Battery Electricity Storage (BES) systems, Utility-scale and Distributed Units

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Quick reference to the two types of systems

Mature technologies but fast evolving

Utility Scale - Front of the meter

Big systems owned by utilities and/or other investors

Revenue from participation in the electricity market

Distributed – Behind the meter

Big systems owned by utilities and/or other investors

Revenue from participation in the electricity market

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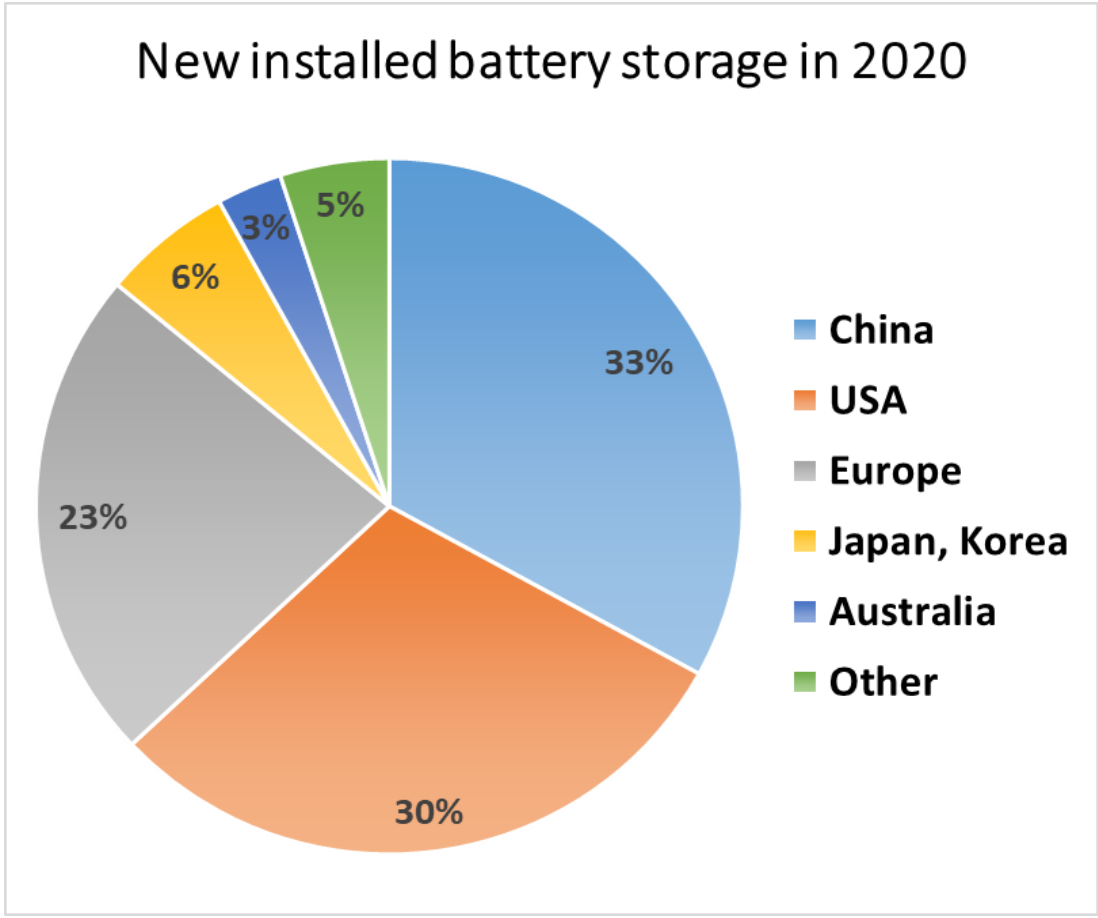
Main Markets Utility-scale and Distributed Systems Today

Growing very fast in USA and China

- **4,7 GW of new installations in 2020**
- **160% increase over 2019**
- Behind the Meter (home and business systems)
  - Germany
  - Other European (smaller markets)
- In Front of the Meter (utility scale system)
  - China
  - USA
  - Australia
  - UK

