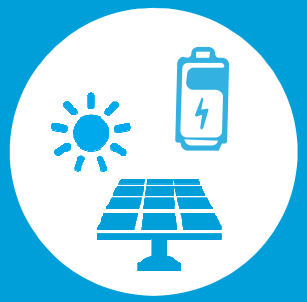
ENERGY

Solar + storage

Sunday conference, 23-11-2016

Haike van de Vegte, M.Sc.



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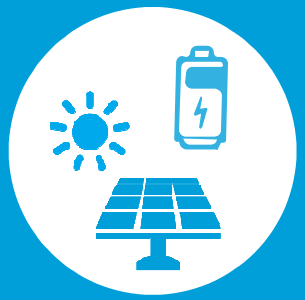
Trends in solar + storage



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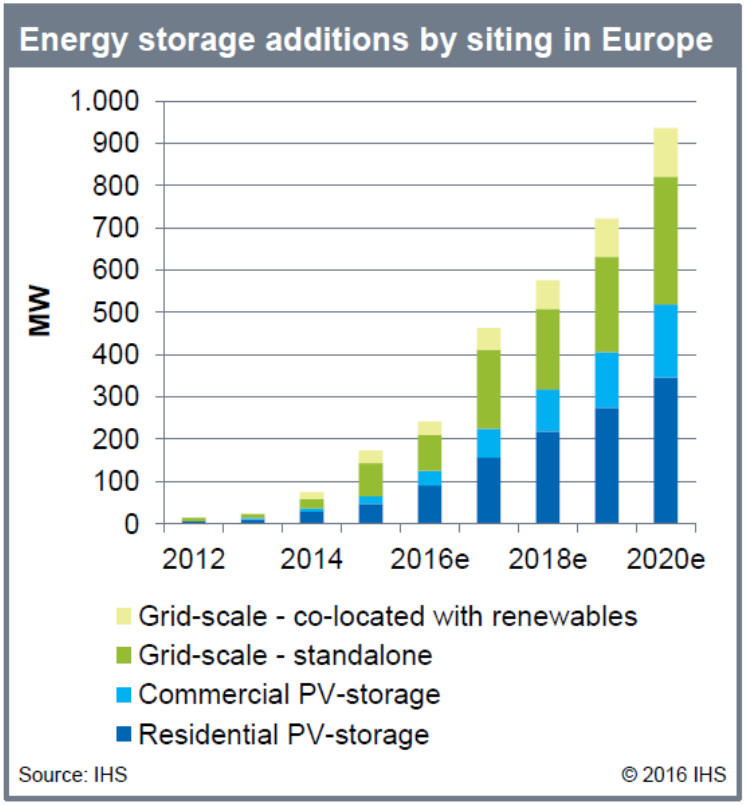
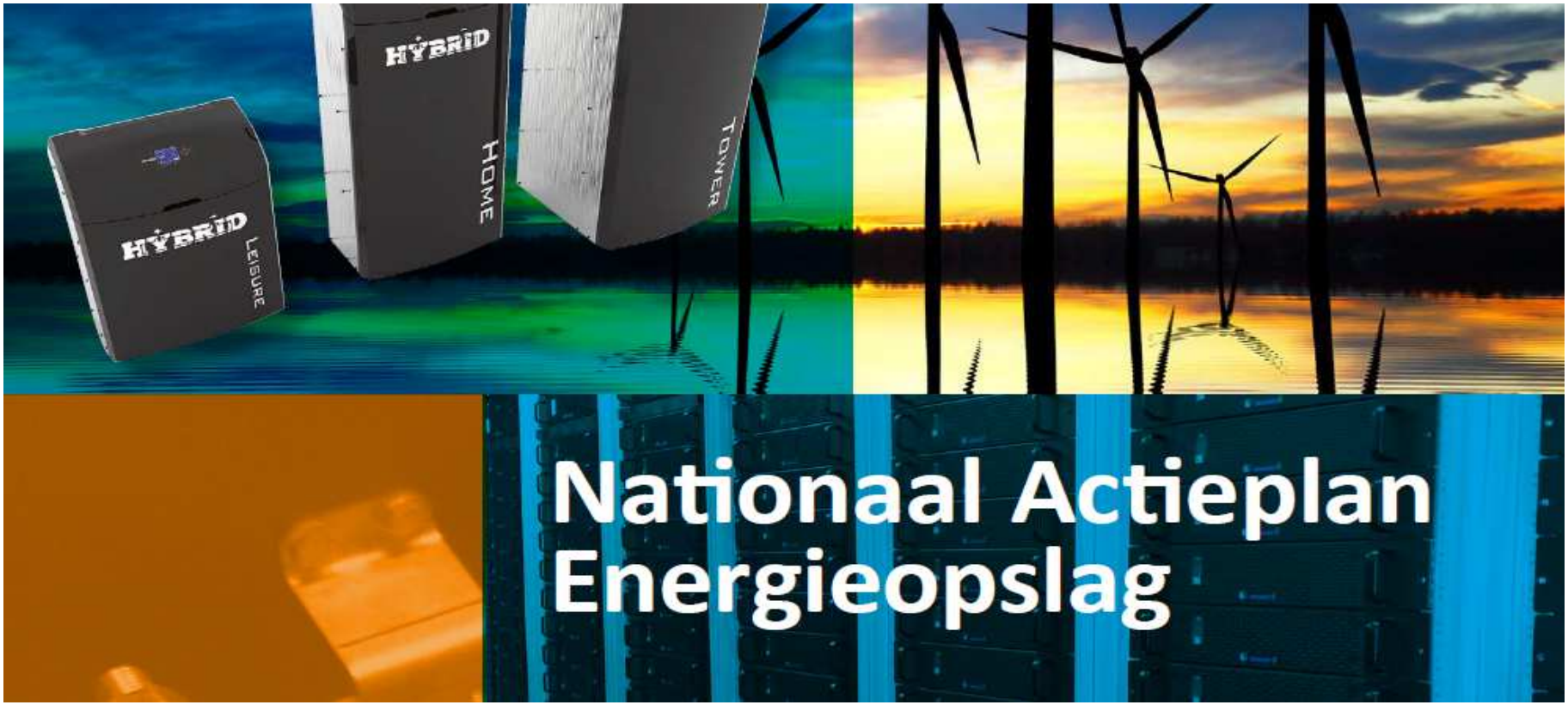
Perception of energy storage is changing



