



Ministry of Defence

**DEFENCE ENERGY CONFERENCE**  
27-28 January 2025

***ENERGY TRANSITION BY DESIGN***

**Conference Slides for Delegates**

*Please note that slides have been shared only where presenters are content for this to be the case*

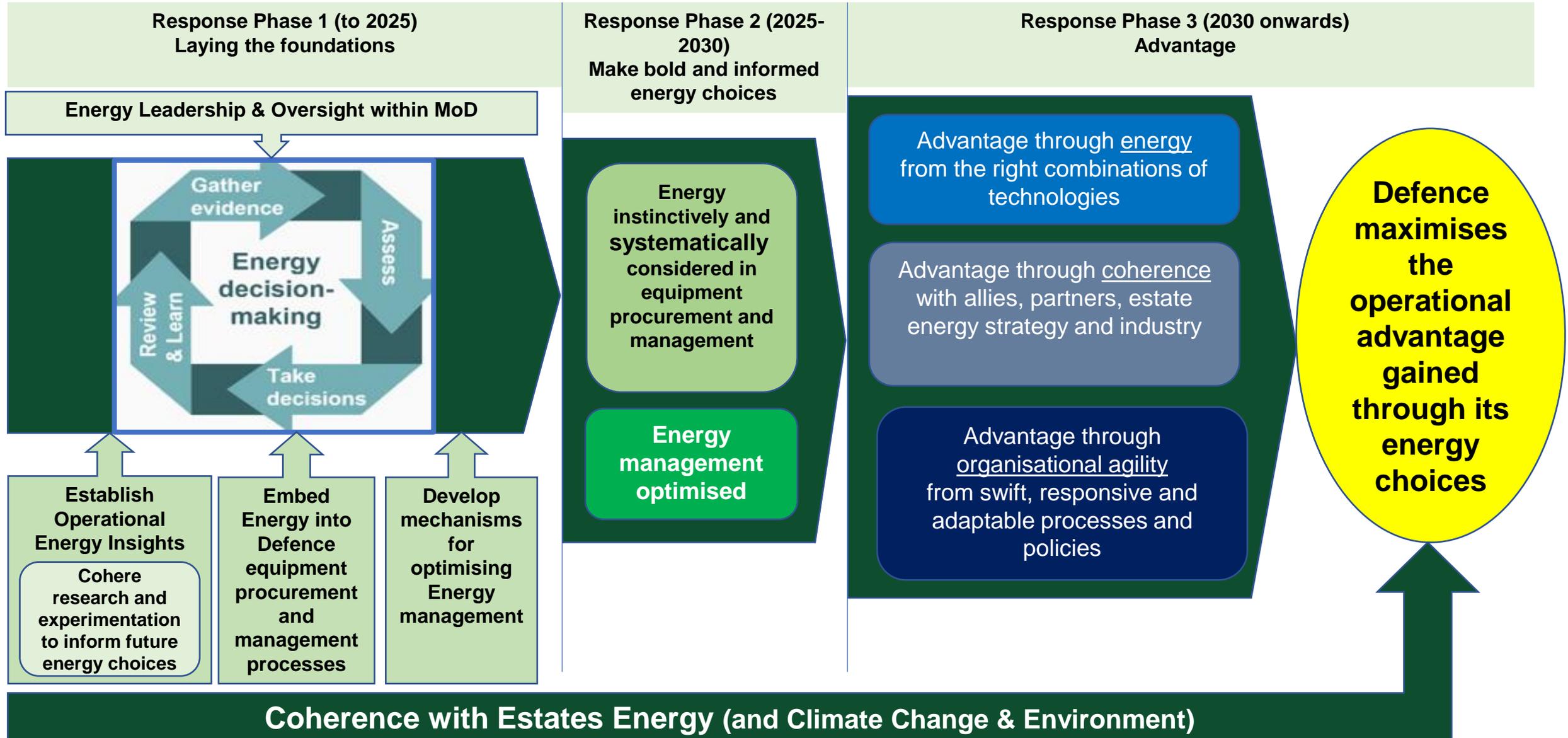


Strategic Command  
Defence Support

# The Defence Operational Energy Strategy (DOES)

*Air Cdre Nick Huntley*  
*Head Operational Energy Authority*

# The Defence Operational Energy Strategy





Strategic Command  
Defence Support

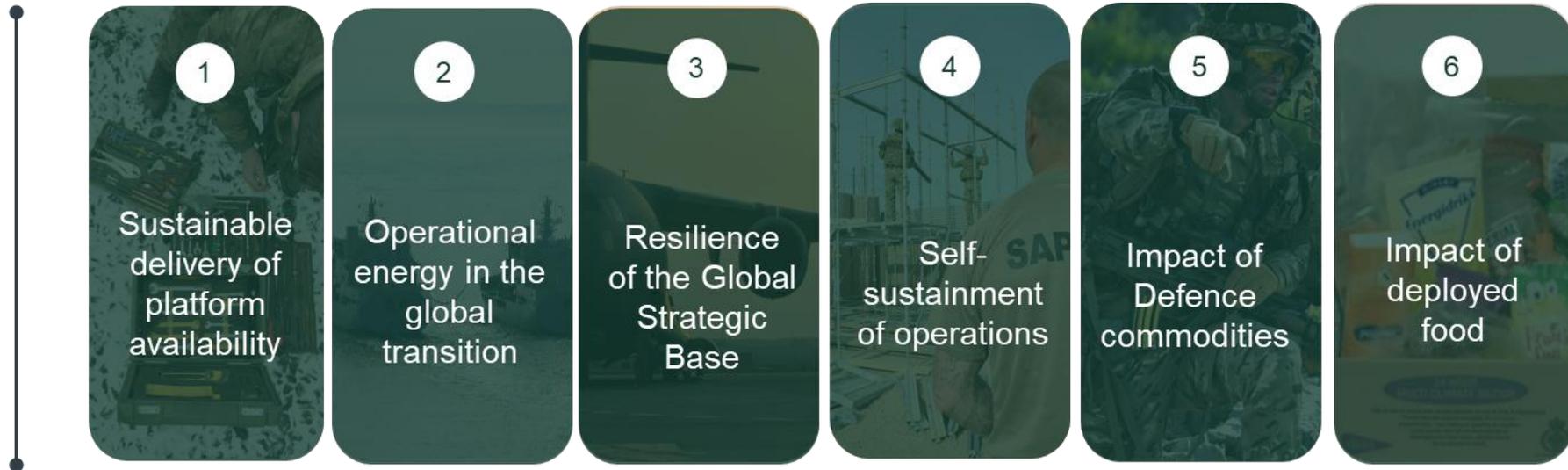
# CADMID to CADMIR

*Sarah Liggins*  
*Defence Support CC&S AH*

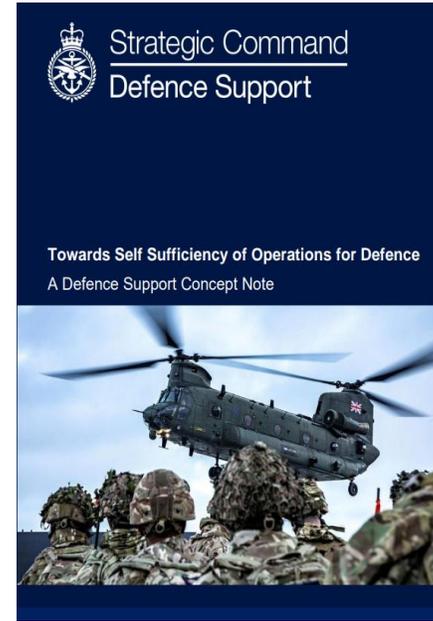


# Sustainable Support Strategy (SSS)

Initiatives

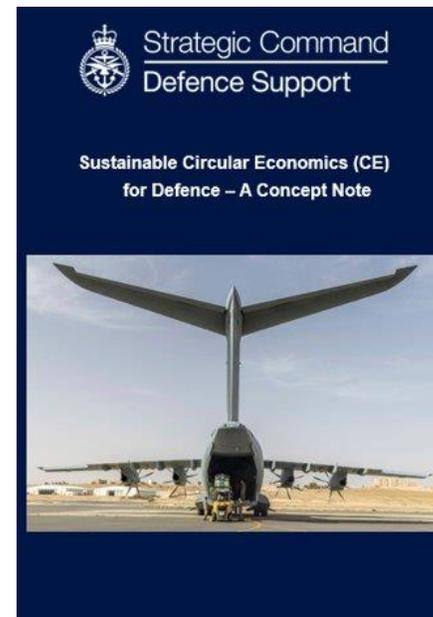


# SSS Concept Notes



Aids in the delivery of Strategic Initiative 4 and focuses on 5 benefits hypothesis areas:

- Energy
- Food
- Water
- Materiel
- Waste



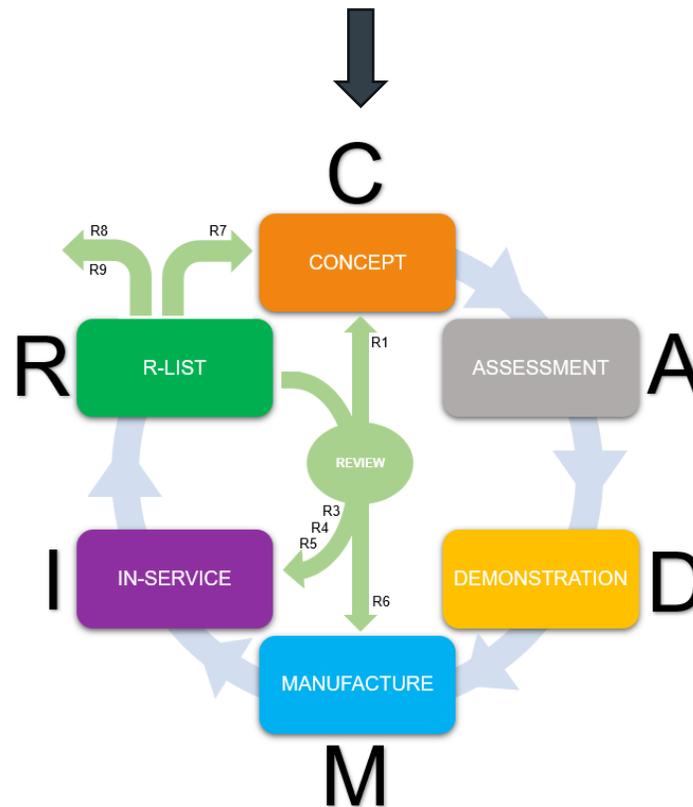
Aids in the delivery of Strategic Initiatives 1, 2, 4 and 5, and focuses on how Defence can adopt Circular economy principles to improve resilience of the E2E Defence supply chain.



## Van Buren et al 9 'R's

- **R0 – Refuse:** preventing the use of raw materials/non-CE products and/or changing the product with a new one.
- **R1 – Rethink:** Review the product design or use a multi-functional product.
- **R2 - Reduce:** reducing the use of raw materials, increase efficiency of products in use, and reduce the number of products used if operationally sustainable and advantageous.
- **R3 - Reuse:** product reuse (second-hand, sharing of products and loans).
- **R4 - Repair:** maintenance and repair of defective products.
- **R5 - Refurbish:** refurbishing a product.
- **R6 - Remanufacture:** creating new products from (parts of) old products.
- **R7 - Repurpose:** use discarded product for a different purpose.
- **R8 - Recycle:** processing products to obtain the same level of quality.
- **R9 - Recover energy:** incineration of residual flows (product's end of life).

# CADMID to CADMIR





# Benefits in adopting a CE

- Cost reduction due to reduced acquisition and longer product life spans.
- Operational self-sufficiency by minimising disruption of supply chains resulting in competitive advantage over our adversaries and reducing competition for scarce resources with our allies.
- Reduced distribution due to sustainable choices, micro-circularity.
- Reduced use of raw materials and reliance on a single country for resources – especially from strategic competitors and adversaries.
- Innovative routes to market (i.e., raw materials) and regeneration projects allowing Defence to better exploit novel technologies and approaches that aid in delivering operational advantage.
- Innovative repair, reuse, remanufacturing and recycling of components and materials, including raw materials and rare earths to maximise efficiency within Defence's supply chain and industrial base.
- Creation and implementation of proximity (i.e., short shoring) in the supply chain and reduced import dependency (especially from adversaries and competitors) increasing resilience within the supply chain.
- Improved maintenance leading to higher quality and/or more reliable and climate resilient capabilities with an increased lifespan and climate resilience.
- Transparency within Defence's end to end (E2E) supply chain.



# Questions?



# ***Energy Market Outlook: Quo Vadis, Net Zero?***

***Defence Energy Conference  
2025***

***Ministry of Defence, Abbeywood  
January 2025 2024  
Ashutosh Shastri***

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# BRITISH PERSPECTIVE ON NET ZERO TWO DAYS AFTER THE TRUMP INAUGURATION



**Martin Lewis** ✓  
@MartinSLewis

Follow

Today's Poll: Where does your sentiment currently lie on green/environmental issues and net zero for the UK?

Asking in the week US says it'll leave UN climate accords & push to drill for more oil. Has this changed things. Which of these is CLOSEST to your view?

We need go greener faster	25%
UK has it about right now	13%
There's no point anymore	21%
<b>I'm always anti net zero</b>	<b>41%</b>

53,003 votes · Final results

12:20 · 22/01/2025 · **417K** Views

1K 1.2K 1K 63



**Martin Lewis** ✓ @MartinSLewis · 4h



Today's Poll: Where does your sentiment currently lie on green/environmental issues and net zero for the UK?

Asking in the week US says it'll leave UN climate accords & push to drill for more oil. Has this changed things. Which of these is CLOSEST to your view?