Market estimate for Europe 100 GW / 300 GWh by 2030



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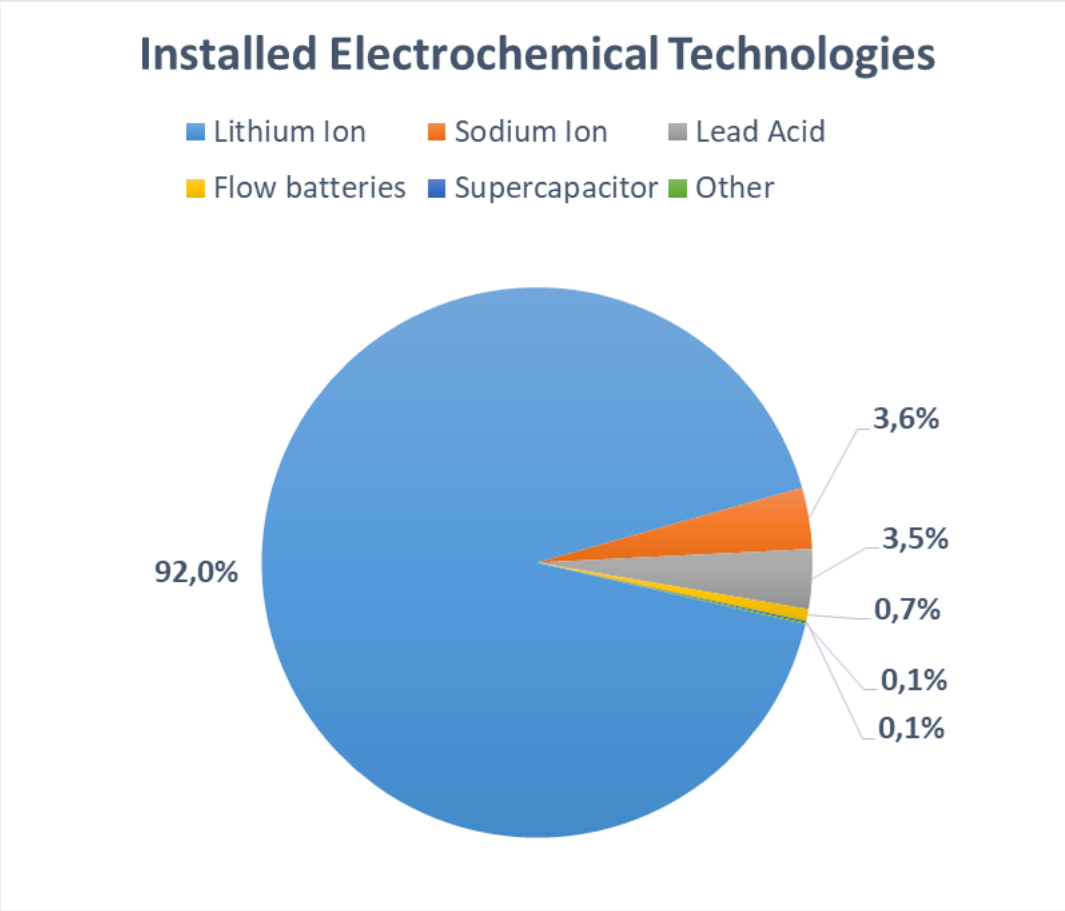
Main Electrochemical Electricity Storage Technologies

Growing very fast in USA and China

- **Electrochemical energy storage is 14,1 GW or 7,5% of total energy storage**

- Lithium Ion is the leading technology (over 10 GW in y2020)



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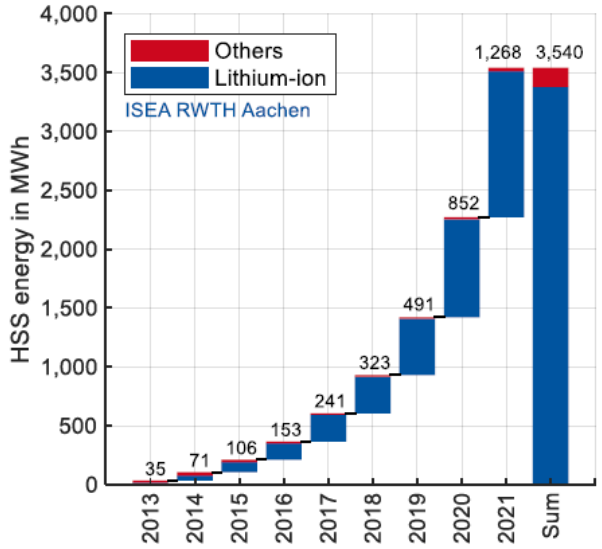
Behind the Meter – Germany - mature market

