ENERGY

Mini seminar Energieopslag

Zonder energieopslag is transitie van fossiele - naar duurzame energie niet mogelijk

DNV GL – Global Leaders in Energy Storage Advisory Services

DNV·GL

Energy | Maritime | Oil & Gas | Software | Business Assurance

Storage Applications

- Access to Global Storage Experts
- Leverage Experience from multiple sectors
- Example projects across the entire value chain

ADVANTICA

GARRAD HASSAN

NOBLE DENTON

KEMA

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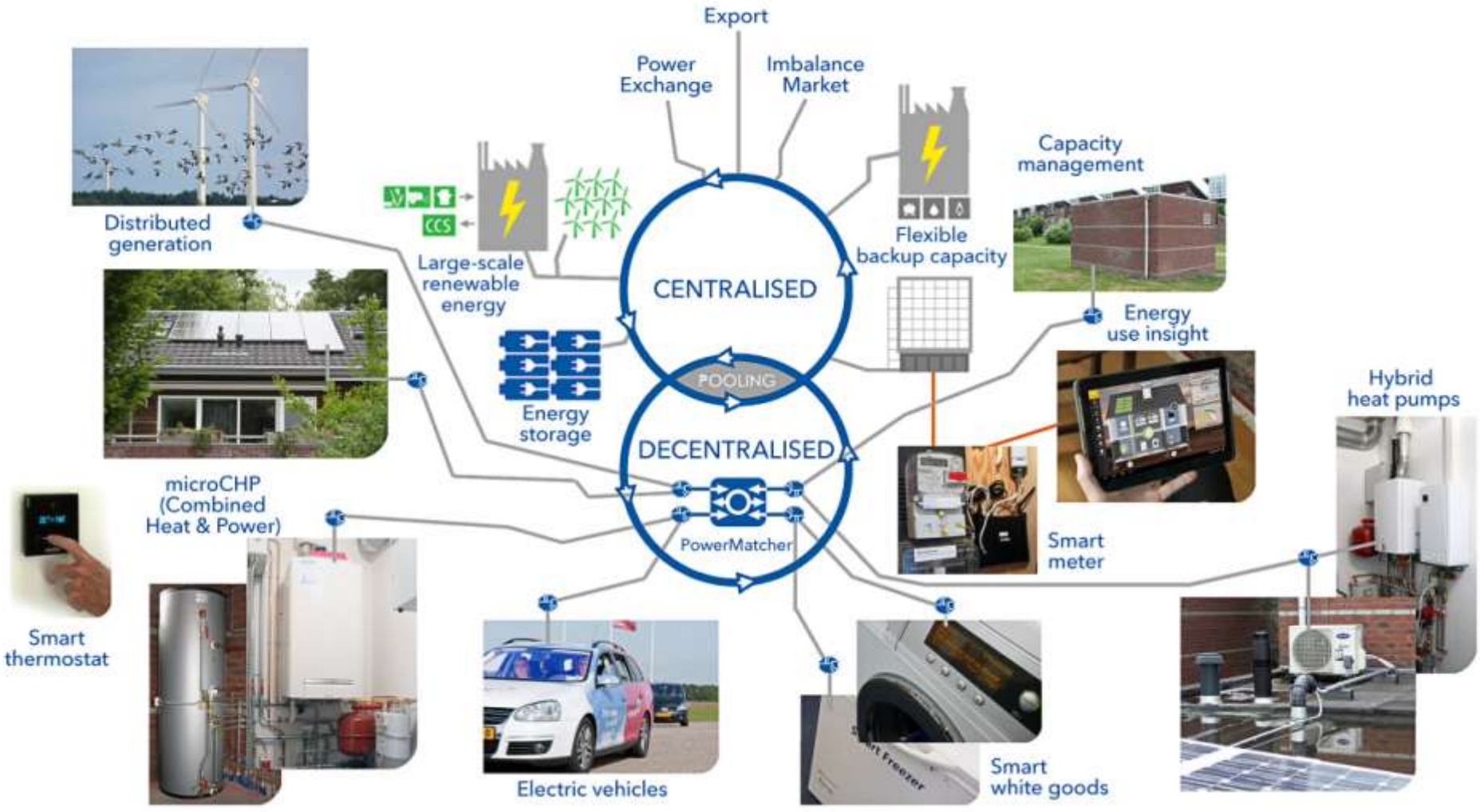
Content




