



# Beyond lithium; Flow battery case studies

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# Agenda:

- Invinity and our Vanadium Flow Battery
- Behind the meter case study
- In front of the meter case study
- Storage across market characteristics
- Q&A





# Invinity Energy Systems

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Vanadium Flow Batteries (VFB) for businesses, industry, utilities and electricity networks.

Invinity's VFB:

- Commercially proven
- Cost competitive
- Safe & non-flammable
- Fully recyclable
- Extremely durable

Our VFBs make renewable energy reliable, delivering low-cost, low-carbon power on demand.

- >10MWh installed worldwide
- Europe, Asia, North America, Australia and Africa

# Invinity's Foundation: Proven Battery Module

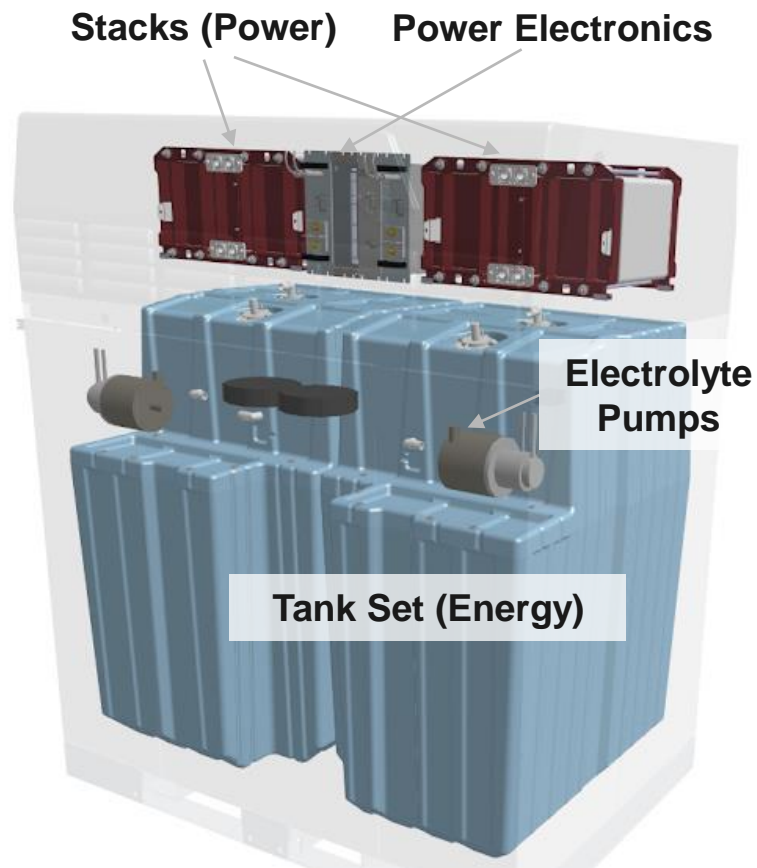
## Invinity VS3



40 kWh, 10 kW module  
Includes BMS, cooling, enclosure.

- 3<sup>rd</sup> generation, self-contained vanadium flow battery
- Shipped fully functional from factory
- Standardised building block for projects from 250 kWh to 12 MWh

## VS3 Internals

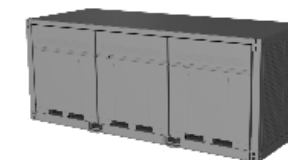


## Scalable Architecture

Battery Module



Battery Pack



Battery Cluster



# Flow batteries behind the meter

## What is behind the meter?

- Demand and generation active behind a single meter
- e.g. rooftop solar & storage at a distribution centre

## What is the case for installing flow batteries?

- Store solar generation in excess of site load, discharging into peak price periods
- Benefit from cheap wholesale pricing
- Upside ancillary service revenue

