IoT INFRASTRUCTURE 2019 Conference and Expo

Data centre as a source of dynamic flexibility for power grid – uninterruptible power system (UPS) as a reserve

by Janne Paananen, Eaton

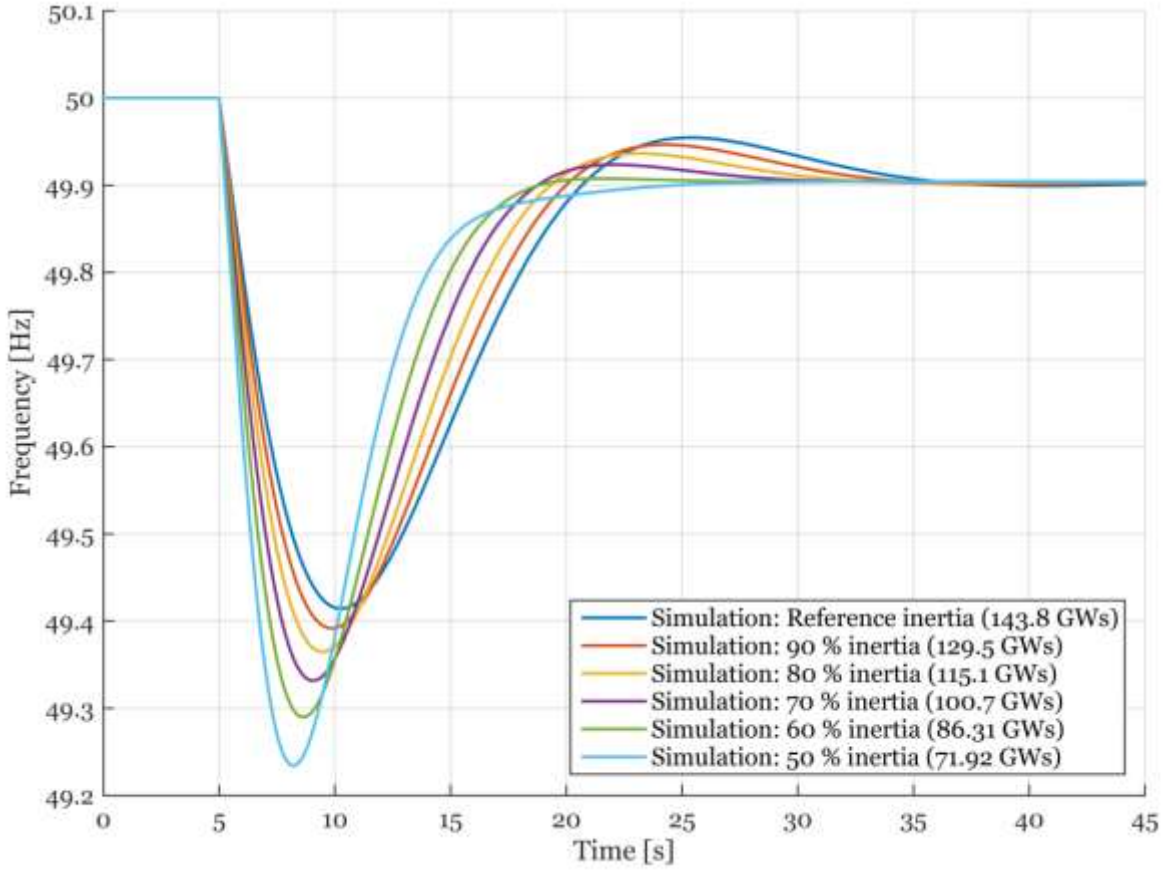
ee publishers

Transformation of energy system

- Transition towards low-carbon energy system driven by societies (people), politicians and companies
- Ambition is to use renewable energy sources such as hydro, solar and wind
- Energy consumption is increasing in developing areas
- This is creating challenges for a power grid:
  - *How to manage variations in renewable energy sources?*
  - *How to manage disturbances and maintain grid reliability?*
  - *How to manage congestion (bottlenecks) in the system?*
- Transmission (and distribution) system operators role is to manage the power system

System inertia

- Spinning mass directly coupled to system voltage and frequency in traditional power plants and factories etc.
- Stabilizes system frequency by releasing and absorbing energy
- Reducing in power grids due to non-synchronous generation and modernisation of motor loads
  - Faster and higher frequency variations
  - More challenging to contain frequency
- Traditional frequency regulation not fast enough – need for faster reserves

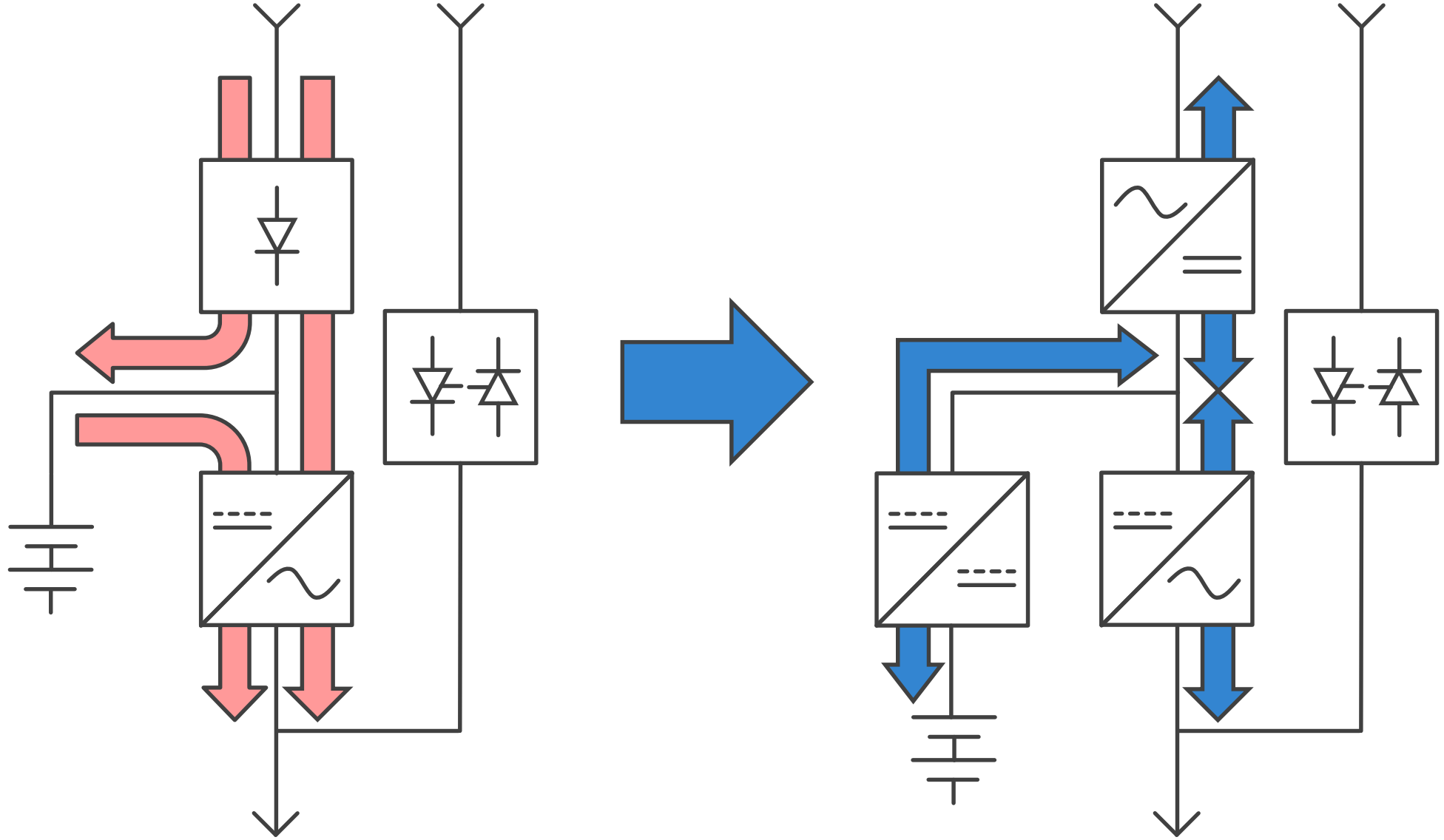


Impact of intertia to frequency transient during a fault, disconnection of 1170 MW production capacity.