Centralised and decentralised energy systems develop in parallel

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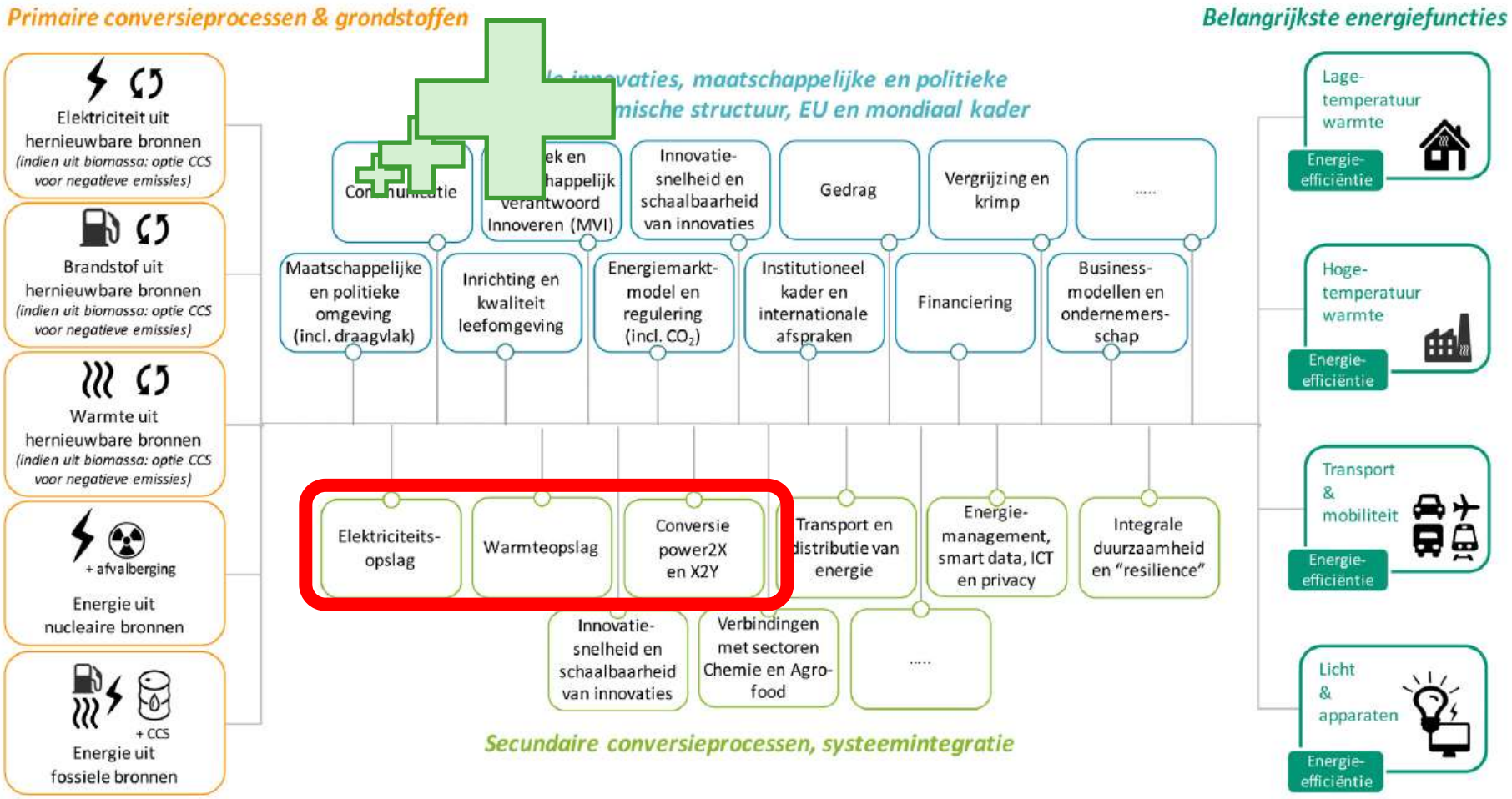
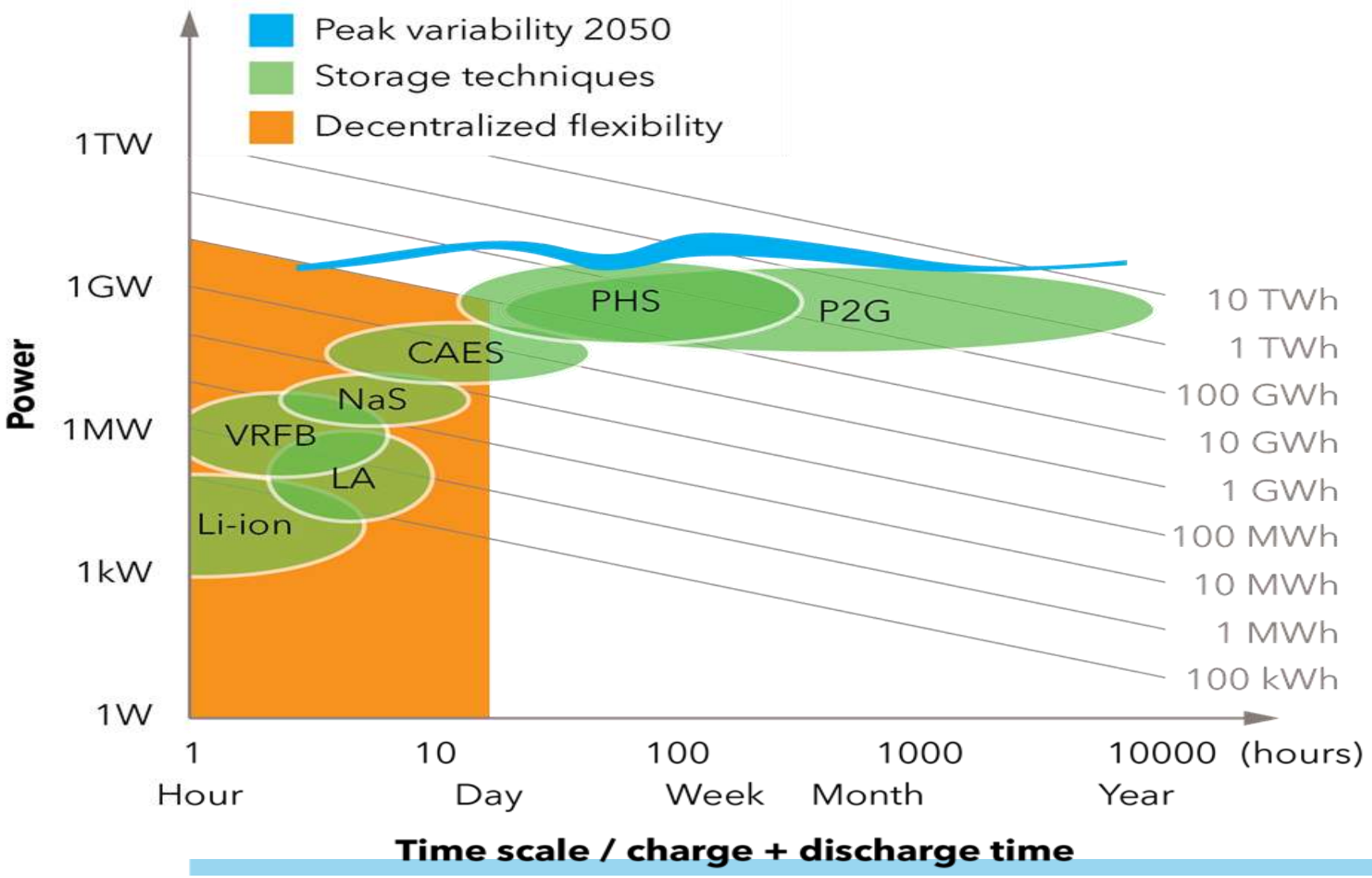
Energy Storage in the Energy System

