The energy transition – from hydrocarbons to chemicals – lets prepare for the change of risk in storage, transport and use.

Mark J Orr, Executive Director - UK and Ireland Spill Association

Bill Atkinson, Chief Scientific Adviser, Adler and Allan Group

CHEMUK2023
SUPPLY CHAIN • PROCESS & PLANT • LABORATORY
10th & 11th May 2023, NEC, Birmingham, UK

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What a wonderful journey we are on!

- The imperative is clear – reduce GHG emissions
- Renewable Transport Fuels Obligation Order 2007
- Transitioning from what we know well and understand to products we know less well

Push to net zero?

- UK remains a leader in the net zero transition
- Government has set its strategy transition to cheaper, cleaner and domestic sources of energy.
- Between 1990 and 2021, we have cut our emissions by 48%, decarbonising faster than any other G7 country, whilst growing the economy by 65%
- Green and growth go hand in hand

Is this the whole story?

- Lot to be positive about!
- Where are we going though?
- Are the timescales realistic?
- Can we deliver what society needs us to?
- How prepared are we?
- What are the options?
- What are the risks?

- Come and see us on Stand J20

Alternative fuels (excluding generation)

The present

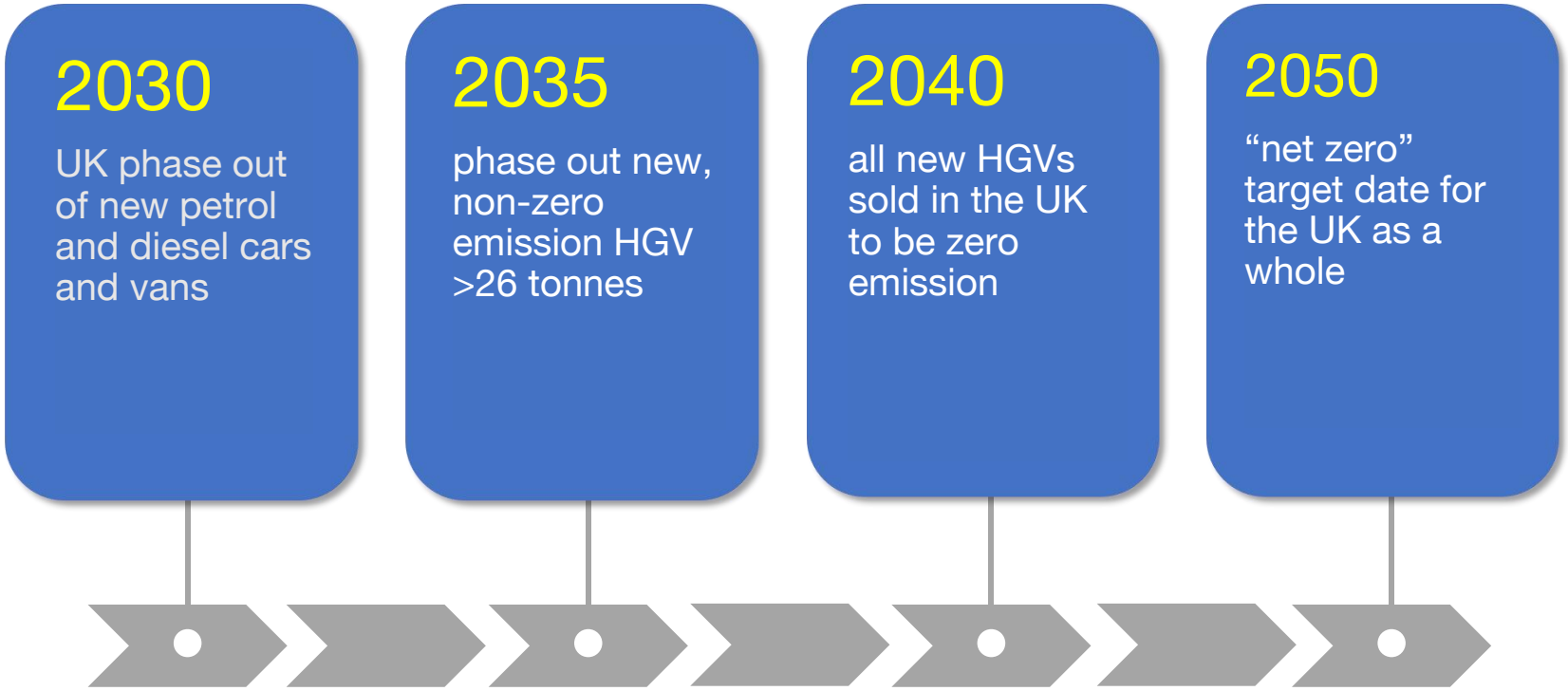
- Road vehicles – diesel, petrol, hybrid, plug-in and full EV
- Domestic heating – electricity, oil, gas, LPG, renewables
- Aviation – kerosene
- Shipping – HFO
- Industrial – electricity, gas, oil, coal, renewables

The future?

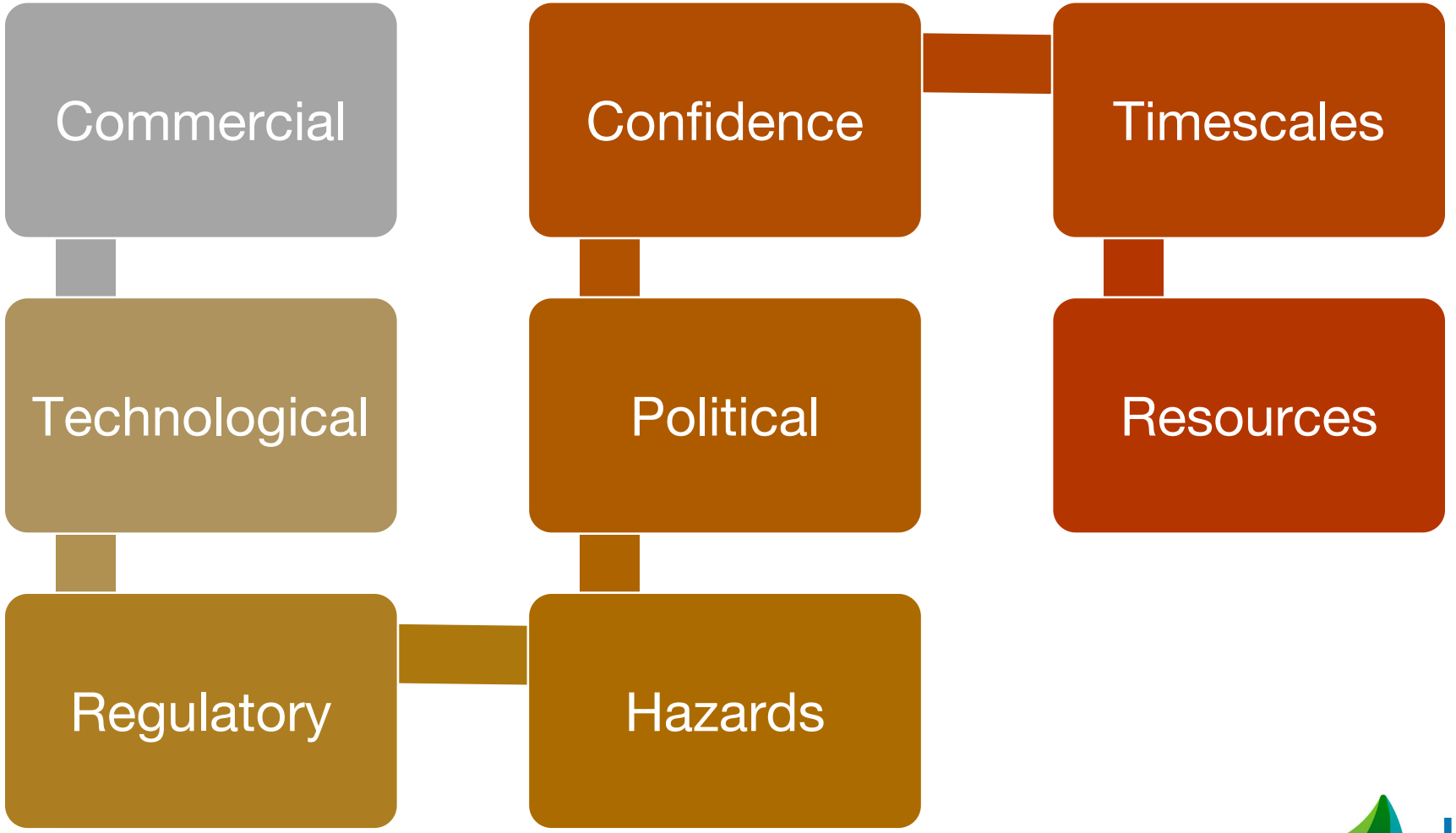
- Road vehicles – electric, hydrogen fuel cell, ammonia?
- Domestic – electrical, heat-pump, renewables & HVO, DME/LPG, hydrogen?
- Aviation – hydrogen
- Shipping – methanol, ammonia
- Industrial – all of the above?

Timeline for change

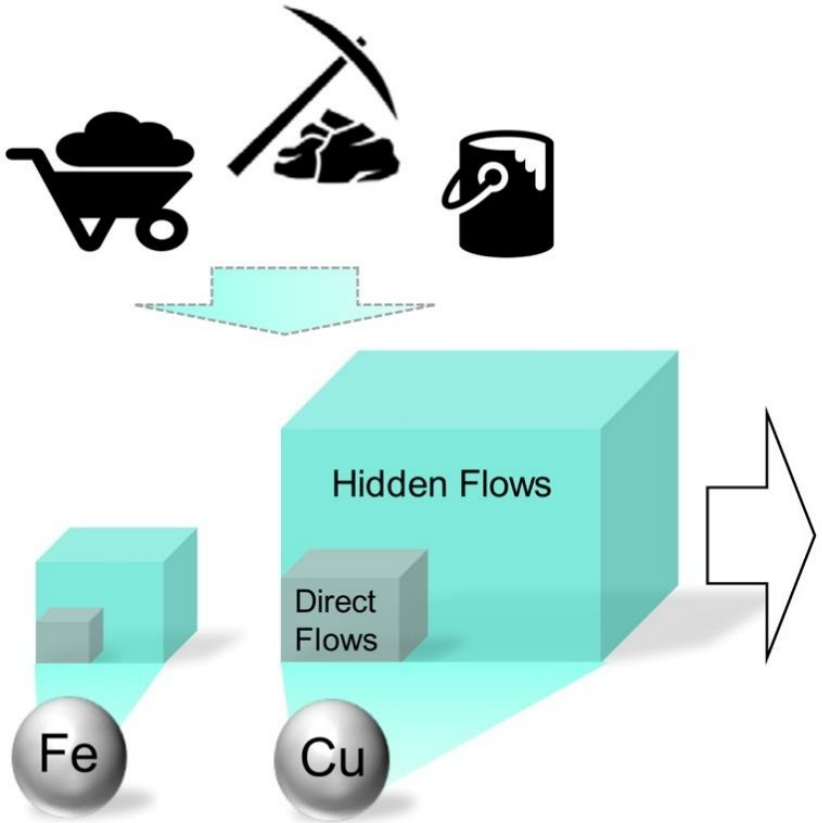
"All new road vehicles in the UK set to be zero emission within the next 2 decades"