From complex and expensive to an essential building block for a largely emission-free energy system

National Actionplan Energy Storage



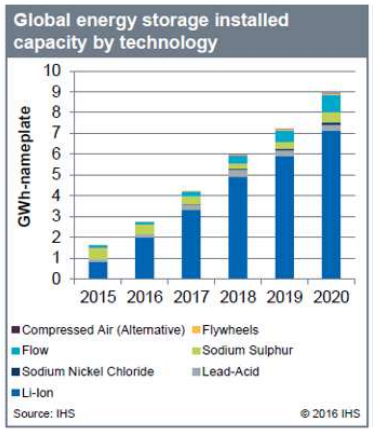
Growing need for flexibility, The Netherlands is falling behind, despite multiple opportunities. Goal: challenges into actions

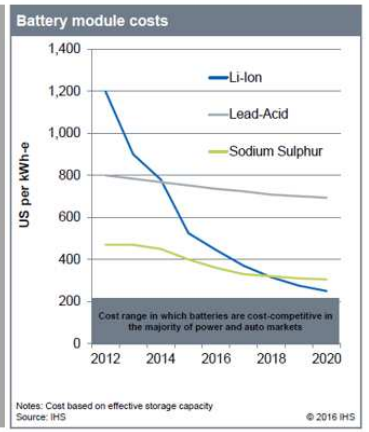
Eight emerging dynamics for solar + storage