Source: *Entso-e report; Future System Inertia*

Powering Business Worldwide

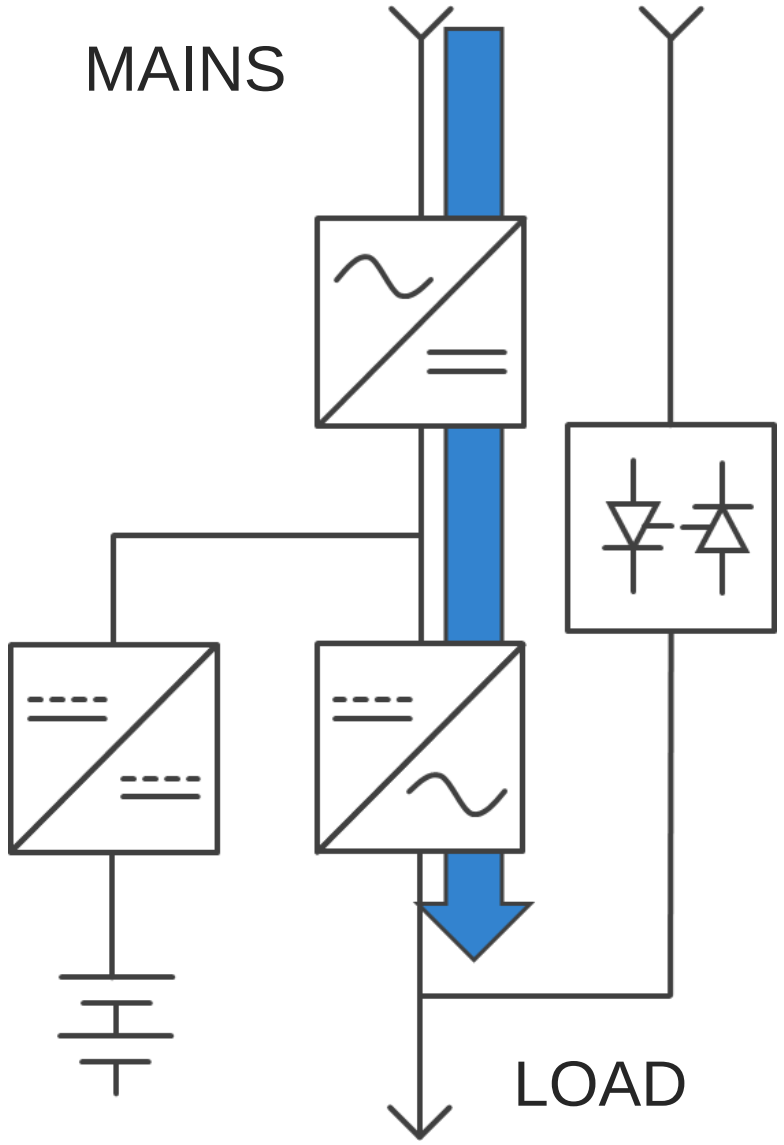
UPS technology – from uni- to bidirectional