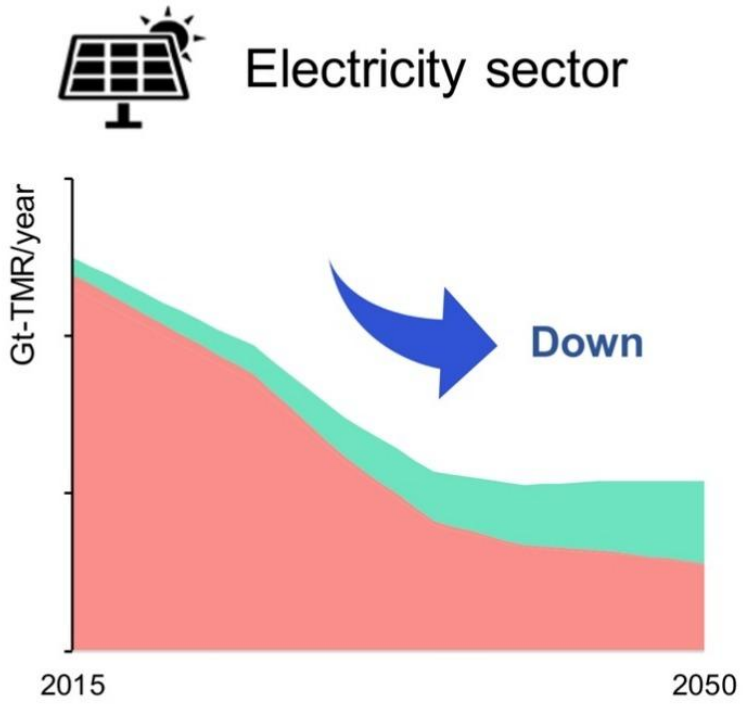
Barriers and risk

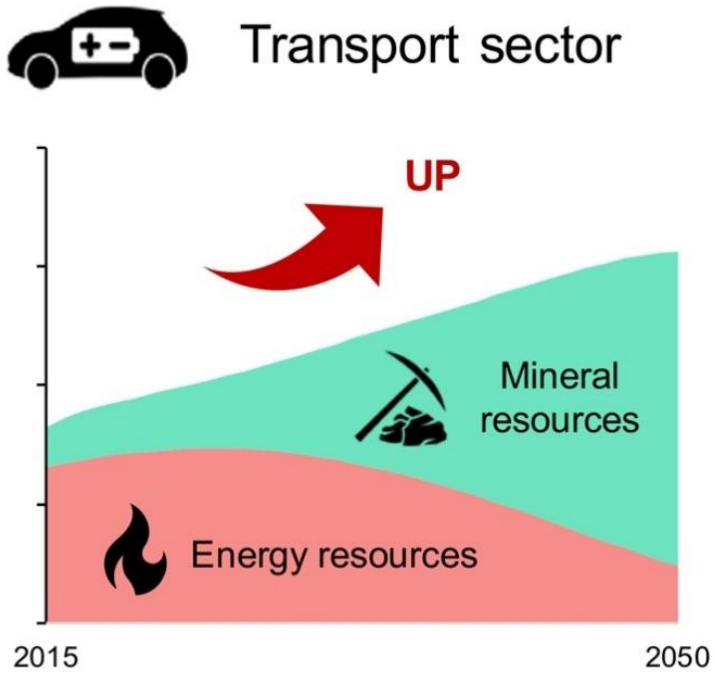


Resources and energy



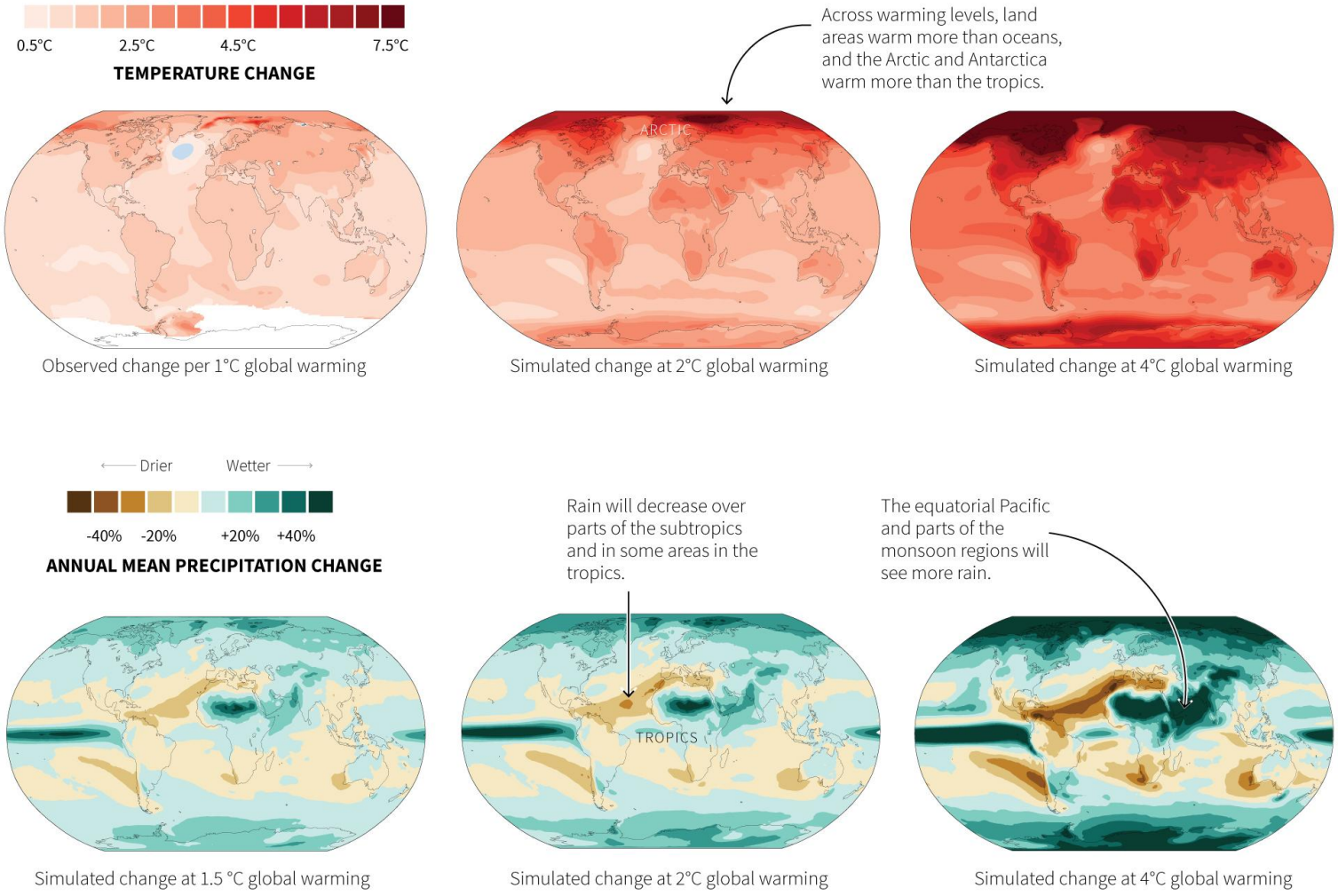
Total Material Requirement (TMR)





Global warming resulting in higher mean temperature and precipitation

Changes in annual mean surface temperatures and precipitation.



Source: UN Intergovernmental Panel on Climate Change (IPCC), Sixth Assessment Report.

M. Hernandez, 10/08/2021

REUTERS


CAZOO
CAZOO
CAZOO

Where are we now?

Current state of play

- Decarbonisation - Government has repeatedly stated its position as “technology neutral”
  - This is an acknowledged barrier to investment in decarbonization technologies
- Renewable Transport Fuel Obligation (RTFO)
  - Increased content of biofuels in retail fuels
  - HVO
- Increased uptake of electrical vehicles
- Hydrogen seen as a future fuel – especially for long distance and heavy industry

Hydrogen

- The current picture in Europe
  - Inadequate manufacturing of hydrogen gas
  - Little transport infrastructure
  - Minimal national storage

- 2050 Net Zero scenario (IEA) - demand potential is 528 million tonnes (10 billion € market)

- EU plan (post Ukraine war):
  - eliminate dependence on Russian gas
  - Diversification gas supplies - more LNG imports from Middle East, US etc
  - Increased levels of biomethane and hydrogen use

Hydrogen infrastructure in the UK

Oct 18, 2022 - 03:18 pm

Shell quietly pulls the plug on hydrogen in the UK

FCEV | HYDROGEN | HYDROGEN FILLING STATION | ITM POWER | MOTIVE | SHELL | UK

Shell has closed down all its hydrogen filling stations in the UK, saying the installed "prototype tech had reached its end of life". However, this is just a small part of the story since the oil and gas corporation now wants to refocus – on bigger vehicles.

Instead of waiting for the very few fuel cell cars to come and refill, Shell wants to explore opportunities to build "multi-modal hubs for heavy-duty trucks" in the UK.

In other words, the refuelling stations have not been profitable for the few hydrogen cars. According to operator Motive, the sites are too small to upgrade for larger vehicles and future technologies.

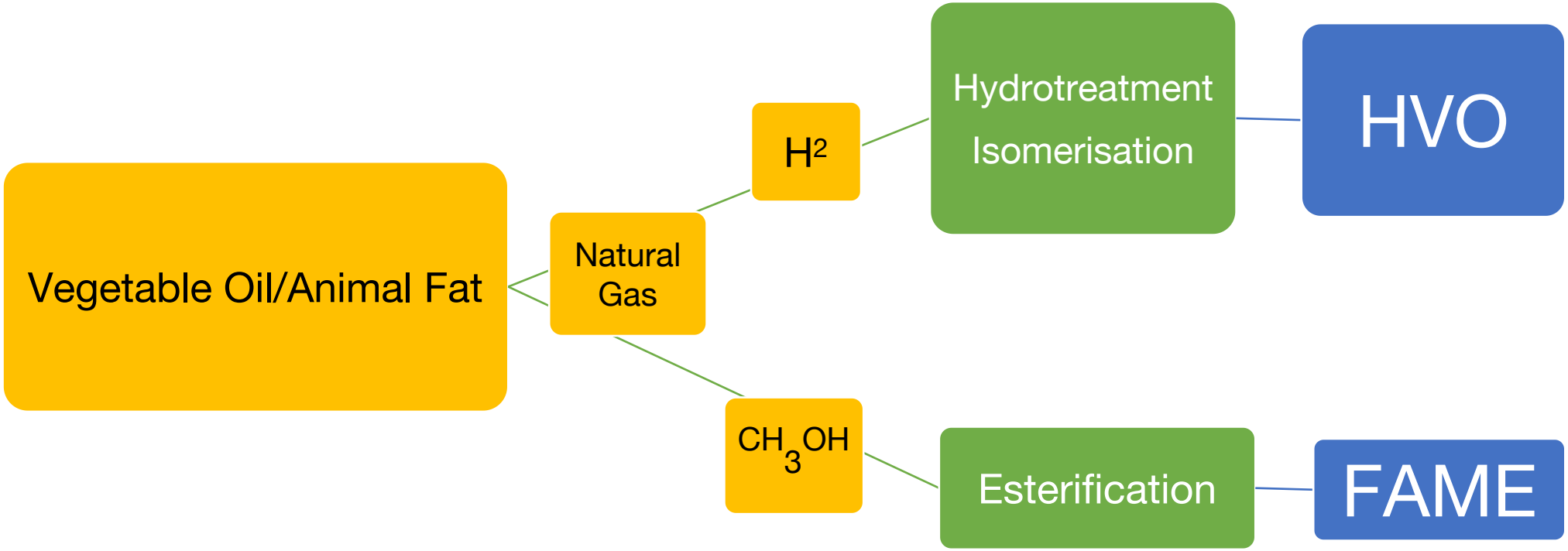
According to Hydrogen Insight, only eleven public H2 refuelling stations now remain open in the UK compared to more than 57,000 public charging points for electric vehicles.

Shell had H2 facilities at Gatwick Airport, Cobham and Beaconsfield under operator, Motive, owned by UK electrolyser maker ITM Power.

The corporation had received funding through the European Fuel Cell Hydrogen Joint Undertaking (now known as the Clean Hydrogen Partnership) and the UK Office of Low Emission Vehicles (now called the Office for Zero Emission Vehicles) for all three stations.

Motive, who also closed the fourth station in Swindon earlier this year, said it had invested over £2m (£2.23m) per year to "sustain its small stations but has decided that it is not sustainable to continue to make this investment".

Biofuels – the “immediate” option



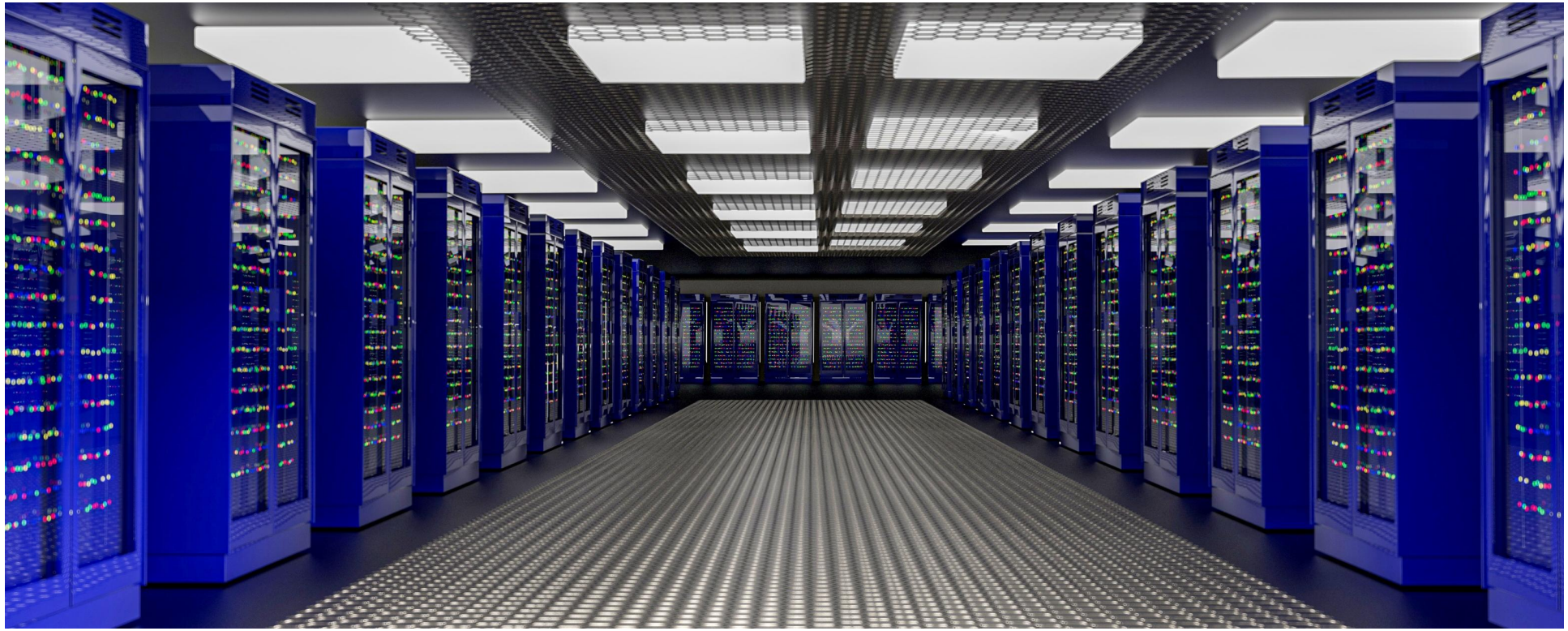
HVO vs Biodiesel

	HVO	Biodiesel
Composition	Pure hydrocarbons. Chemically identical to equivalent compounds refined from fossil fuels.	Fatty acid esters – chemically different to hydrocarbons. Contains oxygen on the molecule which explains issues re water retention, biological action and clouding etc
Feedstocks	More data needed. Likely to be constraints. Options include used vegetable oils or even wood	Typically used vegetable oils
Attractive to water	No	Yes
Risk of biological activity in storage	No	Yes
Affects oil/water separators	No	Yes