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

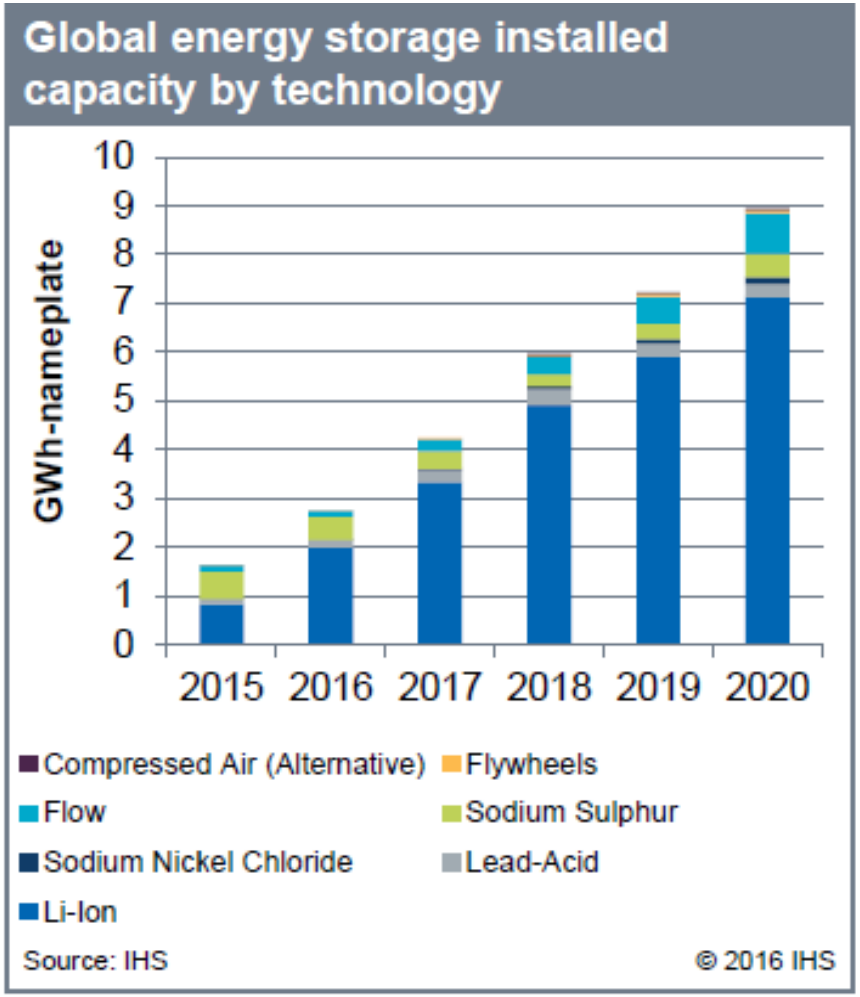


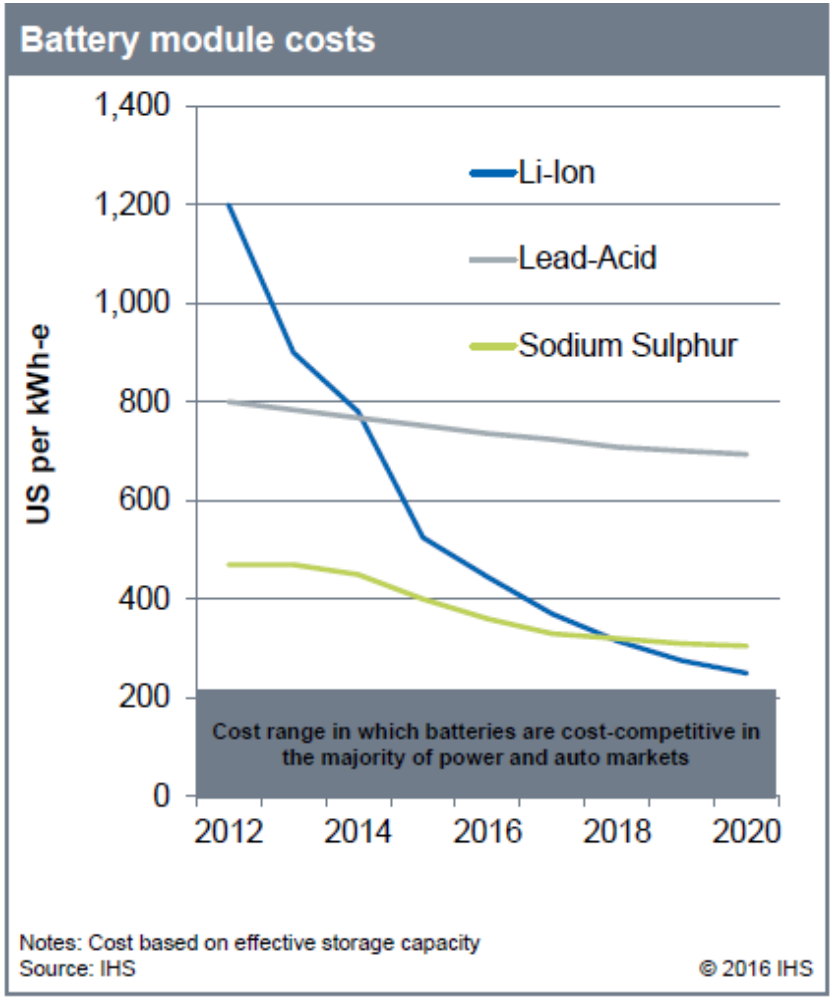


Eight emerging dynamics for solar + storage

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)