NWA Route Energietransitie



Future Energy Storage Requirements



Storage technologies – high power and high energy options

Energy/power ratio ≥ 1 hour

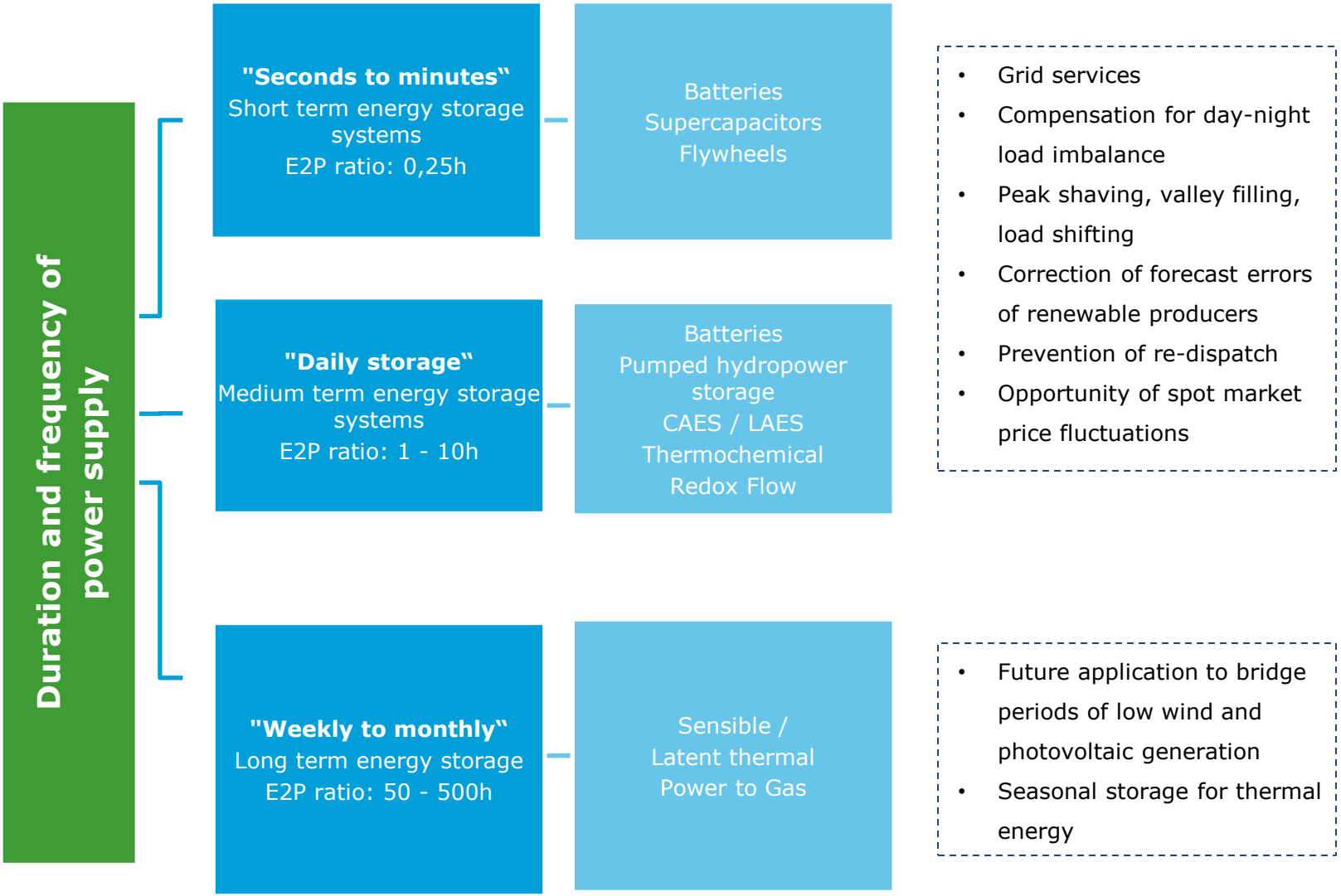
Energy/power ratio < 1 hour

- Pumped storage
- Compressed air energy storage
- Sodium sulfur (NaS) battery
- Vanadium redo x battery

- Advanced lead acid batteries
- Zinc bromine flow battery
- Sodium nickel chloride battery
- Li-ion – high energy

- Li-ion – high power
- Flywheels
- Double layer capacitors (supercapacitors)

Storage Technologies



Eight emerging dynamics for storage

Storage market widely seen as **where solar market was 5 years ago**

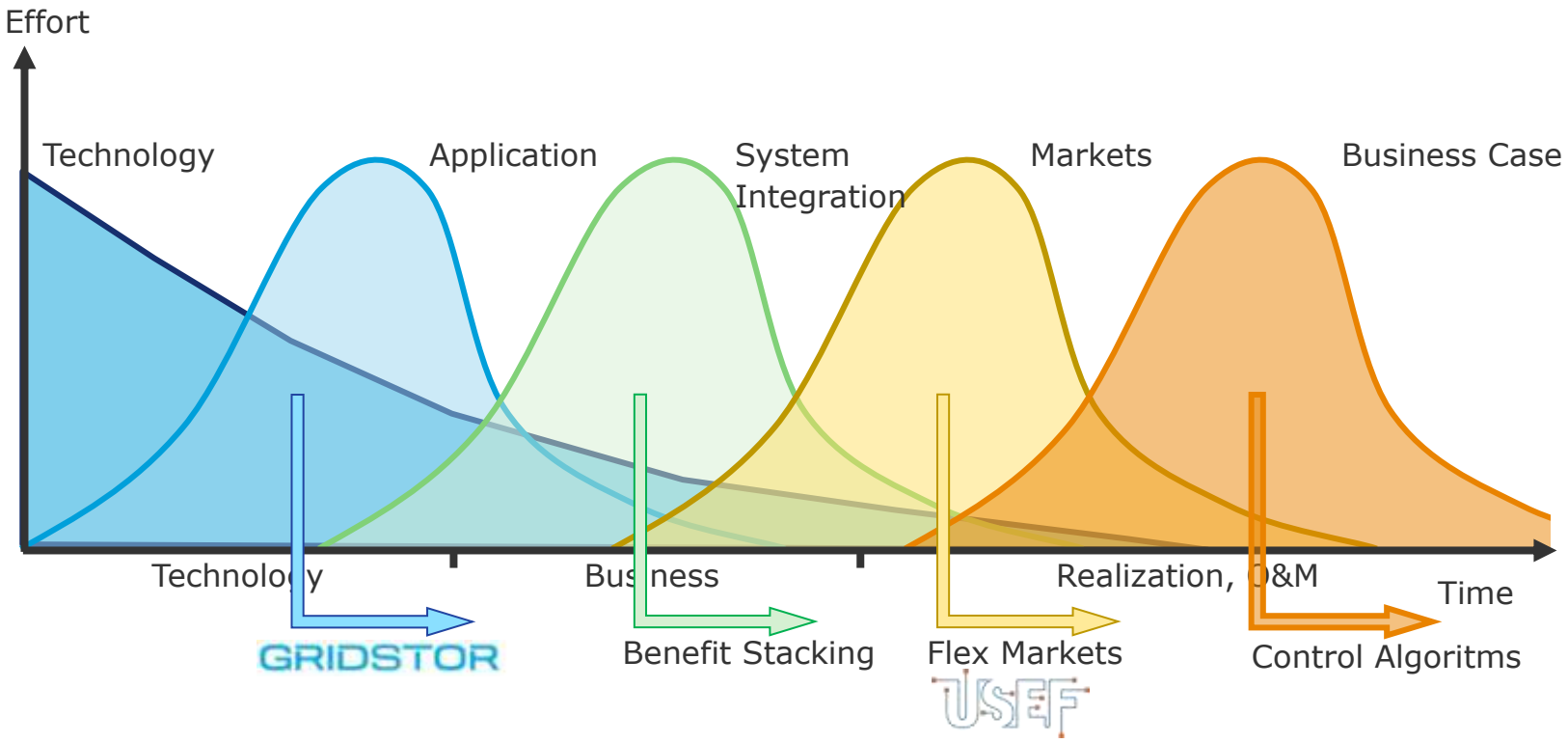
PV started as cost-intensive technology… now becoming competitive with conventional generation

1. **Costs declining** rapidly for energy storage
2. **Storage** will be a key enabler to **increase RES penetration** by smoothing variable resource on the grid **and vice versa!**
3. As with solar-PV, **performance guarantees** are one of the main contributors to market maturation

Eight emerging dynamics for storage

4. **Resiliency:** electric power systems interdependence – back up power – energy security
5. **Stacked values:** Storage deployments with solar PV can provide income and cost benefits on **both sides of meter**
6. **Regulatory requirements** and **financial incentives** emerging in several countries
7. **Income opportunities** for project developers deploying combined technologies in otherwise declining "solar only" markets – self consumption
8. **Emotional appeal**: customer demand for more energy independence – new product /appliance and services (the Tesla effect)