Biodiesel – FAME fuel

Data Centre Application for HVO

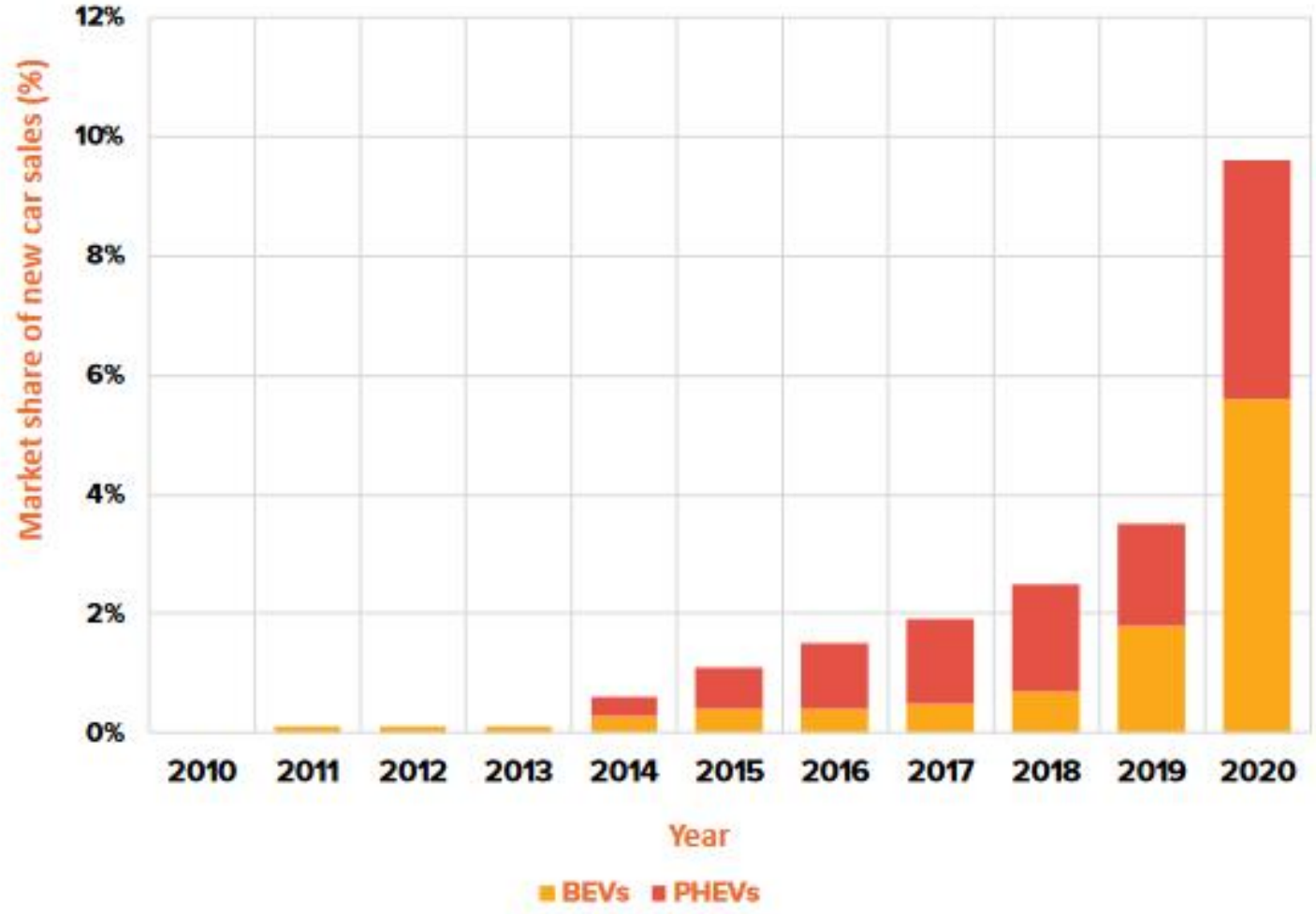
Fuel uplift and replacement – bank data centre



Battery electric vehicles

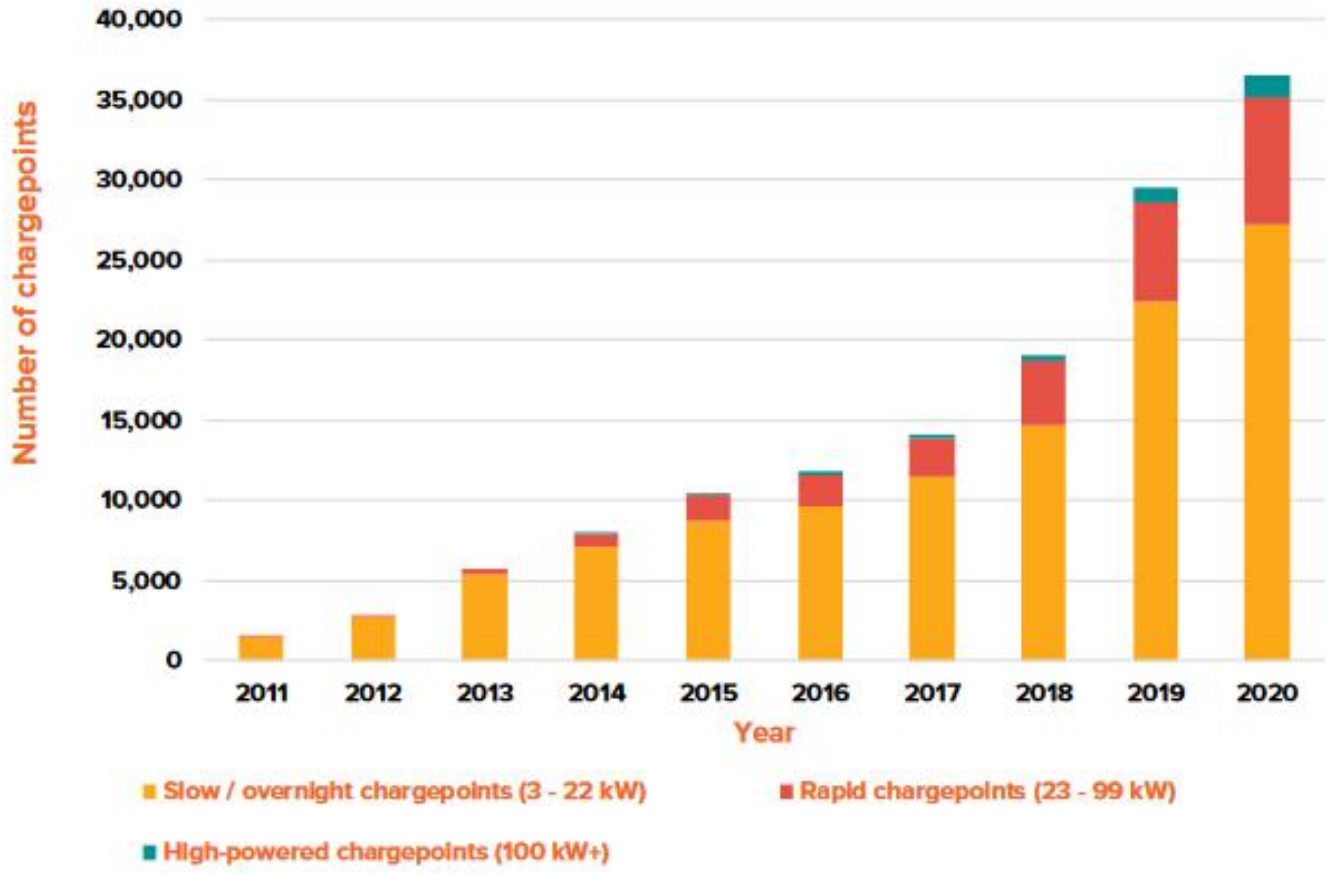
- The UK needs to install public charge points five times faster than the current rate
- By 2030, CPOs will need to invest between £5bn and £10bn in EV charge points and associated grid connection upgrades. This will require significant investment (source: Charging Up. The Policy Exchange)
- The recycling infrastructure needs to be put into place

