Decentralized Energy Storage – Challenges for Batteries

STYRIAN ACADEMY for Sustainable Energies

VARTA Microbattery GmbH – Company Figures

Headquarter:	Ellwangen, Germany
Management:	Herbert Schein (CEO) Jens Stahmann (CFO)
Employees:	Germany: 530 worldwide: 1700
Turnover:	150 Mio. €

Company history and world history go hand in hand

1893

First electromobile

The electric car Baker „Runabout“ captures the German market. VARTA supplied the battery.

1896

First North Pole expedition

Fridtjof Nansen explores the utmost north of our planet. VARTA supplied the expedition with light.

1969

First moon landing

Neil Armstrong entered as first human being the moon. VARTA enabled the historic pictures of the expedition.

2003

Smallest rechargeable hearing aid cell

Small devices with huge help. VARTA develops new microbatteries.

2009

Research company

The car of the future drives with electric current. VARTA is pumping energy into the heart of the electromobile.

2010

Energy turnround

Germany starts with the energy turnround. VARTA makes enery storage possible.

VARTA Strategy

VARTA Microbattery

Core Business Microbatteries

Retail

PPS

OEM

VARTA Micro Innovation

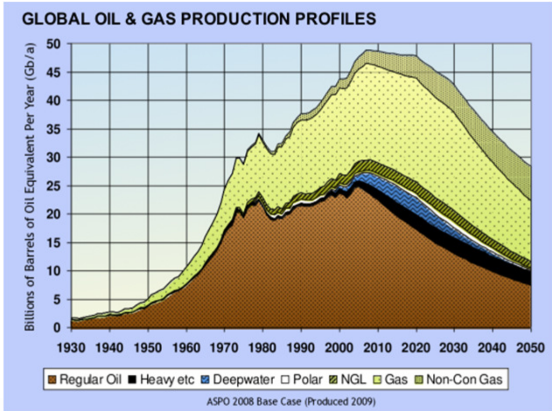
E-Mobility

Research & Development together with Volkswagen

BESS Battery Energy Storage System

Competence Center

Energy Problem of the World



Fossil Fuels

- *Peak Oil*

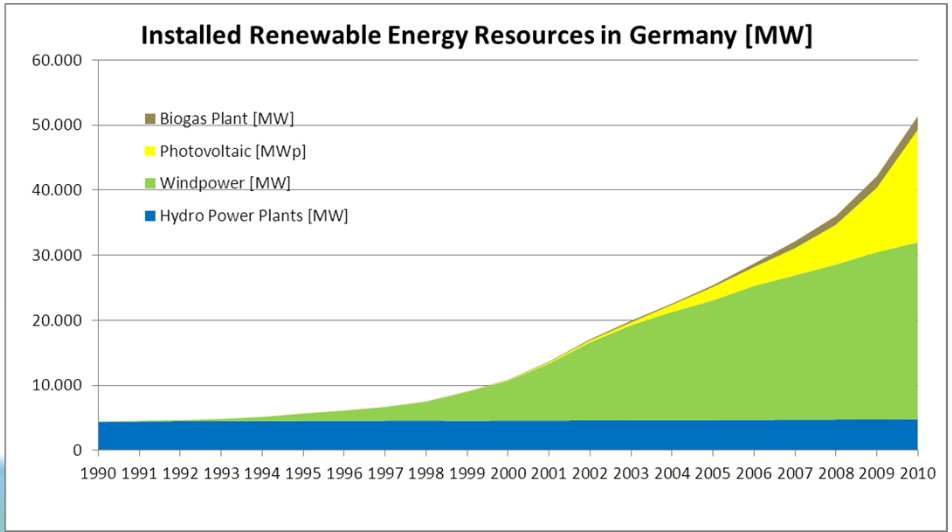
Fossil Fuel Power Station

- *CO_2 Production*
- *Global Warming*

Atomic Power Station

- *Technical Risk*

Solution of the Energy Problem: Renewable Energy



Wind Energy