Home and Industrial Storage Systems

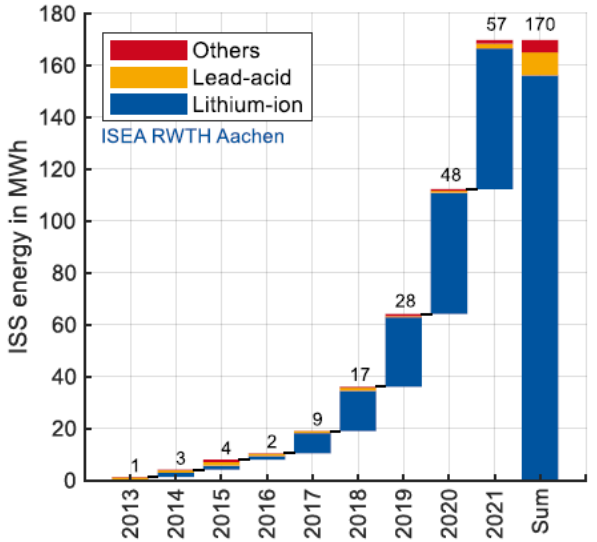
Home Storage Systems

- Total number of installations: **430.000**
- Total capacity: **3,540 MWh / 1.940 MW**
- **98%** are Lithium technologies
- Market growth was **45%** in y2021



Industrial Storage Systems

- Total number of installations: **2.512**
- Total capacity: **170 MWh / 84 MW**
- **95%** are Lithium technologies



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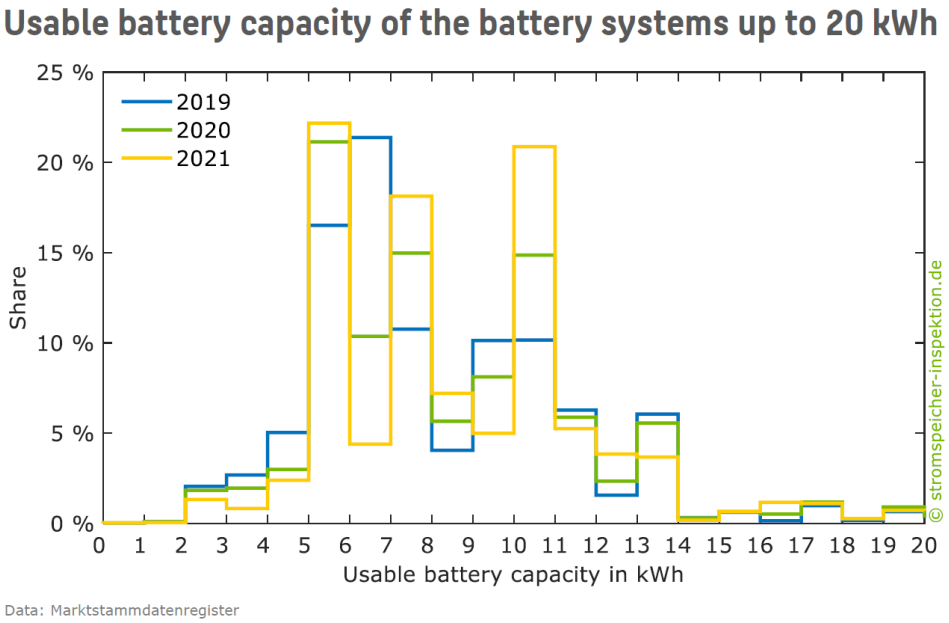
Dominance of Home Storage Systems based on Li Technologies

Large number implies an impact on the grid

- Each home system is from 5 kWh to 10 kWh of storage
- Average energy: **8,8 kWh**
- Average power: **5,0 kW**
- A total of **0,73GW / 1,27 GWh** of storage added in 2021
- Their operation depends on the needs of individual owners. They can be centrally controlled but this seems not to be achievable today.
- Higher specific cost but can act as **UPS**
- **Create Jobs**



