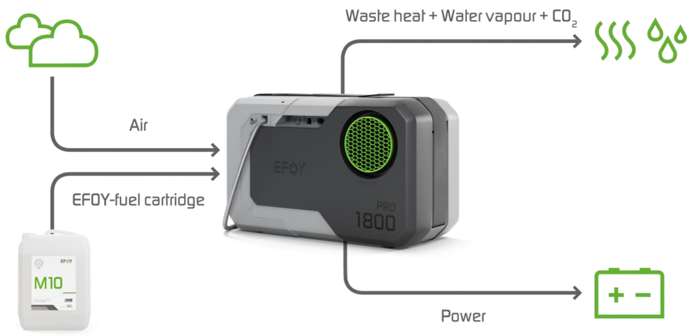
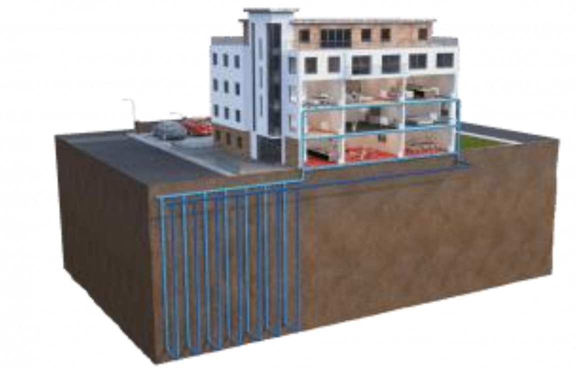


An engineer's glimpse into the consumer future of UK energy

(and the mistakes we are making in renewables and EVs)

Dr Mark Scibor-Rylski FIET, FInstPhys (IET Innovation Management TN)



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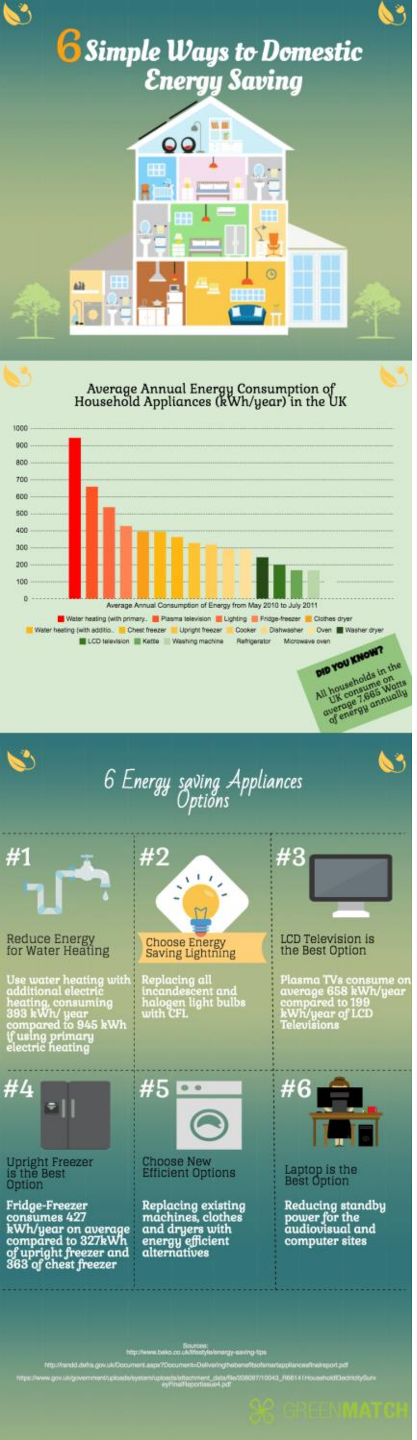
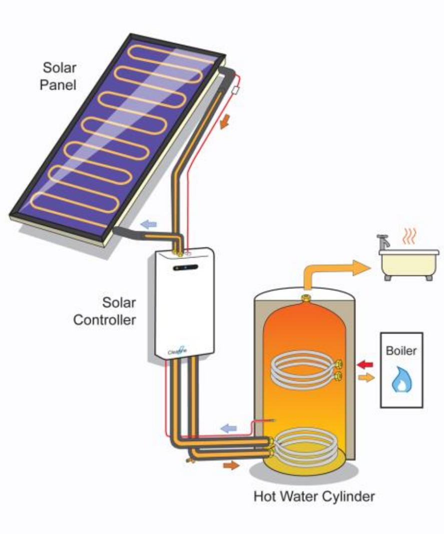


TODAY'S CONTENT- lots of it



- Introduction – making sense of the sector
- Renewables and the Green Economy
- Tariff pricing issues – what needs to be done
- Smart meters repurposed
- AI in the home
- Smart Customers and Smart Energy
- Batteries in Buildings
- Heat Pumps (and what comes after)
- Smart(ish) Grids
- Using batteries correctly (and which batteries to use)
- Heat Batteries and what they lead to
- Real Infra-Red heating?
- EVs – serious problems and tough challenges
- Hydrogen realities
- Summing Up - Problems and Opportunities - checklist

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The Energy Background

UK **electricity** is generated by:

gas/oil	42%,
renewables	38%,
nuclear	17%
coal	3%.

Renewables are intermittent and seasonal and comprise:

wind	26%
solar photovoltaic	10%
hydro (we need more)	2%

Gas has a simpler structure – it is imported, or domestically generated,
It may be used to generate electricity or distributed by a grid system reaching **23 million homes (85% of energy consumers)**

