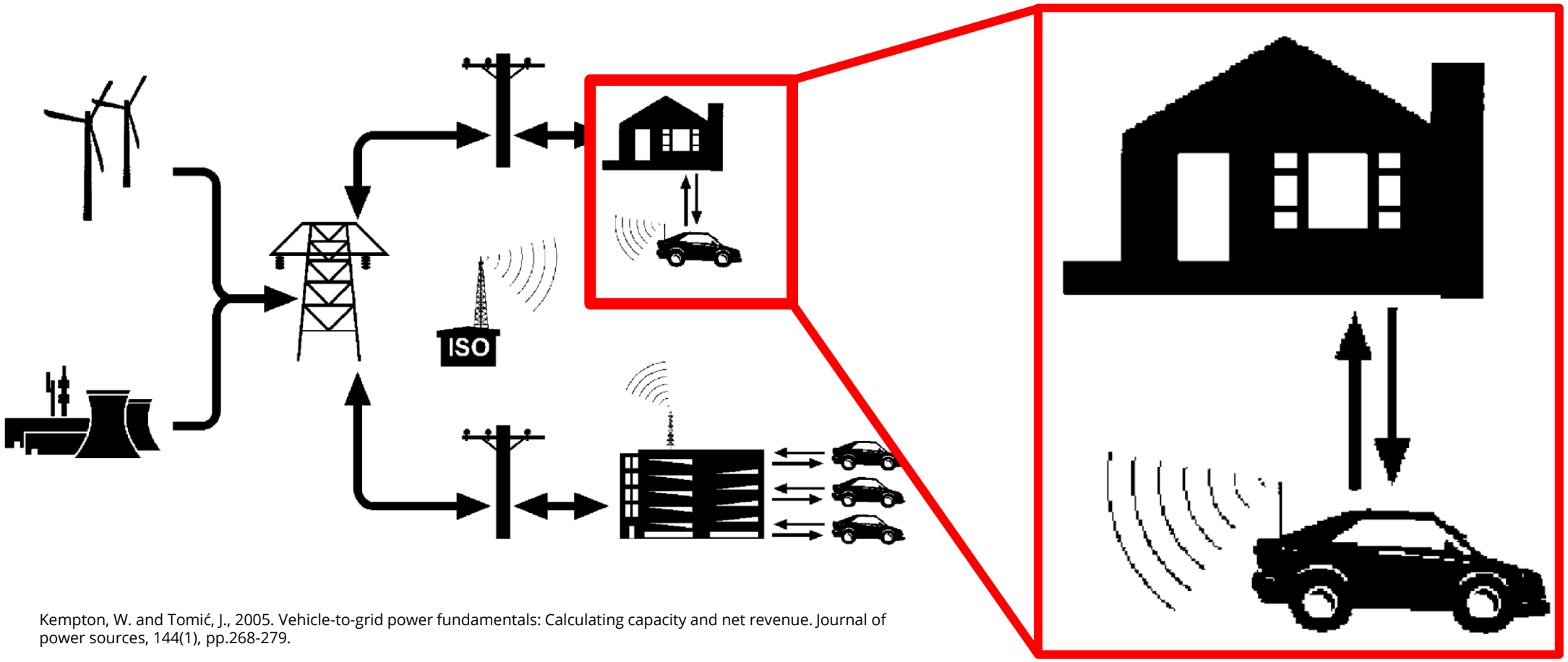
V2G (Vehicle-to-Grid)

Building Resilience in Ulgham Village

What is V2G? How does is work?



Kempton, W. and Tomić, J., 2005. Vehicle-to-grid power fundamentals: Calculating capacity and net revenue. Journal of power sources, 144(1), pp.268-279.

Who is Adrian Jonas?

I was born in Johannesburg, South Africa and moved to The Croft, Ulgham with my family in 2005. I attended Tritlington, Chantry, and King Edward VI School in Morpeth.

Since leaving Ulgham, I have earned a Master's degree in Chemical Engineering and am currently pursuing a PhD in Multiscale Thermofluids under Professor Khellil Sefiane at the University of Edinburgh.

