

# Welcome to our webinar “Thermal Testing & Analysis”

Focus eMobility



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# Presenter

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# The Electrified World



# The Future of Mobility is electrified

25%

By 2025, 12-25% of light vehicles will be hybrid or BEV

SOURCE: ROLAND BERGER

8% growth in of battery energy density per year!

95% of all trips are < 200 km

98% of all trips are > 500 km

50%

In 2030, the share of electrified vehicles could range from 10-50% of new-vehicle sales

SOURCE: MCKINSEY

**2030**

60% of all city busses electric

Need for 12.000 units / year

Load overnight in 3-4 hours

**Zero emission cities in 2025:**

London, Amsterdam, Cologne, Brussels, Paris, Oslo, Stockholm, ...

30%

Almost 30% of vehicle buyers in the U.S. consider an EV purchase today

SOURCE: MCKINSEY

**Alternative CO2 reducers:**

Fuel cell

Synthetic fuel

# Thermal Testing in eMobility Applications

# Typical Requirements for Automotive Batteries

Life-cycle min 10 years, > 15 years or 450.000 km

Re-Charging to miles / km target should be OK

Charging time < 10 min with DC charger > 300 kW

Charging time < 5 hours with AC charger at home OK

2800 cycles still 80%

Safe in operation

(extreme temperature, crash)

500 km / > 300 mi range fully charged

Re-useable / 2<sup>nd</sup> life

Accaptable cost per Wh

No memory effects

High energy density  
> 300 Wh/kg

Sustainable production  
of primary sources

# Thermal Testing

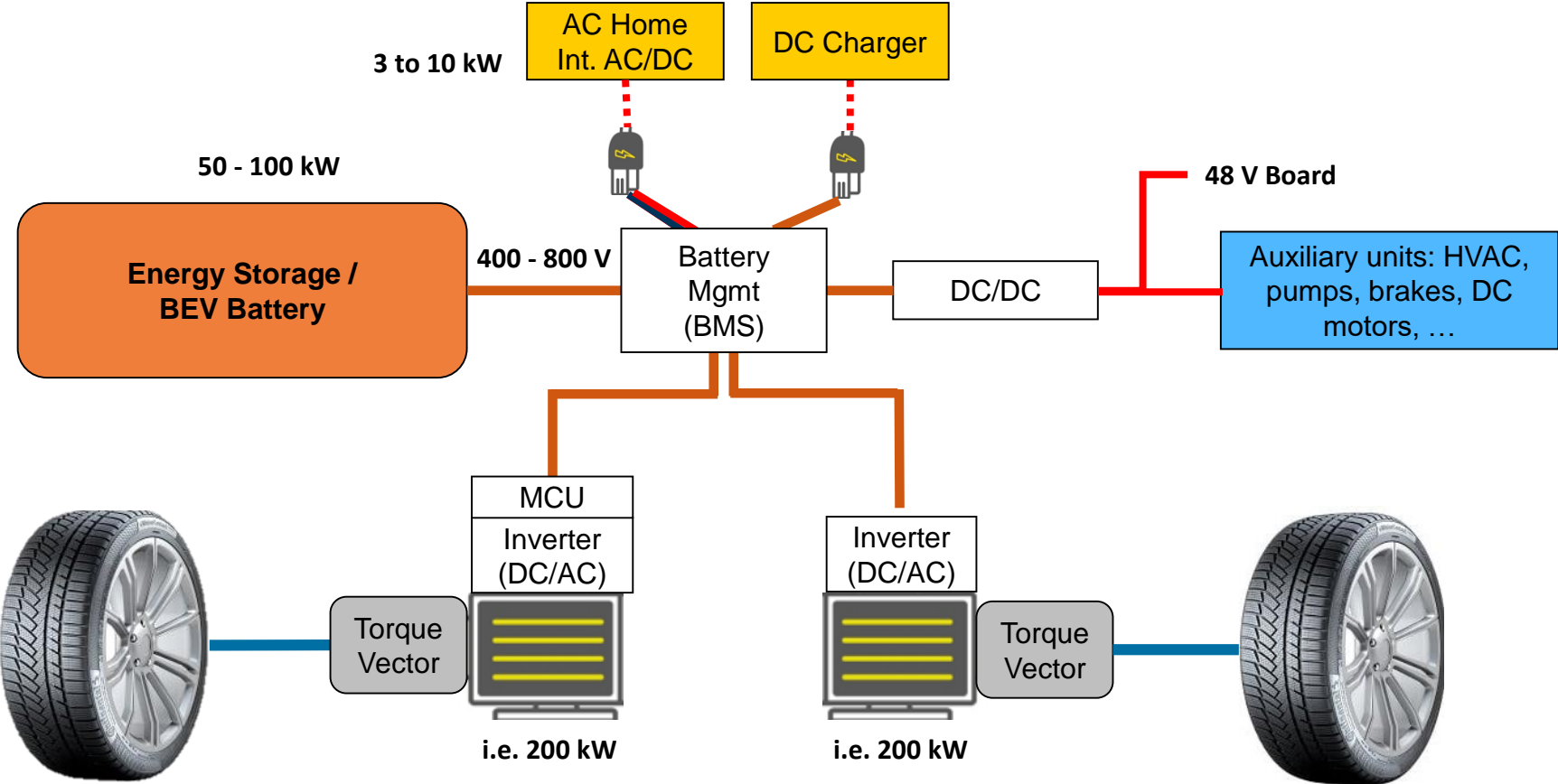
- Thermal Testing is widely established today, increasing confidence in the design, ensuring successful operation, demonstrating robustness / durability, verifying performance within spec, measure critical parameters and to confirm thermal modelling assumptions.
- New requirements out of eMobility especially to tools but also to workflow (electrical safety, sensor and signal types, dynamics, etc.)
- Especially the poor performance of lithium-ion batteries in extreme temperatures is a challenge for thermal management systems (BTMSs)
- Thermal testing standards vary in the certain industrial branches automotive, commercial vehicle, aerospace, railway, ship / vessel, etc. so tool supplier are confronted with many different requirements.

