BATTERY STORAGE – KEY ENABLER FOR RESILIENT ACTIVE DISTRIBUTION GRIDS AND MINI-GRIDS

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Fact-Finding Mission Philippines (Online)

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AGENDA

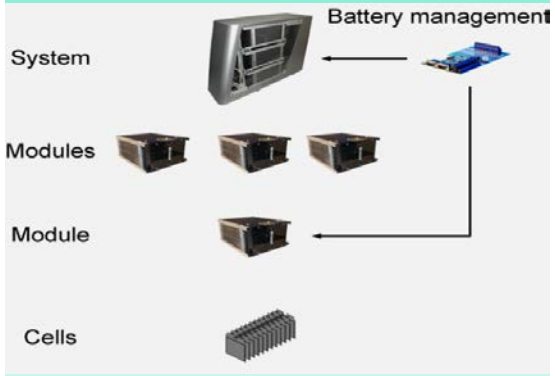
- Introduction to battery research, development and services at Fraunhofer ISE
- Stationary battery storage – Mission and market developments
- National grids – Transformation of power generation and supply structure
- Isolated mini-grids – Transformation of power sources
- The role of battery storage towards highest shares of renewables
- Conclusions

Department Electrical Energy Storage
Overview

Battery Cell Technology
materials, architecture, production

- Development and characterization of materials and battery cells
- Development of process technologies
- Aqueous systems for stationary energy storage
- Lithium-ion battery cells
- Solid state battery cells
- Technical and economical analysis
- Life cycle analysis

Battery Engineering
from cells to systems



- Cell formation
- Cell and system characterization
- Ageing and performance scrutiny
- System design and engineering
- Thermal management
- Battery management
- Algorithms for state estimation and life-time prediction
- Optimized charging and operating control strategies

Applied Storage Systems
system design, integration and quality assurance

- Realization of lighthouse projects
- Business case development
- Consulting during complete life cycle of storage projects
- System modelling, analysis and optimized system design
- Simulation based storage sizing
- Energy management systems
- Technical due diligence: Site inspection, testing and monitoring

TestLab Batteries
electrical, thermal, mechanical testing

- Ageing: calendric and cyclic
- Safety: components and systems including functional safety
- Reliability: consideration of operating conditions and system behavior with aged components
- Performance: efficiency and effectiveness
- End-of-line quality control for cell production

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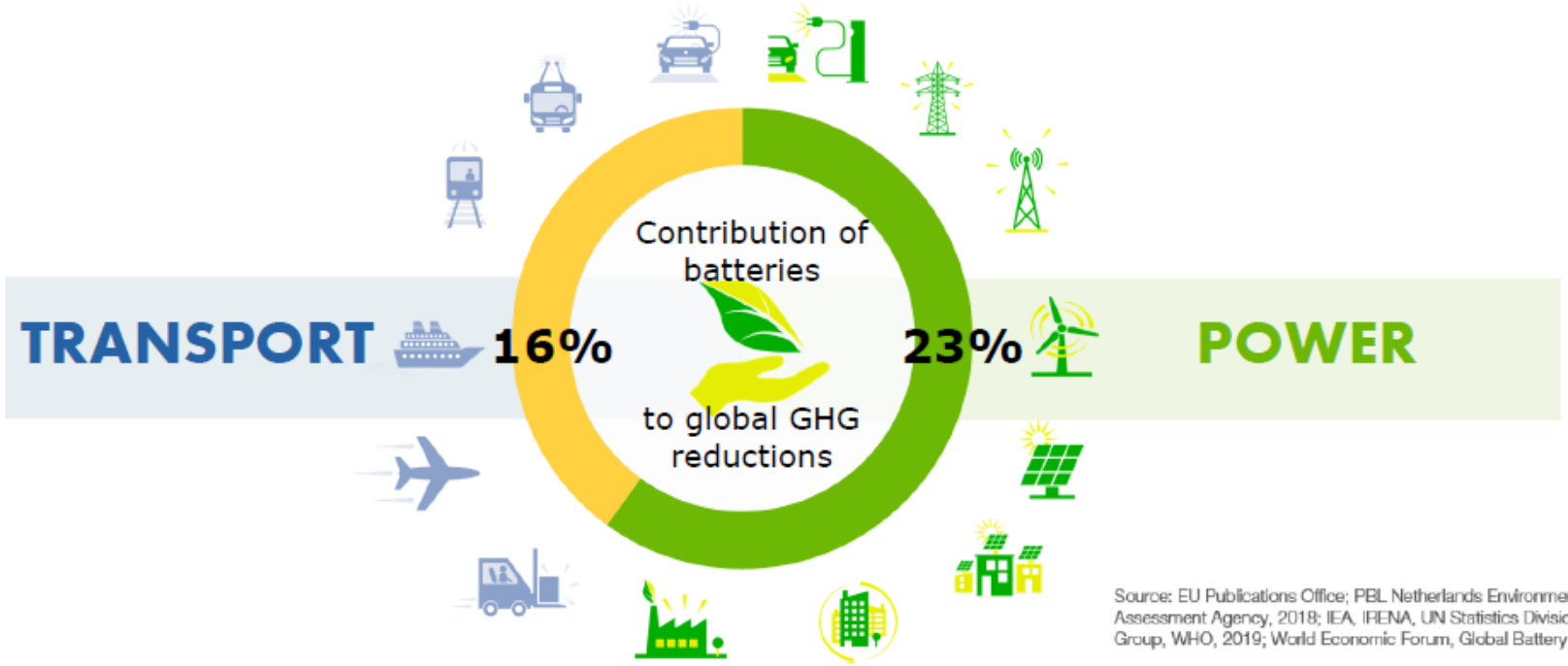
Stationary battery storage – Mission

Batteries Europe: Strategic Research Agenda – Extract

BATTERIES EUROPE
EUROPEAN TECHNOLOGY
AND INNOVATION PLATFORM

« Everything we can electrify will be electrified »



Source: E. Sheridan: Batteries Europe, European Technology and Innovation Platform – Overview of Strategic Research Agenda, Batteries Europe Webinar, 28th of October 2020.

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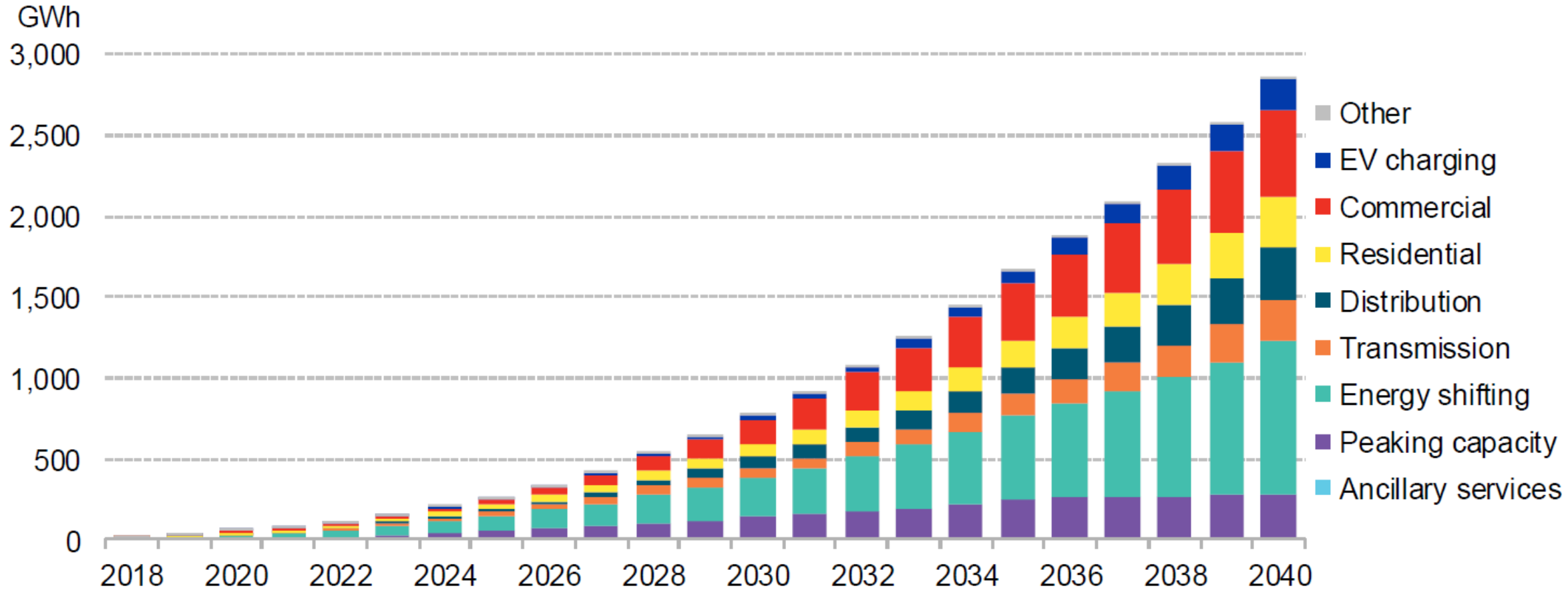
Stationary battery storage – Market developments

Prognosis for global cumulative deployments



Source: BloombergNEF, 2019.