Numbers of electric vehicles sold in UK



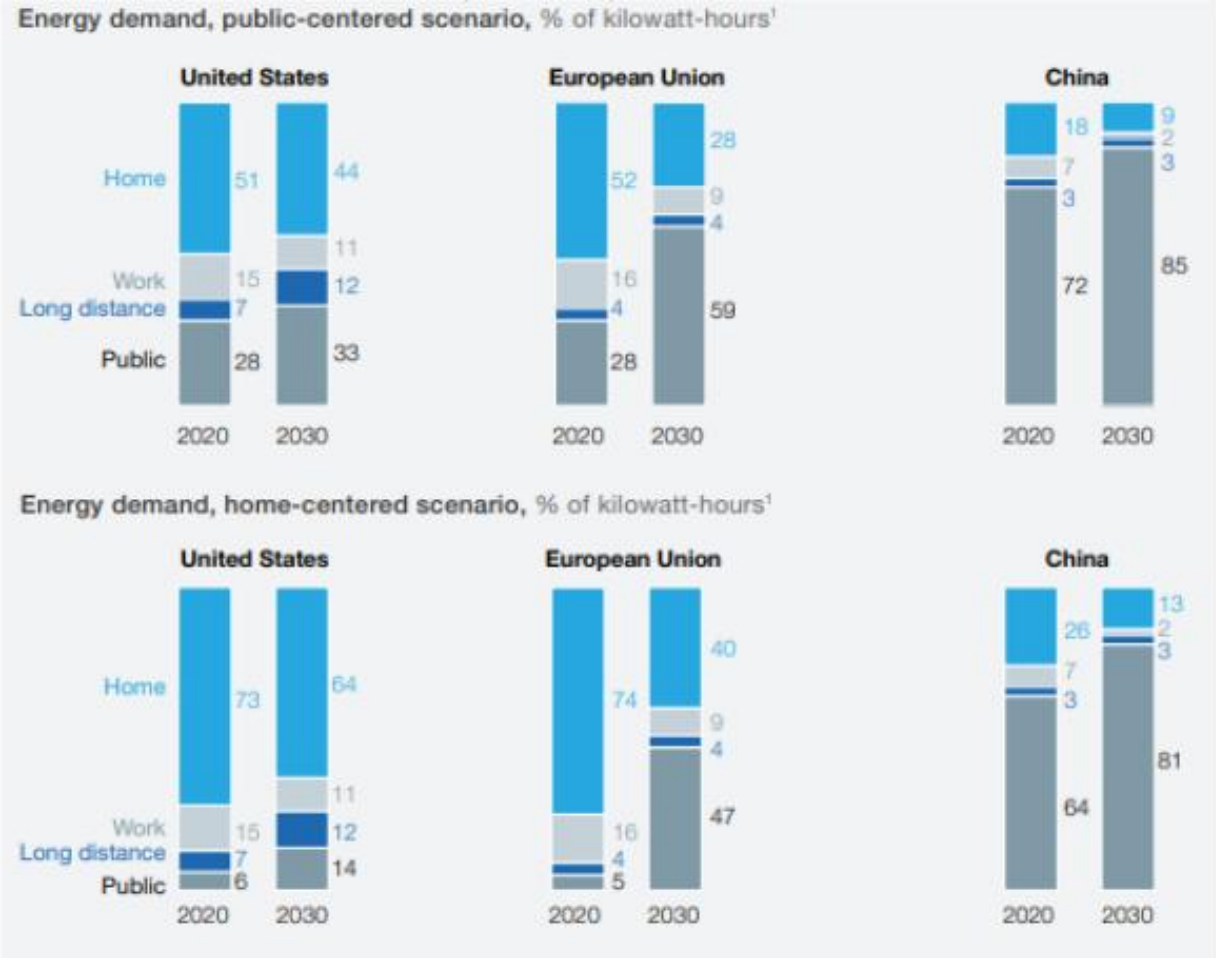
Source: Policy Exchange

Number of UK vehicle public charging points



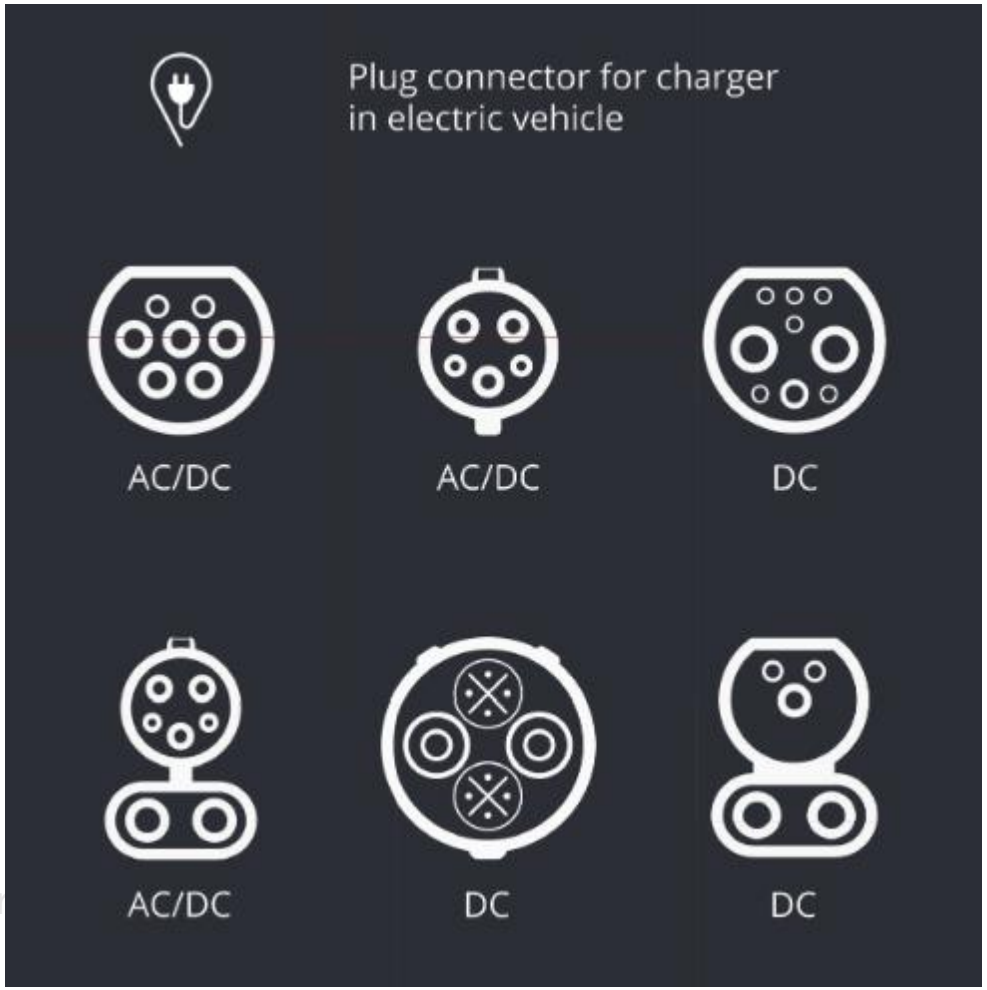
Source: Policy Exchange

Where energy is used for charging



Source: McKinsey and Company

Standardisation?



Source: The Institution of Engineer

Electrical charging infrastructure issues

Future fuel risks

Value-jet Flight 592

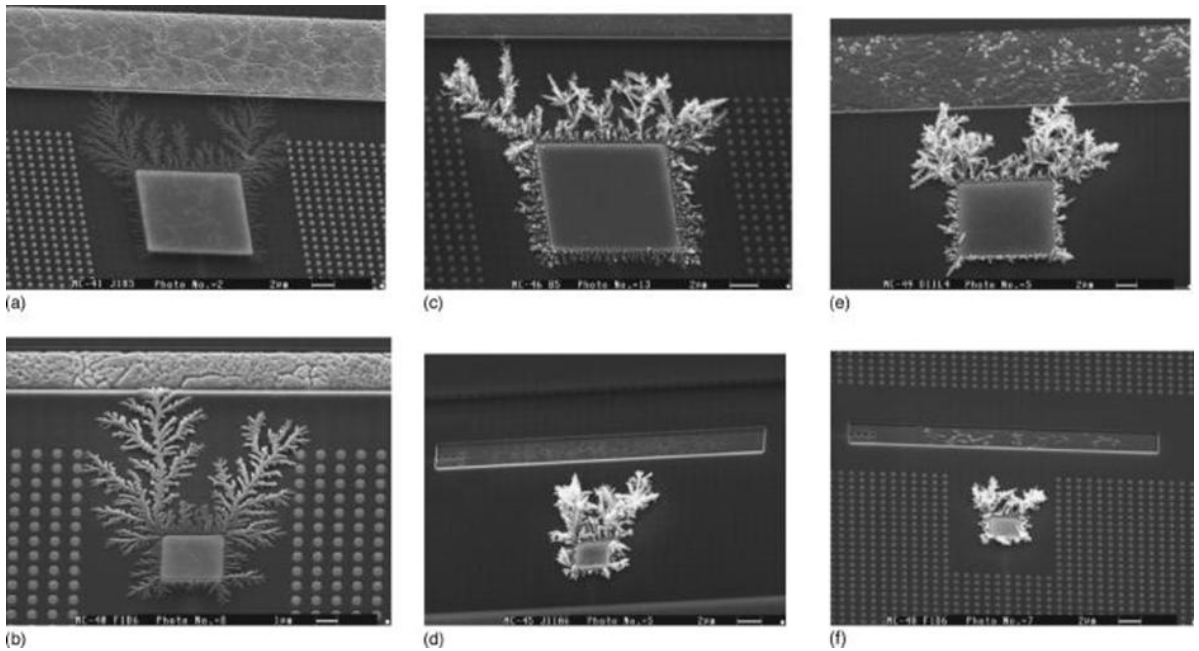
UPS B747-400F - 3 Sept 2010,Dubai to Cologne

Why batteries fail

- LiBatt are energy dense and lightweight
- Heat and mechanical damage
  - Ergo thin partitions between cells and a thin outer covering
  - Partitions and coatings are fragile, so they can be punctured.
  - If the battery is damaged, a short circuit can occur. This spark can ignite the lithium.
- Overcharging

Overcharging

- Rapid charging of lithium batteries can causes the growth of small lithium metal fibres, called dentrites, on the carbon anodes.
- These cause short circuits, causing the battery to rapidly overheat and catch fire
- Poor quality chargers are often the cause

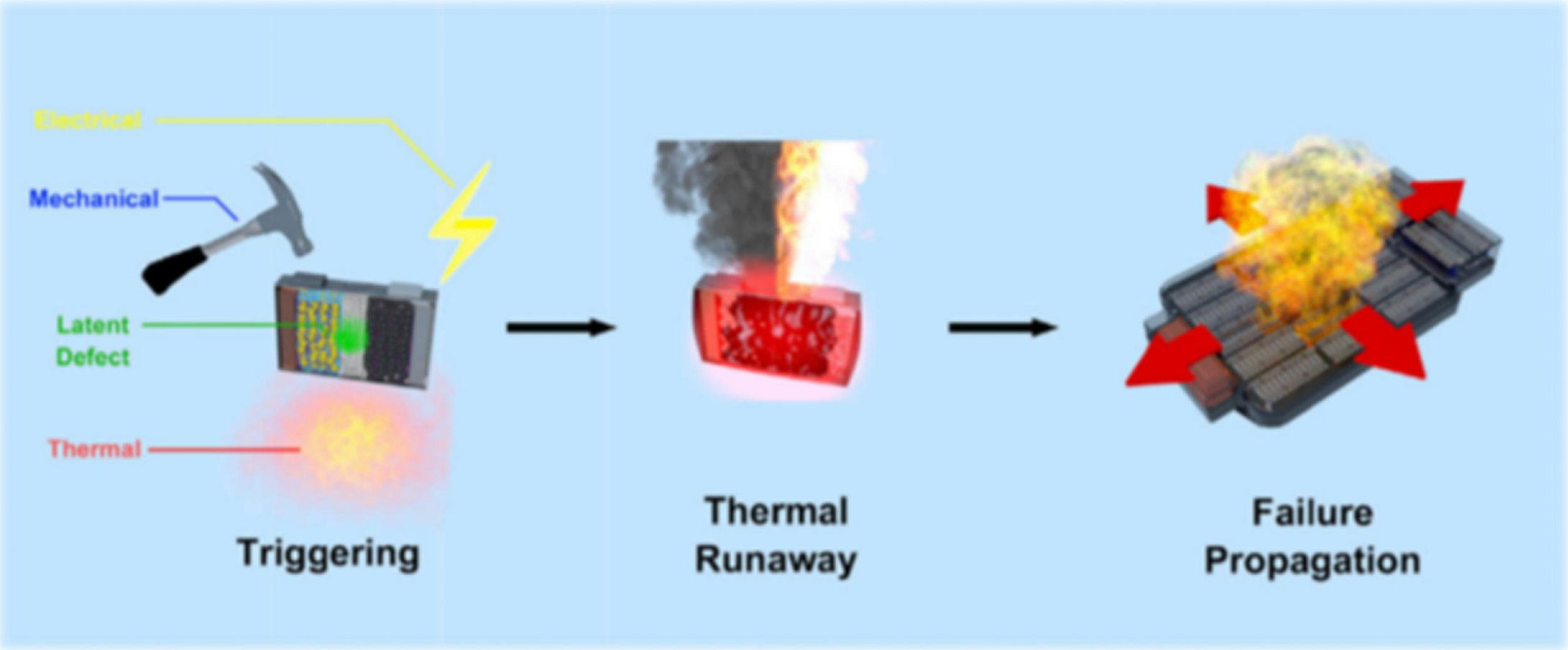


In situ NMR Observation of the Formation of Metallic Lithium Microstructures in Lithium Batteries, R. Bhattacharyya, B. Key, H. Chen, A.S. Best, A.F. Hollenkamp, and C.P. Grey, Nature Materials, 9, 504-510 (2010)

Heat damage

- External heat
- Self-reaction causing thermal runaway
- Ignites plastic components
- Exposes the cell contents

Mechanical damage

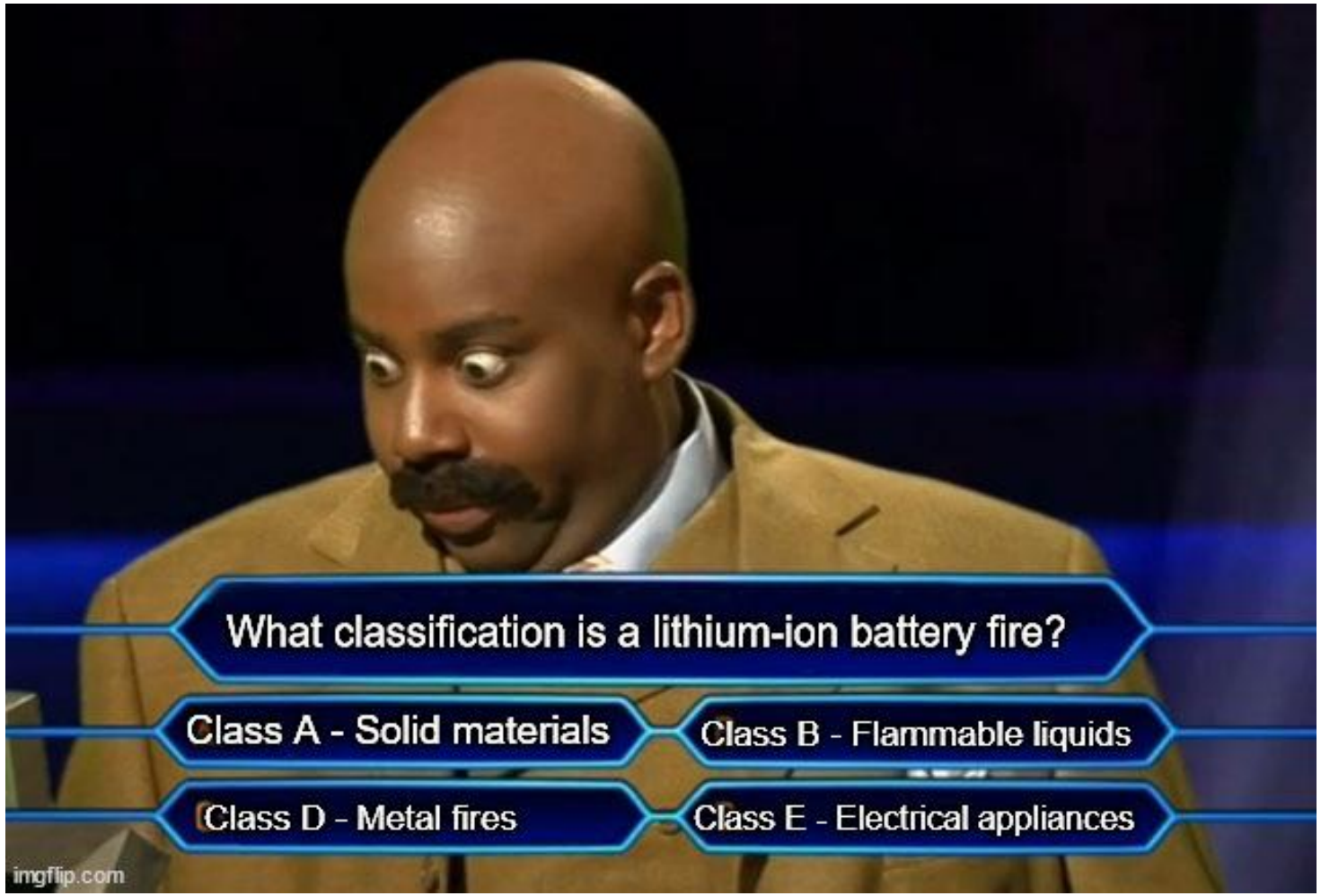


Source - Feng, Xuning, et al. "Mitigating thermal runaway of lithium-ion batteries." Joule 4.4 (2020): 743-770.

