DMAC
Decarbonising the Midlands Aerospace Cluster
Summary of Programme Results and Recommendations

June 2025

Local Industrial Decarbonisation Plans (LIDP)
DESNZ / IUK Programme
Project number: 10090207

Funded by UK Government

Innovate UK

Issue No.	Date	Reason / Changes
1	27 Feb 2025	First Issue
2	17 Apr 2025	Forging information updated following inputs received at the DMAC dissemination event on 27th Feb 2025, including updates to the emission burn-down charts. IUK DESNZ LIDP grant funding corrected from £5 to £6 million.
3	10 Jun 2025	Minor amendments (rephrasing, typos etc.)

Contents

1. Summary

The DMAC (Decarbonising the Midlands Aerospace Cluster) project was launched in January 2024 with the primary objective of defining a decarbonisation strategy for the Midlands aerospace supply chain, which consists of nearly 600 dispersed sites spread across the region. A detailed 'bottom-up' approach was taken working directly and in depth with the DMAC partner aerospace companies with the intention this would have wider applicability across the cluster. A two-phase emissions reduction strategy has been proposed. Key to the first phase is engagement with the aerospace supply chain, via a local regional body or bodies, to drive the uptake of energy reduction strategies, thereby enabling a 25% reduction in emissions by 2035. Here industry can take the lead. The second phase relies on changes to energy pricing and the region's energy infrastructure. Here, industry relies on the policy environment.

2. Scope and Objective

This report summarises the approach, findings, decarbonisation strategy and implementation recommendations produced by the DMAC project within the UK Department of Energy Security and Net Zero's Local Industrial Decarbonisation Plans (LIDP) programme.

Some of the team members at the first DMAC on-site workshop in January 2024 at ITP Aero, Hucknall.

The DMAC team recognises the support and assistance provided by many other organisations, including:

3. Background

3.1. Local Industrial Decarbonisation Plans (LIDP)

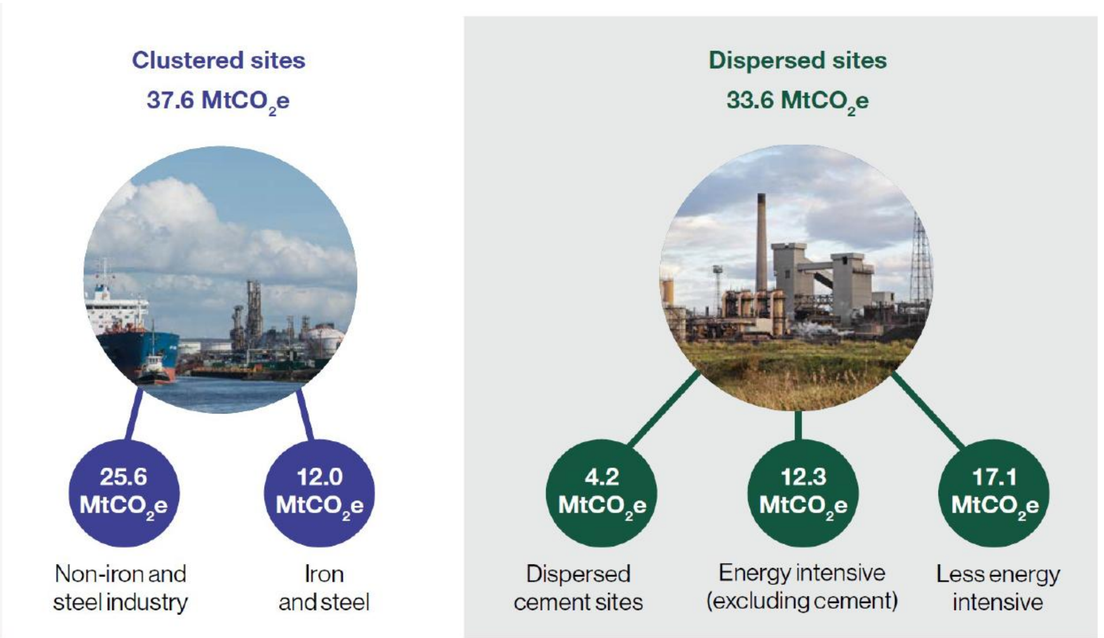
In order to meet the UK's legislation for net-zero greenhouse gas (GHG) emissions by 2050, industrial emissions need to be reduced by at least 90% within that timeframe. It is estimated that nearly half of the UK's industrial GHG emissions are generated by dispersed industrial sites, of which 50% is derived from 'less energy intensive' industry. As such, the Department of Energy Security and Net Zero (DESNZ) launched a new phase of its Local Industrial Decarbonisation Plans (LIDP) initiative focused on such sites.

Innovate UK (IUK), part of UK Research and Innovation, worked with the Department for Energy Security and Net Zero (DESNZ) to invest up to £6 million in grant funding to support the development of strategic, place-based industrial decarbonisation plans for industrial manufacturers located in dispersed sites which could come together to form local clusters.[1]

The LIDP objectives for this phase of funding were:

- To support the development of credible, context-sensitive, strategic plans for decarbonising local industrial clusters.
- To increase organisational collaboration and strengthen decarbonisation planning skills, capacity and capability in local industrial clusters.
- To gather evidence to inform decarbonisation of other local industrial clusters and dispersed sites.

Decarbonising the Midands Aerospace Cluster (DMAC) is one of these LIDP funded projects and was launched in January 2024.



The Industrial Decarbonisation Challenge (IDC) initially targeted geographically tightly clustered sites (left), whereas this phase of the LIDP programme focuses on clusters of more dispersed clusters. Source: IUK

[1] DESNZ was therefore open to proposals from businesses that were not necessarily physically local to one another, but rather dispersed sites that shared common sectoral challenges within a wider region.

3.2. Midlands Aerospace Cluster of Dispersed Manufacturing Sites

Twenty one percent of the approved aerospace manufacturing sites in the UK are located in the Midlands region.[2] These regionally clustered[3] but locally dispersed businesses comprise of a diverse range of companies, both in size and energy consumption.

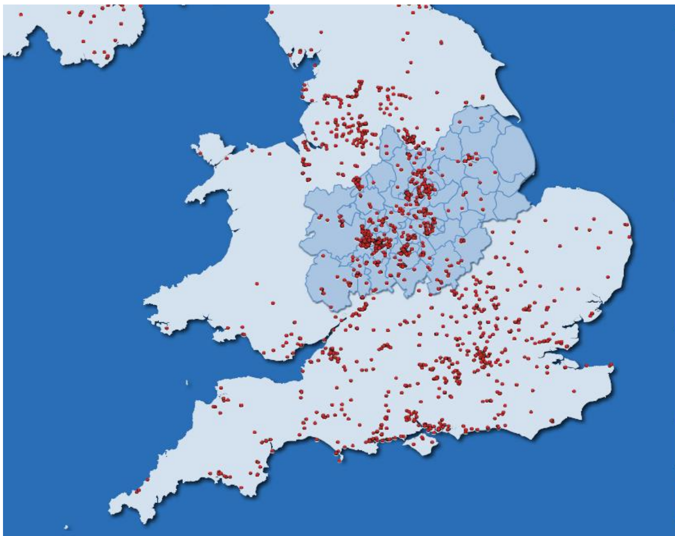


Figure A: The Midlands has 326 AS9100/ AS9110/ AS9120 accredited company sites, 21% of the UK total.

Company Category	Midlands jobs calculation	Individual Midlands companies
A OEMs and Tier 1s	17,753	8
B AS9100 accredited 'Flying Parts' makers	12,020	246
C Other technical specialist suppliers	6,767	290
Total	**36,540**	**524***

Figure B: Companies and jobs across different parts of the specialist supply chain

*A small number of individual companies overlap categories across sites; hence totals do not add up for the number of individual companies.

Over 36,500 people are directly employed in aerospace in the region, yet well over 80% of the sites employ less than 100 people. Over 370 dispersed sites produce aerospace materials, components and systems, with at least 220 additional sites providing specialist equipment and aircraft fleet support.

In the context of decarbonisation initiatives, it is important to understand some of the challenges many aerospace companies face when it is proposed to make improvements to business processes. The aerospace industry is highly regulated and produces safety-critical products. As such, approval is usually required by the design authority customer for any changes to material, design and manufacturing process. For critical components, both the design and precise manufacturing processes may be frozen[4]. Justification for change can range from demonstrating equivalence with a simple set of component sample tests (such as producing cut-up samples to compare the metallurgy before and after change, mechanical property tests etc) to a full re-certification programme with flight tests and the change to the 'type design'[5], with all the associated records and reports. In other words, dependent upon the product, its function and application, the cost of change can range from a few thousand pounds to millions, for which a suitable business case would be required.

[2] "Insights: Aerospace in the Midlands" report by Midlands Aerospace Alliance & Midlands Engine Observatory, 2024.
[3] The term 'regional cluster' is used to differentiate from the DESNZ use of 'cluster' when referring to more integrated, local industrial clusters.
[4] 'Frozen' operations or processes are defined as part of the certification process, and these cannot be altered without design authority approval given appropriate levels of substantiation and supporting evidence, often involving testing etc; approval is not assured.
[5] 'Type design' for a product or sub-system for a certified aircraft or engine is essentially all the information that is required to define that product, such as the drawings (including dimensions, materials and processes), specifications, configuration details etc.

Typically aerospace specifies its own range of materials with tightly controlled properties and grades. This has become necessary to maximise the desirable properties for a given weight of material as well as minimising variation, to ensure that minimal material is required to provide safe solutions. While weight reduction benefits downstream Scope 3 emissions, the additional material processing tends to result in a larger upstream Scope 3 emissions footprint when compared to other sectors, such as automotive.[6]

While the above considerations are relevant to aerospace globally, the Midlands cluster is characterised by an especially diverse range of product and manufacturing technologies. As indicated by the diagram below, all tiers of the aerospace supply chain are catered for, from production of specialist aerospace grade materials, through to component, product and complete systems, including Rolls-Royce aero engines. This scope includes products made from specialist metal alloys, composites, ceramics and electronics and safety critical equipment systems, including control solutions for engines, actuation for flight surfaces, braking, thermal management, etc.

In summary, the Midlands aerospace regional cluster consists of over 590 dispersed sites, of which well over 80% employ less than 100 people. There is a diverse range of manufacturing processes, and not surprisingly this is mirrored by the variation in each site's energy consumption.

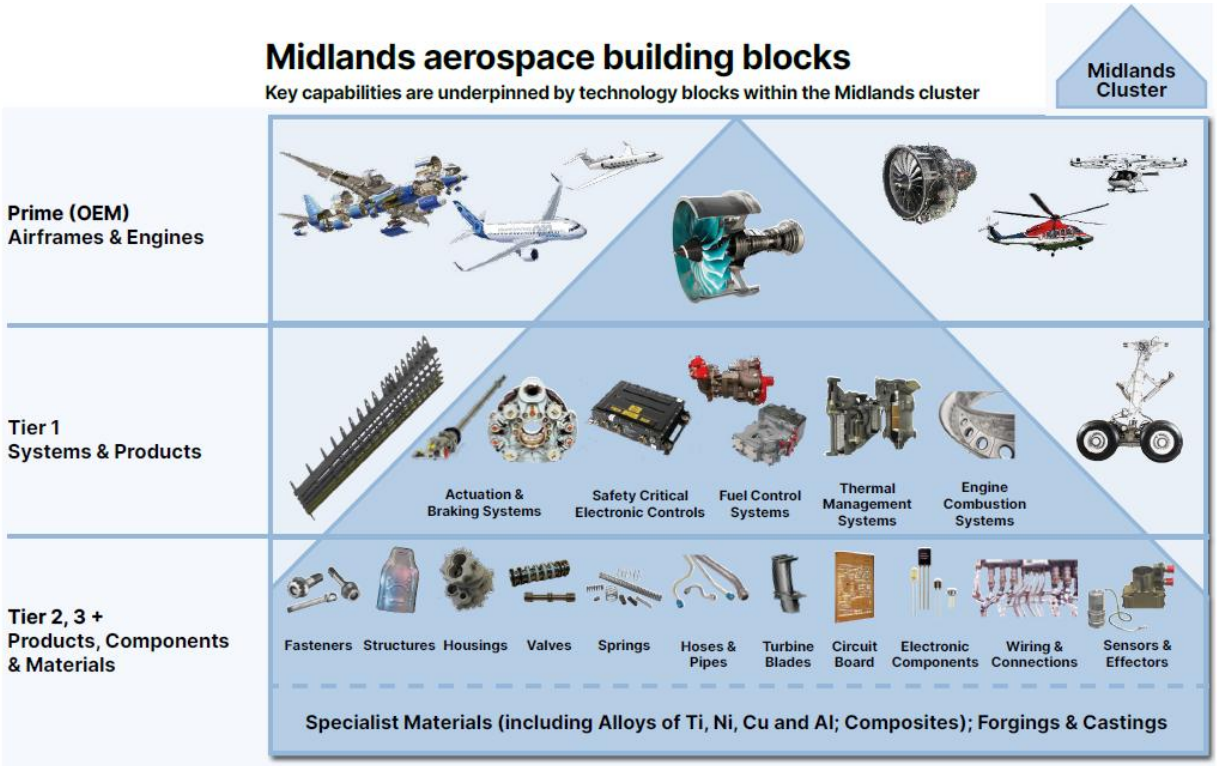


Figure C: The Midlands hosts a wide range of high-value engineering, including high energy consumption processes such as specialist alloy material production, forging and casting as well as other high value manufacturing capabilities including precision machining, fabrication, electronics and composites.

[6] A HVM Catapult study found that aerospace material processing was 60% of supply-chain product emissions, whereas for automotive it was 46%. Reference: "Scope 3 emissions: what about the total supply chain? – Aerospace Sector Overview" presented by Professor Sam Turner, High Value Manufacturing Catapult at 'Jet Zero Midlands' MAA / University of Nottingham Aerospace UP event held on 27th January 2022.

3.3. Decarbonising the Midlands Aerospace Cluster (DMAC) programme

The primary objective of the DMAC programme was to understand how the Midlands aerospace cluster could achieve Net Zero in its manufacturing and supply chains operations by 2050.

Given the size, breadth and depth of the aerospace sector in the Midlands, for this planning phase, the scope was kept to the manufacturing supply chain for metal alloy components and products which form the core of the Midlands aerospace cluster; hence project partners comprise of companies in this sector. Furthermore, the project was instructed to restrict its focus to Scope 1 & 2 sources of GHG emissions, thus setting aside the obviously significant Scope 3 'tailpipe' emissions produced by aircraft in service to focus on emissions supply chain companies were more likely to be able to act upon.[7]

The DMAC deliverables included:

- GHG emissions baseline & fly-forward
- Potential solutions to achieving Net Zero by 2050
- A credible strategic plan, highlighting further areas of research, implementation projects and a re-useable methodology to extend to other high-value manufacturing supply chains, be it within or outside of aerospace.

The approach taken was for the partner aerospace supply chain companies to work together to understand the current status, the opportunities, the lessons learned and the challenges in achieving Net Zero. Different approaches (be it for solutions to reducing emissions or processes for recording and analysing emissions data, such as trialling both manual and AI-assisted product life cycle assessments) and case studies were undertaken. As such, DMAC takes the industrial perspective as recipients of energy, considering both the business and environmental needs. While the project assessed energy needs and met with regional energy infrastructure organisations, it naturally touched upon but did not directly venture into defining energy infrastructure and pricing solutions.

The programme was structured into two phases in conjunction with a parallel dissemination & engagement workpackage that sought to amplify its impact. The first phase was focused on establishing a baseline for GHG emissions for the partners and collating recommendations for how the supply chain most effectively progresses on its decarbonisation journey. The second phase developed a series of real-world case-studies to evaluate emission reduction approaches and produced a fly-forward reduction plan out to 2050, recording the assumptions and challenges. The team worked together via a number of in-person workshops; the key ones are listed below.

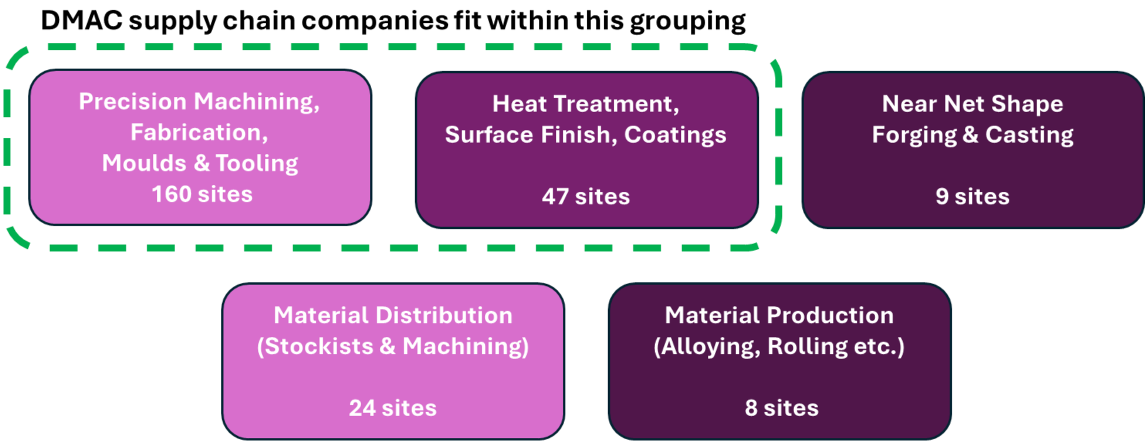
Date	Workshop Theme	Location	Comments
18.01.24	Post-Launch Workshop	ITP Aero Hucknall	Scope 1 & 2 emissions baseline
27.02.24	Upstream Scope 3 Emissions	Collins Aerospace Wolverhampton	Explored challenges and case study solutions
28.03.24	Product Emissions (Lifecycle Assessment)	G&O Springs Redditch	Produced manual LCA, and trialled 'component stream mapping' method
21.05.24	Product Emissions (Lifecycle Assessment)	Collins Aerospace Wolverhampton	Produced manual LCA, and trialled 'component stream mapping' method
19.06.24	Product Emissions (Lifecycle Assessment)	G&O Springs Redditch	Unipart & EmVide demonstrated its AI-assisted software solution
24.09.24	Case Studies & Emissions Reduction Solutions	Helix Milton Keynes	Collated Case Studies from partners & agreed report content

[7] Stated at DMAC Quarterly Management Review #3, 8th October 2024, ref DMAC Consortium Q4 Report, 7th January 2025 Issue 2.

4. Energy Consumption and GHG Emissions: Current State

The six DMAC industry partners consist of two relatively large Tier 1 companies and four supply chain companies, the majority being in precision manufacturing. To add to the detailed information, partner company ASG agreed to include a further 7 sites within its organisation, including one facility dedicated to heat treatment, and Helix included its 3 UK sites.

In terms of DESNZ's industrial 'archetype' definition[8] for industrial sites, the majority of the Midlands aerospace companies fall into Archetype 1 or 3. About half the DMAC team are type '3' with 'high temperature' processes above 240 ^{O}C. While each supply chain site on average only consumes 740 MWh per annum of gas and electric energy, the aerospace sector alone hosts over 200 similar business, of which nearly 50 specialise in heat treatment and tend to consume more energy. Conversely the region only has 6 forging companies, but one site consumes about 135,517 MWh a year, some 183 times greater than the DMAC average. (Note, these numbers exclude the region's five large Tier 1 and Prime sites in the region.) Consequently, it was decided to obtain data for the more energy intensive sites within the Midlands supply chain, including aerospace metal production,[9] forging and casting businesses. This topic is covered in more detail in Appendix 8.3.



Simplified representation of the Midlands metal alloy supply chain
[Darker colours imply higher energy intensity.]