Installed capacity rising and costs decreasing





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 redox 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)

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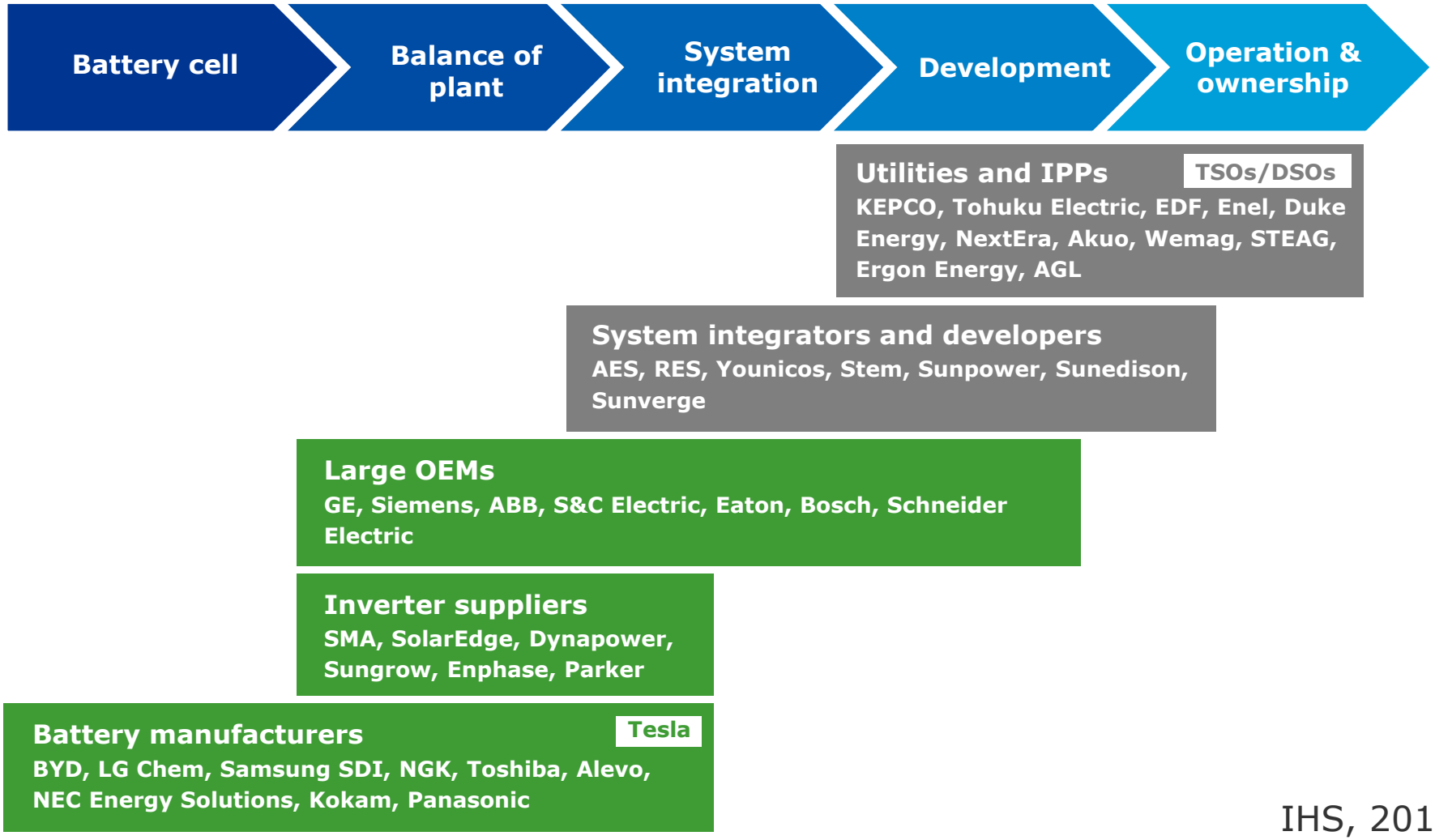
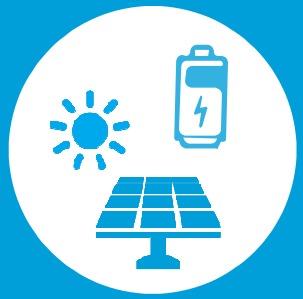
Key players in the battery value chain