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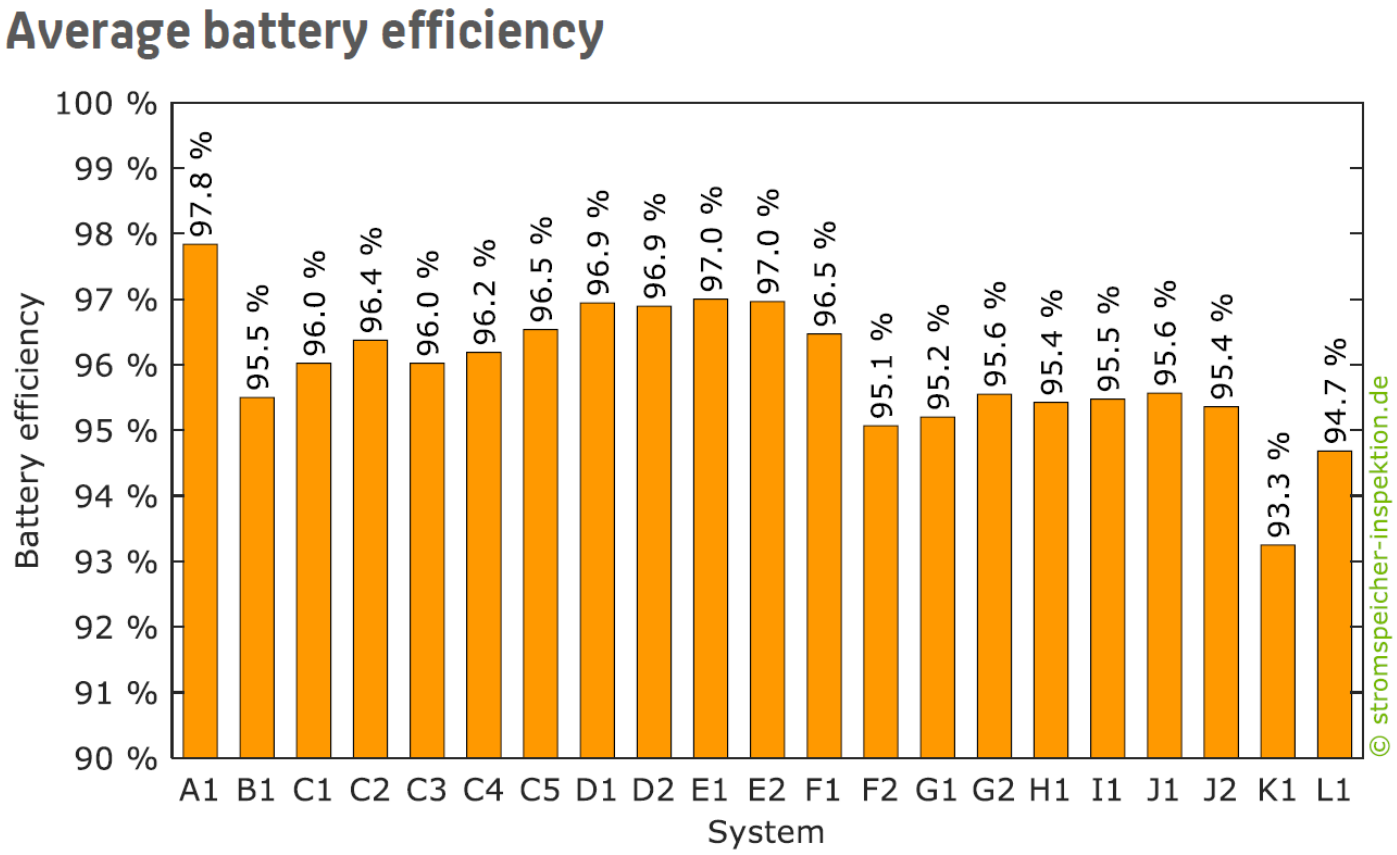
Home batteries and inverters are almost as efficient as in big systems



G1, G2 and J1: Due to a temperature-induced derating, the test could not be run at nominal power.