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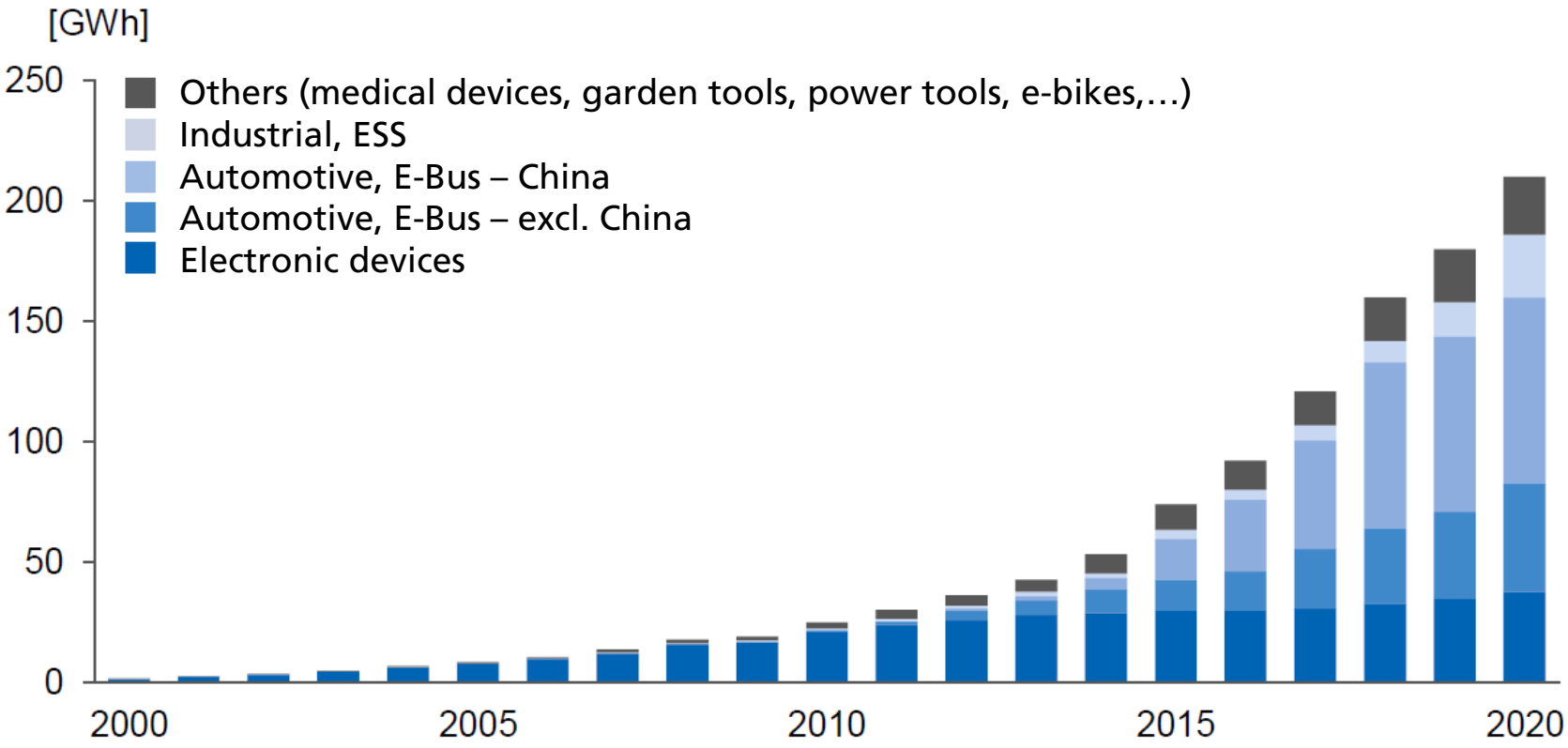
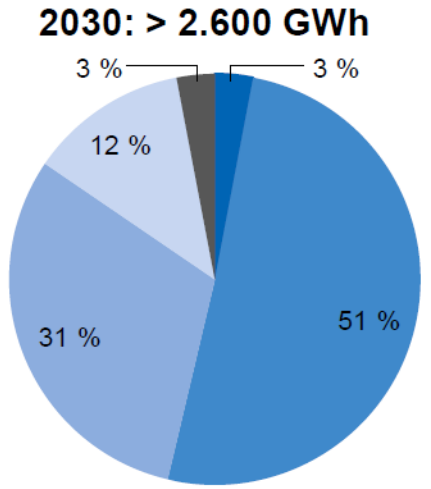
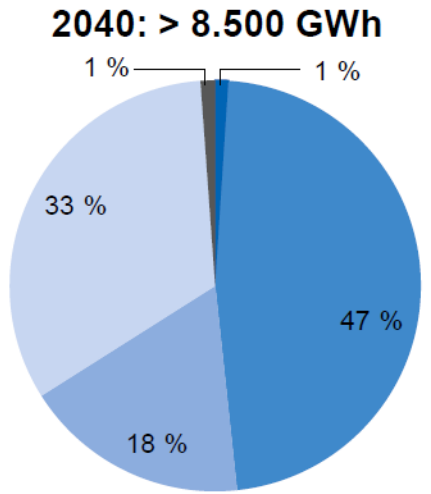
Stationary battery storage – Market developments in relation to automotive Lithium-ion batteries







Sources: J. Mähliß: Trends im Lithium-Ionen Batteriemarkt, 2020; BloombergNEF, 2020; Roskill, 2020; Avicienne Energy, 2019.