I am driven to apply my skillset to protect our communities from the greatest threat that we have ever been exposed to – Climate Change.

How can we use V2G technology to help Ulgham?

We install bi-directional chargers (charging and discharging) into every home here in Ulgham.

We demonstrate the technology practically and financially to provide a global solution to the energy crisis.

We attract investment for a fleet of bi-directional electric vehicles.

The Impact of Extreme Weather

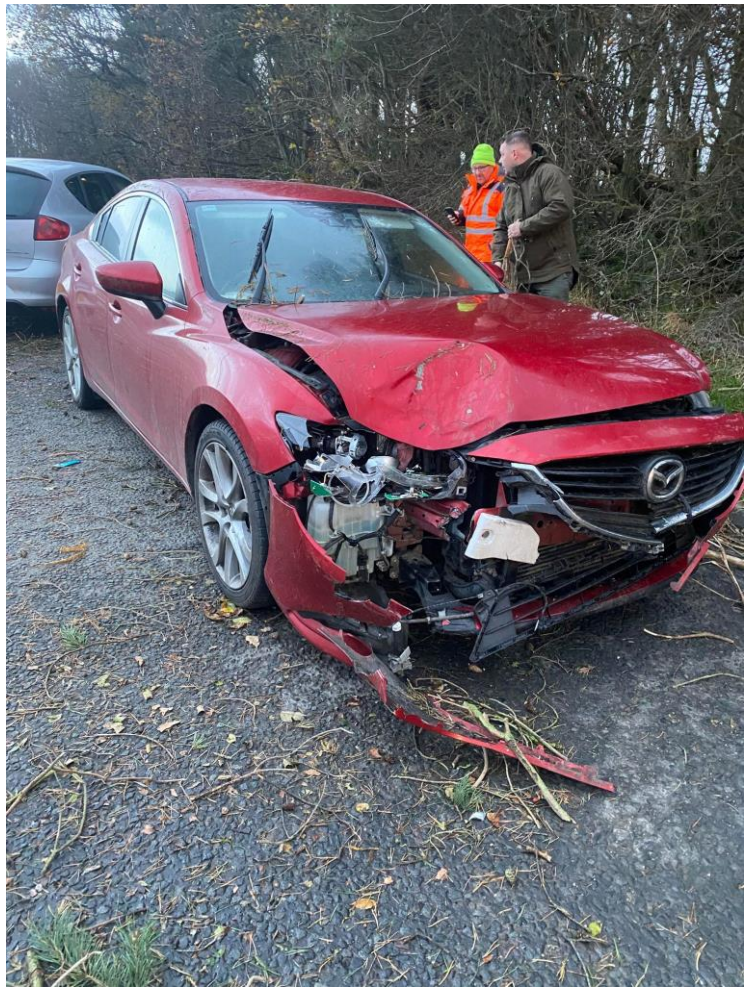
Storm Arwen knocked out Ulgham's power on the 26th November. Power was not fully restored until the 6th December.

Power went out again on 29th January to be restored on the 31st January.