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In Front of the Meter Battery Storage Systems – Australia

Mature market – operational data available

- The Australian Electricity System is approximately 5 times bigger than the Greek one (265 TWh in 2020)
- 756 MWh of front of the meter projects in y2021
- The residential battery market is also strong (333MWh in y2021)
- Approximately the same market size is expected in y2022

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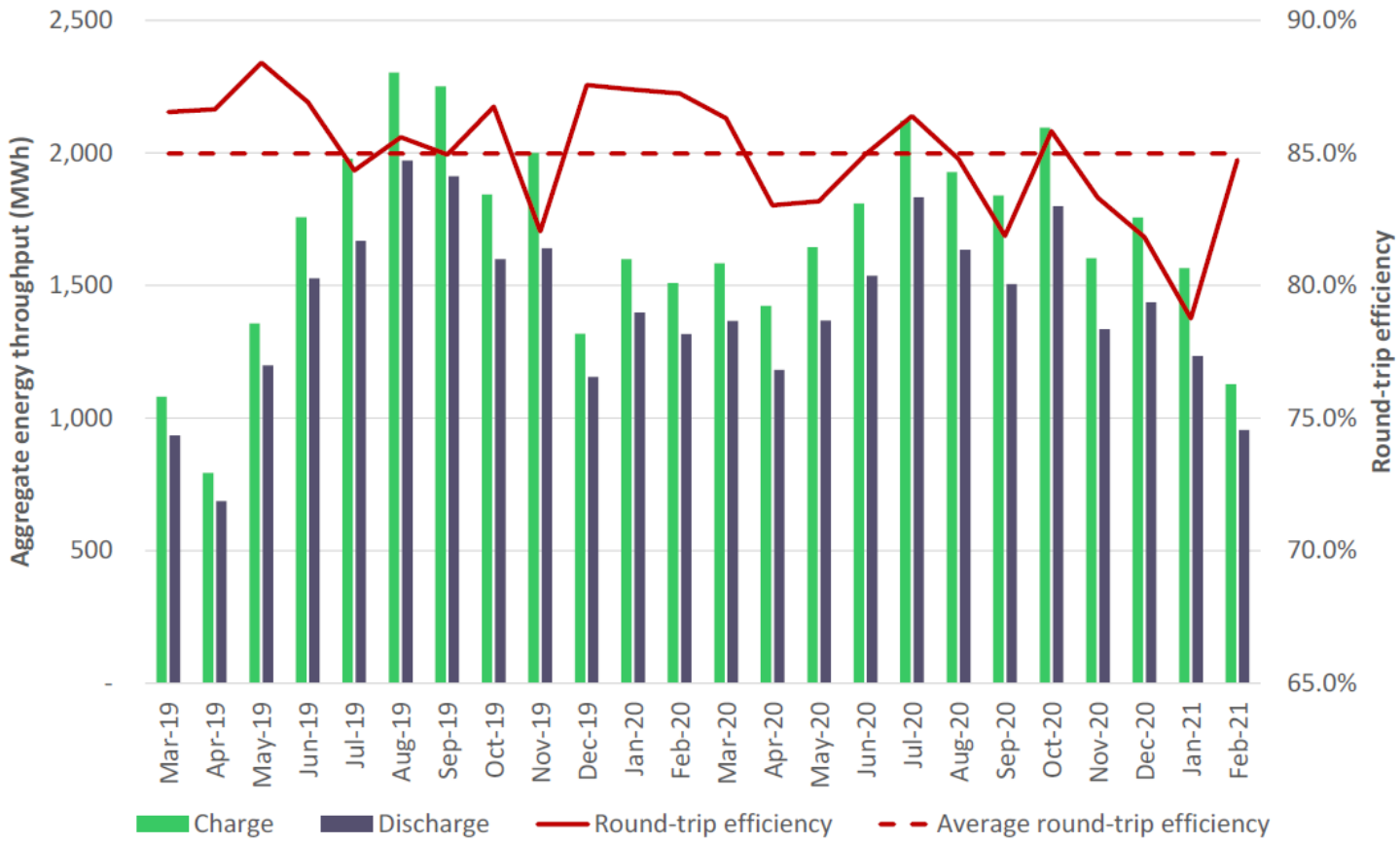
Technical Performance – Round trip efficiency

