

Project DRIVE



Direct Air Capture and Greenhouse Gas Removal Programme - Phase 2

Final Report (Public Facing)



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Contents

1 Acronyms and abbreviations	5
2 Introduction	7
3 Design and Development	8
3.1 Planning and Permitting	10
3.2 MZT DAC general process description	10
3.2.1 Air Contactor (AC) package	10
3.2.2 CO2 Release	11
3.2.3 Control & Electrical Module	11
3.2.4 Stand Alone Reverse Osmosis (RO) Package / Top-up Facilities	11
3.3 Design origins	11
3.4 Relevant data informing the design	11
3.5 Challenges overcome during the design and development of the pilot system	13
3.6 Description of the installation of the pilot system	15
3.7 Final costs of the pilot system	15
4 Project Learnings	16
4.1 Key successes	16
4.2 Lessons learnt	16
5 Assessment of the benefits and challenges of the solution	19
5.1 Estimate of the CAPEX costs, OPEX costs and lifecycle costs per tonne of CO2 captured	19
5.1.1 Capital Costs	19
5.1.2 Operating Costs	20
5.2 Life Cycle Assessment (LCA) of the As-Designed Pilot Process	20
5.2.1 Optimal Operating Conditions	20
5.2.2 LCA Based on the Pilot Design	22
5.3 Monitoring, Reporting and Verification (MRV) methodology	23
5.4 Environmental and social impacts	24
5.4.1 UK Government Priorities and Context	24
5.4.2 Job Creation	24
5.4.3 UK GGR Leadership	24
5.4.4 Knowledge Dissemination	24
5.5 Scaling the system: opportunities, challenges and potential cost reductions	244
5.5.1 Integration with Energy and Infrastructure	25
5.5.2 Supply Chain and Manufacturing Considerations	26
6 Continued technology development beyond the project funding timeline	27
6.1 How this development will be informed by information gained during Phase 2	27
7 Market assessment and commercialisation	28
8 Assessment of the potential rollout for the technology once successfully commercialised	30
8.1 Scaling Strategy and Cost Reduction	30
8.2 Key Enablers and Barriers to Deployment	30
8.3 Project Objectives Review	31
9 Appendix: Photos of the completed DRIVE site	32

1 Acronyms and abbreviations

AC	Air Contactor
CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Utilisation and Storage
CDM	Construction Design Management
CDR	Carbon Dioxide Removal
CFD	Contract for Difference
DAC	Direct Air Capture
DAC-S	Direct Air Capture + Storage
DAC-U	Direct Air Capture + Utilisation
DESNZ	Department for Energy Security and Net Zero
DfT	Department for Transport
DRIVE	Direct Removal through Innovative Valorisation of Emissions
ED	Electrodialysis
EDBP	Electrodialysis Bipolar Membrane
EPC	Engineering, Procurement, and Construction
ETS	Emissions Trading Systems
FEL	Front-End Loading
FIDs	Final Investment Decisions
FTE	Full-Time Equivalent
GGR	Greenhouse Gas Removal
GHG	Greenhouse Gas
HSE	Health and Safety Executive
LCA	Life Cycle Assessment

MRF	Materials Recycling Facility
MRV	Monitoring Reporting and Verification
MZT	Mission Zero Technologies Ltd
OCO	O.C.O Technology Ltd
OPAL	Optimus Plus (Aberdeen) Ltd
OPEX	Operating Expenses
PLC	Programmable Logic Controller
PPA	Power Purchase Agreement
RO	Reverse Osmosis
SAF	Sustainable Aviation Fuel
SBRI	Small Business Research Initiative
TPY	Tonnes Per Year
TRL	Technology Readiness Level
T&S	Transport and Storage

2 Introduction

This report is produced by the Project DRIVE consortium which has been funded by the Department for Energy Security and Net Zero (DESNZ) Direct Air Capture (DAC) and Greenhouse Gas Removal (GGR) Programme – Phase 2.

The Department for Energy Security and Net Zero provides dedicated leadership focused on delivering security of energy supply, ensuring properly functioning markets, greater energy efficiency and seizing the opportunities of net zero to lead the world in new green industries.

Project DRIVE is part of the Department's £1 billion Net Zero Innovation Portfolio which provides funding for low-carbon technologies and systems and aims to decrease the costs of decarbonisation helping enable the UK to end its contribution to climate change.

Project DRIVE stands for the Direct Removal through Innovative Valorisation of Emissions and the project consortium consists of:

Mission Zero Technologies Ltd (MZT): DAC technology developer

Optimus Plus (Aberdeen) Ltd (OPAL): DAC pilot plant Engineering and Design contractor

O.C.O Technology Ltd (OCO): CCUS partner and host for pilot plant

This report is produced as part of the final project report requirement detailed in the contract, where an evidence-based final project report will be provided to DESNZ detailing the design and development of the pilot system, demonstration and trials results, key successes, lessons learned, remaining uncertainties, and next steps.

3 Design and Development

This project, known as Phase 2 of Project DRIVE, was led by Mission Zero Technologies alongside Optimus (Aberdeen) and O.C.O Technology to design, build, and deliver a 250 tCO₂/year plant design Direct Air Capture (DAC) pilot plant based on Mission Zero's IP, contracted to 120 tCO₂/year. With an energy -efficient, heat--free, and continually -operable DAC system, Mission Zero's DAC technology has the potential to reduce the costs and energy consumption of traditional DAC. This pilot plant is the first key step in realising that potential.

The objectives of Phase 2 of the project were to complete a detailed engineering design, obtain appropriate permits and licences and to build and commission a first of a kind pilot plant. The plant is currently being operated and tested according to an in-depth experimental plan, where the data generated has been critical for informing and optimising future scaled- up iterations of the technology. The completed plant is hosted at O.C.O Technology's Wretham site, where the captured CO₂ will be used as a feedstock for their proprietary Carbon Capture Utilisation and Storage (CCUS) process that generates manufactured limestone using CO₂ and waste fly ash, permanently removing CO₂ from the air while synthesising valuable material.

As a result the project will generate tangible value even at a pre-commercial stage and will support job creation and retention within all consortium members. The outputs of the project will inform the design of a first commercial--scale DAC plant within the UK, while directly helping to build out the domestic carbon removal ecosystem. Throughout the build and operation, the collaboration between Mission Zero and O.C.O Technology acts as a practical demonstration to pioneer the integration of DAC with CCUS at scale within the UK.