IHS, 2016

Business cases and example projects



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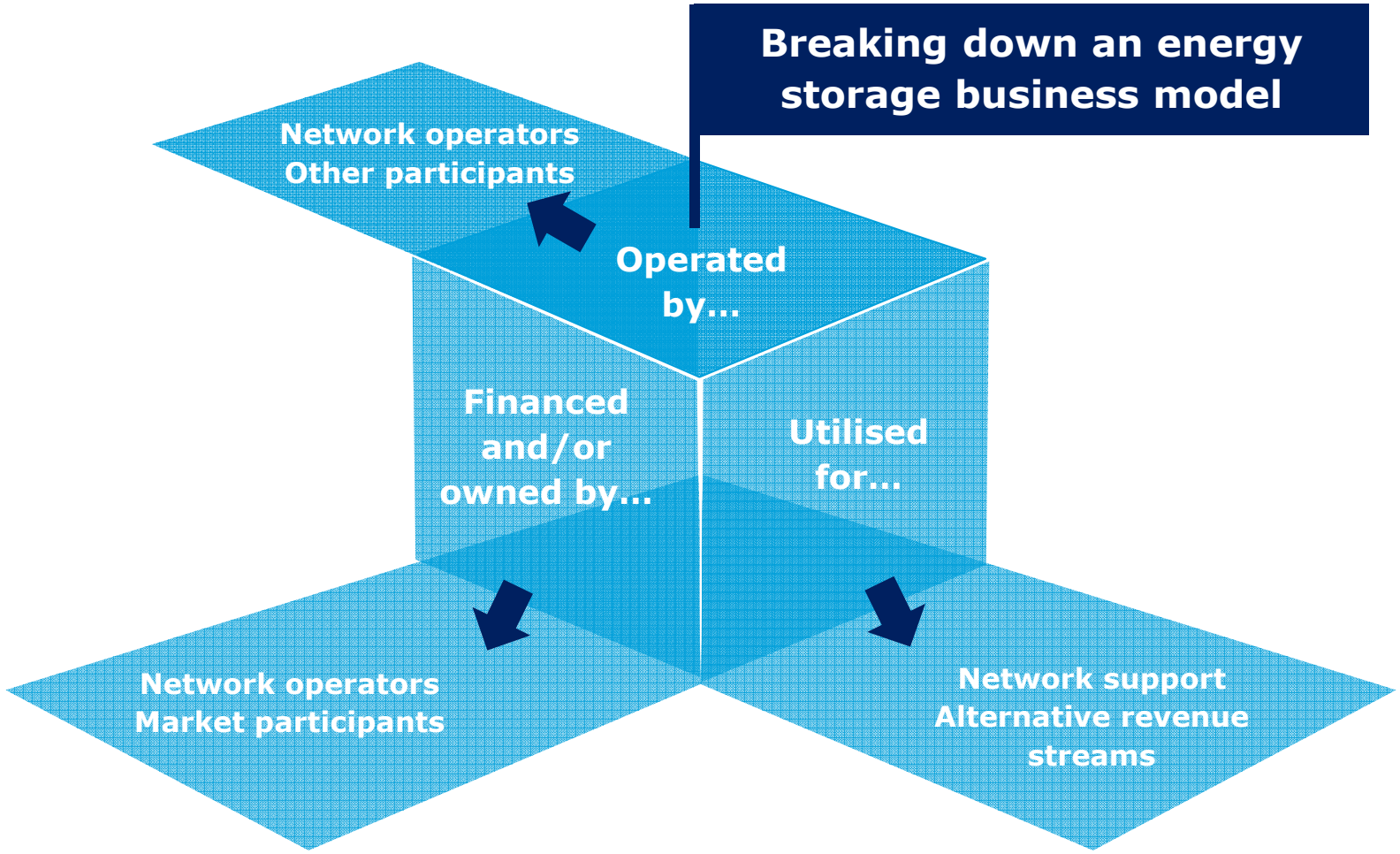
Business models