We need go greener faster	25.4%
UK has it about right now	13.5%
There's no point anymore	22%
<b>I'm always anti net zero</b>	<b>39.1%</b>

27,864 votes · 19 hours left

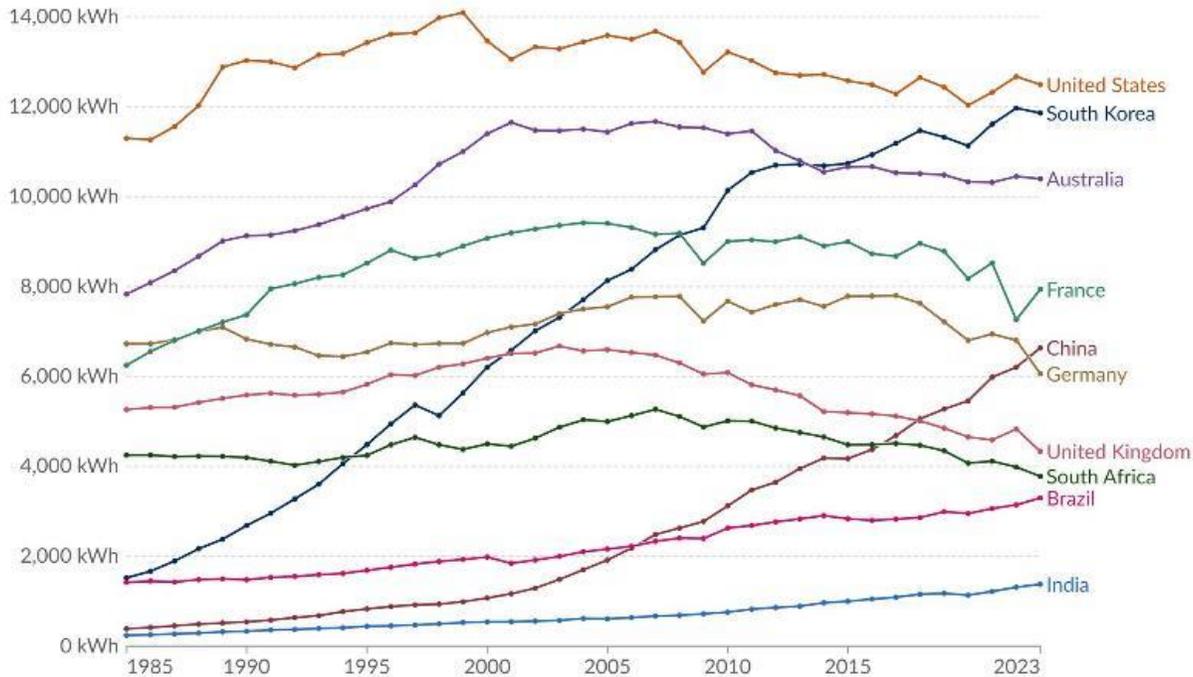
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# BRITAIN IS AT A REAL RISK OF DE-INDUSTRIALISATION

## Per capita electricity generation

Annual average electricity generation per person, measured in kilowatt-hours<sup>1</sup>.



Data source: Ember (2024); Energy Institute - Statistical Review of World Energy (2024); Population based on various sources (2023)  
OurWorldInData.org/energy | CC BY

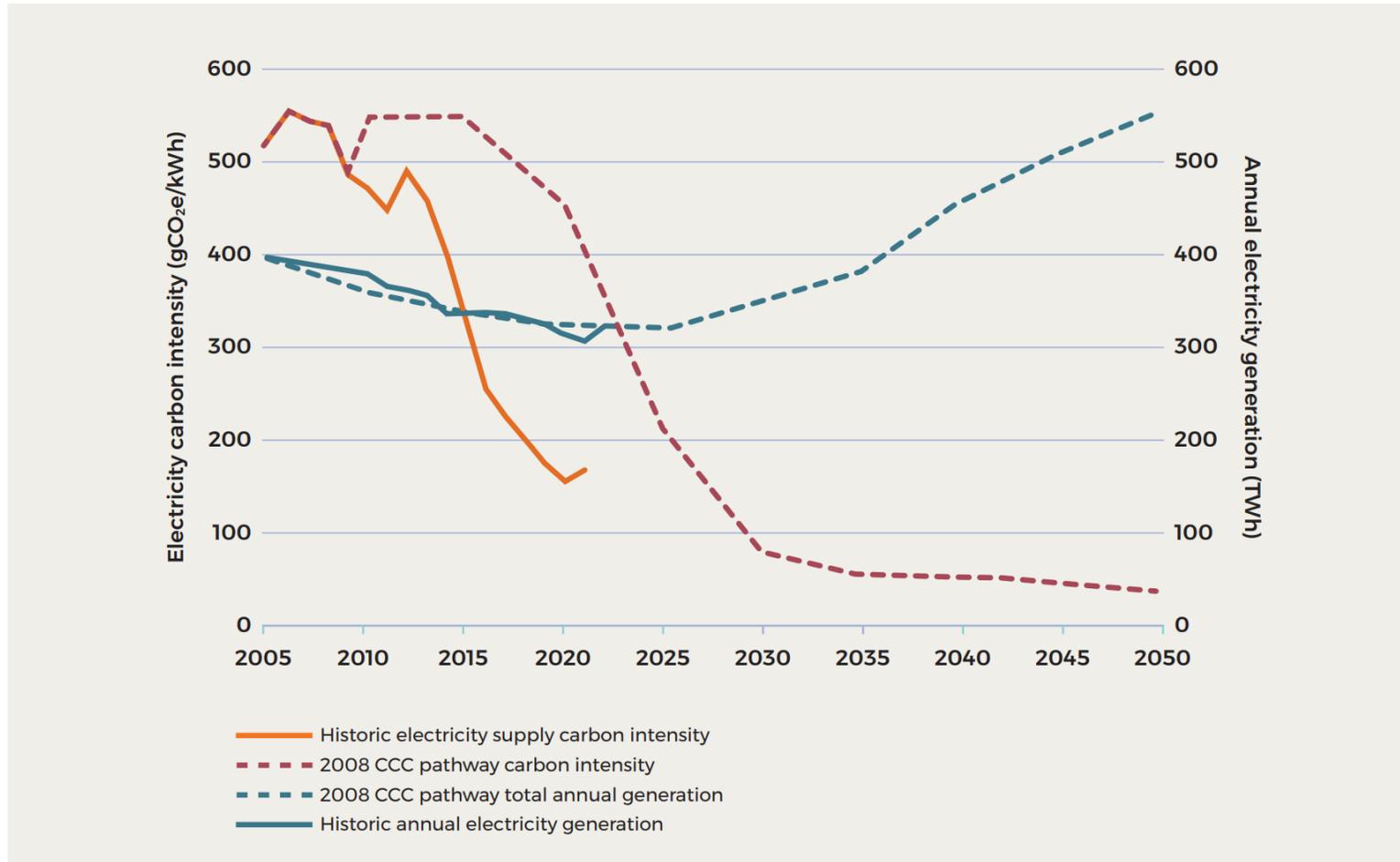
1. **Watt-hour:** A watt-hour is the energy delivered by one watt of power for one hour. Since one watt is equivalent to one joule per second, a watt-hour is equivalent to 3600 joules of energy. Metric prefixes are used for multiples of the unit, usually: - kilowatt-hours (kWh), or a thousand watt-hours. - Megawatt-hours (MWh), or a million watt-hours. - Gigawatt-hours (GWh), or a billion watt-hours. - Terawatt-hours (TWh), or a trillion watt-hours.

**Note the recent sharp drops in Germany and the UK**

**Note that the US isn't buying decarbonisation just yet, and also exporting coal.**

**Note China per capita electricity consumption is now greater than Germany's.**

## THE DON QUIXOTE OF ELECTRICITY DECARBONISATION



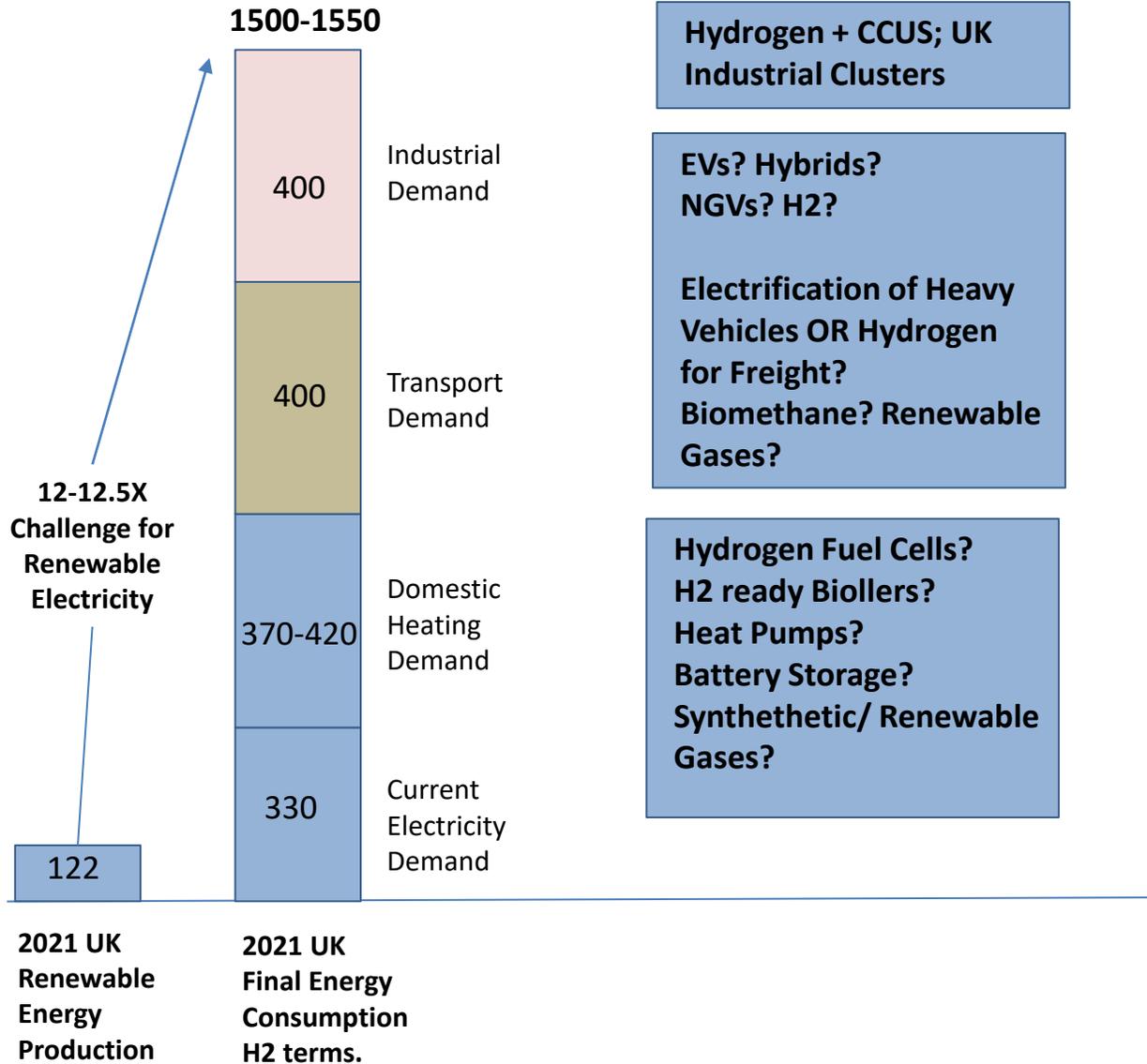
■ Figure 2 | The CCC 2008 projected electricity demand and emissions intensity compared to actual electricity decarbonisation

UK Climate Change Act 2008 is the only one of its kind.

Early and accelerated decarbonisation actions underpinned with carbon budget planning process

Greater decarbonisation implies greater degree of electrification- how do you design a fit for future system today?

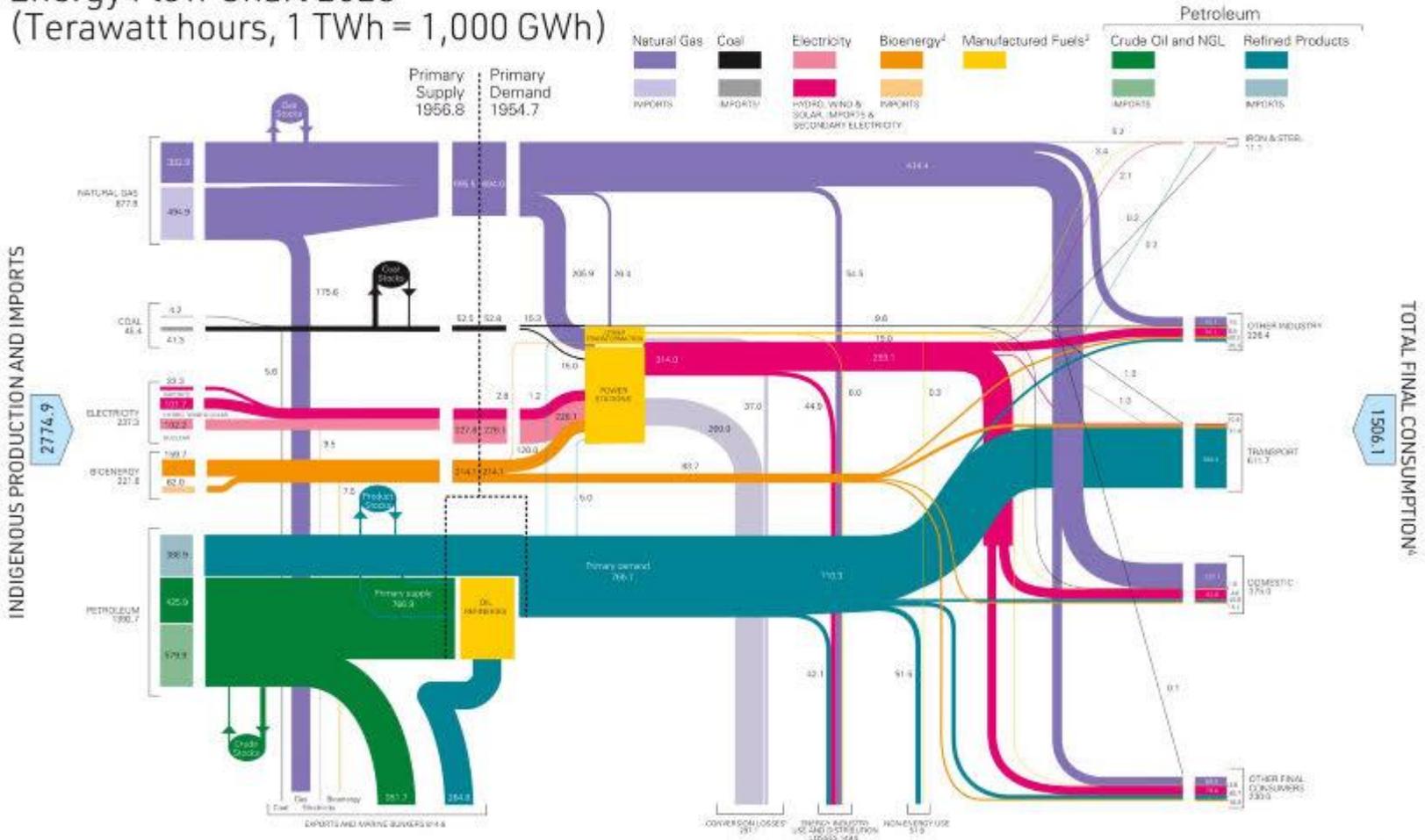
# ELECTRIFICATION CHALLENGE: UK TRANSITION TO “NET ZERO”