# Thermal Testing in eMobility Today

- Thermal tests are comprised of multiple phases: environmental stress screening, performance verification, turn-on demonstration, thermal hardware verification  
Numerous of tests from cell over stack to pack
- Battery long term reliability testing focusing on dis/charging cycles (slow, fast), self-discharge
- Dyno Testing focusing on power, efficiency, reverse load feedback
- Environmental testing in climate chambers (temperature, humidity, pressure, ... combined shaker) running on specific use-case oriented test profile
- Misuse and impact testing (overload, short-circuit, overheating, mechanical stress, defect)
- In-vehicle testing, summer / hot, winter / cold testing with transients



# Example: Battery Electric Vehicle (BEV)

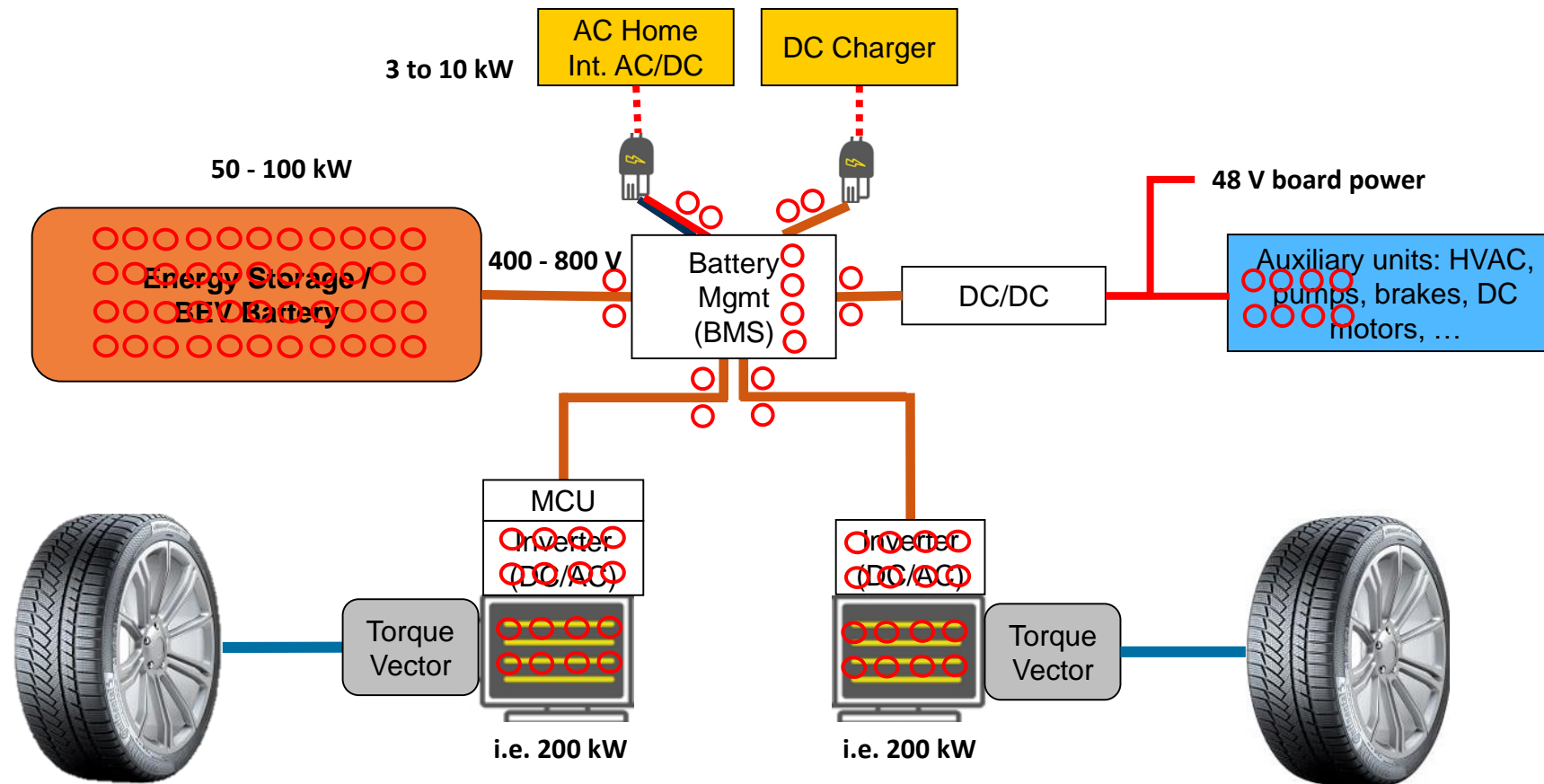


1 kWh = 0,25 ct (home)  
 100 kWh = 25 €

1 kW = 1,35962 mPS  
 100 kW = 136 PS

1 mile = 1.60934 km  
 248 miles = 400 km

# Measurement Spots

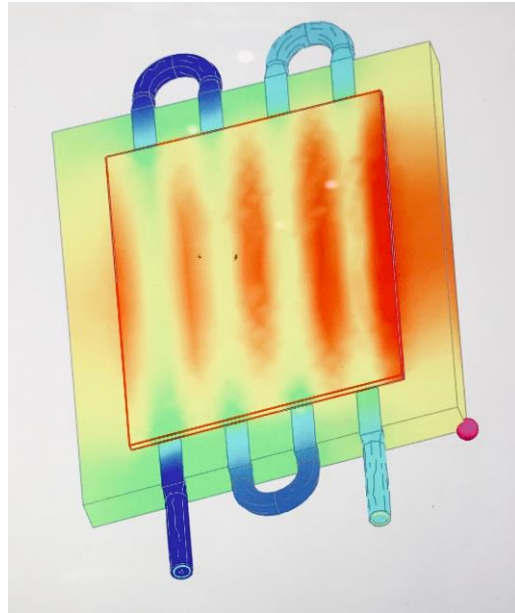


- **Measurement spots:**
- > 200 temperatures
  - Cell voltages
  - Overall voltages and currents
  - Flow, pressure, humidity
  - CAN FD signals (BMS)