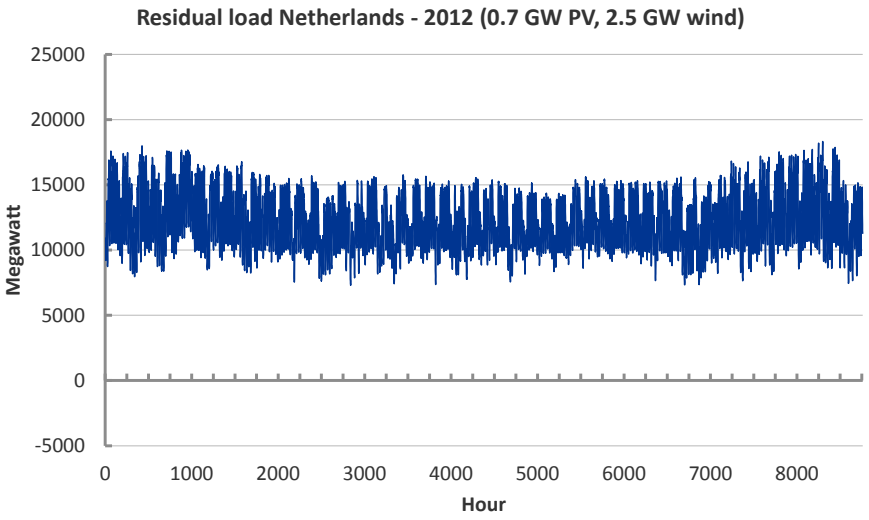
Storage Maturation

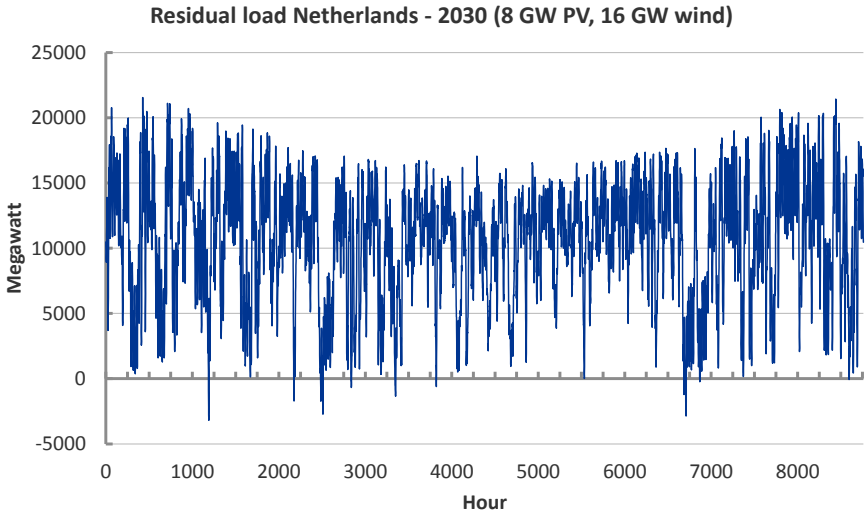


The need for flexibility in our energy system: smart energy

E.g. introduction of DER – in large volumes – will impact power flows, and power quality

- Energy transition will result in larger fluctuations in supply, and in load – mainly in electricity markets
- Large number of inverters (PV solar) will result in voltage issues
- Both developments put pressure on reliability of electricity supply





Flexibility instruments will enable high RES penetration

Flexible Power

Demand Side Management

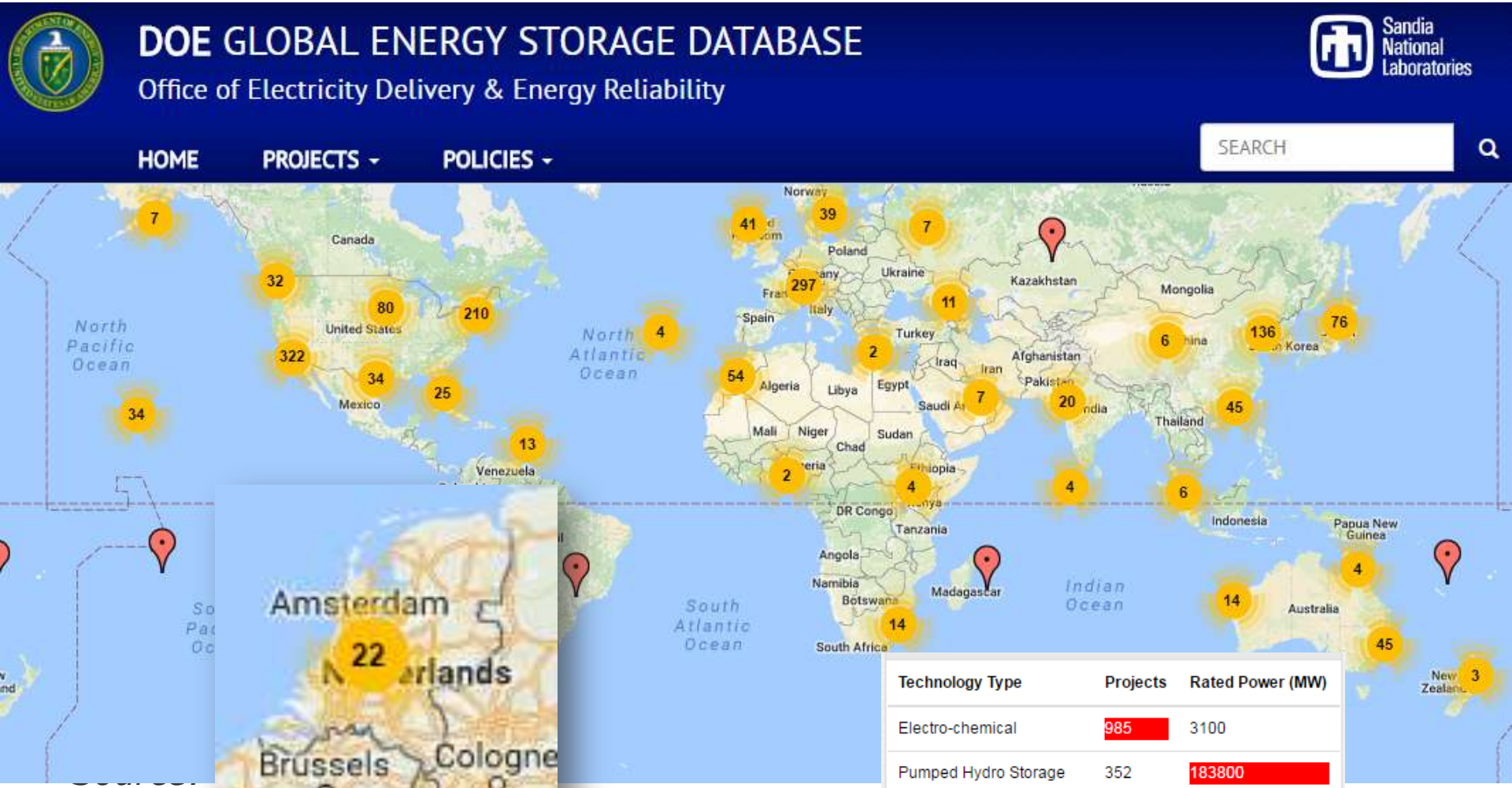
Energy storage

Supergrids / Interconnectors

Global status of energy storage market

Projects and applications

Global status projects



Technology Type	Projects	Rated Power (MW)
Electro-chemical	985	3100
Pumped Hydro Storage	352	183800
Thermal Storage	206	3622
Electro-mechanical	70	2616
Hydrogen Storage	13	18
Liquid Air Energy Storage	2	5