Energy utilisation and the energy costs as a proportion of the cost of sales (CoS) go hand in hand. Hence, for precision machining, sites without significant heat treatment facilities, energy is typically <10% CoS, whereas the figure for a heat treatment facility can be approaching 20%. Moving to more energy intensive processes, estimates[10] for forging and metal production facilities indicate a range of 50% to >70% CoS. This measure is indicative of the sensitivity of a business' profits to energy prices.[11]

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[8] For 'dispersed sites' there are two archetypes, namely '1' with low temperature (<240 ^{O}C) processes, and '3' with high temperature (>240 ^{O}C) (particularly direct fired) processes, ref. "Enabling Industrial Electrification – Call for evidence on fuel-switching to electricity. Summary of responses." Department for Energy Security & Net Zero, September 2024.
[9] The Midlands aerospace supply chain includes both metal producers and distributors; typically the former perform alloying to produce specific aerospace grade materials, or may roll material for form sheet material, whereas the latter generally sizes (machines) billets and/or cuts sheets to size, the former being much more energy intensive than the latter.
[10] Estimates derived from Full Accounts of representative companies via Companies House.
[11] Gross profit being Turnover less Cost of Sales (CoS)

5. Emissions Fly-forward

The energy usage and Scopes 1 & 2 GHG emissions data for the Midlands metal alloy aerospace supply chain, excluding Tier 1 and Prime companies, was used to create a 2023 baseline, described in Appendix 8.3. From this, an emissions reduction strategy was devised, broken down into 2 phases.

Phase 1: Reduce Energy Consumption[12] (2025 to 2030 and beyond)

This first phase predominantly consists of energy reduction measures. Many such approaches were assessed as part of the DMAC case studies, summarised in Appendix 8.2. The starting point is typically understanding how energy is used – and wasted – during the daily operations; data is key.

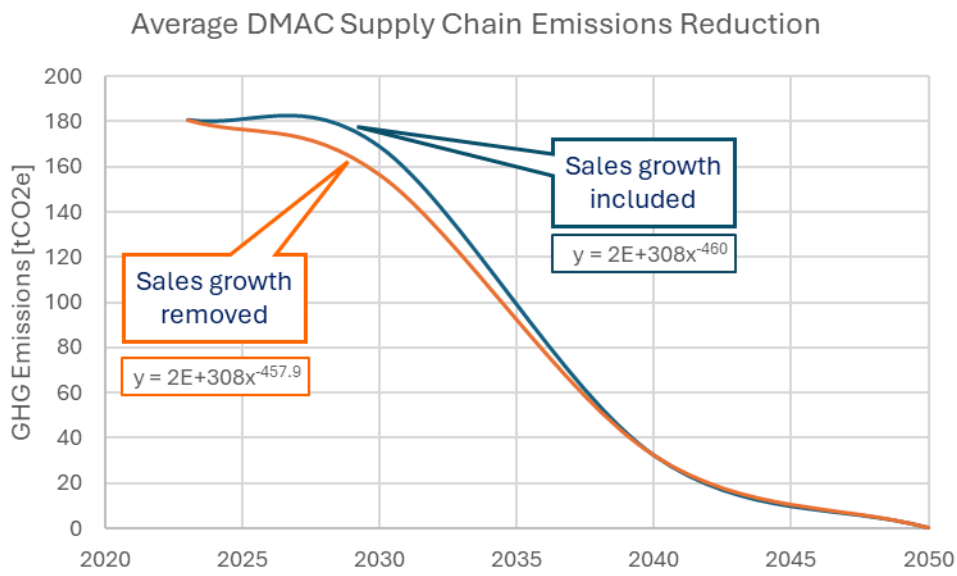
Once engaged and with the insights into how energy is wasted, we have seen how companies have introduced quick fixes, such as behavioural practices (e.g. 'switching off' equipment when not in use), and made investment cases to reduce heat loss from buildings, replace inefficient equipment and/or improve monitoring systems etc.

DMAC experience is that when first initiated, reductions in energy of order 15% are readily achieved. While subsequent reductions tend to be less dramatic, they are still financially beneficial to the business.[13] Furthermore, DMAC has also shown that companies with access to accurate energy data can readily convert this to GHG emissions, enabling decisions to be made on environmental grounds and preparing the company for the impending customer requests for emissions data.

However, to enact this Phase 1 strategy, site engagement needs to be accelerated. Based on MAA and DMAC surveys, at least 50% of supply chain sites are yet to get started on this journey, but, as demonstrated on DMAC, once engaged, catch-up can be rapid. The challenge is engaging with hundreds of small dispersed sites in the region; this is where local regional bodies and trade associations are best placed to deliver this phase.

While it is assumed more companies reduce Scope 2 emissions through access to 'green' electricity, for Scope 1, replacement of natural gas is limited during this phase, especially for the high consumers, where the energy price has a dramatic impact on cost of sales. Indeed, for certain sectors, we predict an increase in gas consumption. One forging company is able to reduce its energy costs by investing in two 3 MW CHPs that are powered by natural gas; not only will waste heat be used for office heating, but the CHPs will be used to produce electricity on-site, thereby reducing its grid demand and associated costs of electricity. For energy intensive companies, this makes good financial sense, but clearly increasing gas consumption when electricity is increasingly green is counter to reducing GHG emissions in the economy as a whole.

[12] Reductions for a given factory output – i.e. energy efficiency measures.
[13] This trend for declining gain in reductions has been considered in the emissions fly-forward forecast.



The effect of growth in sales on emissions was modelled for the DMAC supply chain.

There is a headwind – a nice-to-have challenge – of growth in aerospace sales which alone would increase annual emissions. Despite the DMAC team being engaged on this decarbonisation journey, many still predicted a slight increase in GHG emissions during the first 15 years due to this growth, as shown above.

These insights from the project have been reflected in the DMAC model which relies on local intervention to accelerate the take-up of energy reduction and emissions reporting, and Scope 2 reduction is assisted by further availability and uptake of green electricity. However, these are countered by the 'resilience' of natural gas, driven largely by energy pricing, especially in the more energy intensive sites, and increases in production to mirror the growth in sales. As such, by 2035, Phase 1 is predicted to achieve approximately a 25% reduction in emissions from the 2023 baseline.

Phase 2: Convert to 'Green' Energy (2035 and beyond)

The second phase of the DMAC strategy is to convert – primarily natural gas processes – to a green energy solution, be it electric or a mix of electric and hydrogen. The reductions in emissions from this phase are largely delayed till 2035, in order to permit time for the necessary changes to energy infrastructure, operations and pricing; this is an assumption made based on an initial engagement with the UK energy production infrastructure and the project has not assessed whether this is a reasonable expectation.

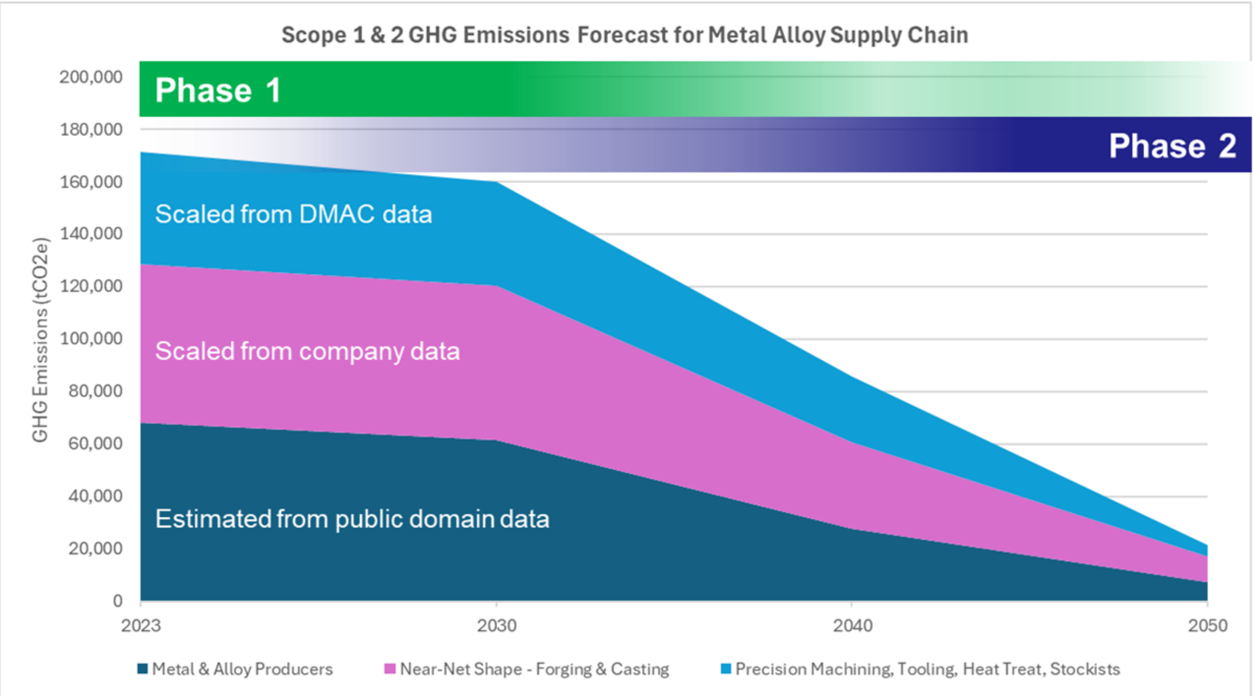
The DMAC team investigated a range of manufacturing processes that combust natural gas today and concluded that these could 'technically' be converted to electric solutions, albeit with potential reductions in efficiency for certain processes (refer to CS.6 in Appendix 8.2). It is recommended that guidelines are produced on optimal heating solutions for industrial buildings of different age, construction and use. However, the DMAC strategy assumes that affordable green-energy solutions become available during this phase.

It would not be possible for all dispersed sites assessed during DMAC to become self-sufficient through on-site generation and storage of green energy, primarily because of available area and space. When factory space was used to provide electrical storage for PV panels, it consumed the same space as a new machining centre; given the long-term growth of the aerospace industry globally and the demand for increased production rates, not everyone in the business supported this decision to store energy on site.

Therefore, the adequate supply of green energy that is competitively priced (when compared to global prices) is fundamental to any industrial emissions reduction strategy. As described, maintaining high energy prices will promote 'economic sustainability' initiatives rather than environmental ones.

Discussions on hydrogen networks in the Midlands concluded that with a high degree of uncertainty, these might appear in the region - first in East Midlands - but the possible dates are deemed too late for the 2050 requirement. Therefore, we have assumed an 'all-green-electric' solution. However, government forecasts on energy prices updated in November 2023 show that electricity will remain significantly more expensive than natural gas out into 2050, with the 'central' data maintaining a factor of 4. If this becomes reality, the DMAC-predicted reduction in emissions cannot be achieved; furthermore, there is a high likelihood that the UK will lose more high energy-intensity sites as production is moved overseas.[14]

Primary Capability	Number of sites	% Total Emissions 2023	% Scope 1 Emissions 2023	% Scope 2 Emissions 2023	% Reduction by 2050
Metal & Alloy Producers	8	40%	37%	43%	90%
Near-Net Shape - Forging & Casting	9	35%	52%	15%	84%
Precision Machining, Tooling, Heat Treat, Stockists	231	25%	11%	42%	90%
	248				



14 Since the IETF 22043 and 23036 studies into waste heat recovery in UK forging industry were completed in 2024, two of the forging companies have ceased trading in the UK, one due to cost of operations, investment needs and cost competitiveness, the other due to a strategic, but cost-based, decision to source all forgings from a low-cost economy.

6. DMAC Strategy Implementation

This is a highly diverse and dispersed supply chain with over 590 sites, the majority of which are medium or small companies, and many of which have not yet set out on the journey to proactively reduce both energy consumption and GHG emissions. Aerospace supply chains are highly structured, and intersect with other industries such as automotive, thus offering good opportunities for industry coordination. At the same time, the pace of change in aerospace can be relatively slow. It is proposed to use the MAA's proven track record as a regional body of engagement with this community, and the strong foundation provided by the current DMAC programme, to accelerate action.

Furthermore, on the back of the success of DMAC, we propose to extend the scope to engage additional, inter-related sectors in the region's dispersed high value manufacturing companies, working with other RTOs such as Manufacturing Technology Centre (MTC) and Warwick Manufacturing Group (WMG) [both are part of the HVM Catapult] and existing support networks that the MAA is already engaged with. Using this network, the MAA will ensure alignment to customer, sector & legal requirements (including preparation for CBAM (Carbon Border Adjustment Mechanism) requirements and ensure companies benefit from a consistent approach and those lessons learned and captured under DMAC.

As such, the Phase 1 DMAC strategy consists of three related workpackages as follows:

Phase 1.1 Extend the detailed regional mapping of industrial energy types and consumption.
The MAA will develop a more complete regional map of energy consumption and emissions by continuing with the DMAC questionnaire and engaging directly with companies to perform site-by-site assessments and emission reduction plans, broadening the scope to include other product and material types, such as composites, electronics etc, as well as further developing the reduction strategy directly with the high intensity metal alloy supply chain.

Phase 1.2 A regional programme of support for the supply chain to drive emissions reduction and reporting.
Building on the approach and lessons learned in DMAC, this programme will provide training and sharing of best practice and proven methodologies to help industry reduce energy costs and emissions, and enable companies to efficiently support both customer and legal requirements where applicable, such as CBAM.

Phase 1.3 Detailed assessment of viable solutions for Scope 1 emissions reduction in Phase 2.
This activity will support both Phase 1 and the subsequent Phase 2 strategy by building on the initial DMAC feasibility study for the conversion of HVM processes and building heating systems that are today dependent upon fossil fuel (e.g. natural gas). The MAA will work with industry, especially the more energy intensive dispersed sites, and technical experts, alliances, sector bodies and energy infrastructure organisations to provide robust recommendations and reduction forecasts. For aerospace companies, there will also be an impact assessment for the approvals, re-qualification and even re-certification due to changes in manufacturing processes.

7. Conclusions

The 'bottom-up' DMAC approach of direct engagement with supply chain companies and their customers has provided insight into the opportunities and issues facing a range of businesses. DMAC has demonstrated that this approach can work and provide detailed information on energy types, consumption and uses, and the opportunities and challenges for achieving net zero.

A two-phase decarbonisation strategy has been proposed that relies on two key aspects, namely:

- For Phase 1, engagement with dispersed sites to drive energy optimisation & emissions reduction;
- For Phase 2, changes to energy pricing, infrastructure and operations.

It has been recommended that this regional approach is continued, extending the scope into both the full aerospace supply chain, working more closely with the more energy intensive sites and extending this to dispersed sites in other high value manufacturing sectors.

8. Appendices

8.1. DMAC Partners

The DMAC team comprises of the MAA with six industrial partners, two Tier 1's and four supply chain businesses (three established aerospace companies, one new sector entrant),here at their meeting at Tier 1 Collins Aerospace in Wolverhampton.

ASG Arrowsmith Engineering
Founded in 1967 and joining the ASG group in 2017, ASG Arrowsmith Engineering specialises in the manufacture of precision components, principally aero engine components in the aerospace industry. We are an AS9100, ISO14001 and Nadcap approved company with a highly skilled workforce providing CNC turning, milling, thread rolling and grinding machining services. We manufacture both large and small volume production runs in Nimonic, titanium, stainless steel, magnesium and plastics, and provide specialist support services such as NDT and pressure testing. Based in Coventry in a newly constructed 18,000 sq ft HQ with capacity to grow, we have a 'blue chip' customer base and hold the SC21 Silver Award consecutively for 9 years. Since 2019 we have been investing in new machinery and introducing robotic machining cells. The Queen's Award was won in 2020 and the Kings Award in 2024.

Collins Aerospace - an RTX business
Actuation & Propeller Systems (APS) is a global leader in actuation and propeller design and manufacturing for commercial and military aircraft. We have facilities in the UK, Europe, US and North Africa, Canada and Singapore which provide design, manufacture, maintenance and support. Our products range from single actuators to complete flight control systems for fixed wing, rotorcraft and missile segments as well as high power propeller systems, fly-by-wire cockpit and cabin controls, THSA and flight safety parts for helicopters. All our products are serviced by a global network including maintenance, repair and overhaul, spare parts, training, logistics and technical support.

G&O Springs
For over 50 years, G&O Springs has been a precision spring provider for aerospace, defence and safety critical applications, and we are renowned for our class leading quality and on time delivery. We design, manufacture, heat treat and apply special processes in-house, to meet the highest standards including AS9100. Our NADCAP accreditations cover heat treatment, mechanical testing, NDT and chemical processing. At the forefront of spring design, we can produce springs in a wide variety of materials including titanium, Nimonic, Inconel, Hastelloy, Elgiloy, MP35N, stainless steel and carbon steel. All of our springs are designed to be of the highest quality, as efficient and as cost-effective as possible.

Helix
Helix engineers and manufacturers the world's most power-dense motors and complementary inverters for demanding automotive, racing, aerospace, marine and industrial applications. Its unique Scalable Core Technology (SCT) and Flexible Manufacturing Facility (FMF) ensure straightforward access to the most powerful, compact, efficient electric powertrains on the market. Helix Scalable Core Technology is delivered through three strategic Product Levels, while the cycle of electric innovation begun by its founders almost 20 years ago continues with X-Division, an advanced technology development group.

ITP Aero (UK)
ITP Aero is an independent global leader in the design, development, manufacture, and servicing of aero components in both the commercial aviation and defence industries with more than 5,000 employees across facilities in Spain, UK, Mexico, USA, Malta and India. Over the last 35 years, ITP Aero has demonstrated its ability to continuously advance its core capabilities and build on new developments, lead large-scale R&T programmes and form strong partnership with its global customers and partners, and today works on some of the world's most environmentally friendly new engine platforms. The company has developed a broad portfolio of aero engine products across six business lines – turbines, compressors, radial structures, outlet guide vanes, combustors and installations – and is a Tier 1 supplier to the world's leading aero engine manufacturers including Rolls-Royce, Pratt & Whitney, Honeywell, and GE Aviation.

Midlands Aerospace Alliance (MAA)
The MAA represents one of the largest aerospace clusters in the world and is one of the strongest advocates for both the aerospace industry and the Midlands region. The Midlands is a leading centre for high-value manufacturing, advanced engineering and innovation, having deep manufacturing supply chains with strong local roots and a global reach. Supply chains in the Midlands serve all the major aircraft and engine programmes for industry primes including Airbus, Boeing and Rolls-Royce. The MAA is very active in raising the profile of the industry and what it needs from government through our partnerships with other clusters and the UK national Aerospace Growth Partnership. We also have strong relationships with influential bodies including the Department for Business and Trade, Innovate UK as well as leading aerospace experts at universities across the region. We work strategically with our members to ensure the Midlands is always at the forefront of the global aerospace industry and are pioneers of innovation.

Technoset
Technoset is a sub-contract manufacturer of high precision turned, milled components and assemblies using multi-axis CNC turning lathes and 3, 4 and 5 axis machining centres with automation and robotics. We supply numerous industry sectors including aerospace and defence, telecoms, automotive, motor sports and medical. Most recently we have become an approved supplier into Green Energy for hydrogen fuel cell applications. Our Quality Management System is mature and accredited to AS9100. We collaborate with approved supply partners that support us with special processes including heat treatment, plating and painting.