Operational data from the Gannawarra BESS (25 MW / 50 MWh)



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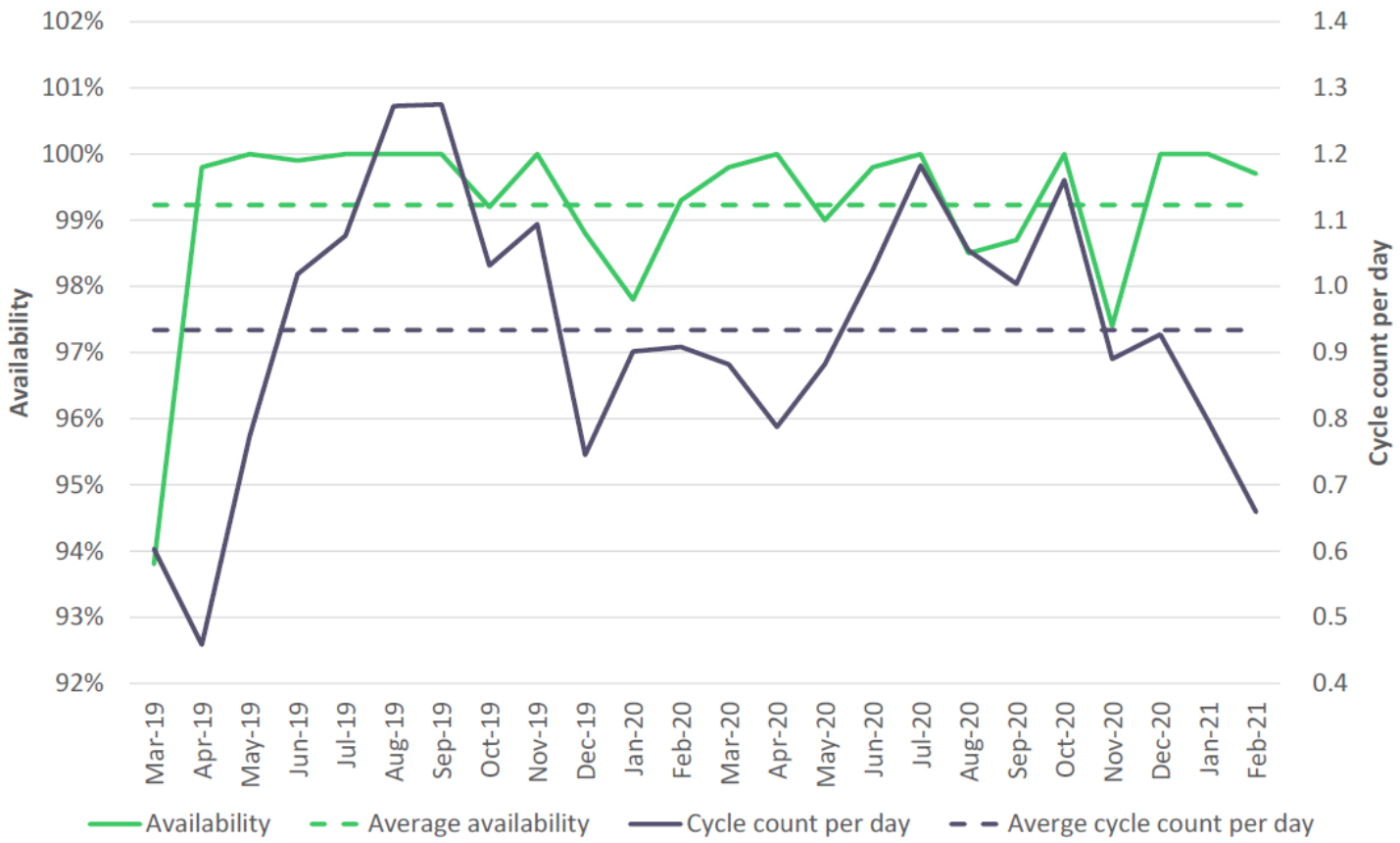
Technical Performance – Availability and cycles per day

