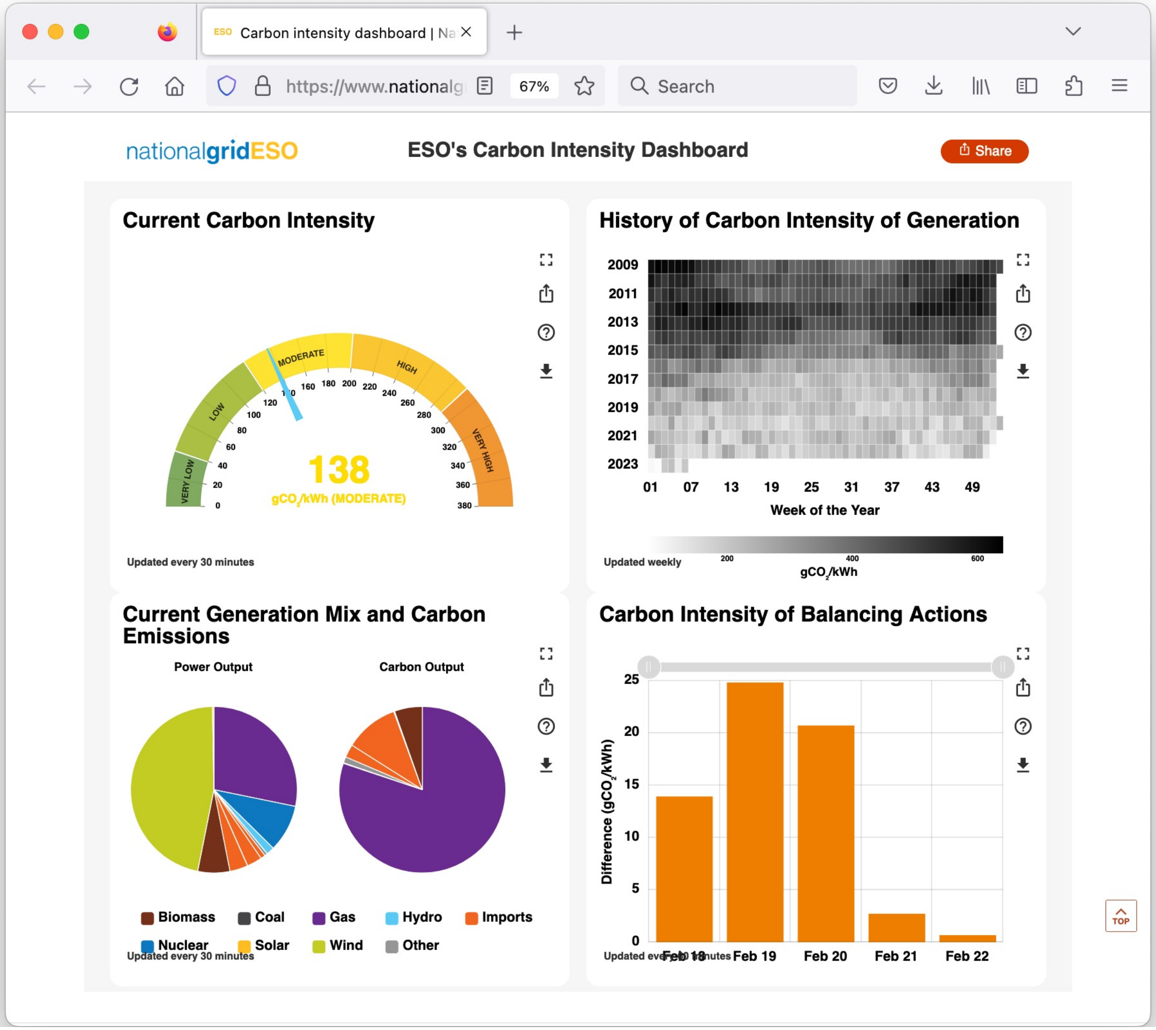
Energy & Information, securing the Next Generation Energy System

Prof. David Wallom

Department for Engineering Science

Transmission

- Highly instrumented network giving excellent real-time visibility of network state,