1. UK will require to grow its RE production, *not capacity, 12.5 X*; in capacity terms the figure could be **40 X!**
2. To pull off Industrial decarbonisation, both CCUS and Hydrogen will have to grow with aligned policies and business models, **politically possible?**
3. **No proven solutions**, deployable at scale are as yet on the horizon in industrial decarbonisation, where solutions exist they **are at FOAK stage**.
4. Individual solutions compete in individual application markets, some will succeed while others fail- **then should policy makers be picking technology winners?**

# UNITED KINGDOM SANKEY DIAGRAM EXPRESSED IN ELECTRICITY TERMS

Energy Flow Chart 2023  
(Terawatt hours, 1 TWh = 1,000 GWh)



**NOTES:**  
 1. Coal imports, exports and power stations include manufactured fuels.  
 2. Bioenergy is renewable energy made from material of agricultural origin derived from land or water.  
 3. Includes heat loss.  
 4. Includes non-energy use.  
 5. Conversion losses from power stations apply to thermal sources (coal, oil, gas, nuclear and bioenergy) only; there are no such losses from non-thermal sources (hydro, wind and solar).  
 This Sankey chart has been produced using the style of tables and figures in the 2023 Digest of UK Energy Statistics, Table 7.1. Agree copyright notice below.



Energy System Efficiency = 54%

## **BRITISH DEFENCE-ENERGY-INDUSTRIAL COMPLEX: WHAT CAN WE DO TOGETHER IN NATO?**

- **Collaborate and Share and becoming a “fast follower” at the same time is difficult- decide where to fast-follow and where to cooperate.**
- **We have a well developed cleantech VC/PE ecosystem- capitalise now on the Oxford-Cambridge Arc revival; engage with the City of London (The Fuellers will be delighted to engage/assist)**
- **One idea Defence can try out that NIMBY-ism in the civilian world got us into the energy emergency in the UK today- Frac on Defence Land- explore partnerships UK shale.**

**THANK YOU**

***@enerstrat***

For further questions please contact:

**ASHUTOSH SHASTRI**  
**ENERSTRAT CONSULTING**  
[ashastri@enerstrat-consulting.com](mailto:ashastri@enerstrat-consulting.com)

*“A shrinking refining base in Europe, coupled with an increased energy demand by Allied military forces, and a projected reliance on liquid fuels, underscores the need to ensure secure, resilient, and sustainable energy supplies, including fuel, to military forces (better interconnections, supported with robust storage capabilities).”*

(NATO Energy Transition by Design, Dec 24)



**OPA Presentation to the Defence Energy Conference**

# **Supporting MOD's Energy Transition**

**28 January 2025**



## OPA: Current and Emerging Activities

- Operations and Maintenance of the 6 Navy Oil Fuel Depots
- Intelligent Customer service to Air Command: Airfield fuel infrastructure
- Support to Directorate Overseas Bases: Singapore, Gibraltar, developing Intelligent Customer support to Akt, Asi, Fls
- Army – Initial discussions held between DCGS / CE OPA: development opportunities
- DIO - Plumley/CoGH Salt Caverns
  - Extraction and sale of existing product
  - Opportunities: Energy Resilience and Renewables storage – significant growth area
    - Hydrogen, CC&S, Compressed Air Energy Storage, LNG, etc
      - Example: ‘Advanced Clean Energy Storage’ project – Utah
    - All feeds National resilience, transition to Net Zero and stability through fluctuation in production, availability and price
- OPA Network: - Tank Storage Association - National Supply Chain back bone
  - FETSA (European tank operators)
  - NATO



**HYDROGEN**

**ADVANCED CLEAN ENERGY STORAGE**

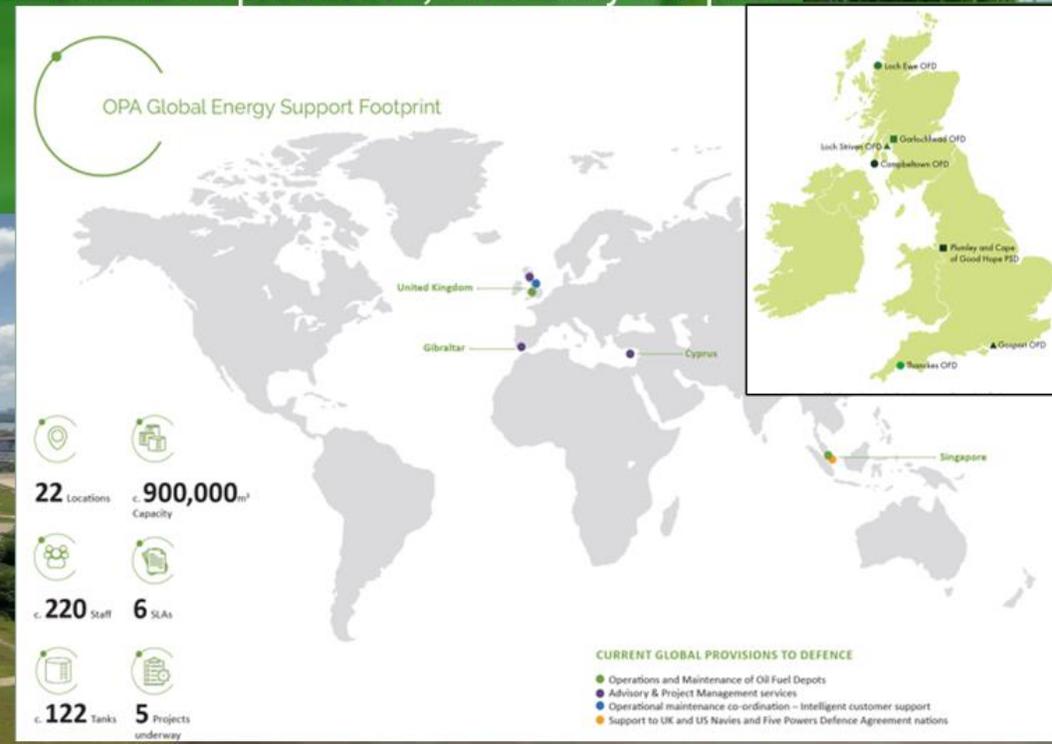
DELTA, UTAH

Nation's largest hydrogen production and storage facility capable of providing long-term seasonal energy storage.

**LOAN GUARANTEE**  
\$504.4 MILLION  
JUNE 2022

FINANCED BY  
U.S. DEPARTMENT OF ENERGY

LPD  
Loan Program Office

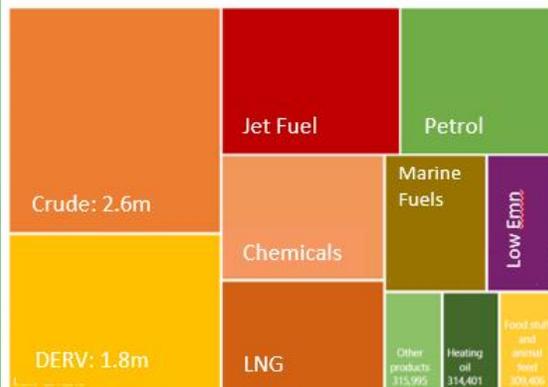


# Tank Storage Association

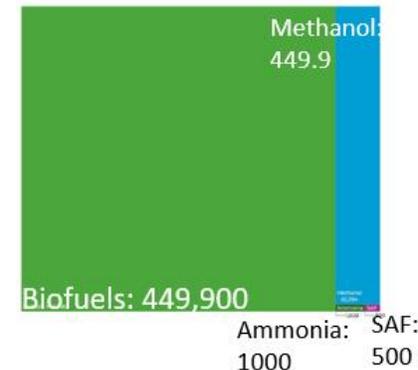
- Central to the UK supply chain - National storage interface between sea, road, rail and pipelines for a wide range of energy vectors
- Membership controls over 300 terminal and distribution hubs across the UK (22 CNI)
- >50% of UK inland secondary distribution terminals
- Contributes to security, resilience and commerce for the energy, aviation, maritime, chemical, steel, health, construction, automotive, food and agriculture industries
- Storage capacity includes strategic reserves (emergencies and supply disruption) – **amid broadening of MOD focus from Expeditionary to National Defence & Resilience and increased risk of hybrid warfare** (access to energy as a weapon)
- UK Remains a net importer of petroleum products (2023: >half UK diesel and >80% jet fuel imported)

## Terminals and Products

Storage Capacity – 11.5 million m3



Storage Capacity – Low Emission Fuels – 500,000m3



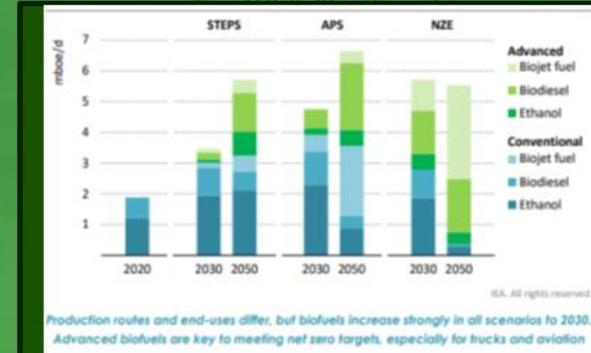
Source: [TSA Annual Review 2024 \(2023 data\)](#)



UK Terminals 2023. Source: Fuel Oil News

## TSA Insights

- UK must maintain domestic stocks to buffer against fluctuations due to uncertain supply routes and product availability
- Resilience measures required for new energy carriers; less reliance on potentially unstable international sources
- The International Energy Agency and EC are currently discussing changes to Compulsory Stock Obligations. EC stockpiling study about to commence:
  - Should existing stock obligations increase?
  - Should obligations consider future energy carriers (especially biofuels)?
- National infra buildout (including MOD's) requires early investment
- Blending of biofuels with conventional hydrocarbons will be required to meet decarbonization targets
  - Terminals will need to evolve:
    - greater blending capacity
    - Storing advanced biofuels might require changes to infrastructure (e.g. heating)
  - Domestic production of alternative fuels may become decentralized/geographically dispersed – adjustment to fuel supply chains & new infra required
- Hydrogen supply chain: Hydrogen 'carriers' adopted (and their storage) will depend on end use – infra design to align with temperature and pressure. Additional processing facilities required to convert carrier to useable form

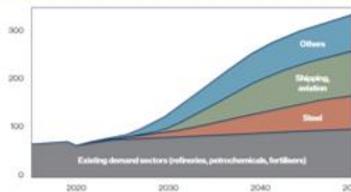


Liquid biofuel demand by type and scenario  
Source: IEA World Energy Outlook 2023  
STEPS: Stated Policies Scenario  
APS: Announced Pledges Scenario  
NZE: Net Zero Emissions by 2050 Scenario

### The large-scale adoption of hydrogen up to 2030 is uncertain

- In Europe, hydrogen is projected to serve as a means to decarbonise heavy industry (and potentially home heating in the future)
- The energy carriers used in hydrogen transport and storage remains unclear. Hydrogen carriers include:

- Ammonia
- Methanol
- Liquid organic hydrogen



Note: 'Others' represent a number of potential applications (road transport, power, heating of buildings) that could potentially give rise to a much higher growth but for which it currently seems likely that hydrogen will play a relatively small role.