DMAC Funded Project Partners, Attributes and Primary Project Roles

Company	Company Attributes	Core Capability	Cluster	Primary Project Role	
Midlands Aerospace Alliance (MAA)	Alliance Organisation	Broad Cluster Network Technology Project Managers	West & East Midlands	Programme Management Access to network	Support with experienced Technology Managers & use local network with industry, academia & local government.
ITP Aero	Tier 1 Sub-System Supplier	Design & Manufacture Engine Modules	West & East Midlands	Design Authority Emissions Reporting Reqs	Design Authority to approve design & manufacturing changes Flow-down Aerospace CO2 emissions reporting requirements
Collins Aerospace (Goodrich Actuation Systems)	Tier 1 Sub-System Supplier	Design & Manufacture Control & Actuation Systems	West Midlands	Design Authority Emissions Reporting Reqs	Design Authority to approve design & manufacturing changes Flow-down Aerospace CO2 emissions reporting requirements
G&O Springs	Supply-chain (Tier 2-3) Design-Make Components	Hi-integrity Springs for Control & Actuation Systems	West Midlands	Established Aerospace Supply-chain	Generation of a current state & f uture fly-forward for Emissions in **Metal Component Design, Machnining & Fabrication**
Arrowsmith Engineering	Supply-chain (Tier 2-4) Make-to-Print Components	Precision Machining	West Midlands	Established Aerospace Supply-chain	Generation of a current state & future fly-forward for Emissions in **Metal Component Machining**
Technoset	Supply-chain (Tier 2-4) Make-to-Print Components	Precision Machining	West Midlands	Established Aerospace Supply-chain	Generation of a current state & future fly-forward for Emissions in **Metal Component Machining**
Helix (Integral Powertrain)	Tier 2 Design-Make Sub-System	Electric Drivetrain (Motors & Transmissions)	Milton Keynes (South-East)	New Entrant Supply-chain	Generation of a current state & future fly-forward for **Emissions in a new-entrant in Motor Technology (inc. metals)**

DMAC Advisory Board:
The intent of the Advisory Board was to ensure that the DMAC recommendations were aligned to the region's key aerospace customers, policy makers and other related bodies, such as HVM Catapult, academia etc. A launch meeting was held on 30th April 2024, where useful customer inputs were obtained. Subsequently, the board was invited to the DMAC engagement events, where Advisory Board representatives provided presentations and support.

Decarbonising the Midlands Aerospace Cluster (DMAC) Advisory Board

Midlands Aerospace Cluster OEM & Tier 1 Companies

Rolls-Royce	ITP Aero	Collins Aerospace	Moog	Parker-Meggitt
(OEM Aeroengines)	(Engine modules)	(Actuation Systems)	(Actuation/Control Systems)	(Equipment/Control Systems)
Jen Houghton	Brendan Kelly	Dr Dawn Pope	Mark Turner	Amanda Martins
Head of Environmental Strategy	HS&E Business Partner	EH&S Advisor - Sustainability	Supply Chain Director	EMEA Sustainability Manager

Representatives from Local Aerospace Cluster Alliance, Project Partners, Academia, HVM Catapult & Local Authorities

Midlands Aerospace Alliance	Project Partner Representatives	Warwick Manufacturing Group / HVM Catapult / University of Warwick	Local Authorities WMCA	Regional Policy Midlands Engine
Dr Andrew Mair	Representatives from partner companies	Simon Webb	Charlie Hopkirk	Jacob Vivian
CEO		CTO - WMG	Cluster Delivery Manager WMCA	Project Manager – Policy & Partnerships

8.2. Summary of DMAC Case Studies

Introduction

This section provides a summary of the some of the case studies performed under the DMAC programme to validate and assess different energy and emission reduction solutions. The table below highlights the relevance of each topic to the proposed DMAC strategy phases.

Case Study		DMAC Strategy Phase 1	DMAC Strategy Phase 2
CS 1	Energy Assessments & Certifications	Reduce	Replace equipment
CS 2	Heating Buildings	Reduce	Replace with green energy
CS 3	Fugitive Emissions	Reduce	Replace
CS 4	Funding for Capital Investment		
CS 5	Electrical Self-generation & Storage	Reduce grid demand (cost)	Mitigate surge demand
CS 6	Conversion of Manufacturing Processes	Reduce energy consumption	Convert to 'green' energy
CS 7	Collaboration opportunities		
CS 8	Process - LCA Reporting		

CS 1: Energy Assessments & Certifications

Energy Audits are an excellent first step in assessing the current-state opportunity to reduce energy consumption and improve a building's Energy Performance Certificate (EPC) rating; however, the DMAC team has identified some important lessons learned.

Audits will typically identify a broad range of opportunities to reduce energy consumption, ranging from simple maintenance actions to significant capital investment. The following example from DMAC partner ITP Aero at Hucknall highlights the breadth of solutions.

- **Maintenance & Repair**:
  <u>e.g. Compressor Air Leakage:</u>
  Estimated saving 205,296 kWh.pa (~£54k pa), payback in 0.1 year, reducing emissions by 43.3 tCO2e.pa.
- **New Equipment**:
  <u>e.g. Optimising Voltage & Power Factor:</u>
  Est. saving 343,313 kWh.pa (~£91k pa), payback in 0.4 year, reducing emissions by 72.5 tCO2e.pa.
  Capital investment: £37.5k
- **Equipment Upgrade/Replacement** (with a range in investment & business case)
  <u>e.g. replace belt-driven air fans:</u>
  Est. saving 302,702 kWh.pa (~£80k pa), payback in 1.7 year, reducing emissions by 63.9 tCO2e.pa.
  Capital investment: £138.6k
  <u>e.g. replace motors for local exhaust ventilation:</u>
  Est. saving 468,468 kWh.pa (~£124k pa), payback in 7.2 year, reducing emissions by 98.9 tCO2e.pa.
  Capital investment: £893.8k

DMAC partners ASG Arrowsmith and Technoset found that not all the auditors' recommendations were necessarily appropriate for their specific circumstances.

ASG Arrowsmith underwent an EPC assessment to evaluate the energy efficiency of its facility. Initially, the site received a D rating, which falls outside the UK government's future mandated standards for commercial properties: a minimum of C by 2027 and B by 2030.

The audit recommended several substantial investments to improve the EPC rating in the following sequence:

1. **Replace gas heaters**, and convert to a more sustainable heating system.
2. **Add over-cladding the roof** to enhance insulation and reduce heat loss.
3. **Install double glazing** to improve thermal efficiency.
4. **Install voltage optimisers**[15] to reduce electricity consumption and improve energy efficiency.

During the assessment, ASG observed that the energy assessor from the audit team had focused on the gas heating system as the primary improvement, requiring a high-investment but low-return solution, in preference for more fundamental and affordable energy saving solutions such as the over-cladding and insulation of the building.

The assessor's focus on removing the gas heater was presumably motivated by the goal of achieving a better EPC rating. It was recommended that the system be replaced with an alternative such as electric radiant heaters. However, this recommendation was dropped once the ASG Arrowsmith team had explained that the gas heaters were not crucial for comfort heating for technicians, but instead were required to maintain appropriate air temperature control for producing precision aerospace components. [The building inside air temperature must be held within an 18 to 21 °C range.] Radiant heaters are not the appropriate technology for this requirement, so the site received an exemption and a reassessed EPC rating of C/B.

Technoset had a similar experience, with the EPC auditor recommending the following remedies:

• Remove gas air heater	C
• Install electric radiant heaters	D
• Install destratification fans	D
• Add occupancy daylight sensors for lights	C
• Vent system	C
• Compressor system update	/
• Insulated over cladding of roof	B
• Add 130kWp Solar PV system	A

Technoset investigated these recommendations with a third party, independent expert. It was concluded that not only was the gas heater the most efficient solution, the recommended electric radiant heaters would not work with destratification fans. It was also noted that the compressor update would reduce emissions by 18,338kg $C0_2e$, but make no impact to EPC rating.

With regards gas-powered heating, it was noted that if the equipment was switched off and decommissioned, but not removed from site, an E rating would typically still apply; in other words, the equipment needs to be removed from site for the assessor to trust that the gas heaters are not going to be

[15] When considering Voltage Optimisation solutions, we recommend following the guidance contained in "A Guide To Voltage Optimisation Systems" by BEAMA, the trade association representing manufacturers of electrical products. BEAMA CAD guide

used. Furthermore, if the equipment is required to achieve specific manufacturing process requirements, an exemption may be applied (as per the ASG Arrowsmith example above).

Following this reassessment, Technoset's revised action plan is:

Action	EPC Impact	Comments
Install destratification fans	E	Pushes warm air from roof space to working space
Add occupancy daylight sensors for lights	D	Reduces the use of lighting when not required
Compressor system upgrade	-	18,338 kg CO2e reduction but no effect on EPC
Insulated over-cladding on roof	C	Reduces heat escaping during winter and heat entering during summer.
Add 130 kWp Solar PV system	B	24,739 kgCO2e reduction and reduce grid dependency by ~22%

In summary, energy audits and EPC assessments are strongly recommended by the DMAC team, but they warrant engagement with the assessors and, in certain circumstances, an independent re-validation of the recommendations.

CS 2: Heating Buildings

The optimal solution for heating buildings is dependent upon a number of factors, such as:

- **age and construction of building(s)**, which in the Midlands aerospace sector ranges from old (often c.1930s) single skin brick buildings with asbestos roofing to modern construction;
- **use and frequency of occupation** (warehouse, factory, offices etc);
- **process and product requirements** (such as air temperature control as described in CS 1);
- **business strategy** which may prioritise energy cost reduction over GHG emissions, etc.

Given this variability, the team has not made specific recommendations, but as a common first step, it is recommended to minimise heat loss from the existing buildings, for example by improving building insulation (spray foam, insulation boards, Rockwool/ISO wool etc), redirecting the heat loss from chiller units via a heat exchanger etc.

The next step might be to maximise the efficiency of the site's electrical systems to reduce energy consumption and therefore running costs and emissions. Often this is achieved by making credible business cases for investing in new, more efficient equipment.

Voltage Optimisation Equipment (VOE) is designed to efficiently reduce the site's electrical system voltage to the lower end of the required voltage tolerance range; according to the trade association BEAMA, this can yield average energy savings of around 13%; indeed, ASG Arrowsmith invested in voltage optimisation equipment and recorded a 10.2% reduction in total power consumption. However, such reductions are highly dependent upon the types of electrical loads that are being powered. It is strongly recommended that when considering this approach, an upfront assessment of the site's electrical loads is undertaken to ensure that savings can be realised. BEAMA has produced a guide on voltage optimisation assessments,[16] from which the following examples have been obtained.

The key characteristic is whether the majority of the electrical loads (i.e. the equipment being powered by electricity) are voltage dependent; if so, then one would expect to obtain savings in energy consumption. Some examples of loads that are and are not voltage dependent are presented in the table below.

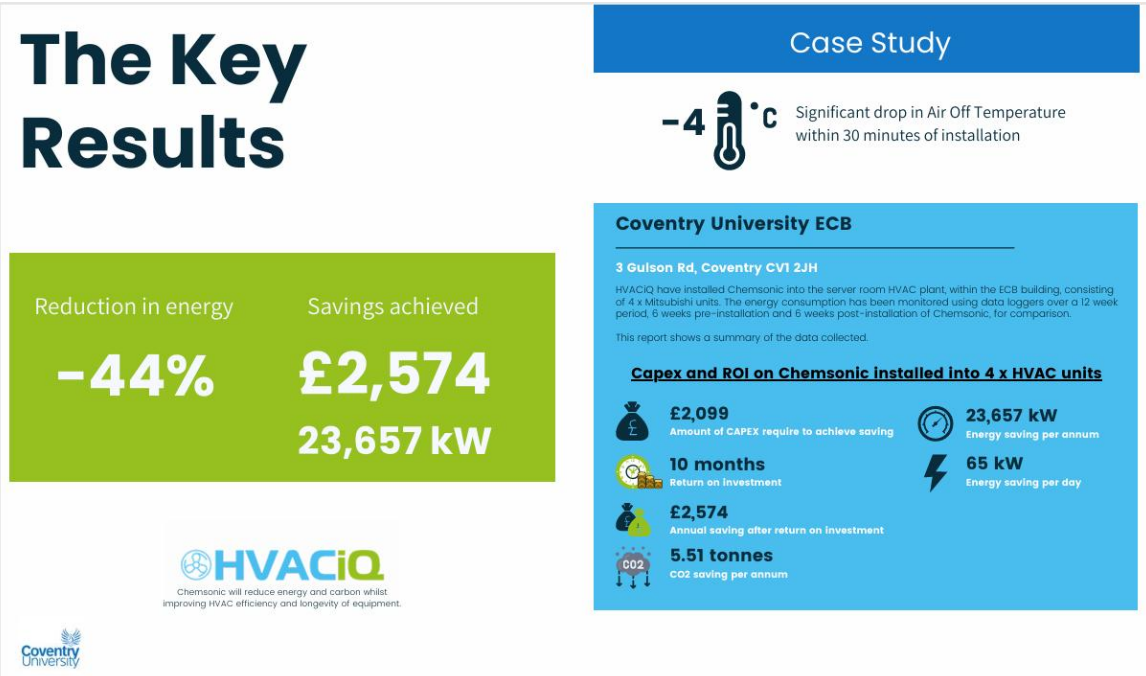
Electrical Load	Voltage Dependent	Not Voltage Dependent
Lighting	• Halogen bulbs • Fluorescent lights (inductive ballast types)	• LED lighting • Fluorescent lights (electronic ballast types)
Motors	• *Some* Asynchronous induction motors (see note below)	• Variable Speed Drives

As with many electrical loads, for motors it depends on the type, sizing, use and control. Asynchronous induction motors are commonly used in industrial processes. If a motor is large (say >20kW) and runs continuously at its optimal running conditions (say between 70% to 90% of rated conditions), then it may be ~95% efficient, and as such, can be deemed effectively voltage independent (i.e. no or little benefit will be obtained from voltage optimisation). However, it is typical for industrial motors to be running continuously at non-optimal conditions - i.e. they are oversized for typical conditions and run at partial load. Under these conditions, a motor's performance is voltage dependent, and savings can probably be made.

In summary, it important to understand all the electrical loads and make an assessment as to whether benefits will be obtained before investing in VOE.

Another example of operating equipment closer to its optimal design conditions to achieve energy savings is the use of the Chemsonic catalyst in heating, ventilation and air conditioning (HVAC) and refrigeration systems. The supplier claims that this synthetic catalyst can reduce energy consumption by as much as 25%, although Coventry University reported a 44% reduction (see the case study image below). This catalyst causes a change in the rate of chemical reaction in the system's refrigerant and oil. "The energy savings are achieved by allowing the system to operate less while at the same time delivering cooler air to achieve the temperature set point faster. It does not make the system use less energy when it is operating; the energy savings are realised by the system operating less." [17]

[16] "A Guide to Voltage Optimisation Systems – designed specifically for energy efficiency" BEAMA BEAMA CAD guide.
[17] Ref: HVACiQ https://www.h2oiq.co.uk/chemsonic



Coventry University made a significant reduction in HVAC energy consumption and emissions with a modest investment (ref: https://www.h2oiq.co.uk/chemsonic)

However, investments in new, green comfort heating systems can struggle to achieve a viable business case for many companies. The following case study from ITP Aero highlights a company that is strategically driving for net zero GHG emissions, whilst recognising that such approaches are not currently an option for much of the aerospace supply chain, given the size of upfront investment and potential on-going increases in energy costs.

ITP Aero – Installing 'green' comfort heating systems

ITP Aero's Environmental, Social and Governance (ESG) strategy is focused on contributing to the development of a sustainable aerospace industry. In this sense, ITP Aero is committed to the application of its Net Zero plan, based on the SBTi (science-based targets initiatives) registered in 2023. These targets include the reduction of its Scope 3 CO_2 emissions, both by improving its products (for example, in the development of ultra-efficient gas turbines and increasing the use of Sustainable Aviation Fuel (SAF)) and research into alternative propulsion systems (electric, hybrid-electric and hydrogen). Regarding the impact of its operations, ITP Aero is committed to reducing its environmental impact, improving the energy efficiency of its facilities and moving towards lower CO_2 impact energy sources and self-generation energy.

A large contributor to the company's Scope 1 emissions is the use of natural gas which is predominately used for facilities' comfort heating. To enact the strategy and meet the company's near term targets, it was deemed necessary to substitute the gas heating with net zero technologies.

Through 2023/24 it was decided that the largest facility on the Hucknall site would be prioritised due to the failing heating system. The main facility was heated by 4 gas-powered Air Handling Units (AHUs) which provided heated air through a series of ducting and ground level diffusers.

Each pair of AHUs were rated at about 400 kW to provide sufficient heating. The implementation plan was to complete this programme in two phases, namely:

1. Replace two gas-powered AHUs with an air source heat pump and new AHUs, and repair the second pair of AHUs; then, at a later date,
2. Replace the repaired gas-powered AHUs with air source heat pumps prior to 2030.

This phased strategy was taken because of the significant investment required to replace gas-powered AHUs with air source heat pump powered AHUs, this being about 8 times greater than conducting a repair.

ITP Aero air source heat pump powered AHUs at the Hucknall site.

The business case presented was one based around the company's strategic direction and its commitment to decarbonise its operations in line with its SBTI targets and not one based on a conventional business case, with acceptable return on investment.

For many companies, this solution is simply not viable today, and so the decision would have been to simply repair the gas-powered AHUs.

Having sourced renewable electric for a number of years, ITP Aero's decarbonisation strategy is focussed on the reduction of Scope 1 emissions, with those emissions being generated from 5 main areas:

1. Comfort heating – Gas
2. Process Heating – Gas
3. Pool Cars – Diesel
4. Fork Lift Trucks (FLTs) – LPG Gas
5. Colling systems – Refrigerant gas

The project has identified that **all systems/equipment can be replaced with technology-ready "Net zero" equivalents;** however, this will require significant capital investment. ITP Aero recognises that while this may be within the means of a large Tier 1 supplier, this is unlikely to be the case for much of the supply chain given the current economics of the aerospace industry.

CS 3: Fugitive Emissions

An observation from the DMAC team is that fugitive emissions are sometimes not calculated because the generation of GHG emissions is assumed to be negligible, and/or that the emissions are not known or recorded. However, especially for less energy intensive operations, fugitives can be a significant proportion of total Scope 1 emissions.

Unintended gas/vapour leaks from industrial processes (e.g., valves, storage, manufacturing) can be significant contributors to GHG emissions which are often undetected, overlooked and/or hard to monitor. A common source of fugitive emissions is from refrigerant losses from air conditioning systems. The total quantity of refrigerant 'top-up' per year can be obtained from maintenance records. By way of example, at Helix, maintenance reports stated that a system pressure test removed 40.8 kg of refrigerant and replenished the system with 53.7 kg.

Given that the emissions conversion factors for refrigerants are very large [the 2023 conversion factor for R410A refrigerant is 1924 kgCO2e], the accuracy of such quantities is very important and can potentially give rise to significant errors.

Operator Details

Plant Name: **FF IT Office** (outdoor) Model No: **PURY-P300YJM-A/PURY-P300YJM-A** (indoor) Model No: **PLFY-P40VCM-E2**

Location of plant: **Left Side of building** Serial No: **39W06020/39W0602** Serial No: **36M02608**

Plant operator: (name, address, telephone)
Brunleys, Kiln Farm, Milton Keynes, MK11 3EW

Operator contact: Daniel Troaca Asset Number – **AC012045**

Cooling loads served: 4.5KW

Refrigerant Factory Charge: 19KG Additional Charge:

Refrigerant	Total Charge (kg)	GWP of Gas	X Total Gas (kg) / 1000 = CO2 Equivalent
R410a	19	2088	39.67

Plant manufacturer: Mitsubishi Electric Year of installation:

Refrigerant Additions

Date	Engineer	Amount Added (kg)	Reason for addition
18/04/2024	**James Townsend**	**53.7kg**	**Pressure test of system**

Refrigerant Removals

Date	Engineer	Amount Removed (kg)	Reason for removal. What was done with the recovered refrigerant?
18/04/2024	**James Townsend**	**40.8kg**	**Pressure test of system**

Leak Tests

Date	Engineer	Test Result	Follow-up actions required

Example of a maintenance report following
a pressure test of an air conditioning system at Helix.

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For less energy-intensive manufacturing, fugitive emissions can be a significant source of Scope 1 GHG Emissions.

The DMAC team summarised the key challenges with fugitive emissions reporting as:

- Detection challenges:
  Gradual and invisible leaks are hard to identify.
- Fragmented oversight:
  Multiple departments managing emissions create inefficiencies.
- Data gaps:
  Over-reliance on third-party contractors risks incomplete or inaccurate records.
- Complexity of calculating for wide range of fluids:
  Managing multiple gas types with unique factors increases opportunity for errors.
- Infrastructure limitations:
  Aging systems and space constraints increase leak risks.
- Emission-free options are limited:
  Alternatives to refrigerant systems are often expensive and less effective.