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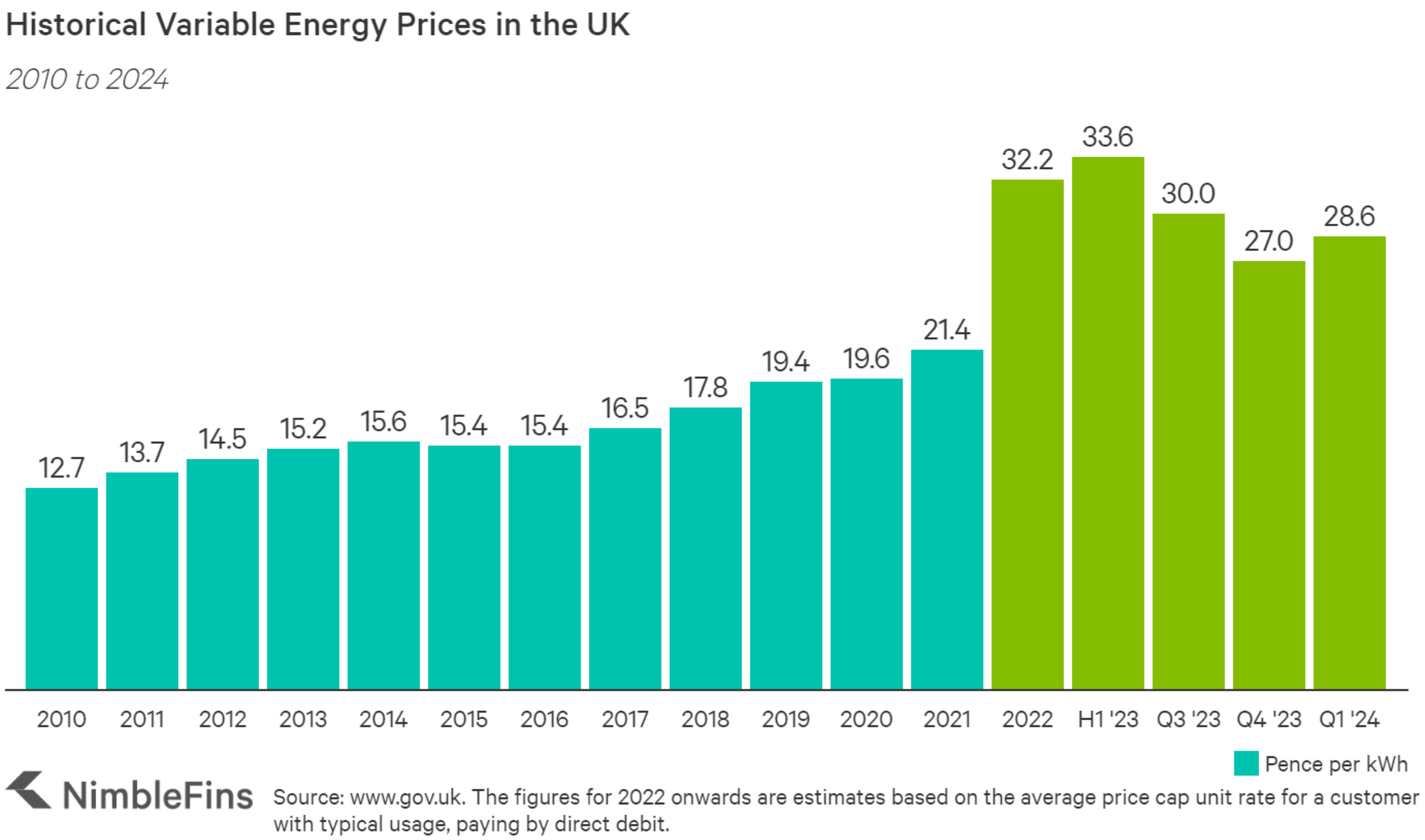
1. Renewables and the green economy are an eco-commercial matter

The renewables sector is chaotic. As energy market prices rise, heat becomes more valuable, and renewables should become more affordable. **Commercial forces must drive the green economy.**



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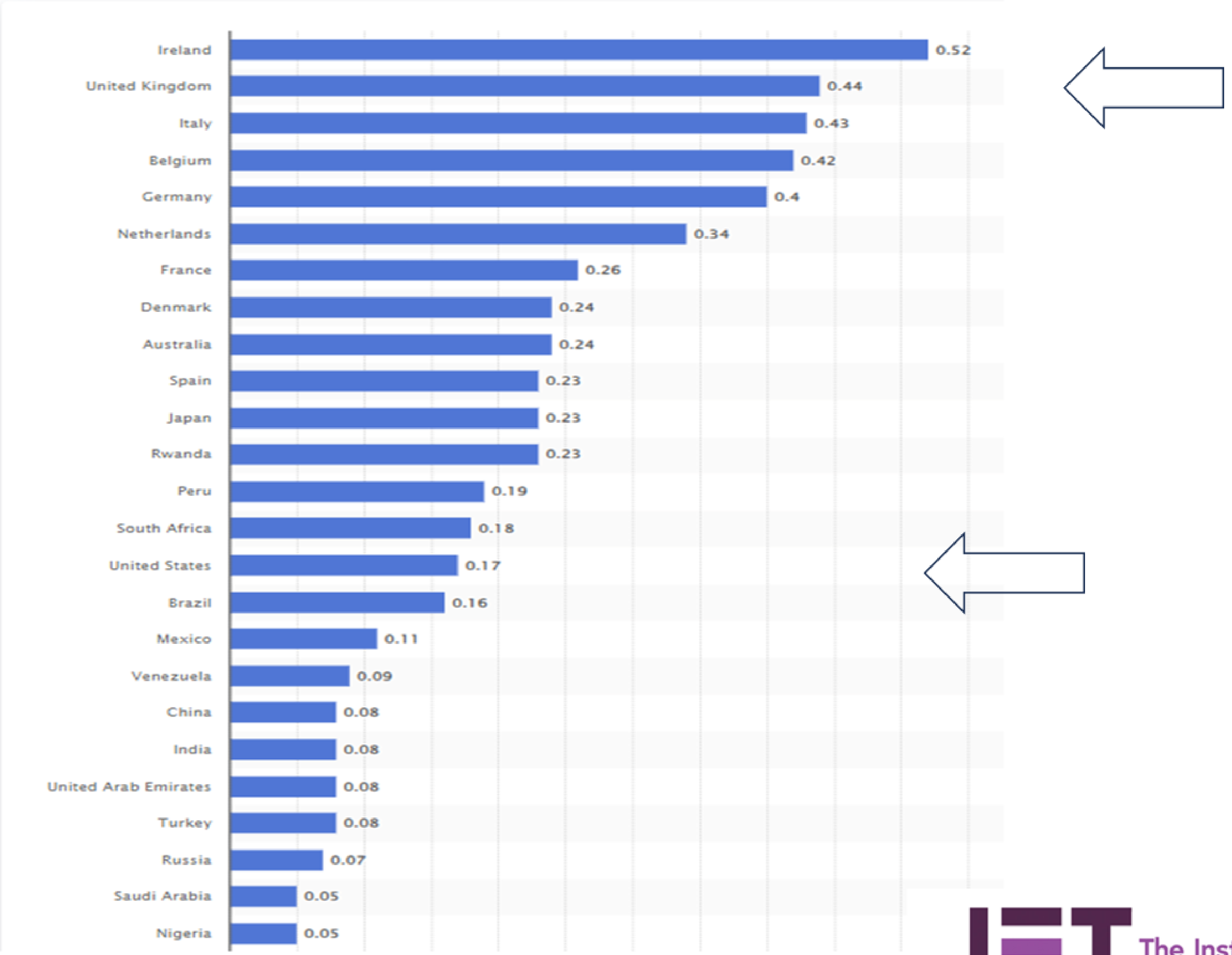
Household electricity prices worldwide in June 2023,

(in U.S. dollars per kilowatt-hour)