# Thermal Simulation and Thermal Testing

## 1) Thermal Simulation

Simulated system and environment



**Computer only**

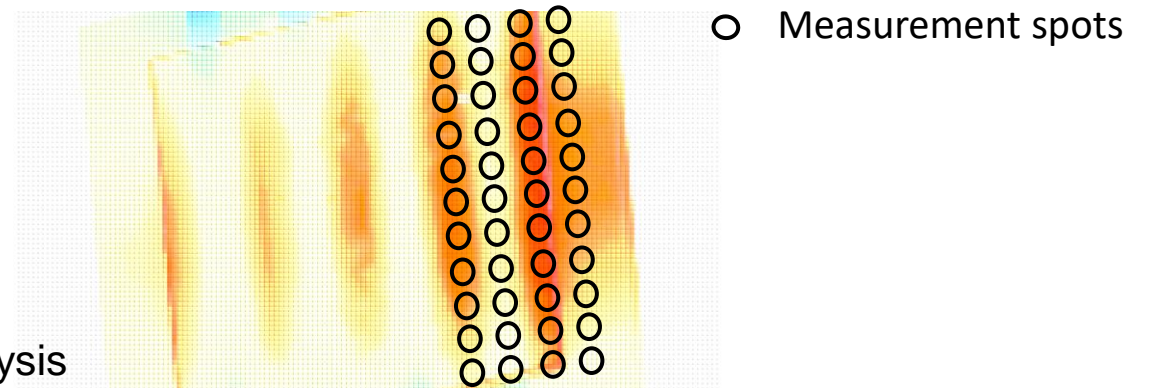
Computer Fluid Dynamics (CFD)

## 2) Thermal Testing

Real physical system / test specimen

S(t)imulated “real” load (test environment)

Data acquisition and analysis



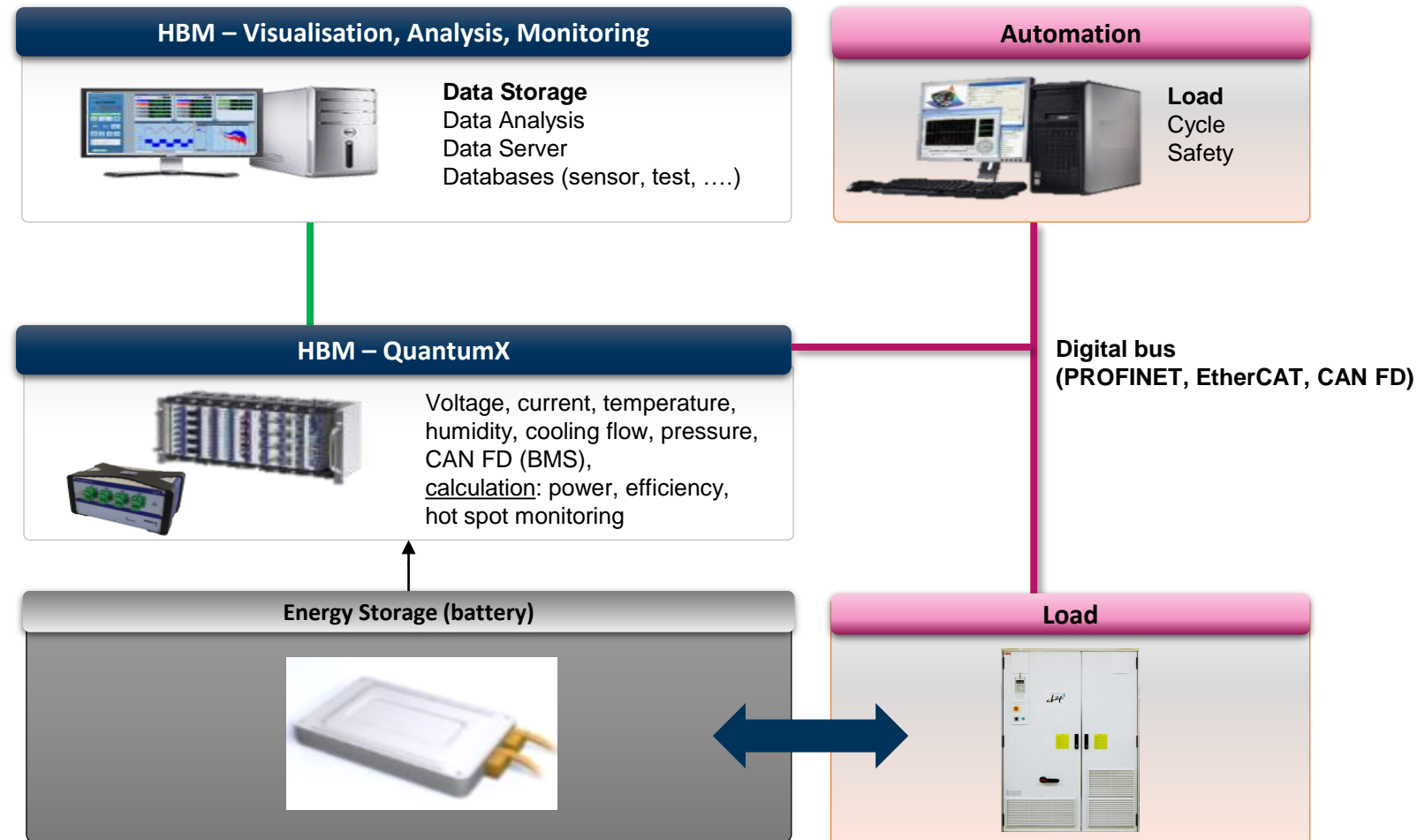
Hot spot analysis  
Math model correl.  
Lessons learned

