ASH
CREATIVE WIRELESS ELECTRONICS

The Impact of the Internet of Things on our Lives.

The Challenge of Legacy Assets

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ASH Wireless is an electronics design consultancy
Specialising in wireless and sensors

electricity north west

Bringing energy to your door

Celsius

An Ofgem funded Network Innovation Competition project

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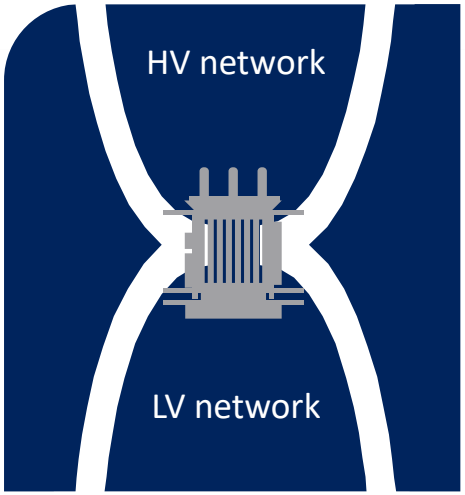
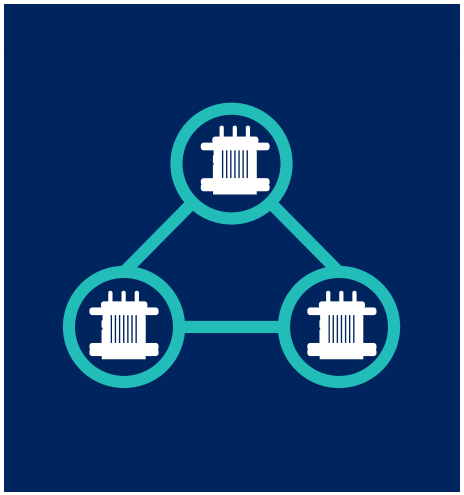
The problem