Value disclosing: potential revenue streams and energy cost savings from stacked applications

PPA

Offtaker
Revenue via energy payments

Multiple revenue streams

Revenue via energy payments

Revenue via availability payments
(TOU, arbitrage, peak shifting)

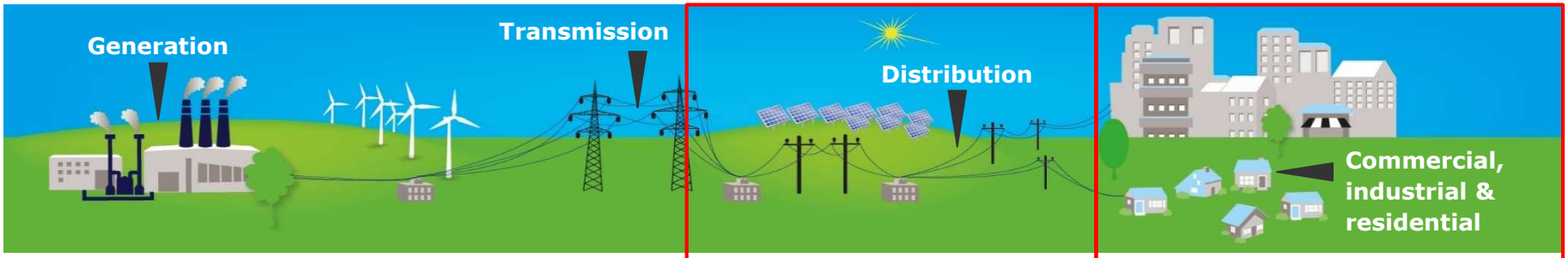
Ancillary services
- Frequency response
- Voltage support
- Ramp rate control

Trade on the spot market

Cost savings

Demand charge reductions
Back-up power

Storage provides different services across the energy network



Bulk storage >50 MW	Aggregated utility scale 2 - 50 MW	Utility scale 100 kW - 10 MW	Customer-led storage <10 MW
Arbitrage			
Synthetic inertia			
Load shifting			
Network support –voltage, thermal constraints support…			
Smoothing and **firming up non-firm generation**			
Ancillary services - frequency and reserve products from the TSO			
			Outage mitigation

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Behind the meter: acceleration by public acceptance

Customer-led storage (behind the meter) <10 MW

Behind the meter: solar integration

Customer-led storage (behind the meter) <10 MW

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
- 35 Tesla Powerwalls
- Testing flexible tariffs
- For trading and avoiding grid congestion

Behind the meter: Post- net metering

Customer-led storage (behind the meter) <10 MW

Replacing net-metering regulation by a 'feed-in subsidy' of which the height can be reduced stepwise over time.

Starting point for this arrangement is the continuation of investment certainty (pay-back time PV installation of 5-7 years) and the stimulance of momentaneous energy usage

Furthermore:

- **Dynamic pricing for end-users**
- **Dynamic tariffs distribution grids**

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Community storage/De Buurtbatterij

Utility scale 100 kW–10 MW	Customer-led storage (behind the meter) <10 MW

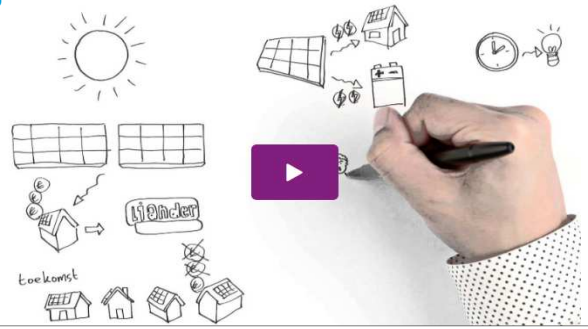
Multiple applications

- Virtual behind the meter storage
- Local grid congestion
- Voltage/power quality
- Trading
- Ancillary services

Multiple challenges

- Technical (dimensioning, connection, etc.)
- Financial (disclosing and prioritizing revenue streams)
- Ownership, regulatory
- Social acceptance