The team recommended the following:

- Detection:
  Regular Leak Detection and Repair (LDAR) programs.
- Equipment:
  Use high-quality seals, valves and gaskets.
- Training:
  Employee awareness and reporting systems.
- Records:
  Accurate tracking for compliance and carbon estimates.
- Expertise:
  Use expert advice to address gaps in data, maintenance, installations and decommissioning.

In summary, it is recommended that businesses focus on proactive detection, efficient management and robust compliance systems.

CS 4: Funding for Capital Investment

During the DMAC programme, one of the partners, ASG, applied for an Industrial Energy Transformation Fund (IETF) grant for its King & Fowler plant in Liverpool.

Background:
King & Fowler, a renowned metal finishing and surface treatment company in Liverpool, has been a leader in providing high-quality industrial coatings for a range of sectors, including aerospace and automotive. However, the company's traditional chromium plating process, while effective, had raised environmental concerns due to its reliance on non-recyclable and hazardous chemicals. In response to these challenges, King & Fowler identified an opportunity to transition to a more sustainable technology called Physical Vapor Deposition (PVD), a 100% recyclable process.

This transition aligned perfectly with the goals of the Industrial Energy Transformation Fund (IETF), which supported businesses with the implementation of energy efficiency and decarbonization projects. Recognizing the opportunity to secure funding for this transformative project, King & Fowler embarked on the time-consuming process of completing an IETF submission.

Project Goals:
- Transition from traditional chromium plating to a 100% recyclable PVD process.
- Reduce environmental impact by eliminating hazardous chemicals and waste.
- Achieve long-term cost savings by adopting an energy-efficient technology.
- Secure funding through the IETF to support the capital expenditure required for the transition.

Application Process:
There is one process to follow for IETF support, irrespective of the amount of funding being applied for and the size of the company applying. As a result, the submission process required extensive data gathering on both the current and projected processes; whilst rigorous, this puts a significant demand on smaller companies. During the open meetings hosted by the IETF, King & Fowler learned that many previous winners

of this grant funding were large blue-chip companies such as Heineken and Toyota; furthermore, many companies employed consultants who specialised in filling in the IETF submission forms. Such consultants had not been budgeted for, within ASG; instead the project lead had worked with engineering, finance and environmental teams, and obtained board approval, prior to submitting all the various technical documents via the portal.

ASG observed a trend among previous winners in how they utilised the funds they received. Many of the successful applicants were focused on carrying out basic decarbonisation projects such as ducting of excess or waste heat and steam to heat other parts of a building or process. In contrast, the project proposal ASG put forward was significantly more ambitious and innovative whilst still being of the highest level of technological readiness. ASG considered that its project aimed to set a new standard for sustainability and environmental responsibility within the industrial sector, replacing a process with Substances of Very High Concern (SVHC) with one that was SVHC-free and 100% recyclable.

Outcome:
ASG was not successful in its application for IETF funding. The scoring system assesses the project under three topics, namely Economic, Transformational and Deliverability. ASG has kindly agreed to share this feedback, which is summarised below. Fundamentally, the assessors considered that the project would not meet the Government's threshold for "its energy use, carbon and air quality impacts on society", implying that the emissions reduction was insufficient to obtain funding.

Economic: "Overall, the applicant provided some evidence and justification for the benefits they claim this project can achieve to improve the energy efficiency and reduce environmental impact of chromium plating." However, despite ASG providing baseline energy consumption data via its ClearVUE energy management system, the assessors required more supporting evidence:

- *to verify the post-intervention annual MWh fuel consumption of electricity; and*
- *on why funding was required and other attempts to secure private funding;*

In summary, "the application failed to meet the minimum value for money threshold for Government spend on the IETF. The project failed to meet this threshold when appraising its energy use, carbon and air quality impacts on society."

Transformational: "The project is deemed likely to deliver a reduction in emissions for the site, with a reasonable justification for the technology chosen. Alignment to net zero is strong, with the company making significant strides in reducing electricity consumption, backed up by the ClearVUE monitoring system as evidence. However, the claim of a 40% percentage reduction in emissions for the process needs stronger evidence in order for this claim to be verified. The discussion around information sharing was reasonable, but more clarity about scalability and replicability would have been required for a higher score."

Deliverability: "In general, the deliverability section was completed to a mostly satisfactory level." However, "the addition of further evidence could have resulted in a higher score…" This included more detail on milestone descriptions, and while "the justification for the use of the subcontractor was fair… the roles and expertise of the staff involved required more detail on their skills and responsibilities, and stronger supporting evidence (e.g. CVs) would have improved the score." While "the risk register was good, with logical mitigation actions and strategy … specific project risks lacked discussion, particularly around the health and safety risks." "A higher score would have required a more detailed breakdown on how the £1.5m project cost was made up, as well as a stronger argument for how costs have been minimised."

CS 5: Electrical Self-generation & Storage

During the DMAC programme, two of the partner companies made progress with their plans for green on-site electrical generation and storage.

G&O Springs (G&O) had already invested in photovoltaic (PV) solar panels, accessing match-funding from the Low Carbon Opportunities programme. These panels contributed to 45% of the company's annualised electricity usage; in the summer months this could reach up to 80%.

Description	Estimated annual savings			Estimated cost[1] (£)	Payback period (years)
	(£)	CO_{2e} (tonnes)	(kWh)		
Install a 108.25kWp roof mounted solar PV system	£11,700	26.6	86,718	£72,525	6.2
LOW CARBON OPPORTUNITIES PROGRAMME	**£11,700**	**26.6**	**86,718**	**£72,525**	**6.2**

However, the local Distribution Network Operator (DNO), in this case National Grid – Western Power Distribution, would only allow G&O to export 33kWp. Any remaining unused green electricity (notably during non-working days) would be wasted.

Furthermore, G&O was required to invest in additional equipment by installing an export limitation device with a specific response time to ensure G&O could not feed anymore electricity into the grid, and had to pay the DNO £1,500 to have this inspected.

G&O has since paid £66k to increase its incoming electricity supply which has in turn increased its export capability to 66kWp. However, this new export capability does not avoid significant waste of green electricity during non-working days, and nor does the supply capacity enable G&O to consider installing an electric heating system to eliminate natural gas combustion on site and significantly reduce its GHG emissions.

Initial investigations into on-site storage using various battery chemistries did not achieve an acceptable investment business case; however, this is now under review following the next case study.

ASG AMF Precision Engineering (ASG AMF) in Birkenhead has a Solar PV array installation consisting of around 700 panels with the business consuming circa 700,000 kW per annum with an excess of self-generated energy.

The local DNO refused permission to allow excess solar PV energy to be fed back into the grid and required a six-monthly inspection to ensure compliance, charging a fee of approximately £2000 per inspection.

To overcome the DNO's constraints, ASG AMF decided to purchase and install a Solax 215 kWh battery storage unit, costing around £58,000. This unit is sufficient to store excess solar energy and utilise it effectively without relying on the grid.

The unit's battery cells are of the Lithium Iron Phosphate (LiFePO4) type. This chemistry is deemed one of the safest for lithium cells, being less prone to thermal runaway. However, a 4-level fire protection system is in place and, given its location in the factory, the potential for thermal runaway will still need to be considered in the safety assessment. This chemistry also enables a greater than 10-year life according to the manufacturer.

Before the installation, ASG AMF was spending around £18,000 per month on electricity; post-installation, the company expects to save approximately £6,000 per month on electricity bills. Return on investment (ROI) is expected to be achieved within 10 months, with the battery storage unit set to be operational in early 2025.

Grid consumption is anticipated to reduce by 33% and the business has installed 4 EV charging stations powered by the battery storage, providing free charging to employees. This strategic investment has not only overcome the DNO's restrictions but also aligns with ASG AMF's commitment to reducing operational costs and promoting environmental sustainability.

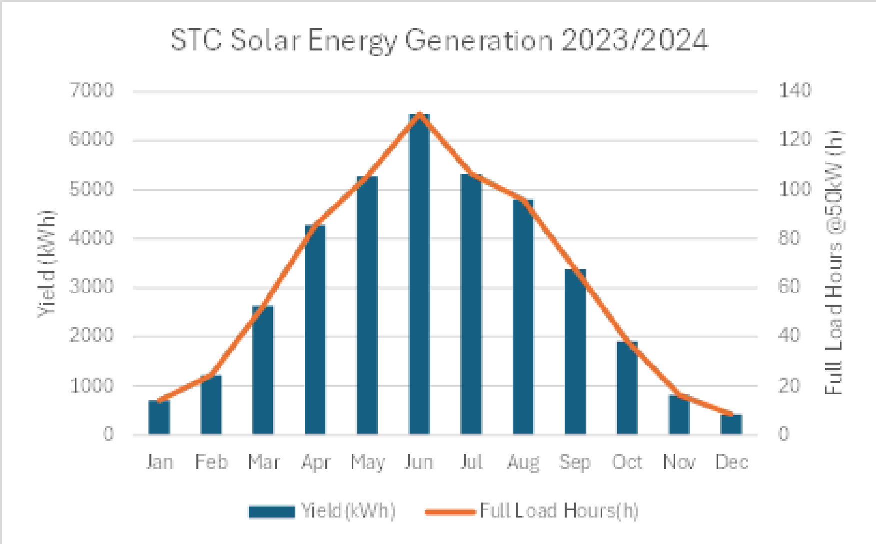
Technical specifications

AC rated power	100 kW
Approval	IEC62619, IEC63056:2000, IEC61000, IEC62477-1, UN38.3, GB/T36276, GB/T34131
Battery capacity	215kWh
Battery type	LFP 280Ah
Battery voltage range	600 ~ 876
Brand	Solax Power
Current	144.4 A
Dimensions	1680 × 2420 × 1200 mm
Grid connection	400V (-20% ~ +15%) 3Phase
IP rating	IP55
Operating temperature	-30 ~ 55
Weight	2800 Kg

ASG AMF's battery storage (shown during installation) is housed in the factory within a dedicated module.

However, the battery storage unit is installed in a dedicated modular room (5m x 5m x 3m height) inside the factory, taking up valuable factory floorspace that can no longer be used for its core manufacturing business. With anticipated growth in the aerospace sector, this is an unwelcome constraint for the site. In order to overcome the constraints of the DNO and grid network, the company has had to constrain its own site's growth opportunity.

In contrast to many of the sites in the DMAC team, Helix's Shenley Technical Centre is a modern building, completed in 2020, that uses electricity for heating the facility. An array of solar panels was installed as part of the original build; the peak power generation of this system is 50 kW gross, about 46 kW net.



Monthly profile of Helix Shenley Technical Centre (STC) PV Panels

There is sufficient roof area to extend this peak power generation to about 4 times the current capacity, giving 200 kW gross or around 184 kW net. A comparison of current and potential output is presented below.

Month	kWh	Cost (GBP)	50kW Solar (kWh)	Percentage from 50kW solar	200kW Solar (kWh)	Percentage from 200kW solar
Jan	66303	31,122.67	708	1.1%	2832	4.3%
Feb	57329	27,263.46	1222	2.1%	4888	8.5%
Mar	65657	31,405.29	2634	4.0%	10536	16.0%
Apr	54524	30,879.51	4274	7.8%	17096	31.4%
May	58085	32,439.64	5269	9.1%	21076	36.3%
Jun	54536	31,009.05	6536	12.0%	26144	47.9%
Jul	61926	33,333.15	5324	8.6%	21296	34.4%
Aug	63540	33,748.09	4790	7.5%	19160	30.2%
Sep	60115	32,358.58	3379	5.6%	13516	22.5%
Oct	70963	35,590.10	1912	2.7%	7648	10.8%
Nov	69205	34,576.03	817	1.2%	3268	4.7%
Dec	55175	31,634.77	426	0.8%	1704	3.1%
Total	737357	385,360.34	37291	5.1%	149164	N/A
Average	61446	32,113.36	3108	5.2%	12430	20.8%

Helix Shenley Technical Centre (STC) current and potential PV Panel generation.

The average PV panel commercial price is about £1200 per kW of capacity; the current 50 kW array cost about £60,000. Extending the capacity on the existing roof to 200 kW would require some £180,000 of further investment to obtain another 150 kW of capacity.

From the summary table, the average yield from the current solar installation is 3108 kWh per month (5.2% of the STC's consumption) giving a total yield for the year of 37,291 kWh. At 50p/kWh retail (including the standing charge) this would save £18,645.50 per 50 kW array per year. The additional 150 kW investment could achieve further savings of £55,936.50 per year, with a payback time of 3.2 years.

With the increased capacity Helix would be able to generate an average of 414 kWh per day or 12,432 kWh per month. This could reduce Helix's annual consumption of grid-purchased electricity by about 20%. Due to roof area and space constraints, this is the maximum that the site could produce with today's solar panel technology. While it is a long way off making the site self-sufficient, the DNO restrictions on returning electrical power to the grid have less impact to the business case.

CS 6: Conversion of Manufacturing Processes

In line with the DMAC Phase 1 strategy approach, it may be possible to change a manufacturing process to reduce energy consumption. However, for qualified components that are part of a certified aircraft or aero-engine design, any change to a production process is likely to require justification, such as testing, and approval from the design authority, and may result in a formal design change or a refusal to make a change based on grounds of insufficient business case etc.

On a product not designed for flight, Helix quantified the reduction in Scope 1 energy consumption by removing a thermal process from its electric motor manufacturing line.

In the original process, motors are manufactured using a hot-cured process for the stator assembly. This requires the stator assembly to be baked in an oven under a controlled cycle as detailed in the table below.

Typical thermal potting cycle	Arms	Vrms	Power (kW)	time (h)	Energy (kWh)
Ramp from 20C to 120C	6.5	240	1.56	0.5	0.78
hold at 120C	0.222	240	0.05328	8	0.43
ramp 120C to 150C	6.5	240	1.56	0.5	0.78
hold at 150C	0.222	240	0.05328	9	0.48
Total	-	-	-	18	**2.47**

This oven cycle with typical door opening losses, and other application losses, consumes approximately 2.47 kWh per motor per cycle.

Anticipated volumes are up to 10,000 units per annum, so this thermal process has a total energy consumption of 24,658 kWh per annum. Helix has subsequently designed a new stator assembly that does not require the thermal cycle, therefore eliminating this energy consumption and the associated emissions, whilst also requiring less factory space and capital equipment for the stator assembly.

With regards DMAC Phase 2 strategy, the team, led by ITP Aero, identified some common types of high value manufacturing processes that can use natural gas today, and briefly assessed these for conversion to either electric power or hydrogen combustion (refer to the table below). Of the lower temperature processes, many already had electric alternatives available and were in use; for the higher temperature processes, either electric or hydrogen were feasible and many were understood to be available.

Manfacturing process / equipment	Description	Typical uses	Typical energy source today	Electric options exist?	Hydrogen options exist?	Comments
High Temperature Furnace/Smelting	Up to c. 2000 °C	Manufacture of steel alloys	Gas	Yes	Yes	There are also hybrid options of H2 and electric
High Temperature Furnace/Sintering	Typically 1000-2000 °C	Sintering of ceramics	Gas	Yes	Yes	There are also hybrid options of H2 and electric
High Temperature Furnace/Annealing	Up to c. 1300 °C Compliant with AMS 2750G	Annealing stainless steels	Gas	Yes	Yes	There are also hybrid options of H2 and electric
Air furnace/Forging	Up to c. 1000 °C	Manufacture of blanks & near net shape parts	Gas	Yes	Yes	There are also hybrid options of H2 and electric
High Temperature Furnace/Casting	2000+ °C	Casting of parts (near net shape)	Gas	Yes	Yes	There are also hybrid options of H2 and electric
Medium Temperature Furnace & Pre-heating	Up to 700°C Compliant with AMS 2750G	Pre heating of toolings	Gas & Electric	Yes	Not known	
Low Temperature Ovens	Low temperatures < 250 °C	Curing of surface coatings	Gas & Electric	Yes	Not known	
Chemical Processing Tanks		Used in metal etching process	Gas & Electric	Yes	Not known	
Plasma/Ceramic Coating		Used to coat parts for protection	Gas & Electric	Yes	Not known	

Companies with more energy intensive processes, such as casting and forging, were consulted. Typically, the lower temperature processes, such as aluminium casting and forging, use electric furnaces today, notably "where the furnace atmosphere needs to be controlled to avoid oxidation etc and where an inert gas atmosphere is required."[18] It is understood that for higher temperature furnaces, natural gas is more efficient than electricity, as well as being significantly lower cost.

To this end, an aerospace forging company working with aluminium, stainless steel and titanium alloys invested in two new 1.5 MW Combined Heat and Power (CHP) units (i.e. total output of ~3 MW) in 2019. Some of the exhaust heat from these CHPs is now recovered to provide useful space heating via a new pipe network that extends to office spaces and rest rooms, removing the need to use local air conditioning units and gas space heaters within operational areas. However, these CHPs are also being used to generate electricity on site, reducing the company's reliance on grid electricity by 73% in 2023, thereby reducing its overall energy costs. In conjunction with other efficiency improvements, the company is reducing its overall energy consumption, but by self-generating electricity on site using its CHPs, it is sustaining its natural gas combustion and associated GHG emissions. With electricity pricing being 4 to 5 times that of natural gas, this is sound business logic for this high energy intensity business.

These more energy intensive businesses may also have greater opportunity to reduce wasted heat energy from their furnaces with improved thermal insultation, more efficient means to heat furnaces and heat recovery technologies. For example, two IETF projects[19] considered the "potential industrial benefit and scalability for the consideration of waste heat recovery (WHR) as a means of supporting industrial decarbonisation..."[20] These studies concluded that the UK forging industry could potentially save more than 40,000 tCO2e and 180 GWh of natural gas consumption each year, with potential roll-out to casting

[18] "UK Forging Industry Study - Considering the potential for waste heat recovery to support industrial decarbonisation." Derek Bond, CBM Forging Consultant, The Confederation of British Metalforming.

[19] IETF 22043 and 23036 were studies into the potential of WHR technology at two Midlands forging companies, namely Somers Forge Ltd, Halesowen, West Midlands, B62 8DZ and Mettis Aerospace Group Ltd, Redditch, Worcestershire, B97 6EF, respectively.

[20] "UK Forging Industry Study - Considering the potential for waste heat recovery to support industrial decarbonisation." Derek Bond, CBM Forging Consultant, The Confederation of British Metalforming.

processes, although further work was required to confirm the commercial viability of this technology, especially for smaller businesses.

DESNZ commissioned a report on future opportunities for electrification[21] focused on opportunities for directly electrifying heating processes for emission intensive industries in the UK. While this scope did not consider the aerospace manufacturing processes, it came to a similar conclusion with regards the potential for electrification.

In summary, the key barriers to electrification are not technical, although certain processes may not be as efficient, but rather down to energy pricing and grid capacity and performance.

CS 7: Collaboration opportunities for dispersed businesses

It is commonplace for small dispersed industrial businesses to be located in an industrial estate, business park or technology campus. The majority of dispersed aerospace supply chain companies in the Midlands operate quite independently from one another – in contrast to more collaborative concepts such as 'industrial symbiosis', whereby different industries work together to optimise the use of resources. This may involve the exchange of materials, energy, water and by-products in a way that benefits all parties involved.