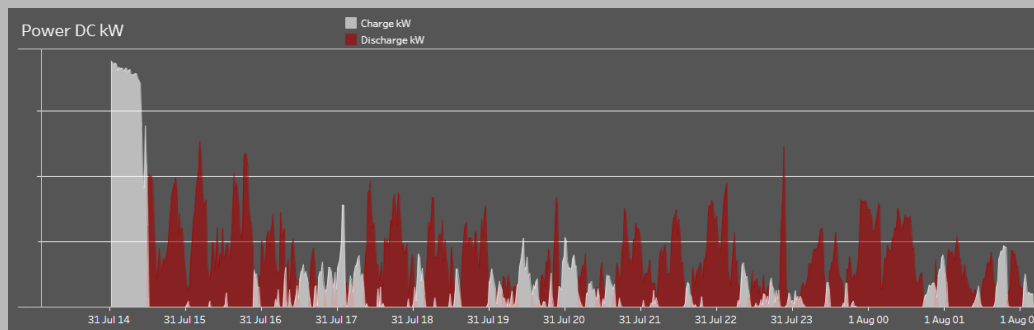
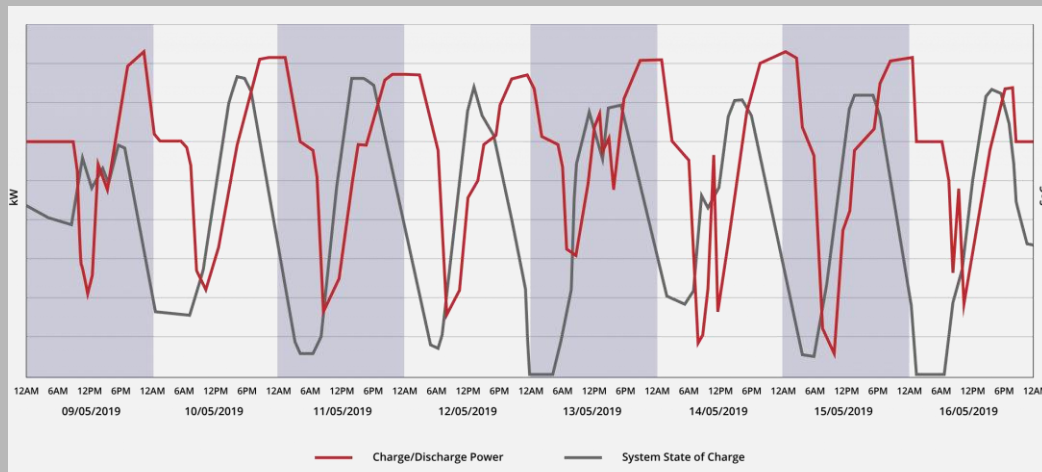
## Why does this work?

- In the UK, excess solar is paid £0-50/MWh, depending on contracting
- Offsetting consumption from grid at certain times can be worth £150-300/MWh



## Does this work in practice?

# Case Study: behind the meter



- Industrial park, Dorset, UK
  - 300kWh flow battery + 250kWp ground mount solar
  - Dispatchable PV offsets site load
- First flow battery to qualify for FFR
  - Proves flow's rapid response ability
  - Has been operating in FFR since 2018
  - Dynamic regulation, what could flow do in the future?
- Invinity view sub-MW installations as a key feature of balancing distributed networks due to the cost effectiveness of the solution



# Flow batteries in front of the meter

## What is in front of the meter?

- ☐ Grid connected
- ☐ No onsite load connected behind the storage meter

## What is the case for installing flow batteries?

- ☐ High throughput, low degradation
- ☐ Highly flexible asset; multiple cycles for trading and applicability for future grid services
- ☐ Non-flammable
- ☐ Significant end-of-life value



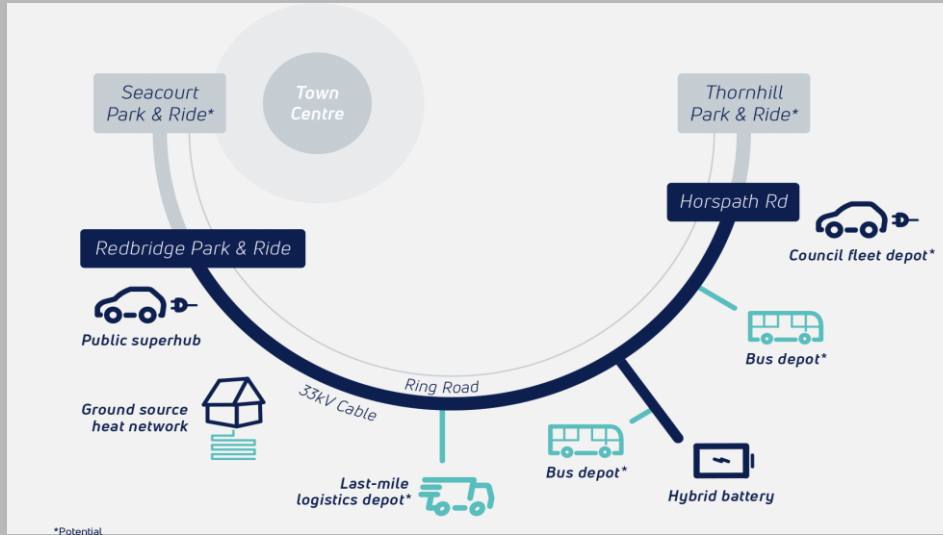
**This is energy storage for our future grid**