Benefits from Project DRIVE will include a stronger economic incentive to proliferate CCUS technologies due to the green, locationally -flexible, and economically competitive CO₂ newly available through this technology, and a more effective pathway to reducing the UK's CO₂ footprint by removing historical CO₂ emissions alongside future CO₂ emissions from sectors that are incompatible with traditional CCS.

The DRIVE plant is located at OCO's Wretham site based in Larkshall Mill, Thetford Rd, E Wretham, Thetford IP24 1QY.

Below is a site plan showing the overall layout of the OCO Wretham site. The DRIVE plant is visible on the far right, bordering the existing soakaway.

3.1 Planning and Permitting

As part of the early project process, MZT worked with external planning consultants to secure planning permissions for the DRIVE project. The submission sent to the Norfolk County Council included key information about the plant and location.

MZT applied to Norfolk County Council for temporary planning permission for a carbon capture pilot project for a period of two years at OCO's site in Wretham. Given the small-scale nature of the pilot project, a public consultation event wasn't considered necessary. As part of OCO Technology's community engagement, a liaison group was set up involving local elected representatives and OCO staff. The proposed pilot project was raised at the meetings which are held on a monthly basis. No concerns were raised.

Larkshall Mill operated as a Materials Recycling Facility (MRF) between 2006 and 2022. The site was subject to numerous applications for waste related development. In 2011 planning permission was granted for the extension of the site. In September 2022, Norfolk County Council granted planning permission to O.C.O Technology Ltd for the change of use from waste transfer station/materials recovery facility to a facility for the manufacturing of carbon-negative aggregates for use in the construction industry, including: demolition of existing storage shed, construction of feed hopper and conveyor, curing bay shed, covered aggregate conveyor system, 7 no. silos, CO₂ tank and associated site works at Larkshall Mill. Construction of the abovementioned development commenced in December 2022, and is now built and operational.

The ultimate goal is for MZT's DRIVE site to be integrated with OCO and to provide DAC-derived CO₂ for their use in creating carbon negative aggregates. This integration will be separate from the DESNZ-funded project and will occur after its completion. This integration is expected to be finalised within the month of July 2025. MZT is currently working with our external planning consultant to extend the temporary planning permissions for another two years, to summer 2027.

3.2 MZT DAC general process description

MZT DAC modular plant installed in Thetford, consists of two main process packages: Air Contactor and Electrodialysis Bipolar Membrane (EDBP). These processes can run either integrated or as stand alone.

In addition to the two main processes, three ancillary systems were also installed to enable power supply, water treatment and management and chemical dosing.

3.2.1 Air Contactor (AC) package

The AC unit captures CO₂ from the air. The package is provided with 4 AC contacting units. A circulation pump moves the capture solution to the AC unit's upper reservoir, from where it drains through nozzles and packing to the lower reservoir (AC sumps).

3.2.2 CO₂ Release

A pump circulates release liquid through a vessel and electro dialysis stack release flow compartments. CO₂ transfers from capture to release liquid in the stacks. Manual butterfly valves (with limit switches) allow a vessel to be the initial receiver for CO₂-rich release liquid.

3.2.3 Control & Electrical Module

This module houses the Electrical Distribution and Control System and a small control room for pilot plant monitoring. It has ample capacity for initial operation and can integrate four additional AC/EDBP modules.

3.2.4 Stand Alone Reverse Osmosis (RO) Package / Top-up Facilities

The standalone RO package replenishes water lost to evaporation from the AC unit. It includes a 5m³ storage tank and pump, fed by site supply.

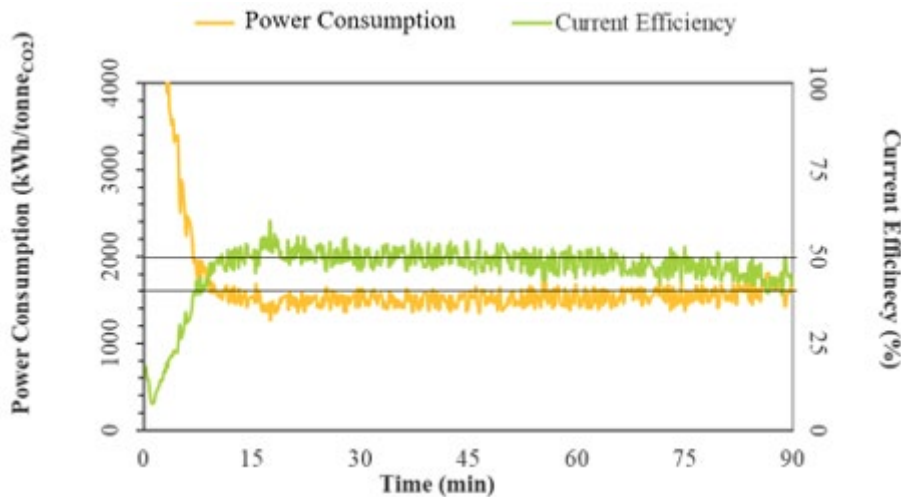
3.3 Design origins

No formal process modelling software was used to guide the unit's process design or operation. Instead, all operational parameters at DRIVE were developed through extensive laboratory and pilot-scale testing, using both batch and fully integrated demonstrations of our DAC process. Data from these experiments were then scaled up to inform the plant's design specifications and operating strategy following engineering best practices described in our Phase 1 Final Report. Process models now demonstrate strong alignment with experimental data, and are used to test hypotheses and anticipate system behaviour beyond the initial design criteria.