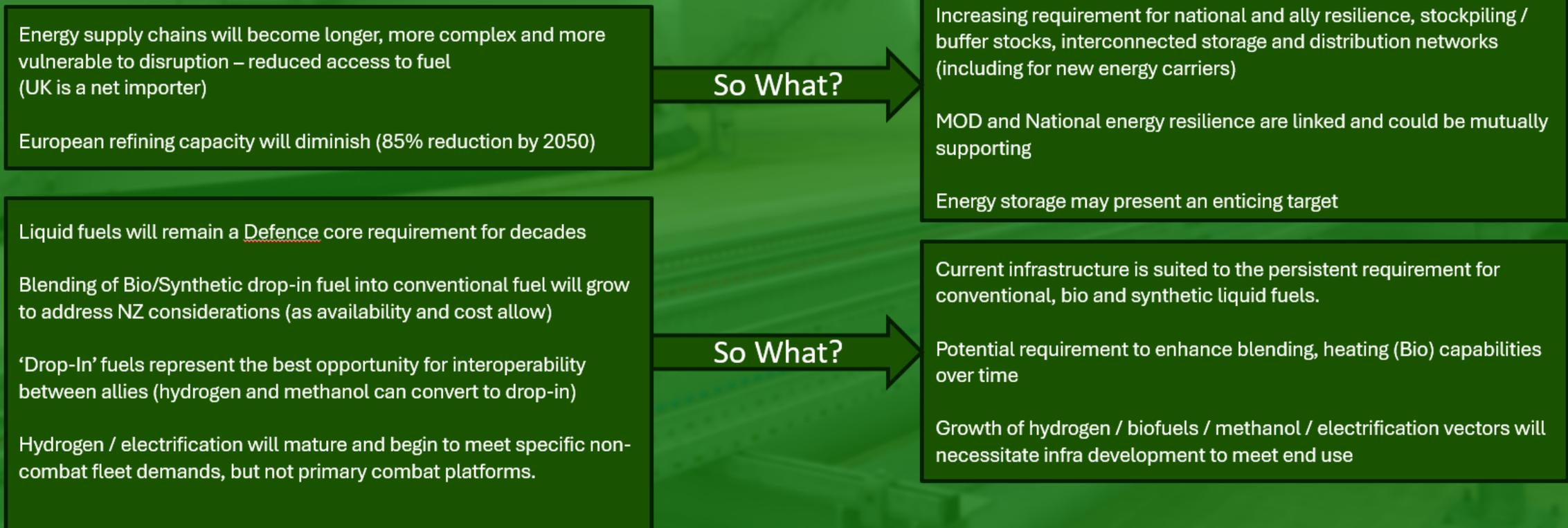
Source: Rystad Energy, 3rd Energy Transition Report.

## Take Aways

- OPA is central to MOD's storage, distribution and operational capability (controls >50% of MOD fuel stocks globally)
- OPA belongs to the MOD and should be seen as MOD in-house capability
- OPA is closely engaged with wider UK supply chain industrial / commercial backbone
- With early engagement OPA can inform and support MOD in adapting to a changing landscape
- Make maximum use of the capital expenditure you have got - It needs to be focused more effectively
- Access to expertise is essential



## General Themes





The Oil & Pipelines Agency

Thanks for your attention.





Strategic Command  
Defence Support

## Renewable Energy Trials

*Flt Lt Richard Griffiths*  
*UK Defence Support Innovation Team*



# Strategic Command Defence Support

## Renewable Energy, evidence from our trials

- Renewable Energy sources
  - Battery and Solar.
  - Wind and Hydrogen.
- User Benefit
  - Make your fuel at point of use.
  - No resupply chain. No fuel trucks. No fuel storage infrastructure. Less storage space, less of a target.
  - Systems are modular.
  - Emission free, no CO<sub>2</sub> to detect.
- Benefit to Defence:
  - Solution to Battlefield electrification.
  - Adds resilience and low operating costs, don't ship diesel.
  - ROI 2-4 yrs compared to diesel.
  - Zero Carbon.



Image of HPU2 500kW



# Strategic Command Defence Support

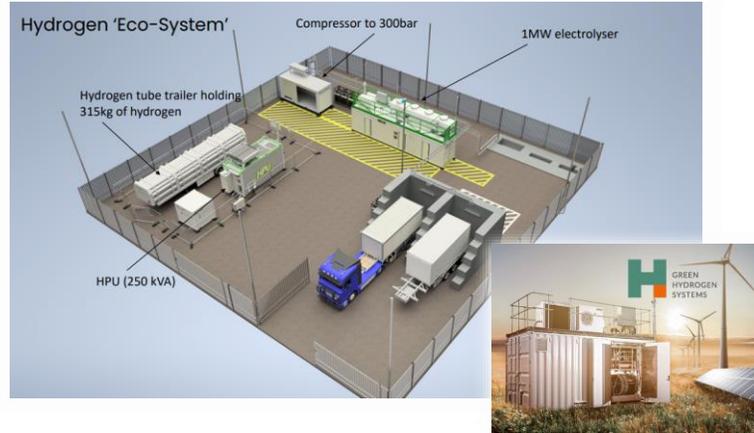
## How – Self Sustaining Energy Production

### Phase 1 – “First Use”

- **Description:** Use Hydrogen at MoD sites.
- **Outcome:** H<sub>2</sub> is credible for use in MOD now but must be made locally.

**Cost: £410K (Actual)**

**Status: complete**



### Phase 3 – “Operational, Supportable & Containerised”

- **Description:** Development & deep test of FI solution.
- **Outcome:** Deployed, supportable H<sub>2</sub> ecosystem in FI with cashable savings in 4-5 years & significant CO<sub>2</sub>e reductions from “*never sending diesel to the FIs again*”.

**Status: outline proposal**



**“Never send diesel to the FIs again”**



Hydrogen Power Unit (HPU) for EV charging



Hydrogen cars & refueller



Mobile HPU

Wind & solar energy harvesting, storage & management

Modular HPU & refueller

Hydrogen production

Jul 23

Apr 24

May 24

Jan 25

Apr 25

Jul 25

Containerised solution  
Nov 25

Pre-deployment testing  
Jul 26

FI deployment  
Apr 27



### Phase 2 – “Develop renewable and hydrogen ecosystem”

- **Description:** Test renewable energy harvesting, storage and management (Project SANTA ANA).
- **Outcome:** a technically & financially viable hydrogen ecosystem proposition, with DLODs mature.

**Status: under approval**



## Conclusion

- Operational Advantage “Never send diesel to the FI again”
- FI is our ambition. Huge cost of getting fuel there. Wherever we deploy, fuel movement is expensive in many ways.
- Renewable energy is often a factor in the tension of the infrastructure budget.



*DSTL support to NATO energy activities, including NATO LCG DSS battery standardisation and  
NATO Mil Eng*

**Dr Darren Browning**

Defence Science & Technology Laboratory



# Dstl support to NATO energy activities

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Including NATO LCG DSS battery standardisation and NATO Mil Eng

Dr Darren Browning  
Defence Science & Technology Laboratory  
[djbrowning@dstl.gov.uk](mailto:djbrowning@dstl.gov.uk)



Ministry  
of Defence

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**UK OFFICIAL**

- **Deployed energy**

- UK is playing a leading role in shaping NATO **Concepts, Guidance & Standards**

- **Batteries**

- UK is working closely with NATO and US on **Standardisation** - Army (NAAG) focussed
- Opportunities for wider NATO coordination on batteries to aid supply chains

- NATO Science for Peace and Security (SPS) – Deployed Camp Energy Efficiency (& monitoring)
- NATO Military Engineering Centre of Excellence (Mil Eng COE)
- NATO Energy Security Centre of Excellence (EnSec COE)
- NATO Climate Change and Security Centre of Excellence (CCASCOE)
- NATO Land Capability Group Dismounted Soldier Systems (LCG DSS)

- **Previous** NATO SPS G5525 successful aims:
  - Better common understanding of key energy flows
  - Identify opportunities to improve interoperability (energy focus)
  - Predict/estimating power and energy requirements of a deployment camp
  - UK MOD was an end user for G5525
  
- **New** NATO SPS G7933 proposed aims:
  - Validating modelling through energy monitoring
  - Predicting performance and suitability of promising energy saving technologies and strategies
  - Testing promising energy efficient technologies and strategies
  - **Dstl to be a co-director**

- NATO Military Engineering Working Group – Infrastructure Management Panel (IMP)
  - Writing team for **STANAG 4133**: Electrical Power Supplies: Standard Types And Rotating Generating Sets (AC-DC)
    - Ensure interoperability between national **electrical generators**
  - Understand future interoperability issues around **microgrids**
    - Explore the need for future STANAG in this space – e.g. **Tactical Microgrid Standard (TMS)**
  
- NATO Energy Security COE
  - Previous Dstl secondee (Jen Doran)
    - Co-authored the **Energy Management Handbook**
  - Dstl (Tim Jackson) Lecturing at Energy Efficiency in Military Operations (EEMOC) course in May 2025
  
- Operational Energy Concept (OEC)
  - Writing team for the **OEC** – accepted June 2024
  - Dstl participation in NATO OEC Experimentation phase during **Ex STEADFAST JUPITER 23**



The use of solar and operating the generators at their prime efficiency results in a 25% improvement in power generation



**FEPS**

**1.9**  
kWh/L

VS

**Hybrid  
Syst.**



**2.4**  
kWh/L

\*\*\*

Considering **only useful camp energy** (demand) rather than total energy produced



Useful camp energy (kWh)

Fuel Consumption (L)

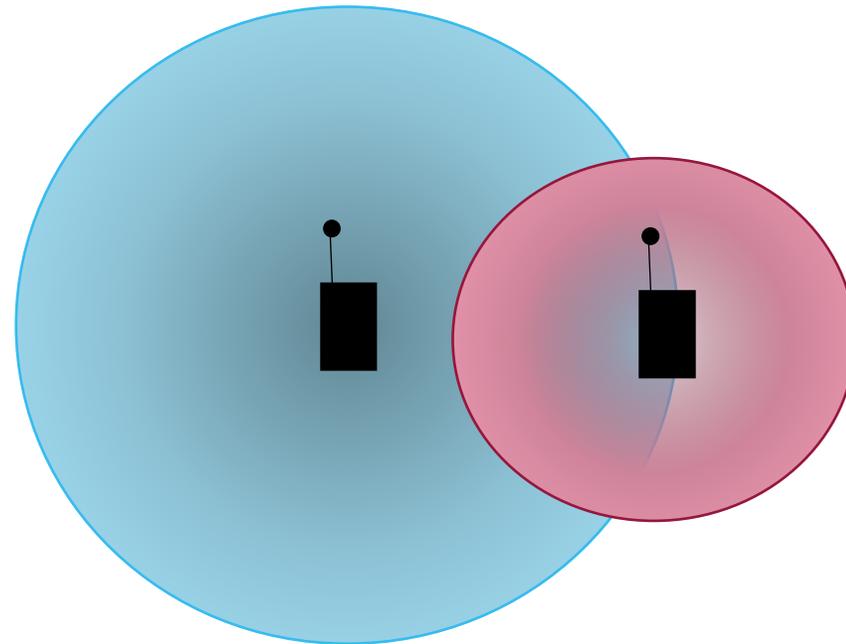
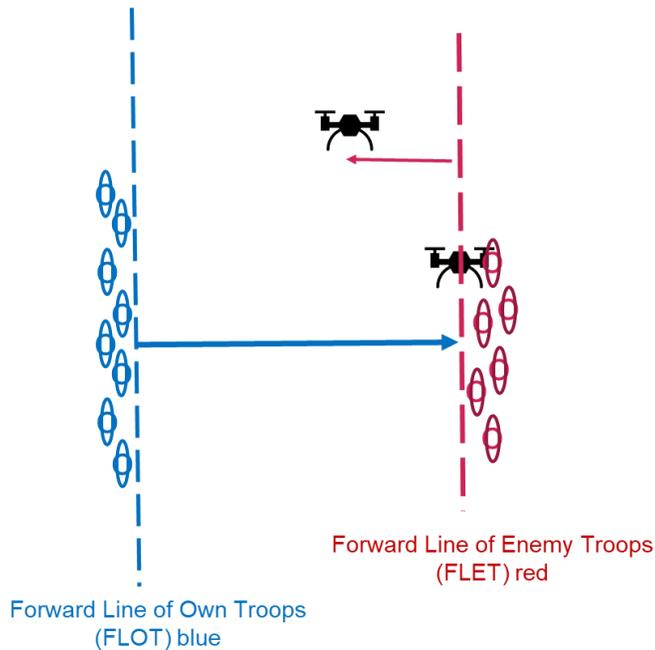


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- Power Team of Experts (Dstl chair)
  - To date focussed on power connector standardisation to allow interoperability
  - **STANAG 4695 – Soldier Power Connector**
  - **STANAG 4851 – Soldier Data Connector**
  - **STANAG 4819 – Interoperable soldier battery charger**
- Now focussing on **battery standardisation**

# Batteries: why are they important?

- Much modern capability is enabled/limited by its batteries
  - esp. UAVs (drones), UGVs, EW, DEW, AI, Comms, Soldier Systems etc.
- Relative advantage can be given by a better battery
- Increased electrification will increase reliance on batteries



- Battery supply is challenging (and getting harder)
- 2 main challenges...
  1. **Far east dominates the battery supply chain** from raw materials through processing to electrode manufacturer and cell manufacture
  2. **Electric Vehicles dominating and skewing the battery market – most defence batteries don't or can't use EV cells**
    - Too large or wrong properties
    - EV cells getting ever larger – 4680s, 46 Π, blade cells etc.
    - The huge EV market is shifting the battery market away from Defence and MOD needs
    - Security of supply will become more important as more defence capabilities rely on Lithium ion batteries

- Battery standardisation could help MOD/NATO in many ways
  - **Tactically** – reduce and simplify number of batteries carried and also enable scavenging
  - **Logistically** – simplify recharging and allow fewer chargers, fewer battery types in stock, simpler logistics
  - **Security of supply** – smooth MOD demand making us a better customer and helping industry support MOD batteries
  - **Economically** – battery cost is related to economies of scale – fewer types of batteries require less qualification, less design and tooling and hence are cheaper
    - Battery costs massively affected by economy of scale
  - **Internationally** – at both tactical and strategic level
    - Having common batteries with allies allows flexibility on the battlefield and more supply options



- US is leading on this
  - New Mil Std 3078 – Defines preferred batteries both by Mil Prf or COTS (e.g. AAs)
  - Aligns with Family of Standard Batteries (FASTBAT)
- NATO – **limited activity**
  - NAAG LCG LE – define shape of 6T for lead acid
  - NAAG LCG DSS – defined connectors for interoperability of soldier batteries
  - NAAG LCG DSS – preliminary work to define the XX90 format battery
    - Will be harder to get agreement on other batteries and legacy issues but a NATO family of batteries is an aspiration
    - Perhaps easier for new batteries that no one has adopted yet e.g. STUB
    - Seeking wider NATO engagement