Objective is to maximise power through transformer

Assets have nominal thermal rating

Ratings = ^{O}C

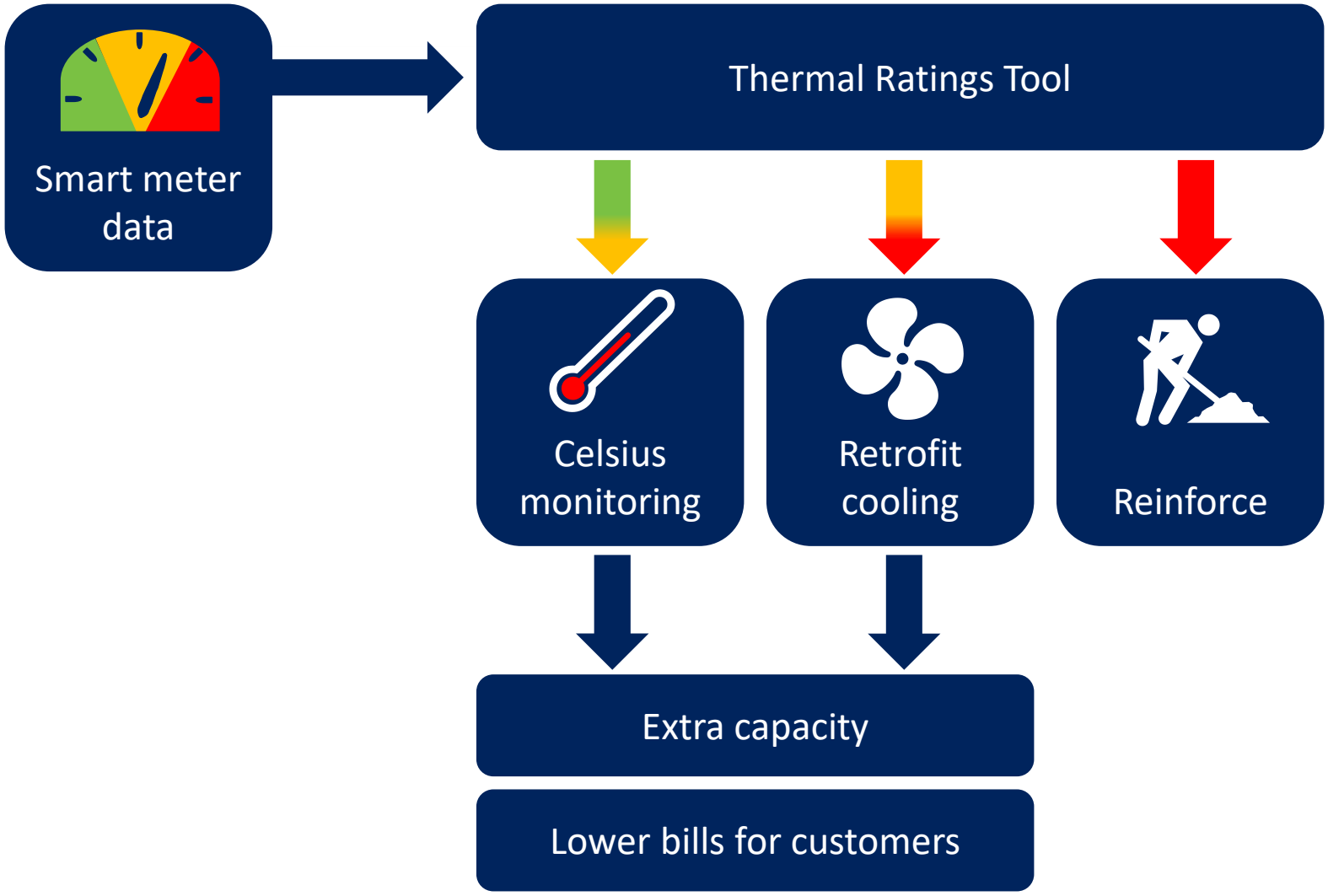
Ratings **K** amps