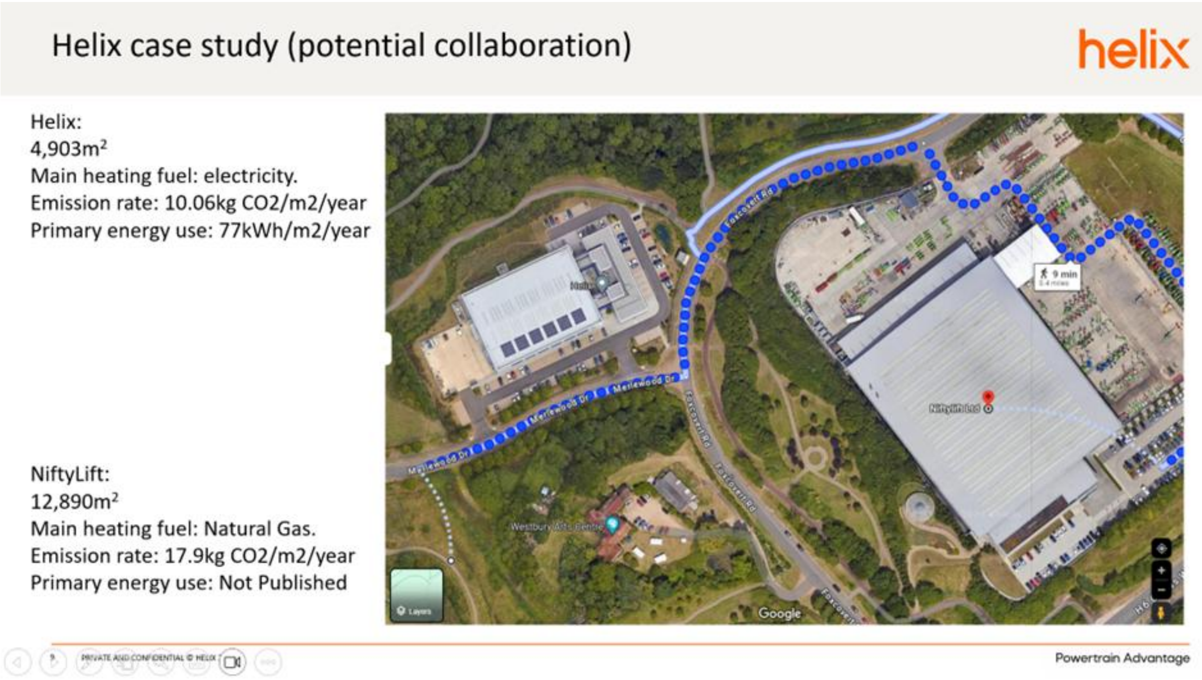
There are examples of 'co-operation' in the aerospace sector, but these typically work to reduce Scope 3 emissions and are not necessarily dependent on co-location. For example, transportation of products from sites is often shared or organised by a customer. When considering co-location cooperation, businesses need to consider the additional risk of becoming dependent on other businesses, potentially small ones operating in unfamiliar sectors.

Co-location cooperation can potentially bring benefits, particularly those derived from an increase in scale for capital investment. For example, if working with other sites with more energy-intensive operations, local collaboration may assure sufficient energy demand to enable the business case for new green energy infrastructure investment to be made. [That said, for a hydrogen pipeline to be installed, Cadent indicated that a very large demand would be required - ideally of order 7 TWh/year, although 4 to 5 TWh/year might make a viable investment case. This level of energy intensity is unlikely to be achieved with dispersed aerospace sites, but this level of demand could possibly be met when collaborating with much more energy intensive industries.] Collaboration may also enable more optimal solutions with one large, shared installation (e.g. one large wind turbine) over multiple individual configurations. Furthermore, sharing the investment across a number of companies for a more optimal solution should reduce both the upfront investment cost and on-going operating costs for the individual companies. In certain cases, finding the space may also be eased by developing a single, shared resource. Acceptance may – arguably – be eased, be it with local planning permission and the local community. The costs of Distribution Network Operator (DNO) inspections would be shared; the DNO may prefer working with one larger facility.

Helix, one of the DMAC partners, evaluated the opportunity for its modern Shenley Technical Centre facility to locally collaborate with an adjacent business, NiftyLift, with regards on-site electrical generation. The Helix site relies on electricity for heating, most of this from the grid, offset with local PV solar panels. [The Helix on-site generation is described in more detail in CS 5 'Electrical Self-generation & Storage' section above.] Conversely, NiftyLift uses natural gas for heating, and therefore has a different strategy for reducing emissions (such as acquiring a more efficient boiler and/or moving to bio-mass fuel).

[21] "Future Opportunities for Electrification to Decarbonise UK Industry - A report for DESNZ" ERM, October 2023.

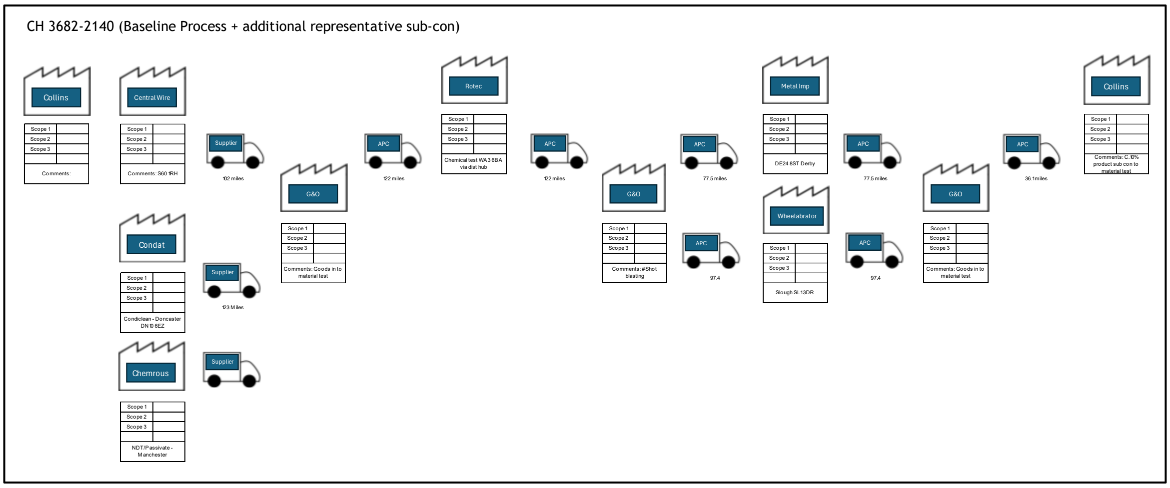
Consideration was given to a significant investment in a large wind turbine and shared battery storage facility (although planning permission and other potential constraints were not investigated). This shared, local self-generation of electricity could not avoid reliance on electricity from the grid. Furthermore, putting to one side the capital investment required to convert from natural gas to electricity, moving to grid-priced electricity would not have been a credible option for NiftyLift because of the significant increase in on-going energy costs.



CS 8: Process: Carbon Stream Mapping (CSM) and Life Cycle Analysis (LCA)

Early in the DMAC programme, it became clear that aerospace companies would need to generate product-level emission footprints as part of a Life Cycle Analysis (LCA). To prepare for this, DMAC developed and tested both a manual process and a commercially available software solution with two of our industry partners. Our focus was a sub-tier part (a spring, Part Number CH3682-2140, made by G&O Springs for Collins Aerospace) which is subsequently built into higher-level assembly (Ramp Gear Assy CH3511-00735 produced by Collins Aerospace).

The manual process was designed around the practice of value stream mapping. Value stream mapping is a lean manufacturing methodology used to analyse and improve the flow of materials and information required to bring a product or service to a customer. It involves creating a visual representation of the entire process, from start to finish, to identify areas of waste and inefficiency.



Draft CH3682-2140 CSM - G&O Springs

For the exercise the DMAC team replaced the usual key process indicators (KPIs) which might track cycle times, waiting times, inventory, and other key data, with quantity and types of energy used at each process stage, and renamed the process Carbon Stream Mapping. The team then used the UK Government GHG Emission Factors [www.gov.uk/government/collections/government-conversion-factors-for-company-reporting] to calculate the overall equivalent CO_2 produced. As part of this activity, a methodology was generated so that the activity could be reproduced. A reusable Excel template was produced and applied to both the individual part and the higher-level assembly. This process was then tested by handing the template to another of the DMAC industry partners, ASG Arrowsmith, who independently carried out the manual activity on three separate part numbers.

Item	By Product	Overhead	Comments	n/a at G&O	Conversion Factors (2023) kg CO2e	CH3162-2140	Unit	Qty average per month	3 month average Co2e (per month)	Kg Co2e per hour (3 months = 2190)	Total parts supplied by G&O over 1 months	
SCOPE 1												
Natural Gas		Yes	By Season		0.18	13.2247	Amortised based on 19[illegible] mc	196	1554	0.709803	23058	0.85%
Passenger Vehicle Miles (Delivering Parts)	Yes								53			Deliveries per 196
Supermini (FOF)			1 delivery per month = 15.355 kg Co2e		0.212676	0.0000	per delivery (using factor)		167			0
Freighting goods (G&O Van)	Yes											
Diesel Miles - Van Class I (up to 1.305 tonnes	Yes		36.1 Miles to Collins (x 2)		0.14212	10.2614	per delivery		44			1
Fugitive Emmisions				n/a								
AC Units				n/a								
Chiller				n/a								
Environmental; Testing				n/a								
Combined heat & power				n/a								
Stored Fuel (eg Gas Forklift)				n/a								
Bio Mass				n/a								
SCOPE 2									3355			
Day Electricity Units	(when metering available)	Yes			0.207074	24.9225	Amortised based on 196 per mc	196	2932		23058	
Night Electricity Units	(when metering available)	Yes			0.207074	3.5983	Amortised based on 196 per mc	196	423		23058	
EV Charging				n/a								
Purchased Heat & Steam				n/a								
SCOPE 3									2855			
Water usage	(when metering available)	Yes			0.177	0.0546	Amortised based on 196 per mc	196	6		23058	
Water treatment (waste water)	(when metering available)	Yes			0.201	0.0622	Amortised based on 196 per mc	196	7		23058	
Scrap Metal	Yes		Assumption for calc 5%		0.001	0.0006	Kg Co2e per 196		0			
									0			
Business Travel									0			
Mini		Yes	Customer where applicable		0.173416				0			

CH31682-2140

Scope 1	0.12	Kg Co2e Per part
Scope 2	0.15	Kg Co2e Per part
Scope 3	0.17	Kg Co2e Per part
Total	0.44	Kg Co2e Per part

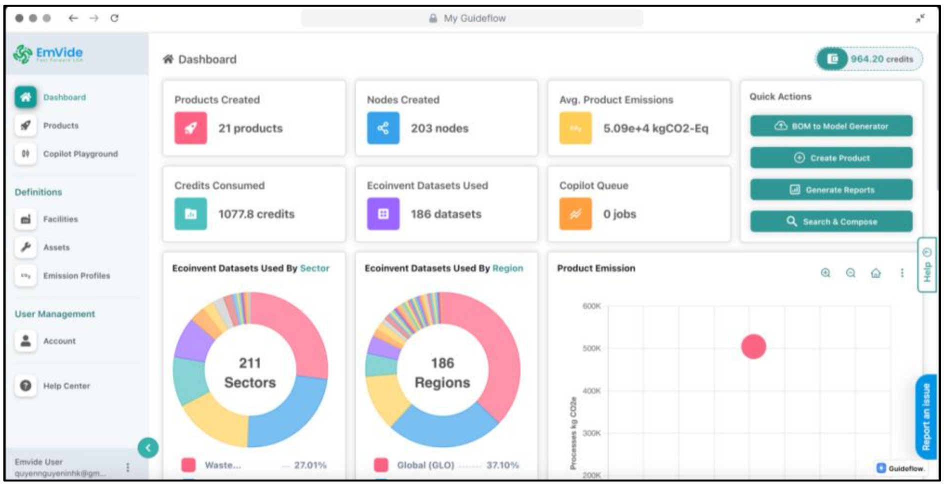
We calculated the total number of parts supplied by G&O per month (an average of the year). Then we looked at the total number of this part supplied and averaged. this part is 0.85% of our monthly output. We then muliply the Co2e by the %. This is an overhead but factored by product

Excerpt from Excel manual process template

After researching software solutions, the DMAC team opted to trial a solution called EmVide [www.emvide.com] which was offered by Unipart Consultancy, who undertook the case study. [The DMAC team greatly appreciates the unfunded support provided by Unipart and Riskoa to the project.]

Unipart has taken a tri-technology approach to enable advanced process mapping techniques of assembly and immediate supply chain, resource measurement through Unipart's Eco Insight tool, which provides real-time energy monitoring, concluding with a Life Cycle Assessment (LCA). Powered by Riskoa's EmVide SaaS platform, this AI-enabled LCA tool provides precise carbon footprint data, empowering engineers and sourcing teams to make informed decisions that reduce embodied carbon. This baseline of Product, Resource and Process allows the carbon reference points to provide accurate reporting and a platform for further improvements and future business performance. Unipart has proven that by refocusing existing operations through this 'lens', a carbon-balanced supply chain can be achieved, optimising environmental and business performance.

The EmVide element has been designed to calculate the environmental impacts of any product in minutes and automatically turn a bill of materials into a full LCA, generating an ISO-compliant LCA report.



Screenshot of EmVide dashboard

Both the manual and software-based product analysis methods tested have their pros and cons. For initial product mapping, the time investment for both approaches is comparable, although the software solution generated a customer-ready, auditable report and made recommendations for potential emission reduction opportunities. The similar initial time commitment is due to the necessary pre-work of data collection and validation of the software's output. However, it is anticipated that the software solution would become significantly more efficient with repeated use. The manual process required much local knowledge, but the process engaged those employees involved in the process and it was easy to interrogate the calculations.

Other observations from the team include:

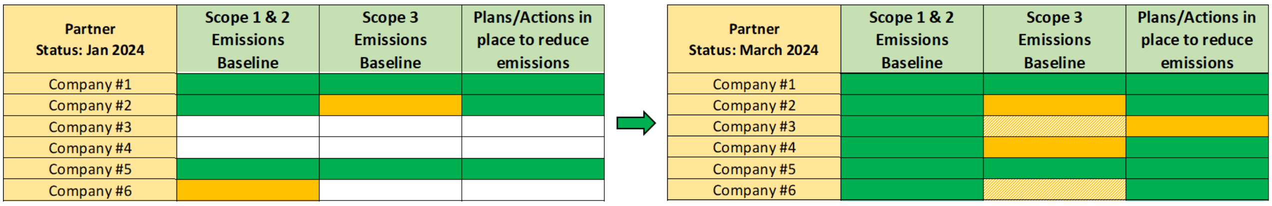
- EmVide is a great starting place for those without an existing process or methodology for developing an LCA.
- The process is quick and reasonably simple, though understandably the more pre-work put in the better and more accurate the output.
- The tool can be applied by someone with a basic understanding of the process but to validate results requires in-depth local knowledge and time to review.
- The EmVide report revealed some 'blind spots' and made good general recommendations.
- The ability for OEMs & Tier 1s to make procurement decisions based on emission calculation derived from LCAs and not just spend would be a significant step forward. The EmVide tool and process can facilitate this and could readily be adapted with additional functionality, such as categorising output into scopes 1,2 & 3, automatically populating CBAM documentation etc.

8.3. DMAC Scope 1 & 2 Emissions and Reduction Forecast

DMAC Team Energy Consumption

The DMAC team consists of 6 industrial companies, two Tier 1s and four 'supply chain' companies. At the launch of the programme, as one might expect from larger global companies, the Tier 1 companies had audited Scope 1, 2 and 3 emissions and reduction plans in place. However, the upstream Scope 3 emissions were typically calculated by factoring sales data, and whilst this is generally considered to provide a pessimistic estimate, as such there is a lack of resolution to understand the key drivers in the supply chain.

Within the four supply chain companies, there was a mix of maturity with regards to emissions reporting and reduction planning, yet all had already invested in energy saving and emissions reducing activities. By March 2024, all partners had Scope 1 and 2 emissions reporting and had initiated work on their energy and emissions reduction plans; this demonstrates the relative ease at which the supply chain companies can progress with emissions reporting when the topic is embraced by the leadership and management.[22]



By March 2024 all the DMAC team had Scope 1 & 2 emissions recorded and had initiated reduction plans.
[Green cells infer 'in place', Amber cells 'work in progress', White cells 'not started'.)

To further extend our sample size, ASG agreed to include all its sites in the UK. Despite many of these being outside the Midlands region, the processes and operations were similar to other aerospace companies in the Midlands, and were therefore highly relevant.

Company		>240 °C processes	Comments	%CoS	Core business
G&O Springs		Y	Heat treat	4.4%	Precision spring manufacture (design-make)
ASG	AMF	Y	Thermal Spray, Welding	4.6%	Precision machining
	Arrowsmith	N		1.9%	Precision machining
	Tooling (B&H)	Y	Welding	4.5%	Tooling - machining, fabrication
	King and Fowler	Y	Heat treat (core business)	17.7%	Surface treatment, plating & NDT
	Phoenix	N		5.6%	Precision machining
	TGM	N		8.0%	Precision machining
Technoset		N		6.8%	Precision machining
Helix		N		4.2%	Electro-mechanical drive trains (motors)
ITP Aero		Y	Heat treat	2.0%	Engine modules & combustion chambers

in-house process, not core business
core business

%CoS: Cost of energy as a % of cost of sales
NDT: Non-destructive testing

[22] Note: Fugitive emissions did present more of a challenge for some of the partners to record accurately – refer to Section 8.2, Case Study CS 3.

For precision machining companies with limited heat treatment operations, energy costs as a proportion of cost of sales are less than 10%, as presented in the table above. With significant heat treatment operations, this increases well beyond 10% (approximately 18% for the AGS site). It goes without saying that as the processes become more energy intensive, the business sensitivity to energy pricing increases; from 2023 data, one forging company's energy costs were about 65% of cost of sales for that year.

As would be expected, the larger Tier 1 sites consume significantly more energy than the smaller dispersed sites; within the DMAC team, the Tier 1 aerospace supplier ITP Aero consumed 29,957,580 kWh[23] of energy, whereas the average total energy consumption for the 13 smaller dispersed sites was 739,097 kWh, as presented in the table below.

Supply Chain Partners 13 Dispersed Sites (excludes Tier 1 sites)	**Average Annual Energy Consumption kWh/PA**	**Min. Annual Energy Consumption kWh/PA**	**Max. Annual Energy Consumption kWh/PA**	**Energy Split** (Average Consumption) **%**	**Minimum Gas Consumption %**	**Maximum Gas Consumption %**
Natural Gas	160,196	14,000	1,064,000	22%	2%	43%
Electricity	578,901	96,000	1,421,584	78%		
Total energy consumption	739,097					

The DMAC team's dispersed sites are indicative of the variation in annual energy consumption and mix within the precision manufacturing companies in the aerospace supply chain.
(Note: this table excludes the larger Tier 1 DMAC companies ITP Aero & Collins Aerospace)

Furthermore, the DMAC team did not include companies operating the more energy intensive processes such as metal production, casting and forging. As way of example, a forging company in the region, Mettis Aerospace, consumed 135,516,760 kWh of energy,[24] about 183 times greater than that of the average DMAC supply chain companies.

The energy split between gas and electricity also changes with energy intensity and temperature of operations. Within the 13 dispersed DMAC sites, natural gas makes up between 2 to 43% of the energy consumed; if the heat treatment business within ASG is excluded, this maximum reduces to 34%. Again, comparing to more energy intensive processes, especially those working with higher melting temperature alloys such as steels and titanium, typical proportions fall within the range of 50 to 85%.

Given the above, in order to provide a more comprehensive analysis of the aerospace metal alloy supply chain in the Midlands, it was decided to obtain data for types of manufacture outside the scope of the DMAC team, namely metal production, casting and forging. This was subsequently used to complement the detailed DMAC team data.

[23] 2023 figures for all ITP Aero Ltd operations.
[24] 2022 data from Mettis Aerospace accounts (Directors Report for period ended 31st March 2023).

DMAC Scope 1 & 2 Results

The results below provide an invaluable level of detail for the aerospace precision manufacturing supply chain, including machining, fabrication and heat treatment processes.