**Lab / test bench**

Climate chamber, cycle / dyno test stand, in-vehicle

# HBK Solutions for Thermal Testing in eMobility Applications

# Energy Storage Thermal Testing Solution



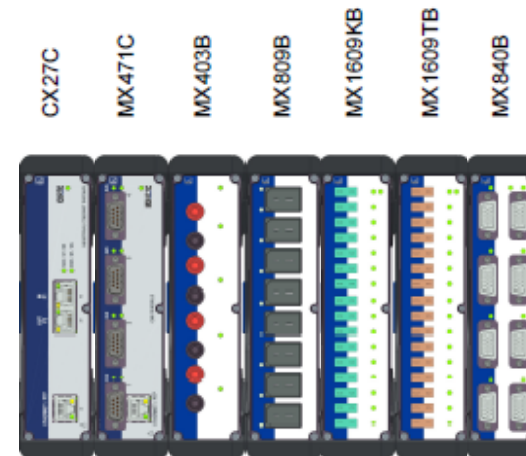
# HBK Data Acquisition and Analysis Solution

## Typical Requirements

- 80 x thermocouples, isolated > 1000 V, 10S/s
- 100 x thermocouple type K, non-isolated, 10S/s
- 40 x voltage -5...5V, isolation > 800V, < 20kS/s
- 4 x voltage 1000V, overvoltage 1400V, ~ 20kS/s
- 4 x current 200A, shunt or zero-flux, 20kS/s
- 4 x universal for flow, pressure, humidity, 20kS/s
- 2 x CAN/CAN FD ports, CAN based shunt

## QuantumX

- 1 x CX27C: EtherCAT / Ethernet gateway
- 1 x MX403B: 10, 100, 1000 V for voltage: **4Chs**
- 15 x MX809B: all type thermocouple, 5 V cell voltage: **120Chs**
- 8 x MX1609KB: type K thermocouple: **128Chs**
- 1 x MX840B: universal, flow, pressure, humidity: **8Chs**
- 1 x MX471C: CAN FD in / out: **4 ports**



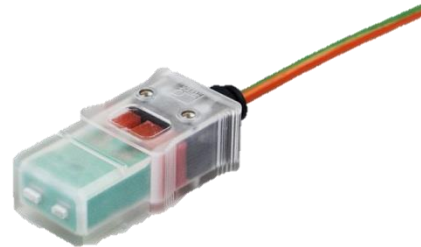
# QuantumX MX809B



1-CON-S1017



1-CON-S1016



1-CON-A1018 (without thermo mini)