ESO's Carbon Intensity Dashboard

Current Carbon Intensity

Updated every 30 minutes

History of Carbon Intensity of Generation

Updated weekly

Current Generation Mix and Carbon Emissions

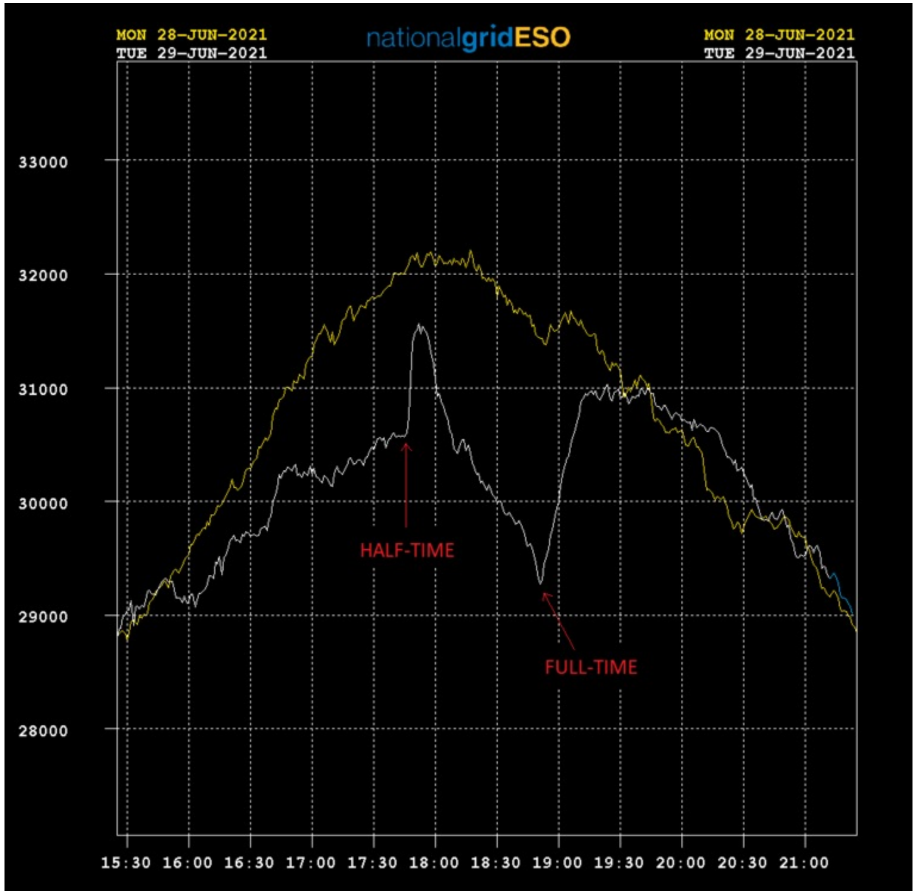
Updated every 30 minutes

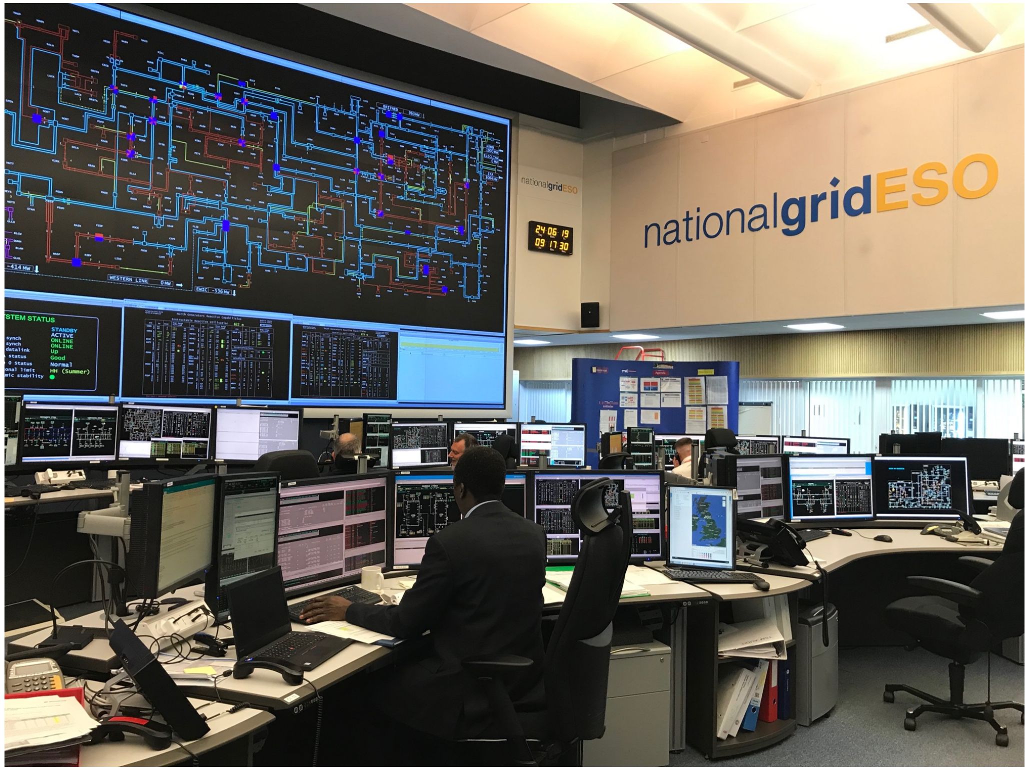
Carbon Intensity of Balancing Actions

Updated every 30 minutes

Transmission

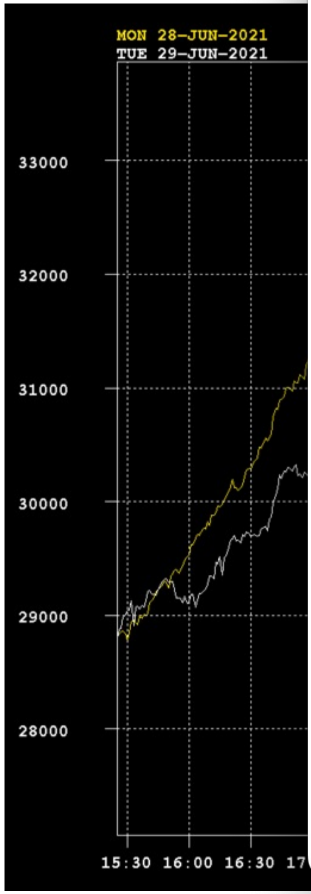
- Highly instrumented network giving excellent real-time visibility of network state,
- Centrally managed by ESO

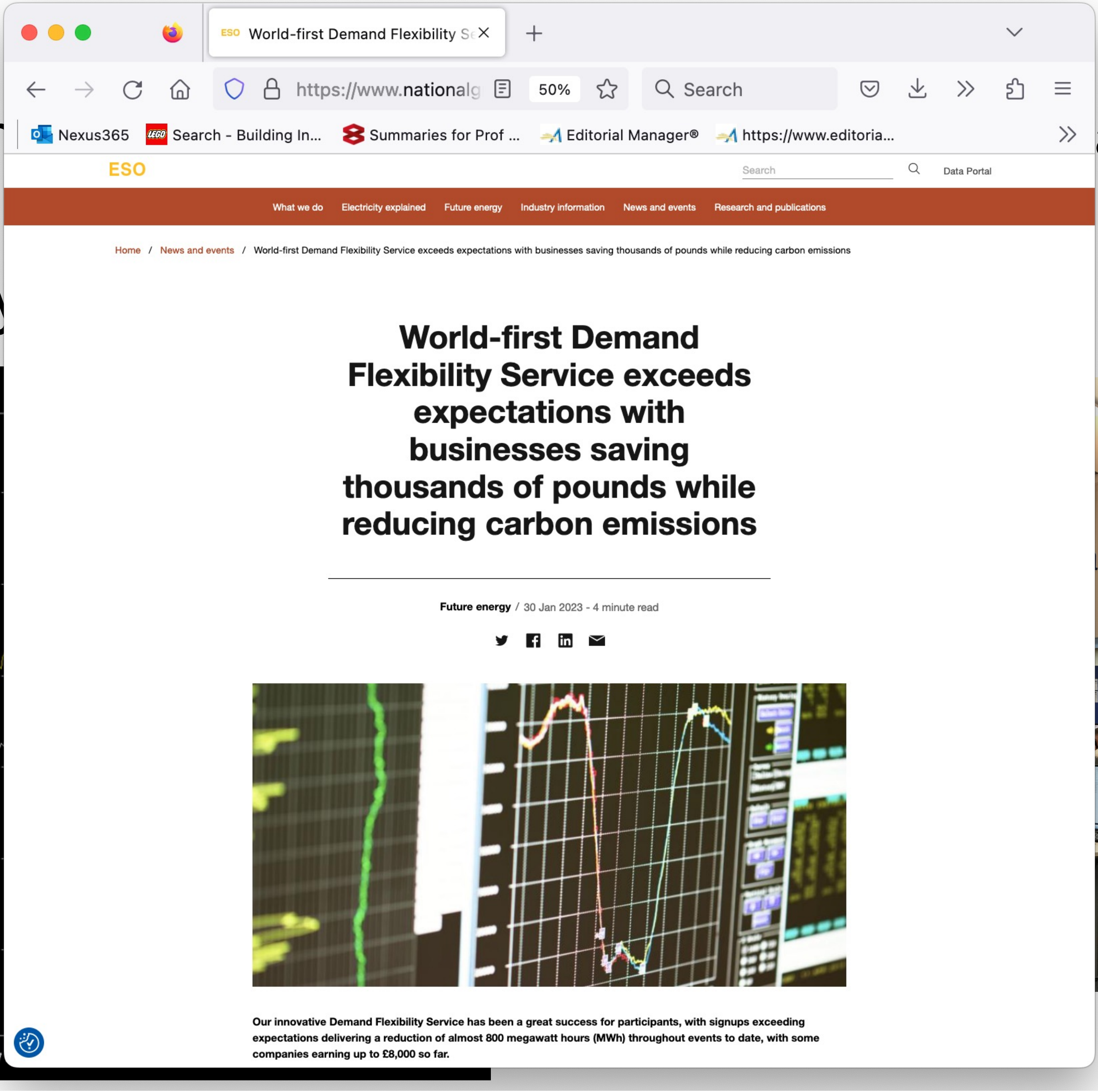




Transmission

- Highly in… al-time visibility
- Centrally…



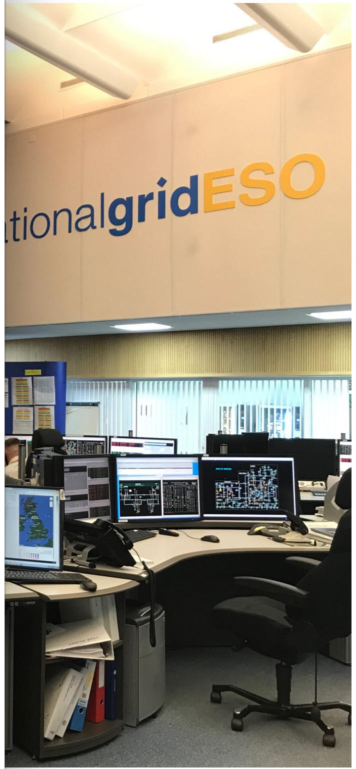


Home / News and events / World-first Demand Flexibility Service exceeds expectations with businesses saving thousands of pounds while reducing carbon emissions

World-first Demand Flexibility Service exceeds expectations with businesses saving thousands of pounds while reducing carbon emissions

Future energy / 30 Jan 2023 - 4 minute read

Our innovative Demand Flexibility Service has been a great success for participants, with signups exceeding expectations delivering a reduction of almost 800 megawatt hours (MWh) throughout events to date, with some companies earning up to £8,000 so far.



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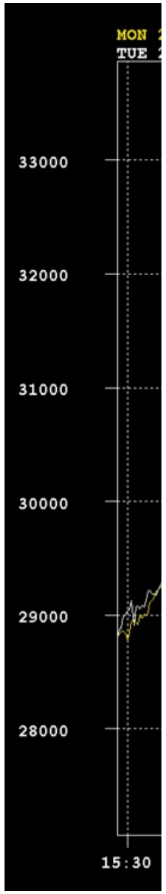