Scope 1	ITP Aero	Helix - Shenley Technical Centre	Helix - Flexible Manufacturing Site	Helix - Kiln Farm	G&O	Technoset	ASG Arrowsmith
Stationary Combustion (Tonnes CO2e)	1485	12.66	18.77	43.74	7.93	5.89	44.94
Mobile Combustion (Tonnes CO2e)	33	1.75	1.75	0	2.89		22.00
Process Emissions (Tonnes CO2e)	371	0	0	0			
Fugitive Emissions (Tonnes CO2e)	71	1.97	0	0			25.00
Natural Gas							
Natural Gas for Heating (kWh per year)	15,444,729	69,217	102,627	43,253	66,072	32,158	250,000
Natural Gas for Processes (kWh per year)	2,725,540	0	0	173,012	0	0	0
Building Energy Rating (A - G)	C,G,E,G,G,D	A (19)	D (76)	D (82)		E	C
Factory floor area (m2)	16,804	1,494	439	728	1,200	1,650	1,582
Typical number of Employees in building(s)	750	151	39	5	42	28	63
Scope 2	**ITP Aero**	**Helix - Shenley Technical Centre**	**Helix - Flexible Manufacturing Site**	**Helix - Kiln Farm**	**G&O**	**Technoset**	**ASG Arrowsmith**
Purchased (grid) Electricity Consumption (kWh)	19,655,084.90	737357	177480	553673	80,043	410,000	540,000
On-site, Self Generated Electricity (kWh)	0	23290	0	0	63,000		20,000
Gross Electricity GHG Emissions (Tonnes CO2e)	-	152.69	36.75	114.65	66.13	150.00	111.78
Green Energy (% of total electricity consumption)	100%	48%	48%	48%	80%	100%	3%
Net Electricity GHG Emissions (Tonnes CO2e)	0	79.4	19.11	59.62	13.23	0	108.43

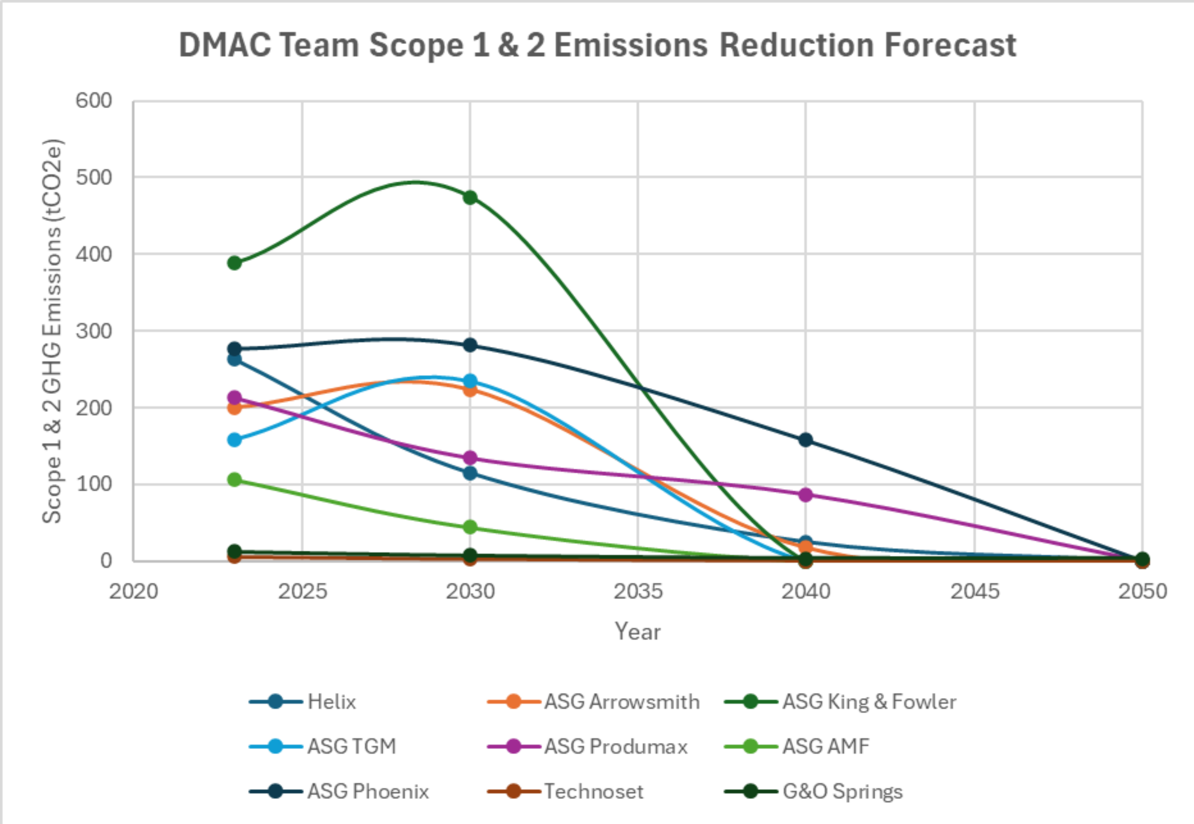
Scope 1	ASG Techni-Grind Machining	ASG King & Fowler	ASG Produmax	ASG AMF Precision	ASG Tooling - Reddish	ASG Tooling - Stockport	ASG Phoenix CNC
Stationary Combustion (Tonnes CO2e)	2.80	92.46	5.61	4.50	2.70	9.00	26.46
Mobile Combustion (Tonnes CO2e)	32.00	1.96		16.80	12.60		16.80
Process Emissions (Tonnes CO2e)							
Fugitive Emissions (Tonnes CO2e)							
Natural Gas							
Natural Gas for Heating (kWh per year)	14,000	560,000	31,206	25,000	15,000	50,000	147,000
Natural Gas for Processes (kWh per year)	0	504,000	0	0	0	0	0
Building Energy Rating (A - G)	C	E		A	D		
Factory floor area (m2)	2,302	3,304	3,615	2,603	1,292	1,422	1,841
Typical number of Employees in building(s)	32	61	84	55	30	24	40
Scope 2	**ASG Techni-Grind Machining**	**ASG King & Fowler**	**ASG Produmax**	**ASG AMF Precision**	**ASG Tooling - Reddish**	**ASG Tooling - Stockport**	**ASG Phoenix CNC**
Purchased (grid) Electricity Consumption (kWh)	600,000	1,421,584	1,001,817	480,000	240,000	96,000	1,009,471
On-site, Self Generated Electricity (kWh)				72,000			
Gross Electricity GHG Emissions (Tonnes CO2e)	124.20	294.37	207.37	99.36	49.68	19.87	208.96
Green Energy (% of total electricity consumption)				15%			
Net Electricity GHG Emissions (Tonnes CO2e)	124.20	294.37	207.37	84.46	49.68	19.87	208.96

GHG Emissions Scope 1 & 2	13 Supply Chain Sites			Tier 1s & Supply Chain		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Scope 1 (tCO2e)	32	6	94	239	6	1960
Scope 2 (tCO2e)	98	0	294	324	0	3591
Scope 1 & 2 (tCO2e)	129	6	389	563	6	4799
Scope 1 % of Scope 1 & 2	25%	95%	24%	42%	95%	41%

DMAC Company's Scope 1 & 2 Emissions and Energy Usage 2023.

DMAC Partner Scope 1 & 2 Emissions Reduction Plans

Most of the DMAC team forecast zero GHG emissions by 2050, but there are some key assumptions that are vital to achieving this.

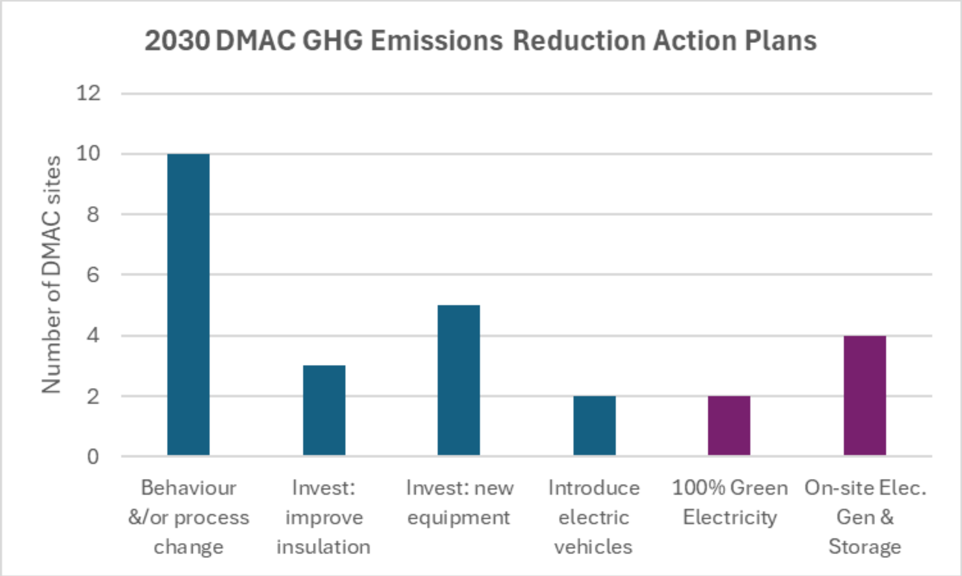


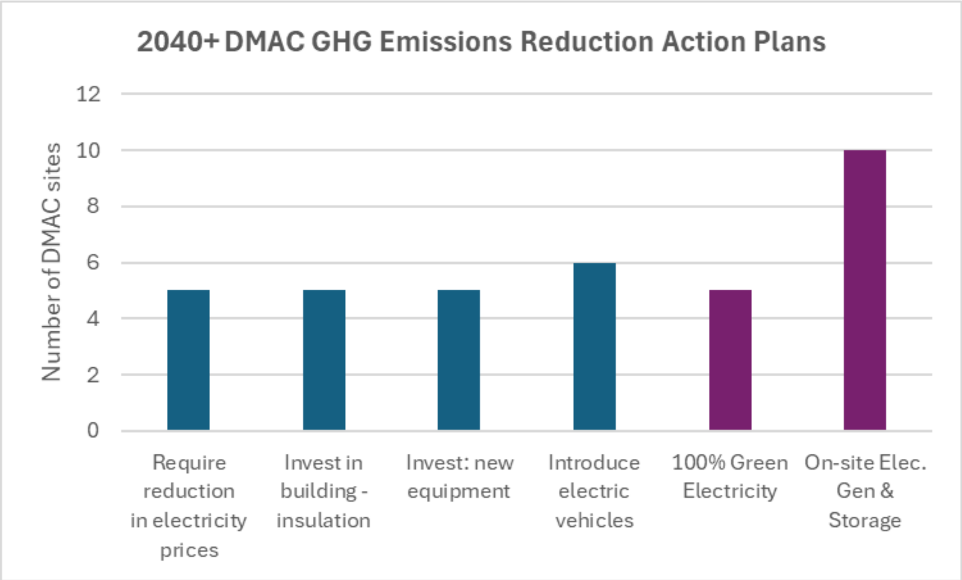
The first phase of emissions reduction up to circa 2030 to 2035 is dominated by actions to reduce energy consumption, these making up 90% of Scope 1 action plans; electric vehicles are the only 'change energy' being considered by two sites. Scope 2 reduction plans assumed that all grid electricity would be 'green' by this time, with four companies assuming that approval would be obtained to invest in on-site electrical generation and storage.

While there are still some energy reduction activities, the second phase relies on more electrification, especially for factory 'comfort' heating. This assumes that:

- the electrical solution meets all heating requirements (noting the tight temperature control some precision machining facilities require – refer to case study CS 2 in section 8.2 of this report); and
- the price of electricity reduces to enable the business case to be made.

Indeed, as shown below, the energy price assumption aligns with the investment in new equipment. Despite this, companies are considering investment in on-site generation and storage, although none of these will avoid reliance on the external supply of electricity, but rather reduce the energy costs, and support other plans such as electric vehicles, with 'free fuel' for employees. As witnessed during the DMAC programme, there can be internal push-back on internal storage, primarily because of the sacrifice of factory space, especially given that the industry is set to grow; in our case study the storage facility took up more room than a new machining centre for producing components. Furthermore, there are additional risks, safety concerns and tasks associated with the operation of these systems. The price-point at which these on-site storage plans would be abandoned has not been established, but assuming that all grid supply is ultimately green, not investing in on-site storage would have no effect on GHG emissions, yet would allow a company to invest in its core business and use the factory space to support growth rather than energy storage.





DMAC forecast for metal-alloy component supply chain emission reduction

The Midlands aerospace supply chain is highly diverse in capabilities, processes and products as it is dispersed. The MAA has a supply chain database that describes what each aerospace-approved site produces, its capabilities, location, number of employees, turnover etc. Using this rich data source, DMAC set out with the ambition to model the emissions reduction profile for a sample of the supply chain that goes beyond the scope of the DMAC partners' industrial processes, namely alloying, casting and forging. The project has engaged with both a casting and a forging aerospace company in an attempt to fill the data gap, and combine this information with the less-energy intensive DMAC partner data and reduction forecasts. Although a bottom-up derived from detailed information, the sample size is small given the variety in key factors such as processes, production quantity, range of alloys etc. Therefore the output is deemed a useful indicative measure of trend. However, with further engagement with additional suppliers, this approach would enable a more robust, absolute measure of the region's GHG emission reduction journey.

Approach for setting the 2023 baseline:

Primary Capability	Number of sites	% Total Emissions 2023	% Scope 1 Emissions 2023	% Scope 2 Emissions 2023	% Reduction by 2050	Source data for baseline Scope 1 & 2 (2023)
Metal & Alloy Producers	8	40%	37%	43%	90%	Av. of 3 material producers; 70% reduced due to alloy etc
Metal & Alloy Stockists & Machining	24	2%	1%	4%	90%	Estimate from machining company data
Near-Net Shape - Forging	6	33%	50%	11%	83%	Average of 2 forging companies, adjusted by turnover
Near-Net Shape - Casting	3	3%	2%	4%	90%	Estimate from non-ferrous casting company
Near-Net Shape - Moulds, Tooling etc.	12	1%	1%	1%	90%	Assumed similar to DMAC averaged data
Precision Machining & Fabrication (metal alloys)	148	11%	5%	19%	90%	DMAC averaged data from 13 sites
Heat Treatment, Surface Finish & Coatings	47	11%	5%	18%	90%	DMAC heat treatment company
	248					

Midlands Metal Alloy (Material & Components) Supply Chain excluding Tier 1 & OEM companies.

The 2023 estimate for gas and electricity consumption, and hence Scope 1 & 2 emissions, was derived from the following sources:

- DMAC team for low energy-intensive operations;
- One of the DMAC companies for heat treatment;
- Emissions data from Full Accounts accessed via Companies House;
- Information provided by Mettis Aerospace (forging & heat treat) and Maycast-Nokes (castings).

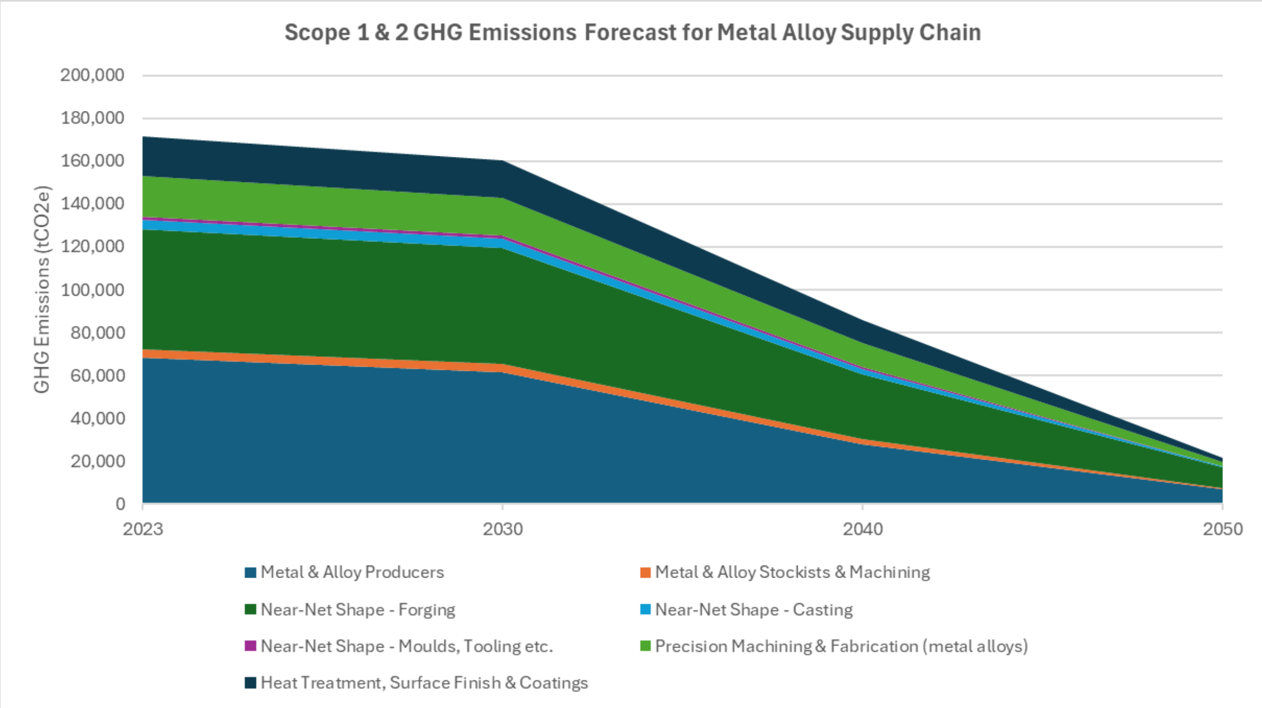
For certain groups, such as forging, the emissions data was typically scaled with turnover, on the basis that the range of materials were similar to the reference company or reduced if only lower melt temperature alloys were produced etc. Descriptions of the base data for the 2023 baseline for each capability grouping is provided in the table above.

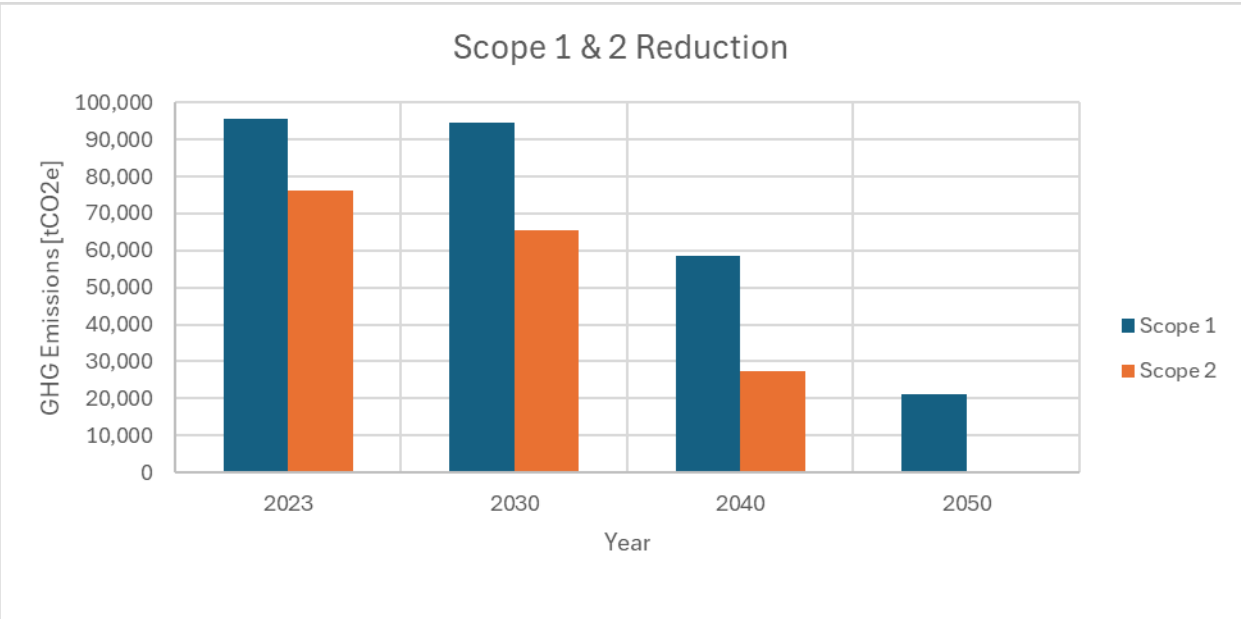
Approach for defining the reduction curves:
The reduction curves for low energy intensity processes were derived from the DMAC profile. To cater for the range in maturity across the largest population – and hence the different rate of progress between companies – a simplistic stagger was introduced for the 2040 results; the progress was split 50:50 between the leading companies and the trailing companies; post-2040, the latter group then accelerates reduction activities within the following decade to almost catch up with the former group.