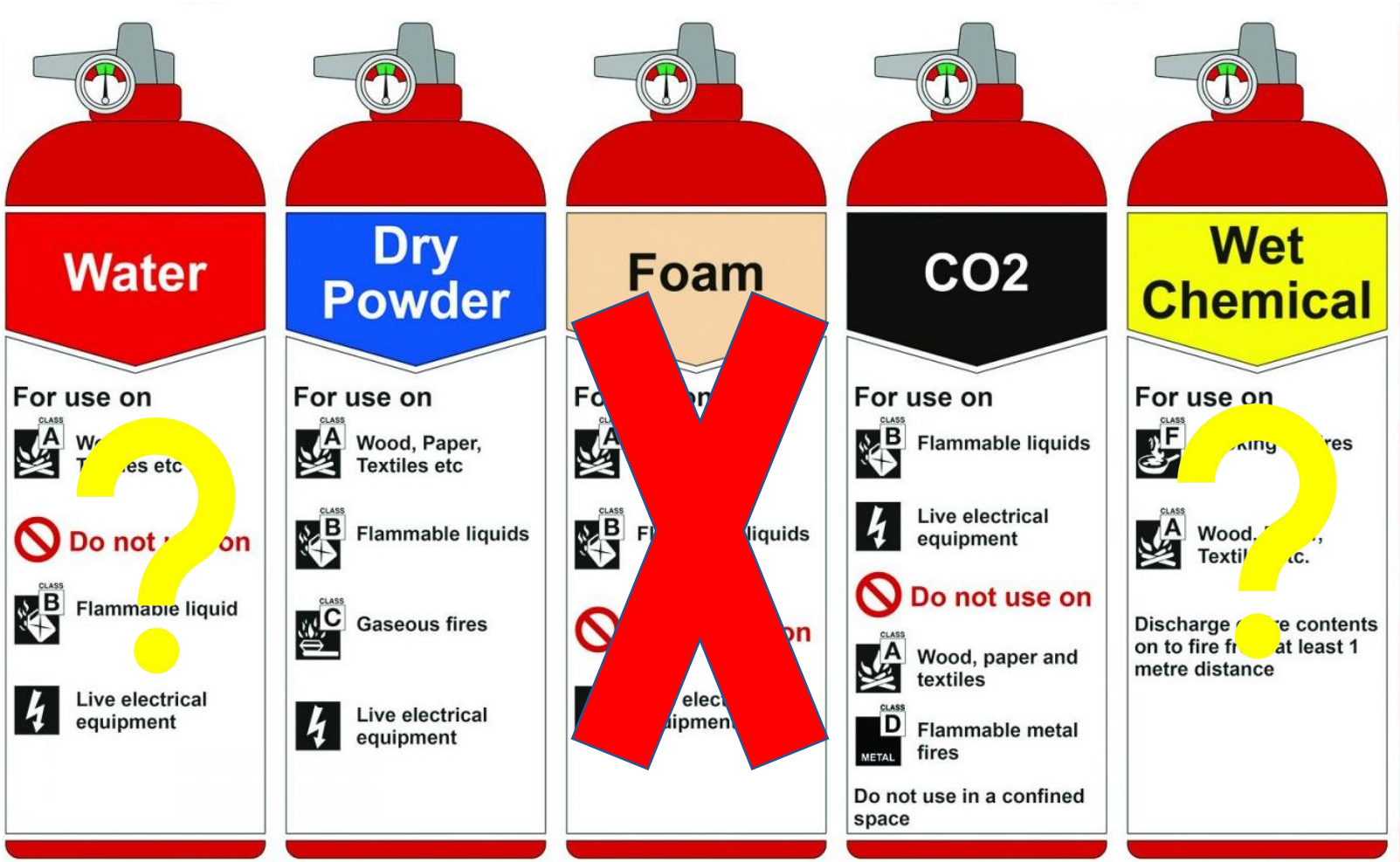
Lithium battery fires

(source: Sky News)

Extinguishing a lithium-ion battery fire



Suitable fire extinguishers



Example chemical extinguishers

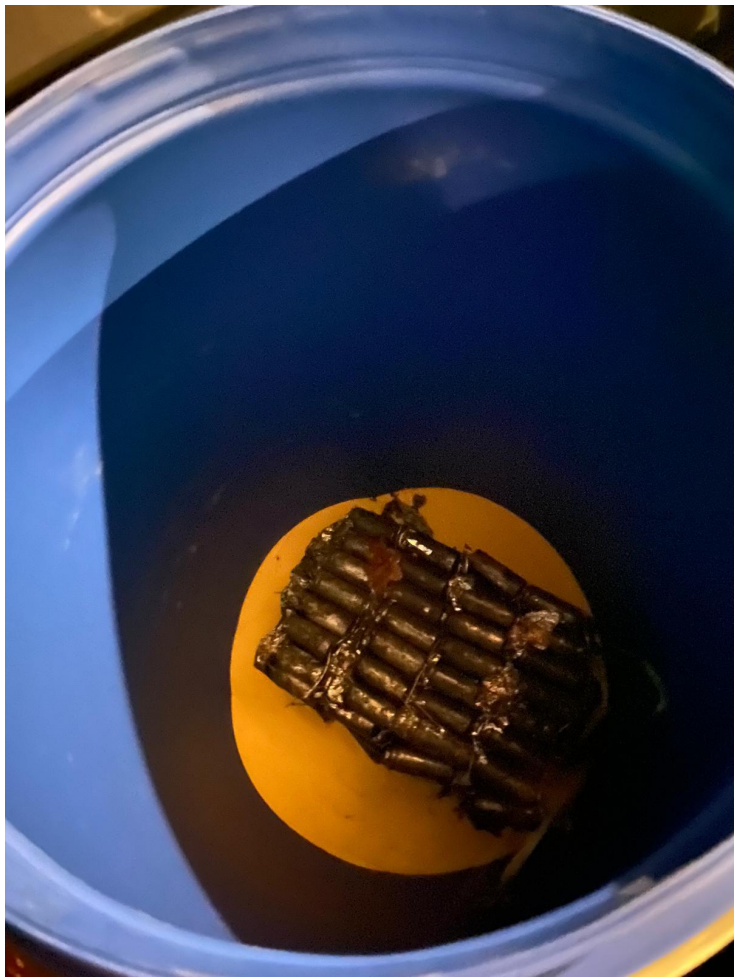
- Water-vermiculite
  ammoniu
  sulfa

Water –

Other fire suppression examples

- Bags

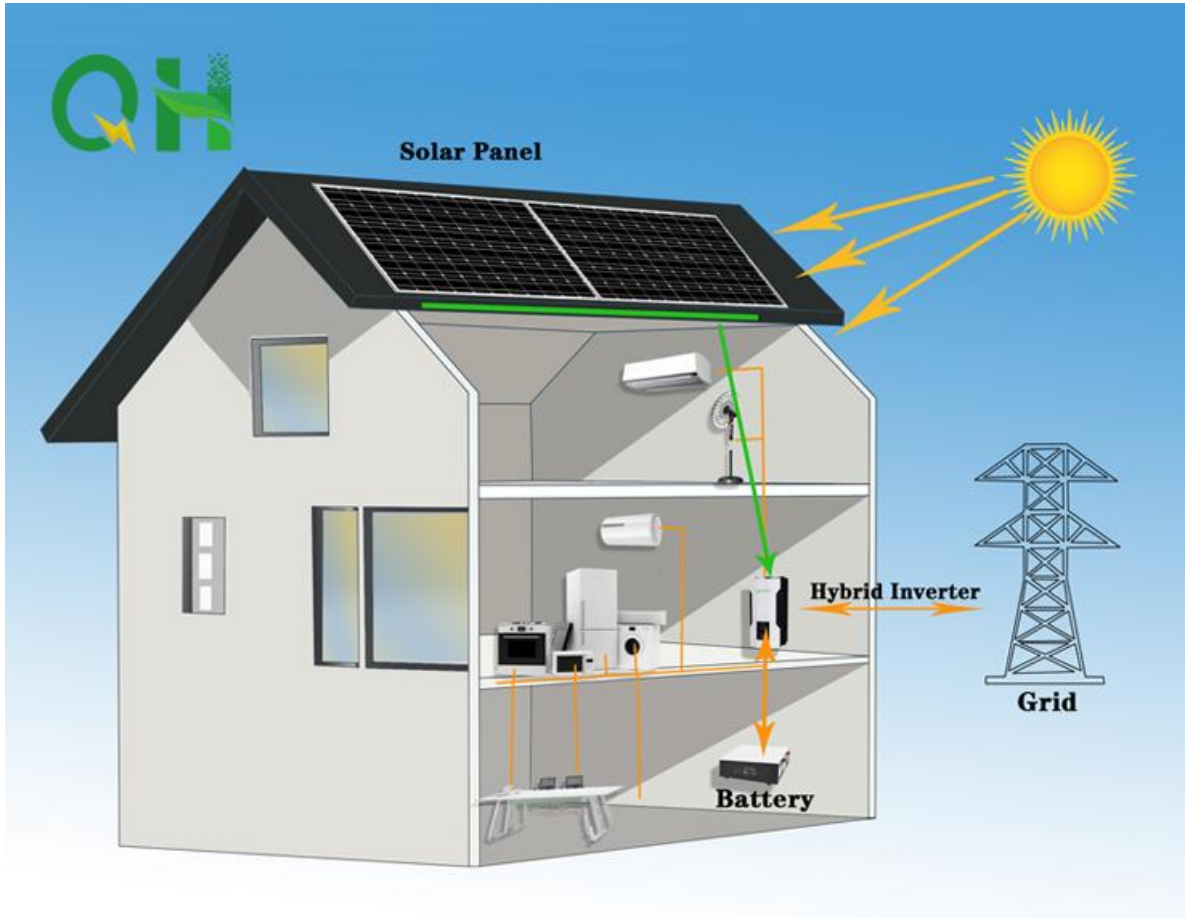
Recovering damaged batteries



Electric vehicle risks and issues

- Second-hand battery assemblies
- DIY “maintenance”
- Lack of specialist service agents
- Different methods of HV isolation even within the same product range
- Is the recycling infra-structure fit-for-purpose?