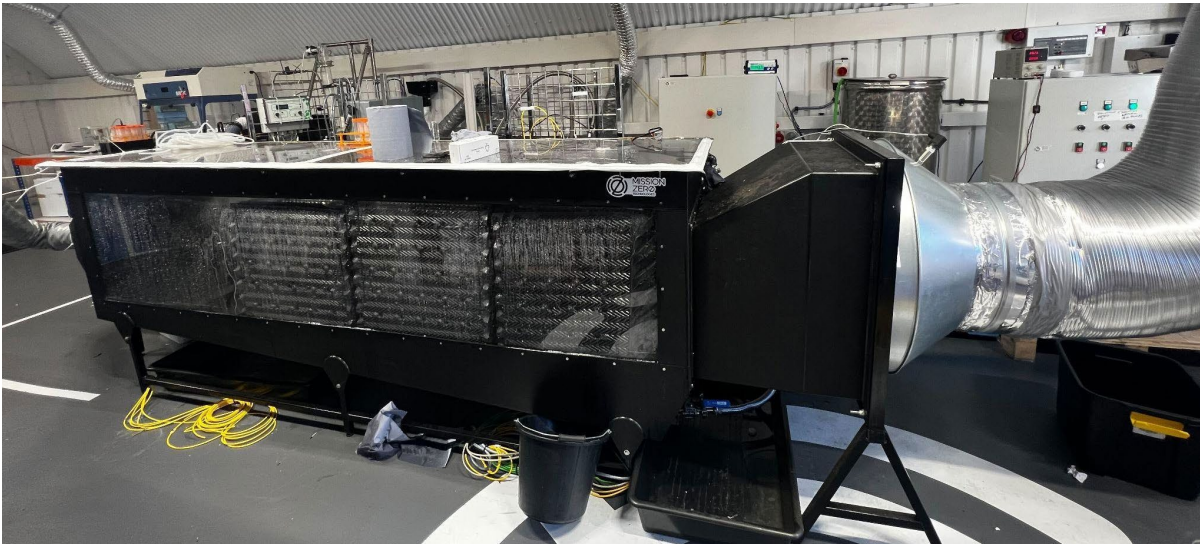
3.4 Relevant data informing the design

During Phase 2, we undertook high-throughput screening of a wide range of CO₂ absorption promoters to evaluate their performance in enhancing solvent absorption kinetics. These experiments measured CO₂ absorption rates as a function of pH, helping to identify optimal promoter candidates for contacting.

Following confirmation of the membrane-based regeneration route, we selected a membrane configuration through systematic characterisation of various membrane combinations. Using Micro-ED stacks we evaluated multiple membrane types with different physicochemical properties, assessing them on the basis of power efficiency and supply chain robustness. These data were used to scale the design to the required capacity of the Drive plant, ultimately informing the number and size of stacks needed.

Figure 3: Performance of selected membrane combination for the Drive plant

We developed a prototype cross-flow contactor to evaluate the gas–liquid contacting performance of one of the amine-based capture solvents. The contactor’s depth matched the design basis for the Drive plant. Experimental measurement of CO₂ flux (mg/m²/s) under controlled conditions enabled us to estimate the contactor surface area required to meet the plant’s CO₂ capture targets.

Figure 4: An image of the cross flow air-contactor used for design and sizing calculations of the Drive air contactors

The design basis of the air-contactors was to create a containerised design that would sit on top of the regeneration system. To create this design we worked with a supplier on two design cases. The first case considered was converting a shipping container into a single air-contacting module. This first design case was abandoned due to cost and complexity of realising the retrofitted design and instead we pivoted to producing smaller air-contacting modules that still fit within the constraints of the existing plant design and layout.

Bunding: HSE assessments led to bund capacity being sized based on the total liquid inventory within the system, in accordance with best practice.

Water Treatment and Climate Data: We used historical site-specific weather data (temperature and humidity profiles) to model annual water loss through evaporation from the contactor. This informed the sizing and turndown capability of the water treatment system (RO) and associated storage tanks.

Pollutant Impact Assessment: A pollutant impact report was produced in anticipation of local air quality conditions. Climate-controlled experiments simulated the effects of SO_x, NO_x, and particulate matter in the inlet air. Only PM₁₀ and PM_{2.5} were identified as concerns. As a result, appropriately rated screen filters were specified in the plant's air handling units to mitigate these risks.

3.5 Challenges overcome during the design and development of the pilot system

There were many challenges that had to be overcome during the design and development of the pilot system. After the completion of the detailed design in March 2023 the main focus of the project was vendor engagement and placing of orders. The major package of the DAC plant (Electrodialysis (ED) system) was purchased on the 31st March 2023. Further purchasing then stalled due to a number of design iterations and vendor clarifications arising. At the beginning of June 2023, quotes for two of the larger remaining packages were received that were well over the budget/constraints set during the setup of the contract. These packages were the Air Contactor system and the Fabrication package. A decision was made to carry out a value engineering exercise with the following objectives in order of precedence:

1. Maintain DESNZ project objectives
2. No increase in Health and Safety risks
3. Reduce CAPEX costs
4. Reduce Installation costs
5. Maintain the project timeline
6. Maintain the MZT Product Vision (where possible)

The value engineering of both the Air Contactor and Fabricator package were considered concurrently as the outcomes were linked. The major outcomes of the value engineering were as follows:

- Pipework and steel outsourcing
- Reduce the number of instruments
- Simplify container connection points
- Site layout optimisation

- Bunding simplified
- Drains tanks simplified
- Only one platform needed to access the ED/Solvent Management containers and provide emergency access to the safety shower.
- Procurement strategy to shift to MZT purchasing all equipment and delivering to site.
- Installation contractor to be responsible for all on site hook-up, install and commissioning activities.