Businesses with similar energy splits generally followed this model. The energy intensive companies, with a higher reliance and use of natural gas, were modelled with just improvements in efficiency being assumed until 2040, by when it was assumed the impact of a globally competitive electricity price enables the transfer from natural gas. This is clearly a significant assumption as it is the basis for the post-2040 reduction from this energy intensive sector.

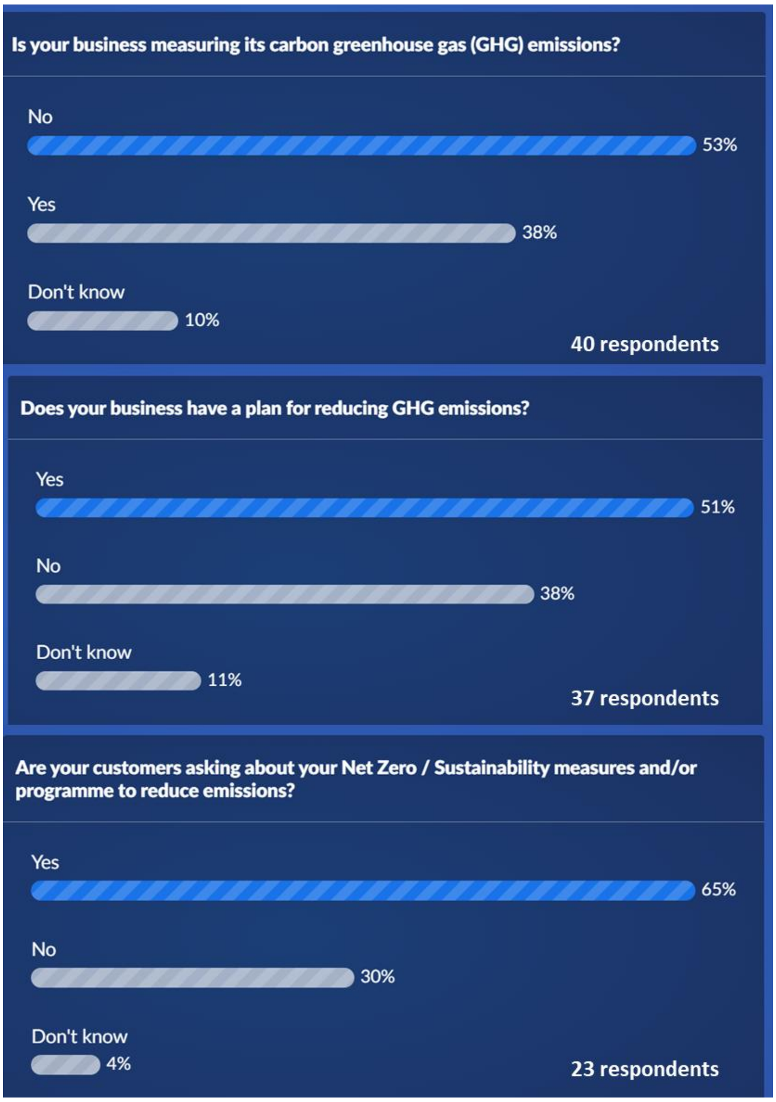
It is important to stress that these reduction curves represent a possible outcome and set of actions that rely on a number of key assumptions and:

- for the DMAC team, were considered plausible both in terms of action and outcome, but in no way do these represent commitments by the companies involved and such actions have not been assessed with the rigour and due diligence that such investments would require;
- for the other sectors, these are potential solutions that – apart from conversations with some individuals from such companies – have not been bought off by these companies.





Supply chain engagement on emissions reporting and reduction:
It is also noted that the DMAC partners are already committed to energy and emissions reduction, and as such are engaged on this journey. How reflective this is of the whole supply chain is difficult to assess. From polls taken at MAA Net Zero events (refer to the table below), about 40% of attendees claimed to be reporting GHG emissions.[25] However, this poll does not include those companies who were not engaged on the Net Zero journey and hence were unlikely to attend the event. During DMAC, a questionnaire was sent out to contacts within the Midlands aerospace supply chain, the results of which are presented in section 8.8. For modelling purposes, a conservative figure was selected with an assumed 60% of the supply chain yet to actively introduce emission reduction plans.



Poll results in 2022 indicated about 50% engagement on emissions reporting and reduction - but this is from an audience that was already sufficiently engaged to attend a Net Zero event.
[Source: MAA/University of Nottingham Aerospace UP "Jet Zero Midlands" event 27th January 2022]

[25] As ever with event polls, there are some surprising results – such as 53% were not recording GHG emissions but 51% had plans for reducing emissions. Such plans may be more focused on energy reduction initiatives, which would not in itself require GHG emissions to be calculated – one possible explanation.

8.4. Scope 3 Emissions

At QRM 3 (8th October 2024), the DMAC project was instructed to focus on Scope 1 & 2 emissions. Prior to this, DMAC had been assessing the challenges of upstream Scope 3 and had studied a number of case studies, listed in the table below. A very brief summary of the case study projects is also provided below.

#	Upstream Scope 3 Category	Case Study	DMAC Partner Lead(s)
1	Purchased goods and services	Challenge of removing plastic packaging from supply chain.	Collins Aerospace G&O Springs
2	Capital goods		
3	Fuel and energy related activities		
4	Transportation and distribution	EU transportation changes to address both emissions, costs and time.	Collins Aerospace
5	Waste generated in operations	Waste management	Technoset
		Recycling of Rare-Earth Magnetic Materials	Helix
6	Business travel		
7	Employee commuting		
8	Leased assets		

With regards to packaging, the case study on removing plastic from the supply chain highlighted the barrier of incremental change. Customers want simplicity and standardisation in their production systems, so when one supplier proposed a change in packaging materials, there was pushback. Furthermore, the plastic bags in current use have a high percentage of recycled plastic and provide corrosion protection for the components. The project did not go beyond this initial assessment. However, Collins Aerospace has teamed up with a local Wolverhampton company, Kite Packaging, that offers sustainable packaging solutions. This company is a certified carbon neutral business in both Scope 1 and 2 emissions, a packaging leader in finding alternatives to plastic products and transitioning to paper-based products and has experience with a variety of industries including aerospace, automotive and retail. One solution is made entirely from paper-based packaging and is 100% recyclable with no single-use plastics (e.g. bubble wrap).

For transporting goods to and from the EU, Collins Aerospace concluded that it would replace air transportation with road, with weekly ‘Milk Runs’ from Wroclaw (Poland) to St Ouen (France) [shipping ~13 metric tonnes] and onto Wolverhampton [shipping ~25 metric tonnes]. Not only did this reduce the GHG emissions but it also provided 10%-15% cost reduction and reduced transit time by 2 days (because of the post-Brexit delays in customs with air freight).

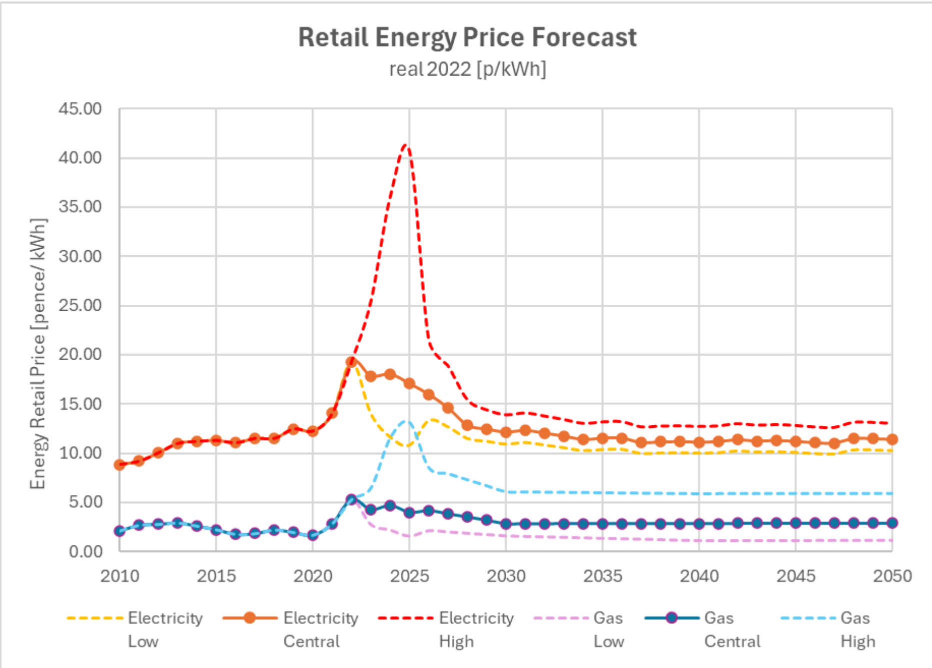
Waste management and recycling of materials are a common requirement across the industry, requiring strict adherence to segregation of swarf by material type, and the avoidance of contamination (from the likes of coffee cups!). Given that aerospace grade materials already typically carry a larger carbon footprint due to the additional processing, the long term goal should be to find affordable ways to recycling back to aerospace grade rather than down-grading to commercial or other such grades. Helix assessed the recycling of rare-earth magnet materials, and found this to be a cost effective process, although the expertise was in the EU, not the UK.

8.5. Energy Pricing and Infrastructure

To ensure that industry remains competitive against global competition and that the Net Zero 2050 target can be achieved, the price of energy needs to be globally competitive, most notably electricity.

As part of the HM Treasury's Green Book[26], DESNZ provides energy pricing forecasts[27] which were last revised in November 2023. Tables 4 & 5[28] provide the retail price forecasts for Electricity and Natural Gas in the UK. DESNZ "strongly advise[s] [that] the use of the full range of prices in all analysis [is used] due to the current uncertainty in energy prices, especially where the level of price has a material impact on your outcomes. This is due to the significant uncertainties across all components of prices, as observed from historic and current volatility, and in the transition to Net Zero."

These energy price forecasts for electricity and gas are presented below.

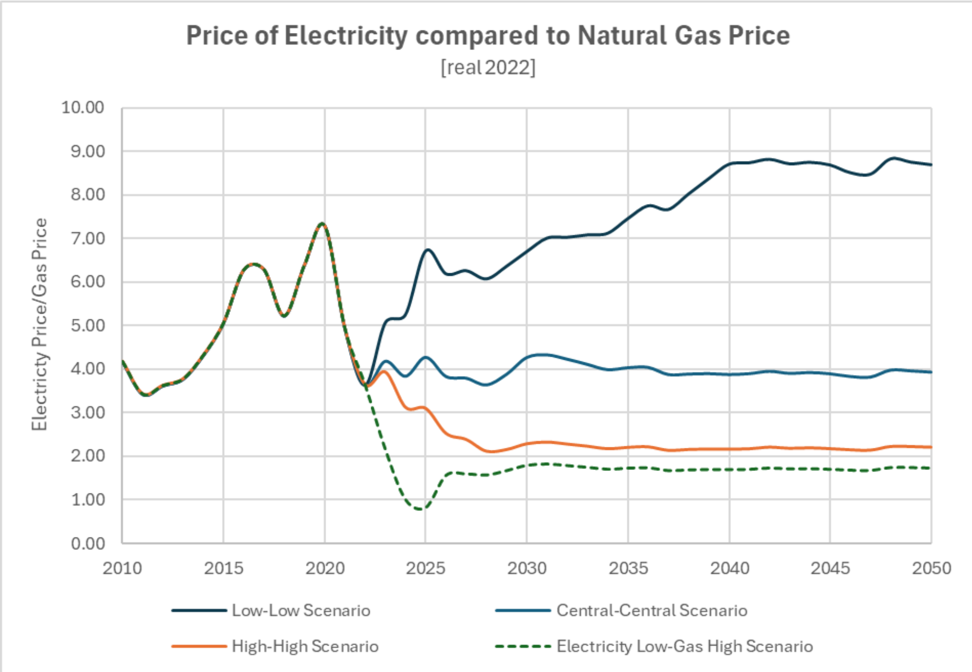


DESNZ Energy Price Forecasts predict that electricity prices will remain about 4 times higher than gas. (based on 'Central Scenario')

[26] The Green Book – Central Government Guidance on Appraisal and Evaluation", 2022. https://assets.publishing.service.gov.uk/media/6645c709bd01f5ed32793cbc/Green_Book_2022__updated_links_.pdf

[27] "Valuation of energy use and greenhouse gas emissions for appraisal - Supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government" DESNZ, November 2023 https://assets.publishing.service.gov.uk/media/65aadd020ff90c000f955f17/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal.pdf

[28] Set of tables that supports the Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions includes Tables 4-8: Retail fuel prices (real 2022 prices); Tables 4 & 5 cover electricity and gas. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fmedia%2F6567994fcc1ec5000d8eef17%2Fdata-tables-1-19.xlsx&wdOrigin=BROWSELINK



DESNZ price forecasts indicate that electricity could be between about x2 to nearly x9 more expensive than gas.

DESNZ forecast data shows a persistent trend of electricity prices being higher for industry than gas; the 'central' forecast indicates this is a factor of 4, whereas the high scenario is approaching a factor of 9. Even if the best-case electricity scenario (low) is compared to the worse-case gas (high), electricity is about 1.7 times higher. These scenarios offer no viable incentive for high-energy-intensity gas consumers to invest in green, electrical solutions.[29]

Globally Competitive Energy Pricing:
Global competitiveness is vital for advanced manufacturing supply chains such as aerospace, and yet to date, UK companies typically face higher electricity prices than their overseas competitors; this poses a threat to business continuity and growth. As reported in the government's October 2024 Industrial Strategy Green Paper: [30]

> "… a number of growth-driving sectors, including advanced manufacturing and digital … technologies have cited electricity costs as a barrier to growth. Electricity prices in Germany are 34% to 39% lower than for comparative businesses in the UK of any size, while in France they are 31% less for small businesses rising to 53% for the very large. On average, very large UK energy users face relatively high electricity prices compared to EU competitors (£228/MWh in 2023, compared to £108/MWh in France and £148/MWh in Germany), although about 400 of the most electricity- and trade-intensive UK industrial users benefit from lower electricity prices due to Government policies. These high electricity costs are a major barrier to growth and investment."

With regards electrical infrastructure, National Grid, DNO/Western Power Distribution, Energy Systems Catapult and Net Zero Industry Wales (NWID) were approached, where such topics as strategy for short

[29] Clearly, simply increasing the price of gas to close this difference is not a credible option, and would likely close these businesses or move the work overseas, something already experienced in the UK forging industry; refer to footnote #14 in Section 5 of this report.
[30] Ref: "Invest 2035: The UK's Modern Industrial Strategy" UK Government Green Paper, October 2024

and medium term electrical grid storage, increased capacity, smart export guarantees, future energy scenarios and grid limitations were discussed.

Hydrogen Infrastructure Plans for the Midlands

Drawing from conversations with Cadent and DESNZ information[31], it is understood that the UK government decision on the role of hydrogen is due in 2026, including the decision on domestic energy. Where the post-2030 HyNet expansion might go is not clear yet; there may be further work near the Humber, potentially followed by South Wales. The Black Country might be somewhere between 2040 to 2045.

Another alternative might be the development of an isolated network, such as that proposed in East London, covering 80 km.

An East Midlands pipeline could be in place by 2037, although in 2021 this was estimated to be 2035. The West Midlands would then be after this, circa 2040 or beyond. Despite the significant uncertainty, were such infrastructure to be delivered within these timescales, it would be too late to make a significant contribution to the DMAC strategy, nor it would seem the government's 2050 target.

Dispersed manufacturing sites will require pipeline supply. However, to make a credible investment case, these sites would ideally collectively draw of order 7 TWh/year, although 4 to 5 TWh/year might be sufficient. As such, this suggests that the majority of aerospace dispersed sites would need to rely on a much more energy-intensive industry, and/or potentially transition from dispersed sites to a set of industrial clusters.

Source: East Coast Hydrogen[32]

[31] Information from meeting with Sally Brewis, Cadent (19 Nov 2024) & "Hydrogen Strategy Update to the Market: August 2023", DESNZ, Aug 2023.

[32] "An Introduction to East Coast Hydrogen, a Hydrogen Pipeline Programme: 'Bringing Hydrogen to You'" 15th September 2021,

8.6. Customer Requirements and Legislation for Emissions Reporting

Customer Requirements for Emissions Reporting

Aerospace Primes and Tier 1 companies have assessments of their upstream Scope 3 GHG emissions, i.e. their supply chain's carbon footprint. In the majority of cases the DMAC team found such companies were assessing 'Category 1 Purchased Goods and Services' using secondary data via the spend-based method.[33] This does not necessarily give the level of resolution to enact precise emission reduction activities. The GHG Protocol warns that "data collected from a supplier may actually be less accurate than industry-average data for a particular product. Accuracy derives from the granularity of the emissions data, the reliability of the supplier's data sources, and which, if any, allocation techniques were used. The need to allocate the supplier's emissions to the specific products it sells to the company can add a considerable degree of uncertainty, depending on the allocation methods used."[34]

The aerospace Primes and Tier 1s have been working globally via the International Aerospace Environmental Group (IAEG), in part to provide a consistent flow of requirements into the supply chain. This aspirational objective is welcomed, as historically such unified initiatives have typically resulted in customer-specific outcomes, restricting re-use of information and resulting in additional work for suppliers into multiple customers.

As a first step, IAEG has recommended the flow down of the EcoVardis benchmarking platform for assessing where companies are on the sustainability journey, which includes, but is not limited to, GHG emission reduction. (Note, to date this platform is not being used to store actual GHG emissions data, but rather assess supplier's sustainability 'maturity'.) The supplier pays an annual fee and provides documentary evidence to receive a benchmarked reference. As an alternative, Collins Aerospace produced a spreadsheet questionnaire, shown below, which also requires evidence to support responses and collates actions etc.

While obtaining an understanding of where companies are, the aerospace sector Primes and Tier 1's have not dictated a rigid timetable for requiring product emissions reporting to support their own emissions reporting.[35] However, many suppliers believe that this will be introduced in the next round of contract negotiations, and some, such as Safran, are already requesting data. For those companies affected by EU CBAM legislation, reporting a sub-set of product emissions has already become a reality, which for many had been a surprise. Furthermore, many of the companies in the aerospace supply chain work in other sectors and hence will potentially encounter different customer requirements and/or deadlines.

At the launch of the DMAC programme, we found a mix of maturity with regards organizational emissions reporting, but that none of the companies were reporting product emissions. As such, DMAC undertook an exercise with G&O Springs and one of its customers, Collins Aerospace, to perform a 'cradle-to-grave' product lifecycle emissions report, using both a 'manual' approach and an off-the-shelf software solution, provided by Unipart Consultancy and the EmVide AI-enabled assessment tool. [Once configured, one of the

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[33] Spend-based methods are "estimates emissions for goods and services by collecting data on the economic value of goods and services purchased and multiplying it by relevant secondary (e.g., industry average) emission factors (e.g., average emissions per monetary value of goods)." Ref: "Technical Guidance for Calculating Scope 3 Emissions (version 1.0) Supplement to the Corporate Value Chain (Scope 3) Accounting & Reporting Standard" GHG Protocol, World Resources Institute & World Business Council for Sustainable Development, 2013

[34] Ref: "Technical Guidance for Calculating Scope 3 Emissions (version 1.0) Supplement to the Corporate Value Chain (Scope 3) Accounting & Reporting Standard" GHG Protocol, World Resources Institute & World Business Council for Sustainable Development, 2013

[35] Certain sectors have defined clear timeline for required product emissions reporting, such as the NHS.

advantages of the Unipart solution is to rapidly produce auditable reports and hence it is apparent how this could work very efficiently for complex supply chains such as aerospace.]