# US Family of Standard Batteries (FASTBAT)

<p><b>OSCAR</b> Operational Single-Cell Accessory Readiness</p>	<p><b>STUB</b> Small Tactical Universal Battery</p>	<p><b>CWB</b> Conformal Wearable Battery</p>	<p><b>XX90</b> Primary and Rechargeable Batteries</p>	<p><b>6T</b> Lithium Ion Battery</p>
<p><b>ENABLER</b></p>	<p><b>HANDHELD</b></p>	<p><b>SOLDIER-WORN</b></p>	<p><b>EQUIPMENT</b></p>	<p><b>VEHICLE</b></p>

Source: C5ISR



Lower TRL US lab developments

Only 1 US programme to date (DAPS). UK experimenting with

UK used on exercises along with competing formats

UK and much of NATO uses

UK uses same format lead acid and has experimented with Li version

- Deployed energy
  - Good progress being made
  - UK is playing a leading role in shaping NATO **Concepts, Guidance & Standards**
  - Continue engaging with those NATO organisations we already work with – esp. microgrids
- Batteries
  - UK is working closely with US on **Supply Chain** & US and NATO on **Standardisation**
  - **Explore future battery supply chains and standardisation wider than LCG DSS and NAAG**
    - battery supply is a NATO wide issue
  - Possible solutions via:
    - Security of Supply Centre of Excellence (SOSCOE)
    - Energy Security Centre of Excellence (EnSec COE)
    - Defence Assured Production Act (DAPA)



**Delivering  
Mission Success**

Discover more



# Advancing Emerging Solar Technologies for Defence and Sustainability

Defence Energy Conference 2025

Dr Amy Neild

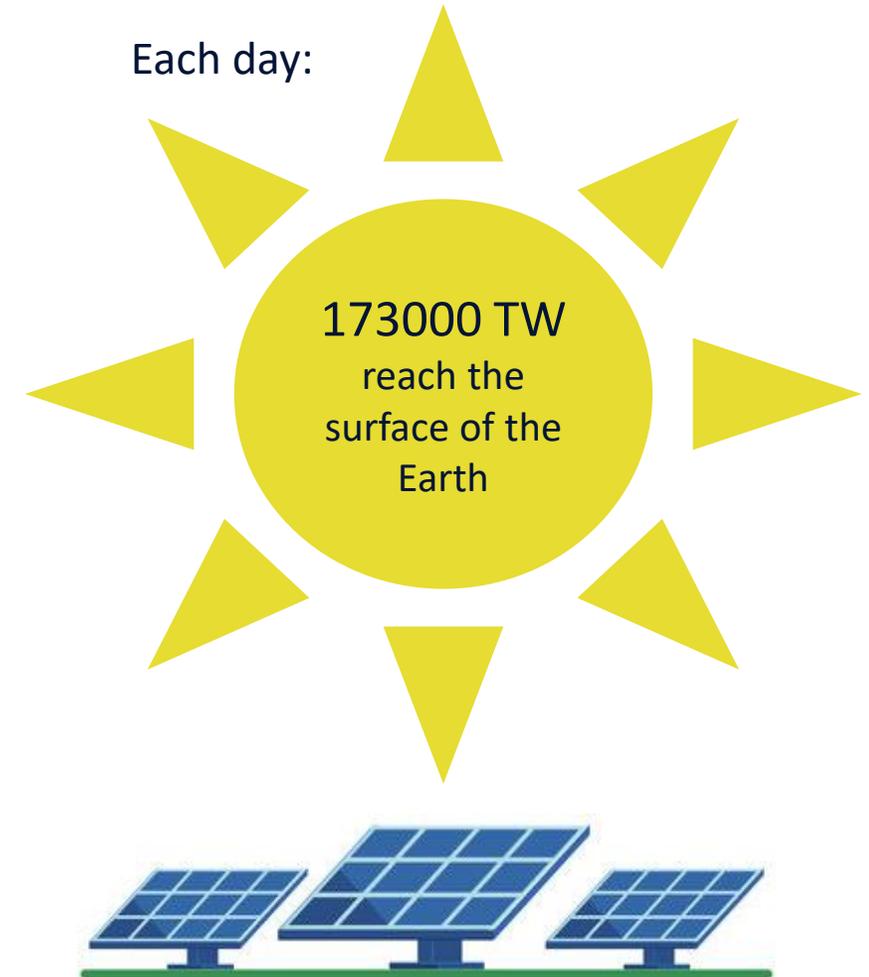
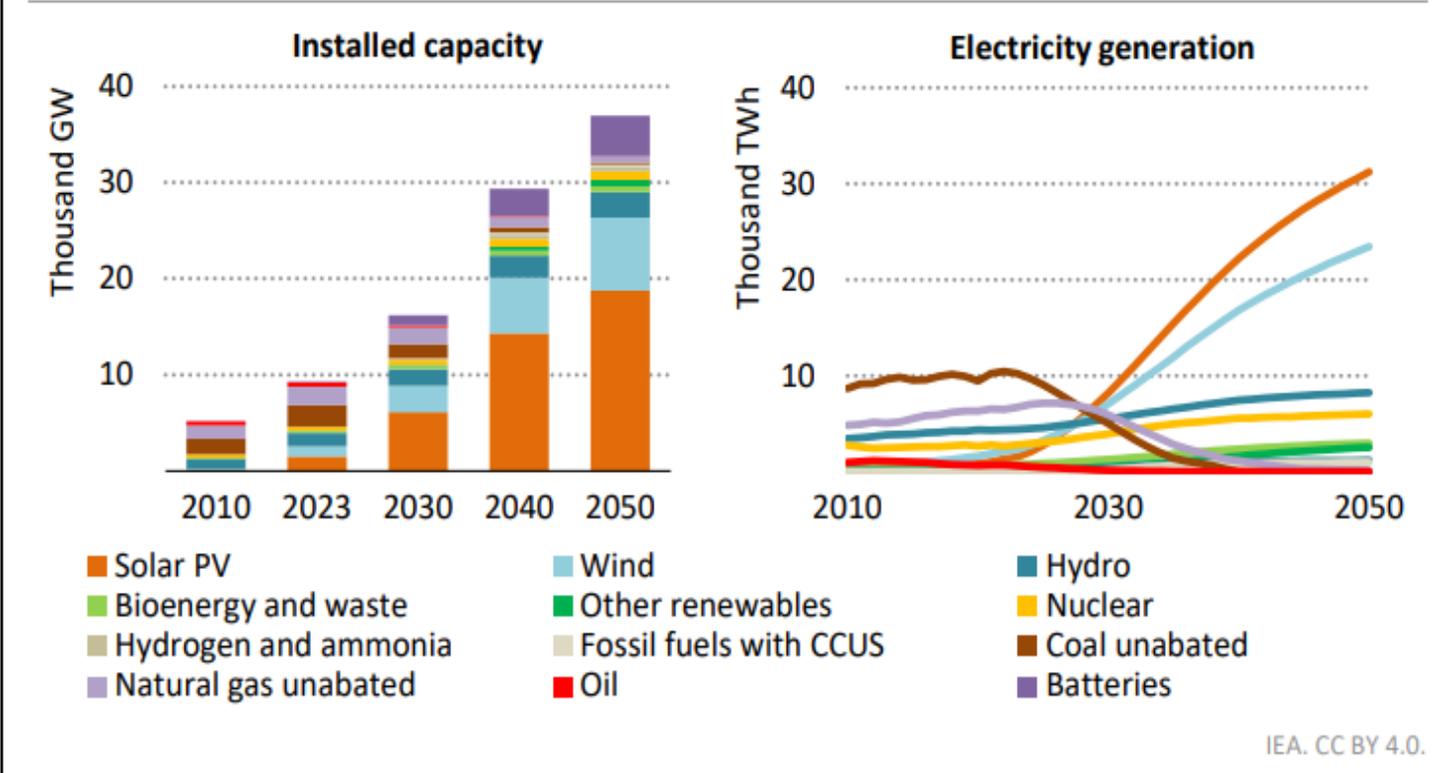
[amy.neild@newcastle.ac.uk](mailto:amy.neild@newcastle.ac.uk)

28/01/2025



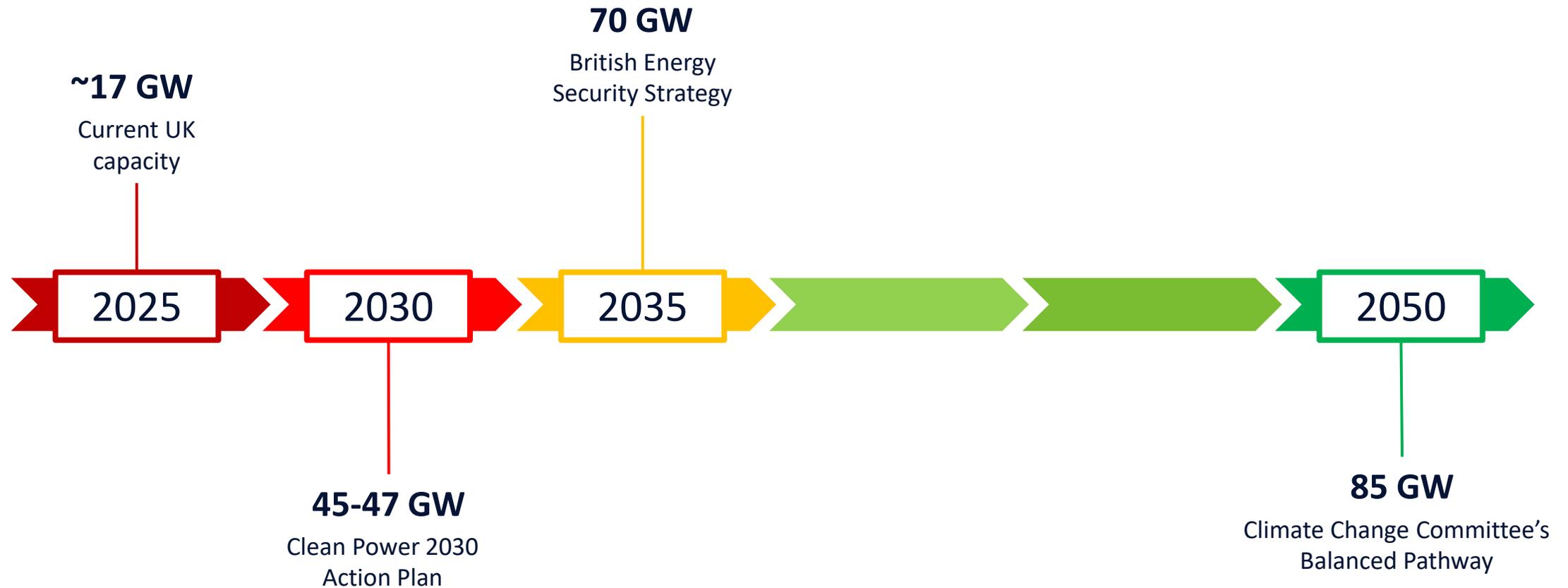
# Solar PV in the Net Zero Scenario

**Figure 2.17** ▶ Total installed capacity and electricity generation by source in the NZE Scenario, 2010-2050 [1]

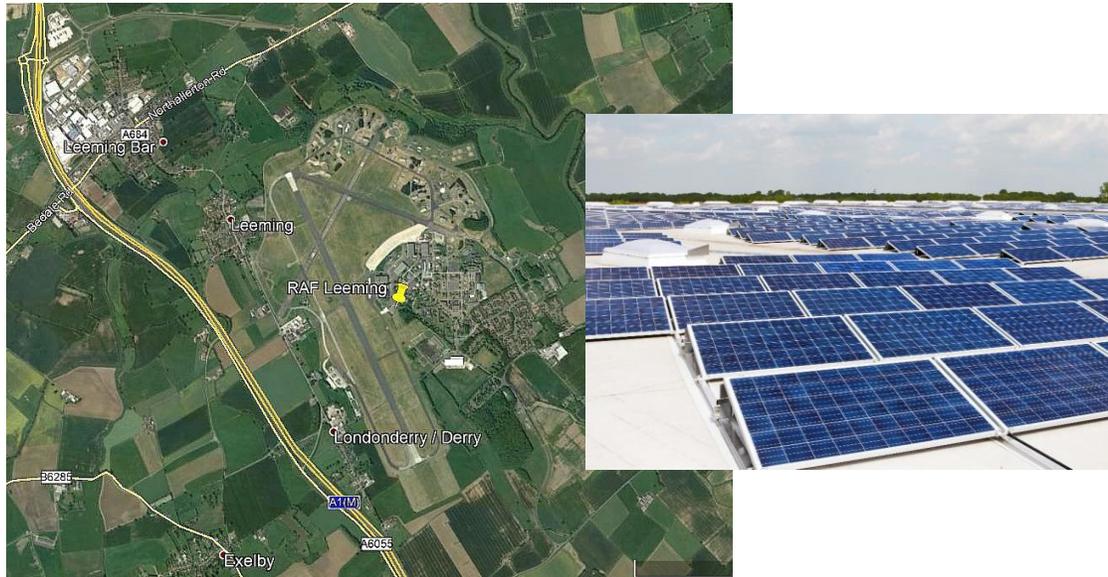


[1] IEA (2023) Net Zero roadmap: A global pathway to keep the 1.5°C goal in reach

# Solar PV in the Net Zero Scenario



- ❖ MOD operates over 1.4% of the UK land mass [2]
- ❖ McKinsey reports that a typical base could support its annual electricity demand with 40 to 50 acres of solar panels (~ roof area of a mid-sized site) [3]



**Decentralised energy  
reduces reliance on external  
grids, increasing energy  
resilience and security.**

[2] Ministry of Defence (2024) *MOD Land Holdings: 2000 to 2024*

[3] McKinsey & Company (2021) *Decarbonizing defence: Imperative and opportunity*

- ❖ Solar PV can also play a critical role in supporting off-grid operations in remote environments.
- ❖ NATO exercise Capable Logistician 2015 saw solar panels air dropped to troops, allowing them to be independent from power grids, diesel generators and roads.