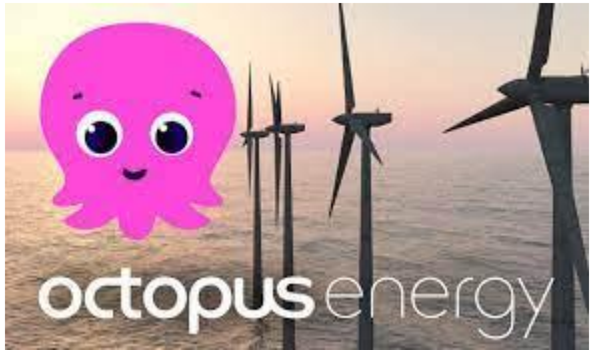
The 3 steps we need to take

1. The relationship between UK energy generators, suppliers and consumers must change and become rational.

2. We must migrate to a smarter and more logical system for energy distribution and use.

3. We need to become **smart customers**, using **intelligent energy.**

British Gas
Looking after your world



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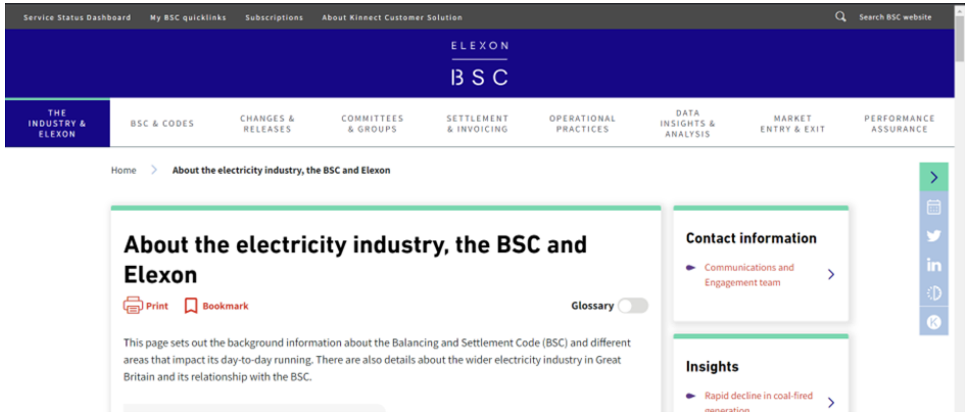
2. Elexon and the variable energy tariff challenge Part 1



Open market energy pricing
Contracts for difference
Internal energy market?
HAVE WE GOT ENERGY PRICING RIGHT?

Elexon oversees the Balancing and Settlement Code, comparing how much electricity generators and suppliers say they will produce or consume with actual volumes.

The range of traded tariffs between **£121/MWh and £800/MWh** increased recently due to supply instability. This could not be managed by raising fixed tariff prices – load levelling was also needed.

PROPOSAL : Such 6:1 variations in tariff may be shared with smart consumers in the form of intelligent energy, which uses price to level load with demand.

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2. Energy pricing anomaly – a mistake using trade pricing for energy? Part 2

AN INTERNAL ENERGY MARKET (for domestic generated and consumed energy)
An internal energy market, involving smart customers and intelligent energy can steer the UK to a stable price energy future.

The UK energy market faces two problems.

First, energy is unnecessarily valued at a commodity trading price, even if it has not been purchased and its costs of generation have not increased. This sector should be replaced by a fair internal energy market for energy generated and consumed domestically.

Secondly, tariffs for energy vary between ever greater extremes due to imbalance between supply and demand but currently become fixed when it is consumed. Energy to the home must take the form of variable tariff energy.

Following these steps, the UK should seek to become more self-sufficient in energy to minimise the impact of a weaponised or unstable energy market. This process raises the importance of UK's renewable energy sector.

3. At last , a use for Smart Meters?

SMs were designed by QinetiQ to capture data in an unusable and unreachable manner
Both SMETS1 and SMETS2 do not allow data to be interpreted.
Only saves meter readings cost

SMs - Energy Saving to user – power planning for grid/utility. Original design affected by utility competition issues

A link to the energy supplier – important if variable tariff is to work?

However, we may need to use other devices to collect local data or initiate load levelling activity

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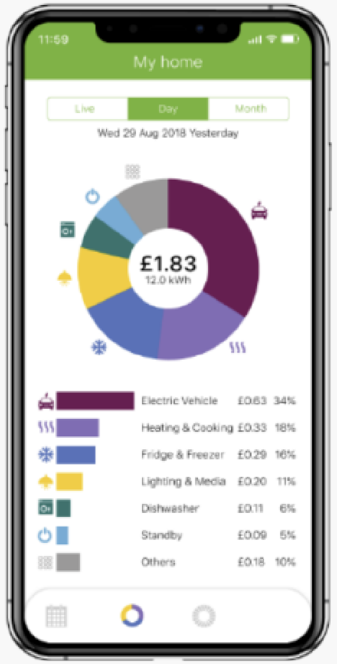
4. AI and domestic energy – Voltaware

https://voltaware.com/amazon-shop a Smart Customer energy dashboard

Voltaware | Request a demo | Shop | Our technology | For utilities | Team | Support | Blog



The appliance fingerprint detection (disaggregation) algorithm is at the heart of Voltaware technology, unlocking new opportunities such as helping you save energy, reduce bills, improve your security and comfort, help reduce carbon footprint and more.

Voltaware works by analysing electricity data either from its patented sensor or smart meter data. The Voltaware algorithm then automatically breaks down individual appliances from the total load, enabling a wide range of home insights.

Voltaware can instantly detect appliance fingerprints without requiring any calibration from you as a user. The Voltaware data science team is continuously improving and adding new machine learning models to provide you with a seamless experience.

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5. Variable tariff energy for **Smart Customers**

SMART CUSTOMER DEFINITION:

1. **Variable tariff** energy to the home
2. A **battery in the home** (electric [and heat])
3. **Smart consumer unit** (switch, low current and high current rings)
4. **Inverter** (home and grid feed in)
5. Renewable energy source/s for **self-consumption**
6. **Low energy mode** for high tariff periods
7. **Energy timeshift**, grid feed-in, off grid situations
8. Smart meter or other **link to utility** for tariff data/load levelling
9. **AI dashboard** on energy being used

Q – pay as you use energy?

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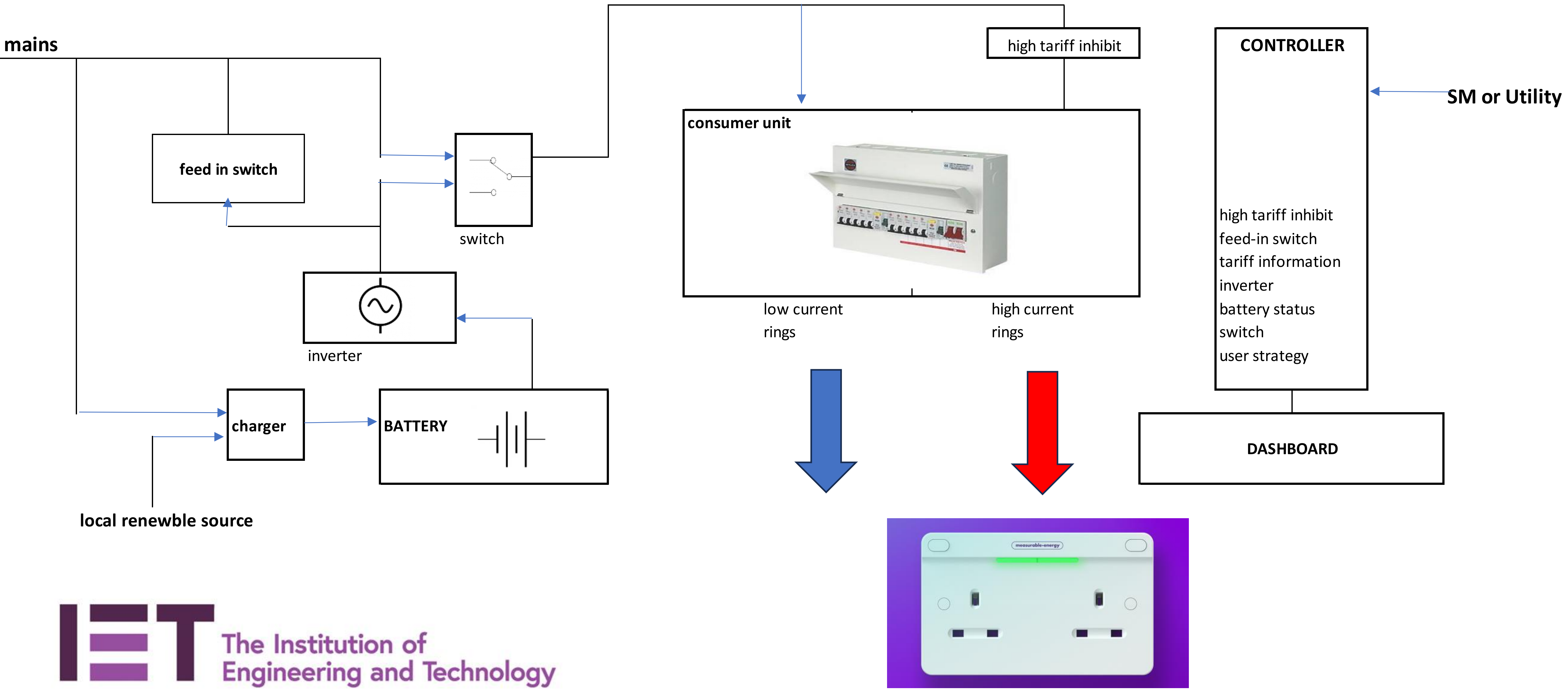
SMART CUSTOMER VARIABLE TARIFF INSTALLATION