Diverse range of environments

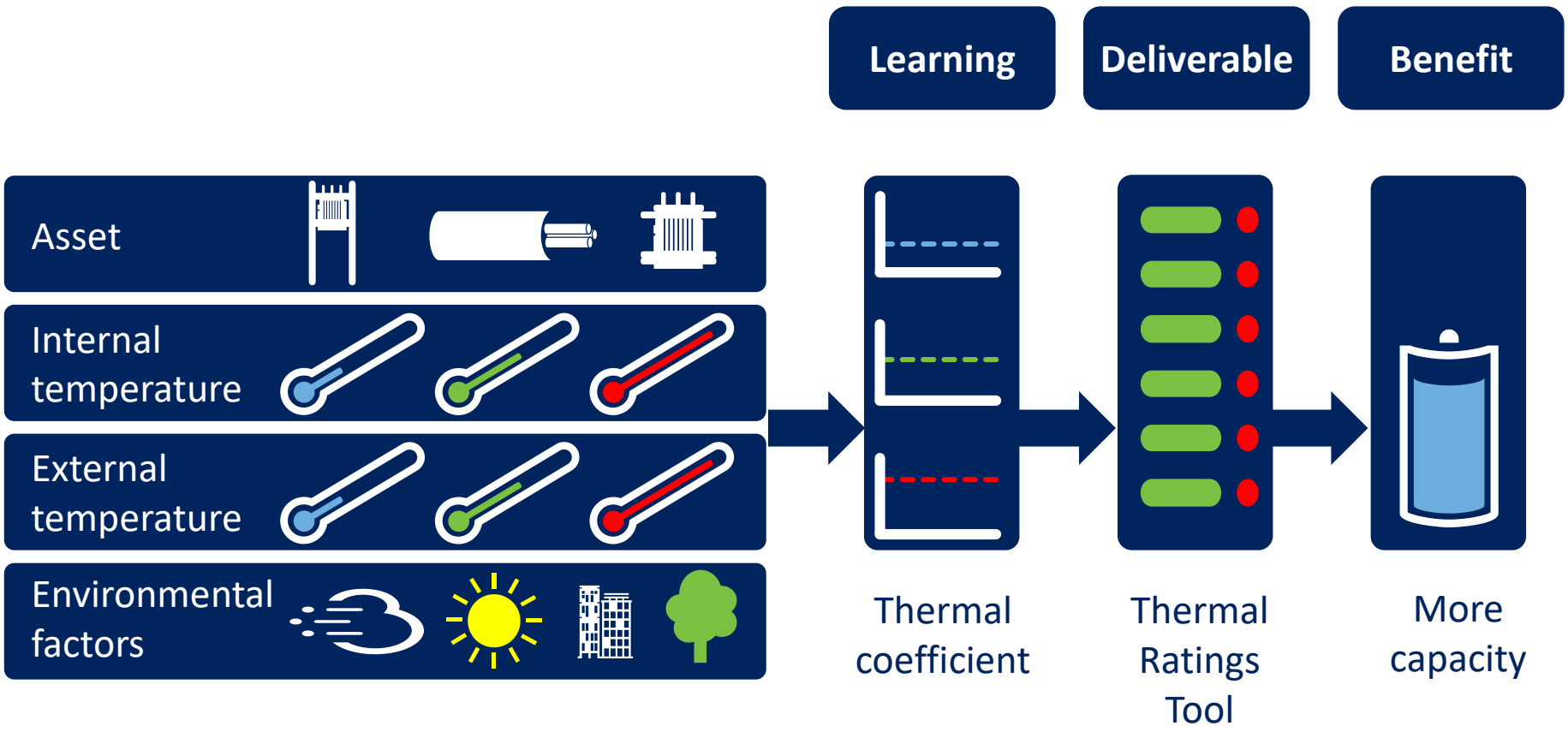
Small changes in environmental factors can result in very different actual ratings

