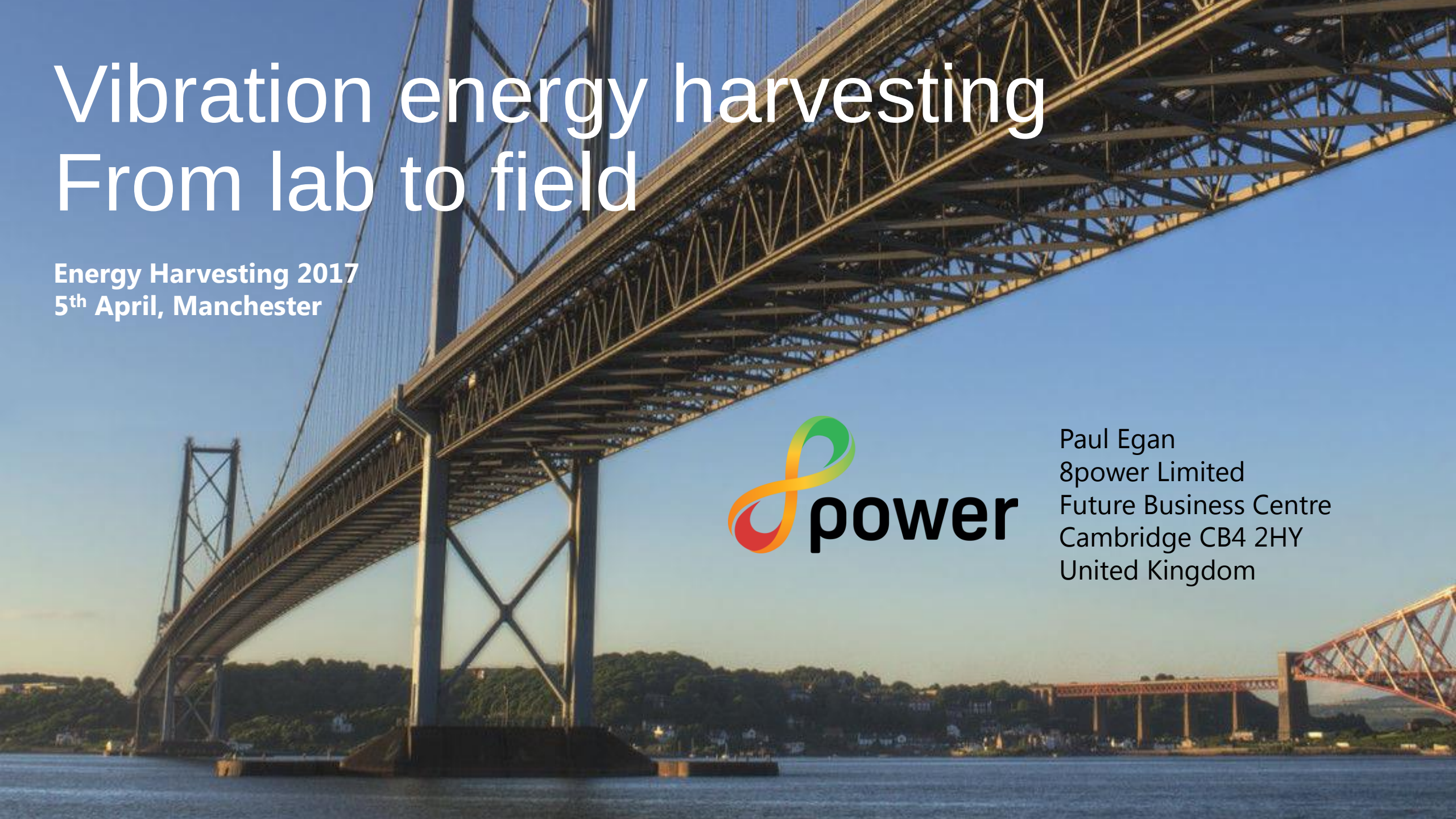
Vibration energy harvesting From lab to field

Energy Harvesting 2017
5th April, Manchester



Paul Egan
8power Limited
Future Business Centre
Cambridge CB4 2HY
United Kingdom

About us

- Cambridge, UK
- USD$1M/£700k seed investment June 2016
- 3 patents
- Extensive publications in leading journals such as *Nature: Scientific Reports* (July 2016)