**Solar PV provides a significant operational advantage, increasing flexibility in remote environments.**



[4]

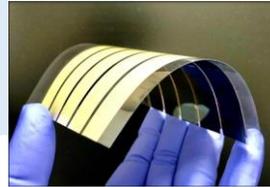
“A **strategic competition** exists between all nations to be the first to capture the military benefits of **new energy types and technologies**”

- Defence Operational Energy Strategy, Foreword by CDLS and DCDS MilCap



## Lightweight & Flexible

- Can be integrated onto more surfaces/roofs



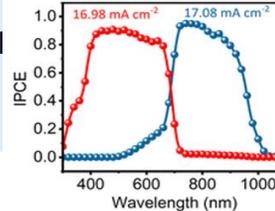
## Earth Abundant Materials

- More secure supply chain for UK markets



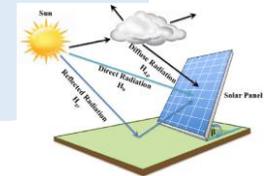
## Higher Efficiencies

- Designed to absorb a wider range of light



## Low-Light Performance

- Perform better in low light/cloudy conditions



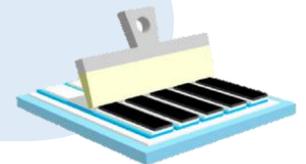
## Indoor Compatibility

- Can be tuned to specific lighting types



## Simple Fabrication

- No energy intensive refining processes



How can these advantages benefit defence operations?

## Portable Power Generation



## Hangar Roof Deployment



## Energy Independence and Security



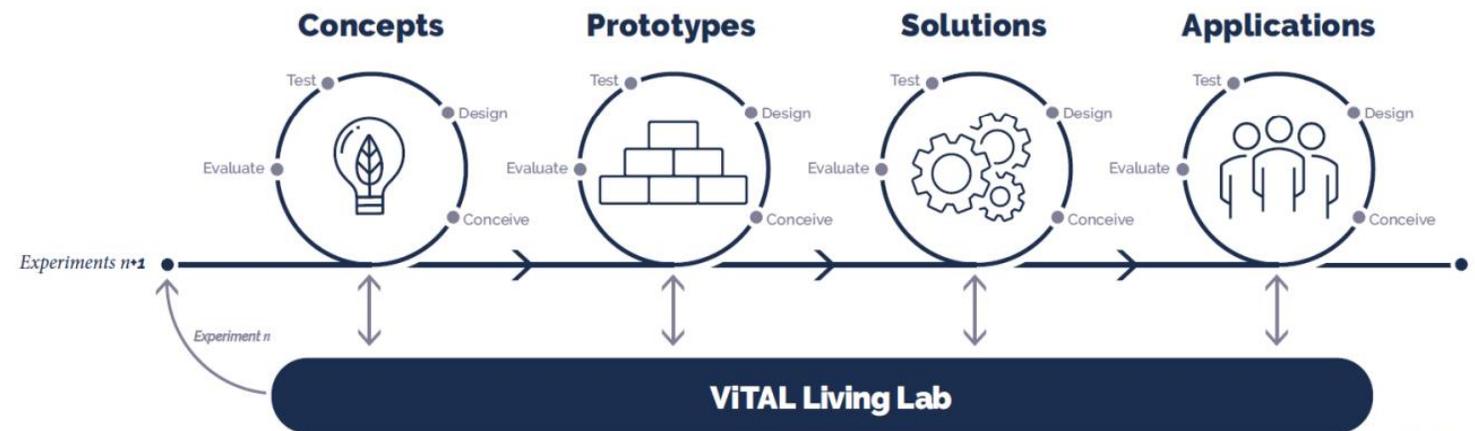
[5] U.S. Army (2010) *Army evaluating transportable solar-powered tents*  
[6] U.S. Army (2014) *Soldiers of the future will generate their own power*

**Aim:** To create a living laboratory for the RAF and the MOD to investigate new and emerging technologies for tackling climate change.



Living Lab at RAF Leeming provided a framework to enable rapid assessment of new technologies under real-world conditions.

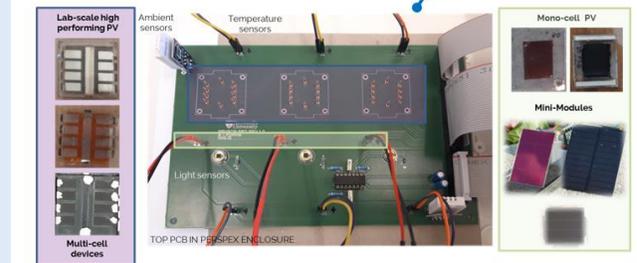
The ViTAL Living Lab and evolutions of Experimentations



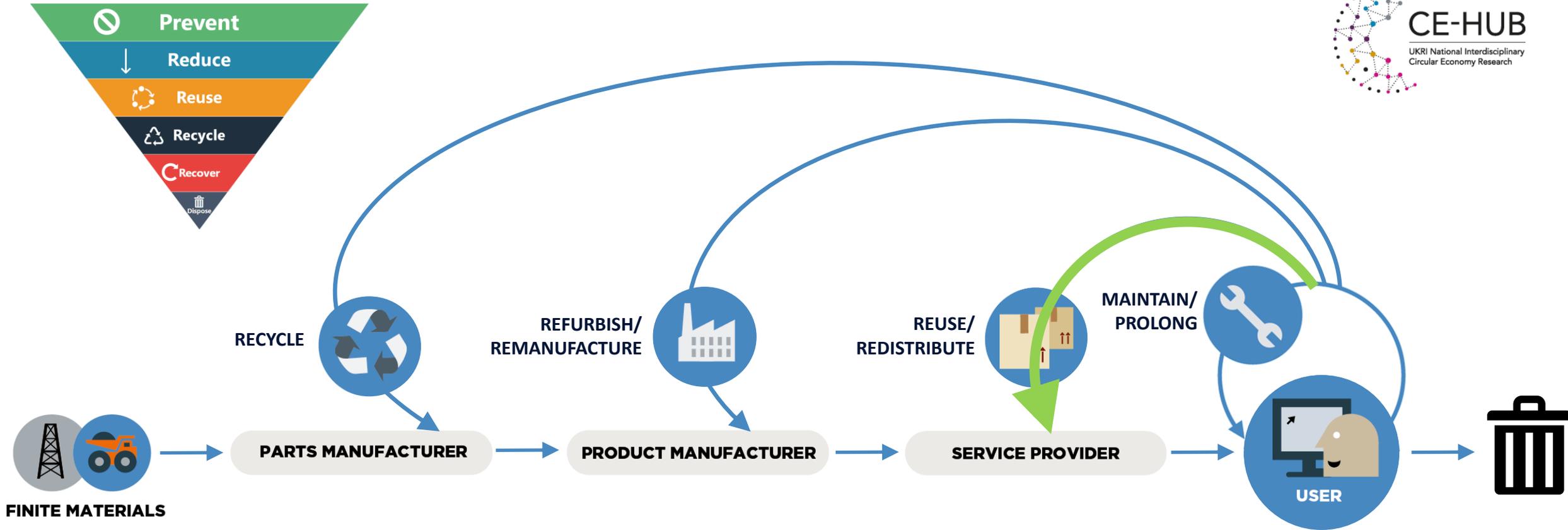
The methodological framework of ViTAL Experimentations.

Doing the science with **stakeholders embedded** means we can **identify the challenges** that are important to them.

- ❖ Energy Security in Defence
- ❖ UK's Sustainability and Defence Goals
- ❖ Collaboration and Stakeholder-Driven Science
- ❖ Innovation and Technological Advancement
- ❖ Real-World Challenges
- ❖ **Circularity and Sustainability**



# The Circular Economy



By implementing a device designed for end-of-life reusability, and by offering a service that facilitates this reuse, we effectively close the loop for a circular economy



## Resource Security

- Mitigates risks associated with global supply chain reductions



## Drives Innovation

- Advancement in materials science, recycling and repair technologies for defence



## Long-Term Readiness

- Extends equipment lifecycle to ensure operational capability



## Sustainability

- Aligns defence operations with sustainability goals



## Cost Effectiveness

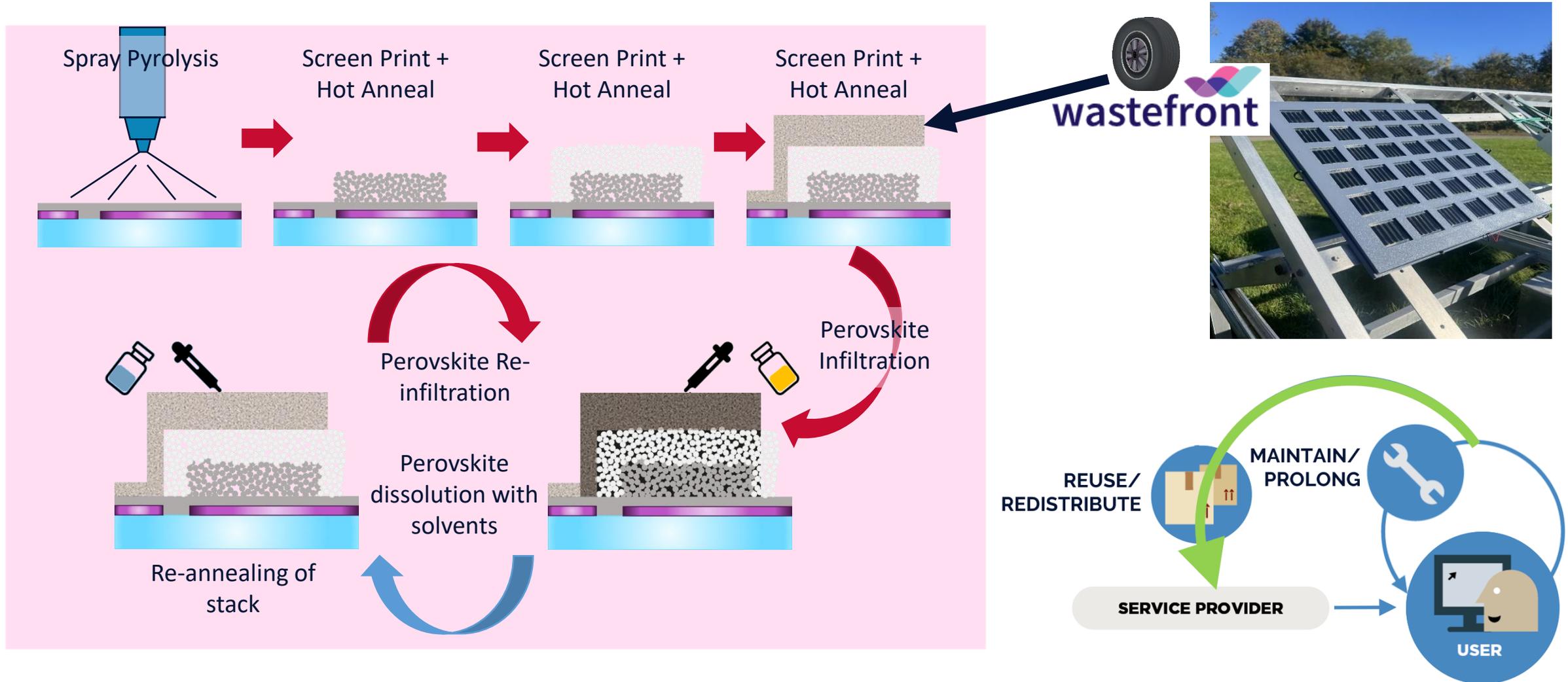
- Reduces procurement and disposal costs through resource repurposing