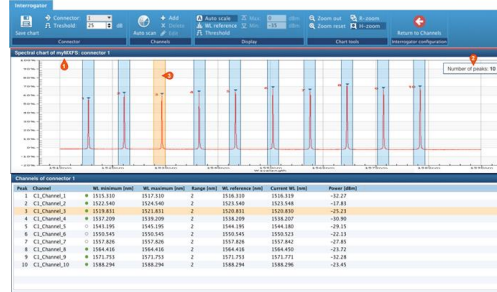
Insulated complete thermocouple (1-ITC-K1000)

**High contact safety**  
**Cost-effective ready to go solution**



# Coming: Optical Measurement Chain

Release: early 2020



Automatic peak detection



QuantumX optical FBG module



newLight optical sensors:  
strain, temperature, force



# MXFS – Fiber Bragg Grating Optical Module

## Optical Interrogator module for Fiber Bragg Grating based sensors

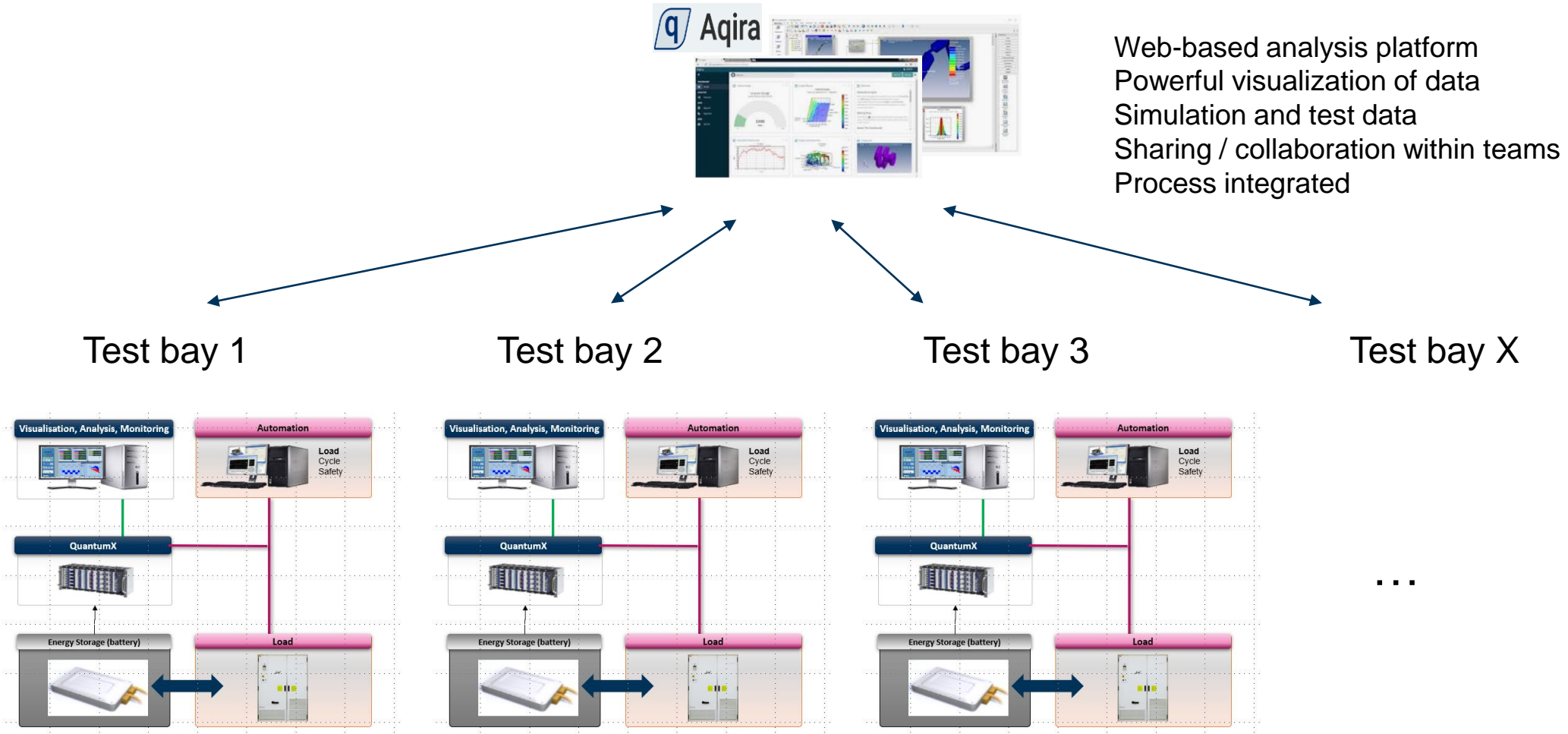
- 8 optical **connectors** (typical 15 sensors per connector, depending on measurement ranges)
- Datarate: up to **2 kS/s** simultaneous per sensor
- **FC/APC** or **SC/APC** connectors
- Wavelength measurement capabilities
  - **Smart Peak Detection**
  - **High dynamic range**
- Large sensor portfolio (strain, acceleration, displacement, temperature, tilt / inclination)