Planted 100+ years ago – drawn 1980s

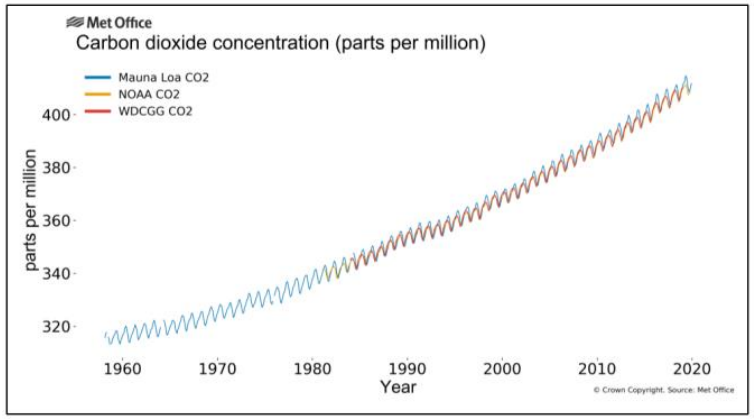
Photo by Lisa Crichton - 2022

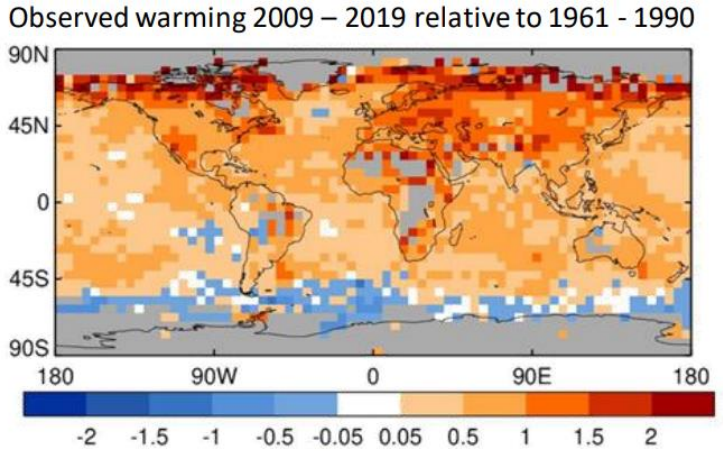
What will happen to Ulgham?

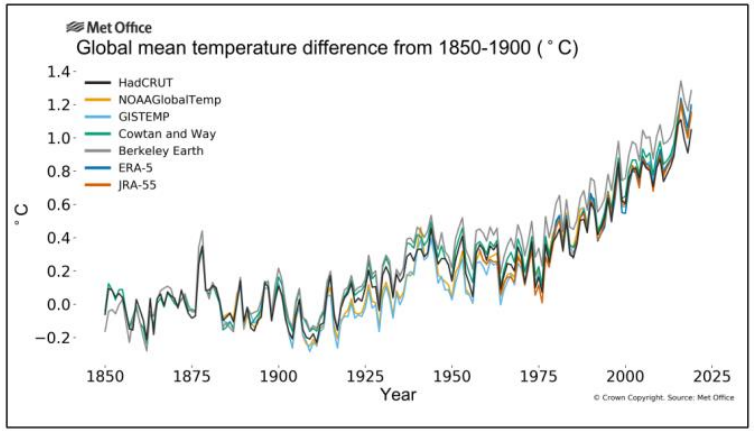


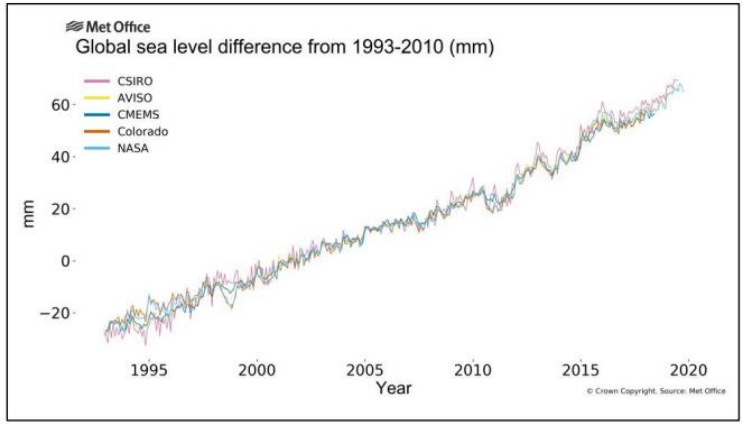
- Ulgham will likely witness more and more **severe weather**, like Storm Arwen.
- We should expect **more violent storms, more power outages** and **more damage to infrastructure**
- The more global temperatures rise – the more likely extreme weather events will occur.