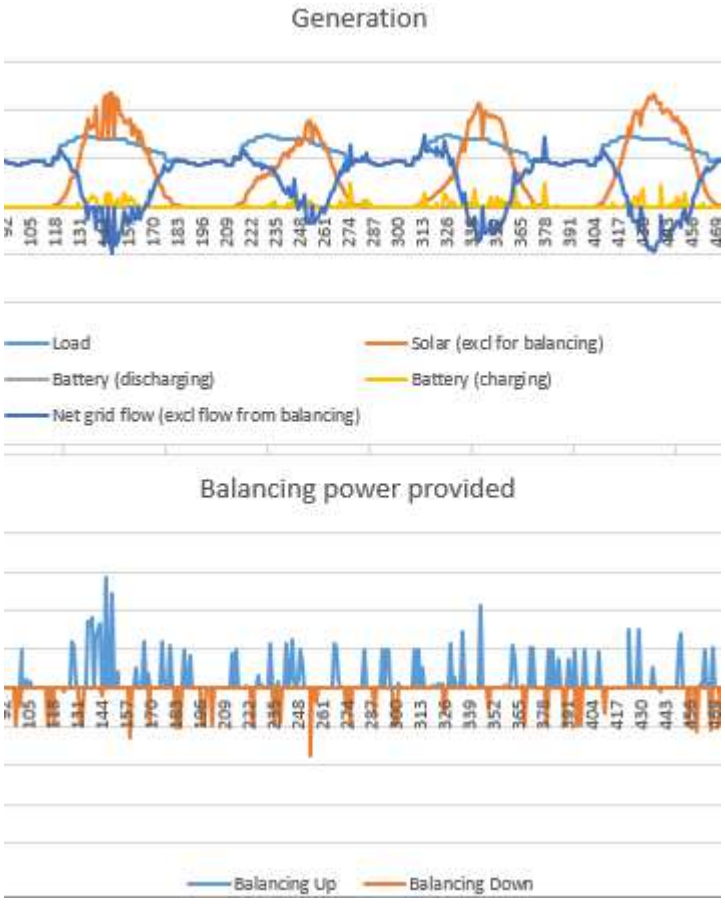
Buurtbatterij



Commercial & industrial solar + storage

Utility scale
100 kW–10 MW

- Storage system 10MW/20MWh
- Solar-PV system 30MW AC
- Revenues from:
  - Balancing market
  - Self-consumption
  - Grid-connection



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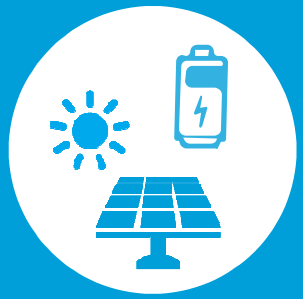
Risk identification & mitigation



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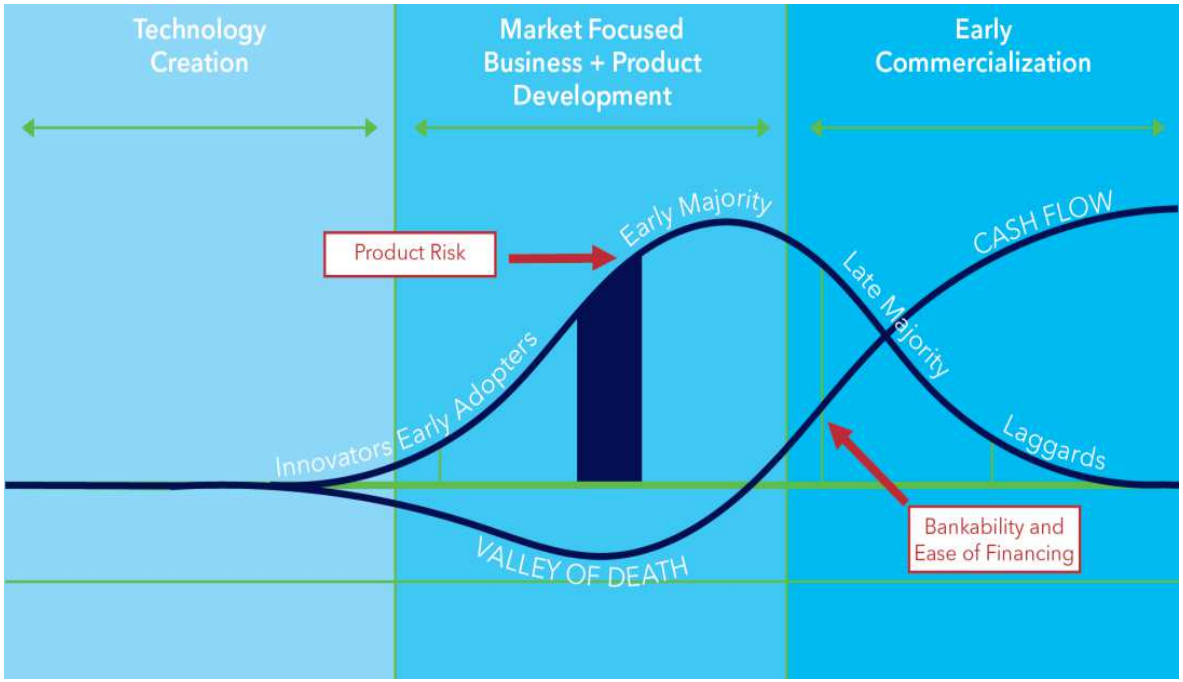
Technology development: crossing the chasm of risk