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6. Batteries in Buildings

Modern buildings need plant room space – architects please note, otherwise outdoor location.

Batteries in buildings are a logical ingredient to allow self-consumption of renewables, timeshift of low-price energy and power cut resilience.

In a variable tariff situation, they may also allow for profitable grid feed in which could result in **free energy use.**

Batteries can be Li-Ion – either new or **post EV second user**.

The use of classic static batteries in buildings. **NiFe cells** made in the 1900s are still working.
Average storage efficiency but are cheap to make and safe to use.
They use nickel and iron with caustic soda electrolyte. These require some maintenance but are essentially everlasting, so no depreciation. **Consider UK manufacture?**

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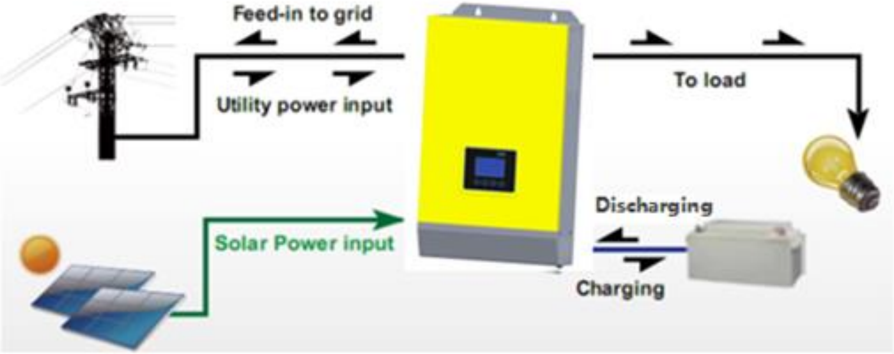
7.Grid feed in

Not guaranteed to work - grid is not designed for multipoint distribution.

Grid feed-in may only warm up a step-down transformer.

To work, the location of the grid feed-in user should be along an active long grid spur.

A high-quality DC-AC inverter in the home is needed



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8. Low energy mode and free electricity

If **smart customers** with batteries store more low tariff energy than they need and then fed power back back into the grid when they have energy to spare, **their electricity bills could be smaller or even zero.**

That needs a **large enough battery, a grid feed in inverter and a variable tariff** arrangement with the utility which reflects the value of the feed in energy at high tariff (peak load) times. Because the range of tariff pricing may be very wide, this benefits the energy provider and the consumer. It may also be used in social housing.

This shows the need for a **low energy mode** in smart customer territory and the high current ring issues which would allow the avoidance of high tariff times by white goods usage . **Later this may become a feature on new white goods hardware, meanwhile it can be delivered by smart sockets or smart cables**.

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9. Heat Pumps – air source or ground source?

Heat Pumps generate more heat than they consume power by a ratio of 3:1 or 4:1 on average. They are most efficient when producing 30ºC water.
Air source heat pumps (ASHPs) are imported and may work well in many climates. They are less efficient than ground source but struggle with damp cold air because they may ice up.
Ground source heat pumps (GSHPs) draw heat from the ground and are quieter and more efficient and work well in the UK and are made here. They can be connected to a ground loop in a trench (slinky), a pond or drilled hole. Multiple GSHPs can be attached to a single ground work coil. Ground Source HPs cost more but are more durable. Both require energy efficient buildings to be effective. See https://www.kensaheatpumps.com/

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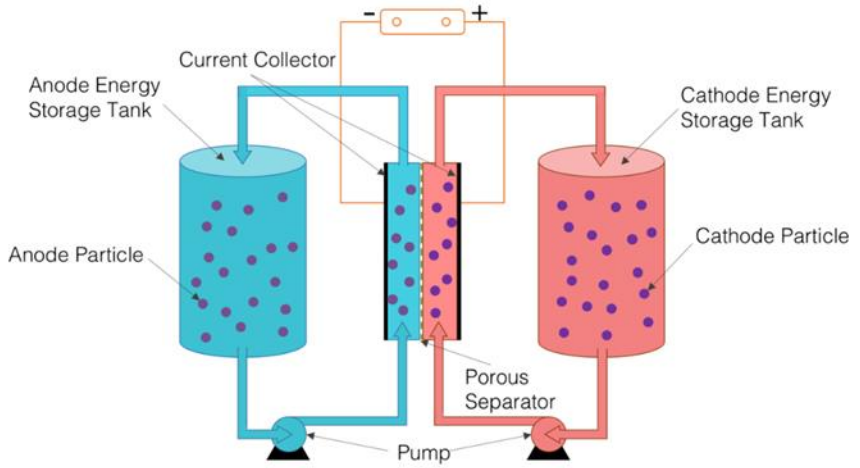
10. Batteries on the Grid and Smart Grids

A smart grid allows for **multi-point energy sources** rather than just distribution from a power station. It may also allow for renewables to be used **as a peak load energy source.**
The use of on grid **Salt or Redox batteries** could allow for energy timeshift of renewable energy.

It may be easier to place **small batteries in buildings** than **big batteries on the grid (**or beside wind farms, tidal, hydro or PV arrays).

Grids are not obvious investment vehicles so who pays for the smartening of the grid?

Redox batteries have a self-discharge process which may make their use much less effective than a full-size battery BUT **nanoFlowcell technology** may turn this around.



If grid batteries are in place, **load levelling** can be attempted upsteam of users.
Otherwise, it can be done by local batteries in the home

11. Smart Customers vs Smart Grids

If the Salt and Redox batteries are added to a dumb grid it will become smart. It may be more sensible to distribute batteries at the user end. Many small batteries will be needed rather than a few large ones.

Both would need to be integrated so that peak load avoidance (load levelling) could take place.