Figure 5: Pre-Value Engineering - 3D Model - Product Vision Optimised

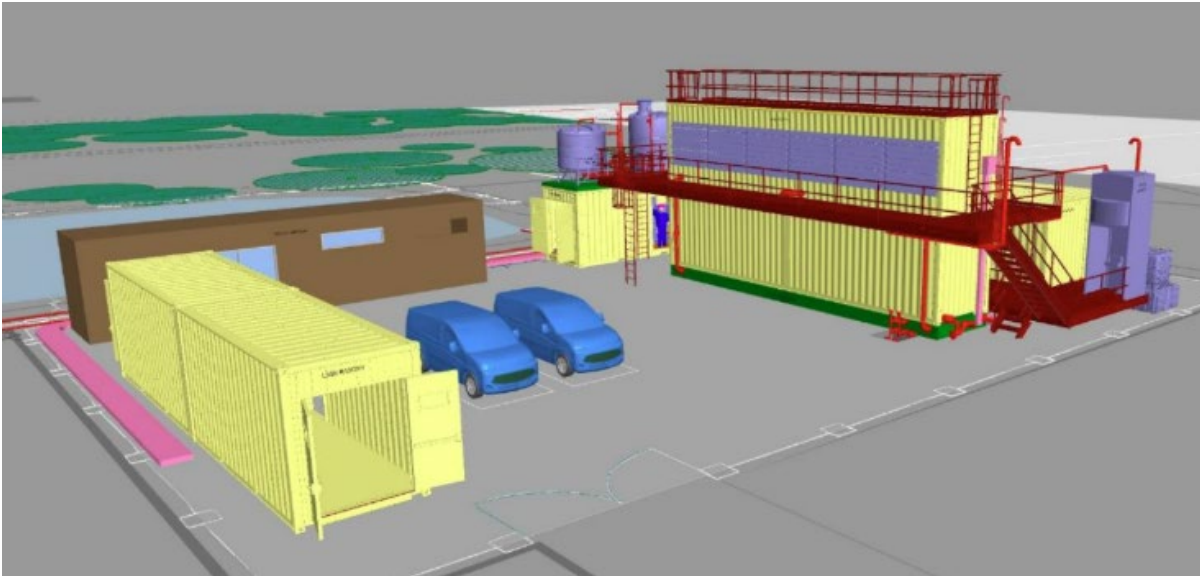
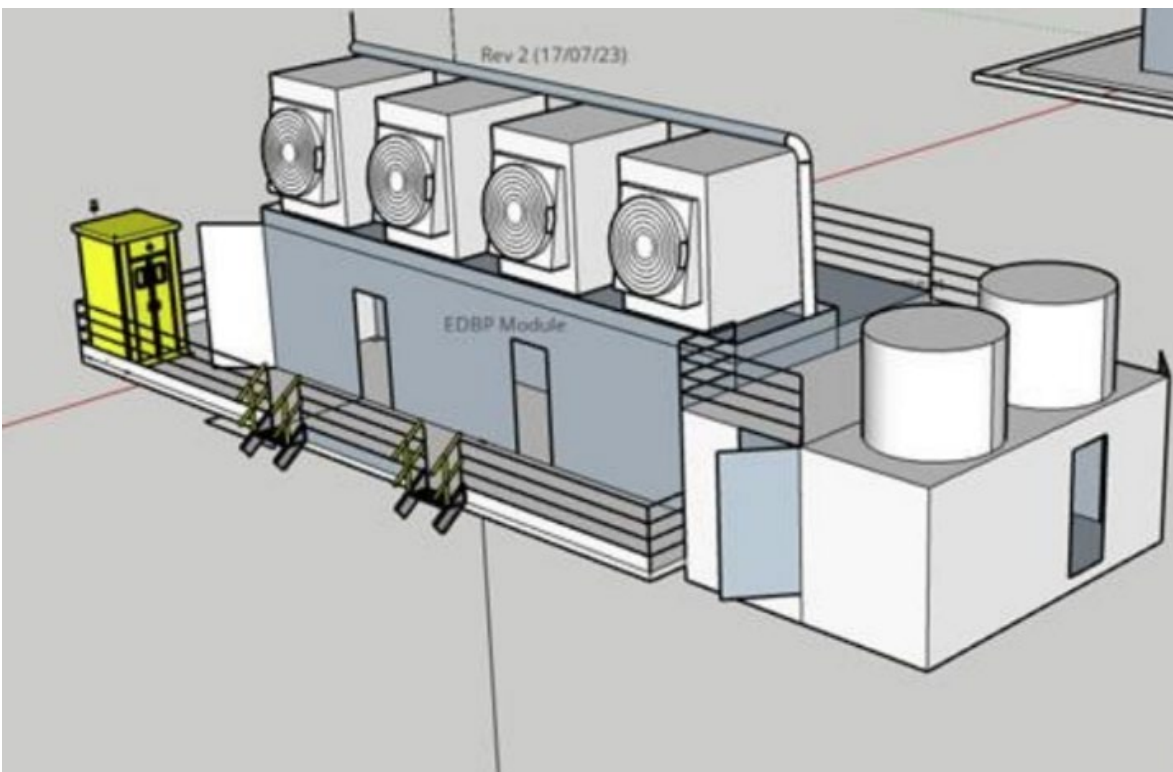


Figure 6: Post-Value Engineering - Optimised



Beyond the Value Engineering Exercise, some additional design challenges overcome include:

- Having our major pump for the Air Contactors within the Electrodialysis Container created challenges between separate work package interfaces
- No concrete site bund was available, so we had to integrate drainage and bunding within the design / layout
- Controls scope added complexity as taking in multiple packages into a single master PLC
- Transition from batch operation to continuous operation during the course of the project

3.6 Description of the installation of the pilot system

The DRIVE pilot system was installed over the course of 3.5 months primarily by our mechanical installation contractor. All equipment was Free Issued and delivered to the Thetford site except for electrical cabling/bulks and pipework. Electrical tasks were managed by two electrical installers. Control system design and installation was carried out by our control system supplier.

The controls package for the DRIVE pilot plant was especially complex. The control system in the DRIVE project is divided into three main zones: (1) ED Container , (2) Control Room, and (3) Office. All devices in these zones are connected through a centralised Ethernet network called Ethernet PN/IE_1.

All devices are integrated through a single Ethernet segment named Ethernet PN/IE_1. This standardisation supports Profinet communication and enhances overall system integration and maintainability.

3.7 Final costs of the pilot system

Final costs for this project were significantly higher than originally projected. This budget increase was one of the main challenges and risks for Mission Zero over the course of the project. The largest contributors to the final costs being higher than original forecast were the ED, Fabrication, Control System, and Site Preparation packages.

4 Project Learnings

The DRIVE project was the first capital project contract for Mission Zero Technologies. It has allowed us a number of invaluable opportunities for growth, and to apply lessons learned to our future projects.

4.1 Key successes

The DRIVE project has been invaluable to MZT. It has technically inspired additional projects within MZT (Fable, Mission Zero TestStand, Alpha, next generation products, etc.) and without DRIVE we may not have been as successful in selling additional products. Key successes from the project include:

- The DRIVE project gave us an opportunity to build relationships with multiple key suppliers and Consortium partners. MZT will prioritise maintaining these relationships for future potential opportunities.
- As with any First-of-a-kind project, we experienced many challenges. Through these challenges, our team developed a positive and resilient approach to problem solving. This will certainly serve us well as we continue to develop and scale our technology, undoubtedly continuing to face challenges and unknowns.
- Mission Zero has been able to utilise local companies for ad hoc site work including scaffolding, civils, electrical work, and septic installation/servicing.
- DRIVE is the first and only project of its size that Mission Zero will continue to own and operate after the conclusion of the DESNZ contract. This gives us amazing opportunities for continued Research & Development on site, continued data analysis, and to use the site as a real and visual example of our technology for potential future customers.
- This project has given us an opportunity to learn more about CDM (Construction Design Management) requirements. We have served as the Principal Contractor and Principal Designer on this project. This will make us much more knowledgeable and prepared for future projects with significant construction elements.