Dr Antony Rix, **CEO & Co-Founder**

20 years' device & software experience

PhD applying machine learning to telecoms

Co-Chair, CW Connected Devices SIG

Co-founder, Psytechnics

Paul Egan, **VP Business Development**

Over 30 years in the wireless tech industry. Co-founder, Neul, Pioneer of LPWAN Technology, acquired by Huawei in 2014. Part of the founding teams of IoTUK, CSR, ARM

Richard Green, **Chairman**

Richard is a serial entrepreneur, non-executive director and business mentor. He was co-founder and CEO of Ubisense, the award winning Industrial Internet of Things pioneer.

Dr Ashwin Seshia, **NED & Co-Founder**

Reader, University of Cambridge

Co-founder, Silicon Microgravity

Technical lead and MEMS expert

Dr Yu Jia, **Co-founder**

Lecturer, University of Chester

Inventor of energy harvesting technology

Dr Jize Yan, **Co-founder**

Associate Professor, University of Southampton

Key contributor to applications development

Prof. Kenichi Soga, **Co-founder**

Chancellor's Professor, University of California, Berkeley

Expert in structural condition monitoring

Investors

PARKWALK investing in innovation

UNIVERSITY OF CAMBRIDGE enterprise

ipgroup

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Sensors can make a thing smart…

Radio

Microprocessor

Sensors

Battery

The thing you want to monitor

=

A smart thing

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… but batteries become the problem

Radio

Microprocessor

Sensors

Battery

The thing you want to monitor

=

A thing that needs its battery replacing every few weeks or months

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Can energy harvesting solve the battery problem?

Radio

Microprocessor

Sensors

Energy harvester

The thing you want to monitor

=

A smart thing powered by its environment

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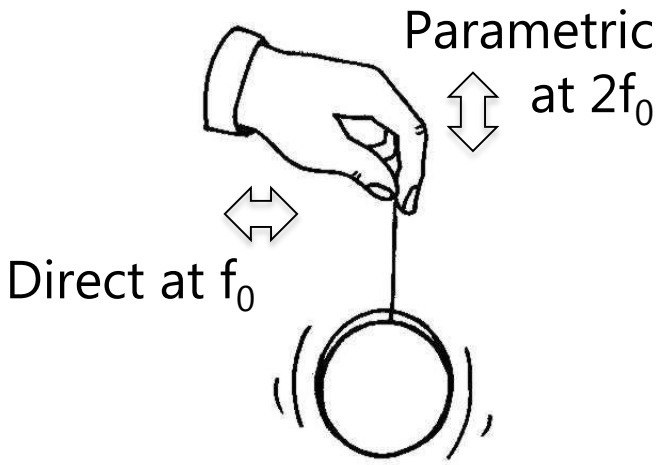
Parametric resonance for vibration energy harvesting

Conventional direct excitation

- **Parallel** to displacement *x*
- Direct transfer of energy
- Resonance at $\boldsymbol{f_0}$
- Resonant build-up limited by linear damping



Parametric excitation

- Usually **perpendicular** to displacement *x*
- Parameter modulation
- Resonance at $\boldsymbol{2f_0/n}$
- Resonance build-up **not** limited by linear damping

Harvesting of excitation to electrical power

- **Electrodynamic** (magnet/coil) generator in macro devices
- **Electrostatic** and **piezoelectric** generators in MEMS devices