Powering Business Worldwide

UPS technology – power management

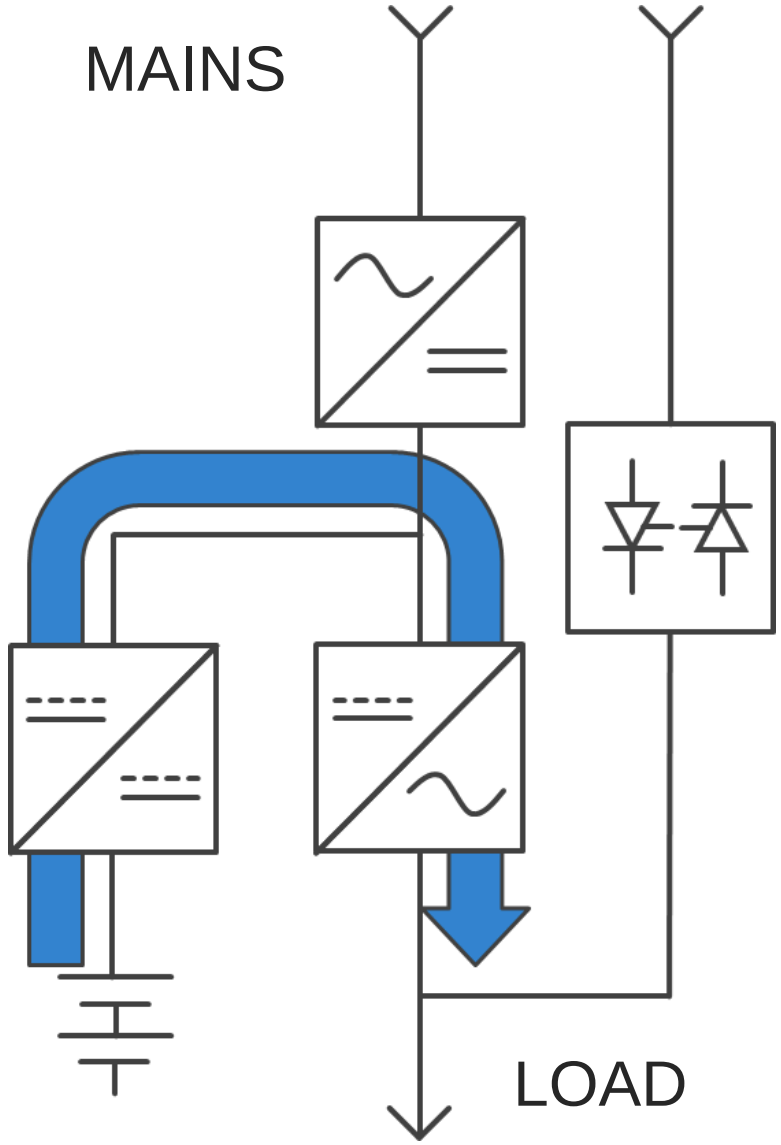
Support critical load from mains



Powering Business Worldwide

UPS technology – power management

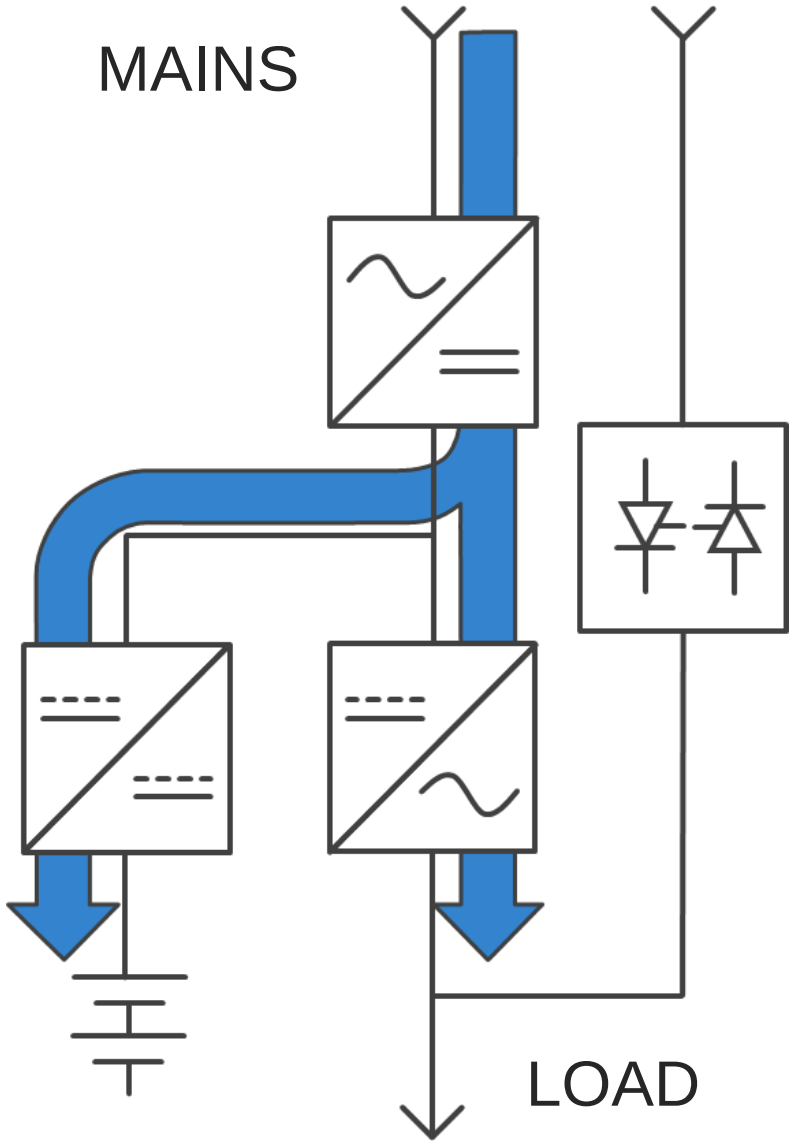
Support critical load from battery



Powering Business Worldwide

UPS technology – power management

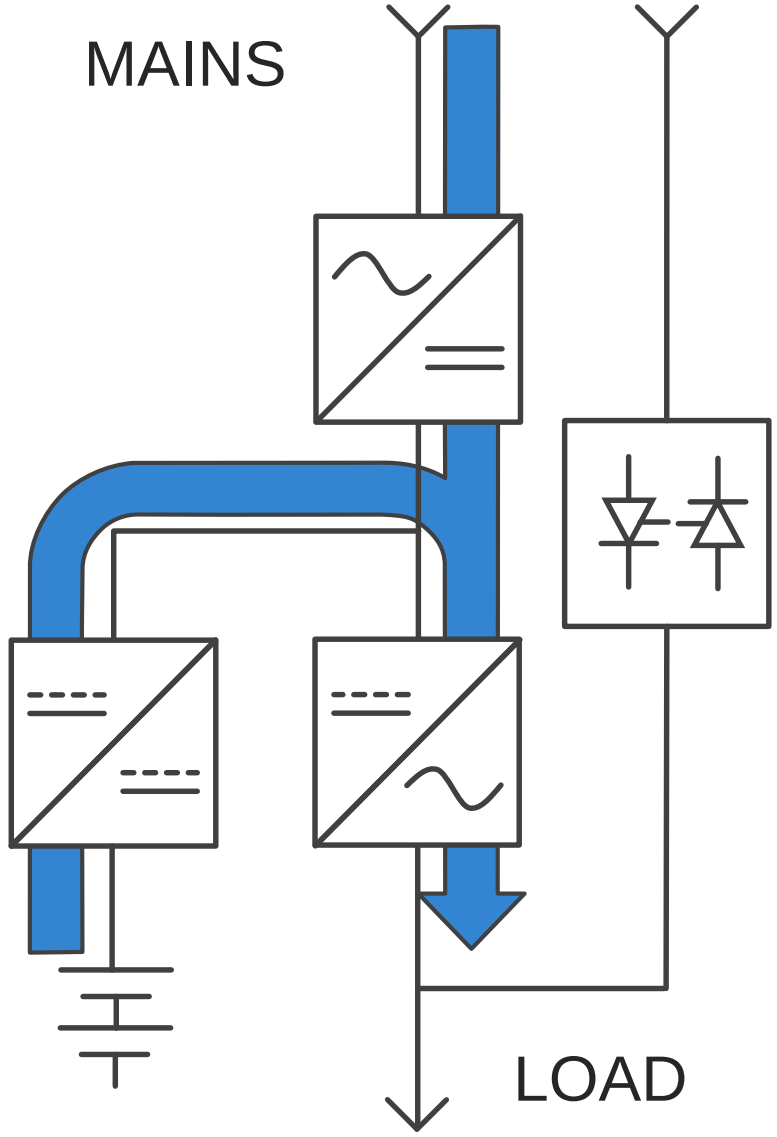
Support critical load and charge battery to increase demand



Powering Business Worldwide

UPS technology – power management

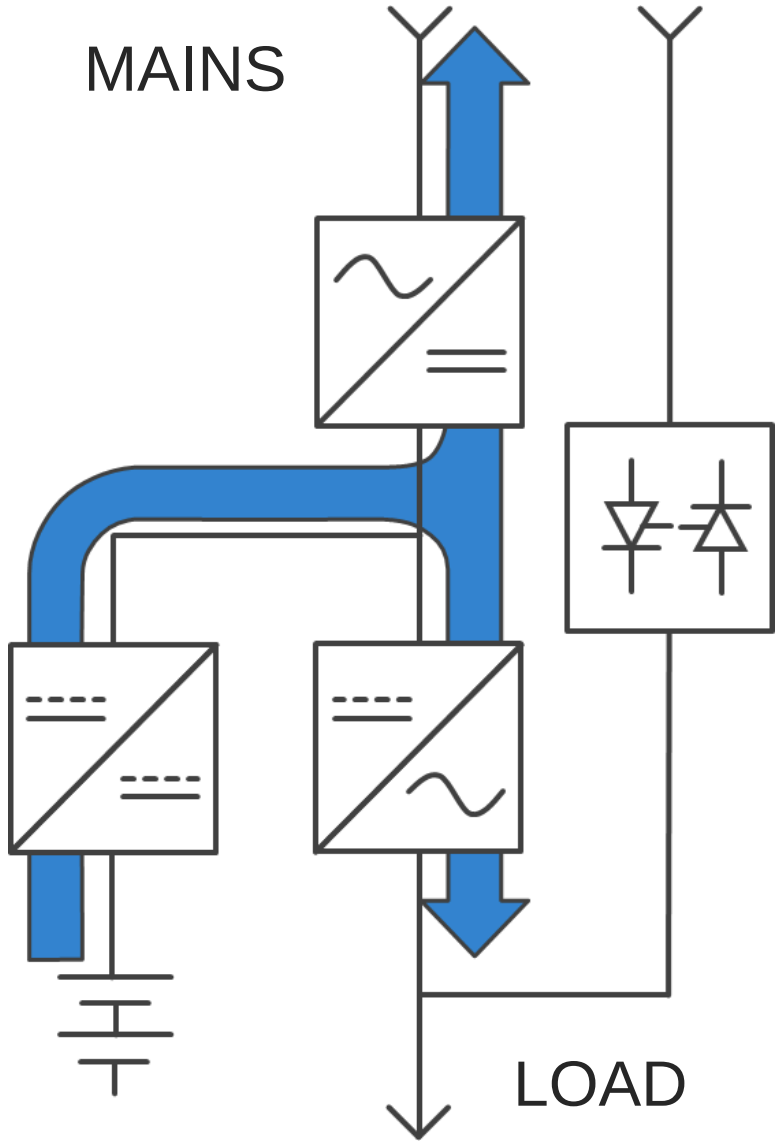
Support critical load from grid and discharge battery to reduce demand