Maturity Questions
Is supplier aware and/or interested in sustainability and has intention to collaborate on this argument?
Does supplier have an internal process or policy to reduce carbon footprint
Maturity Level 1: Initial
Does supplier have a policy or initiative to measure, monitor and reduce GHG emission?
Does the supplier have an internal process for Environmental Management
Maturity Level 2: Managed
Has supplier started any initiatives related to GHG emission?
Has supplier assessed its scope 1 and 2 based on a validated or recognized standard
Maturity Level 3: Defined
Does the Supplier have an accredited EMS such as ISO 14001, ISO 15001 or equivalent
Has the supplier defined objectives on scope 1 and 2 and has formally communicated on it
Has supplier got a scope 1 and 2 plan defined with related organization, budget and resources
Maturity Level 4: Quantitative
Does supplier’s roadmap on scope 1 and 2 progess as per plan?
Has supplier started scope 3 initiative in addition to scope 1 and 2
Maturity Level 5: Optimizing
Has the supplier defined a roadmap on scope 3?
Has the supplier validated it’s 1.5°C trajectory with validation of SBTi or a supplier has been defined as carbon neutral?

Collins Aerospace GHG Emissions Maturity Assessment Questionnaire

Legislation - Carbon Border Adjustment Mechanism (CBAM)

Apart from the UK’s 2050 Net Zero target that is set in law, some of the supply chain has been affected by the EU’s CBAM initiative, introduced to complement its Emissions Trading System in order to avoid ‘Carbon Leakage’. For this report, a brief summary of the issues presented by the EU CBAM is set out below, as these are deemed relevant to the UK’s impending roll-out of its own CBAM.

The intent of the EU CBAM was to address imports entering the EU which have a significant carbon footprint[36] and that have not been subject to an equivalent ETS in the country of origin. As such the EU included raw and bulk materials, such as aluminium alloys and iron and steel alloys. To define the scope of affected items, the EU used global commodity codes, which were originally introduced for import and export purposes, not carbon footprint impact. So when the EU included all the commodity codes for such materials, it incorporated some finished products into CBAM, such as fasteners. Whether intentional or not, this specific category does not align with the original intent of the regulations, but its inclusion has impacted

[36] The selection was based on two key factors, namely high risk of ‘carbon leakage’ and high GHG emission intensity.

the supply chain, notably distributors, where obtaining the data from suppliers – notably overseas - has been extremely difficult.

It is the responsibility of the importer to apply the appropriate commodity code. Here the DMAC team has found an apparent inconsistency in how customers do this. Parts of a commercial aircraft or gas-turbine engine can be covered by specific commodity codes that do not fall under EU CBAM legislation. For example, aircraft and aero-engine parts may be classified with commodity codes from the following series:

- 8807: Aircraft, Spacecraft, and Parts [Includes parts of goods of heading 8801, 8802 or 8806]
- 8411: Turbojets, turbo-propellers and other gas turbines, and parts thereof

There are exceptions to certain products being included in these categories. For example, to fall within 8807, the parts "must be essential for the operation of an aircraft, and identifiable for use solely or principally with aircraft classified under either of these headings."[37] However, in all the cases studied to date, the parts have all been bespoke designs, made for a specific aircraft or aero-engine application, and hence fall into this category; in other words, these are not general, multi-use components.

However, with the specific example of engine pipework, a customer has selected a different commodity code series by defining the part as metal pipework, and selecting from the generic material commodity code series, that falls under CBAM. Furthermore, for the same engine application, another customer has used an aero-engine commodity code that falls outside of CBAM.

DMAC recommends that primes and tier 1 companies formally agree the commodity code structure for their products in a consistent manner. Meanwhile, for the supply chain, some simple questions up front can quickly confirm whether your products are affected by EU CBAM, such as:

1. Are any of our parts exported to the EU? (If 'No', you are unlikely to be affected.)
2. Do any of our exported products have commodity codes affected by CBAM? (If 'No', you are unlikely to be affected.)
3. If 'Yes' to #1 and #2, then check with your EU customer as to what commodity code it has for your specific products.

As EU CBAM has been 'live' since the launch of the 'Transition period' on 1st October 2023, and with the 'Definitive Period' starting 1st January 2026, by now, most affected suppliers should have been notified.

While the emissions that need to be reported for CBAM are a sub-set of the 'cradle-to-grave' product emissions, the recommended calculation spreadsheet is complicated. (At an EU customer CBAM training session, the recommendation was to employ an expert consultant to fill in the form.) Make UK informed the MAA that it signposted affected companies to the Carbon Chain website (https://www.carbonchain.com) as a means to simplifying the procedure for completing the form.

Further engagement with the UK Government on the design of the UK's CBAM solution would be most welcome.

[37] UK Government "Guidance: Classifying drones and aircraft parts for import and export" https://www.gov.uk/guidance/classifying-aircraft-parts-and-accessories#:~:text=Aircraft%20parts%20are%20classified%20under,balloons%20and%20dirigibles

8.7. Recommendations for companies about to set out on reducing emissions

The DMAC team produced some generic recommendations for those about to start the journey on emissions reduction.

a) Get started

Where companies have not already started on their emissions reduction programme, it is strongly recommended that they do. The primary reasons for this are:

- The first phase is likely to make cost savings by reducing spend on energy;
- Your customers will most probably require some of this information from you, so don't wait to be told; and
- This is not going away.

Decide what is important for you, be it the financial benefits, the environmental need or both.

Engage with your key stakeholders by speaking with

- Employees to obtain buy-in;
- Customers to understand their current and future needs;
- Local authorities, for example, to obtain access to free energy audits and potential funding.
- Furthermore, much can be gained by engaging with, and learning from customers, suppliers, peers and universities.

Top tips:

- There are a lot of passionate people with useful experience - tap into them. While individuals don't necessarily represent a whole organization they make great allies.
- Decide why you're doing this work; there's a myriad of good reasons from reducing costs and increasing profitability to doing the right thing for the planet.
- Engage your workforce, they're vital for implementation.
- Make a start, there's no wrong first step.

b) Reduce energy consumption

For a given output of production, reducing energy losses is a common starting point. There will be a range of opportunities, be it simple changes in behaviours ('last one turn off the light'), improved maintenance actions (stop pneumatic air leaks), improved insulation or investment in more efficient machines. The 'easy to implement', quick wins can help initiate momentum and give time for the more considered changes and investments.

Top tips:

- Energy audits are a great starting point and can identify opportunities to reduce consumption, from simple maintenance actions to capital investment, but as described in the case studies (ref CS 1), certain recommendations should be checked with a subject matter expert.

- Follow the money to reduce CO_2 emissions, from machine utilisation to voltage optimisers, leaking compressors to light bulbs. Establish your biggest costs/contributors and make a reduction plan. Old equipment may be very inefficient when compared to modern solutions; when looking to upgrade and replace, make sure to consider the energy efficiency savings and emissions reduction opportunities in capex and ROI calculations.

- Funding is sometimes available but the landscape changes; sign-up to regional newsletters to access support.

- Look into alternative power and energy sources; solar, wind and green energy are gaining in popularity.

- Data is vital; monitor usage and working patterns to make informed decisions. Perhaps more obvious insights will become apparent, for example when reviewing energy consumption during down-times. (Some CNC machines have surprisingly high base loads, enabling significant savings to be made by simply switching them off during downtimes.) There may be value in investing in equipment to provide further insight and resolution, for example on electricity usage by specific manufacturing processes or machines; however, there are different solutions, some more affordable than others. Many have found that installing a third party data platform has helped visualise the data and enabled faster decisions.

- Right first time applies more than ever to avoid wasting energy; if it costs it usually contributes to carbon emissions.

- Heat generation and air-conditioning can have significant impacts, so assess the building's insulation and air circulation etc.

c) Start measuring GHG Emissions

With robust energy data and reduction plans in place, the business can start to record its carbon footprint. There are numerous guidelines for doing this, but it is strongly recommended that:

- the overall GHG Protocol approach is used;
- start with just the Scope 1 and 2 GHG emission categories as these are within your control;
- start with emissions for a site, i.e. organization rather than product emissions;
- select a baseline year for which there is sufficient data so this can act as a reference set of data by which to assess improvement;
- Assess the impact of your reduction plans on emissions and consider further steps to reduce sources of GHGs from your organization;
- Then consider:
  - Most relevant categories under the Upstream Scope 3 emissions;
  - Product emissions, from 'cradle to gate' lifecycle assessment or the subset of product emissions required for export legislation (EU CBAM) if relevant (see next section below).

Top Tips:

- There are numerous online resources, guides and assistance available to help you calculate your footprint, for example, local authorities, trade bodies, local networks, government guidelines, consultants etc.
- Talk to your customers as they may provide support and/or have recommendations or preferences (such as baseline year, sources for conversion factors etc.).

d) Prepare for Legislation and consider Certification

Refer to section 8.6 for recommendations on Carbon Border Adjustment Mechanism (CBAM).

If not already in place, it is recommended that organisations consider:

- ISO 14001 Environmental Management Systems
    - designed to help reduce the environmental impact of the business, aligned with the GHG Protocol; and
- ISO 50001 Energy Management System
    - designed to improve energy performance and reduce costs.

Organisations can work towards compliance without going for accreditation, although this is becoming more of an expectation from customers rather than a differentiator.

8.8. Findings from DMAC Survey of Aerospace Supply Chain Organisations

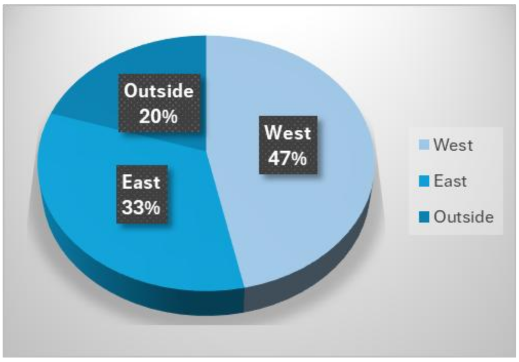
As part of DMAC, the MAA asked individual companies to complete a simple questionnaire, consisting of the following questions.

#	Questions
1	Company Name
	Company Postcode
2	Size (SME, Medium, Large)
	Region (East Midlands, West Midlands, Outside Midlands)
3	How many employees in your company?
4	How important is environmental sustainability to your business?
5	How important is environmental sustainability to your customers?
6	What was your total natural gas usage last year, in total KWH? (an element of scope 1)
7	What was your total electricity usage last year, in total KWH? (an element of scope 2)
8	Do you calculate your full Scope 1 emissions?
9	If YES to Q.8 - What were your Scope 1 emissions last year? (figure in tCO2e/PA)
10	Do you calculate your Scope 2 emissions?
11	If YES to Q.10 - What were your Scope 2 emissions last year? (figure in tCO2e/PA)
12	Do you calculate some or all of your Scope 3 emissions?
13	If YES to Q.12 - What were your Scope 3 emissions last year? (figure in tCO2e/PA)
14	Have you considered or do you use an alternative or sustainable energy?
15	Which alternative or sustainable energies have you used?
16	Have you experienced any issues using sustainable energy supply, and if so, what were these?
17	Do you have any other comments or information you'd like to share?

The following slides summarise the feedback and observations.

DMAC Survey

As part of DMAC, the MAA asked individual companies to complete a simple questionnaire.

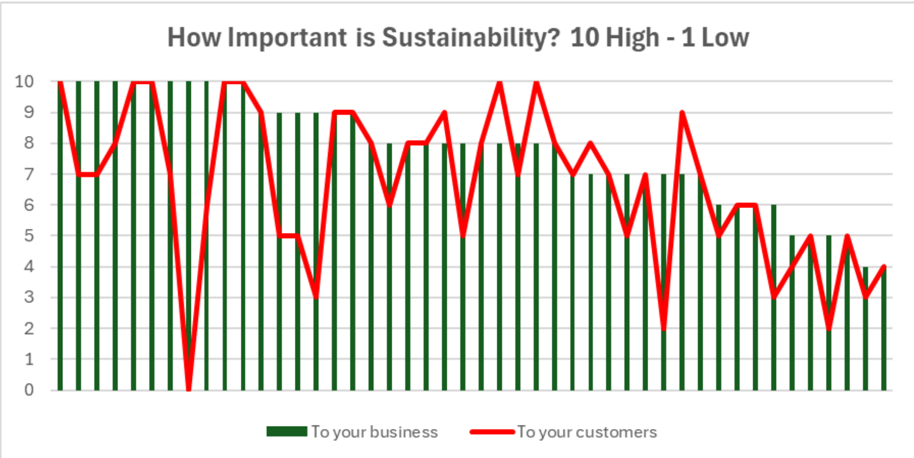


45 respondents:

- 12 Micro – 2 to 19 people
- 20 Small – 24 to 84 people
- 10 medium – 125 to 279 people
- 5 large - from 520 to 1840 people

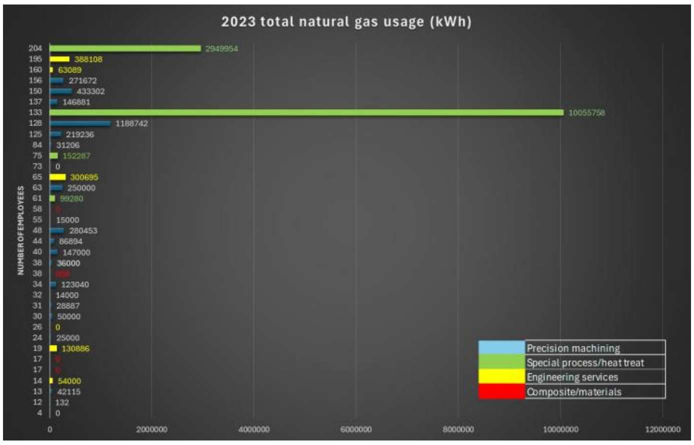
- 4 OEM/Tier 1s
- 23 Precision machining
- 6 Engineering services
- 4 Composites/materials
- 4 Special process/heat treat

DMAC Survey



Perceived Importance: 61% rated between **8 - 10** for Business **41%** rated between **8 - 10** for Customers

Total Natural Gas Usage – 2023



Precision machining:
Average usage – 161,408 kWh
Lowest 0 kWh – highest 9,287 kWh

Special process/heat treat:
Average usage – 3,314,320 kWh
Lowest 99,280 kWh – highest 10,055,758 kWh

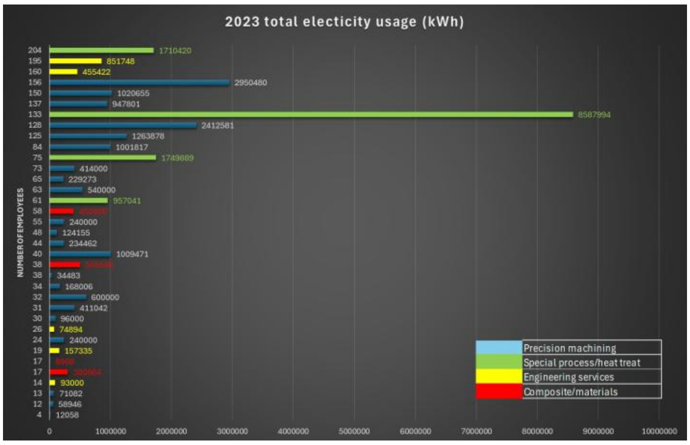
Engineering services:
Average usage – 156,130 kWh
Lowest 0 kWh – highest 388,108 kWh

Composite/materials:
Three of the four responders do not use natural gas
Highest 888 kWh

Note: averages of companies with <250 people

IUK DESNZ Local Industrial Decarbonisation Plans: **Decarbonising the Midlands Aerospace Cluster (DMAC)** Innovate UK Project No: 10090207

Total Electricity Usage – 2023



Precision machining:
Average usage – 1,200,950 kWh
Lowest 12,058 kWh – highest 10,345,000 kWh

Special process/heat treat:
Average usage – 3,251,336 kWh
Lowest 957,041 kWh – highest 8,587,994 kWh

Engineering services:
Average usage - 310279 kWh
Lowest 74,894 kWh – highest 851,747 kWh

Composite/materials:
Average usage – 185,979 kWh
Lowest 8,568 kWh – highest 400,000 kWh

Note: averages of companies with <250 people

IUK DESNZ Local Industrial Decarbonisation Plans: **Decarbonising the Midlands Aerospace Cluster (DMAC)** Innovate UK Project No: 10090207

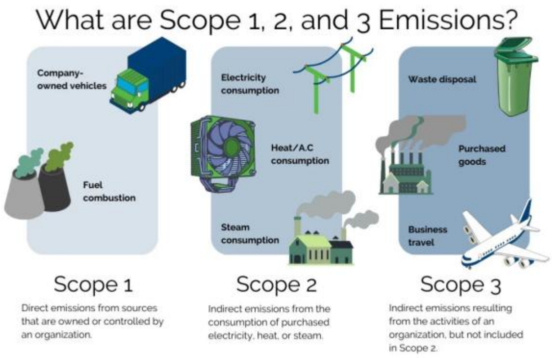
Emission Categories

Funded by UK Government Innovate UK

Scope 1
Only 37% of participants know their scope 1 emissions

Scope 2
Only 41% of participants know their scope 2 emissions

Scope 3
Only 30% of participants have a measure for scope 3



Note: averages of manufacturing companies with <250 people i.e. not special processes

Renewable Energy – Survey Findings

Funded by UK Government Innovate UK

83% of participants have explored renewable supply:

- Most popular solar, followed by green tariffs, and installing optimisation transformers

Only 2% have considered hydrogen as an alternative

Most common issues using greener solutions:

- Buildings; structural integrity, ownership and landlord permission
- Inability of Distribution Networks to receive surplus energy back to the grid
- Battery prices for energy storage, consider longevity and space needed on site

Success stories:

- Companies generating >50% of annual electricity consumption with solar power
- Some producing enough electricity to offer free EV charging to visitors and employees
- Introducing a 4-day week & planning core hours to maximise efficiency and reduce costs
- Appropriate deployment of voltage optimisation transformer to reduce energy consumption

IUK DESNZ Local Industrial Decarbonisation Plans: **Decarbonising the Midlands Aerospace Cluster (DMAC)** Innovate UK Project No: 10090207

8.9. Summary of DMAC Engagement Events

WMIP (West Midlands Innovation Programme) stakeholders round table
Date: 7th February 2024
Location: Online
Attendees: 16 external attendees
Personal invitations to stakeholders such as AMRC, WMG, SWM, Energy Systems Catapult.

DMAC Launch Event
Date: 26th March 2024
Location: Online
Attendees: 26

Decarbonising the Midlands Aerospace Supply Chain: how you can get involved!
Date: 11th July 2024
Location: AMTC Coventry
Attendees: 91

DMAC final event (sustainability showcase)
Date: 27th February 2025
Location: Ansty Hall Hotel
Attendees: 70 booked (no places left)

8.10. Abbreviations

ADS	UK's aerospace, defence, security and space industries trade organisation
AHU	Air Handling Unit
AMTC	Advanced Manufacturing Training Centre
Arms	Root mean square current
ATI	Aerospace Technology Institute
CBAM	Carbon Border Adjustment Mechanism
CHP	Combined Heat and Power
CoS	Cost of Sales
DESNZ	Department for Energy Security & Net Zero
DMAC	Decarbonising the Midlands Aerospace Cluster (DESNZ IUK LIPD Project)
DNO	Distribution Network Operator
EPC	Energy Performance Certificate
ESG	Environmental, Social and Governance
ETS	Emissions Trading Scheme (or in the EU, Emissions Trading System)
FLT	Fork Lift Truck
FMF	Flexible Manufacturing Facility (Helix facility)
GHG	Green House Gas
HVM	High Value Manufacturing
IETF	Industrial Energy Transformation Fund
IUK	Innovate UK
kWh/PA	Kilowatt hours per annum or yearly energy consumption
kWp	Kilowatt peak power output
LCA	Lifecycle Assessment or Lifecycle Analysis
LDR	Leak Detection and Repair
LIDP	Local Industrial Decarbonisation Plans
LPG	Liquefied Petroleum Gas
MTC	Manufacturing Technology Centre (part of the HVM Catapult)
NDT	Non-Destructive Testing
p/kWh	pence per kilowatt.hour (cost of energy)
PV	Photovoltaic (referring to solar panel technology)
PVD	Physical Vapor Deposition
SaaS	Software as a Service
SAF	Sustainable Aviation Fuel
SCT	Scalable Core Technology (Helix facility)
Vrms	Root mean square voltage
WMIP	West Midlands Innovation Programme