Assumed thermal ratings can lead to capacity being under-utilised or unnecessary risk

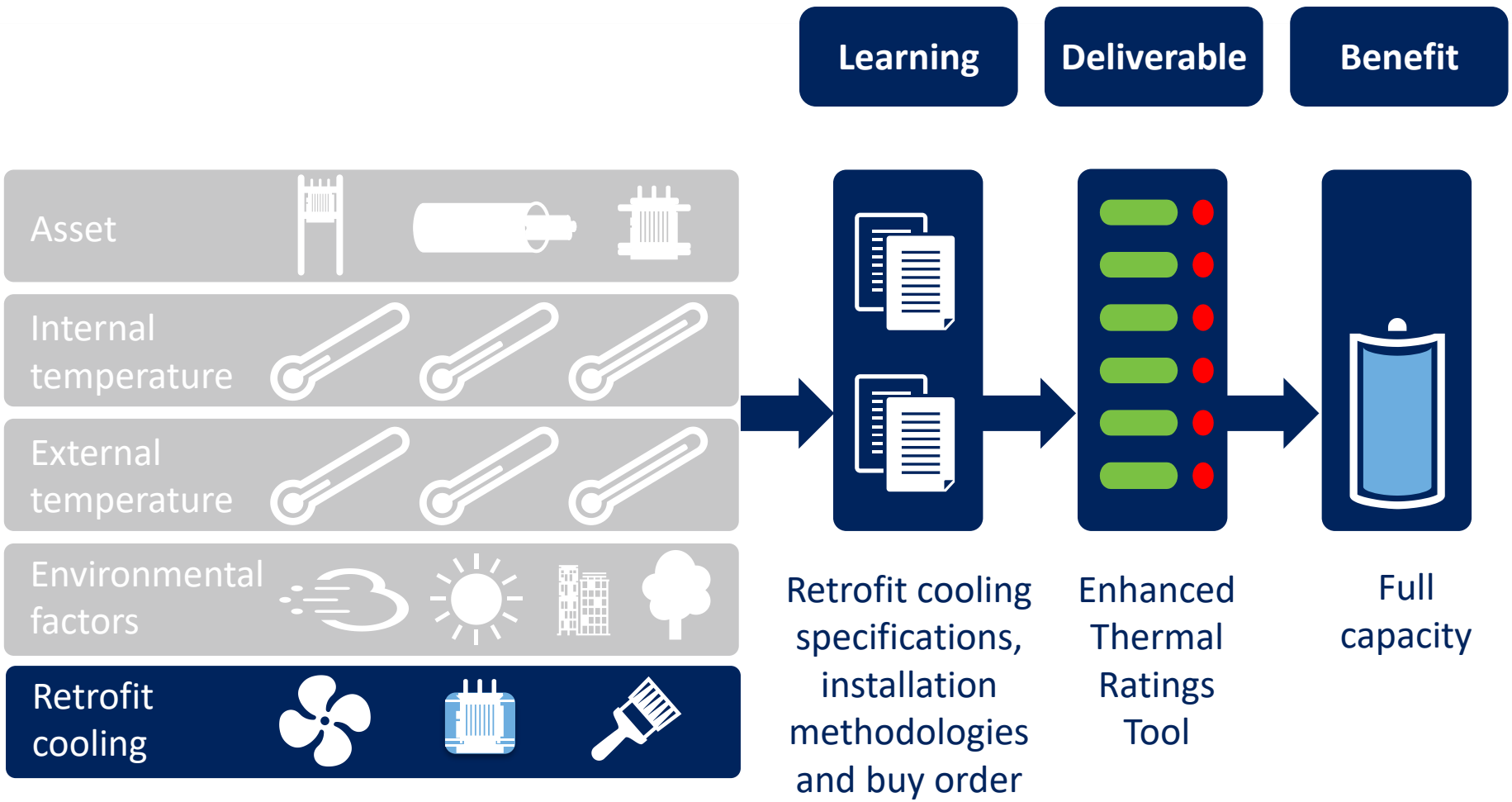
Celsius as part of the smart future



Step 1: Fit thermal monitoring



Step 2: Retrofit cooling



Partners and roles on project

ASH – Creative Wireless Electronics	Ricardo-AEA	UK Power Networks – Delivering your electricity	Impact Research	University of Southampton
Supply complete retrofit monitoring solution Provide ongoing support throughout installation, commissioning and operation of the retrofit thermal monitoring workstream	Analyse trial data Develop methodologies to understand relationship between asset temperature, load characteristics and surrounding environment Determine impact of cooling technologies Develop tool and spec for low cost temperature sensor Recommendations for BAU rollout	Work with ASH, Ricardo-AEA and Electricity North West to develop retrofit thermal monitoring solution Participate in evaluation and selection of retrofit cooling techniques	Facilitate customer focus groups Develop customer communication materials Lead the customer survey engagement	Peer review of the analysis methodology of the retrofit temperature sensor part of the project An investigative study on the impact of Celsius on the lifetime health of network assets

Monitoring site selection and timescales

		
520 substations	100 cooling technique sites	Four year project
Enough substations to represent 80% of GB substation population	Subset of 520 substations – enough sites to adequately trial all techniques	To enable trials to take place during all seasons and to trial all cooling techniques

Celsius

Awarded: 9th December 2015

- Go live
- Monitoring installation Mar 2017
- Monitoring trial Mar 2018
- Thermal ratings tool stage 1 Oct 2018
- Retrofit cooling installation Jun 2018
- Cooling trial Jun 2019
- Thermal ratings tool stage 2 Jan 2020
- Closedown Mar 2020

Investment

£5.5 million

Up to £583m across GB by 2050

Financial benefits

RICARDO-AEA

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Impact Research

UK Power Networks Delivering your electricity

So the answer's simple

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1. Gather data on the power throughput & characteristics, asset temperature,
2. Work out the relationships, and how you can change these with retrofitted cooling technology
3. Decide how long you can postpone reinforcing or replacing assets,
4. Save lots of money

But there are some practical problems……..

Legacy Assets

- **A significant percentage of electrical substations are more than half a century old**
- **Most are not installed with measurement equipment for voltage, current, power, power quality, temperature of key assets**
- **Critical infrastructure – any work must not intrude on continued operation.**
- **Access to the sites is restricted for safety reasons**