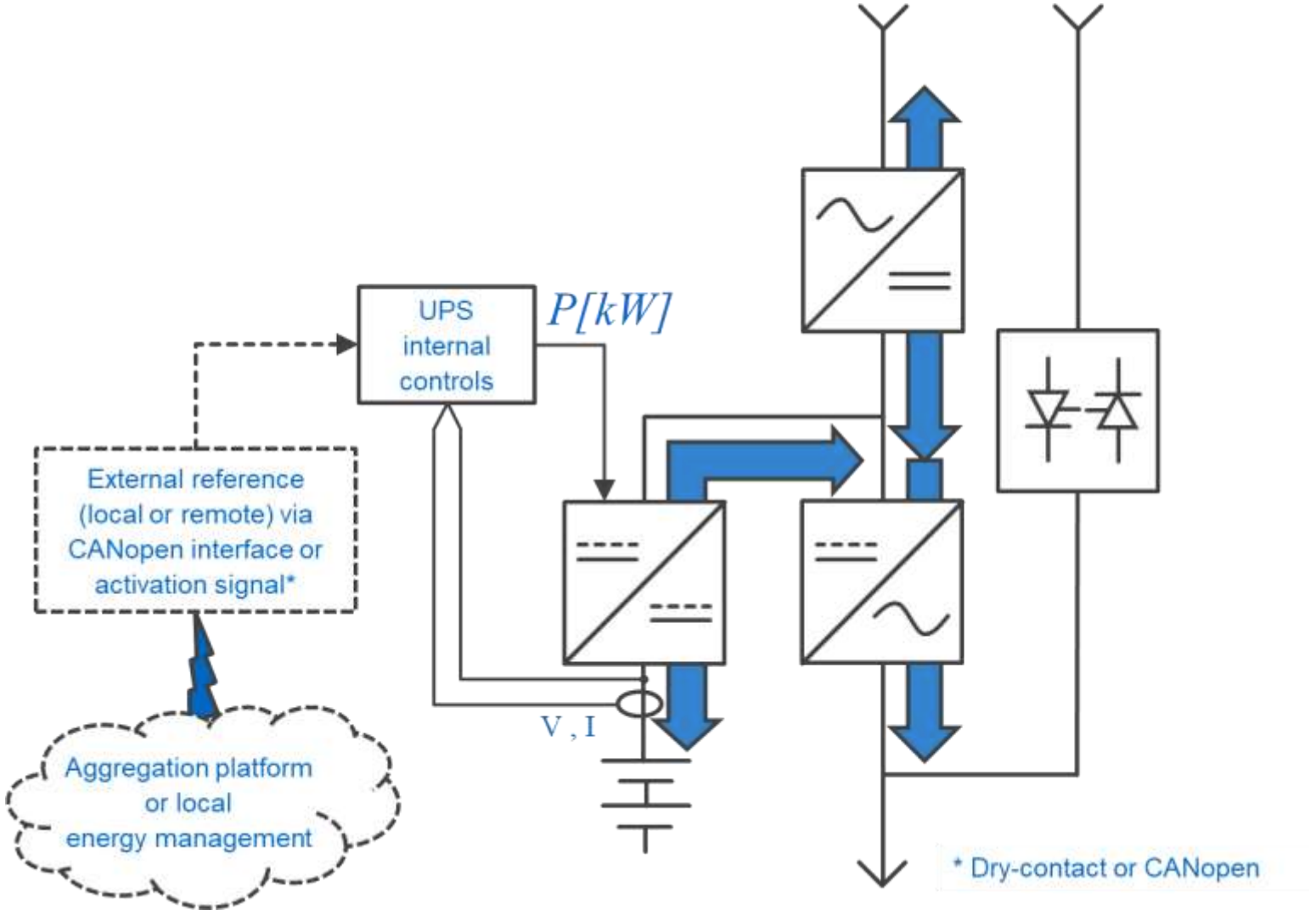
Powering Business Worldwide

UPS technology – power management

Support critical load and grid from battery
(load independent response)

