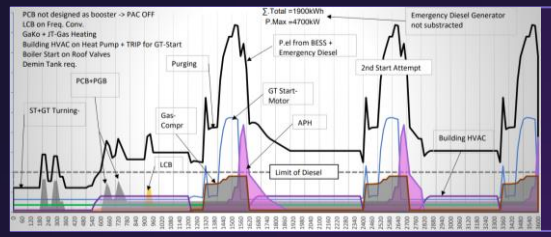
Requirements for Black Start and aFRR (POS & NEG)



Requirements for Black-Start:



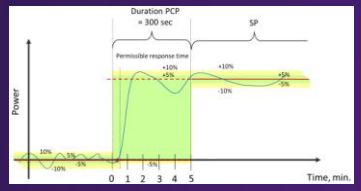
Demand with SGT-800 3x1:

- **GTs and ST on turning gear**
- **Cooling system intermittent**
- **Control system remains powered**
- **HVAC reduced to min.**

		min.	+ failure invest.	+ cool down
Capacity depending on factor of safety:	**3 failed starts:**	**2.5**	**1.0**	**0.4 MWh**
	4 failed starts:	**3.3**	**1.5**	**0.4 MWh**

Requirements for SFR / aFRR:

> 5 MW, capacity reserved > 60 min (compared to marketable power for aFRR POS and aFRR NEG)
Activation sequence requirements:



Response time < 30 s
Power Change period: < 5 min.
Stationary Period: ≥ 10 min (> 60 min mandatory reserved)

- no fuel may be drained or burned unused for aFRR POS or aFRR NEG
- Recharge management must be established and qualified according to spec.
- guaranteed availability 100%

Reference: PQ-Anforderungen (regelleistung.net)

Disclaimer

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

Battery Energy Storage Solutions
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Published by

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