4.2 Lessons learnt

Project DRIVE has taught us many important lessons which will inform our future product plans. Some key lessons include:

Procurement-Related Lessons

- The absence of a developed and reliable supply chain caused delays, increased costs, and generated procurement challenges, including difficulties in sourcing critical components and materials on time, which directly impacted project timelines and budget. This project has provided us with valuable insights into how we can improve our tendering process for future projects. Initially, there was no dedicated process to evaluate and compare offers from suppliers efficiently, which led to potential delays and confusion in decision-making. As a result, we recognised the need and already

implemented changes within MZT to have a more structured and consistent approach to perform procurement processes and evaluate supplier bids. After the installation phase, the supplier for mechanical installation issued an unexpected invoice to cover their Extension of Time on site. This cost was not anticipated, as we had placed purchase orders for snag-related activities, assuming the quoted snag costs would include any additional time needed on site. MZT renegotiated these costs, but this was part of the learning process with the construction company.

- The project encountered negotiation challenges due to the lack of clearly defined budgets for each work package.

Lessons learnt beyond Procurement:

- Our Communications and Public Relations were previously quite far reaching but generally passive in approach. MZT now understands the importance of PR/Comms as a tool for achieving the next round of funding, winning sales and in pursuit of resources both labour and suppliers. MZT has experienced significant growth in the Communications and Public Relations division.
- Successful funding becomes much easier with a successful reference to prove our capabilities. Winning an SBRI Contract from DESNZ has provided MZT with a large amount of credibility. This will increase even further with a successfully operational DAC plant to showcase at the DRIVE site.
- We have learnt the value of having access to as much data as possible from the MZT laboratory to enable informed decisions for our scale up and real-world designs. Therefore, we have established an experimental platform in the lab that records and visualises data in real time. The most notable demonstration of this in MZT's labs is the continuous monitoring of an integrated test-platform containing all the features of the Drive plant, which is able to run and collect data 24/7. On this platform we collected over 400 hours during an uninterrupted run, and completed a test campaign exceeding over 1100 hours over the course of ~3 months.
- As with any First of a Kind operation, our timelines and budgets have become much better defined over the course of the DRIVE project. This has been invaluable, as it will allow us to predict costs and create programmes with much more accuracy on future projects.
- The importance of record keeping. We fully appreciate the importance of tracking the history of technical data modifications and requests to vendors.
- The importance of 3D modelling with high engineering maturity: we now appreciate the critical importance of reaching a high level of design maturity before procuring any materials. Many snags and adjustments had to be made on site due to clashes that were not identified during the initial 3D design. Similarly, a 3D scan of the site earlier in the design process would have prevented snags and delays down the line. The site is on a slight slope, and this had to be addressed after the foundation work had already been completed.
- The design of our bunds leaves room for streamlining and potential cost reductions. This is something that we have already highlighted for future projects.
- For on-site supply, footprint may be a key constraint for potential customers. The DRIVE project has given us experience with how to handle this. Footprint was deemed to be a

key driver in being able to benchmark our technology against comparable offerings. Reducing footprint is high priority with prospective customers, and is a design constraint we will ultimately optimise for.

5 Assessment of the benefits and challenges of the solution

5.1 Estimate of the CAPEX costs, OPEX costs and lifecycle costs per tonne of CO2 captured

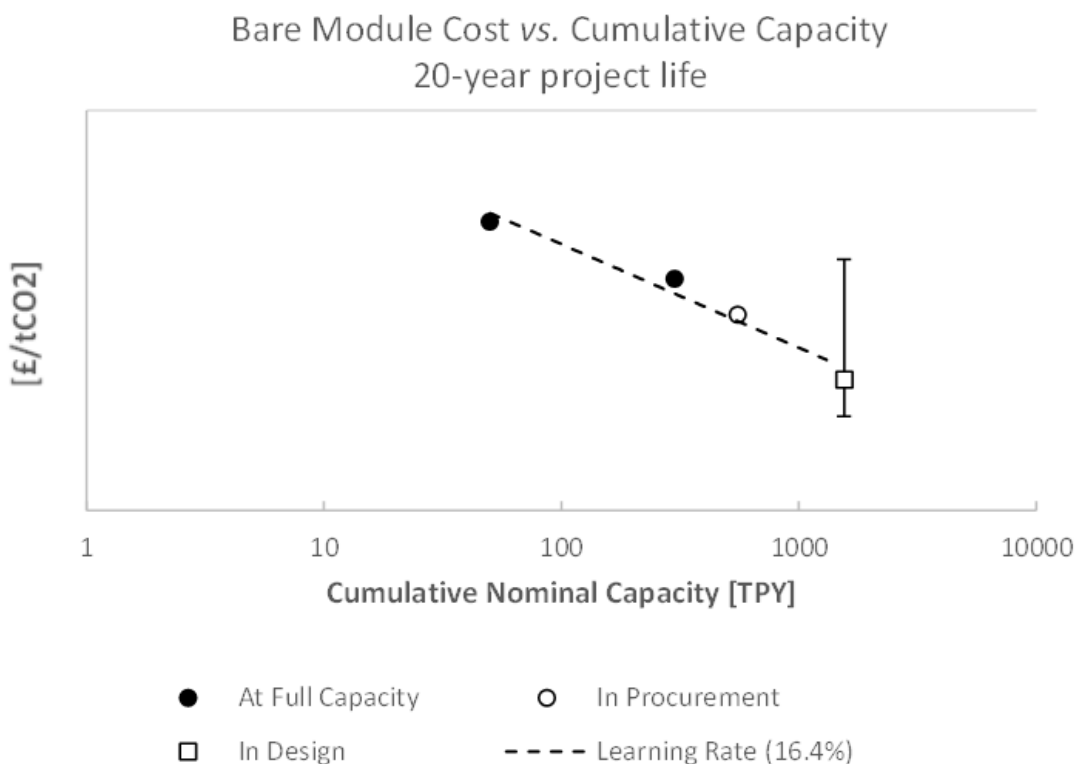
The funding for this project was largely allocated to CAPEX expenditure, with the largest expenses being the Electrodialysis Package, Air Contactor Package, Controls Package, Switchgear Package, Construction, Integration and Site Preparation.