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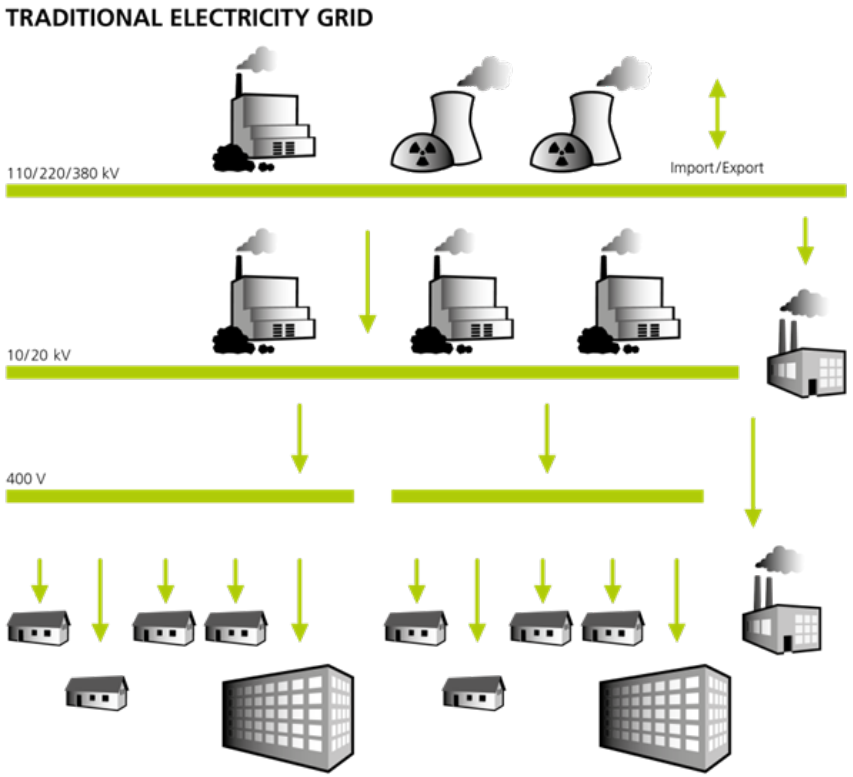
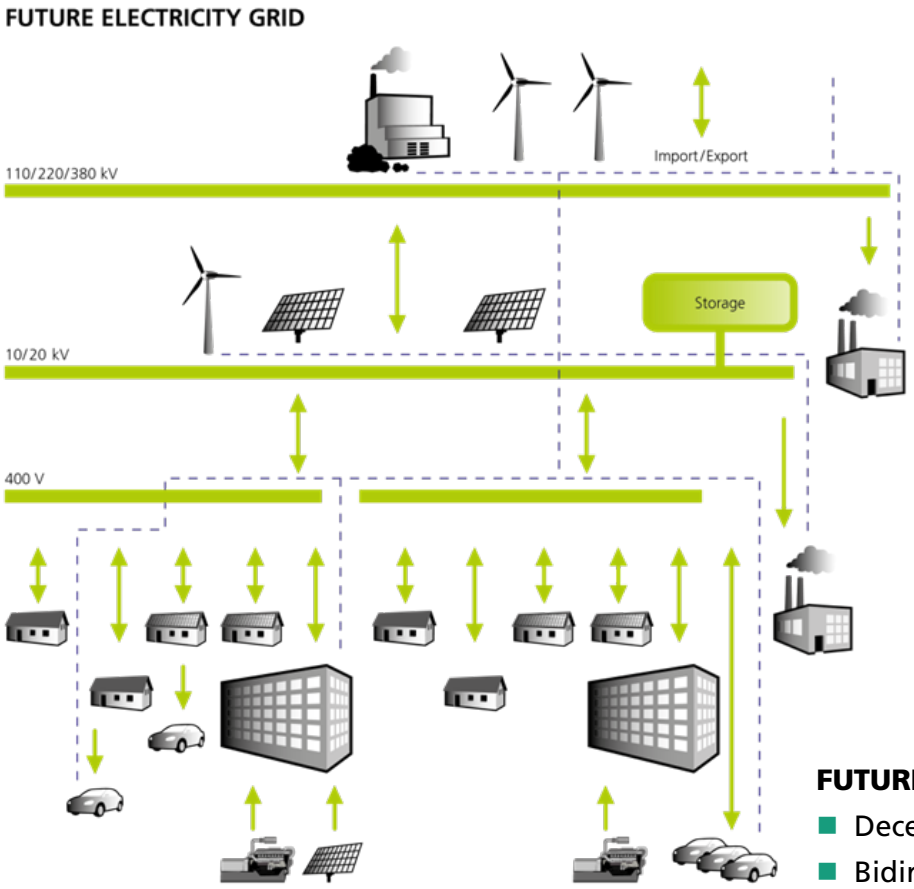
National grids – Transformation of power generation and supply structure

Towards active distribution grids with high shares of renewables





TRADITIONAL ELECTRICITY GRID

- Load coverage by large central power plants
- Top-down unidirectional distribution

FUTURE ELECTRICITY GRID

- Decentral fluctuating generators
- Bidirectional distribution
- Need for communication on distribution level
- Integration of storage

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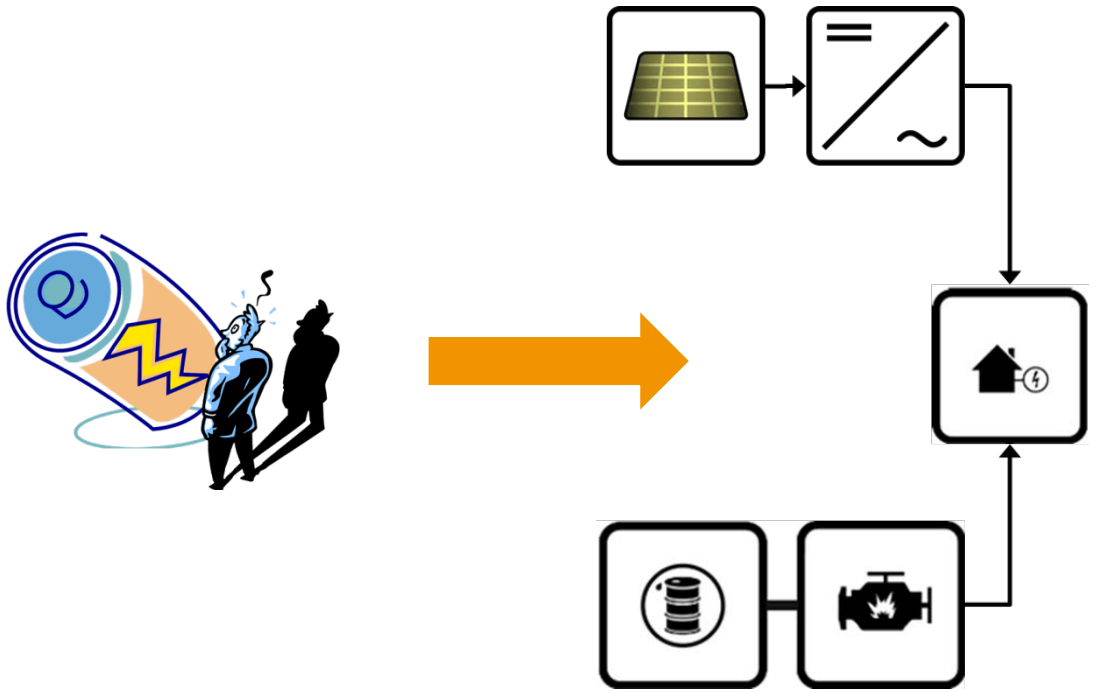
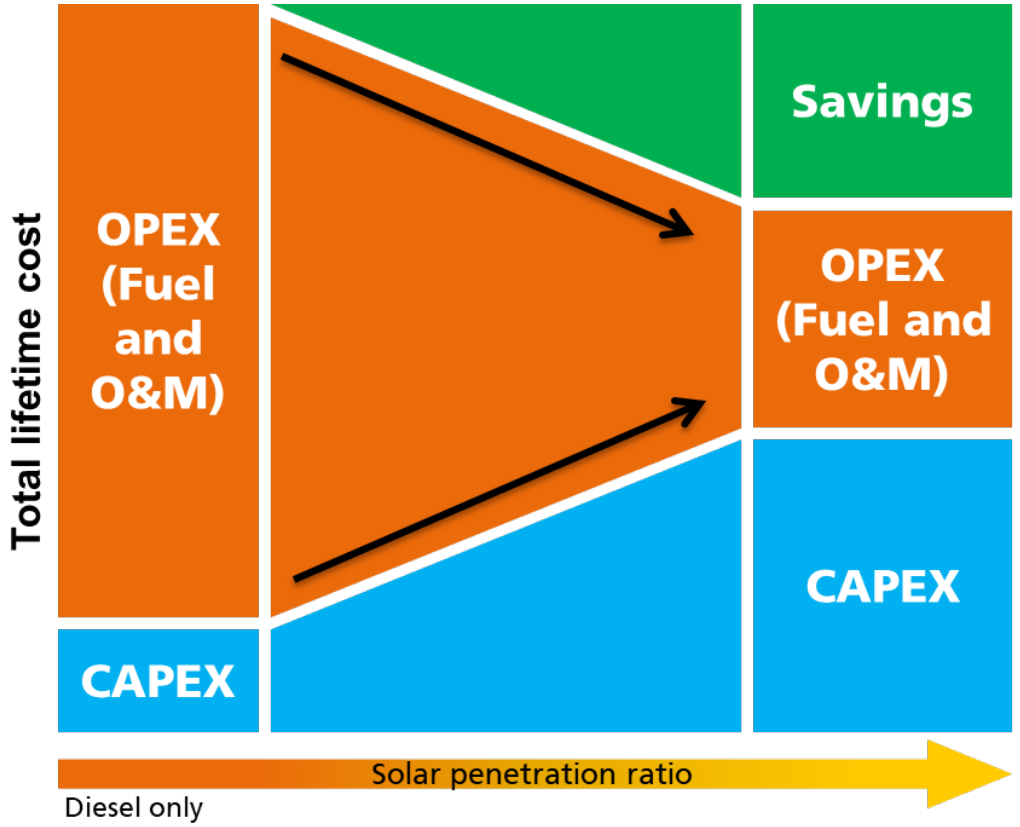
Isolated mini-grids – Transformation of power sources