- **Early stage technology is traditionally funded through cash or owner-operated sources until the technology and projects are deemed *bankable***
- **Emerging technologies undergo the risks of independent engineering to secure confidence in future returns and become bankable**

- **Risk categories:**
  - **safety**
  - **operation**
  - **performance**
- **How to mitigate risks?**
- **How to prove risk mitigation?**



Technical performance indicators - definitions

Key Technical Metric	Definition
C-Rate	Measure of the rate at which a battery is discharged relative to its maximum capacity. The ratio between the power and energy (W:Wh) A High C-Rate = High Power
Self-discharge rate	Reduction of the energy content relative to actual energy capacity) of an EES while the system idles (%/month)
Round trip efficiency	EES system efficiency over one cycle with equal final and initial SoC and with a specified DoD (either positive or negative)
EES System Efficiency	The useful energy output at the PCC divided by the energy inputs to the EES system including all parasitic energies needed to run the system, such as heating or cooling, etc. and expressed as percentage, at specified service conditions

Key Technical Metric	Definition
Partial Cycle	A cycle in which the SoC at the end is different from the SoC at the start
State of Health (SoH)	Actual capacity relative to the initial rated capacity of the EES, given as a percentage (%)
Cycle lifetime	Theoretically achievable number of cycles when the EES is cycled with equal full charge-discharge cycles
Calendar lifetime	Theoretically expected lifetime if the EES is not cycled at all, caused by EES degradation over time
End of Life	Moment in time after commissioning of the EES system when its performance, whether technical, financial or otherwise, has degraded to the point of being no longer usable in its current application (# of cycles)

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Real-life examples of materialised risks

Feasibility risks

- Business case calculated for general /other application
- Market saturation not taken into account

Performance risks

- Cycle life data under different conditions
  - DoD, temperature, C-rate, …

Contract risks

- System boundary unclear
- Guarantees and conditions unclear

Regulation/certification risks

- Systems not allowed to participate in markets (changing…)
- Systems not meeting standardisation (gaps!)

Safety risks

- No FMEA analysis, no adequate measures and training
- Cyber safety

… and many more!

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**

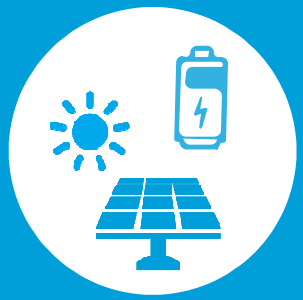
Defining building blocks for an open competitive market place

Continuous updates following technology development and end-user applications

SAFETY	OPERATION	PERFORMANCE	APPROACH
FMEA/Bowtie analysis	Monitoring	Definitions	System and component level
Risks and mitigation	Control	Conditions	Technology-agnostic and -specific
Design consequences	Grid connection	Measurement	Applications and life cycle phases
Procedures & documentation	Environmental analysis	Life cycle costs	Standards, guidelines and regulations

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

Key take-aways



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Key take-aways

Drivers are price, regulation and emotional appeal	**Several markets already interesting, 'new value' to be disclosed**	**Important to distinguish customer value and system needs**	**Benefit stacking – both parallel and in series**	**GRIDSTOR Recommended Practice as the technical framework for risk analysis**

Thank you

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