A smart grid (= a smart customer) would ensure that locally generated energy would be consumed locally.

Domestic batteries may be indoors or outside and can be Li-Ion or NIFE

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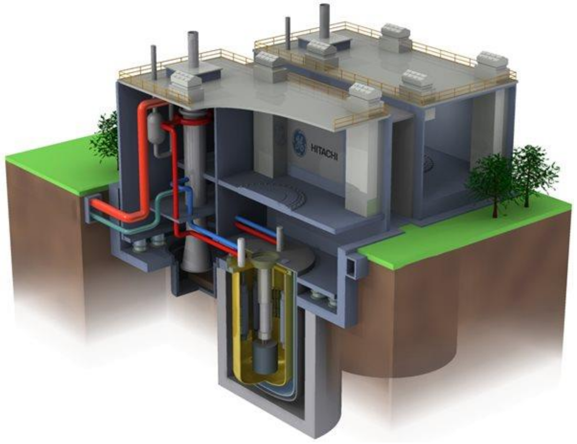
12.Small Nuclear and (renewable micro power stations)

Distributed mini power stations or batteries can be linked with Renewables, turning them from intermittent sources to local power station status – local energy use strategy.

Increased tariff value needs to pay for battery cost. Not a Smart Grid.

Now a much bigger challenge. SMRs are based on proven technology but have not **taken off in the US**. They have not yet been used as part of any grid system although **countries are considering these safer small units in many locations instead of large nuclear power stations**. They need a football field sized site, **located at strategic locations**. A possible problem.

We have a choice of licensed (GE?) designs or Rolls Royce prototypes, and the route to complete mini power stations where they balance renewables is obvious. May be hampered by applying big nuclear standards to much smaller SMR nuclear risks.



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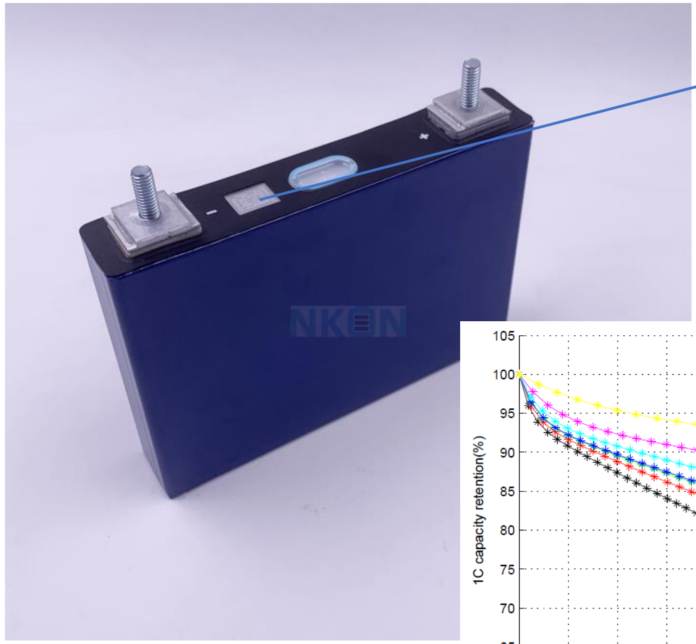
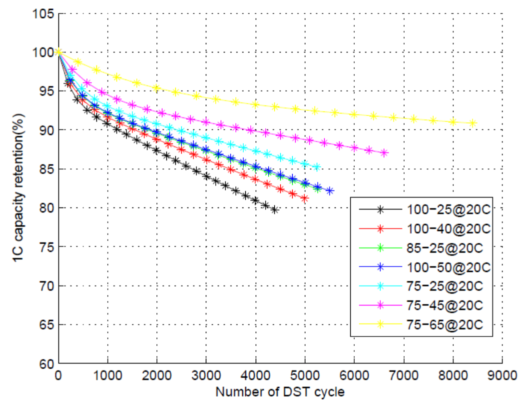
13. Do we use batteries correctly?

or how we can monetise batteries effectively

1. EV BMS usage suggests we don't in that marketplace
2. We need a cell-level battery economy so that batteries have value and use up their whole lifespan
3. Battery Maintenance Companies are needed to fill the gap in battery management (supply chain companies)
4. **IoT based super battery – maximises battery life and creates a Super Cell**





(b) Reproduced DST Data.

IoT Cell Device

- Powered by cell energy
- Measures charge and discharge current
- **Calculates stored charge and actual capacity**
- Stores event data (full discharge, temp anomalies, high current etc)
- Interfaces to Battery Management Systems
- Permanently attached to battery
- Single chip device

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14. Heat storage – heat batteries/CHP

- Heat can be treated like electricity and stored or timeshifted
- Combined heat and power (CHP) should also capture wasted heat
- Heat can be turned into electricity (Seebeck Effect)
- Solar thermal heat can be stored for nighttime
- **EVs should use stored heat instead of battery power for heating**
- Heat storage is most efficient if phase changes are made use of
- Heat can also mean Coolth

For an example see Sunamp - https://sunamp.com/en-gb/
Sunamp's patented Plentigrade technology stores energy in high-performance phase cha
materials and releases it to give hot water, heating or cooling on demand.

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How the zero emission boiler works

https://www.tepeo.com/

1

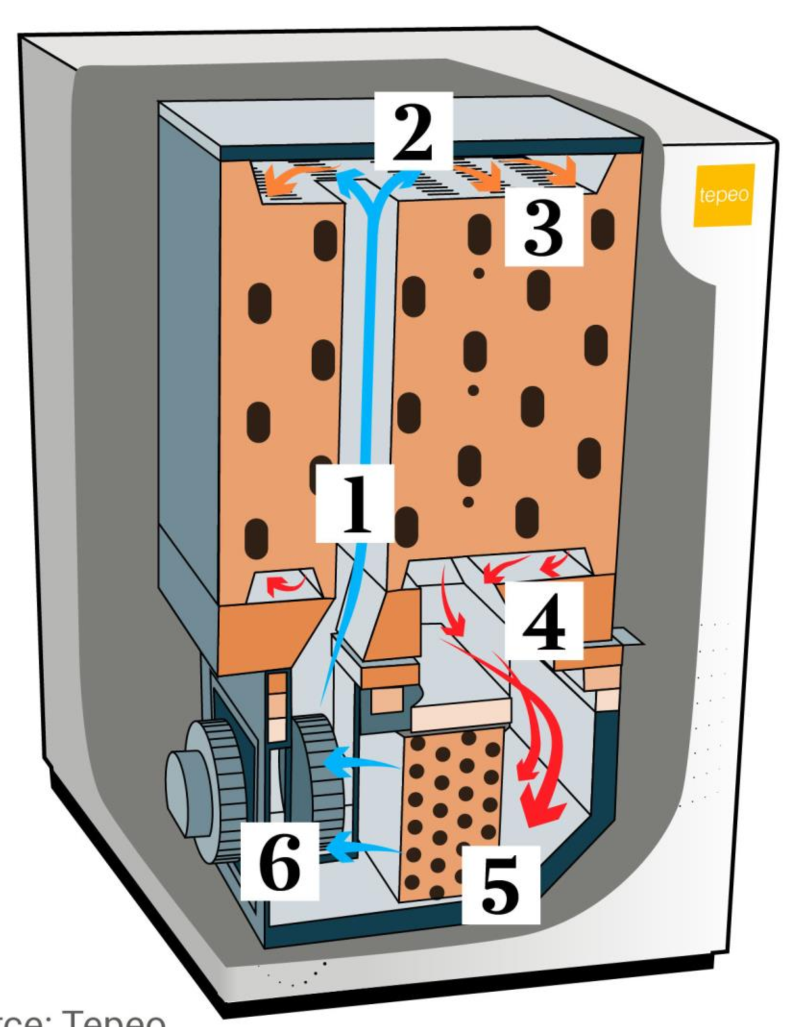
A fan blows cold air up a 'chimney' where it is heated by elements either side