Towards hybrid PV battery systems

The business case of PV integration in Diesel powered mini-grids

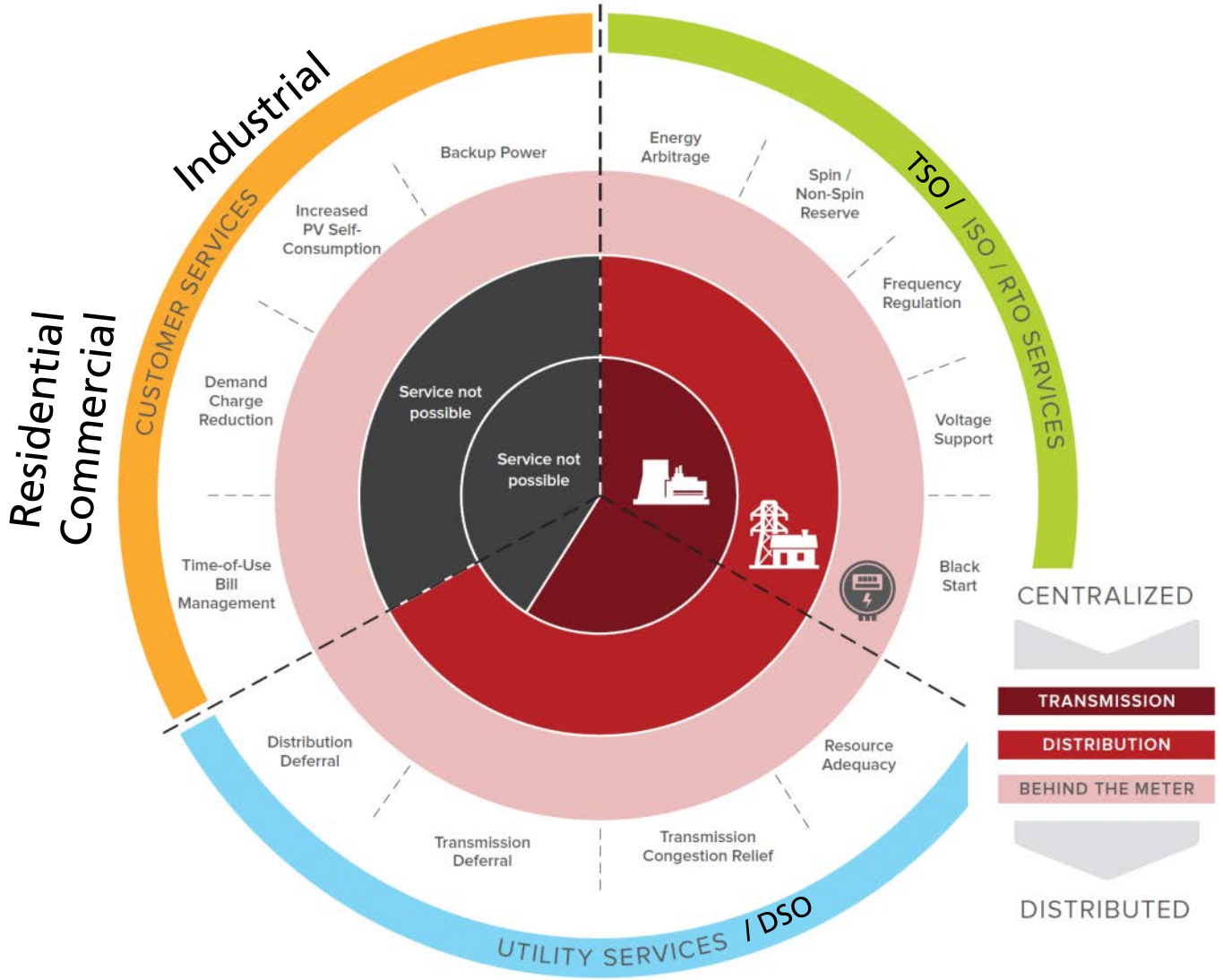




The role of battery storage towards highest shares of renewables

Business cases

Provision of services to three stakeholder groups



Source: F. Garrett, The Economics of Battery Energy Storage, Rocky Mountain Institute, September 2015.

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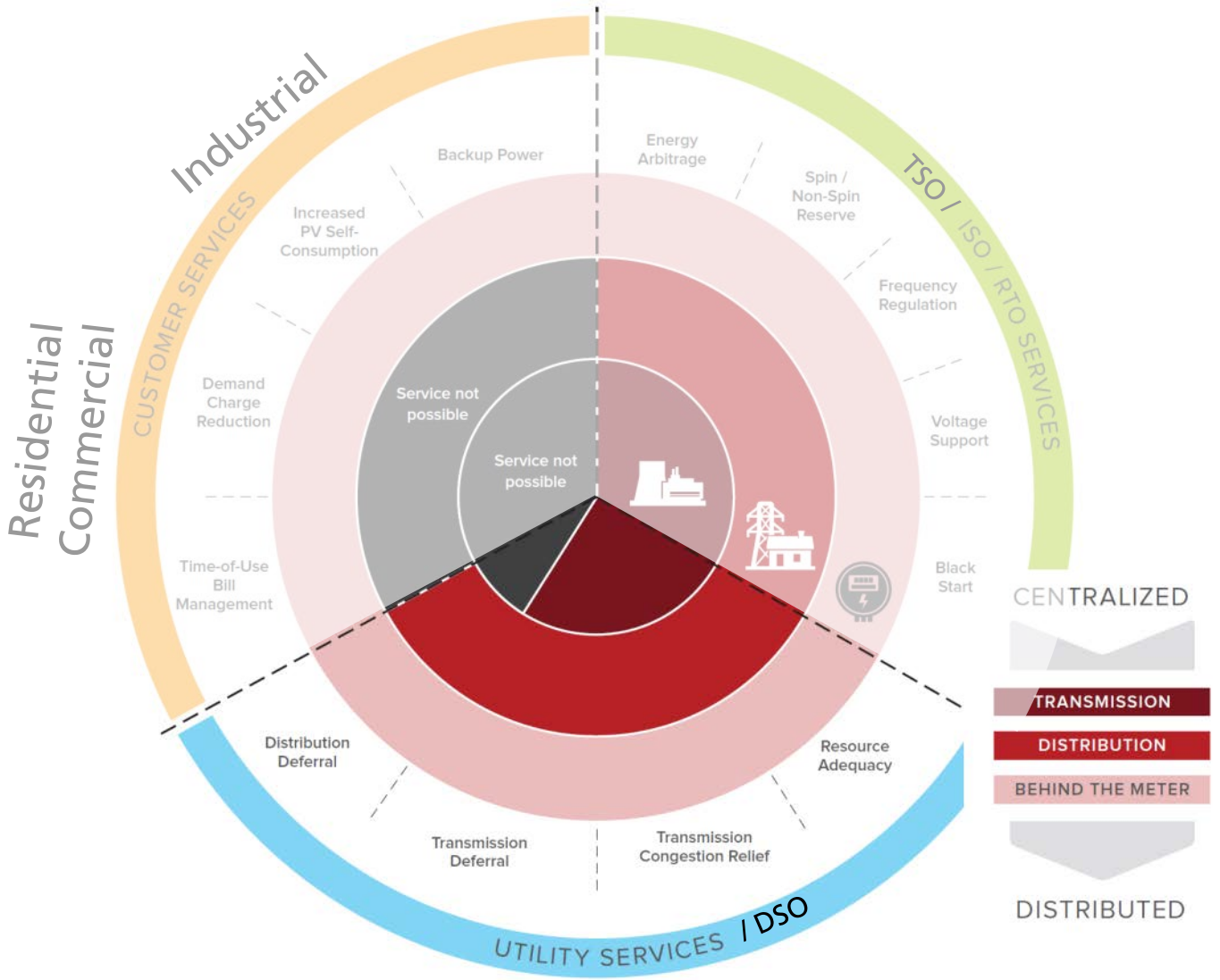
Distribution level