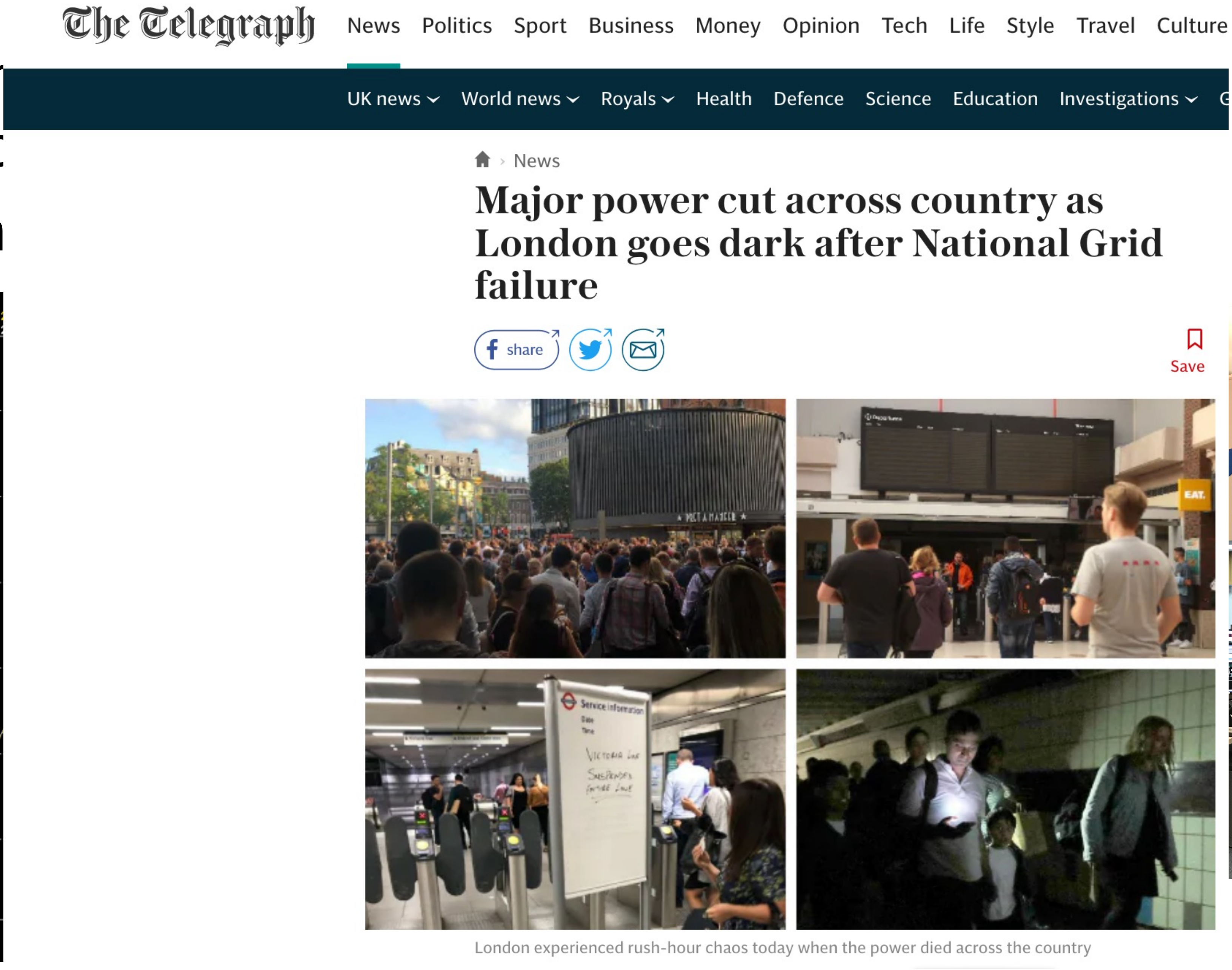
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UK news World news Royals Health Defence Science Education Investigations

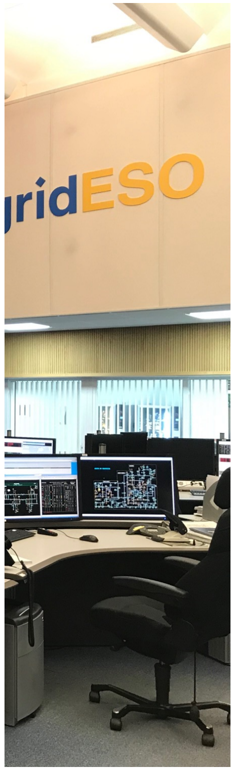
News

Major power cut across country as London goes dark after National Grid failure

share

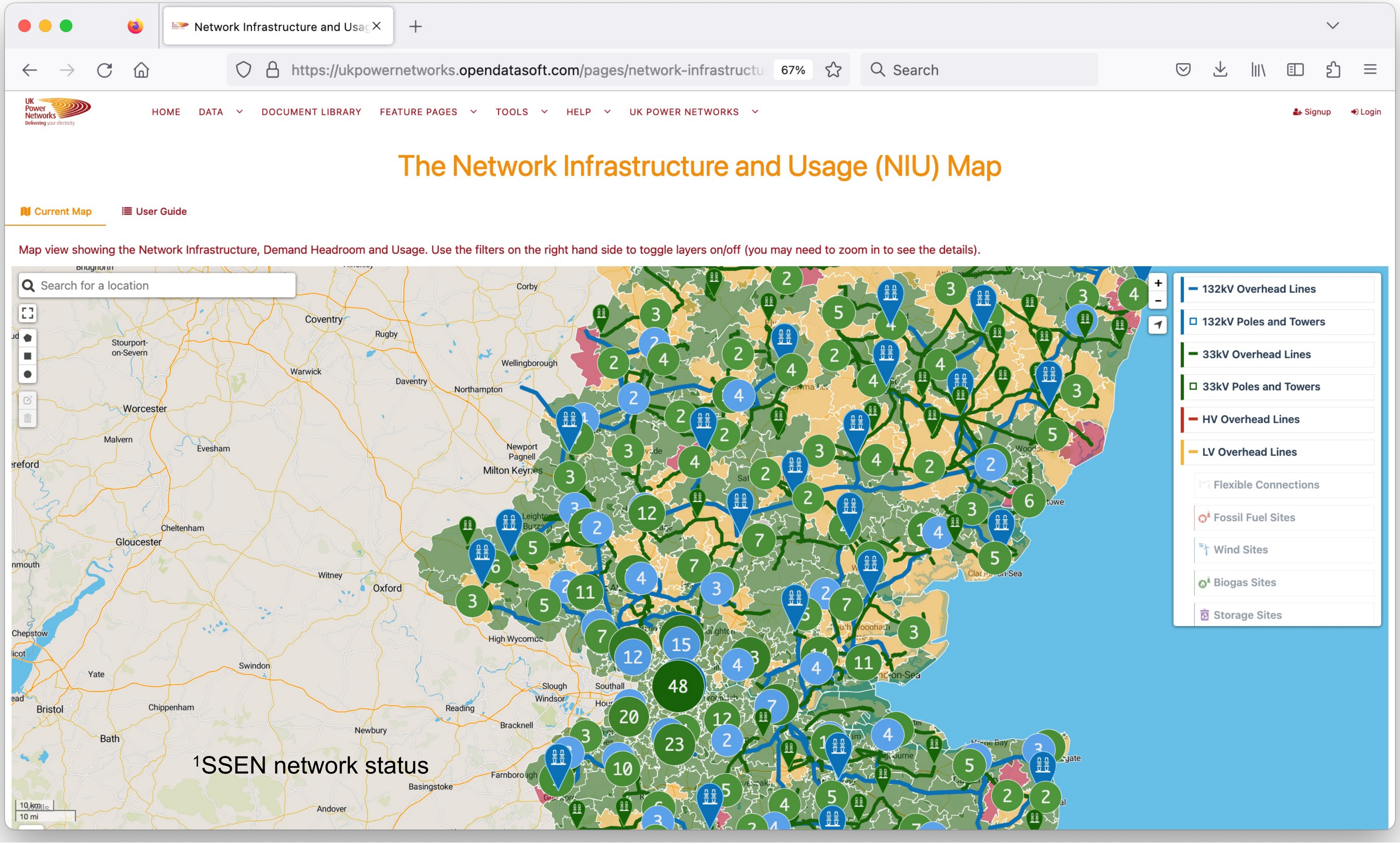
Save

London experienced rush-hour chaos today when the power died across the country



Distribution Network

- Connects from the High Voltage Transmission network to the consumer @ the meter
  - Substantially greater diversity in network assets
    - 4.8k primary substations
    - 230k secondary substations



The Network Infrastructure and Usage (NIU) Map

Map view showing the Network Infrastructure, Demand Headroom and Usage. Use the filters on the right hand side to toggle layers on/off (you may need to zoom in to see the details).

- 132kV Overhead Lines
- 132kV Poles and Towers
- 33kV Overhead Lines
- 33kV Poles and Towers
- HV Overhead Lines
- LV Overhead Lines
- Flexible Connections
- Fossil Fuel Sites
- Wind Sites
- Biogas Sites
- Storage Sites

[1]SSEN network status

Distribution Network

- Connects from the High Voltage Transmission network to the consumer @ the meter
  - Substantially greater diversity in network assets
    - 4.8k primary substations
    - 230k secondary substations

- Area of the network with least visibility

- Only ‘Newer’ equipment with monitoring over last 10 -15 years

- Outages generally consumer informed…

- Most congested part of network due to introduction of distributed assets
  - In Oxfordshire:
    - **35%** of primary substations ‘**constrained**’ to additional demand[1]
    - **61%** of primary substations ‘**constrained**’ to additional generation[1]

[1] SSEN network status

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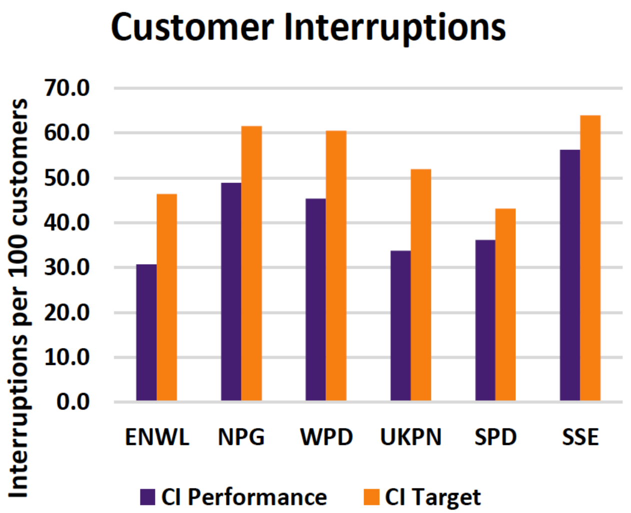


Source: Ofgem RIIO-ED1 Network Performance Summary 2021-22

[1]SSEN network status

Future Network Problem?