5.1.1 Capital Costs

Project DRIVE has enabled MZT to enhance its understanding and forecasting of the capital cost associated with its technology. The insights and experience gained thus far from Project DRIVE and concurrent MZT projects have led to improvements in procurement strategies, system and solvent design (altogether “accumulated experience”). This accumulated experience is reflected in the realisation of a learning rate for capex (defined as the bare module cost). Current data suggest that this learning rate is in the range of 16% as discussed in this section.

As the systems realise their full nominal capacity, the per-tonne-CO2 capex reduces and the learning rate decreases towards a lower limit of 16.4% as illustrated in Figure 7:

Figure 7: Bare Module Cost vs Cumulative Capacity



5.1.2 Operating Costs

Operational data from project DRIVE will provide feedback to MZT models, which will improve system design optimisation and operating cost prediction.

Early estimates suggest that electricity costs are the largest burden for Project Drive, given a power price of £283.50/MWh under the local power purchase agreement. This creates a strong incentive to procure electricity actively through competitive day-ahead and intraday power markets. The average electricity price for the year ending 27-Mar-2025 in the day-ahead market is £80.77/MWh (a 71.5% reduction). Further, the lowest prices are attributable to a surplus of renewable energy, which would reduce lifecycle impact.

With enhancements in system efficiency, capture rate, drift rating, and scale, the next generation MZT system is expected to have an even lower cost. Lessons learnt from Project DRIVE continue to inform the design of the next generation system.

5.2 Life Cycle Assessment (LCA) of the As-Designed Pilot Process

An attributional gate-to-gate life cycle assessment (LCA) was conducted on the as-designed process, accounting for construction materials (e.g., steel, concrete, plastic) as well as the consumption of electricity, water, chemicals, and electrochemical inputs. The goal of the LCA is to inform engineers, scientists, and stakeholders about the dominant aspects of the overall system that determine the net global warming potential. The main function of the system is to produce concentrated carbon dioxide of use in a downstream carbonation process. The functional unit is one tonne of carbon dioxide produced. Three reference flows are explored: 100 TPY, 210 TPY, and 250 TPY (tonnes per year), corresponding to different ways of operating the system.

Operation of Project DRIVE will continue to provide data which will help us define optimal operating conditions, providing critical feedback for updating LCA studies with actual utility usage, and rates of carbon capture and utilisation. From the pilot to commercial scale, we anticipate design changes and efficiency gains that provide a significant reduction in embodied carbon as described herein.

5.2.1 Optimal Operating Conditions

Regarding optimal operating conditions, the DRIVE plant consists of 3 process units and 2 systems as listed below.

- Water management system
- Reverse osmosis unit (RO);
- Air contacting unit (AC);
- Electrodialysis unit (ED);
- Chemicals storage and management system;

In addition to the above, the plant counts with tuff tanks which are the final containment of the spent chemicals. These spent chemicals can be either recycled to O.C.O. raw water tanks (subject to quality checks although it has always been the case since commissioning) or disposed of offsite.

CO₂ gas product flows from the ED unit to O.C.O. through a pipeline and it is stored in a pressurized vessel located at O.C.O. plant battery limits.

Design intent of the plant process units and systems as integrated or on standalone mode, considered different scenarios to enable the operation not only at name plate capacities but also at minimum production levels which provides flexibility to operate during low or zero downstream demand periods. The operation of the plant to date has included the following phases:

- Commissioning (completed);
- Performance tests (completed), and
- Experimental plan (on-going).

The experimental plan as “still on-going” aims to cover the whole envelope of process conditions: flowrate, pressure, temperature, stacks current, chemicals mix pH, chemicals mix conductivity, final CO₂ gas product specifications and to test the plant and equipment stability over time.

RO process unit

The RO process unit works integrated with the water management system and consists of the equipment shown on Table 1 which also presents the most relevant process conditions.

Table 1. RO main equipment, capacities and process conditions.

Equipment description (tag)	Capacity	Process conditions
Raw water tank (T-700)	10 m ³	Atmospheric pressure Ambient temperature Incoming raw water pressure= 1-2 Barg
RO Unit (A-200) - 2 x cation exchange softeners - 1 x carbon bed - 4 stage RO unit	RO membranes vessel inlet flowrate = 1,600 L/h RO DI water (permeate flowrate) to T-500 = 1,200 L/h	Pressure= 2-6 Barg Temperature= 5-25 °C DI water pH = 7 (although it can vary between 6.5-7.5) DI water conductivity <10 µS/cm
DI water tank (T-500)	4 m ³	Atmospheric pressure Ambient temperature Incoming DI water pressure= 0.5- 1 Barg
DI water top up pump (P-	Discharge pressure =	Top up on demand

500)	0.4-0.9 Barg Flowrate range= 0-6 m3/h	Top up flowrate = 5 m3/h Top up duration per cycle = 5 mins
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AC process unit

The AC process unit receives DI water from the RO plant on demand and runs integrated with the ED process unit. The AC unit can also operate in standalone mode when only pumps from the ED unit run. As part of optimisation, we have optimised the air fan speeds, the fan power, the temperature and flow of the solvents in the report.

ED process unit

We have optimised our stacks for pressure, flow, temperature of all parts of our electro dialysis system.

5.2.2 LCA Based on the Pilot Design

For a pilot system capturing approximately 100 TPY (tonnes per year) of CO₂, we estimate the net greenhouse gas (GHG) capture under the following electricity scenarios:

- Grid electricity (carbon intensity of 0.207 kgCO₂/kWh)
- Wind electricity (carbon intensity of 0.011 kgCO₂/kWh)
- Solar electricity (carbon intensity of 0.041 kgCO₂/kWh)
- A mixed supply (25% grid, 75% wind)

The OCO site is powered by a renewable power purchase agreement that combines solar energy and grid energy. At present the specific carbon intensity of the PPA is not known and hence a number of cases were modelled.