Domestic storage



An auction website listing

Check the item description to confirm this fits your vehicle

2021 9.4kwh - 48v Battery Hyundai Kona Batteries Lithium Solar li-ion 180ah+

2 watched in the last 24 hours

Condition: Used

Price: **£1,200.00**

From £56.60 per month for 24 months

Buy it now

Add to basket

Best Offer:

Make offer

Watch this item

Returns accepted

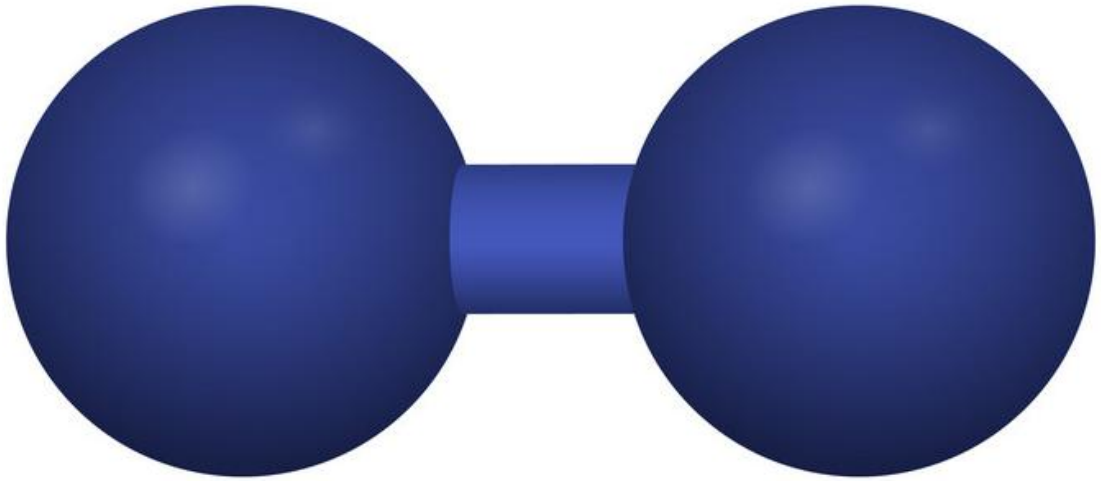
Recent incident in the West Midlands

Grid Storage

Emergency planning

- Li Battery Storage – not subject to COMAH
- Statutory duty to inform the fire service
- Consider:
  - fire detection and suppression systems
  - The risks of fire contagion
  - Wind direction
  - Fire-water run-off pathways and receptors

HYDROGEN



Hydrogen properties

- Hydrogen has the second lowest boiling point and melting points of all substances, second only to helium.
- Boiling point of 20 K (–253 °C; –423 °F;) melting point of 14 K(–259 °C, –434 °F) at atmospheric pressure
- Hydrogen's boiling point can only be increased to a maximum of -240 °C at 13 barg pressure
- Explosive limits in air of 4-75% (very wide range!!)
- The molecules of hydrogen gas are smaller – so can diffuse through many materials considered airtight or impermeable to other gases
- Therefore hydrogen more difficult to contain than other gases

Advantages and disadvantages

Advantages

- Low-to-zero emissions (potentially)
- Hydrogen is abundant element
- Reliability
- Energy flexibility
- Energy security
- Durability
- Scalability
- Quiet in operation

Disadvantage

- Whole new infrastructure needed
- Expense
- Cannot easily be compressed as gas
- Flammability
- High permeability of the gas

Colours of hydrogen

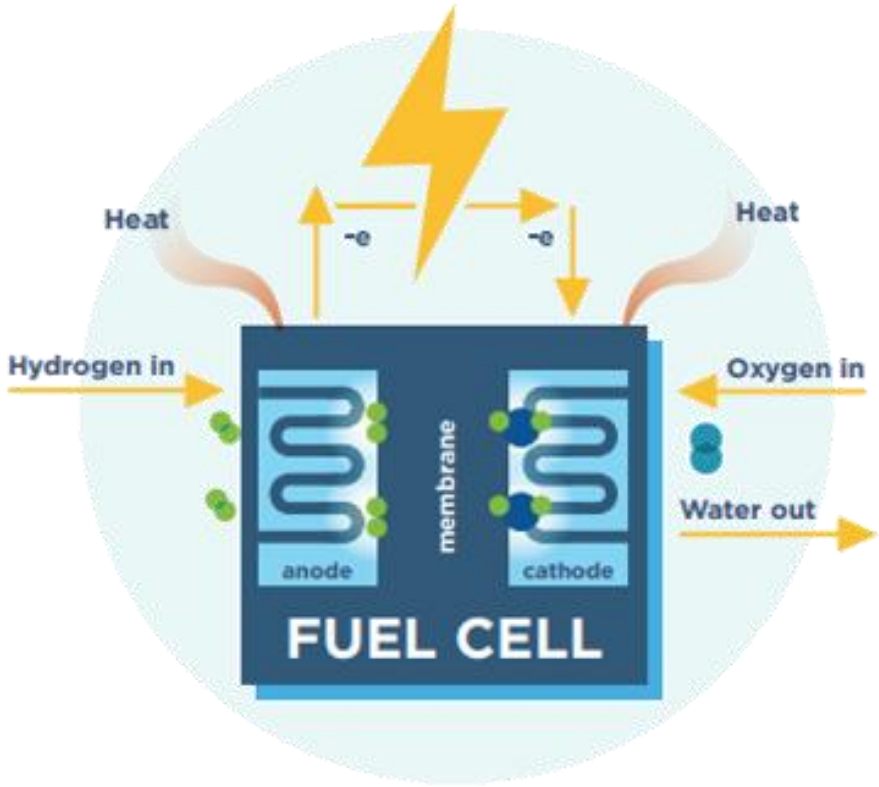
Colour	Production method	Emissions
Green	Renewable energy	Zero emissions
Blue	Natural gas with carbon capture and storage	Low emissions
Grey	Natural gas without carbon capture and storage	Medium emissions
Brown	Coal	High emissions

Transportation – Fuel Cell Electric Vehicle

- Performs like a ICE vehicle
- No internal moving parts
- Fuel tank filled in minutes
- Tail pipe emissions water vapour only
- Range of traveling 300-400 miles
- Honda, Hyundai, and Toyota - leased and sold >6,500 FCEVs in California to date

How fuel cells work

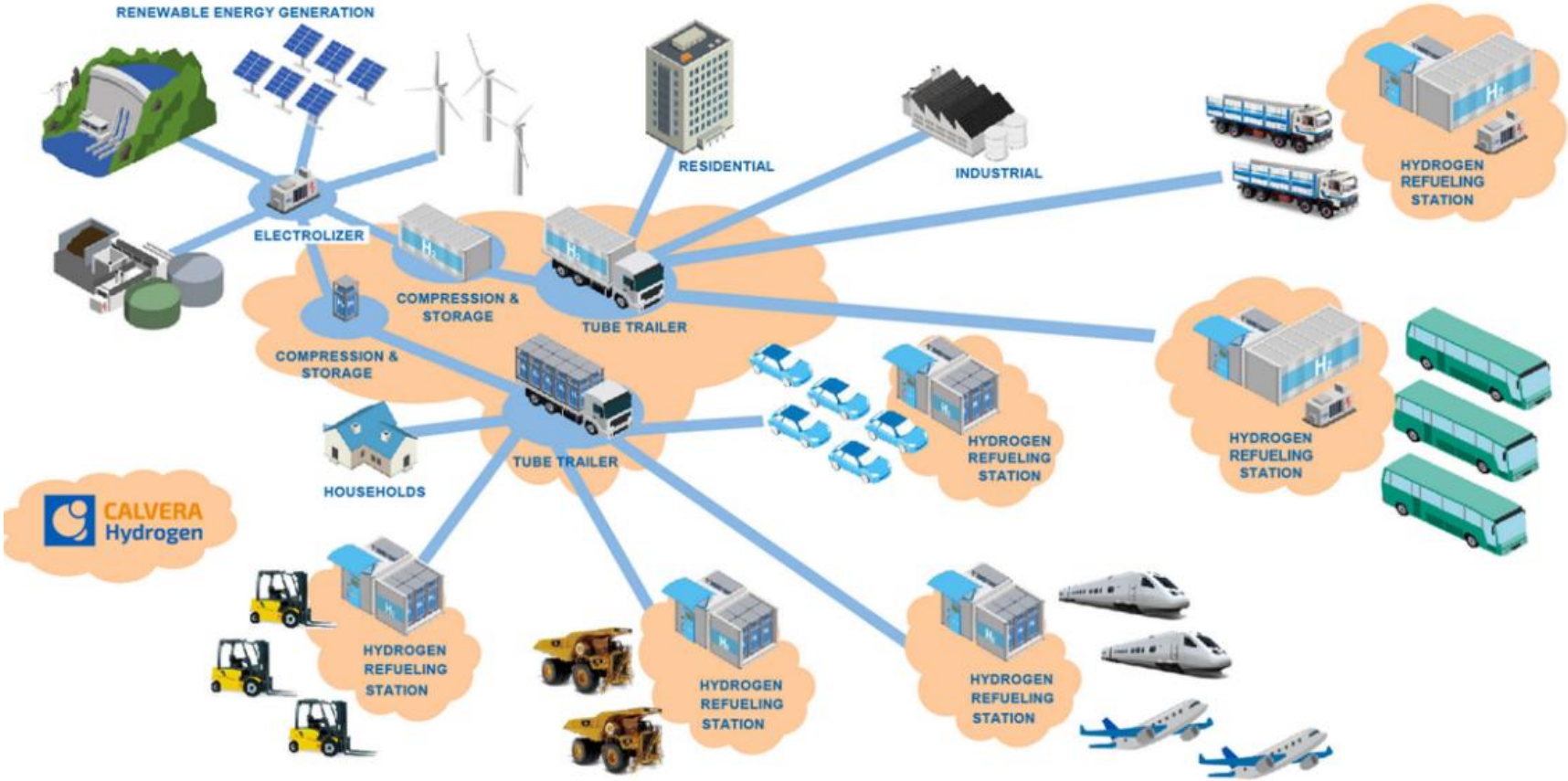
1. The hydrogen atoms enter at the anode.
2. The atoms are stripped of their electrons in the anode.
3. The positively charged protons pass through the membrane to the cathode and the negatively charged electrons are forced through a circuit, generating electricity.
4. After passing through the circuit, the electrons combine with the protons and oxygen from the air to generate the fuel cell's byproducts: water and heat.



Source: Fuel Cell & Hydrogen Energy Association

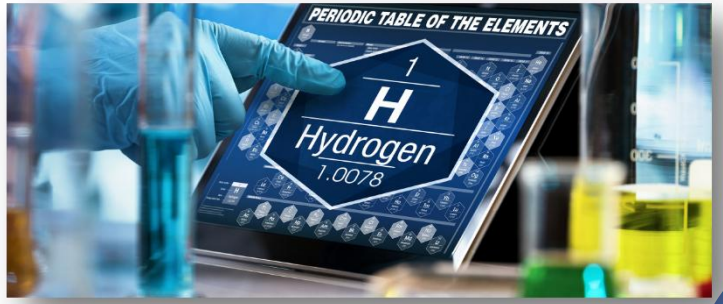
Infrastructure required

- Source: Calvera

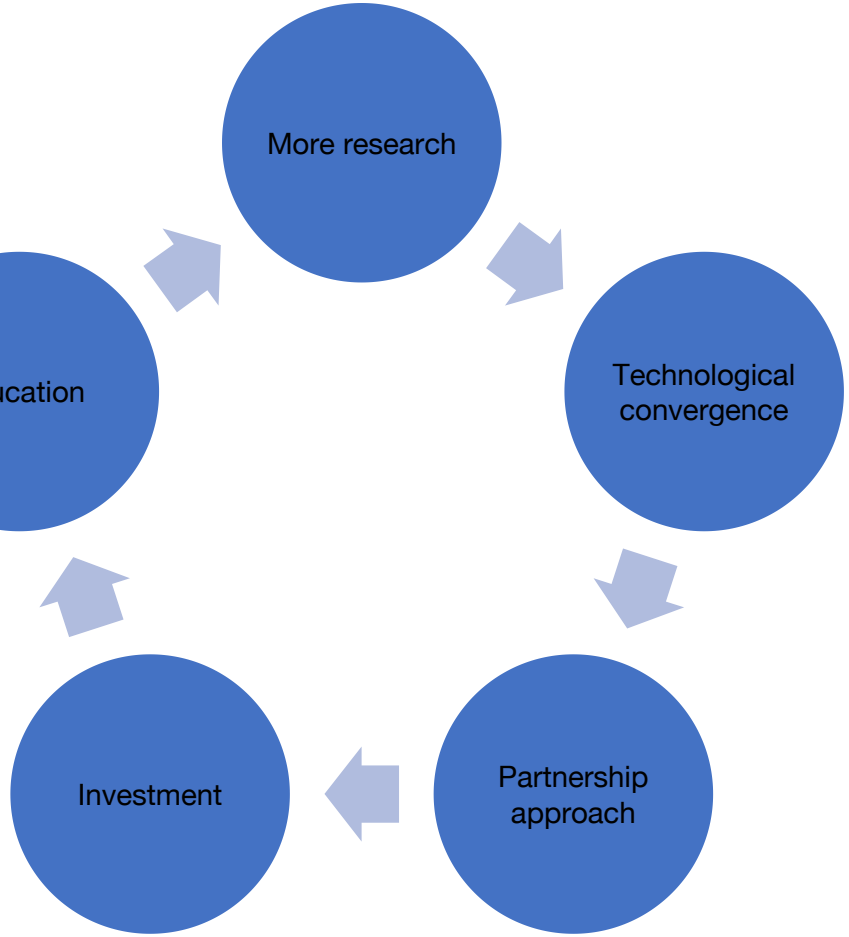


Hydrogen refuelling storage

The future for hydrogen?