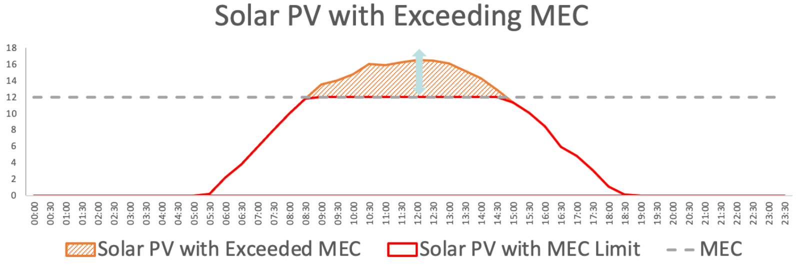
- ‘Uncontrollable’ variable renewable generation
- More distributed generation
- Increased electrical demand (from heat and transport)

leads to…

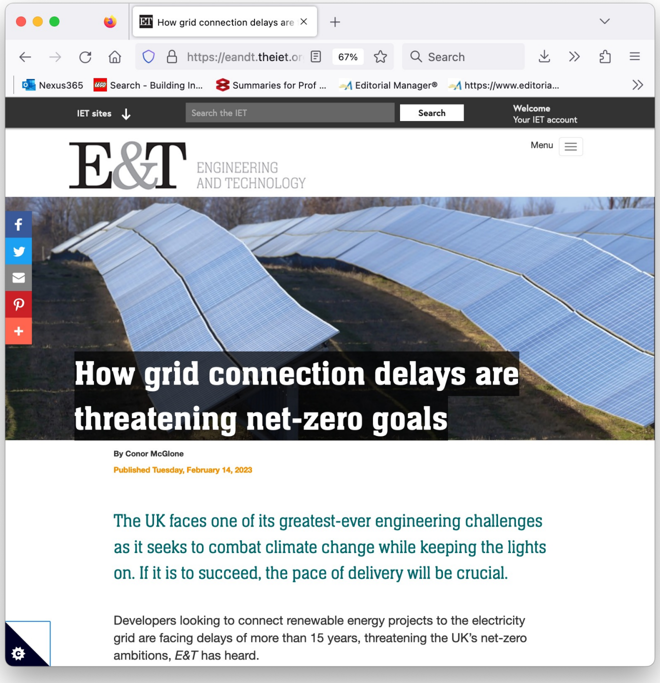
© Richard Cave

~~Future~~ Network Problem Now

- Power constraints on the local network
- High cost of network upgrade – passed to bills or renewable developer
- Limits renewable generation or risks network outages



solar power data taken from: https://ww
data.html



How grid connection delays are threatening net-zero goals

By Conor McGlone

Published Tuesday, February 14, 2023

The UK faces one of its greatest-ever engineering challenges as it seeks to combat climate change while keeping the lights on. If it is to succeed, the pace of delivery will be crucial.

Developers looking to connect renewable energy projects to the electricity grid are facing delays of more than 15 years, threatening the UK's net-zero ambitions, *E&T* has heard.

The solution... Smart Local Energy Systems?

Smart: technologically innovative, automated & uses ICT for communication.

Local: generation and other assets close to the people.

Equitable: offer access to affordable energy services for all.

environmentally Sustainable: transition to Net Zero carbon and resilience.

Smart Local Flexibility

Trialling DSO enabled flexibility services – capacity trades between Peers located at the same point in the network.

- *Max Export Capacity*

Buyer
Seller

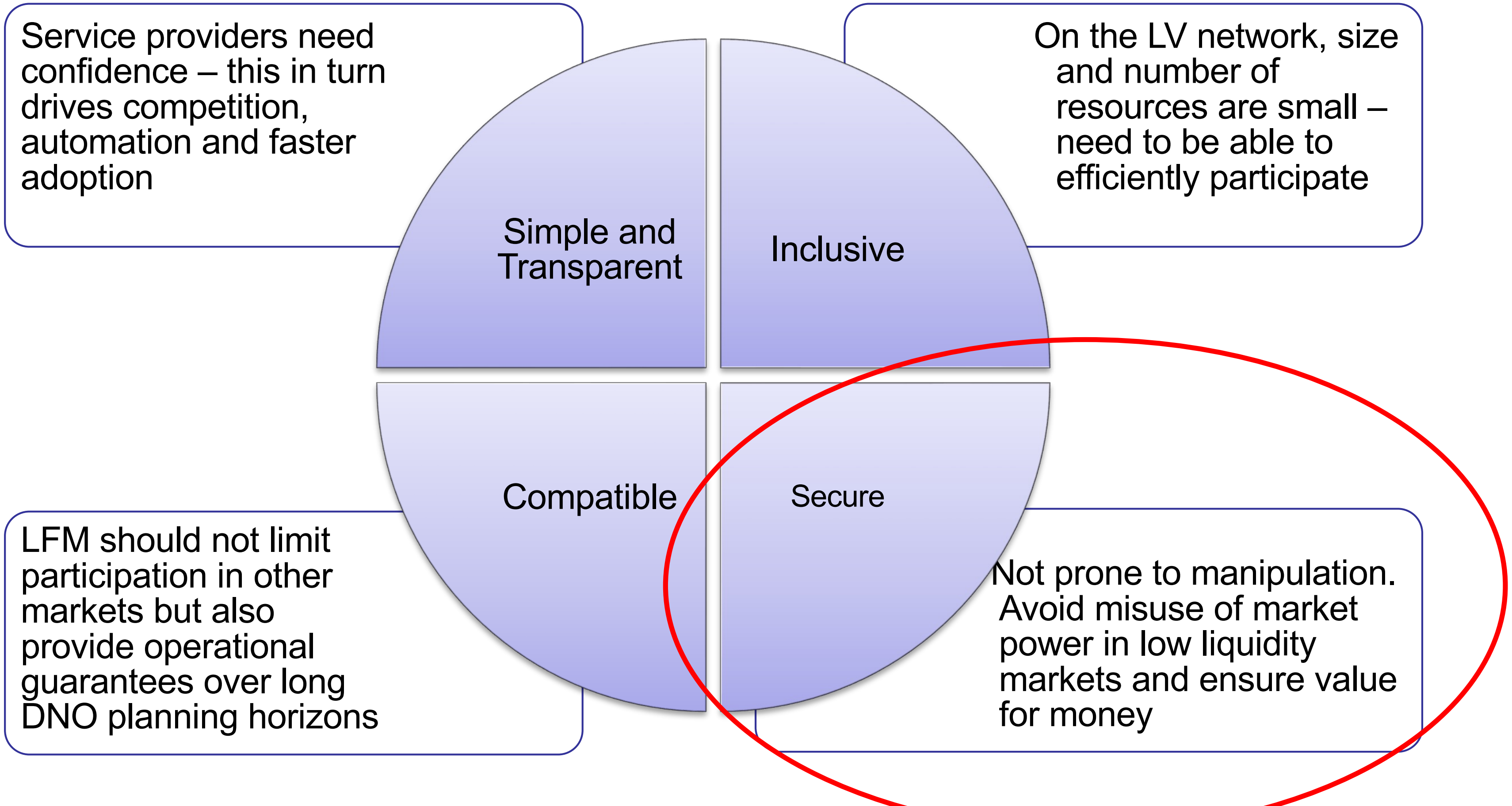
- *Max Import Capacity*

Buyer
Uses above MIC
Seller
Uses below MIC

- *Offsetting*

Buyer
Generates above MEC
Seller
Uses above their baseline

Local Flexibility Market requirements…



Service providers need confidence – this in turn drives competition, automation and faster adoption

Simple and Transparent

Inclusive

On the LV network, size and number of resources are small – need to be able to efficiently participate