2

The now 'warm' air spreads out in the top cavity of the core

3

The warm air distributes down through air tubes in the core



4

The now very hot air comes out and mixes in the 'hot cavity' in the bottom of the core

5

The hot air is forced through the heat exchanger, which has the plumbing pipes weaving back and forth through it

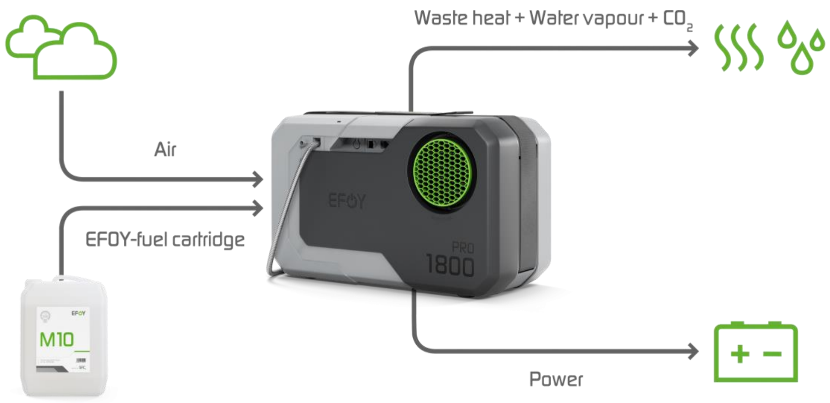
6

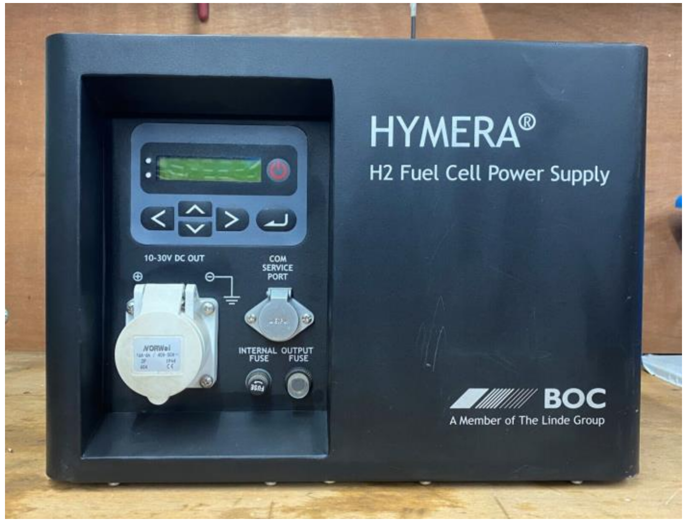
The air emerges cool again, for the cycle to repeat

Graphic: The Times and The Sunday Times • Source: Tepeo

Tepeo's ZEB – iron ore heat battery based variable tariff electric boiler

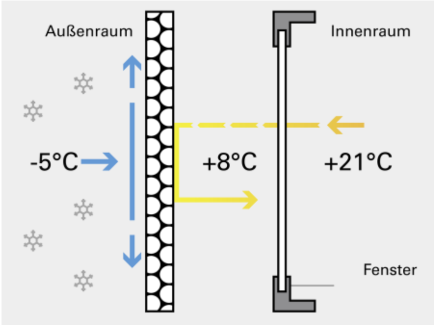
15. What else comes after Heat Pumps? CHP?





Hot fuel cells are interesting – producing heat and electricity, Methanol fuel cells and hydrogen fuel cells are both effective, but a **hybrid gas fuel cell might be needed**. If electricity and heat can be stored, silent and efficient CHP solutions will be an on-gas solution for heat and power.

CHP – [Hybrid] Hot Fuel Cell – with storage battery and heat battery?



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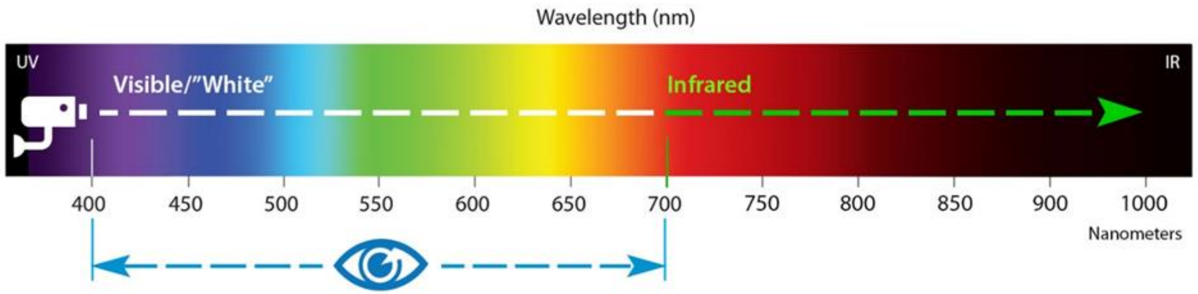
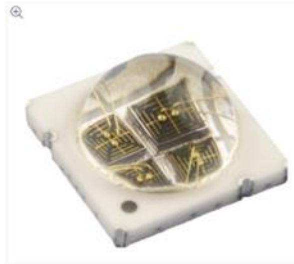
16. Narrow band Infra-Red heat solutions

heat the person, not the space



Solid State Supplies has a range of devices delivering 5,250mW at 850nM and they are inexpensive so I can see an armchair aimed IR heater using < 20watts doing the work of 1kW of traditional power.

I think the H&S level is delivery of 10mW/cm2 if IR is safe. (Full broadband sunlight is 43 - 137mW/cm^2.



LED Engin – LZ4-00R708 – 940nm Infra Red Dual Junction 5250mW

Product Overview

The LZ4-00R708 840nm Dual Junction Infrared LED emitter generates 3.2W nominal output at 8.5W power dissipation in an extremely small package. With a 7.0mm x 7.0mm ultra-small footprint, this package provides exceptional radiant flux density. The patent-pending design has unparalleled thermal and optical performance. The high quality materials used in the package are chosen to optimize optical performance and minimize stresses which results in monumental reliability and flux maintenance. The robust product design thrives in outdoor applications with high ambient temperatures and high humidity.