Hydro Power

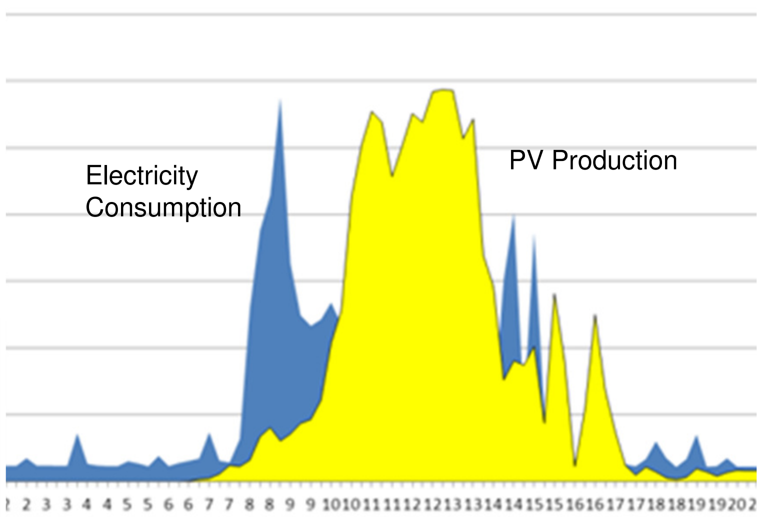
Bio Gas

Solar Energy

Quelle: AGEE-Stat

Problem of Renewable Energy

The balance between power production and consumption must be ensured every second…..



….but the production of renewable energies is decoupled from the consumption

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How to integrate Renewable energy

Expansion of the Power Grid	Demand Side Management	Centralized Energy Storage	Decentralized Energy Storage
Transmission line, Distribution line Suficiant up to 35 % renewable energy*	Smart Home, Smart Metering	Pump storage hydro power plant, Compressed air power plant, Hydrogen, Methan storage	Batteries - Lead-Acid - Li-Ion - NaS - Redox Flow

*Source: Dena II Study

Battery Storage: Chemistry

	Lithium Ion Battery	Lead-Acid Battery	NaS High Temperature Battery	Redox Flow Battery
Energy density	200 – 400 Wh/l	50 – 120 Wh/l	170 Wh/l	20 – 30 Wh/l
Power density	700 – 1300 W/l	10 – 400 W/l	20 – 40 W/l	5 W/l
Efficiency	90 – 95 %	75 – 85 %	75 %	75 %
Lifetime	~8 Years ~3000 Cycles	~3 Jahre ~250 – 1000 Cycles	~7 Years >2500 Cycles	~35 Years ~13000 Cycles
Costs (Cell)	500 – 1000 €/kWh 1500 – 4000 €/kW	150 – 350 €/kWh	200 – 300 €/kWh 1000 – 2000 €/kWh	300 – 800 €/kWh 1500 – 4000 €/kWh
System costs	1800 €/kWh	300 €/kWh	estimated 700 €/kWh	estimated > 1000 €/kWh
Market maturity	Development	Mature	Development	Research

Source: FhG Energietechnologien 2050

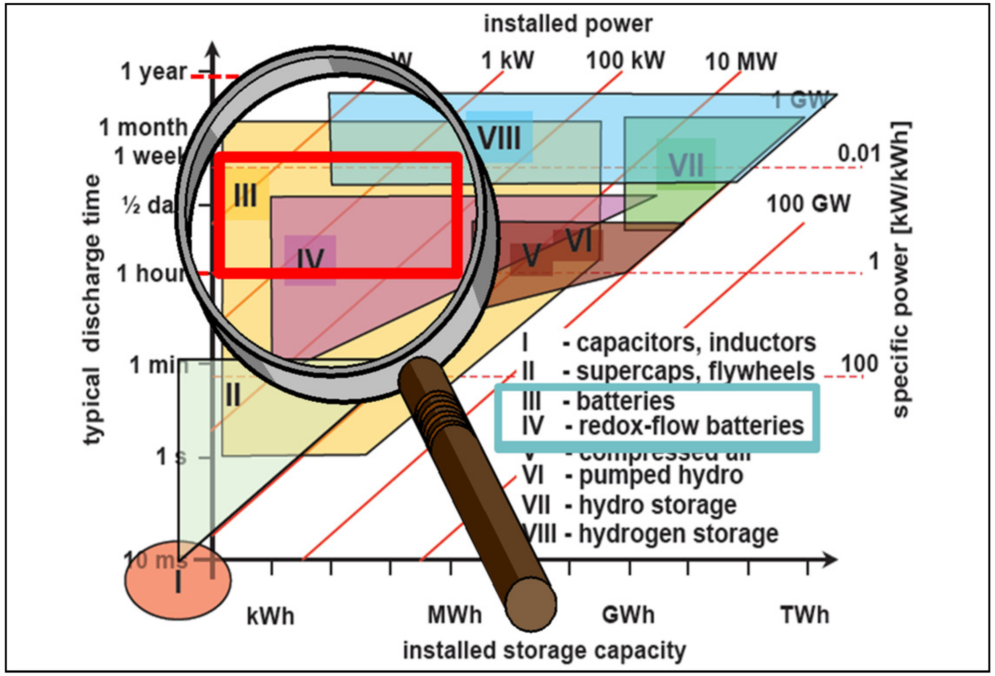
Applications for Battery Storage

EXHIBIT 1 | Financial Attractiveness of Electricity Storage Applications and Related Technologies