	Quick Charging EV's Powered by the Sun (Bodegraven A12) Bodegraven, Bodegraven, Netherlands Description ›	Lithium Iron Phosphate Battery	50	2:00	Operational	
	SOPRA HAN University Arnhem, Gelderland, Netherlands Description ›	Lithium Iron Phosphate Battery	60	0:50	Operational	
	SOPRA WUR Farm Lelystad, Flevoland, Netherlands Description ›	Lithium Iron Phosphate Battery	60	2:39	Operational	
	SOPRA Zero Watt project Hague, Zuid Holland, Netherlands Description ›	Lithium Iron Phosphate Battery	60	0:50	Operational	
	Fotonenboer 't Spieker Dairy Farm Vierakker, Gelderland, Netherlands Description ›	Vanadium Redox Flow Battery	10	8:00	Operational	Sep 01, 2010
	Smart Storage Etten-Leur, NBr, Netherlands Description ›	Lithium-ion Battery	400	0:30	Operational	Sep 03, 2012
	Vlissingen Advancion Energy Storage - AES Vlissingen, Zeeland, Netherlands Description ›	Lithium-ion Battery	10,000	1:00	Operational	Dec 31, 2015
	Amsterdam ArenA Storage Amsterdam, Amsterdam, Netherlands Description ›	Lithium-ion Battery	4,000	1:00	Operational	Jan 01, 2017

Add New Project

Project Name	*Service/Use Case 1*	*Service/Use Case 2*	*Service/Use Case 3*	*Service/Use Case 4*	*Service/Use Case 5*	Service/Use
SOPRA HAN University	On-Site Power	Renewables Capacity Firming	Microgrid Capability	Electric Energy Time Shift		
SOPRA WUR Farm	On-Site Power	Renewables Capacity Firming	Electric Energy Time Shift	Microgrid Capability		
SOPRA Zero Watt project	On-Site Power	Renewables Capacity Firming	Electric Energy Time Shift	Microgrid Capability		
Fotonenboer 't Spieker Dairy Farm	Electric Bill Management with Renewables	On-Site Power	Onsite Renewable Generation Shifting			
Smart Storage	Black Start	Distribution upgrade due to solar	Microgrid Capability			
Vlissingen Advancion Energy Stora	Frequency Regulation					
Amsterdam ArenA Storage	Demand Response	Frequency Regulation	Grid-Connected Commercial (Reliability	On-Site Power	Renewables Energy Time	Resiliency

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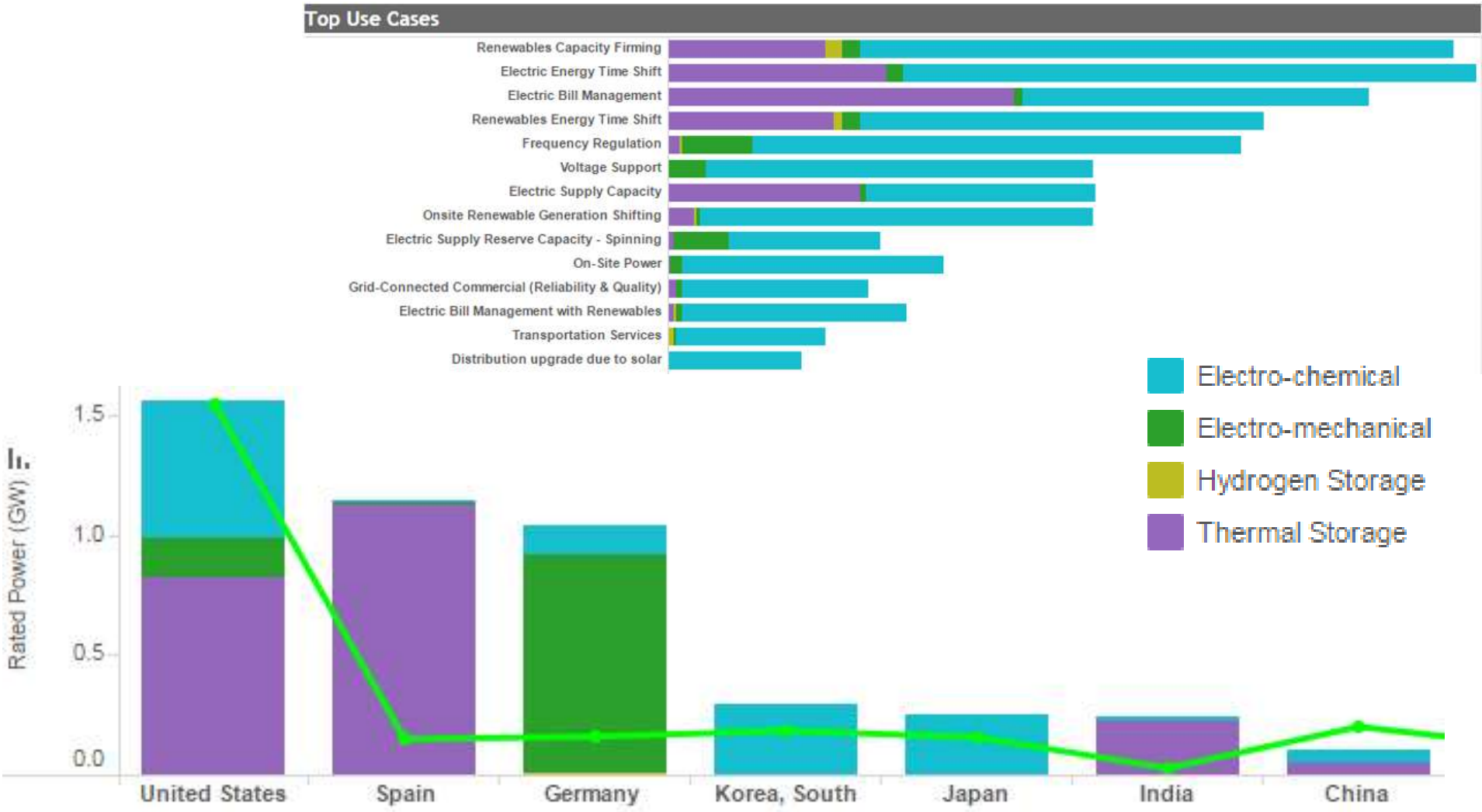
In comparison: the top 7 countries