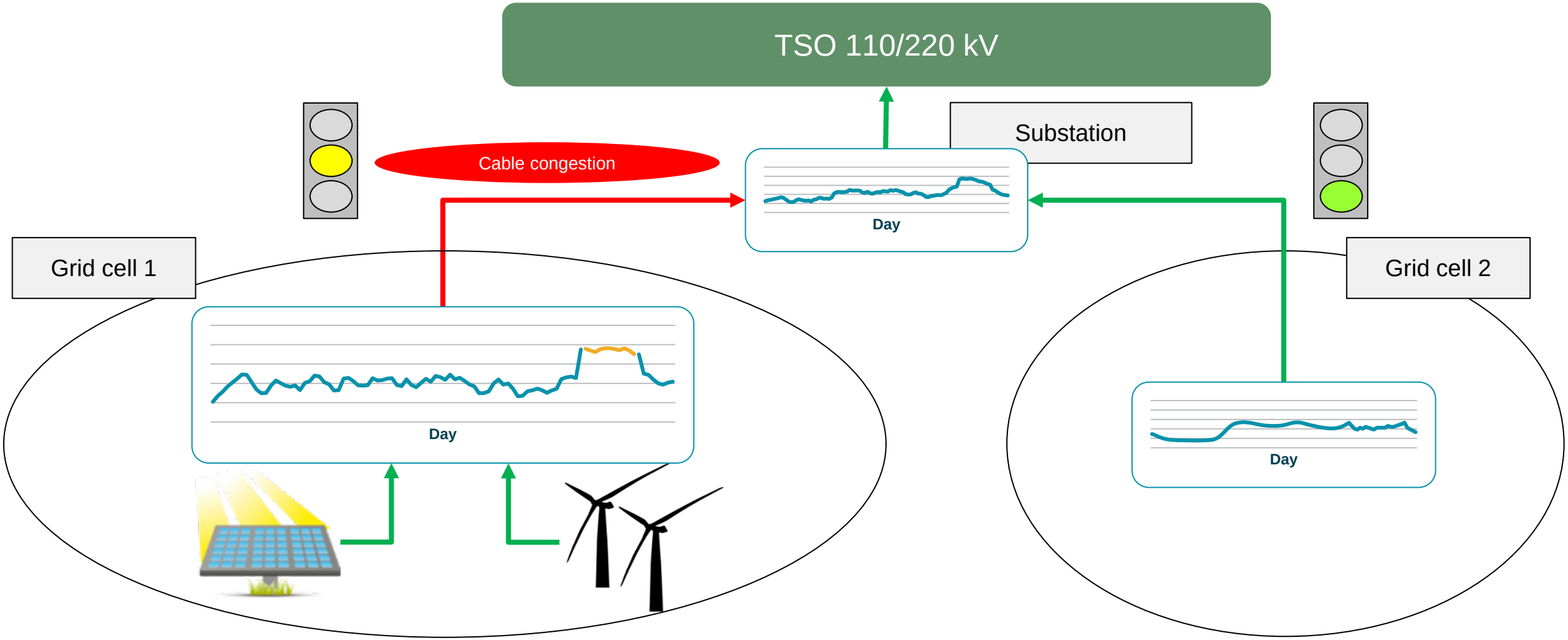
Provision of services to three stakeholder groups



Source: F. Garrett, The Economics of Battery Energy Storage, Rocky Mountain Institute, September 2015.

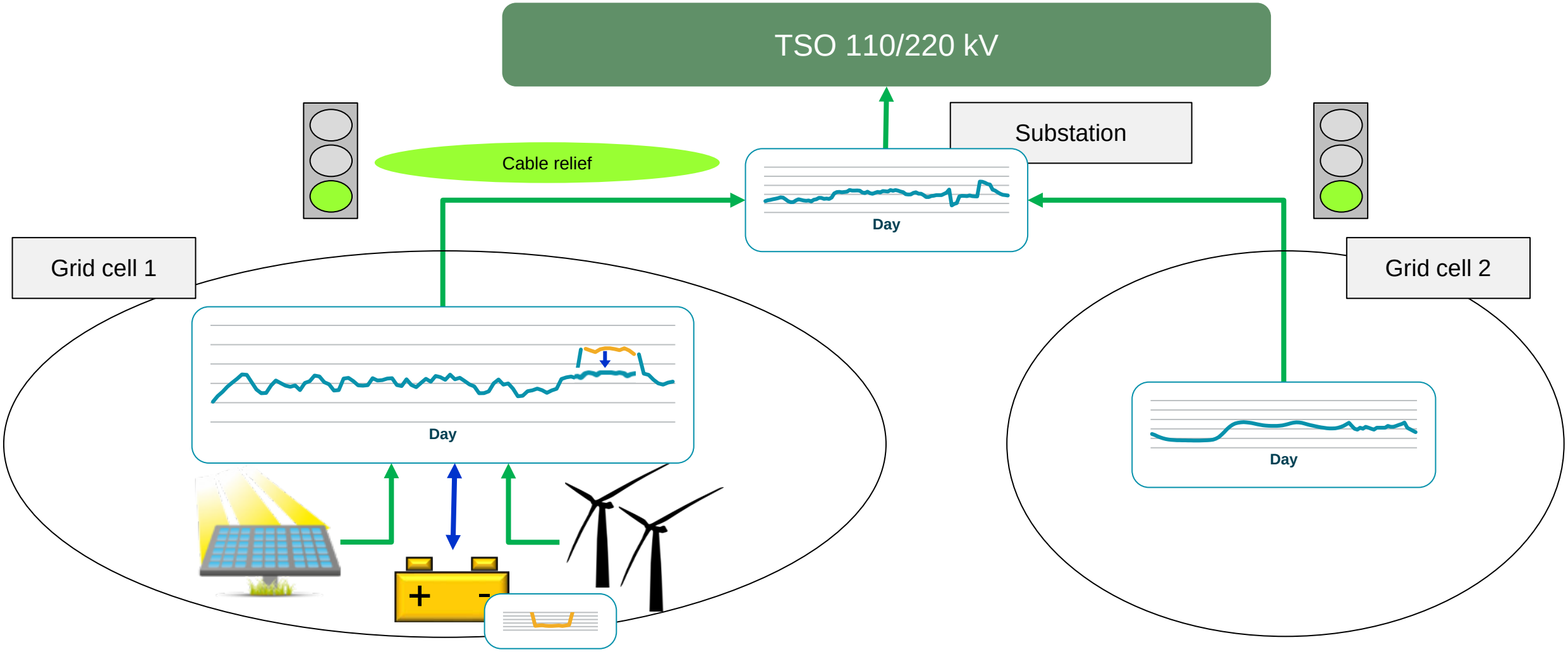
The role of battery storage towards highest shares of renewables

Example: Grid overload in grid cell 1



The role of battery storage towards highest shares of renewables

Example: Grid relief via usage of flexibility option in grid cell 1



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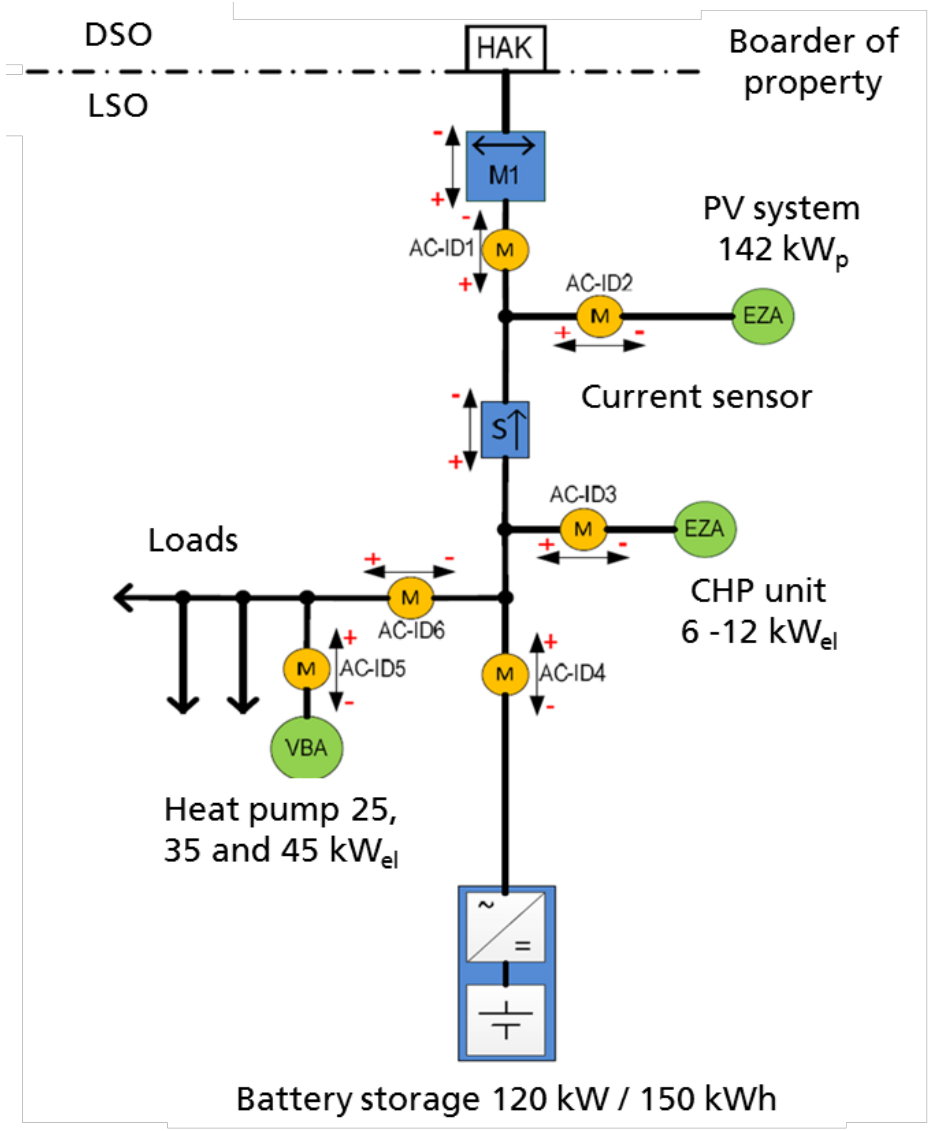
The role of battery storage towards highest shares of renewables