The Climate is Changing









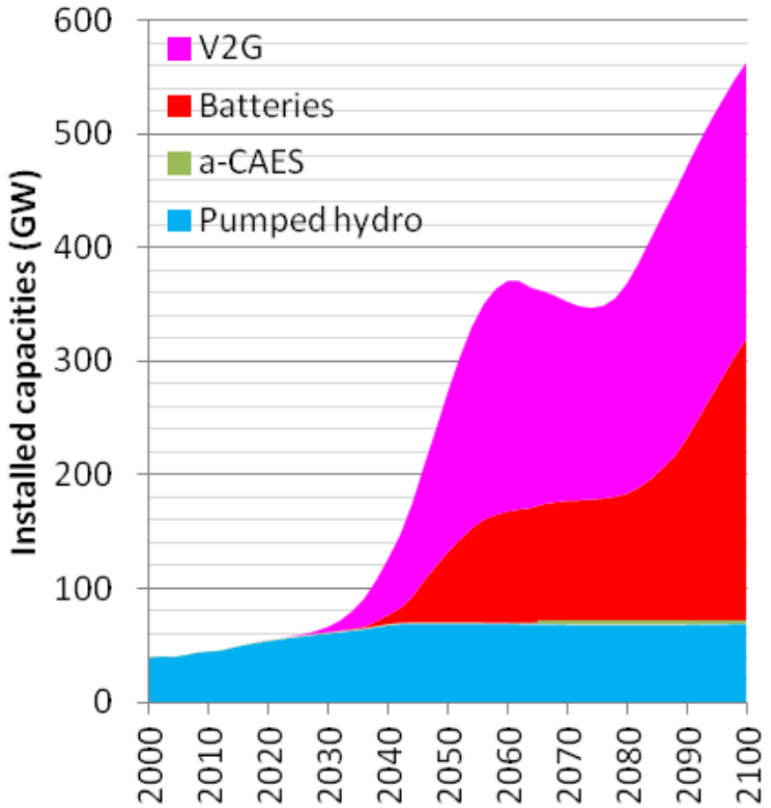
- CO_2 concentration has increased from 200ppm since 1960.
- **Global temperatures** have increased by 1°C since 1850 (0.6°C since 1975)
- **Sea levels** have risen by 80mm since 1995.
- The majority of warming is happening in the **Northern hemisphere**.

Carbon Brief. 2022. *Revealed: The 11 slides that finally convinced Boris Johnson about global warming*. [online] Available at: <https://www.carbonbrief.org/revealed-the-11-slides-that-finally-convinced-boris-johnson-about-global-warming> [Accessed 15 February 2022].

William Armstrong was an English Engineer and is famous for building the first house in the world to be lit by hydroelectricity (Cragside, Rothbury).

“Coal is used wastefully and extravagantly in all its applications, and we (Britain) will cease to produce it within two centuries” - William Armstrong, 1st Baron Armstrong (1863)

What does the future look like?



- The UK government have committed to **the ban of fossil fuel** car sales by **2030.**
- Within the **next 80 years** – the **vehicles** we drive **will form** more than **50% of our energy economy**.
- This technology is known as **Vehicle-to-Grid** (or **V2G**).

- **Moixa** in collaboration with **Honda** have already implemented V2G technology in **Islington, UK** and **Renault** have committed **£7.5m** to build a **Smart Fossil Free Island (Porto Santo, Portugal)** where a fleet of 14 Zoe electric cars and 6 Kangoo electric vans are being used to build a V2G environment.

Després, J., Mima, S., Kitous, A., Criqui, P., Hadjsaid, N. and Noirot, I., 2017. Storage as a flexibility option in power systems with high shares of variable renewable energy sources: a POLES-based analysis. Energy Economics, 64, pp.638-650.

Building Resilience in Ulgham

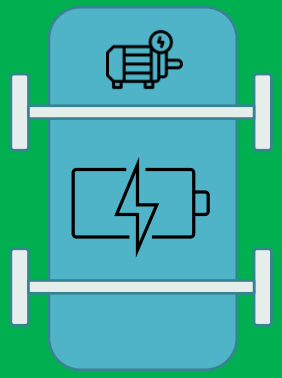
We **cannot continue to rely on fossil fuel generators** to save our selves when things go wrong.

We **cannot continue to rely on fossil fuel power stations.**

We **cannot continue to rely on fossil fuel powered vehicles** for transportation.