?How to fit monitoring sensors when…

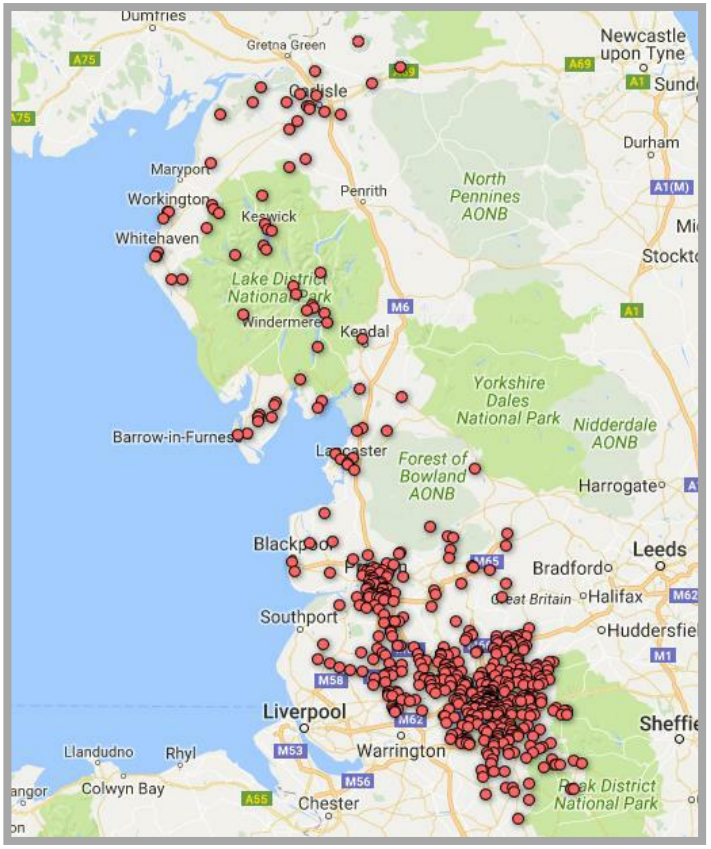
- **No internet connection available**
- **No mains power available**
- **Can’t install wiring, mount equipment, etc without intruding on critical operations**
- **Challenging RF environment for radio connections,, multipath, multiple monitoring points needed**

KeLVN
- Design Requirements

- Monitoring system can be installed non-invasively;
- All equipment magnetic or cable-tie mounting;
- *All* equipment battery powered for duration of data gathering project (3.5 years).
- All equipment wireless, only leads are those required to actually take measurements.
- Daily reports to back end. 30 minute measurements of V, I, P, Q, THD, Temperature

Backhaul Choices

- Clusters of sensors over a small area
  - Spread over a large part of the country
- Mobile network is clear winner
- LPWAN
  - Possible, but patchy network support
- 2.5G GPRS chosen
  - Coverage, component cost



Local Wireless Sensor Network

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- Requirement for large substations (30m x 15m), sensors may be in cabinets
- Path loss at 2.4GHz expected less than 90dB
  - Avoid stationary nulls by using antenna diversity
  - Energy-efficient 802.15.4 transceivers used, no front-end-modules
- Operation needs to allow for more than one hub
  - Large coverage
  - Check installation from outside the substation