Compatible

Secure

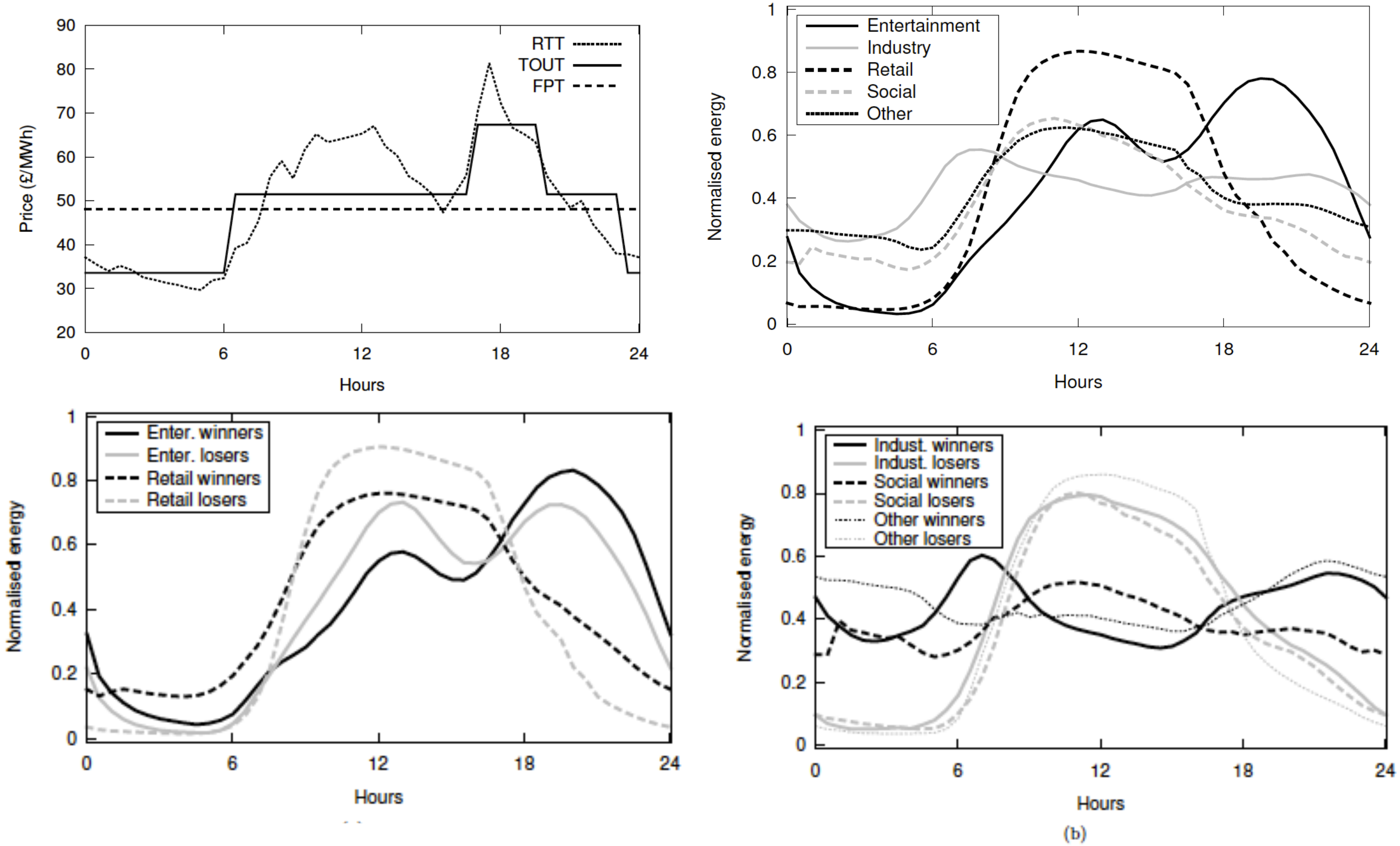
LFM should not limit participation in other markets but also provide operational guarantees over long DNO planning horizons

Not prone to manipulation. Avoid misuse of market power in low liquidity markets and ensure value for money

Ziras, C., Heinrich, C., & Bindner, H. W. (2021). Why baselines are not suited for local flexibility markets. *Renewable and Sustainable Energy Reviews*, *135*. https://doi.org/10.1016/j.rser.2020.110357

Advanced Dynamic Energy Pricing and Tariffs (ADEPT)

Who wins and loses from changing energy tarrif?



Research Councils UK Digital Economy Transforming Business and Society

OXFORD e-Research CENTRE

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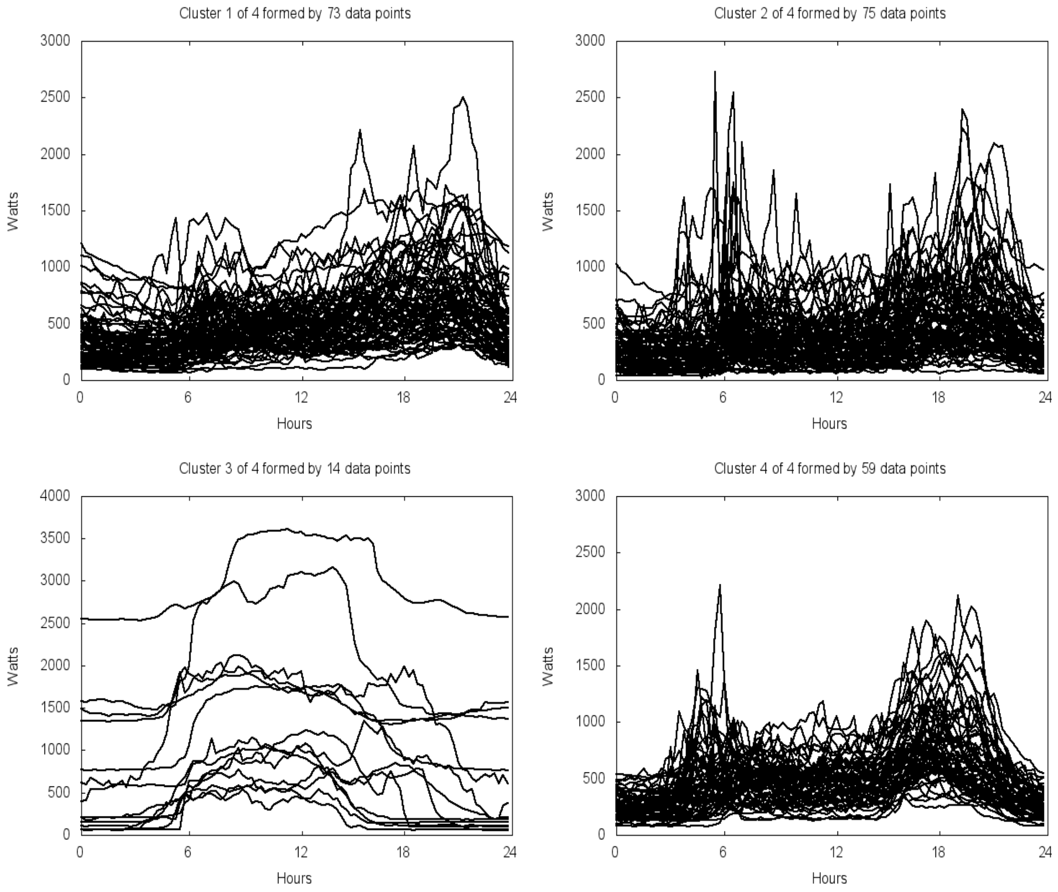
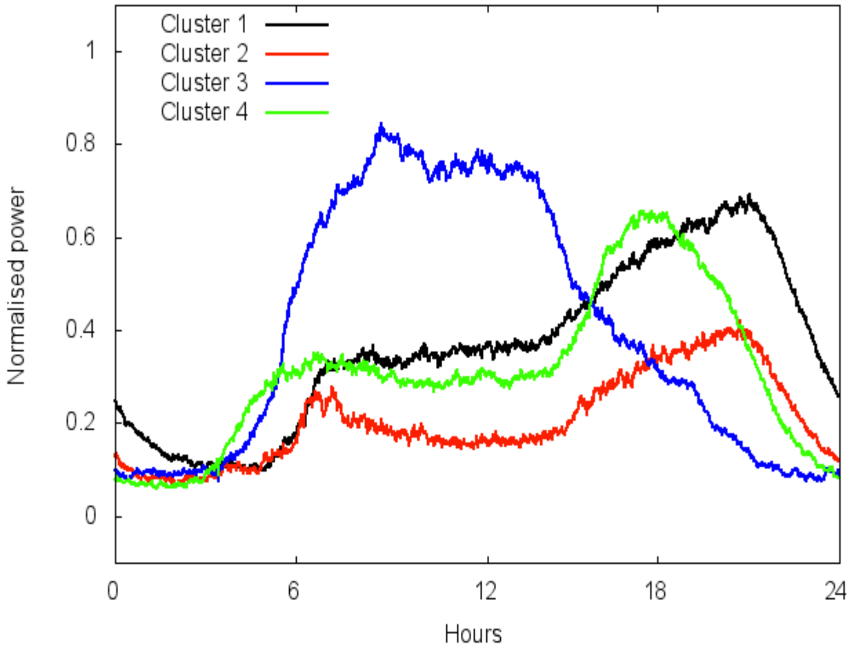
Bips innovative research for the power industry

Research Councils UK Energy For a Low Carbon Future

Investigating domestic load profiles





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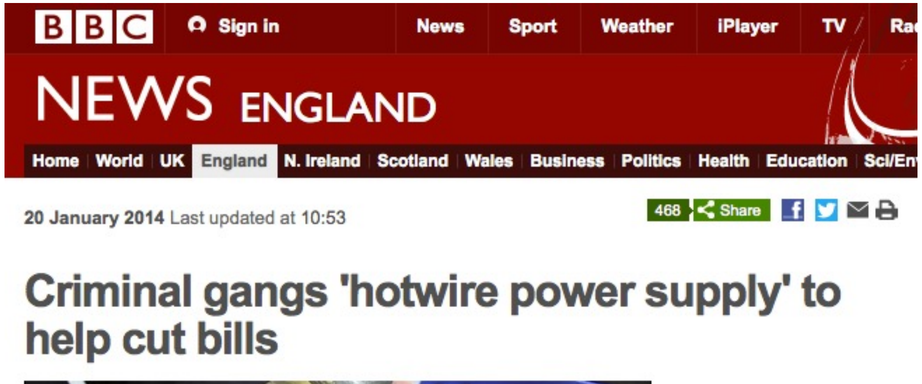
Research Councils UK Energy For a Low Carbon Future