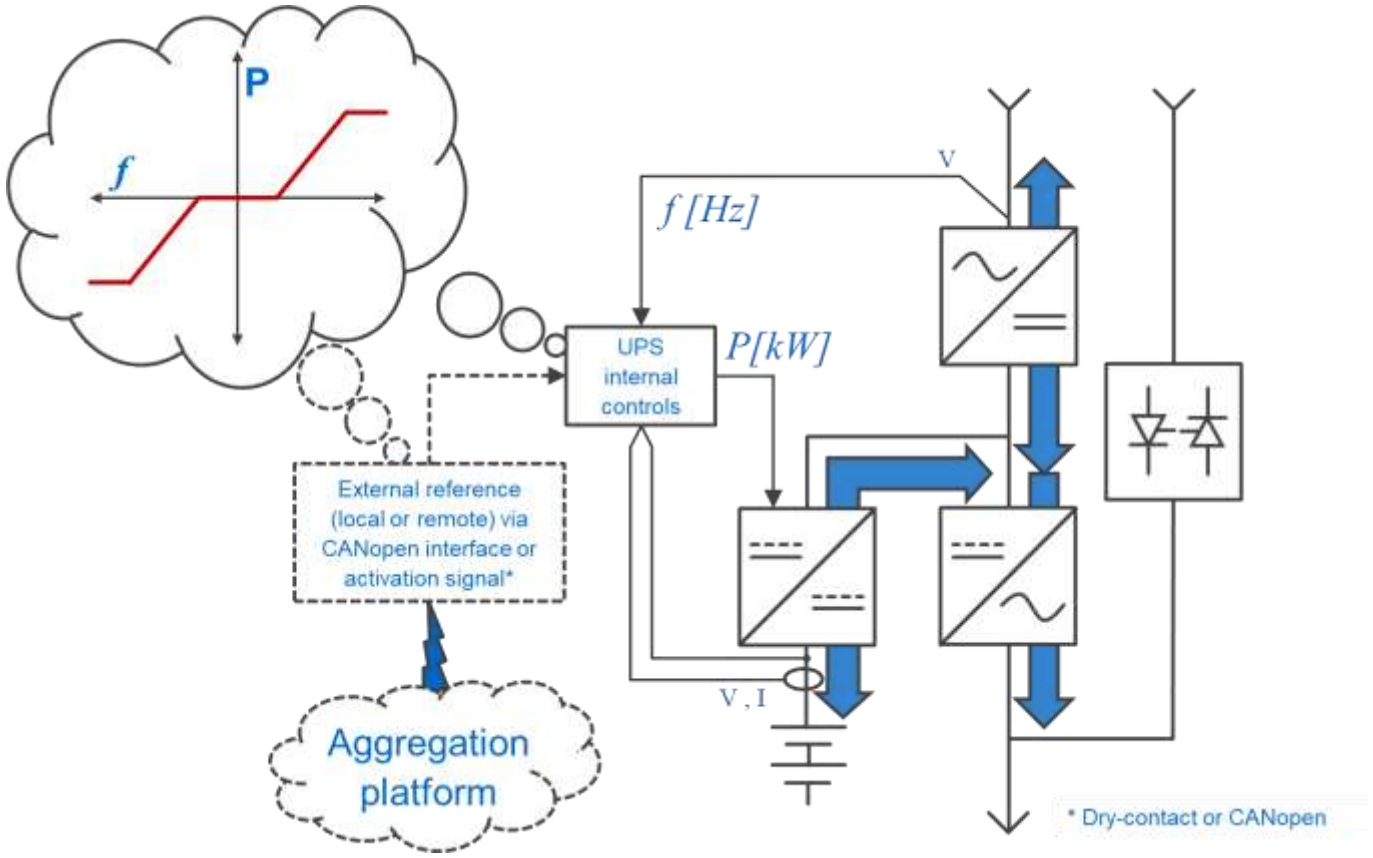


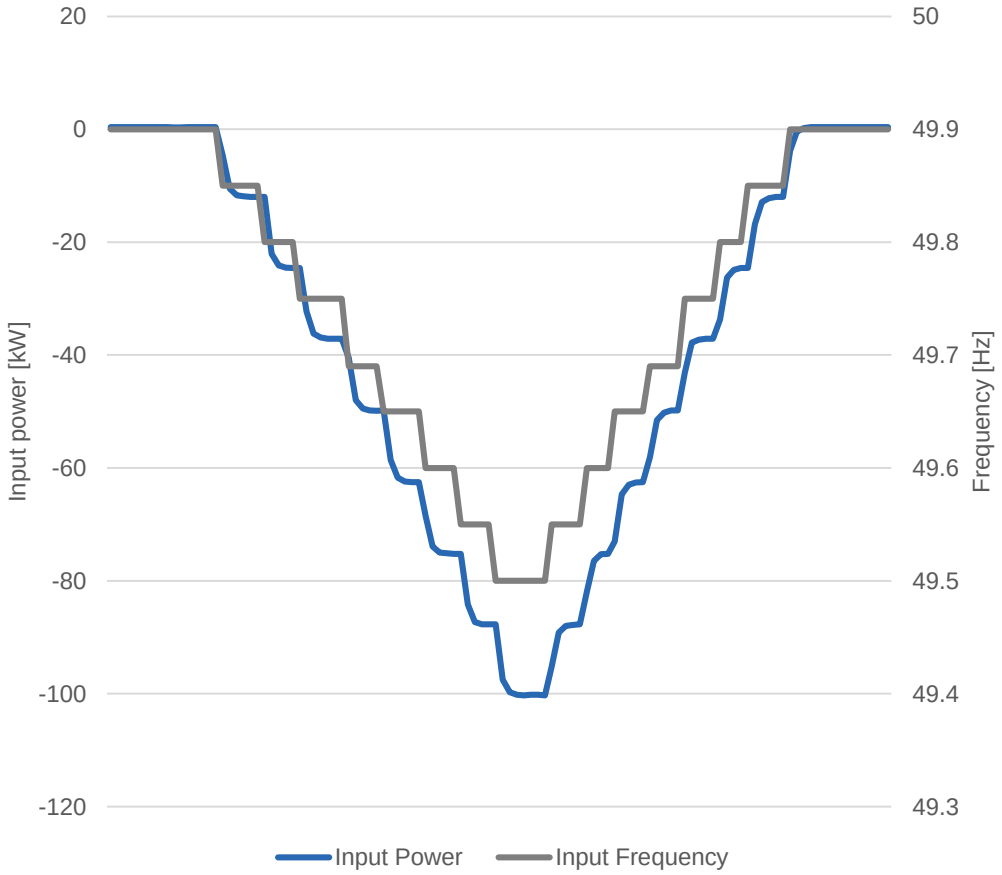
Demand response (peak shaving, time-of-use)



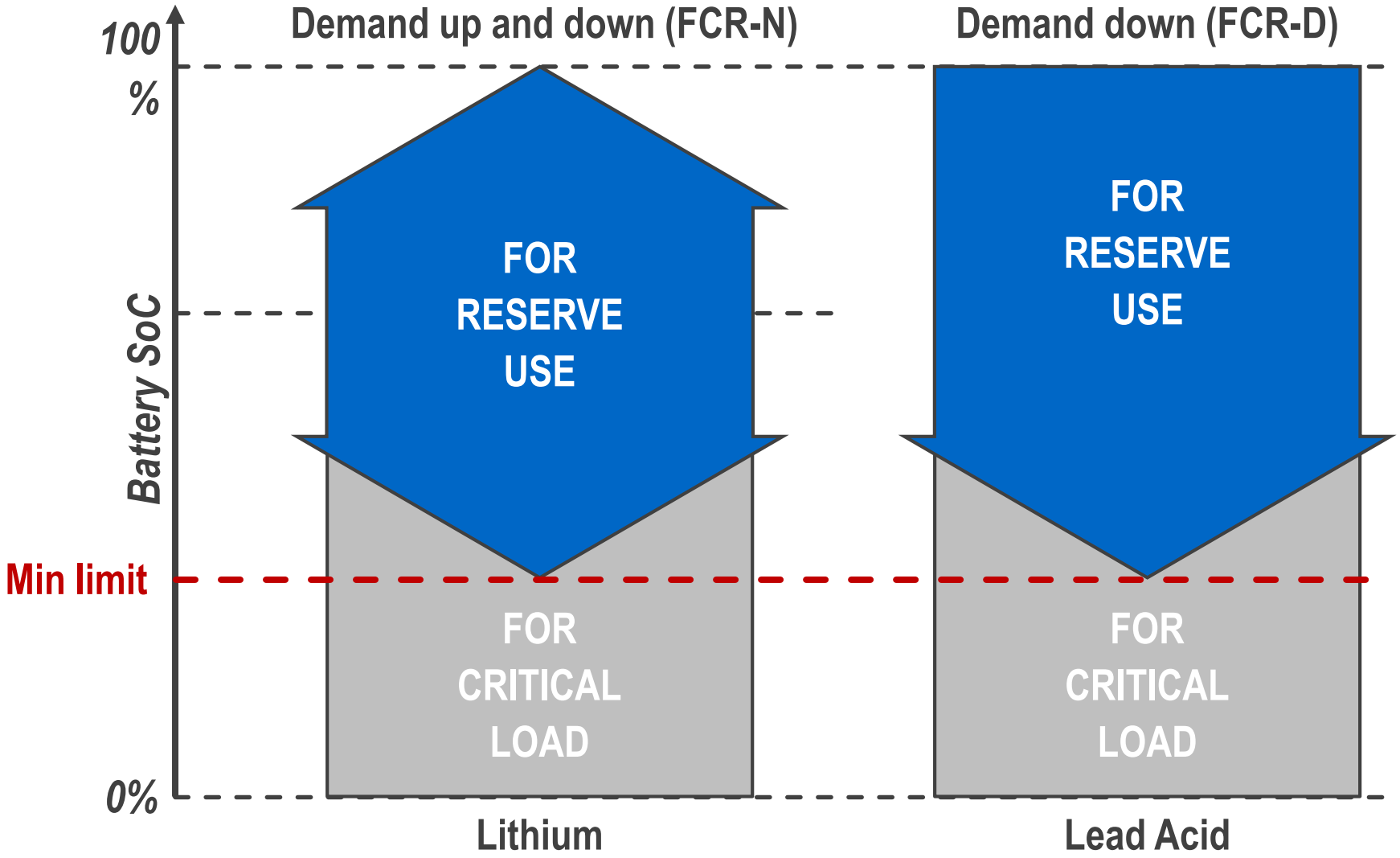
Powering Business Worldwide

Frequency regulation





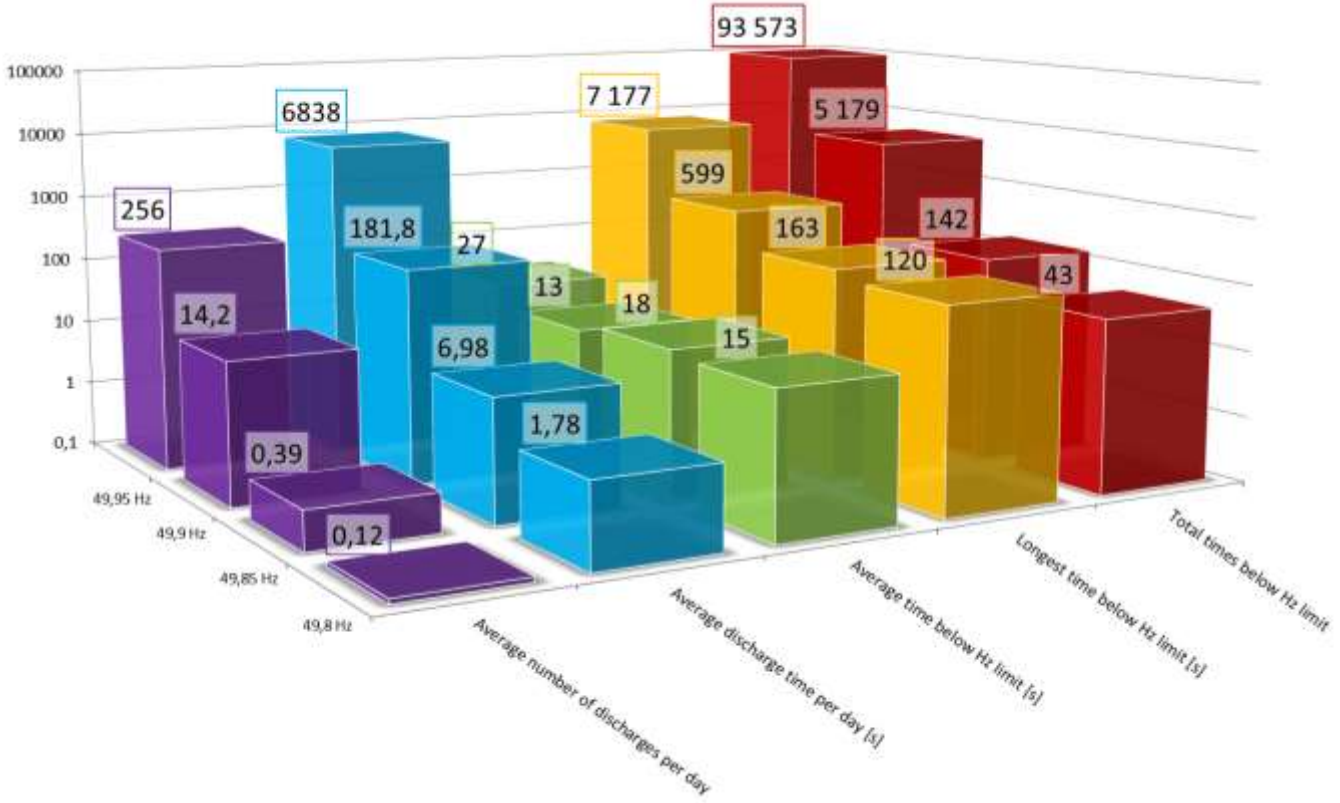
Demand (frequency) regulation – Battery State of Charge