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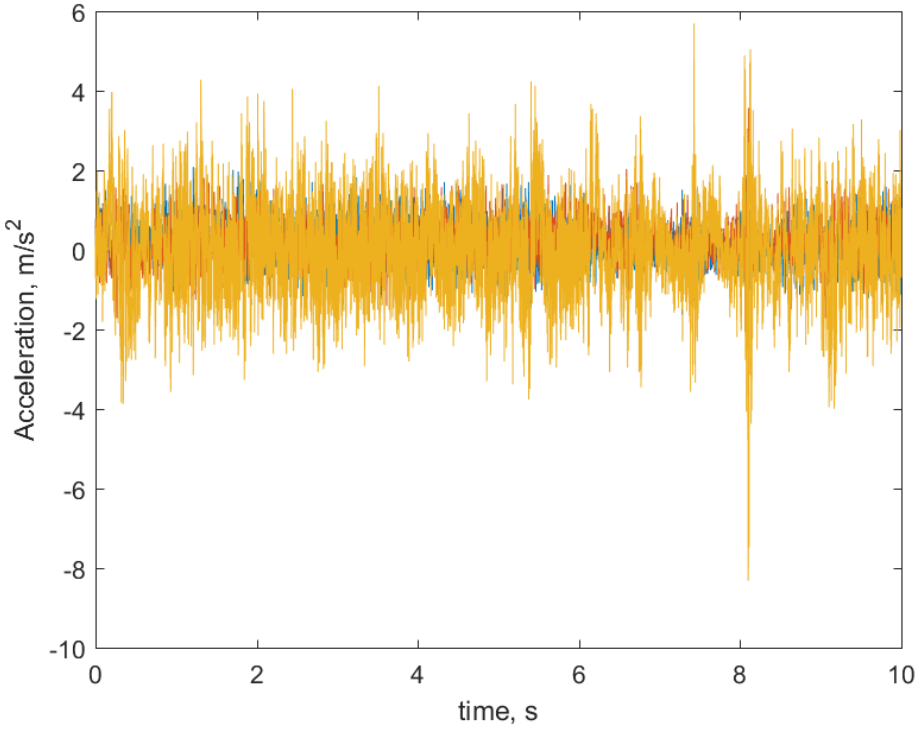
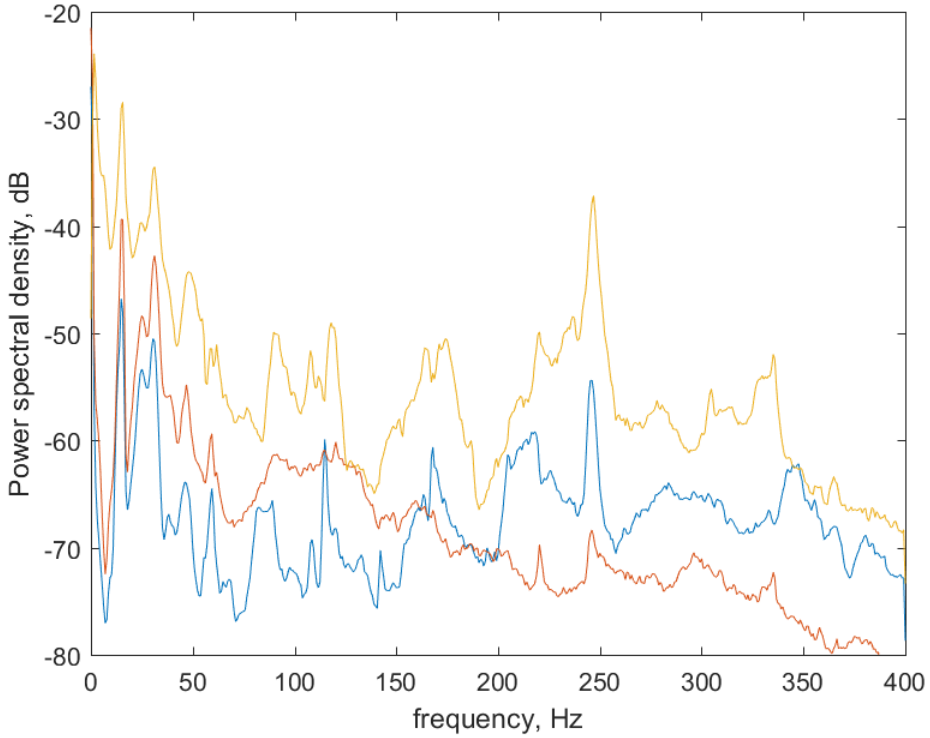
The secret of vibration energy harvesting