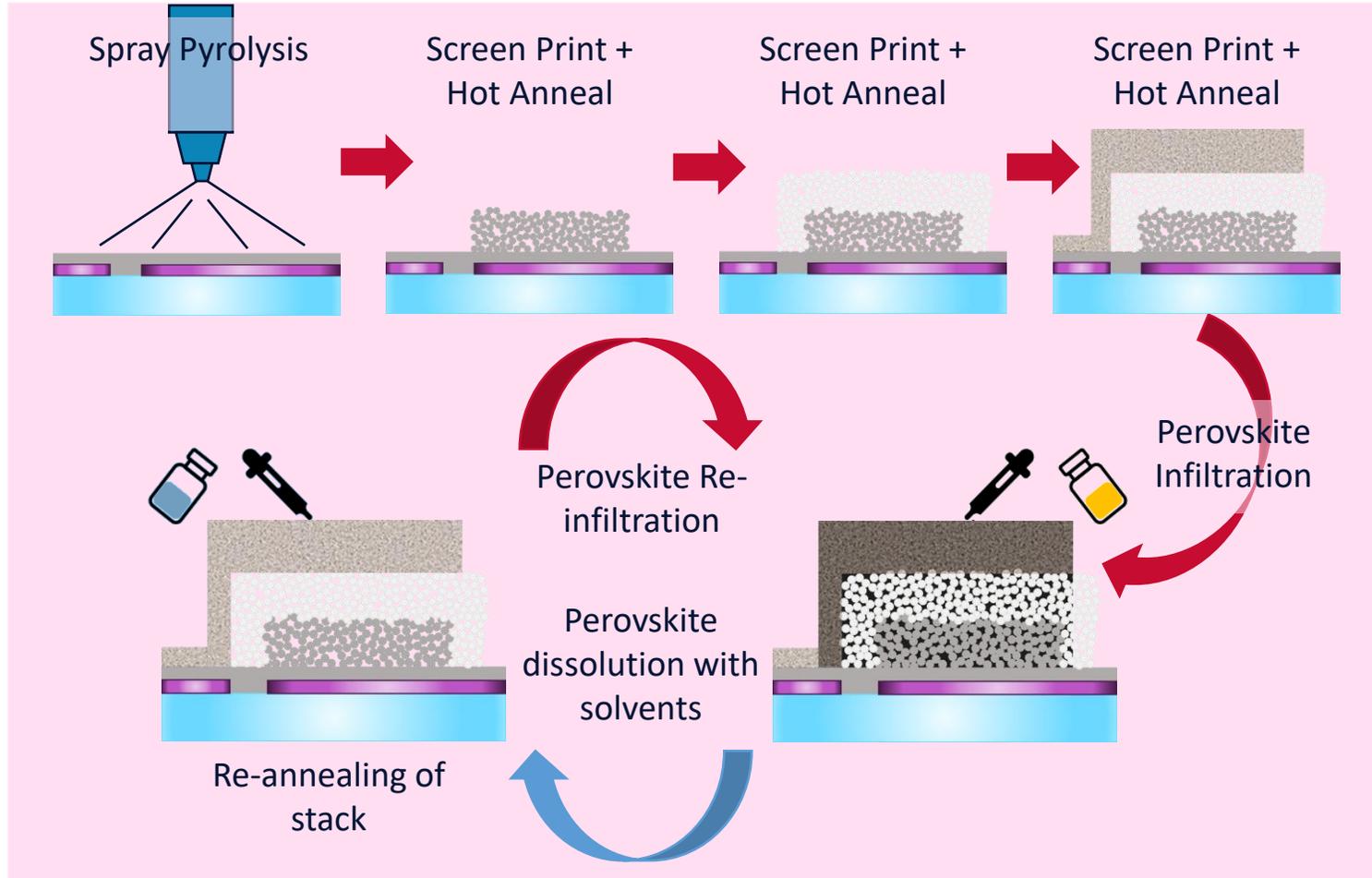
## Self-Sufficiency

- Reduces reliance on external resources to enable independent operations

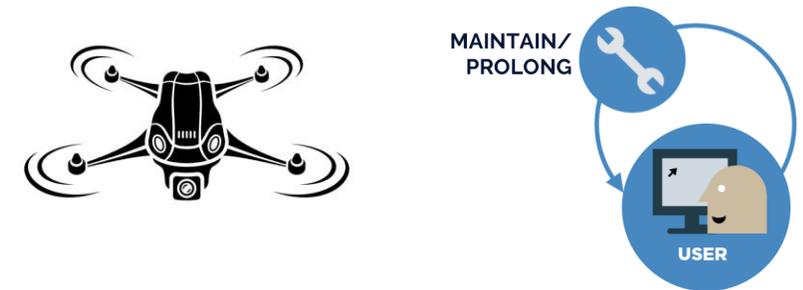
# Project ViTAL: Case Study



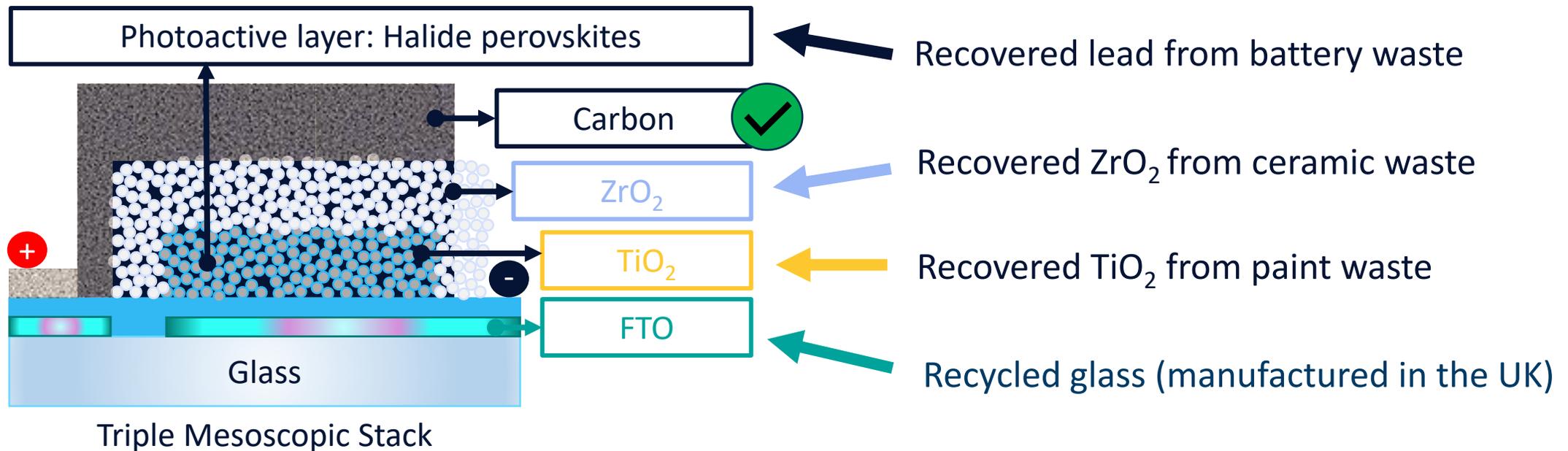
# Project ViTAL: Case Study



Project ViTAL outdoor data has uncovered a mechanism to maintain and extend the lifespan of the devices!



Are we able to fabricate an emerging PV in the UK using waste streams to ensure circularity and energy security?



# Acknowledgements



Prof. Elizabeth Gibson  
Solar Project Lead  
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Dr Susana Iglesias-Porras  
Solar Project RA



RAF Leeming  
Project ViTAL



ViTAL Living Lab  
Project Team  
September 2024



**Thank you**  
**Any questions?**



Peak output of solar panel under ideal conditions (when exposed to direct sunlight at  $1000 \text{ W/m}^2$ )



## For our silicon panels:

- Silicon panel 400 W of peak power with  $1.94 \text{ m}^2$
- 4 panels =  $7.76 \text{ m}^2 = 1.6 \text{ kW}$
- Peak power density =  $206.2 \text{ W/m}^2$
- Cost of 4 panels = £756



## For circular emerging PV technology:

- Good minimodule (12.87%) 0.772 W of peak power with  $60.08 \text{ cm}^2$  [1]
- 1 panel seen in picture ( $0.252 \text{ m}^2$ ) = 32.47 W
- For same area as silicon system,  $7.76 \text{ m}^2 \approx 1 \text{ kW}$
- Peak power density =  $128.77 \text{ W/m}^2$
- Area of emerging system =  $12.43 \text{ m}^2$
- At  $£40/\text{m}^2$  [2], cost of emerging system to provide 1.6 kW = £497.20

\*\* general estimate for perovskite module production hovers around \$40-\$50 per square meter, assuming similar efficiencies and economies of scale as other perovskite technologies. (ACS Energy Lett. 2022, 7, 9, 3039–3044)

[1] Nano Energy, 2020, 74, 204842 (<https://doi.org/10.1016/j.nanoen.2020.104842>)

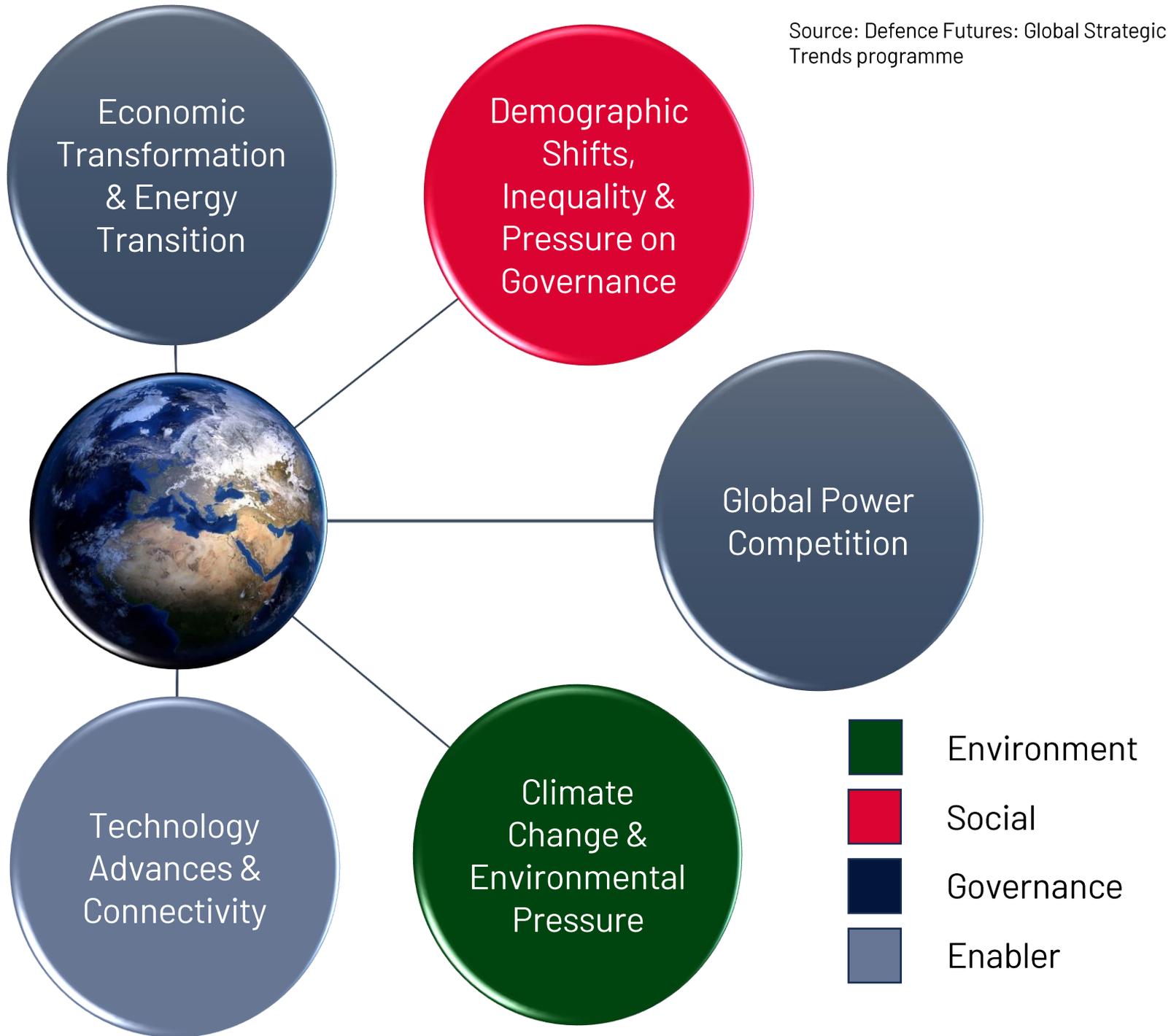
[2] ACS Energy Lett. 2022, 7, 9, 3039–3044 (<https://doi.org/10.1021/acseenergylett.2c01728>)

# Navigating the Future: The Royal Navy's Strategic Response to the Maritime Energy Transition

**Lisa Hammock**

**RN Head Climate Change & Sustainability**





# Global Megatrends

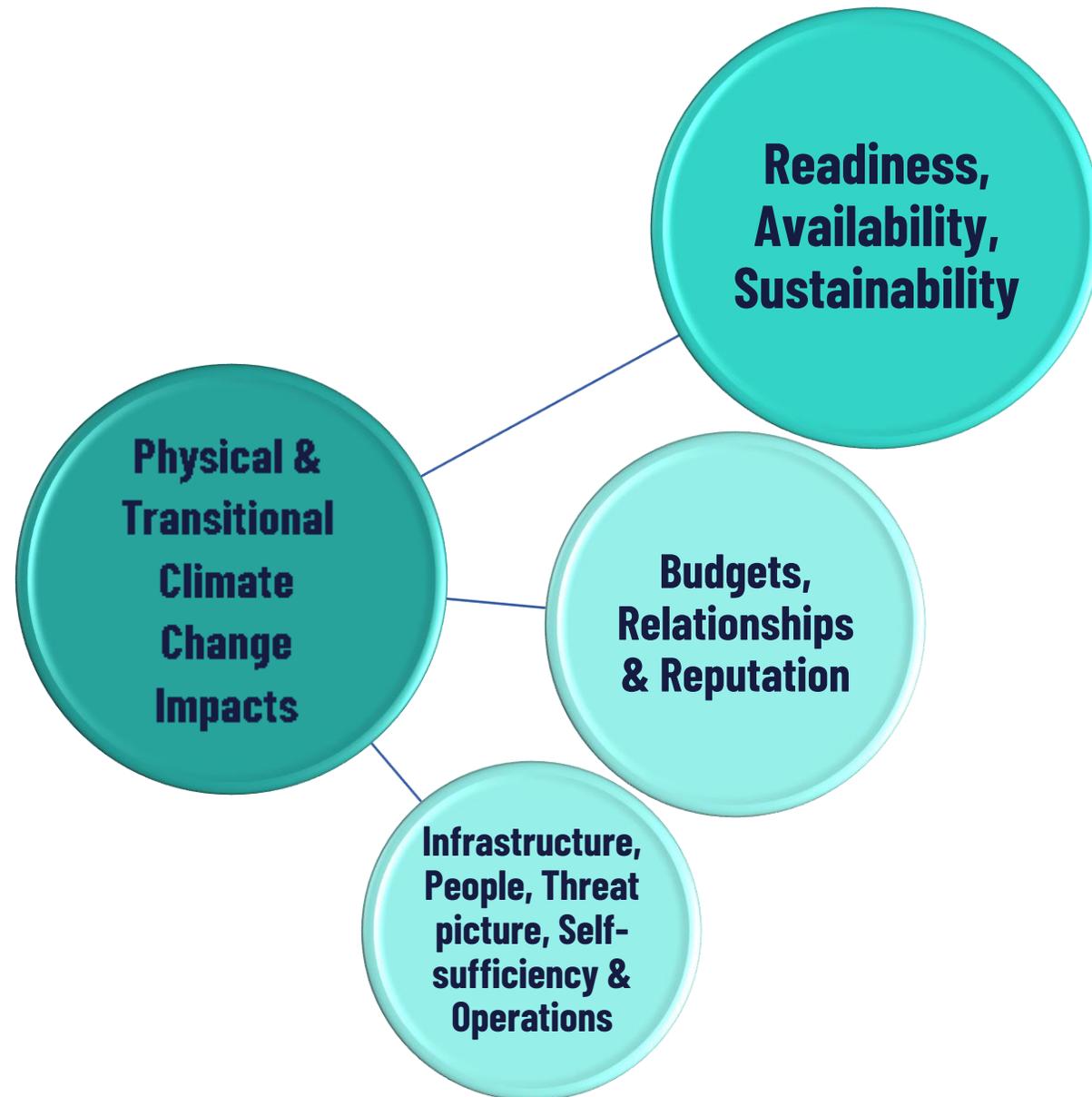
**Complex dynamics redefining:**

- The natural World
- Economies
- Governance
- Security
- Defence

# How does climate change impact the Royal Navy?

## Ultimately:

- **adds complication** to the existing complexity of maritime operations;
- **amplifies risks** to key success factors of Readiness, Available and Sustainable.