Average availability exceeds 99% - 0,93 full charge/discharge cycles per day



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Financial Performance

Different perspectives on the business case by owner and utility

Owner

- The owner receives a fixed annual payment by providing battery services
- The owner assumes the risks of owning and operating the asset
- Business case has met expectations

Utility

- Business case has slightly exceeded expectations as market revenues in the first two years of operation exceed contracted cost
- Still a risk regarding future market revenues as more batteries enter the market place
- It should however be noted that there will be market competition from new batteries entering the system

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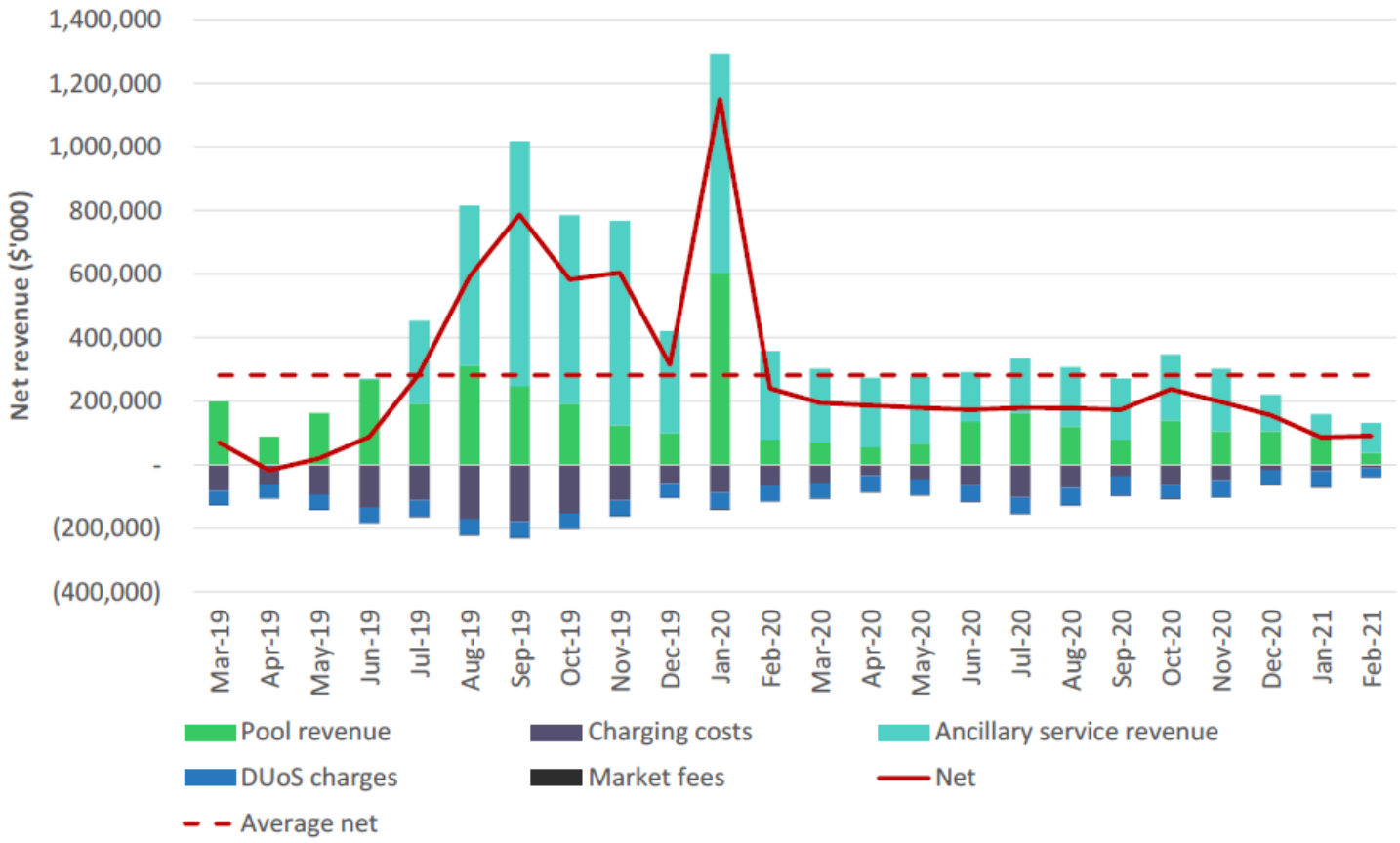
Market Revenues