Under current pilot contactor constraints, at least a mixture of renewable and grid electricity is required for the operation to be net zero. Relying solely on grid electricity would render the system net-emitting.

This outcome is largely attributable to the efficacy of the current design of contacting. Modest increases in air contactor performance would more than double the CO₂ capture rate, significantly improving overall performance to attain a net negative GHG capture rate with even lower or no penetration of renewable energy.

The carbon intensity of the electricity supply is the dominant factor affecting net carbon negativity of the process. Additional factors affecting the OPEX costs include chemical replacement and labour costs. MZT is looking to reduce costs for these factors in future project iterations.

A lesser but still substantial contributor to net emissions is the loss of solvent attributable to drift. Current estimates, inferred from drift-eliminator data, suggest that chemical makeup

requirements would contribute to a significant portion of CO₂ emissions, for a 50:50 mix of grid:solar electricity as does the use of material. Material requirements of the pilot system consist of Steel, Concrete and Plastic.

5.3 Monitoring, Reporting and Verification (MRV) methodology

The amount of carbon captured can be easily measured due to the controlled nature of the process. However, given the recognised importance of GGR and the importance of building confidence in the process, MZT have decided to put in place an independent monitoring, reporting and verification regime to ensure that the amount and permanence of removals are quantified, robustly and transparently, with tolerable uncertainty. Therefore, MZT has contracted an independent CO₂ verification specialist to develop a robust plan and carry out all verification tasks in an open and transparent manner. A Verification Plan has been developed and was used as the basis for the independent verification being carried out through the life of the project.

The parameters to be verified concerning the technical performance of the MZT DAC pilot unit focus on confirmation of the scale of operation and input rates as well as system performance in terms of CO₂ capture.

The verification process was conducted in several phases:

Phase 0: An initial review of documents,

Phase 1: An initial site inspection and process observation site visit.

Phase 2: Continuous remote monitoring via access to digital records supplemented with periodic data requests, and

Phase 3: A final site visit.

Phase 4: Review and verification of final MZT - submitted data package or report.

The verification of the Mission Zero Technologies DRIVE pilot facility was completed across three categories: Technical Performance and Scale Parameters, Environmental Performance Parameters and Administrative Parameters. The verification of these parameters is to be completed across two sets of data verification and associated findings reports representing two operational periods and development progress points, depending on the nature of the parameter and available operational data. The parameters to be evaluated and verified are based on commissioning data collected so far by MZT as well as data from a bench top unit based in the MZT lab. These data points are being used as interim references until 100 hours of operational data from the DRIVE demonstration site becomes available, which is expected in October 2025.

The first stage of verification was based on a review of limited commissioning data provided by MZT for the DRIVE pilot facility as well as findings from site visits during periods that the Pilot facility was not operational. The second stage of the verification shall review future operational data as well as 3rd party data including an LCA model and lab data associated with system

performance. The second stage verification shall consist of enough data points for the reviewers to assess additional parameters for which insufficient data was available in Stage 1, including system performance, water usage, waste generation, financial performance and scalability. The second stage of the verification shall be completed by the end of 2025, once a meaningful amount of operational data has been collected by MZT and other important documentation has been prepared. Verification parameters that are assessed during stage 1 shall be reassessed during stage 2 to confirm the findings based on commissioning data align with the operational dataset.

5.4 Environmental and social impacts

5.4.1 UK Government Priorities and Context

When this project was originally funded for Phase 1 in early 2022, the Government's November 2020 'Ten Point Plan for a Green Industrial Revolution' (highlighting CCUS technologies as one of the ten points where government funding, private sector support, and job creation opportunities would be strategically focused through 2030) was a significant driving force laying the path to future environmental and social benefits through accelerating GGR technologies in the present. Subsequently, the Government's 2024 pledge of over £20 billion funding to take CCUS even further, alongside certain other major economies stepping back their leadership in this sector like the USA, means the UK is better positioned than ever to be a global leader in exemplifying green growth.

Aligned with these tailwinds, our execution of Phase 1 and now Phase 2 has resulted in the successful development of the UK's first homegrown DAC technology to TRL7 (Technology Readiness Level 7), being delivered through Project DRIVE and several other projects alongside. The expedited commercialisation of our DAC technology facilitated by this project, is well positioned to show positive environmental impacts to the Government, its citizens, environment and economy once it is scaled up and commercially widespread by 2030.

5.4.2 Job Creation

Alongside developing the technology through Phase 2, the project has focused significantly on growing a domestic workforce to deliver this GGR solution. Mission Zero's achieved a headcount of 24 by early 2024 and brought on new private investment; as a result its current headcount stands at 53, of which 51 are UK-based FTEs. Optimus also added to their team over Phase 2, and were acquired by PDMS group, consolidating their green technology experience into a much larger organisation's capabilities that is now ready to tackle bigger projects domestically. OCO has also grown their UK headcount. All jobs created pay far above the national living wage.

Further jobs have also been created along our supply chain across the European region. We have also built out our supply chain in the UK specifically, with our mechanical fabrication, Air Contactor, electrical, controls, and integration partners. This is significant as the green skills workforce must be grown holistically across the value chain to ensure end-to-end delivery of such GGR technologies at scale is possible.

5.4.3 UK GGR Leadership

Mission Zero has experienced significant commercial growth aided by the Government's support via the GGR programme, representing the UK's GGR innovation potential on the global arena. It was the only UK-based DAC technology selected as a USD \$1 million Milestone Award winner in Phase 1 of the XPRIZE for Carbon Removal in 2022, and today Project DRIVE is in the top 50 shortlist for the Grand Prize for the same competition. Recently, it is deploying its technology in North America for the first time where it is recognised that the technology definition and maturation process facilitated through the GGR innovation programme significantly added to its credibility and attractiveness for partners. Similarly, OCO is underway with its expansions in Japan, Australia, and Spain, with ambitions of integrating technologies like DAC into its supply chains where possible. Hence both technologies are on track to deliver meaningful environmental benefits through continued commercial success.