Powering Business Worldwide

Grid frequency vs number of cycles

Annual battery usage in frequency regulation with different activation frequency (regulation band); based on Irish national grid frequency data from 2016



- Battery aging impacted by number and depth of discharges (DoD)
- Different applications give different requirements for battery technology:
  - FCR-N uses continuous charging and discharging – Lithium cells (energy)
  - FCR-D (FFR) has fewer or occasional cycles, shorter duration – Lithium cells (power), lead acid etc.
  - Demand response typically has long discharge times done regularly, energy intensive
- Application to match the capabilities of the battery

Powering Business Worldwide

Grid support functionality – Eaton UPS

Safety:

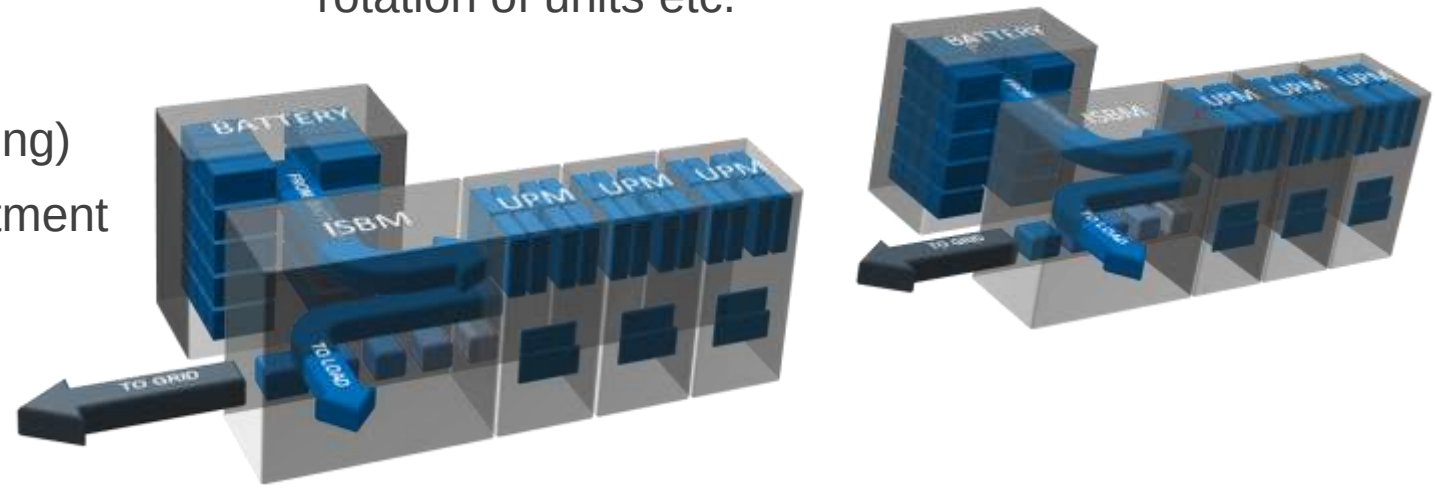
- Battery SoC limit – always enough for critical load
- Battery used in parallel with mains – tolerates mains and battery failure
- Follows a request to participate when safe for load
- Control with potential free contacts or by using limited CANopen protocol with timeouts

Applications:

- Frequency regulation (FCR-N, -D, FFR)
- Demand response (time-of-use, peak shaving)
- Local energy management (PV, EV, investment deferral)
- Generator (engine) dynamic support

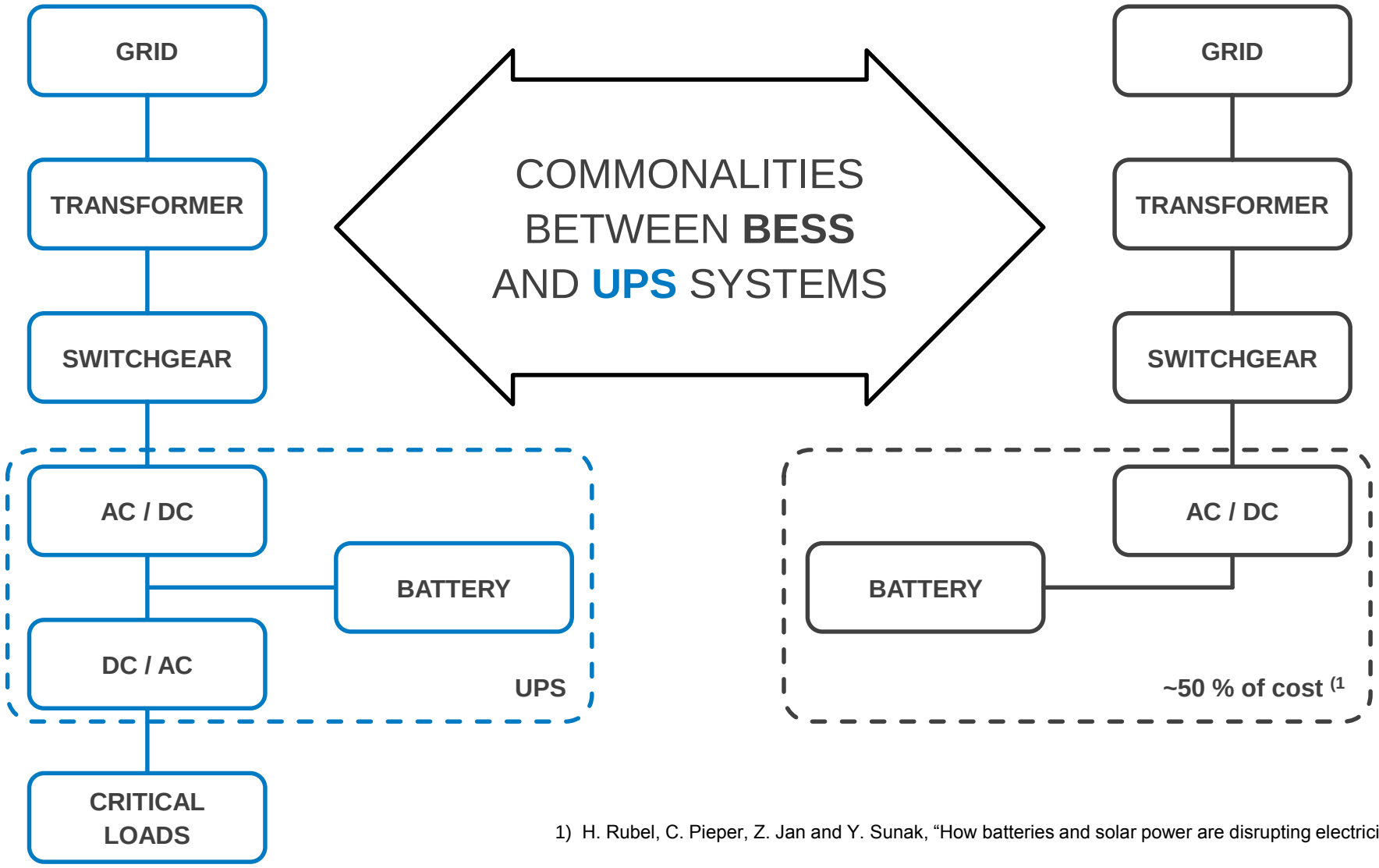
Flexibility:

- Static or dynamic response (proportional to frequency deviation)
- Autonomous regulation or following external reference
- Response is independent of UPS load level
- Single UPS, whole system, whole site
- Aggregation platforms and Virtual Power Plants, rotation of units etc.