- *Source: DOE database*

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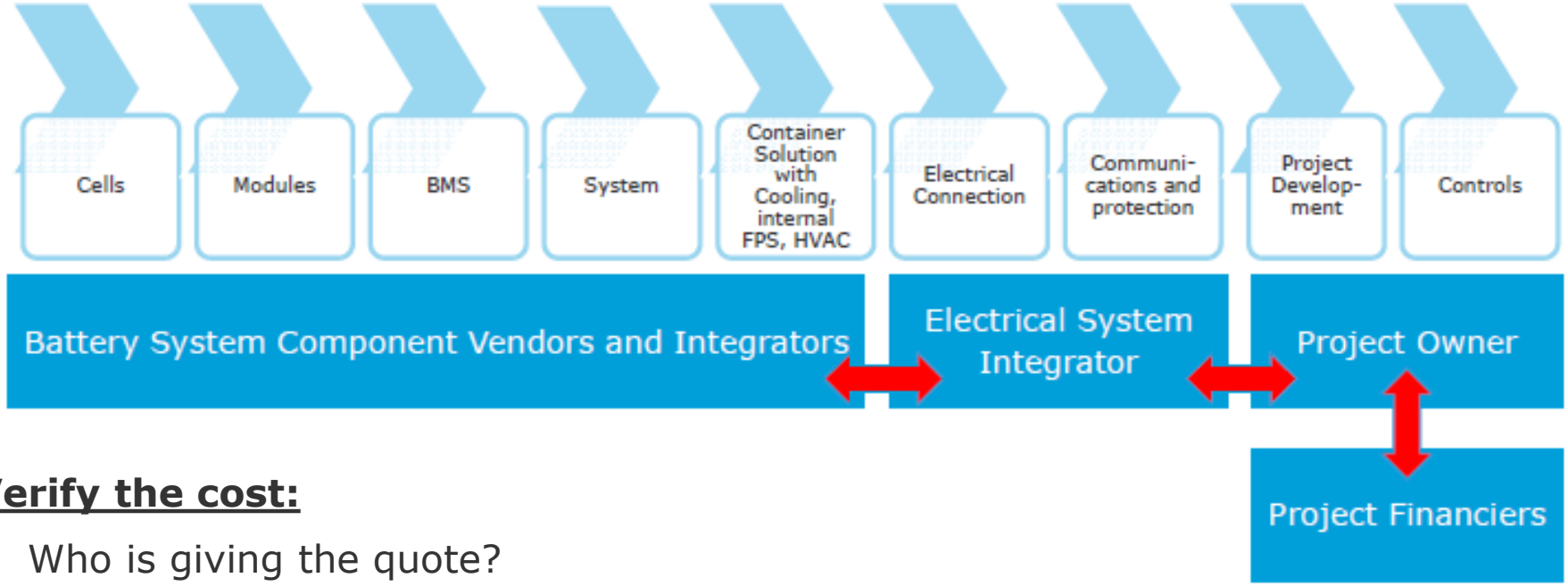
Global status of energy storage market

Economics – li-ion

Capital Cost

€125-310/kWh → €330-2500/kWh



Verify the cost:

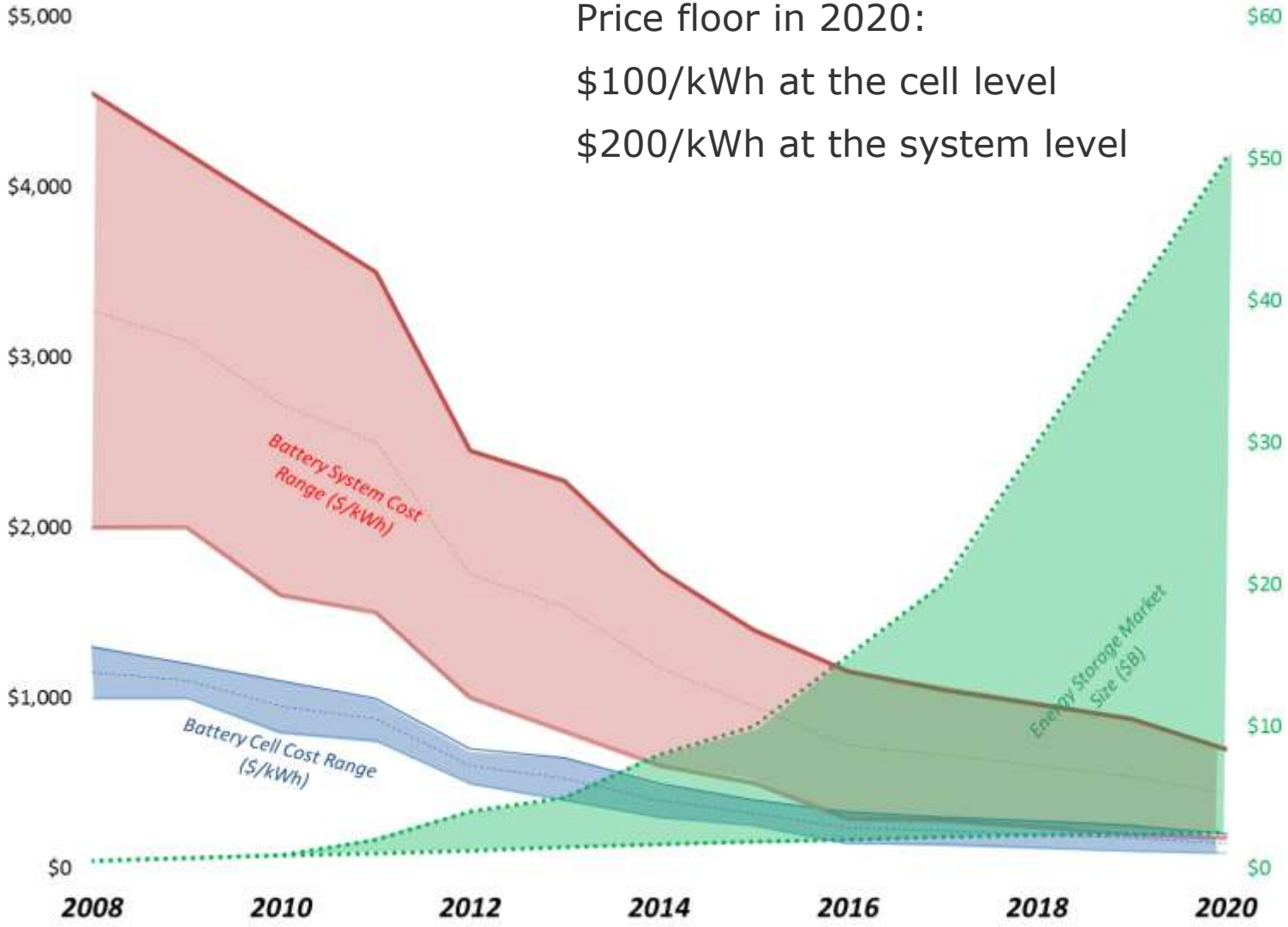
- Who is giving the quote?
- Is it turnkey?
- Who else is involved?

Projected costs

Price floor in 2020:

$100/kWh at the cell level

$200/kWh at the system level



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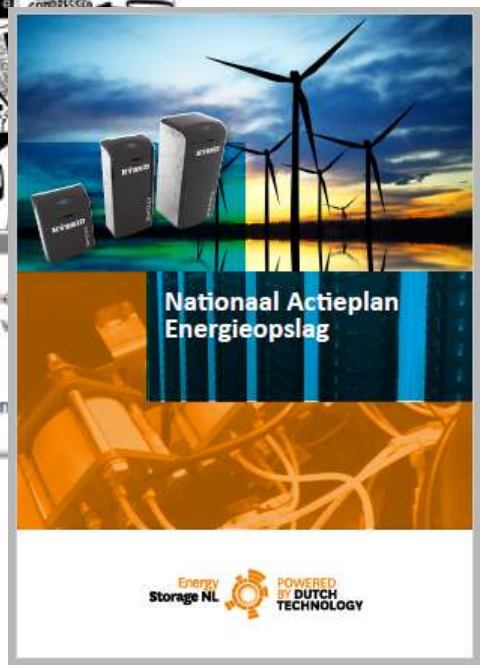
Project realisation in the Netherlands

Routekaart 2030 & Nationaal Actieplan EnergieOpslag

Middels een spectrale analyse, scenarioanalyse en een marktconsultatie zijn die
diensten geïdentificeerd waar in de periode tot 2030 de beste mogelijkheden v
energieopslag technologieën bestaan. Dit zijn:

- Handel op de wholesale markt
- Handel op de balanceringsmarkt, het leveren van regel- en reservevermogen
- Energiemanagement achter de meter