# Case Study: In front of the meter



World first project decarbonising power, transport and heat to accelerate Oxford's journey to zero carbon

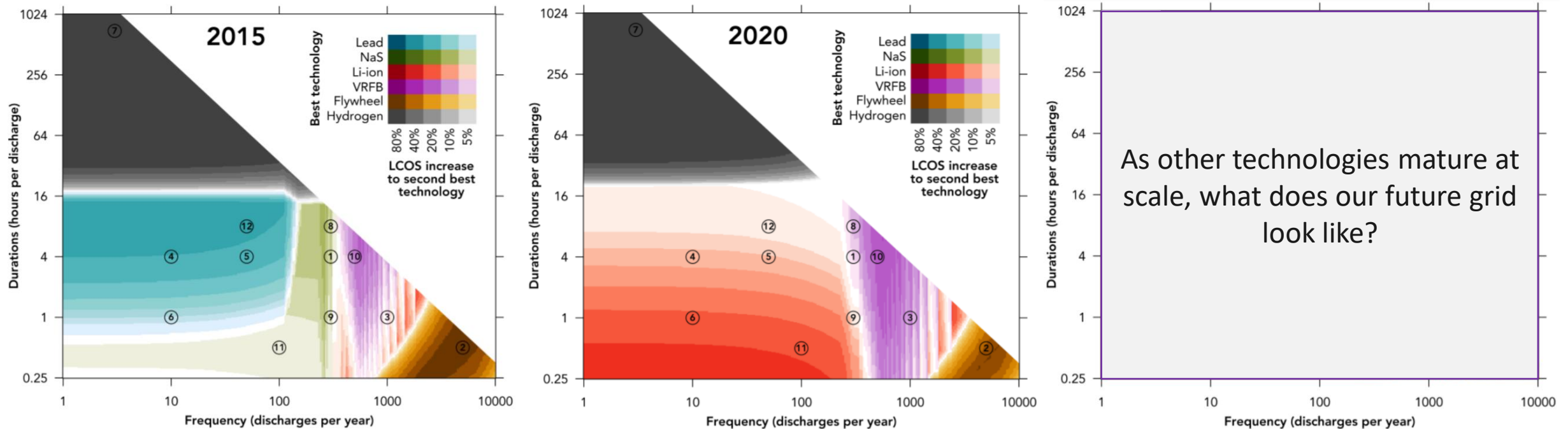
- UK's largest flow battery – 2MW, 5MWh
- Transmission connected hybrid vanadium / lithium flow system
- The system will help to balance electricity supply and demand and maximise use of renewable energy
- Optimisation & Trading Engine will unlock synergies and optimise system for Firm Frequency Response (FFR) and energy trading, including day-ahead and intra-day markets and Balancing Mechanism





# Storage characteristics across the market

- No one storage technology is perfect
- Lithium is dominant in the market today following cost reductions as the technology has matured and use cases are mostly driven by today's ancillary service requirements



Source: O.Schmidt, S. Melchior, A. Hawkes, Iain Staffell "Projecting the future levelized cost of electricity storage technologies"

# Summary & Key Takeaways

- ❑ Vanadium flow is a leading non-lithium energy storage technology
  - ❑ >10MWh deployed in the field to date by Invinity
- ❑ Flow generates profitable, low carbon business cases without subsidies
  - ❑ Opportunities today behind the meter across EU, US, East Asia & Australia etc!
- ❑ Infront of the meter applications are in development
  - ❑ 2021 operating UK's largest flow battery
- ❑ There is no one-size fits all
  - ❑ Technology should be chosen on the application in question



Visit our website: **<https://invinity.com>**

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