Features

Key Features
. 940nm Dual Junction Infrared LED
. Ultra-small foot print - 7.0mm x 7.0mm
. Surface mount ceramic package with integrated glass lens
. Low Thermal Resistance (2.8°C/W)
. Individually addressable die
. Ultra-high Radiant Flux density
. JEDEC Level 1 for Moisture Sensitivity Level
. Lead (Pb) free and RoHS compliant
. Reflow solderable
. Emitter available on Serially Connected MCPCB (optional)

LED ENGIN

Documentation

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Cyberster


HV12 UUJ

Astra Electric

17.Electrified cars and real EVs

We are still in the electrified cars period – real EVs should not pretend to be like IC cars.

A REAL EV has to:

1. be made of light heat insulating material (it does not need to shed heat)
2. offer the range that a modest sized battery allows (eg avoid 3 Tonne vehicles)
3. be the basis of a serial hybrid via range extenders
4. use a storage heat battery for heating (charged when charging)
5. use a dry ice cartridge for air con (loaded when charging)
6. use moderate voltage drive system (not 800v!)
7. have a corrected Ackermann steering to reduce rolling drag.
8. seek lightness in design, the payload should be the passenger, not the batteries

Current **3 drive systems based on an IC chassis** are misguided. The most efficient vehicle would be a clean fuel IC version of a real EV chassis. Hybrids should not be parallel but serial.

BMS

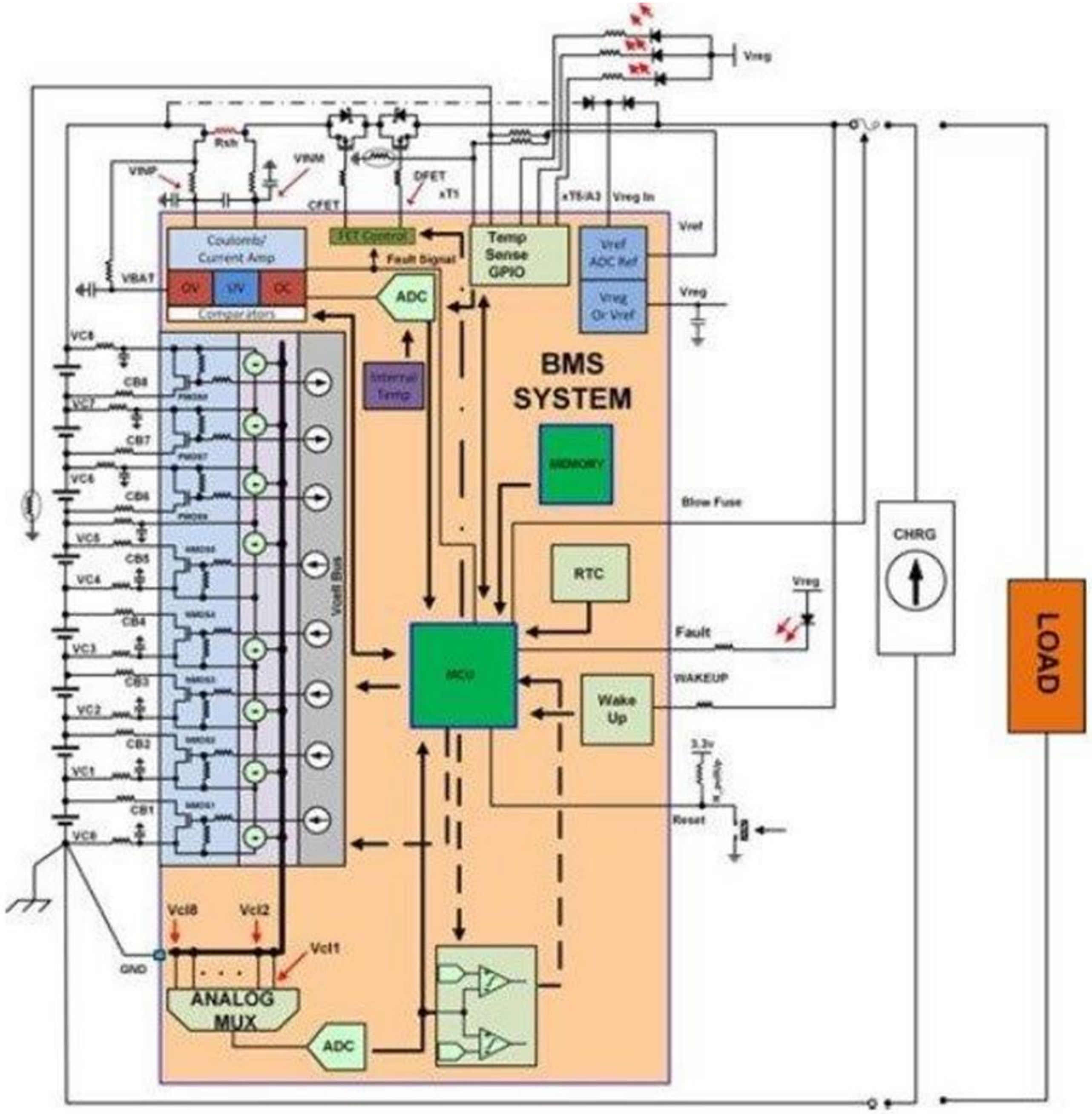

Figure 1. A Simplified Diagram of the Building Blocks of a Battery Management System

18. Battery Management Systems or Battery Monitoring Systems?

- EV batteries come with a protective Battery Management Systems which precludes servicing
- BMS systems address data collection, charging, temperature and cell protection issues and are intended to protect
- BMS circuits suppress the effects of cell degradation but accelerate the end of life of EV batteries
- BMS circuitry is expensive and may make battery fires more likely

There is a better approach….

- Replace with **Battery Monitoring System** and a **Battery Maintenance Company** which replaces weakest cells and gives them a second life.
- This supply chain company is needed to add value to the battery economy, EV use and to shield batteries better in other markets

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19. Battery Maintenance Companies – the missing ingredient

- EV Battery Maintenance is about **weakest cell replacement** to allow overall charging capacity to be maximised.
- Such Maintenance implies that condition monitoring of batteries is linked to the BM company
- The company will agglomerate cells which are unsuitable for EV use but may be matched and used in batteries in buildings applications – a second market for BMs
- Value is created by charging the true depreciation cost of the EV battery, while the value in the cells taken out is captured with second life applications (via batteries in buildings)
- Battery Management Companies can also address battery replacement in post BMS EVs