Energy Storage NL POWERED BY DUTCH TECHNOLOGY

Nieuwe salderingsregeling mag toepassing opslag niet belemmeren

9 januari 2017

Op 3 januari 2017 heeft de minister van Economische Zaken de evaluatie van de huidige salderingsregeling naar de Tweede Kamer gestuurd. In de evaluatie... meer »

New TU Delft 'battolyser' technology combines electricity storage and hydrogen production in a single system, enabling electricity to be stored efficiently and affordably

22 december 2016

For the first time, TU Delft researchers led by Prof. Fokko Mulder have produced an integrated battery electrolysis system – known as a 'battolyser'... meer »

Tweede Kamer neemt motie aan over saldering

15 december 2016

De Tweede Kamer heeft op 13 december 2016 een motie aangenomen waarin minister Kamp wordt gevraagd de salderingsregeling te continueren of te verbeteren. De... meer »

Kabinet gaat dubbele energiebelasting energieopslag aanpakken

13 december 2016

Het kabinet heeft op 7 december 2016 haar Energieagenda gepresenteerd. In deze Energieagenda worden de transitiepaden naar een koolstofarme energievoorziening in 2050 geschetst. De... meer »

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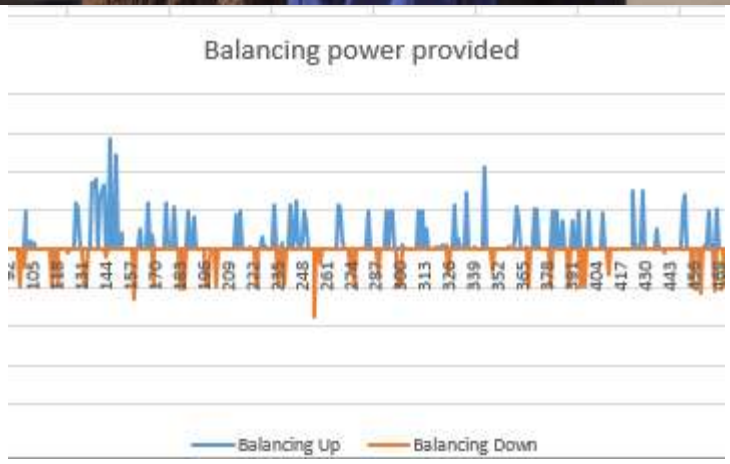
Frequency Containment Reserve – AES

- 10 MW of interconnected advanced, battery-based energy storage
- First deployment of AES' Advancion solution in continental Europe
- First battery project in the Netherlands for Frequency Containment Reserve purposes
- 45.000 lithium ion batteries

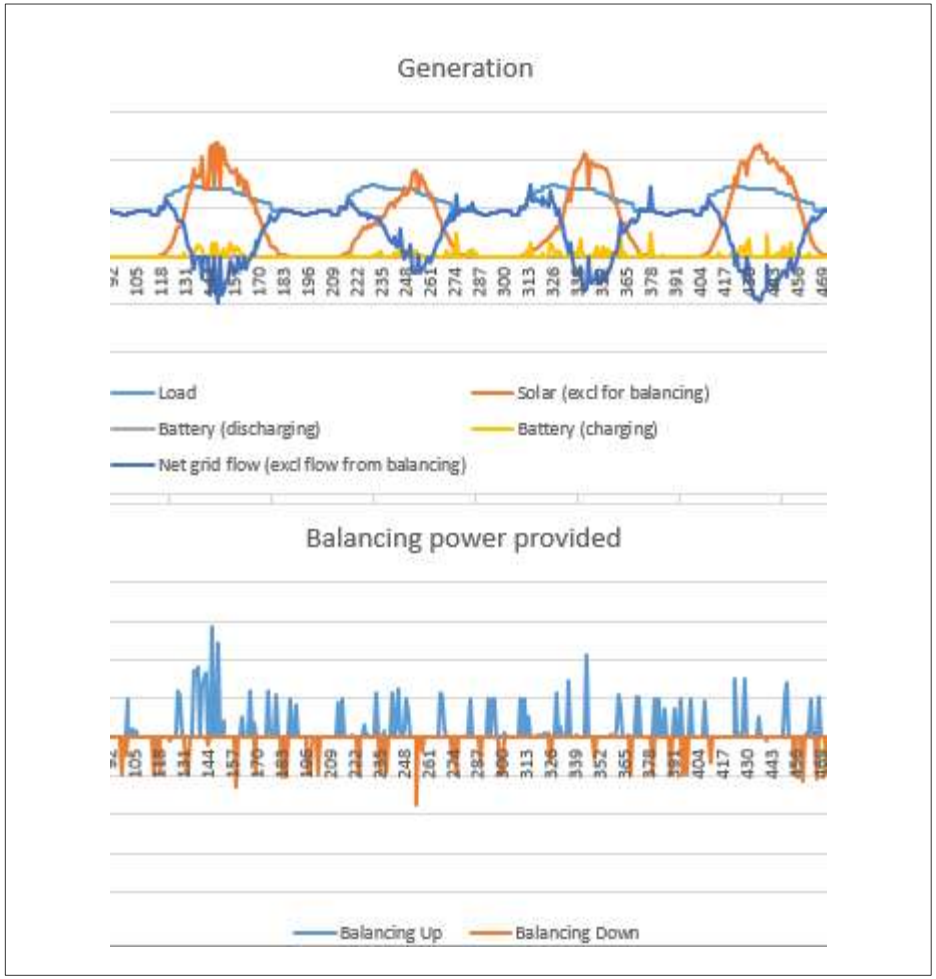
Energy storage for Alexia wind farm - Nuon

- Currently balancing and FCR
- Storage system 3MW to expand to 12MW
- Prinses Alexia Windpark (122 MW), Zeewolde
- Car batteries
- Alfen as system integrator



Solar+storage at a farm in Odoorn for multiple applications

- Solar + storage
- Balancing, self-consumption, peak-shifting
- At farm 'De Jong en Bos'
- 294 kWh system
- ATEPS, Jules Energy, GroenLeven



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Community storage/De Buurtbatterij

Etten-Leur

- Enexis
- Smart Storage Unit
- Economically most attractive rev.
- 100kW-400kW / 240 kWh
- Jouw Energie Moment

Haarlemmermeer

- Alliander
- 120kW/120kWh
- Rijsenhout
- Distribution grid services
- Market services
- Solar storage