Local Wireless Sensor Network

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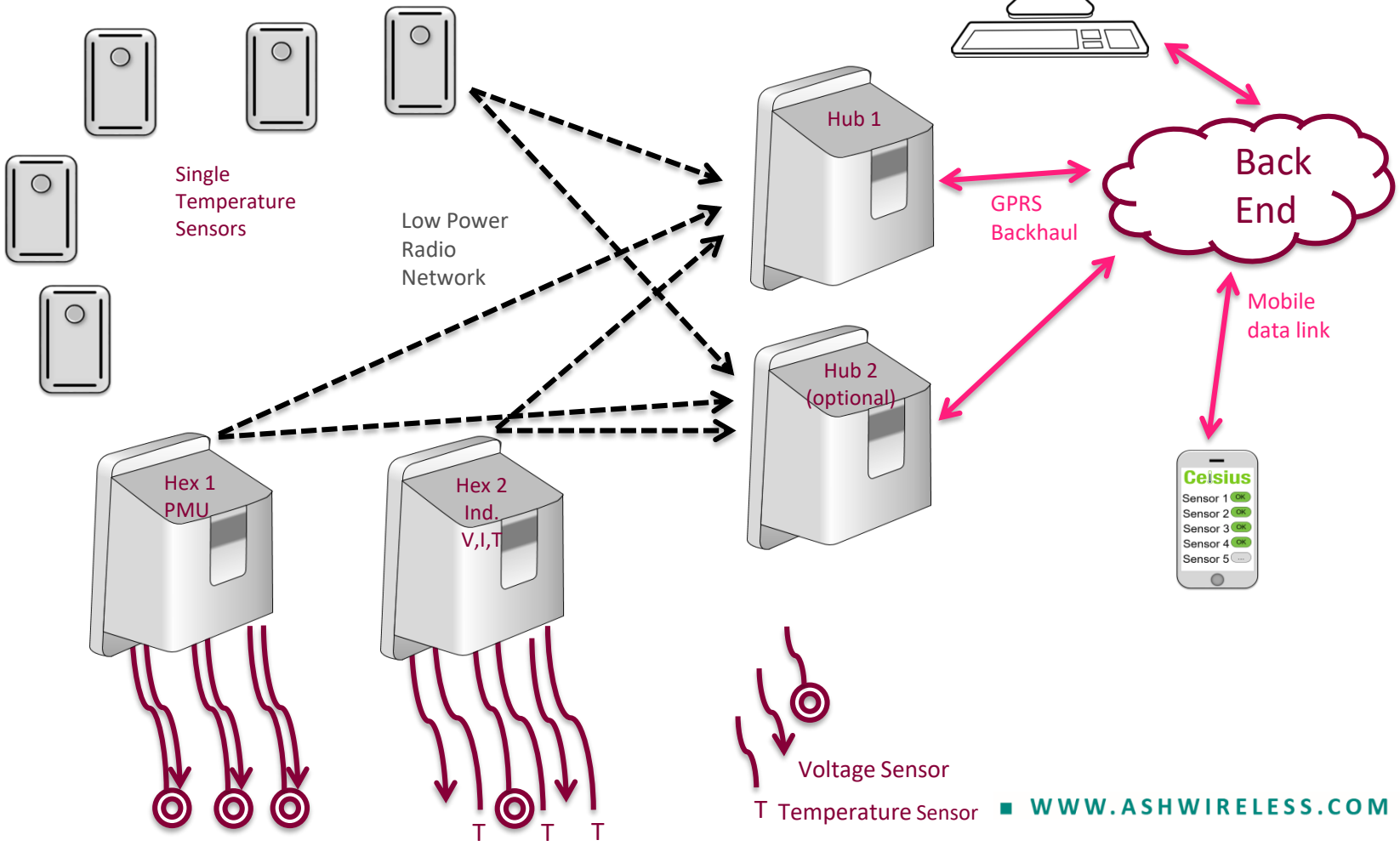
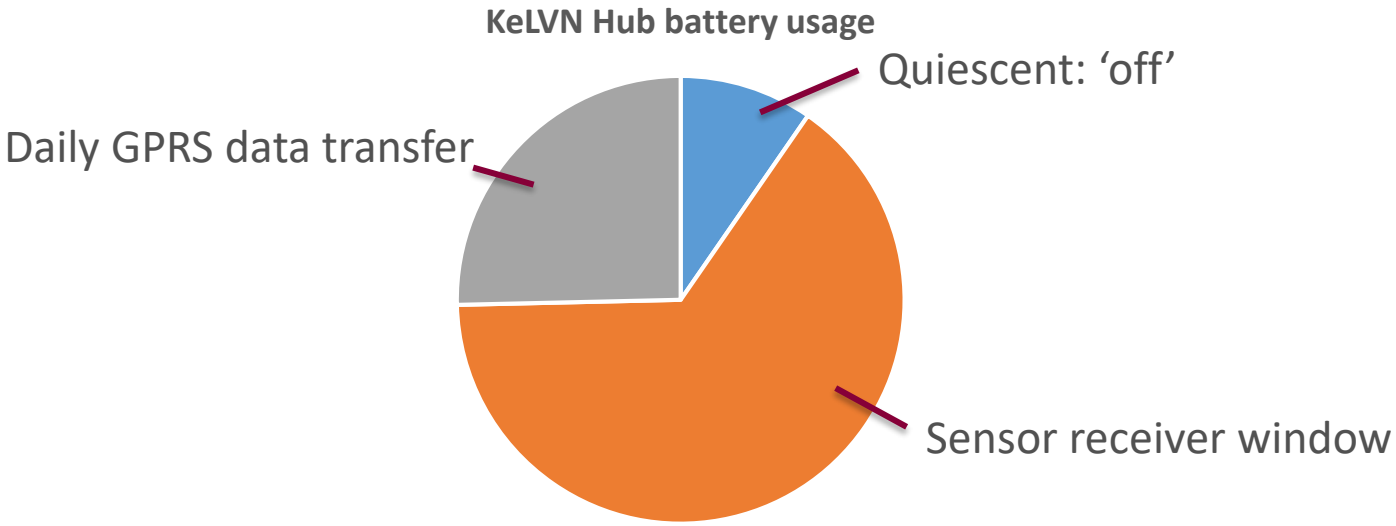
- Simple, non-paired network access, minimised energy
  - Sensors transmit the last 6 hours of measurements (1 packet) every 30s
  - Time-jittered to avoid multiple collisions from time-aligned sensors
  - A hub listens for 60s for reports every 6 hours
  - Hub transmits a daily report to a back-end database
- Hub operates for 3.5 years on a Lithium D-cell
- Other sensors use AA or D cells for >3.5 year life