Powering Business Worldwide

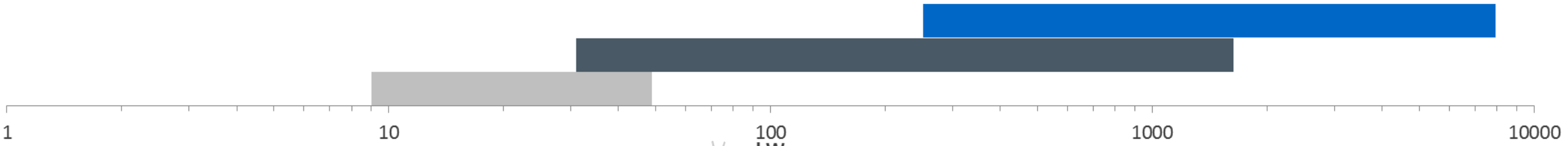
Critical power (UPS) vs Battery Energy Storage Systems



1) H. Rubel, C. Pieper, Z. Jan and Y. Sunak, "How batteries and solar power are disrupting electricity markets," BCG, Boston, 2017.

Powering Business Worldwide

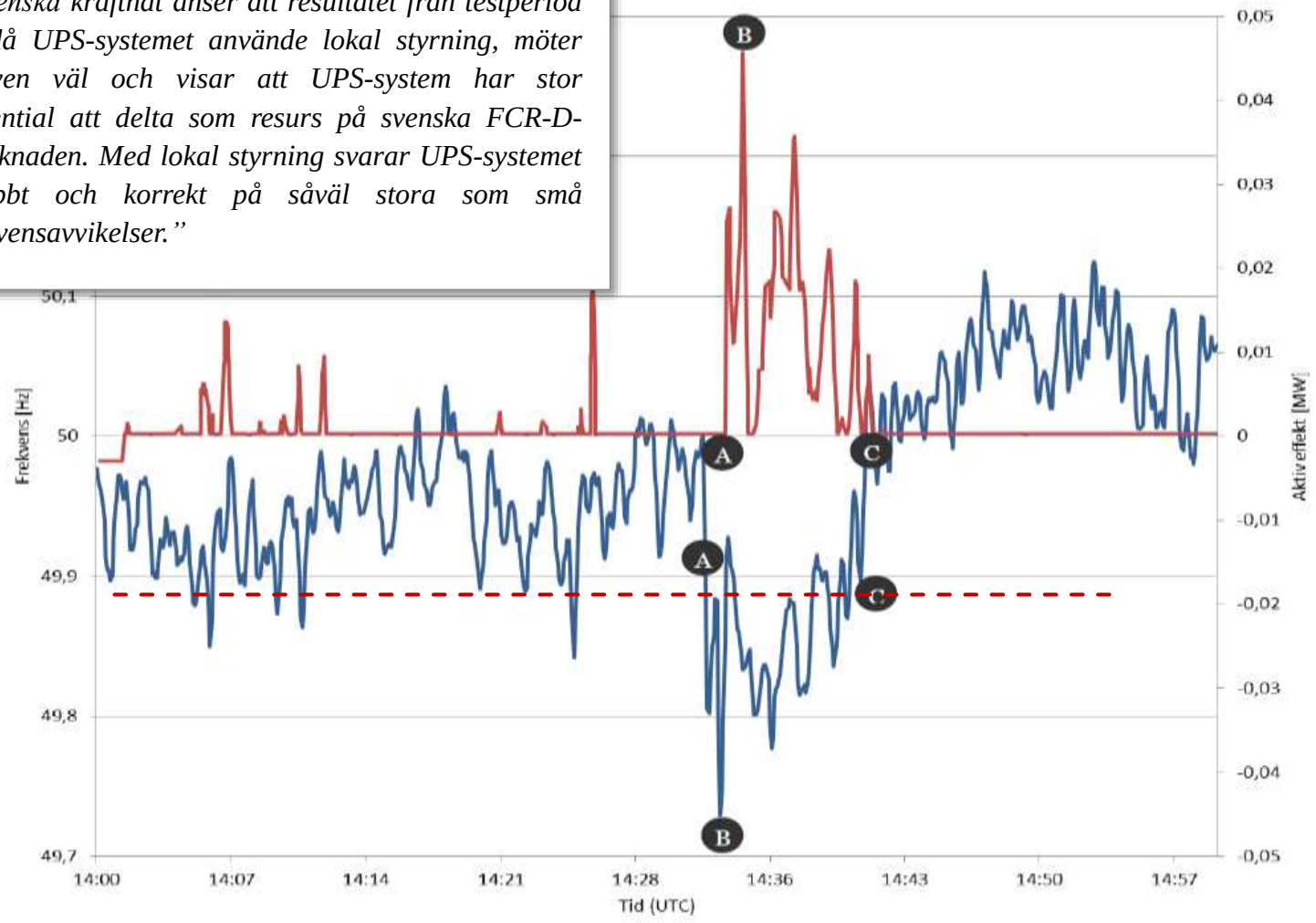
Eaton Energy Aware UPS's with UPS-as-a-Reserve feature



Powering Business Worldwide

Svenska Kraftnät, Sweden – FCR-D pilot

”Svenska kraftnät anser att resultatet från testperiod 2, då UPS-systemet använde lokal styrning, möter kraven väl och visar att UPS-system har stor potential att delta som resurs på svenska FCR-D-marknaden. Med lokal styrning svarar UPS-systemet snabbt och korrekt på såväl stora som små frekvensavvikelser.”