Application	Pumped hydro	CAES	A-CAES[1]	Hydrogen	Sodium-sulfur batteries	Redox-flow batteries (VRBs)	Lithium-ion batteries
Price arbitrage	Needs further cost degression	Needs further cost degression	Needs further cost degression	Needs further cost degression	Needs further cost degression	Needs further cost degression	Needs further cost degression
Balancing energy	Attractive today	Attractive today	Needs further cost degression	Needs further cost degression	Needs further cost degression	Pooling of many dispersed installations needed to achieve minimum power	
Provision of black-start services	Attractive today	Attractive today	Needs further cost degression	Needs further cost degression	Needs further cost degression	Needs further cost degression	NA
Stabilizing conventional generation	Attractive today	Attractive today	Attractive today	Needs further cost degression	Attractive in 2015	NA	NA
Island and off-grid storage	NA	NA	NA	Needs further cost degression	Attractive in 2015	Attractive in 2015	Attractive in 2015
T&D deferral	NA	NA	NA	NA	Attractive in 2015	Attractive today	Attractive in 2015
Industrial peak shaving	NA	NA	NA	NA	NA	NA	Attractive in 2015
Residential storage	NA	NA	NA	NA	NA	NA	Needs further cost degression

Attractive today[2] — Attractive in 2015 (given expected 2015 costs) — Needs further cost degression and/or subsidies to be viable

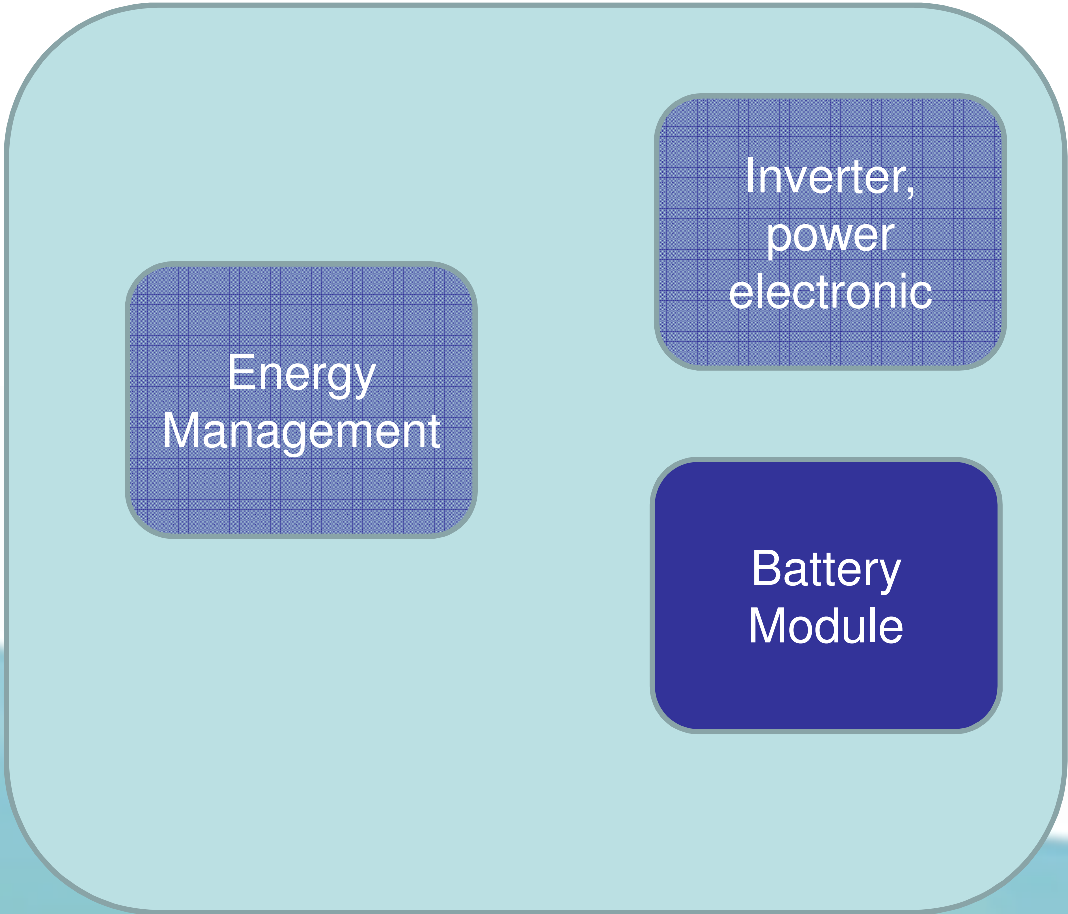
Source: BCG analysis.
[1]A-CAES is the second generation of CAES technology. It includes a thermal storage unit to avoid thermal energy losses during compression and decompression, thereby potentially increasing round-trip efficiency to approximately 70 percent. The technology is not yet mature and faces several challenges.
[2]Expected IRR of 7 percent or more.