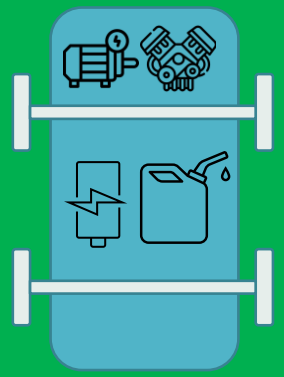
We must transition to a green economy.

Types of Electric Vehicle (EV)



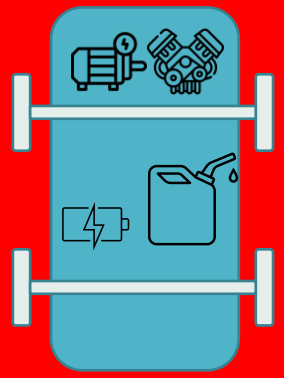
Battery Electric Vehicle (BEV)

- Driver(s)
  - Electric Motor
- Power Source
  - Battery



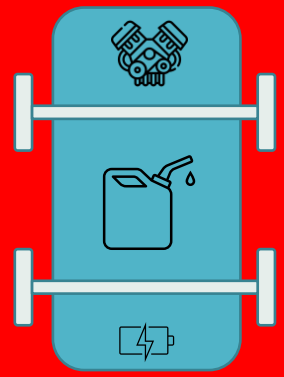
Plugin Hybrid Electric Vehicle (PHEV)

- Driver(s)
  - Electric Motor
  - Petrol/Diesel Engine
- Power Source
  - Battery
  - Petrol/Diesel



Hybrid Electric Vehicle (HEV)

- Driver(s)
  - Electric Motor
  - Petrol/Diesel Engine
- Power Source
  - Petrol/Diesel



Mild Hybrid Electric Vehicle (mHEV)

- Driver(s)
  - Petrol/Diesel Engine
- Power Source
  - Petrol/Diesel

Home Battery Systems (HBS)

What is it?

- A big battery (like the ones used in cars) stored somewhere in your home.

How does it work?

- HBS allows a homeowner to charge the battery when electricity is cheap and discharge the battery when electricity is expensive.

- This takes advantage of the Economy 7 Tariffs, where electricity plans offer two different rates on electricity: One during the day and one during the night.

What are the benefits?

- Cheaper electricity in a world that is becoming more electrified.

EDF. (n.d.). Powervault battery storage. [online] Available at: https://www.edfenergy.com/for-home/solar-battery-storage [Accessed 16 Mar. 2022].

Vehicle-to-Home (V2H) Systems

V2H work in the same way as home battery systems (HBS) but instead of a separate battery – they use the battery already installed in your car.

An electric car battery can hold around 40 kWh

An average house uses less than 10 kWh per day

NISSAN MOTOR Co., Ltd.. 2022. NISSAN | ZERO EMISSION | The Holistic Approach | Comprehensive Approach | Power Supply Ecosystem. [ONLINE] Available at: https://www.nissan-global.com/EN/ZEROEMISSION/APPROACH/COMPREHENSIVE/ECOSYSTEM/. [Accessed 16 March 2022].

How do we plan to help Ulgham?

ATTRACT INVESTMENT FOR A FLEET OF BI-DIRECTIONAL ELECTRIC VEHICLES.

INSTALL BI-DIRECTIONAL CHARGERS (CHARGING AND DISCHARGING) INTO EVERY HOME HERE IN ULGHAM.

DEMONSTRATE THE TECHNOLOGY PRACTICALLY AND FINANCIALLY TO PROVIDE A GLOBAL SOLUTION TO THE ENERGY CRISIS.

What do we need from you? - Support

Use Ulgham as a **“Rural Pilot”**

Pilot Plants in V2G are expensive

I will approach the **UK government**, **local energy providers**, and **industry** to support this technology and prove that it can help us fight climate change.

If we can make it work here – we can work anywhere.

Thank you for listening

Can we agree to form a **Work Group** and perhaps organise a **follow-up meeting** where we can talk about our next steps?