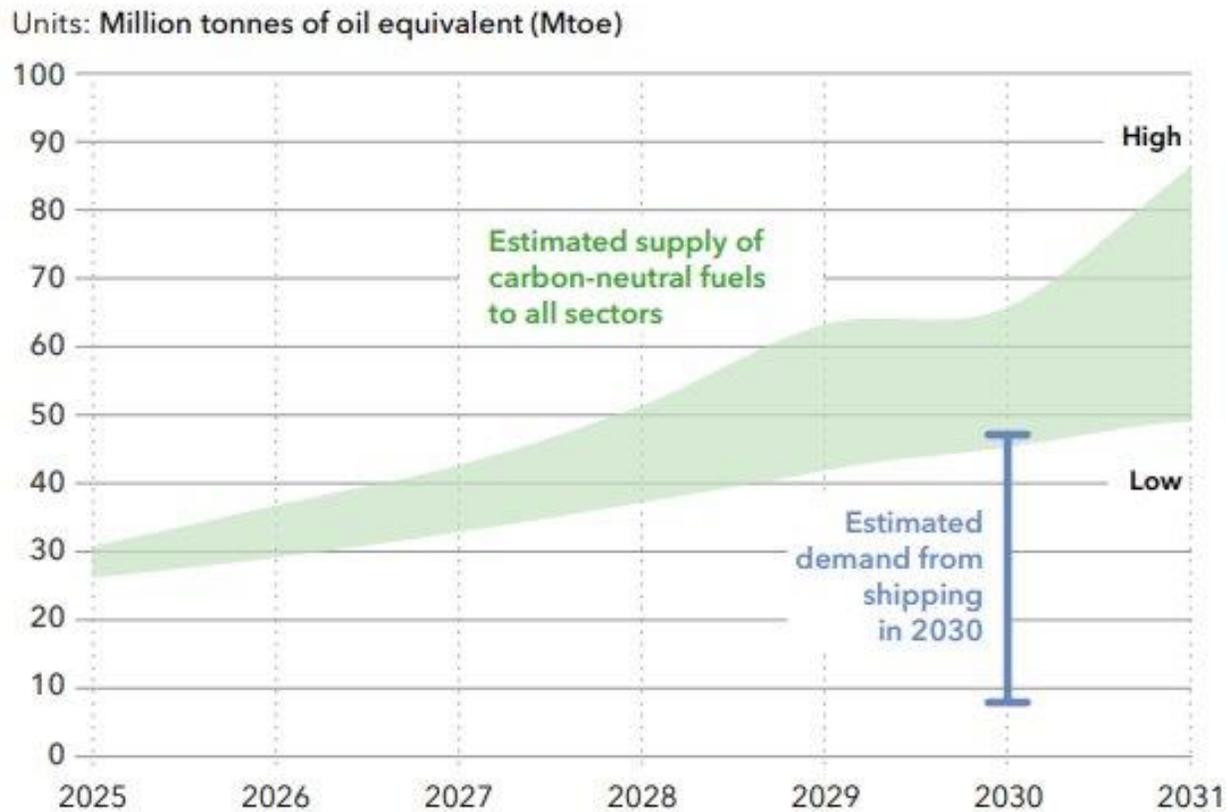
# Maritime Fuel

- Renewable
- Electric
- Diesel
  - Fossil Fuel
  - Bio
  - Synthetic
- Hydrogen
- Methanol
- Nuclear
- Ammonia

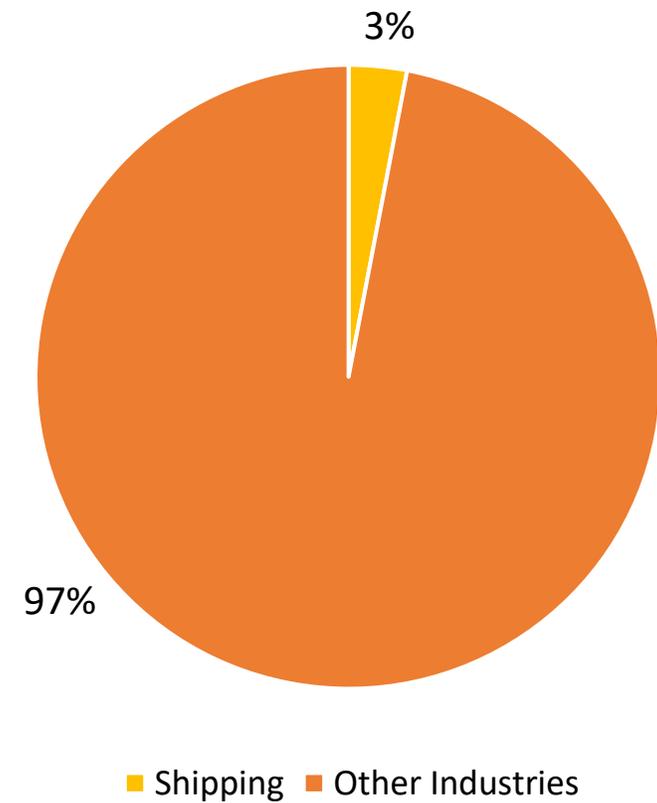


# Maritime Future Fuel Use

Estimated supply of carbon-neutral fuels to all sectors



Distribution of Global Energy Use



## RESILIENCE – Readiness, Available, Sustainable

ADAPTATION  
– Managing  
unavoidable  
impacts

MITIGATION –  
Avoiding  
manageable  
impacts

### GUIDING PRINCIPLES

Resilient

Innovative

Evidenced

### RESILIENCE ACTION PLANS

Estates

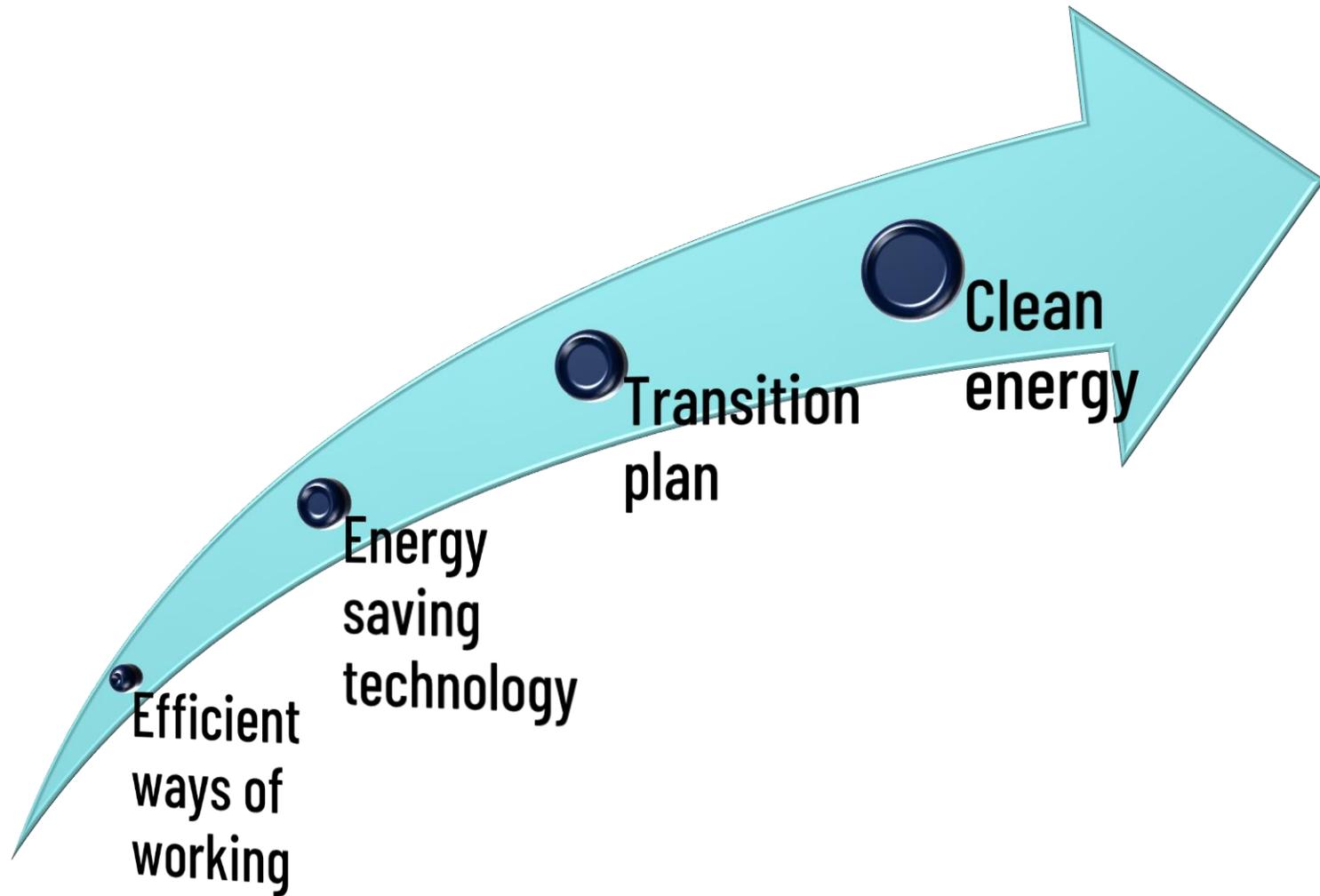
Operational  
Capability

Value Chain

## The RN CC&S Phase 2 Plan

Resilience Action Plans (RAPs) will reflect our responses to the changing landscape.

RAPs will cover both adaptation and mitigation activities.



# Decarbonisation Approach

Considers operations and assets.

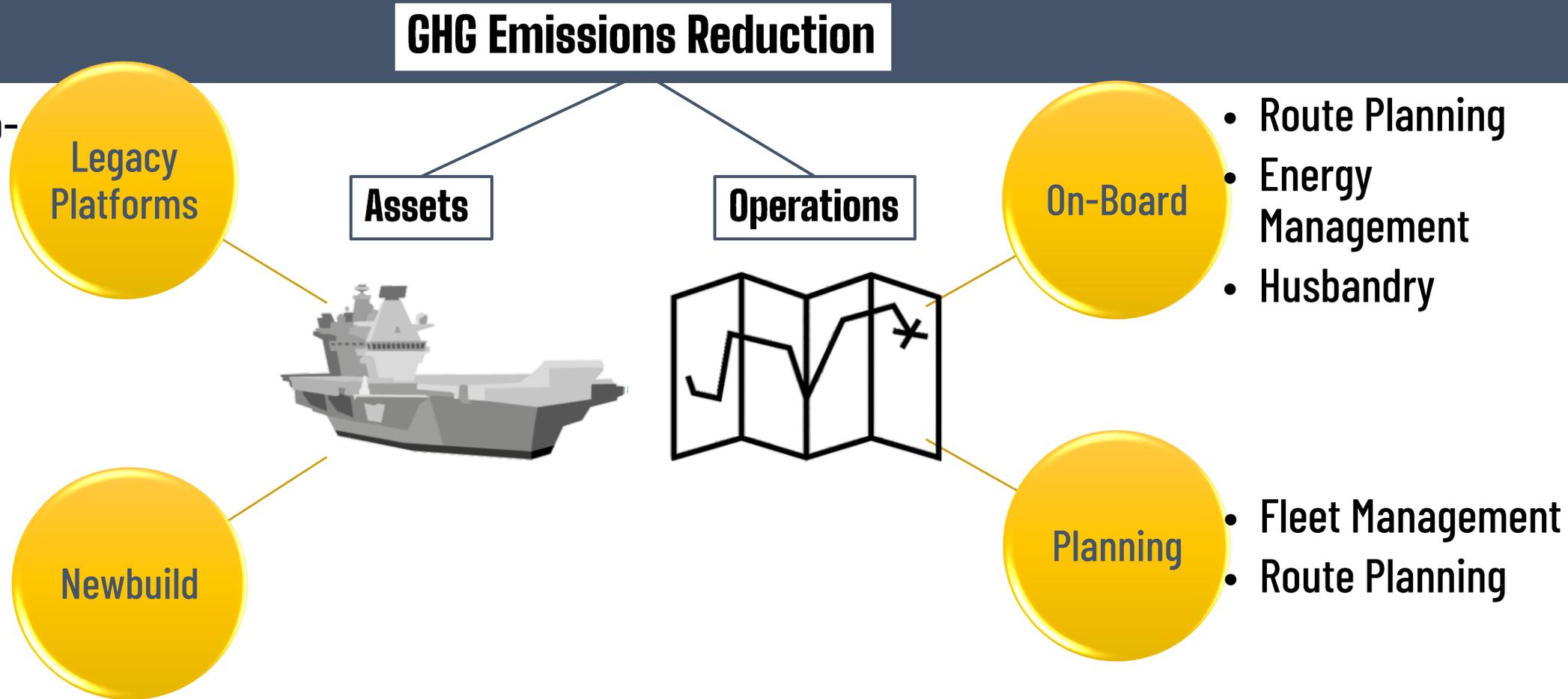
Legacy platforms & new procurements.

Fleet management and on-board energy management.

Future energy shift.

# GHG Emissions Reduction Options

- Energy Saving Technology
- Sustainable Drop-in Fuels
- P&P Upgrades
- Low GHG Refrigerant
- Energy Saving Technology
- Hull Form
- Adaptable P&P
- Low GHG Refrigerant



- Route Planning
- Energy Management
- Husbandry

- Fleet Management
- Route Planning



Ministry of Defence

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