Distribution level – Example: Smart district “Weinsberg”

Optimization criteria:

Minimization of grid dependency –

Physically not only accumulated



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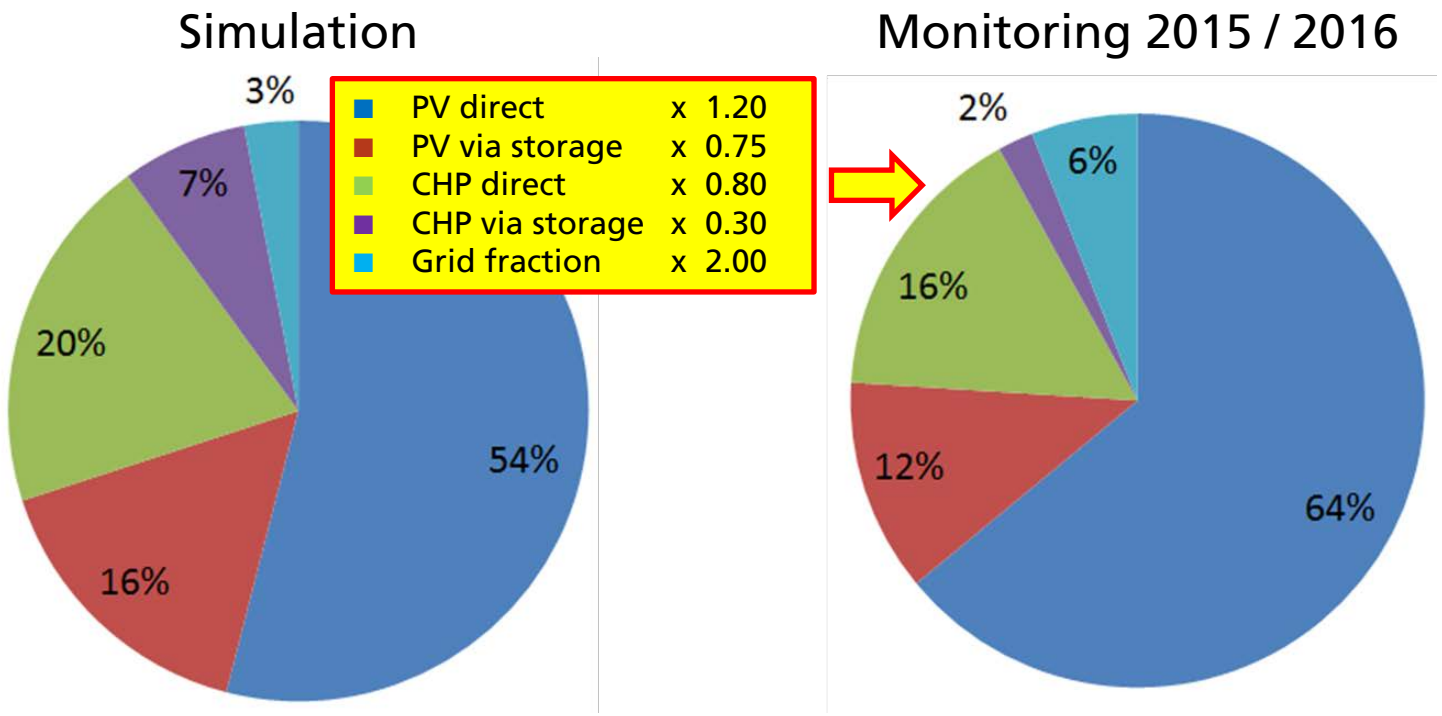
Distribution level – Example: Smart district “Weinsberg”

Accumulated annual electrical energy quantities



Reasons for differences:

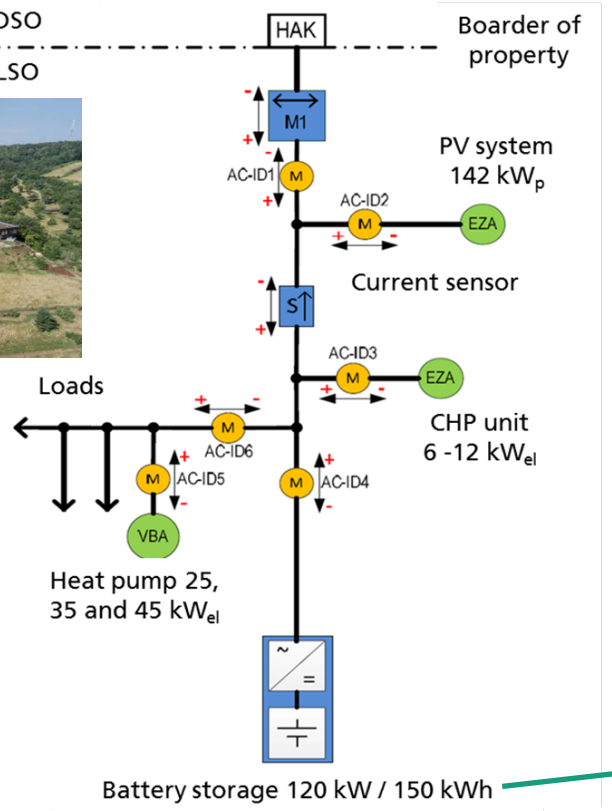
- Problems with air conditioning → To high temperatures in operation room → Shut-down of CHP unit and battery inverter
- Necessary maintenance interval of CHP unit in winter (!)
- End-users do not behave 100 % as predicted (!)

The role of battery storage towards highest shares of renewables

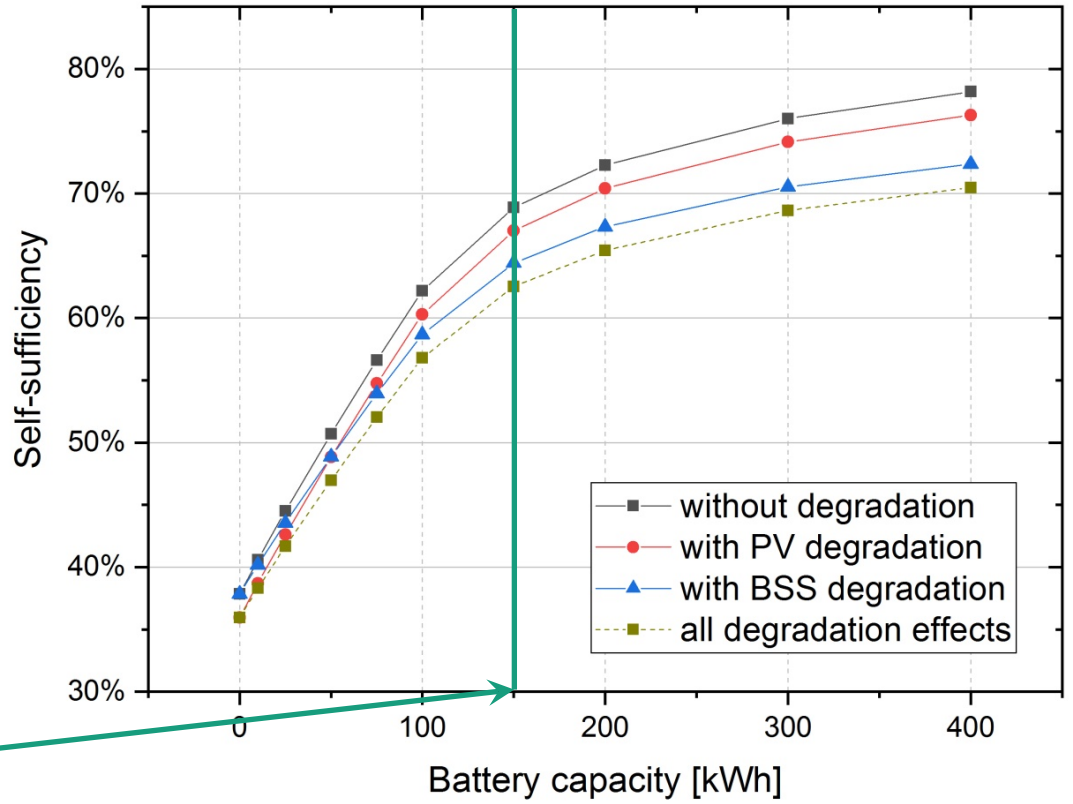
Distribution level – Example: Smart district “Weinsberg”