An old problem, energy theft…

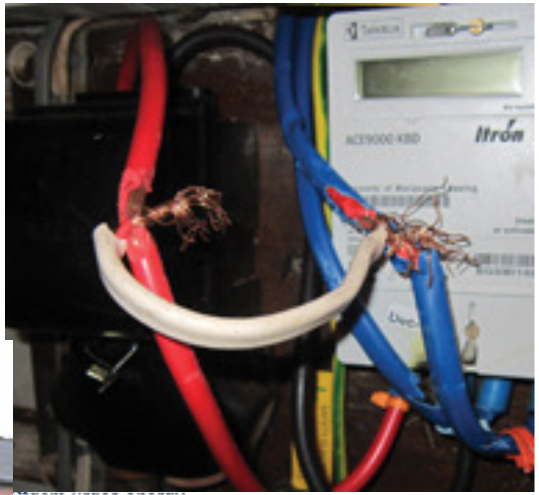


20 January 2014 Last updated at 10:53

Criminal gangs 'hotwire power supply' to help cut bills

As the row over
people are choo

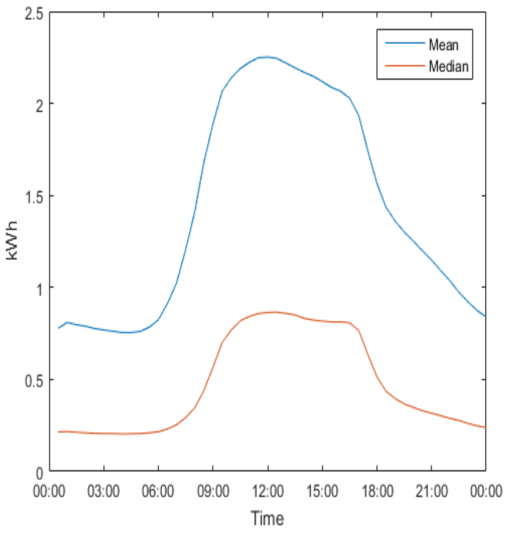
Criminal gang
for power by
has learned.



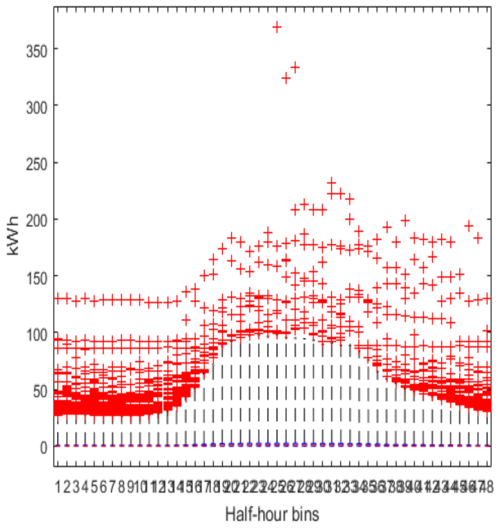
- >£400M lost in theft per year
- £8 - £20 per property per year
- Smart Metering only commercially viable by reducing human interaction.
- Current detection method based on credit history and physical property visits

DIET – Data Insights against Energy Theft

Daily consumption plots



Extremes and outliers

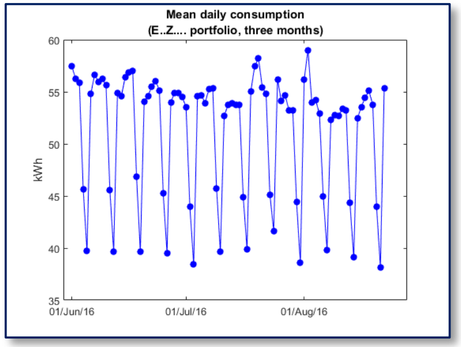


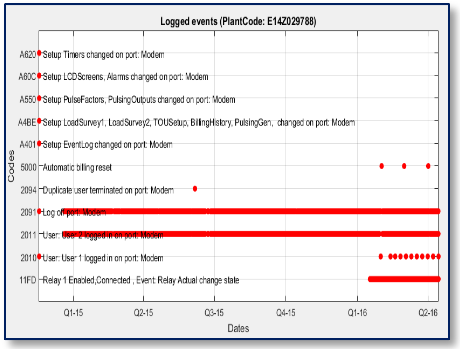
- Data Insights against Energy Theft (DIET)
- 2 year Innovate UK
- British Gas(Lead), G4S & EDMI

- 300k meters per day, commercial customers
- 48 half-hour kWh readings per day
- Details of 200 confirmed theft events provided by partners ‘on demand’

- How to scale to near real-time for 50M meters?
- ~50k potential theft triggers per day

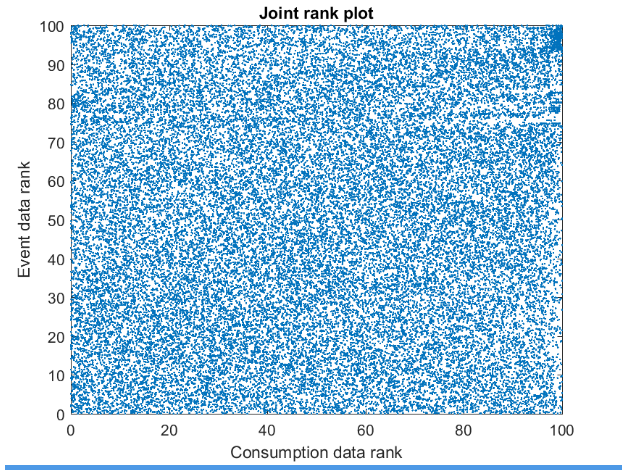
- Need data driven method for detecting theft*

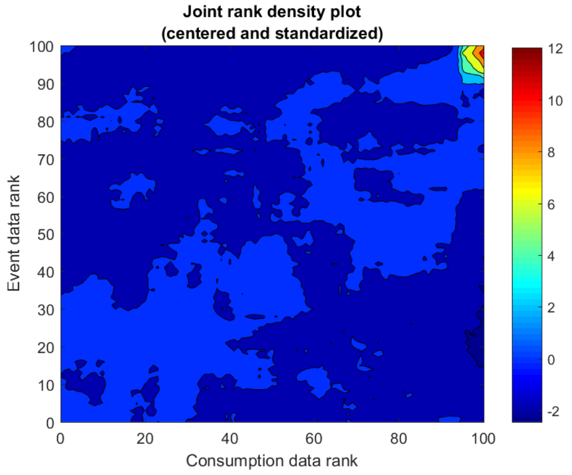


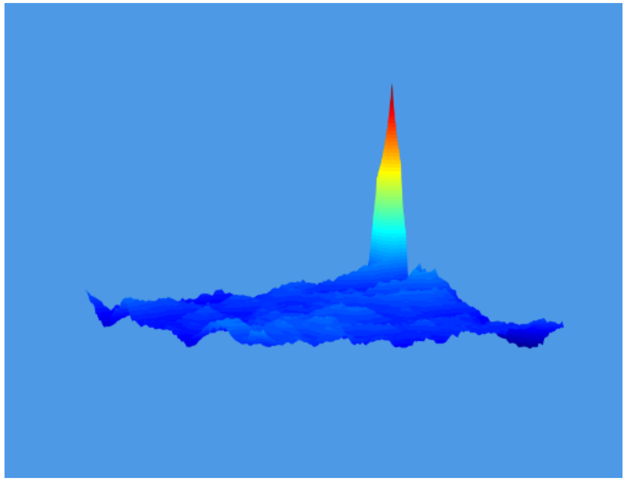


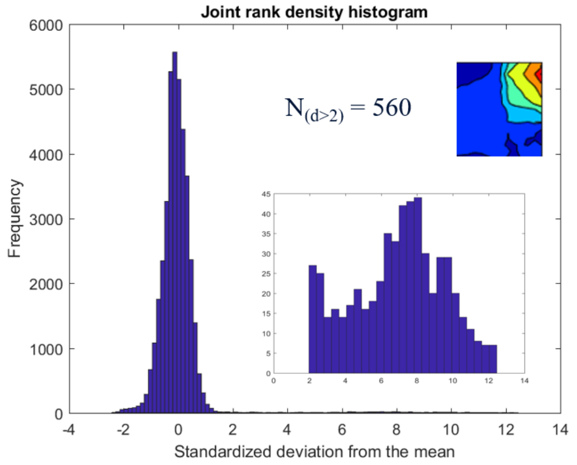
*No training set available as non-consumption data never recorded in existing theft cases