Picture: Getty Images



BIG H2IT
Building Innovative Green Hydrogen Systems in Isolated Territories

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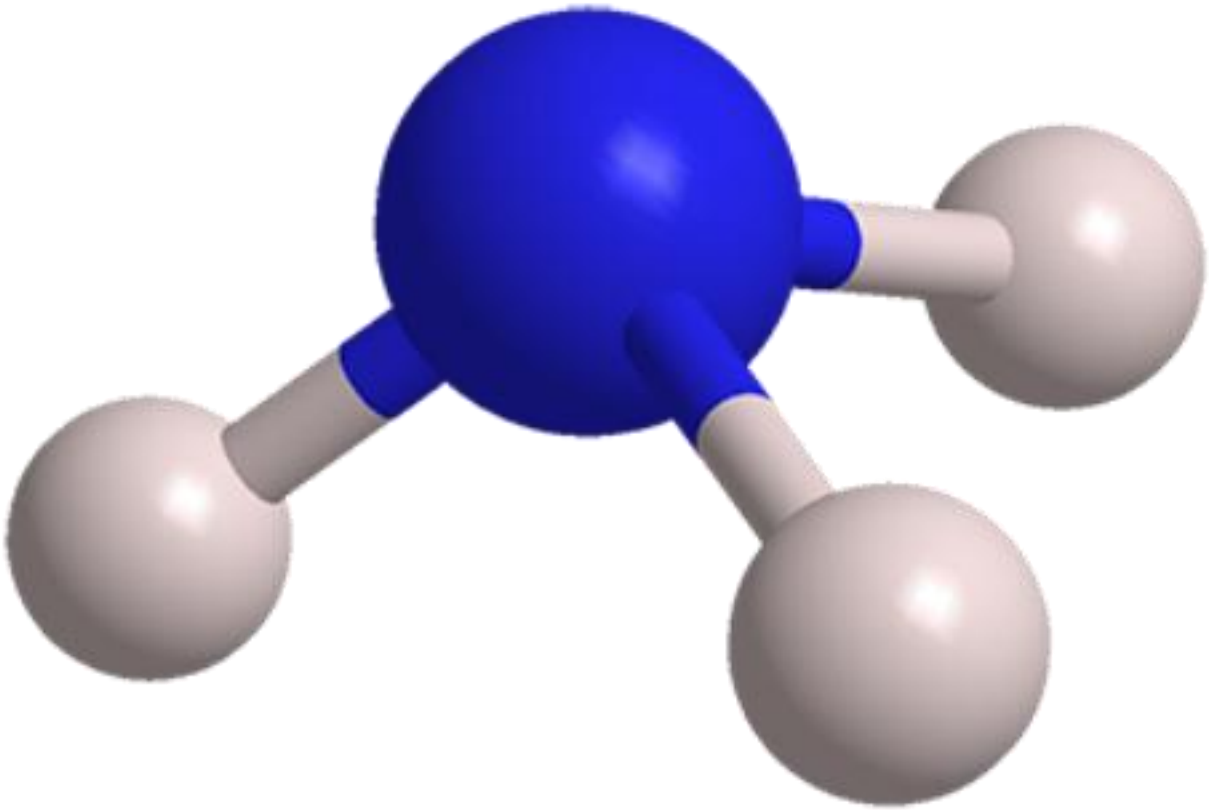
AMMONIA



Ammonia

- Already commonly used in refrigeration
- Means of transporting hydrogen
- Flammable as well as toxic by inhalation and corrosive

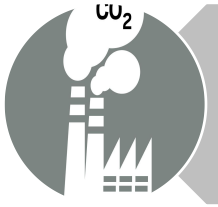
A NASA-Backed Study Will Test Ammonia as a Carbon-Free Alternative to Jet Fuel

The research team will work with a modified Boeing 737 aircraft to test new ammonia-fueled jet engines.

By DANA GIVENS

John Keeble / GettyImages

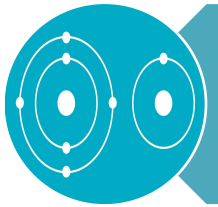
Types of ammonia



Grey

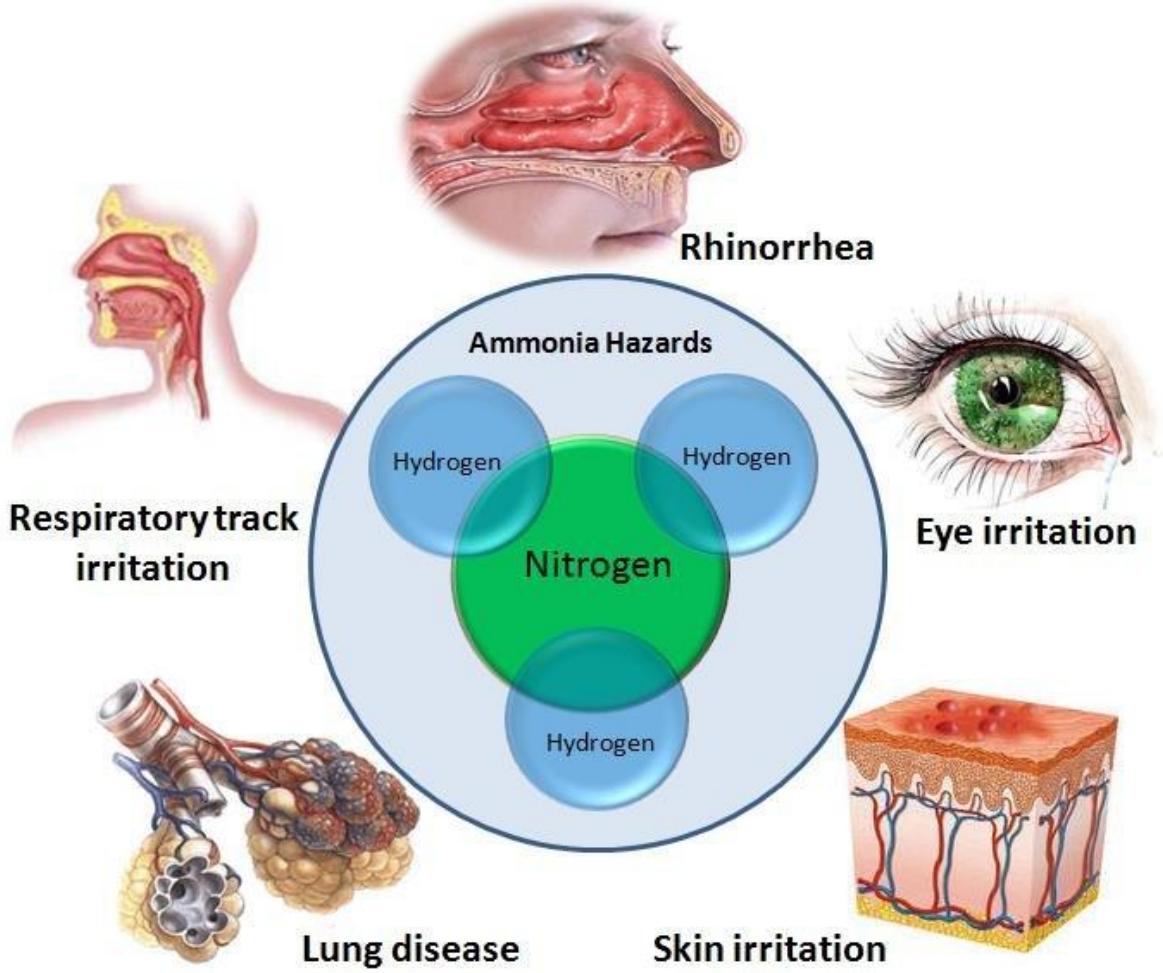
Blue

Green



Turquoise

Ammonia exposure



Source: Punithavathi Thirunavakkara

Case study – Carlsberg brewery

One dead after ammonia leak at Northampton brewery

Man in his 40s dead and more than 20 people remain in hospital, one in serious condition, after gas leak at Carlsberg factory site

The Carlsberg brewery in Northampton where an industrial accident caused an ammonia leak. Photograph: Google Maps

A man has died and another is in a serious condition after a gas leak at a Carlsberg factory, the brewer said.

Emergency services were called to the brewery in Northampton town centre at 12.30pm following reports of an industrial accident. Northamptonshire police said the victim was in his 40s.

"Other staff from Carlsberg and emergency service personnel remain at the hospital receiving treatment. Northamptonshire police are working with the health and safety executive to investigate the incident," a police statement said.

Twenty two people - including 11 staff, two police officers and nine firefighters were taken to hospital.

Carlsberg fined £3m following 2016 ammonia gas leak

28th June 2022

Share

Carlsberg has been fined £3 million after a contractor died and another was seriously injured following an ammonia gas leak at one of its breweries.

The incident happened at Carlsberg's site in Northampton. An investigation by the Health and Safety Executive (HSE) found Carlsberg hadn't put proper controls in place.

Father-of-two David Chandler, 45, was killed and David Beak, now 57, was seriously injured.

David Chandler was a father of two, from Bridge North, Shropshire. His family today said they welcomed the end of the case against Carlsberg and hoped no other families would have to suffer as they have.

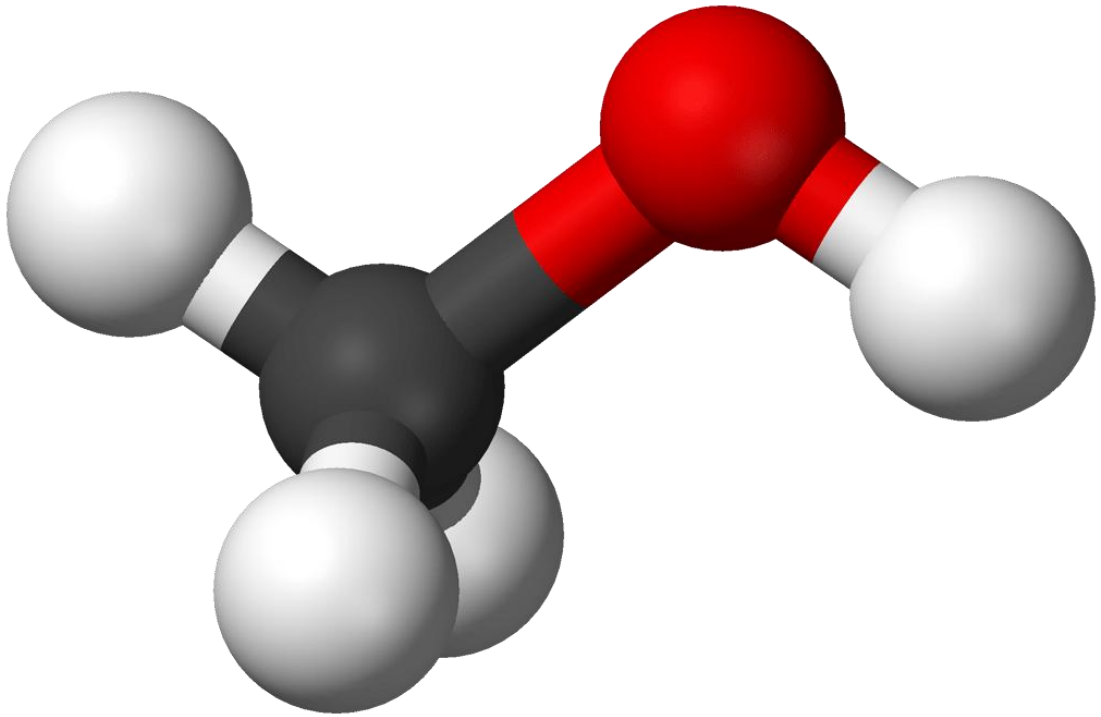
Birmingham Crown Court heard that at its Northampton brewery Carlsberg had failed to put in place appropriate isolation controls to prevent exposure to ammonia before work started to remove a compressor from a refrigeration system.