Vibration time-series and spectrum in a vehicle application

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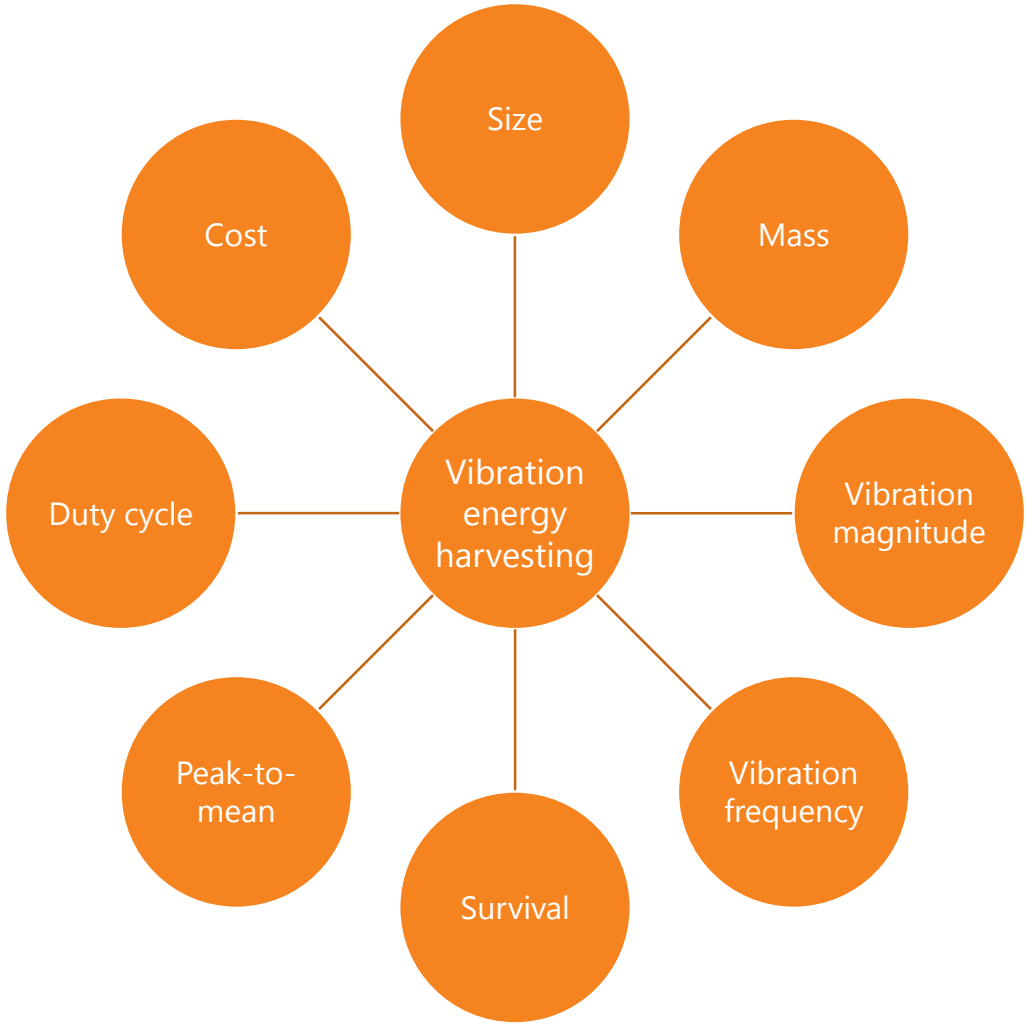
Challenges to the viability of vibration energy harvesting



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Forth Road Bridge case study

- December 2015: the Forth Road Bridge near Edinburgh, UK, closed due to fatigue cracking of a truss
- The bridge was closed to cars for three weeks, and to freight vehicles for three months, for remedial works – *The Scotsman* reported that this closure is estimated to have cost the Scottish economy £50M
- Could a sensor network detect this problem before failure occurs?
- 8power's prototype macro VEH generates interesting amounts of power in this real-world scenario:

Location and orientation of VEH	Active frequency range (Hz)	Raw AC power (µW)	Conditioned DC power (µW)
Cross girder, vertical	10-30	160	32
Top lateral, vertical	10-30	800	174
Top lateral, horizontal	7-26	1050	315

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8power's approach to systems

Our customers & partners provide things

Radio

Microprocessor

Sensors

Power

The thing you want to monitor

Local network

Security, updates

Service creation

Interoperability

Application design, support

Every one of these elements (and several others) is critical to delivering a scalable connected device.