Detecting outlier/anamolies





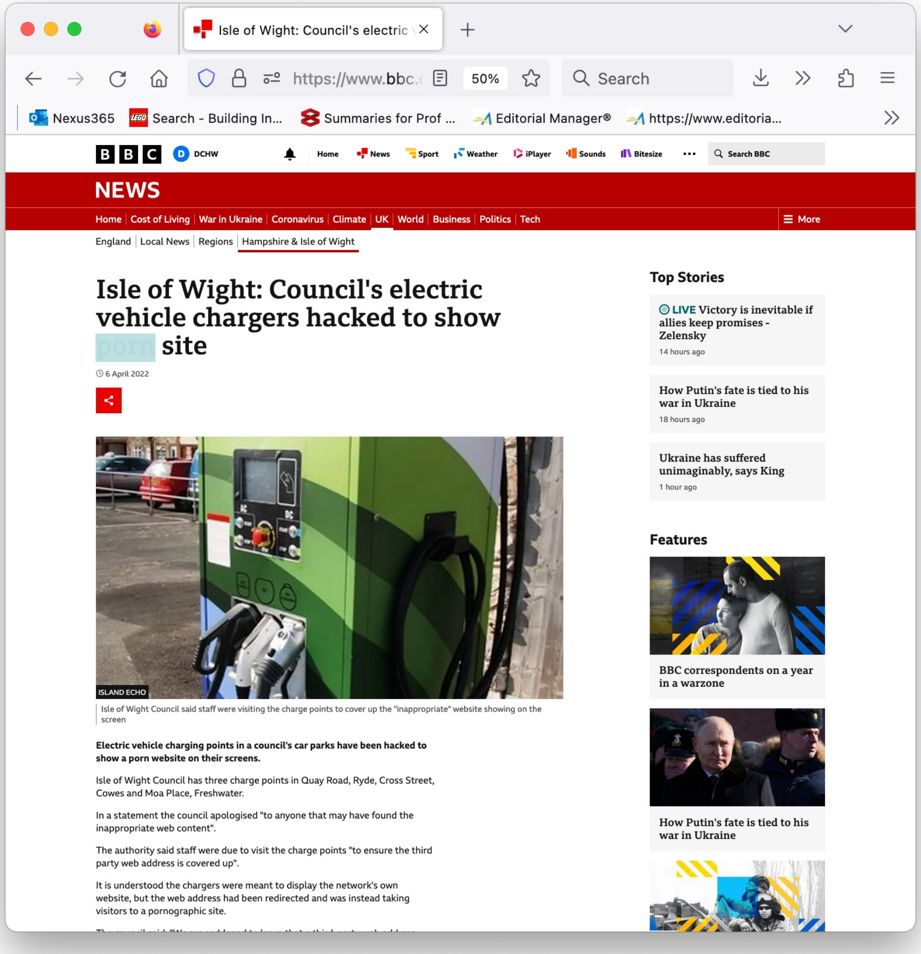




- Caithness, N. and Wallom, D. (2018). **Anomaly Detection for Industrial Big Data**.In *Proceedings of the 7th International Conference on Data Science, Technology and Applications - Volume 1: DATA,* DOI: 10.5220/0006835502850293
- WIPO patent #WO2019038527

Energy System hacks

- Energy system part of CNI
- Increased attack surface
- Vulnerability to Nation State Actors



Isle of Wight: Council's electric vehicle chargers hacked to show porn site

6 April 2022

Isle of Wight Council said staff were visiting the charge points to cover up the "inappropriate" website showing on the screen

Electric vehicle charging points in a council's car parks have been hacked to show a porn website on their screens.

Isle of Wight Council has three charge points in Quay Road, Ryde, Cross Street, Cowes and Moa Place, Freshwater.

In a statement the council apologised "to anyone that may have found the inappropriate web content".

The authority said staff were due to visit the charge points "to ensure the third party web address is covered up".

It is understood the chargers were meant to display the network's own website, but the web address had been redirected and was instead taking visitors to a pornographic site.

Top Stories

LIVE Victory is inevitable if allies keep promises - Zelensky
14 hours ago

How Putin's fate is tied to his war in Ukraine
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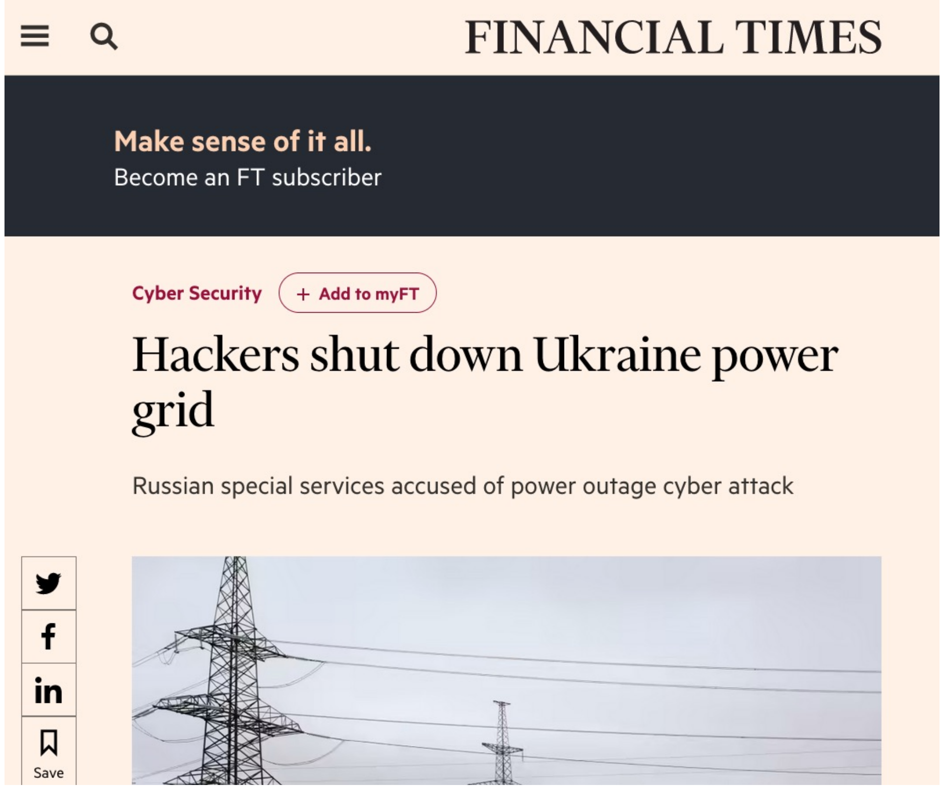
Ukraine has suffered unimaginably, says King
1 hour ago

Features

BBC correspondents on a year in a warzone

How Putin's fate is tied to his war in Ukraine



Hackers shut down Ukraine power grid

Russian special services accused of power outage cyber attack

Trust & Data sources

Vulnerabilities

- Physical Access
- False Data Injection
- Main in the middle

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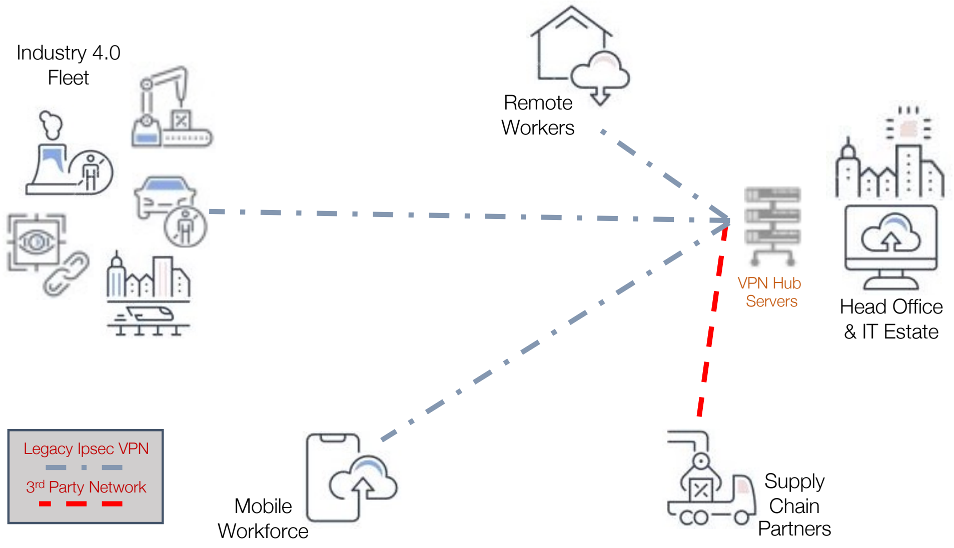
ENERGY AND ENVIRONMENTAL INFORMATICS

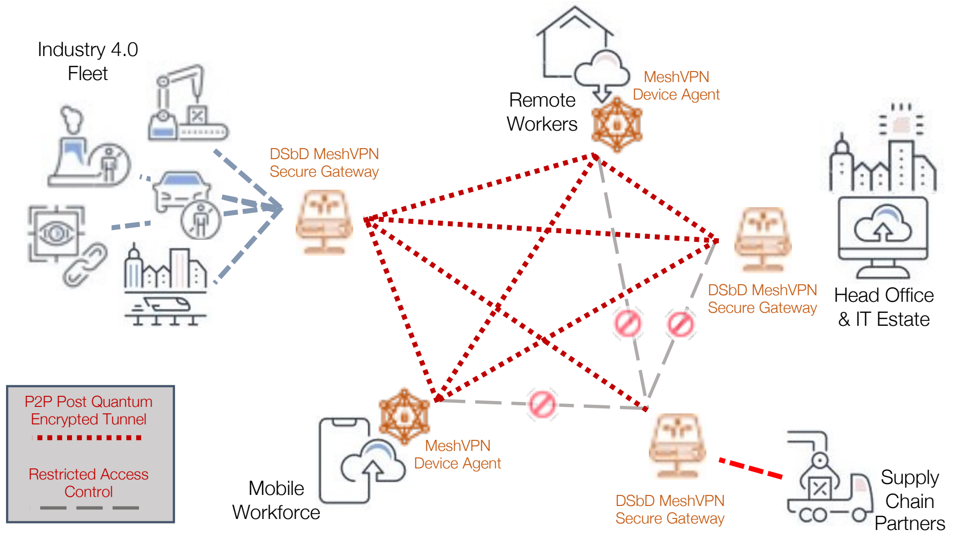
BEFORE: Traditional Hub-and-Spoke Network