- Simulation based analyses

System concept of district power supply



Reduction of self-sufficiency over time



Source: L. Millet et al.: Extensive analysis of photovoltaic battery self-consumption: Evaluation through an innovative district case-study; Applied Physics Reviews, 2019.

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Isolated mini-grids – Example: SKA power supply in Australia

Developed design proposal

- Central power plant powering 80 % of total telescope load (2.4 MW in average)
  - PV system: 17 MW_p
  - Lithium-ion battery storage: 40 MWh / 5.5 MW
  - Diesel genset: 3.2 MW
- 20 % outermost antenna clusters
  - Powered locally
  - 15 remote processing facilities (distance from central processing facility > 10 km)
- LCOE: ~ 0.307 €/kWh

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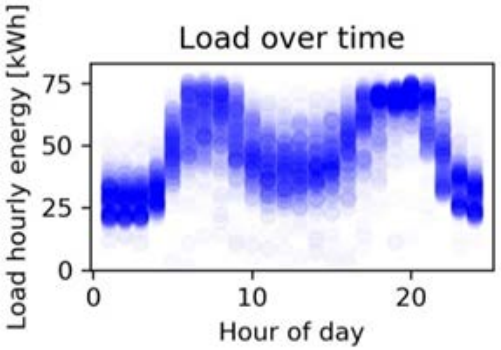
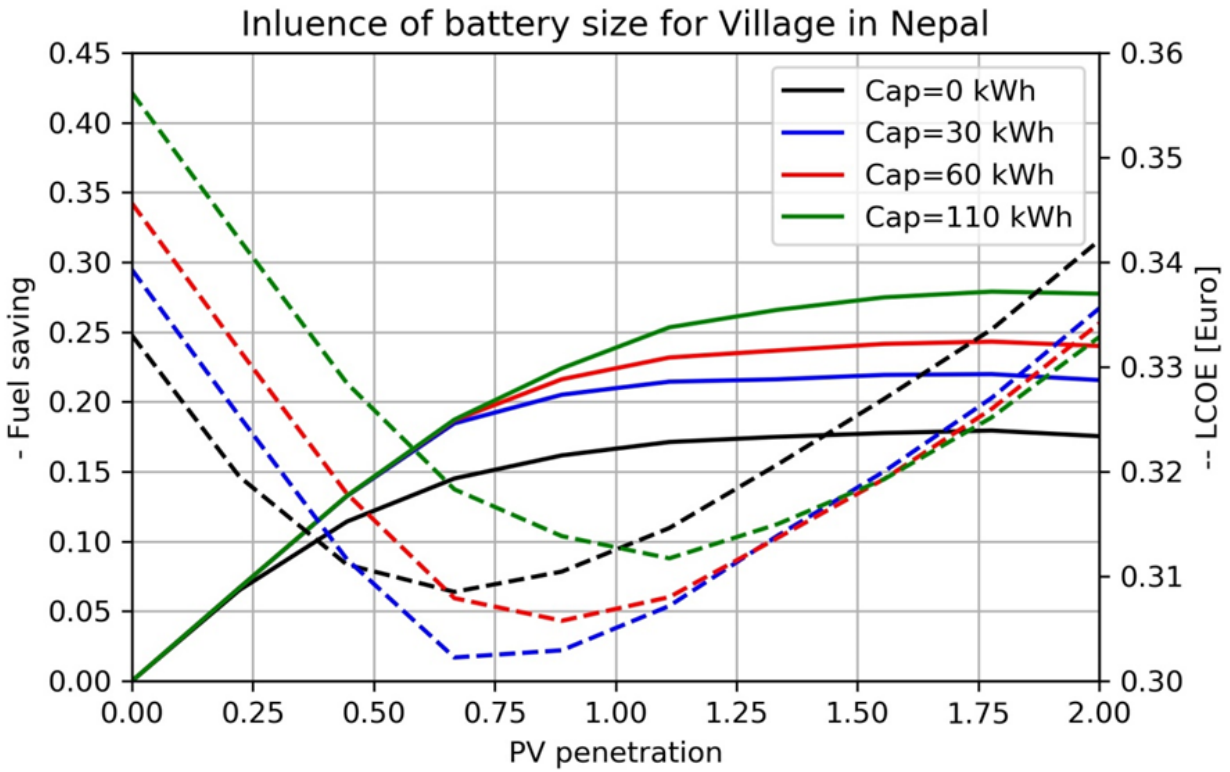
Isolated mini-grids – Example: Village in Nepal



The business case of PV integration in Diesel powered mini-grids

- Nepal case: Electricity demand and PV generation is not matching well
- With today's battery storage prices a reduction of the LCOE can be achieved already
- With "near" future battery storage prices the economics will look much better !!!
- With help of a battery storage the overall CO_2 emissions can be reduced



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The role of battery storage towards highest shares of renewables
Isolated mini-grids – Examples of project REACT*

Current situation:

- More than 2.200 inhabited islands in the EU with high population gradients (territorial & seasonal)
- High energy costs (mainly diesel powered) and grid instabilities

Pilot sites of project REACT:

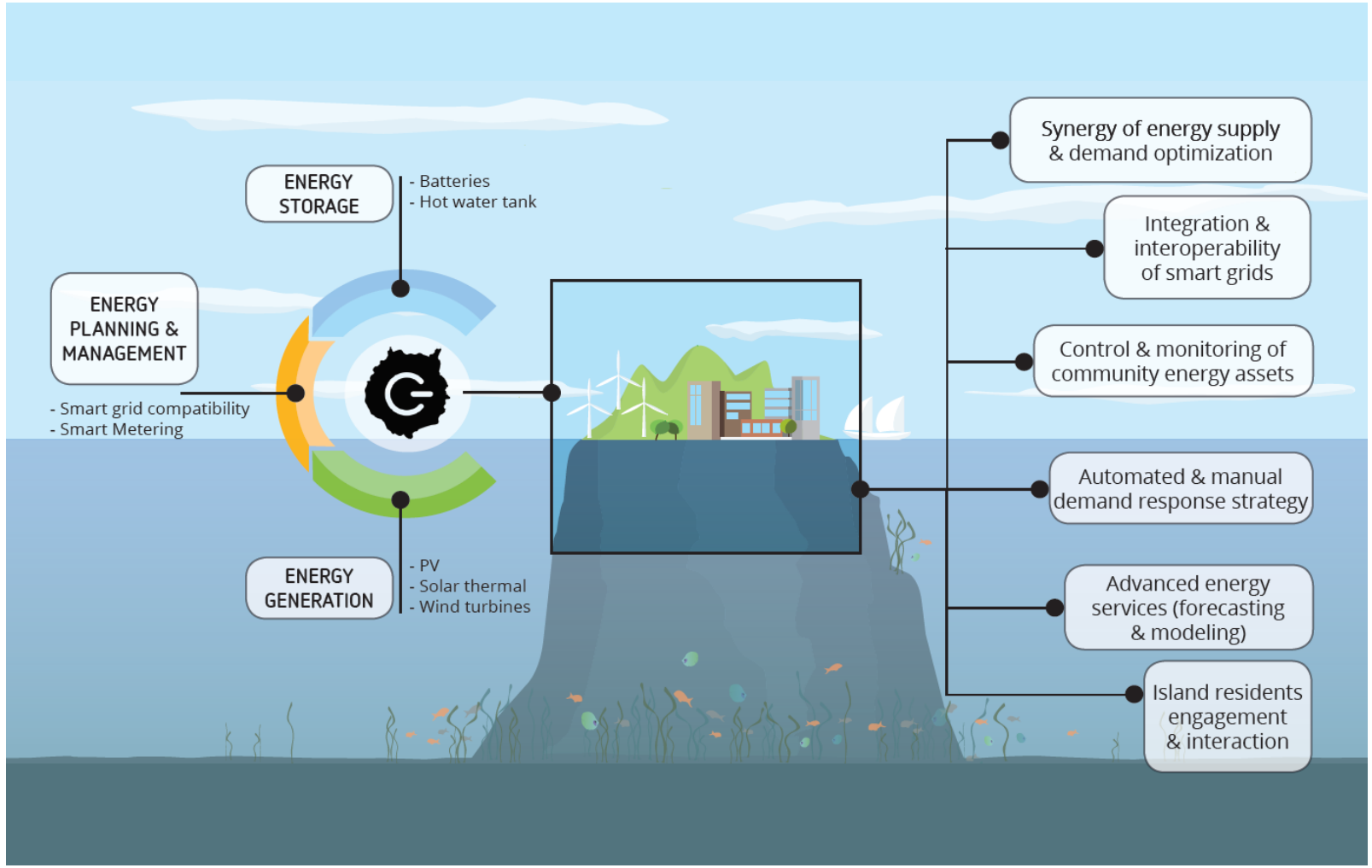
*REACT: EU funded project "Renewable Energy for Self-Sustainable Island Communities. www.react2020.eu.