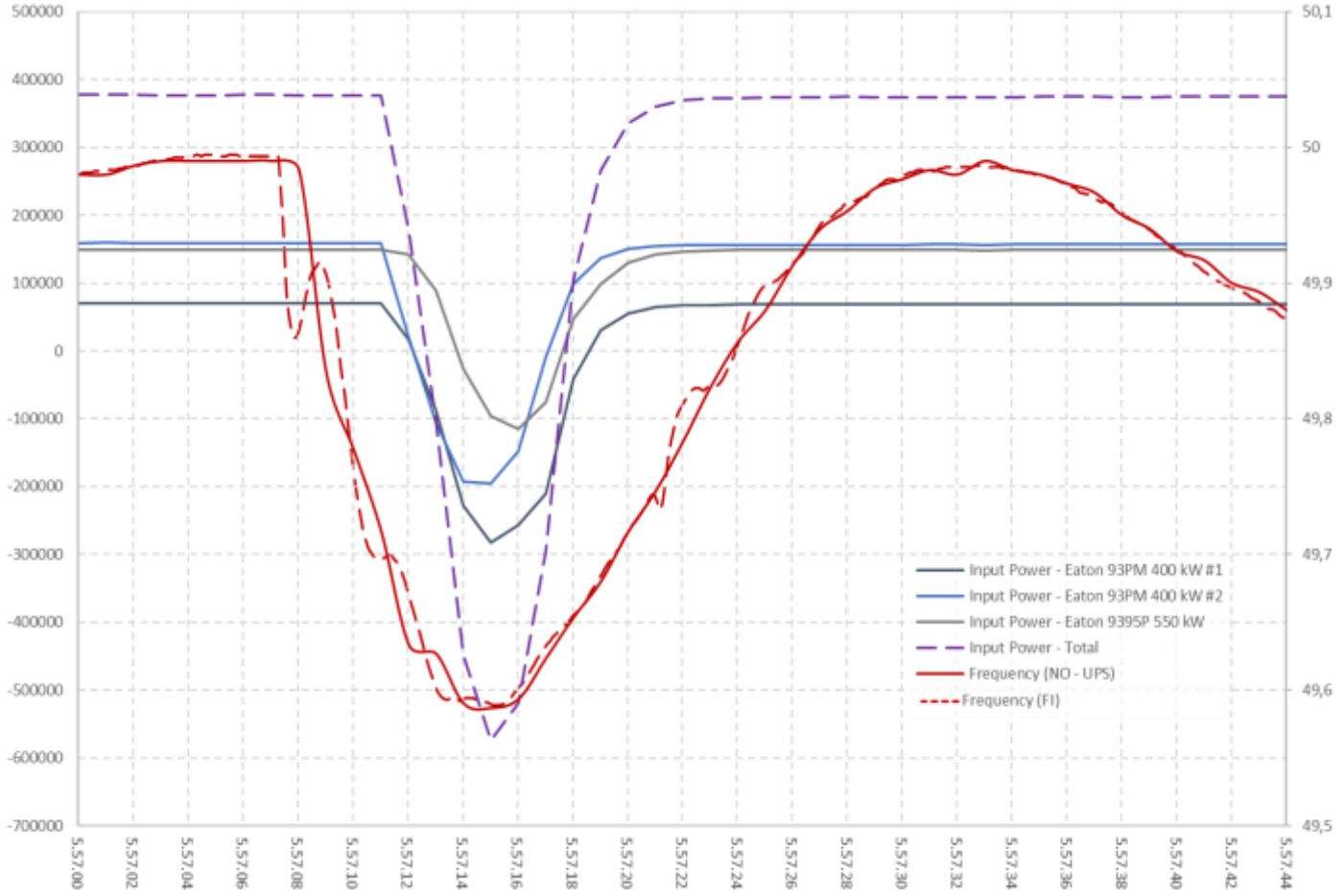


- Eaton 93PM UPS in SvK pilot, operating as frequency containment reserve against distrubances (FCR-D).
- Using dynamic response to grid frequency with autonomous regulation, activation frequency set to 49,90 Hz.

Source: Svenska Kraftnät; Slutrapport pilotprojekt inom förbrukningsflexibilitet och energilager, 2018-06-29

Powering Business Worldwide

Statnett, Norway – FFR pilot with Basefarm DC



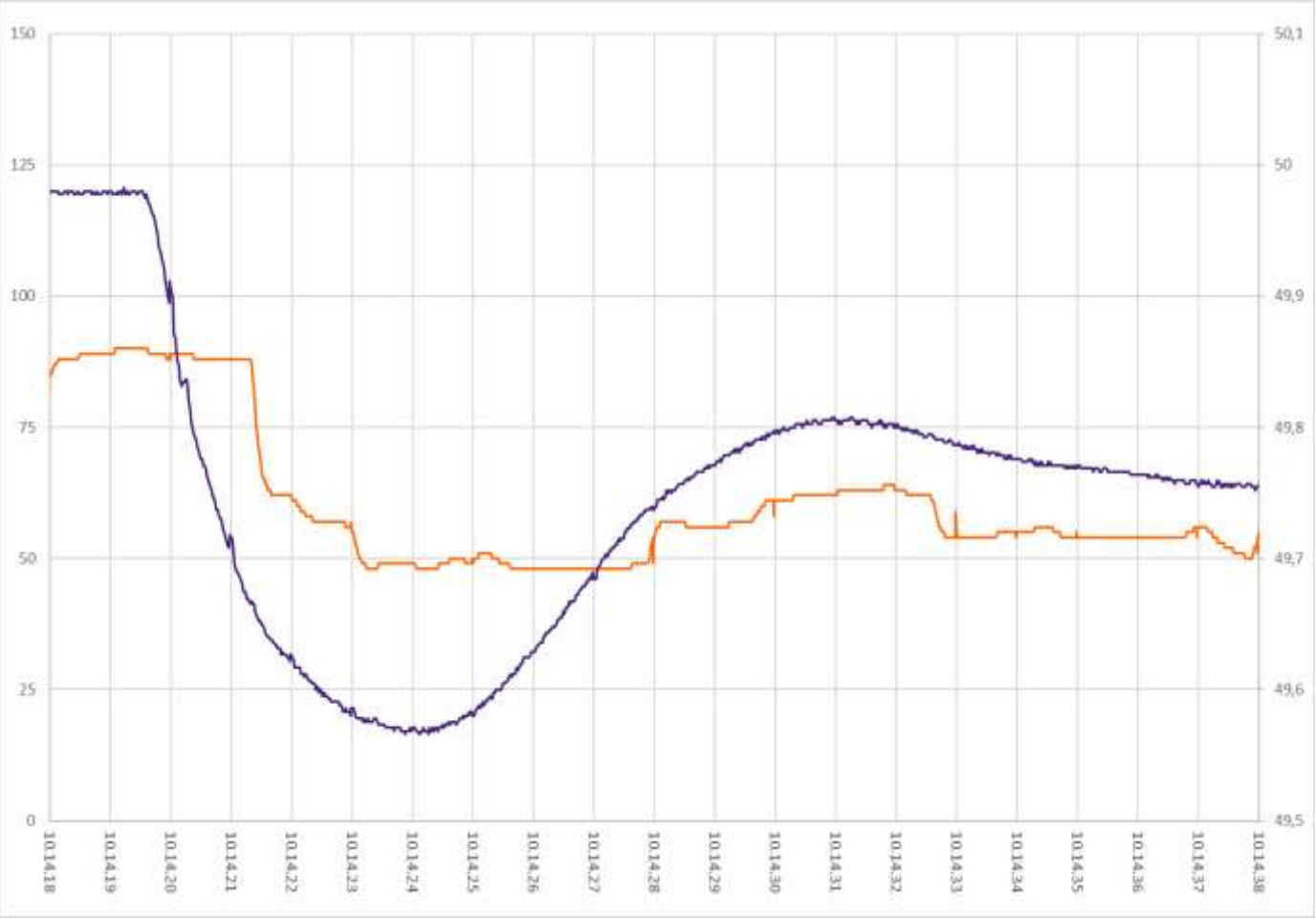
Response to grid frequency with total input power of UPS's (purple) and frequency (red) plotted. UPS input power measurement uses moving average (~1 s)

- Two Eaton 93PM and one Eaton 9395P unit participating in the FFR pilot
- 18th July 2018 a nuclear power plant in Finland dropped off the grid (876 MW)
- UPS's in Norwegian data center (part of same synchronous area) autonomously reduced their demand to respond to frequency deviation and to support the grid

https://www.statnett.no/om-statnett/nyheter-og-pressemeldinger/Nyhetsarkiv-2018/fleksibelt-forbruk-bidrar-til-stabilitet-og-verdiskapning-i-det-nordiske-kraftsystemet/

Powering Business Worldwide

Eaton House, Dublin, Ireland – FFR



UPS response to grid frequency (purple) with total building input power (orange) plotted.

- Eaton's Energy Aware 93PM UPS operating as a part of Enel X's virtual power plant
- Response to grid frequency using 25 kW static response (FFR)
- Activation at 49,70 Hz

Powering Business Worldwide

Eaton - Microsoft collaboration

E&E NEWS

ENERGY

How Big Batteries at Data Centers Could Replace Power Plants

Battery systems intended as backups may help companies like Microsoft increasingly employ renewable energy

By Benjamin Storrow, E&E News on July 19, 2018

"I don't know if you just see some lines, but for us this is like seeing a lightbulb turn on for the first time." – Sean James, Microsoft director of energy research

Conclusions

- Future power systems need more flexibility and cost efficient reserves
- Essential to maintain lower energy price and reliable power system
- Helps to reduce GHG-emissions:
  - Replaces spinning reserves based on **fossil fuels**
  - Supports higher penetration of renewable (non-synchronous) power generation
- Smarter use of assets and new earning models
- Flexible and safe – when done right

Powering Business Worldwide