## Benefits

- + NO electromagnetic interference (EMI)
- + Fully isolated (glass fiber)
- + High sensors density with one device
- + Long distance, can go in climate chamber (-40...85°C)
- + Sensor can stay in the battery (just cut it off)
- + Small diameter (reduced impact to test specimen)
- + Ability to measure on electric drive rotor with rotary joint



# Overall Centralized Simulation and Testing Data Hub



# Reference

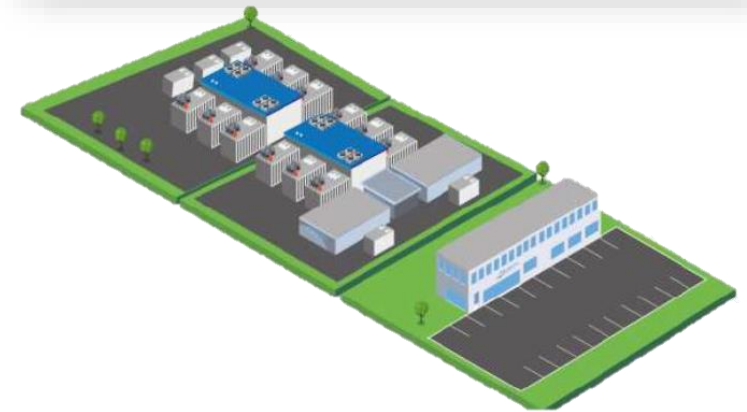
# Millbrook, UK – Battery Testing

## Performance and Thermal Testing

- + 12 test cells cycling complete automotive battery packs
- + up to 500 kW per cell (max 1000 kW continuous / 1200 kW peak)
- + -40 ... 90 °C environmental chamber

## Millbrook Battery Testing Service Facility

- + Test rapid changes in temperature while cycling the battery pack
- + Containerized concept giving max. safety
- + Based on HBM QuantumX DAQ system and HBM nCode data analytics



# Summery – Thermal Testing from HBM

## Your Benefits

- Maximum safety (electrical according to EN 61010 / CAT or optical measurement chain)
- Electromagnetic noise immunity (EMI), isolation
- Best scalable and flexible multi physics DAQ measuring all signals in a time sync'd way: current, voltage, temperature, humidity, strain, flow, pressure, ... for daily changes
- Powerful software package: online data visualization in any curve style: over t, x-y, frequency
- Automatic procedures (stimulation) ensuring reproducibility of results and short processing times
- Integration in real-time PROFINET, EtherCAT, CAN FD in parallel to high datarates
- Bench, lab and mobile data acquisition and testing
- HBK as cost effective one stop shop solution provider for thermal, mechanical and electrical test specimen analysis

# Any questions?

- If you have any questions, please do not hesitate to contact us: [webinar@hbkworld.com](mailto:webinar@hbkworld.com)
- Or email the presenter directly: [christof.salcher@hbm.com](mailto:christof.salcher@hbm.com)



# Thank You

Let's talk about your test case....