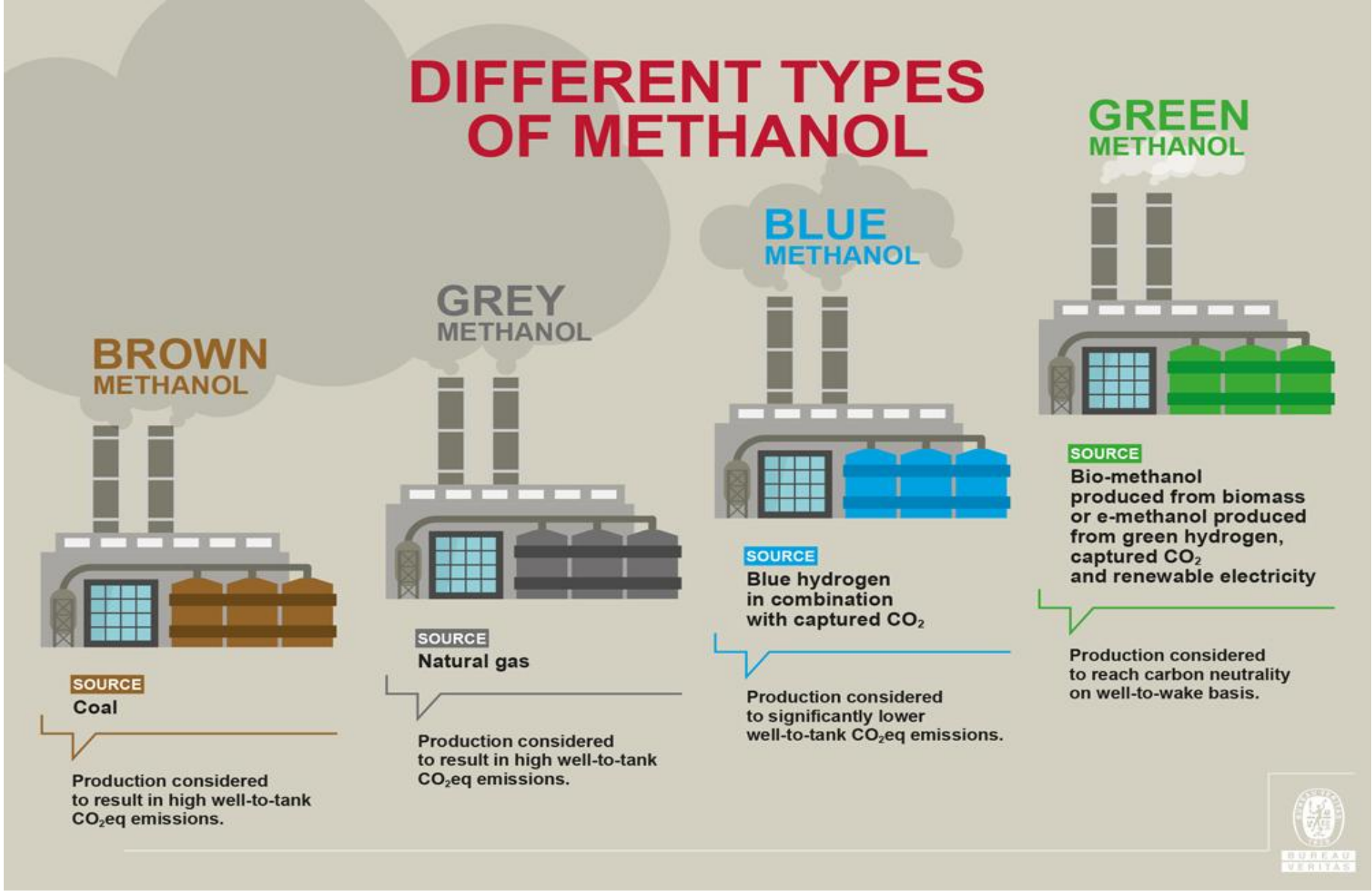
The Principal Contractor for the project was Crowley Carbon UK Ltd, which had appointed numerous contractors to assist in the works.

On 9 November 2016 while the compressor was being removed, there was a large, uncontrolled release of ammonia.

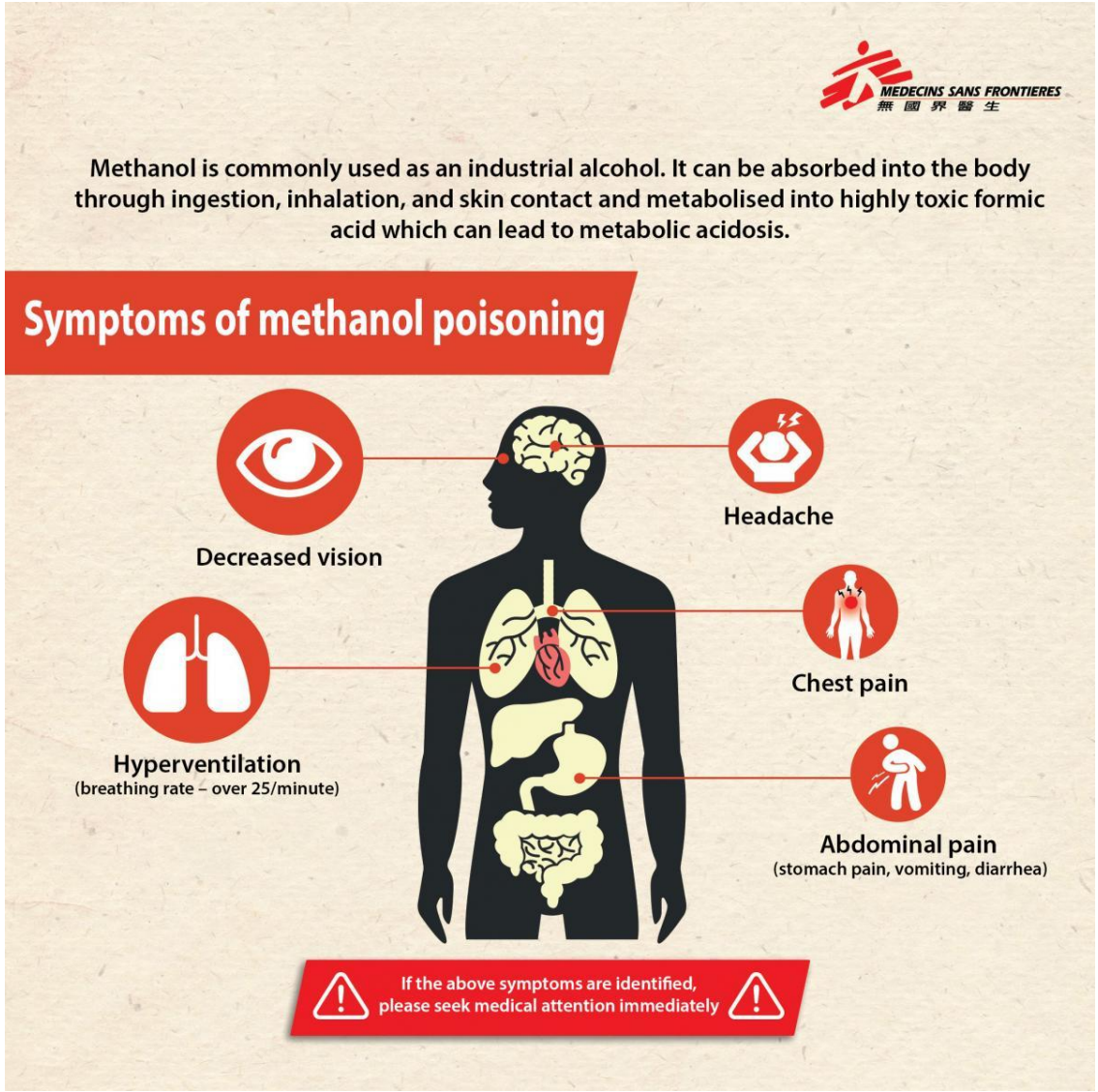
David Chandler and David Beak were both employees of sub-contractor Speedrite NE Ltd.

METHANOL





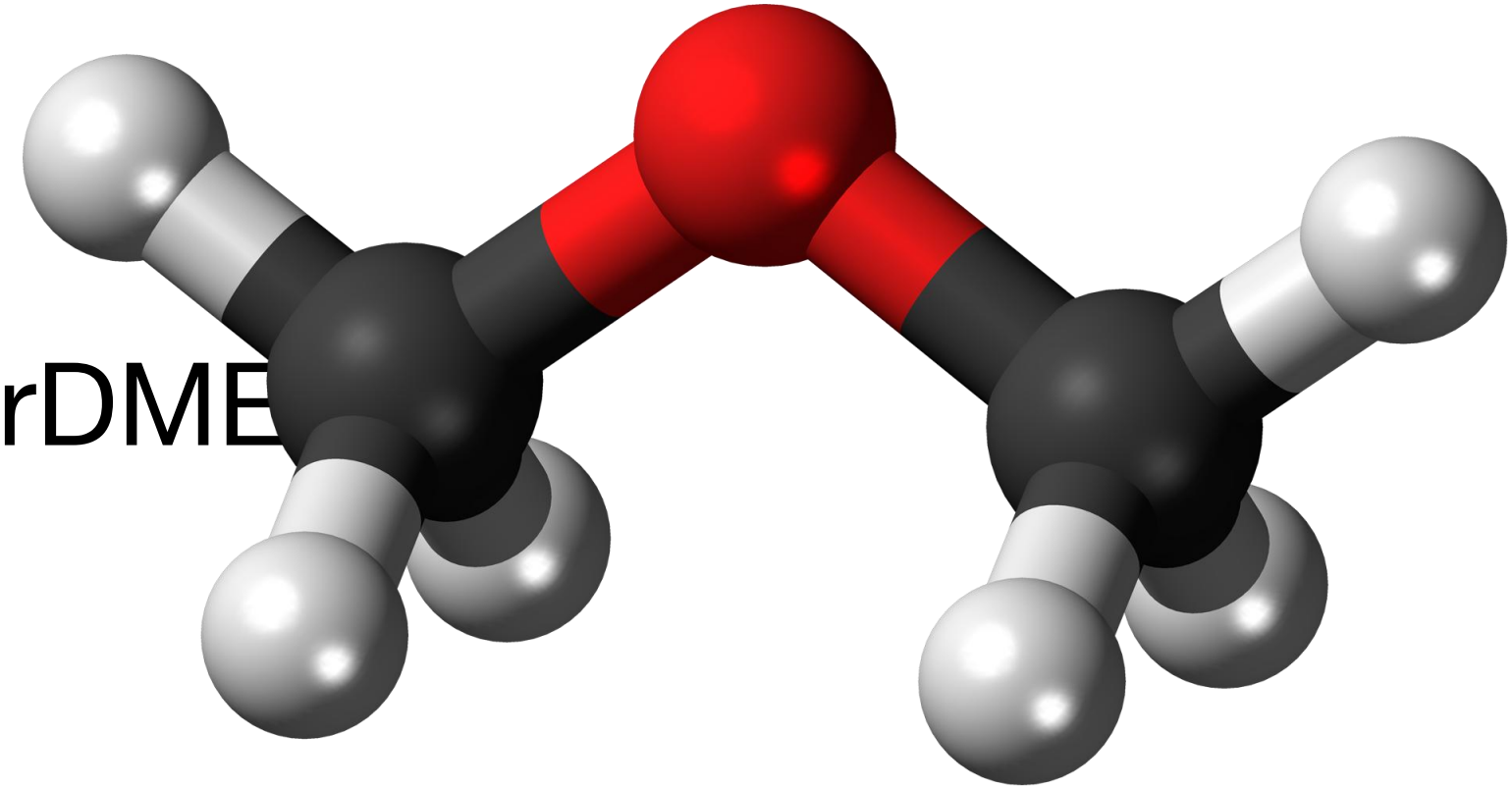
Methanol



Issues and risks associated with methanol

- Immediate - toxicity
- Cost – running and capital of using blue or green methanol
- Currently in limited availability
- Lower energy density than HFO
- More volume required to be stored onboard
- Still a carbon containing molecule!

BIO-LPG AND rDME



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DME potential

- It burns cleaner than many hydrocarbons
- Does not form explosive peroxides, unlike some other ethers
- High cetane number
- Similar vapour pressure to LPG
- Can use in existing infrastructure
- A number of other industrial applications
-

(picture: Oberon Fuels)

Ambition

- 100% renewable LPG alternatives by 2040 (source: Liquid Gas UK) – using Bio LPG and rDME

Observations

- The UK energy infrastructure is changing… but not fast enough
- The technologies mainly already exist BUT
  - More standardisation and consensus on certain technologies needed
  - Government intervention probably required – policy and financial
  - Existing technologies carry different risks to the ones we are used to
- In the meantime?
  - Consider your future options
  - Identify and manage your concordant risks
  - Sector initiatives
  - Investment
  - Lobbying

Links

- The Policy Exchange, “Charging up”, https://policyexchange.org.uk/publication/charging-up/
- NFCC guidance for emergency responders: https://www.nationalfirechiefs.org.uk/Emergency-responders-guide-for-alternatively-fuelled-vehicles
- Institute of Engineering Technology Guide for Emergency Responders for EV: https://electrical.theiet.org/guidance-codes-of-practice/publications-by-category/electric-vehicles/electric-vehicles-first-responders-guide/
- The BIG HIT hydrogen project: https://www.emec.org.uk/projects/hydrogen-projects/bighit/
- Liquid Gas UK: Pathway to Net Zero: https://www.liquidgasuk.org/uploads/DOC62BED9462606B.pdf
- McKinsey, “The Net Zero Transition, What would it cost. What it could bring”: https://www.mckinsey.com/capabilities/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring

Tug of War!

- Options are many
- Destinations not clear
- Market forces will choose direction unless Government makes and fund the route
- Shipping is global and is taking it own route

Shipping

- Transition route:
- Fossil fuel at sea SWITCH to clean fuel (methanol/electric/blue gas/hydrogen) in EU or clean air zones
- 100% clean fuel – methanol/ammonia/hydrogen?

Will we dash to new tech too quickly?

What do we do when it all goes wrong?

- Risk profile for incidents is changing
- New fuels harder to recover than 100% hydrocarbon fuels
- Time is of the essence as new fuels take time to break down in sea water

Conclusion

- Innovation never follows a linear curve to success
- Expect some wrong turns on the journey
- We are moving to fuels that carry more risk – explosive, environmental, handling.
- Risk assessment and management MUST improve and safety legislation must keep up

Questions

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