KeLVN
- Substation Monitoring



Battery Life

- The Hub is an interesting challenge:
- Lithium D-cell, 10AH
- Over 3.5 years life
- Distribution of where the capacity is used:



Key learning points

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- The installation and environment defines
  - Equipment design (e.g. magnetic mounting)
  - Protocol (e.g. multiple hubs allowed)
  - installation procedure (fast, non-invasive)
- GPRS modem auto-connect modes are not reliable, process needs detailed design
- Alarms
  - Not required in Celsius
  - Low latency for alarms is managed with a hub software extension, and external power to the hub

Example of how legacy assets can be made to yield valuable data

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Retrofitting monitoring equipment to legacy assets:

- **Ease of installation is primary consideration**
- **Use of a local wireless sensor network eases installation**
- **Optimise air interface to manage trade off between latency, data rate, battery life**

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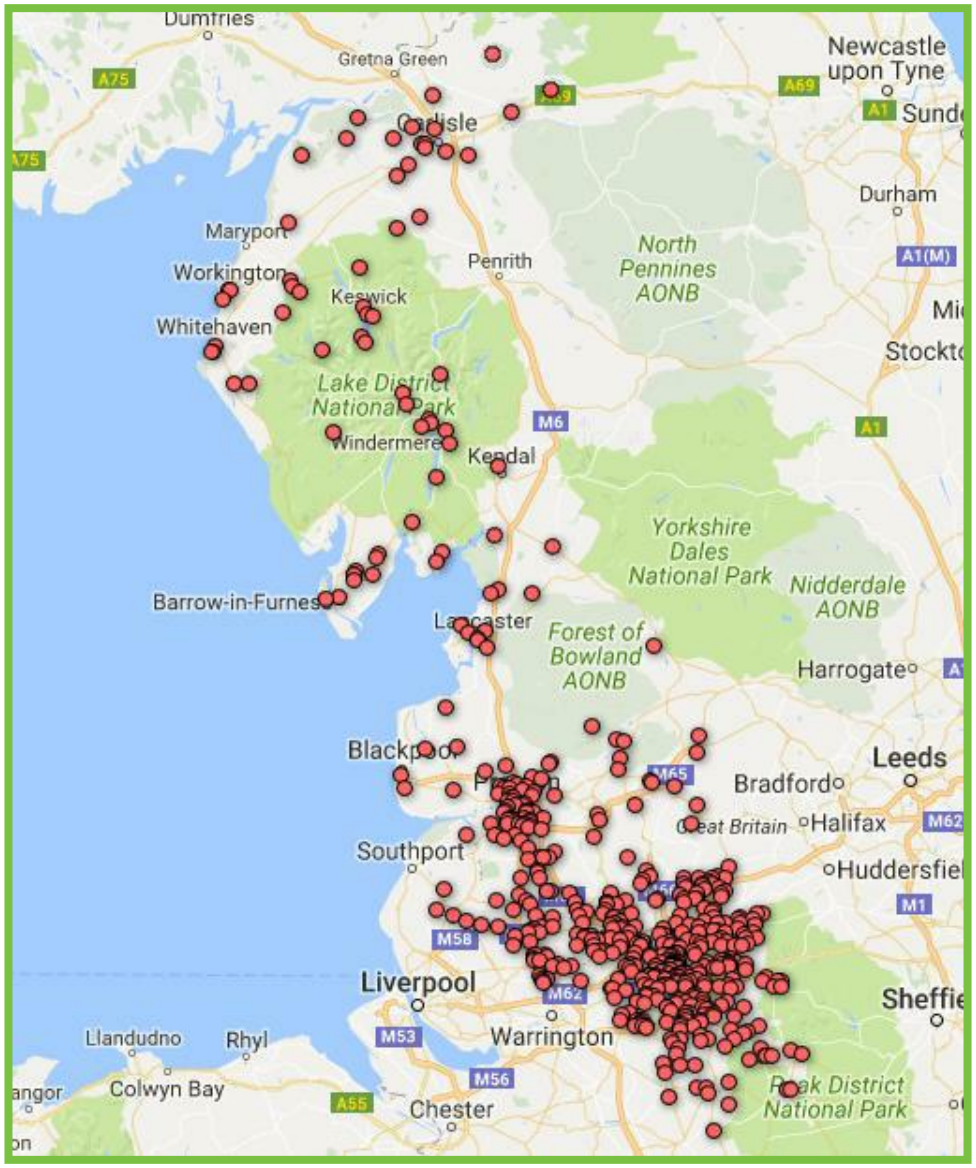
Additional material