Average $281 per month – Mainly from “Frequency Control Ancillary Services”



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Greek Behind the Meter Market

Just initiated – No technical issues

Residential market

- Slow to start
- Profitable today and low risk not to be in the future - Must be combined with residential PV systems
- Products exist but are expensive due to small market size
- Lack of skilled installers
- UPS function may be an incentive (concerns for power cuts)

Industrial market

- Practically does not exist
- Profitable today - Must be combined with PV systems

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Greek Front of the Meter Market - Revenue

Investor point of view

Simulations for batteries participating in the electricity market show that projects are profitable

Assumptions:

- Gas price: 60 €/MWhth
- CO2 : 100 €/tn
- We also assumed that installed renewables reach 18 GW and battery installed capacity reaches 2 GW / 4GWh by year 2033
- “Realistic” scenario for RES penetration in the Greek electricity grid

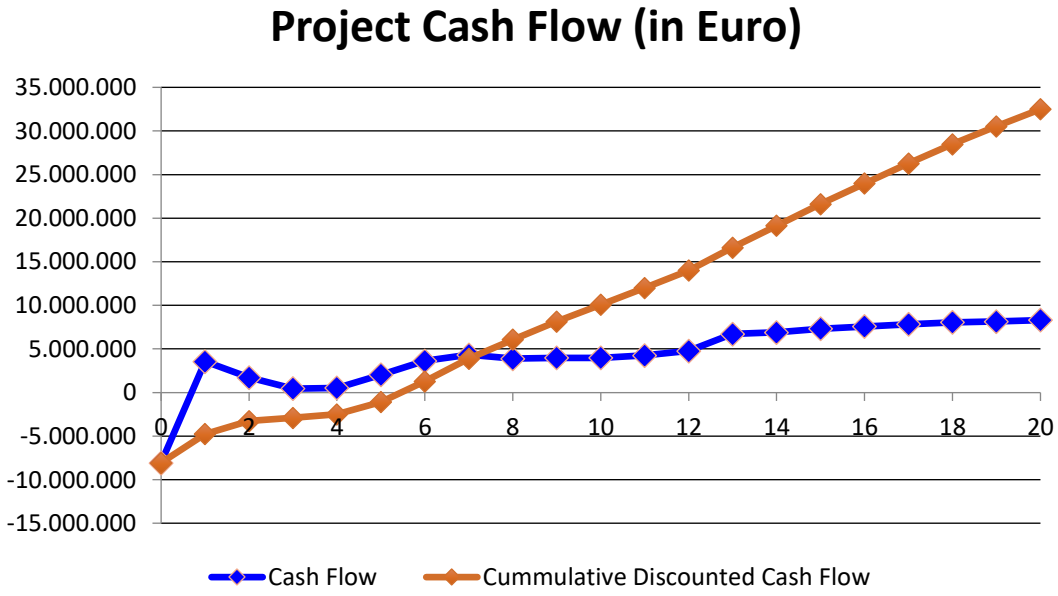
- Project IRR is **17.2%**

<u>However</u>

Revenue risks due to:

- Asset risks (technical)
- Competition from other batteries
- Electricity market instability

Tender is a solution but creates market distortions



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Greek Front of the Meter Market – Technical, regulatory and cost issues

Similar issues are faced all over the world

- Technologies are evolving – It is not easy to know what systems will be eventually used in two years from now

  Regulatory issue: Projects were planned with specific existing technologies and with certain estimations about needed hours for storage capacity. How easy will be to change specs at RAE?

- Standards are still under development

  Will they put constraints on the products and projects? Will they result to cost increases? (e.g. control, grid compatibility, fire protection)

- Cost Uncertainties

  Battery costs were already below 250 k€/MWh (including connection) in year 2020. Today prices have increased approximately 30%. However we expect significant cost drops as costs will be back to normal (or not?).

  What will the cost be during implementation? Wil the project be profitable?

- **Connection Bonds** - to be submitted asap by investors

  How will they be recovered in case they do not succeed in the tender?

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Thank you

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