- High Latency hops
- Complex to scale
- Hub Bandwidth Bottleneck
- No direct connection to nodes

- Network-Level Access & Trust
  - Privacy not Security
  - IOT Lateral Attack Vulnerability
  - Record/Replay Attack
- Multiple Firewall Configs
  - Exposed Public Gateways
  - Vulnerable IOT device risks entire network and vice-versa

AFTER: Post-Quantum Mesh SDN Network

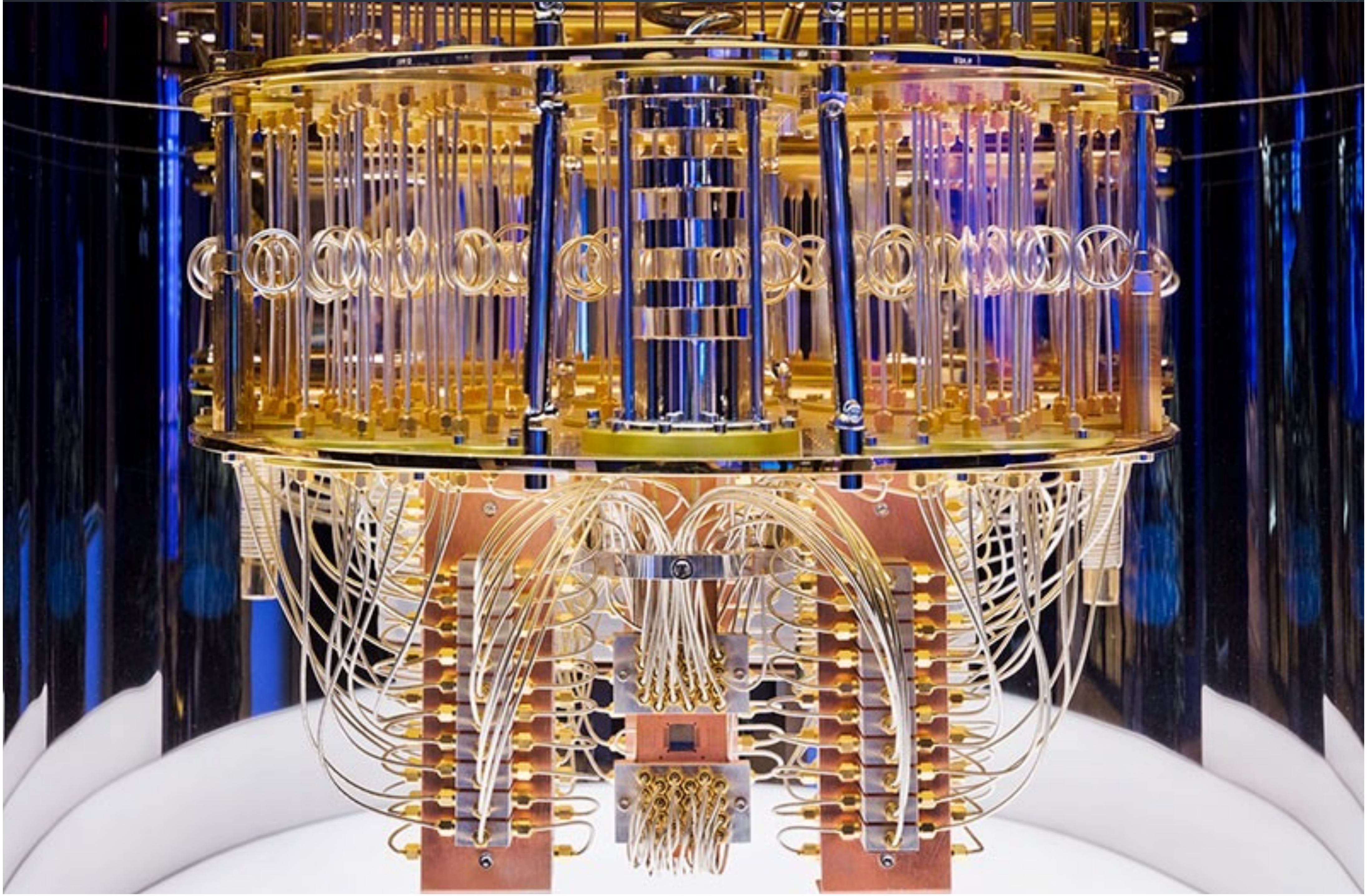


- Direct traffic, distributed P2P
- Simple deployment
- Central audit-compliant logging
- Role/App based access control
- Rapid reconnect time:
  <3ms vs. IPsec >500ms

- Patented Next-Generation multi-layer PQ Encryption
- Regular Secure Key Rotation
- Low Blast Radius vs Traditional VPN
- Enhanced with Trusted Cloud

UKRI Innovate UK cyberhive

Project
Honeycomb



New nefarious ‘Business’ model

- Flexibility makes possible greater reward than straight energy theft

1. Reprogram charger to ignore ToU charging messages, 24hr charging.
2. Leave charger to claim to flex system only charging when told.

3. Cheap charging!

New nefarious ‘Business’ model

- Flexibility makes possible greater reward than straight energy theft

1. Reprogram charger to ignore V2G message to discharge car.
2. Leave charger to claim to supplying V2G when told.
3. Paid for energy your not supplying!

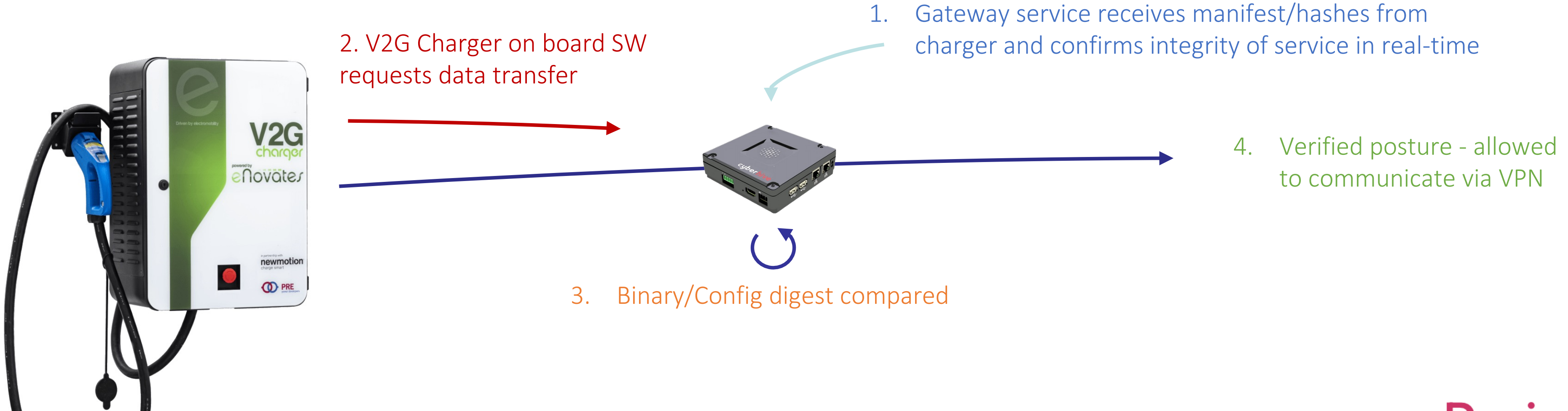
Project Honeycomb

Attesting Application Integrity

- Firewalling by source/dest IP and port etc. doesn't detect if an application is sending the data it is supposed to.
- Named binary allow-lists don't check the contents.
- Deny-lists don't identify 0-day vulnerabilities or novel malware.
- ML can give false positives.

- Trusted Cloud was developed and patented to remotely attest using TPM integrity of services running on cloud infrastructure
  - Sign, store and send an audit trail of running processes, libraries, and configuration files.

- This technology has been adapted for use with client endpoints and using CHERI on the Morello platform.



1. Gateway service receives manifest/hashes from charger and confirms integrity of service in real-time

2. V2G Charger on board SW requests data transfer

3. Binary/Config digest compared

4. Verified posture - allowed to communicate via VPN

Innovate UK cyberhive

Project Honeycomb

Conclusion

- Future Energy System requires moving energy through time
  - Smart Local Flexibility appears to be our best first step

- Energy system becomes more vulnerable to penetration with increasing digitisation and due to its distributed nature
  - Security must not be an afterthought.
  - Legacy infrastructure needs protecting
  - Insider threat increasingly an issue

Thank you
&
Questions