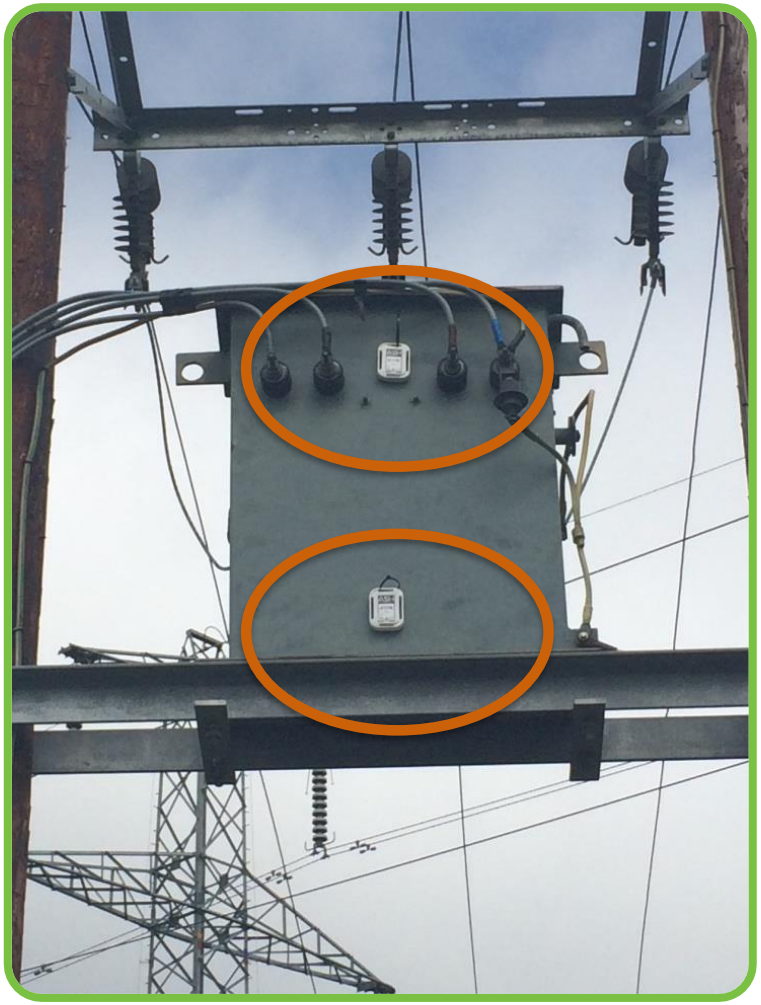
Site selection map



Celsius technology

Hub

Wireless sensor



Celsius technology – trial fit

LV board with three sensors

Celsius technology – trial fit

Transformer

Trial site data