Buurtbatterij

Behind the meter

CrowdNett

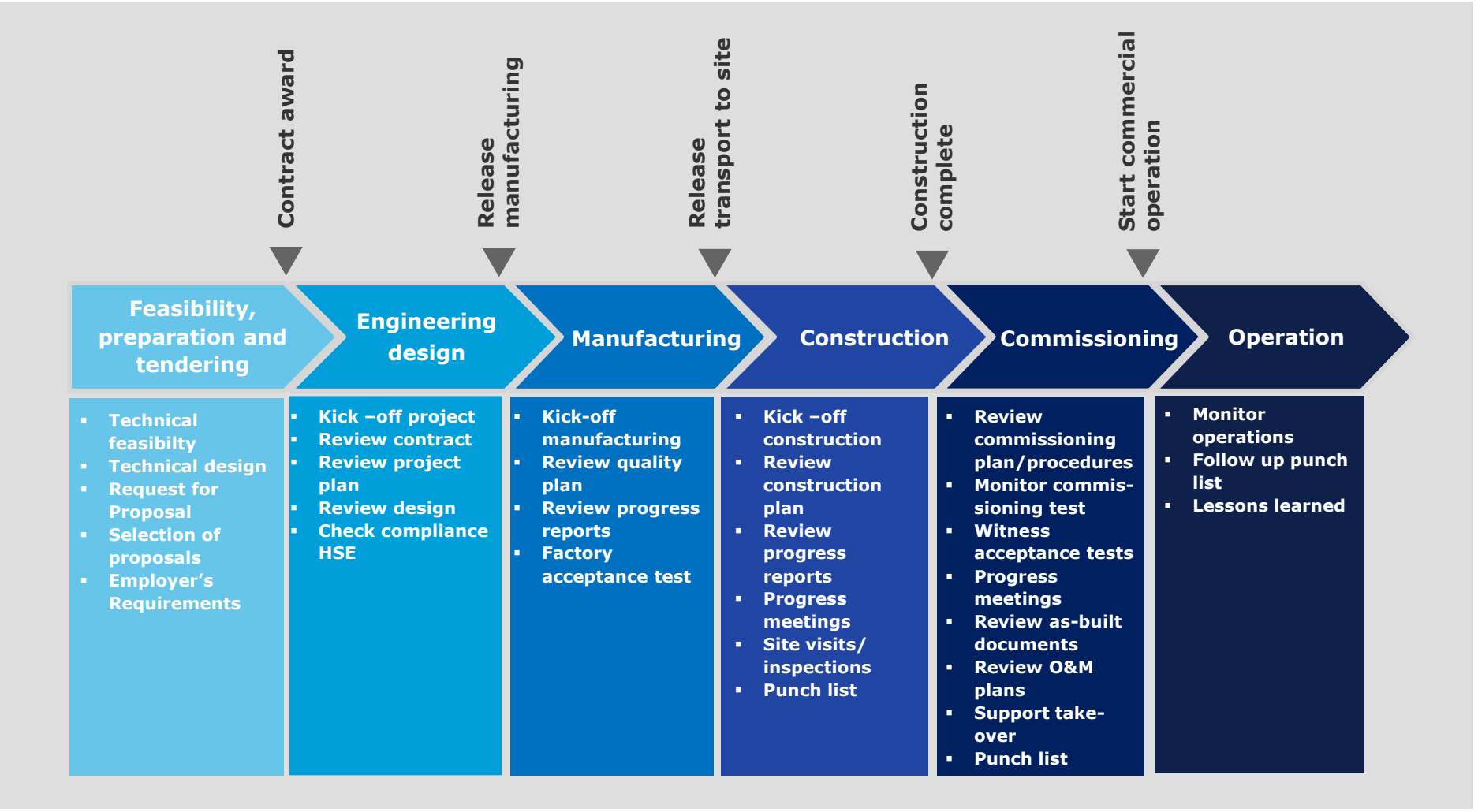
- 400 Powerwalls = 1 MW_{FCR}. In NL by Q1 2017.Then scaling up in NL and starting in BE.
- Eneco aggregates capacity for FCR application at first instance
- Additional value streams at later stage (e.g. post-net metering)

Jouw Energy Moment

- Meulenspie in Breda
- 39 Tesla Powerwalls
- Testing flexible tariffs
- For trading and avoiding grid congestion

Project realisation and risk mitigation

Realisation – best practices & lessons learned



Real-life examples of materialised risks

Feasibility risks

- System dimensioned on minimum CAPEX instead of TCO
- Market saturation not taken into account
- Sub-optimal combination of technology and applications

Performance risks

- Cycle life data under different conditions (DoD, temperature, C-rate)
- Standby losses not taken into account

Contract risks

- Conditions warranty and guarantees unclear
- System boundary unclear – e.g. safety responsibility

Regulation/certification risks

- System specification not in line with market regulation / grid code
- Systems not meeting standardisation

Commissioning risks

- FAT / SAT testing inadequate
- Handover unclear

Safety risks

- Fire suppression for li-ion batteries
- No FMEA analysis, no adequate measures and training
- Cyber safety

Methodology for de-risking energy storage: GRIDSTOR

DNV GL issued a Recommended Practice (DNVGL-RP-0043) on grid-connected energy storage

- **Guidelines and methods to evaluate, assess and test safety, operation and performance of grid-connected ES**
- **Referencing ISO, IEC and IEEE standards if possible, enhancing where needed**
- **Industry supported: created by consortium of 7 parties, 36 parties involved in review process**
- **Comprehensive**
- **Free to use**

SAFETY	OPERATION	PERFORMANCE
FMEA/Bowtie analysis	Monitoring	Definitions
Risks and mitigation	Control	Conditions
Design consequences	Grid connection	Measurement
Procedures & documentation	Environmental analysis	Life cycle costs

GRIDSTOR Update!

- **New technologies (CAES, ultra-caps, inorg. Li-ion)**
- **Cybersecurity**
- **Communication protocols**
- **Decommissioning**
- **Warrantees, guarantees**
- **Contracting aspects**
- **Bankability**
- **LCoS**
- **Residual value assessment**
- **Procurement**
- **Inverter aspects**
- **…and more…**

For more information, see www.dnvgl.com/services/gridstor-recommended-practice-for-grid-connected-energy-storage-52177 and rules.dnvgl.com/docs/pdf/DNVGL/RP/2015-12/DNVGL-RP-0043.pdf

Training course Grid-connected energy storage – March 23 & 24, 2017

ENERGY ACADEMY

TRAINING COURSE GRID-CONNECTED ENERGY STORAGE

Increase your understanding of the technical, market and financial aspects as well as risks associated with grid-connected energy storage.

This two-day course on grid-connected energy storage is intended for professionals wishing to acquire a comprehensive overview of grid-connected energy storage and to have the latest technology, market conditions and issues clearly explained. The topics covered are: energy markets in relation to energy storage, the role of storage in providing flexibility to solve intermittency issues in the grid, business models, performance indicators, warranties, safety, risks and risk mitigation, and more.

DNV GL will provide you with international examples and present our view on best practices for grid connected energy storage using our industry-supported GRIDSTOR methodology.

Your benefits

After this course you will be able to:

- Identify opportunities and risks for grid-connected energy storage in your business.
- Understand the complexity of grid-connected energy storage projects, be able to make decisions and interact with stakeholders during the entire project life cycle.

Course topics

The following topics will be addressed:

- Roles of storage in the electricity grid
  - Electricity markets
  - Types of energy storage systems (e.g. Li-ion, vanadium redox flow batteries, etcetera)
  - Components of energy storage systems
- Essential elements - life cycle phases and planning
  - Performance indicators/reliability
  - Sizing
  - FAT/SAT
  - Warranty/safety items
  - Contracting, actors and responsibilities
- Business models
  - Value of flexibility
  - Levelised cost of storage (LCOS)
  - Technology/market combinations
  - Examples/case studies
- Risk in energy storage
  - Risks & risk mitigation
  - Safety, health and environmental aspects
  - Design FMECA/operational FMECA
  - Standards

Key take-aways

Key take-aways

2016 was an important year for storage in the Netherlands and globally

Costs becoming commercially attractive, but depending on many aspects

Various projects in the Netherlands, breakthrough yet to come, new values to be disclosed

As a relatively new and complex item, various examples of materialised risks

GRIDSTOR Recommended Practice as the technical framework for risk analysis

Thank you

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