8power solves all of them in one integrated, modular device and service platform.

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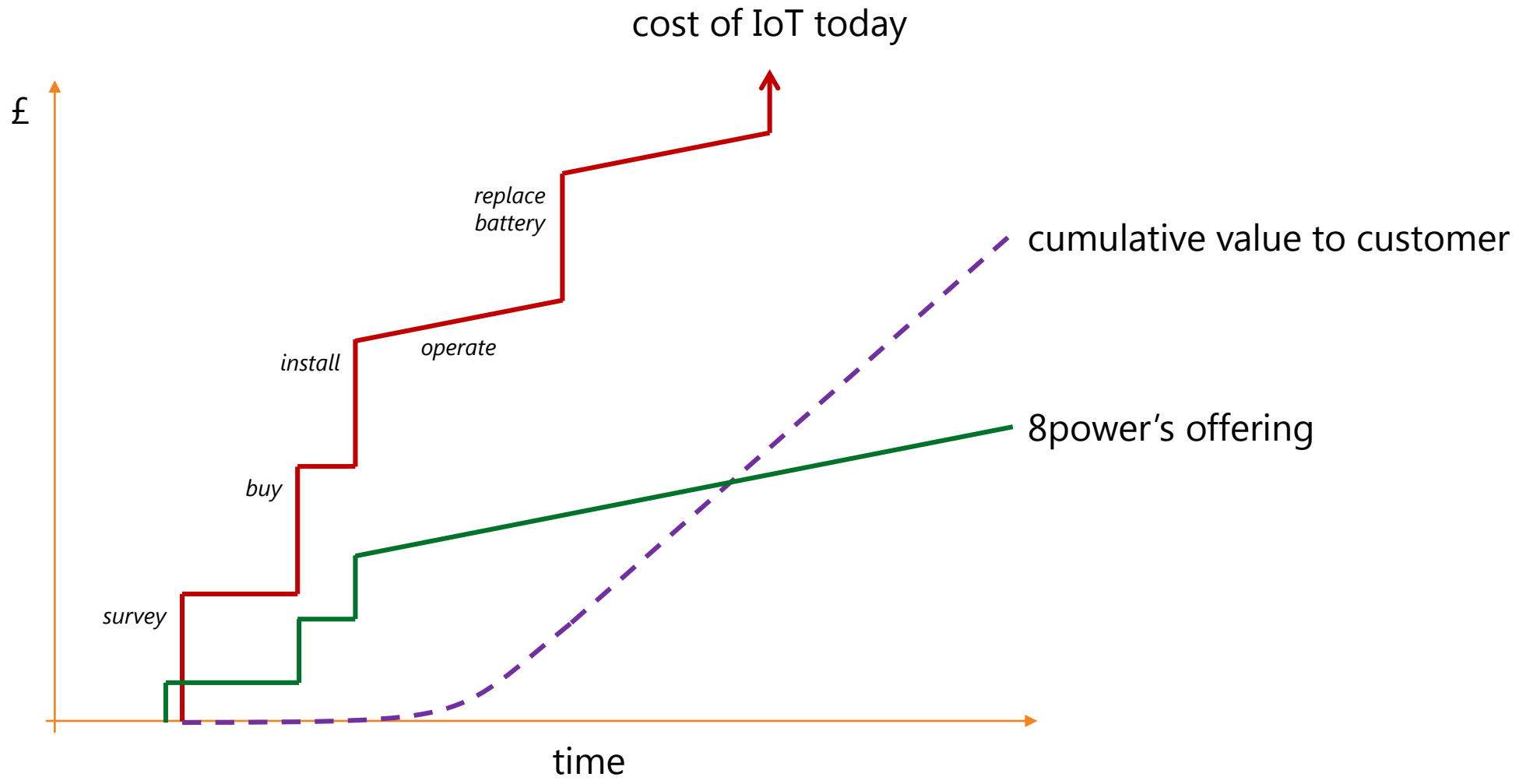
Making the business case work



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Powering the sensor revolution

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