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Additional Details

- A car spends 4% of its life moving – 16% at an office/work, and **80% at home**[1].
- 365 people live in 166 households in Ulgham. There are an average of 1.7 cars per household – and so **282 cars**[6].
- The electrical grid consists of 4 markets; Baseload Power, Peak Power, Spinning Reserves, and Regulation[1]

  Baseload Power: provides round-the-clock power

  Peak Power: provides power when demand surges

  Spinning Reserves: provides back up in case of emergencies

  Regulation: control frequency and voltage of power supplied*, i.e., 230V at 50Hz*
- V2G is most suited to serve the regulation requirement within the grid[1].

Additional Details

*"Vehicle-internal circuits for full-function electric vehicles are typically upwards of **100kW**. For comparison, a US home's maximum power capacity is typically **20–50kW**, with an average draw closer to **1 kW**."* – W. Kempton

*"Regulation is controlled automatically, by a direct connection to the grid operator. It is **used more often** (~ 400 times per day), requires **fast response** (less than a minute), and is required to continue **running for shorter durations** (typically a few minutes at a time). The actual energy dispatched for regulation is some fraction of the total power available and contracted for. The ratio of **energy dispatched** to **energy contracted** is important to the economics of V2G"* – W. Kempton

Additional Details – Revenue

Take a **Toyota RAV4 Hybrid Vehicle**. Assume that the power contracted is the power limited by the line connection to the house. Assume this is **15 kW**[1].

Mike Ryan (Habitat Energy) claims that battery storage optimisers capture revenue at **£17 MW-hr** in 2021[7].

Electricity price is **£0.18 kWh**.

Assume that a vehicle is plugged in for **6570 hr/year** and that the dispatch\contract ratio is **0.10**[1].

$$Revenue = p_{cap} P t_{plug} + p_{el} R_{d-c} P t_{plug}$$

From frequency regulation services alone – **Ulgham** could see a revenue of £1,000,000/year (£972,688.50/year).

Or £3449.25 per car per year.

References

[1] – Kempton, W. and Tomić, J., 2005. Vehicle-to-grid power fundamentals: Calculating capacity and net revenue. Journal of power sources, 144(1), pp.268-279.

[2] – Carbon Brief. 2022. Revealed: The 11 slides that finally convinced Boris Johnson about global warming. [online] Available at: <https://www.carbonbrief.org/revealed-the-11-slides-that-finally-convinced-boris-johnson-about-global-warming> [Accessed 15 February 2022].

[3] – Després, J., Mima, S., Kitous, A., Criqui, P., Hadjsaid, N. and Noirot, I., 2017. Storage as a flexibility option in power systems with high shares of variable renewable energy sources: a POLES-based analysis. Energy Economics, 64, pp.638-650.

[4] – EDF. (n.d.). Powervault battery storage. [online] Available at: https://www.edfenergy.com/for-home/solar-battery-storage [Accessed 16 Mar. 2022].

[5] – NISSAN MOTOR Co., Ltd.. 2022. NISSAN | ZERO EMISSION | The Holistic Approach | Comprehensive Approach | Power Supply Ecosystem. [ONLINE] Available at: https://www.nissan-global.com/EN/ZEROEMISSION/APPROACH/COMPREHENSIVE/ECOSYSTEM/. [Accessed 16 March 2022].

[6] – "Northumberland County Council Policy and Research Team" (2013). *Census return for Ulgham, Morpeth, Northumberland.* ONS 2011 Census Key and Quick Statistics tables via Neighbourhood Statistics downloaded 01/06/2013. Available at: <https://www.northumberland.gov.uk/NorthumberlandCountyCouncil/media/Northumberland-Knowledge/NK%20place/Parishes%20and%20towns/Parish%20fact%20sheets/FactSheetParishUlgham.pdf> (Accessed: 21 February 2022).

[7] – Lempriere, M., 2022. UK battery storage revenues from new dynamic frequency regulation services won't take long to fall. [online] Energy Storage News. Available at: <https://www.energy-storage.news/uk-battery-storage-revenues-from-new-dynamic-frequency-regulation-services-wont-take-long-to-fall/> [Accessed 21 February 2022].