Source: BCG Study Revisiting Energy Storage

Source: DU Sauer

Components of a Storage Battery



Challanges for Batteries

Capacity	Costs
Safety	Lifetime

Challanges for Batteries

Capacity

- Energy of laptop cell ~11Wh
- Energy of a large format cell ~150Wh
- Assembly of a huge number of cells necessary to reach reasonable capacity of a battery system
  - 4500 respectively 300 cells for 50kWh
- Battery storage system's suited for decentralized energy storage
  - The energy will be stored were it was produced before e.g. energy from photovoltaic system's
- Vision: virtual storage plant
  - Connection of a huge number of battery storage system
  - Needed:
    - Centralized intelligence
    - Communication system

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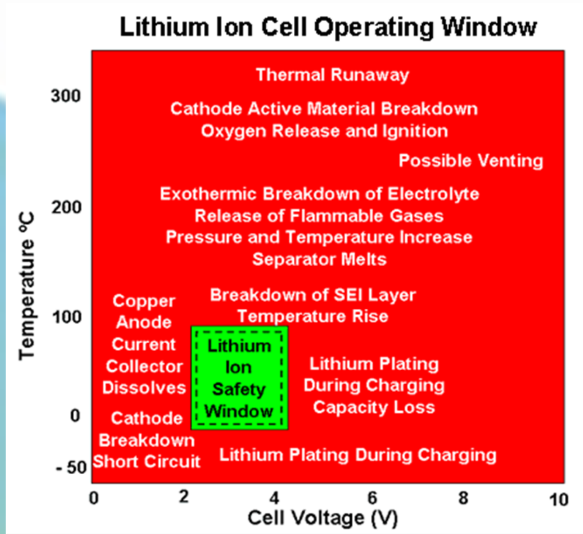
Challanges for Batteries

Safety



- Operation of lithium ion cells only in a small operating window safe

- Research of cell chemistry to extend operating window
  - New electrode material
  - Improved electrolyte

- Every cell has to be controlled with respect to voltage, current and temperature → protection circuit

- Battery management system for series connected battery cells
  - Passive BMS: bypass with a resistor (loss of heat)
  - Active BMS: charge transfer from weak cell to strong cell

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Challanges for Batteries

Lifetime

- 2 modes of aging
  - Calendric aging
  - Cycle aging
- Target Lifetime
  - >20 years
  - >7000 cycles
- Short lifetime increases life cycle costs
- Ways to increase lifetime
  - Research of cell chemistry
    - E.g. new electrode material
  - Reduced depth of discharge (DoD)
    - Example cell was cycled till 94% of its original capacity is remaining
    - 100% DoD: 500cycles, 80% DoD: 2500

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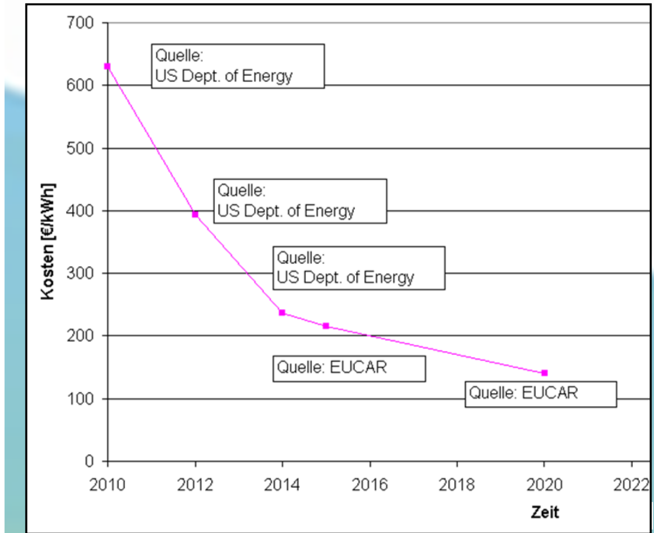
Challanges for Batteries

Cost

Cost roadmap EV lithium ion cells



- **Costs for battery storage system's are still to high**
  - Costs Today (Cell Level): 500-1000€/kWh
  - Target Costs (Cell Level): 150€/kWh
- **Action needed**
  - Incentive program by government to stimulate the market, (e.g. like at the PV market)
  - Research for cost reduction
  - Using synergies with EV batteries (economy of scale)

VARTA Battery Energy Storage System

Engion by VARTY Microbattery

Residential energy storage in combination with PV system

6kWh usable Capacity.

THANK YOU.