The role of battery storage towards highest shares of renewables

Isolated mini-grids – Examples of project REACT*

Targets:

- Energy consumption:
  -10%
- Renewable energy penetration:
  +50%
- Fossil fuel consumption:
  -50%
- Emissions:
  -60%
- Energy cost:
  -60%



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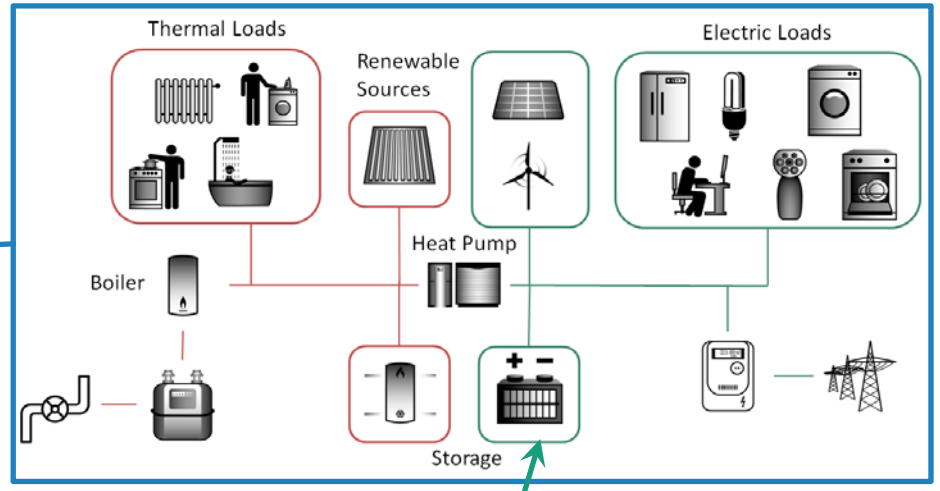
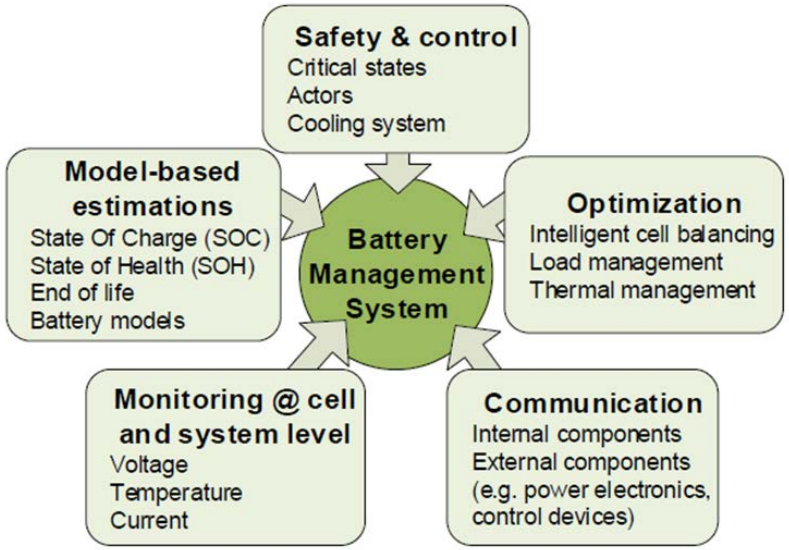
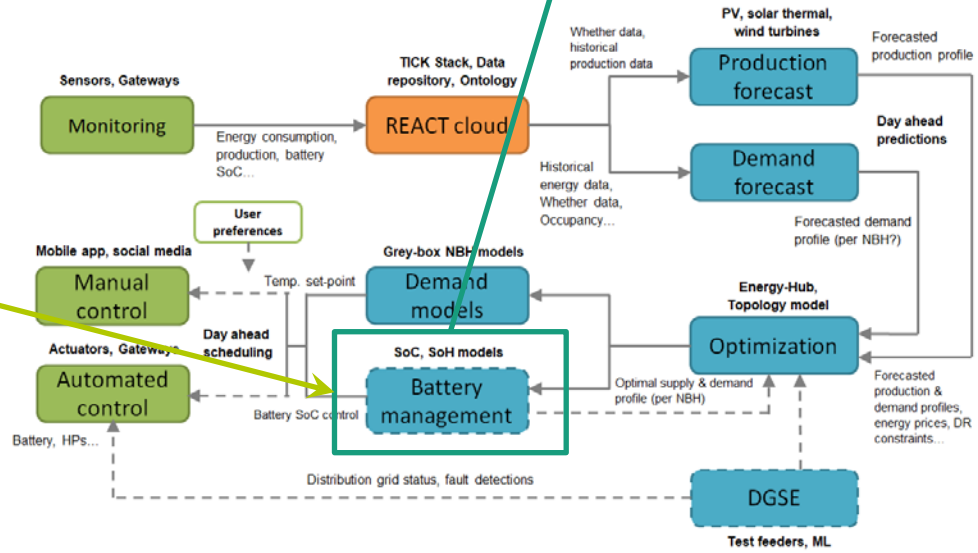
Isolated mini-grids – Examples of project REACT*



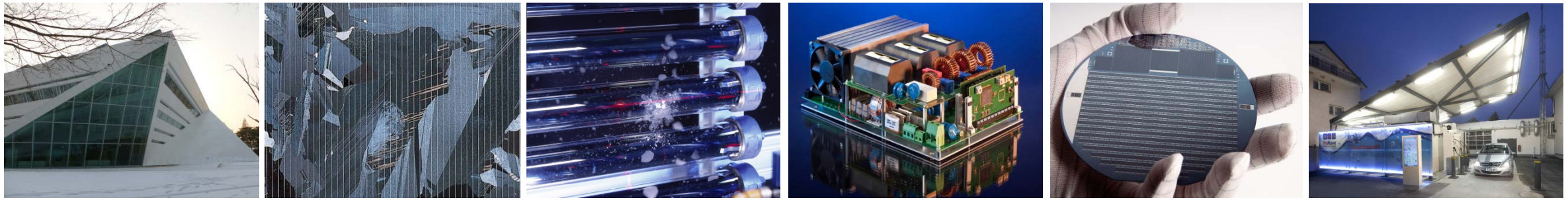




Conclusions

- Large-scale integration of fluctuating renewable energies in power supply systems require storage (grid-connected and isolated mini-grid applications)
  - Technically
    - → Reliability of power supply
  - Economically
    - → Grid connected: Business models in post feed-in tariff times
    - → Mini-grids: Reduction of fuel cost and fuel dependency
  - → Huge market growth for stationary battery storage expected !
- "Real world" projects with battery storage
  - No long-term experience with "new" technologies
  - → Appropriate quality assurance measures are key for risk mitigation

Thanks for your attention !!!



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