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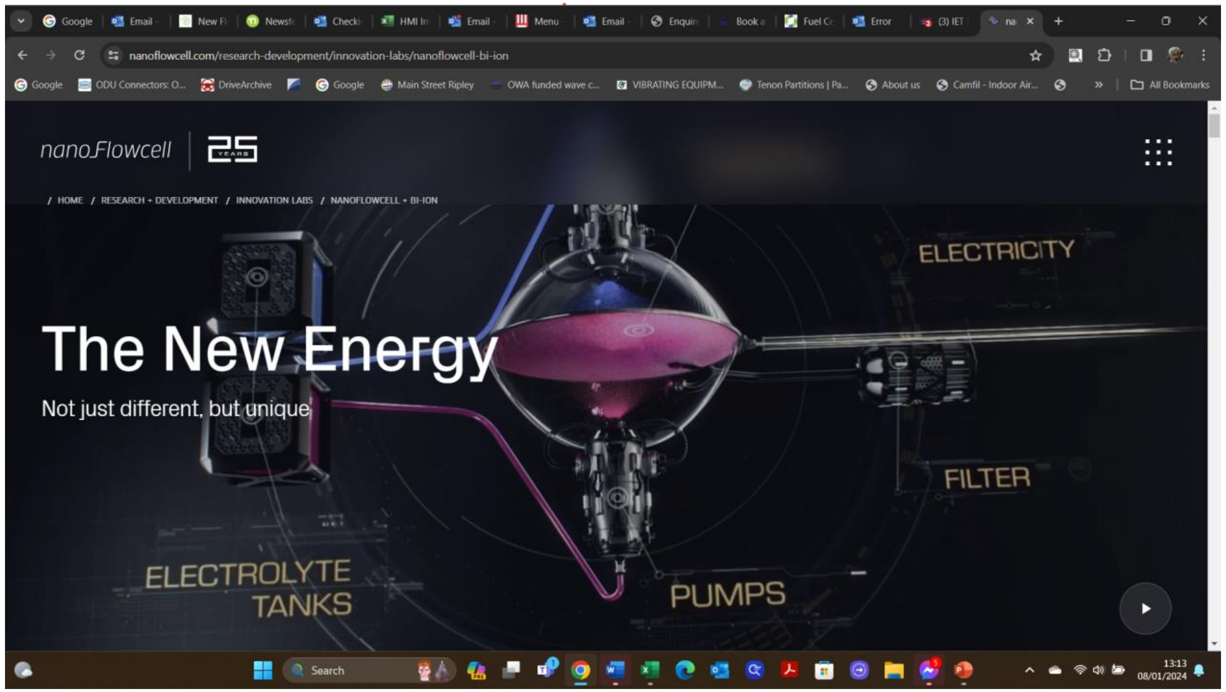
An [EV] long shot – liquid flowcell batteries?



Quantino 25 flowcell - 2,000km range

1. Static applications first?
2. “Fuel” costs?
3. Infrastructure?
4. Battery rather than EV future?

https://cleantechnica.com/2023/12/31/new-flow-battery-electric-car-usa-ira/

https://www.nanoflowcell.com/research-development/innovation-labs/nanoflowcell-bi-ion

https://www.nanoflowcell.com/info-center/flow-magazine/one-who-can-do-what-no-other-can-do

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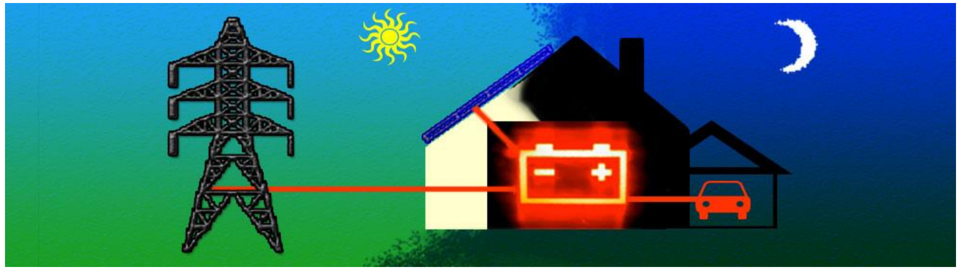
20.EVs and the Grid (V2G and V2H) - Nissan’s V2X

The V2G idea is illogical and makes no economic sense.

If batteries are needed for peak tariff load levelling, they should be static batteries in buildings, not high cost/depreciation EV batteries.

Using EV batteries makes no economic sense. The energy in these batteries is intended to energise the vehicle for travel, not service the local grid.

However – **the V2H role** in emergencies may be useful if the stored EV energy is not more urgently needed for transport purposes.



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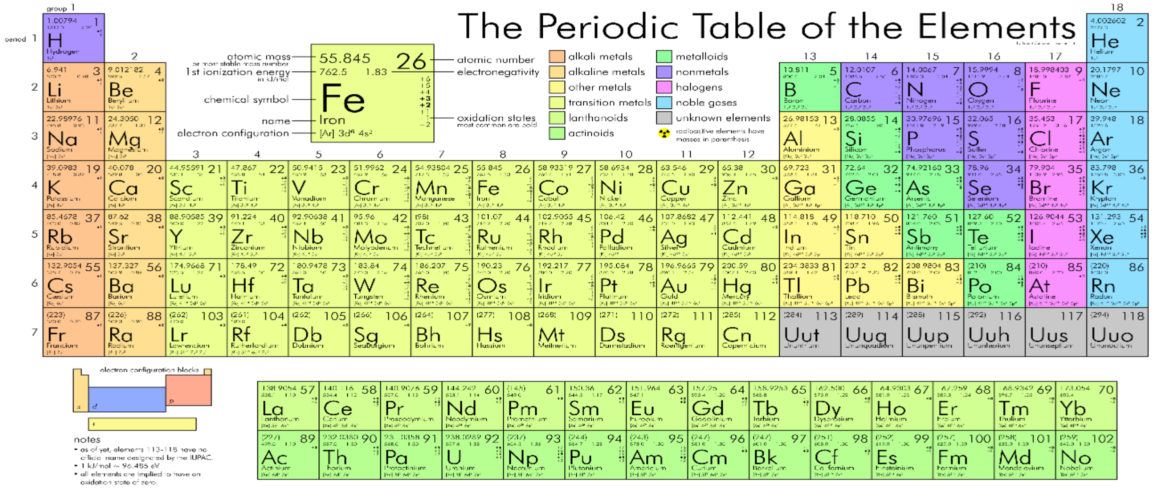
21. Hydrogen – cars and fuel cells

H2 is liquid at -240º C
Hydrogen can be used in IC engines – alternative to fuel cell +EV powertrain, but storage is challenging
Other gases are available (NB forget hydrogen for aircraft)



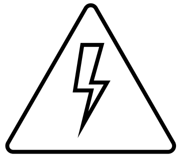
Mitsubishi Mirai – 10,000psi (70MpA)

NAMX HUV – France IC Hydrogen instead of fuel cell EV

COMMENT LES ANGLAIS, IL Y A UN SIECLE, COMPRENAIENT L'AVENIR DES VOITURES A VAPEUR

Losing energy with hydrogen

100%



electricity

-25%

electrolyse, store, pump, transport

-50%

convert back to electricity with fuel cell

25%

electricity

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SUMMING UP

Mistakes (16)	Opportunities (19)
Air Source Heat Pumps in UK climate	Real EVs
EV Battery Management Systems	Battery Servicing Companies
Heavy EVs	NiFe Batteries
Many Hydrogen applications	IoT and batteries
EV energy used for heating and cooling	CHP and heat batteries
Fixed tariff electricity	Variable Tariff energy
Energy pricing at commodity levels	Internal energy market
Local use of renewable energy	Batteries in buildings
Second user batteries	Grid batteries balancing renewables
V2G	V2H as resilience
Hydrogen generation	Clean fuels in IC engines and turbines
Hydrogen with fuel cells	Smart Customers (BIB)
Grid feed-in assumptions	Off grid communities
Smart Meter purposes	Low energy mode buildings
IC based IC, hybrid and electric vehicles	Hydrogen/clean fuel with IC engines
Parallel hybrids on IC chassis	AI on domestic energy usage
	EV based serial hybrids
	SMRs as renewables balancing
	Narrow Band IR heating?