5.4.4 Knowledge Dissemination

Throughout Phase 2, knowledge dissemination has remained a focus for consortium members. OCO have held several public consultations about the developed site so as to openly inform the community about the implications and benefits of project DRIVE. They were also awarded the King's Award for Sustainable Development in 2024 for their core business activities, raising the national profile of carbon removing projects like DRIVE by association. Alongside, Mission Zero has focused on skills building for the next generation entering the green workforce. We have delivered 7 lectures at 4 higher education institutions across the UK in the past 2 years, sharing with students how innovation in climate tech can be delivered, what our learnings through Phase 1 and Phase 2 have been, and what technical skills seem most critical for graduates-to-be who wish to get involved. Alongside, we have helped sow the seeds of further innovation beyond our GGR sphere, by supporting initiatives like the Climate Pre-Accelerator (held annually) to empower current students to explore how to bring new climate solutions to life.

5.5 Scaling the system: opportunities, challenges and potential cost reductions

The DAC process developed by MZT is housed as a containerised form factor. Scaling the technology will involve a combination of scaling up and scaling out different parts of plant design.

The key driver in scaling & cost reductions is the balance between Scaling up (making the components bigger) vs. Scaling out (repeating the same component). Project DRIVE has been designed so it can be repeated (Scaled Out) and it forms the baseline for how MZT will scale its technology. This is based on containerised components that can be repeated and duplicated to expand the capacity of the site. This analysis is currently being undertaken for our next generation of technology and the outputs from Project DRIVE are core to this optimisation. It will also be key for MZT to take CAPEX cost projection versus scale into consideration when finalising our next generation design. Scaling up our production numbers would allow us to access more beneficial rates.

The optimal scaling strategy depends on the plant size, customer needs, and project objectives.

5.5.1 Integration with Energy and Infrastructure

Large-scale plants will likely require dedicated renewable energy installations to ensure a stable power supply. By designing early direct air capture technology to thrive on intermittency and co-locate easily with renewable infrastructure, our young industry can generate climate and economic value for renewable projects. Developers can feed surplus renewable energy that cannot be fed into the grid to power the recovery of CO₂ from the atmosphere. The same logic can also be applied to monetise energy generated by renewables awaiting grid connection, which in the UK alone is on average a five-year wait.

Direct connection to renewables could prevent curtailment losses and reduce energy costs via Variable Load Management. This is currently happening with project developers in the power-to-X industry, and due to LCA implications, the energy must be renewable. Project developers of large capital projects such as data centres, hydrogen generation, desalination etc. do typically bring in dedicated renewables to generate power.

Connecting intermittent processes like DAC to harness surplus energy when it is generated offers renewables developers massive savings. It provides a revenue stream for energy that grid consumers are unable to use — or that is practically unable to ever reach them — which serves to increase the profitability of both existing and stranded new renewable infrastructure.

It also offers one of the cheapest pathways for stripping carbon from the atmosphere, as energy generated directly from a renewable asset at peak production is among the cheapest in the world — free from the added costs of battery storage or inverting the power into AC required by the grid. Lower the cost of doing DAC, and you increase the return of this revenue stream.

When using curtailed energy, there's simply no reason not to double or even triple the output of our system relative to its normal base rate of CO₂ output under regular conditions. This production flexibility is crucial for subsequent use or storage of that CO₂, where downstream processes often need to run continuously for production cost and maintenance considerations.

For many other DAC approaches, and indeed chemical processes in general, the twin considerations of energy and output consistency sandwiching the technology are often treated as technical and economic hindrances, but at Mission Zero, we see them as opportunities for better fulfilling the market's needs.

All of which underlines our thinking that in a world where the price, availability, and demand for green energy is highly variable, DAC solutions must be built to offer energy flexibility as standard.

For sequestration projects, minimal CO₂ post-processing is required, as existing CCS clusters already provide the necessary infrastructure for direct integration.

5.5.2 Supply Chain and Manufacturing Considerations

Large-scale deployment requires collaboration with EPC firms, major equipment manufacturers, and site fabricators to streamline construction and commissioning. MZT served as the Principal Contractor for the DRIVE site but are considering working with an EPC firm to hold this role for our next generation product. Commissioning of the overall plant will always be supervised by MZT, but commissioning of individual systems will fall within the remit of our suppliers.

Membranes used in our Electrodialysis systems are the primary supply chain constraint at scale. Manufacturers are scaling up production, but advanced procurement strategies will be necessary to ensure availability.

6 Continued technology development beyond the project funding timeline

After the conclusion of the Phase 2 Direct Air Capture and Greenhouse Gas Removal Programme, our plan as a company is to continue developing the GGR technology demonstrated at the DRIVE pilot site. The DRIVE site is just the beginning for MZT, and we will absolutely be applying our learnings to upcoming projects.

6.1 How this development will be informed by information gained during Phase 2

The design of our next generation product is deeply based on lessons learned from previous capital projects, especially the DRIVE project. Key learnings regarding scaling and cost savings will inform our next generation product.

The success of the DRIVE Pilot site proves the concept for onsite supply of CO₂, cutting out transport and liquefaction requirements and the energy required for them. This opens the door to scaling the solution from partial supply to full supply to customers such as OCO. The image below shows the carbon negative building aggregates currently produced by OCO, which will soon incorporate CO₂ from the DRIVE DAC pilot plant.

Figure 7: OCO Carbon Negative Building Aggregate



7 Market assessment and commercialisation

Direct Air Capture (DAC) offers a scalable, carbon-negative source of CO₂. This CO₂ can be permanently stored underground (DAC-S) or used in the carbon-to-value industry (DAC-U), where it substitutes fossil fuels (e.g., e-fuels). While DAC can be commercialised through either path, DESNZ currently supports DAC-S as a carbon dioxide removal (CDR) technology.

Particular benefits of DAC include the potential for co-location, removing emissions and costs associated with compression or liquefaction and transportation. DAC also allows for a dedicated supply of CO₂, providing protection against supply volatility including market shocks. This technology can unlock new areas of deployment for processes requiring CO₂, expanding into areas where a lack of supply or high transport costs were previously prohibitive. Finally, a relatively small footprint requirement can be beneficial. In comparison, large tracts of land are often required for feedstock growth needed for some other forms of carbon removals.

The short-term potential for DAC faces challenges in the UK and globally. The DAC industry is constrained by market limitations and transport and storage (T&S) infrastructure. DAC relies on the voluntary CDR market for revenue certainty, which lacks the depth to support long-term project viability. T&S infrastructure is under development but is generally not expected to be widely available until the next decade, with some exceptions in a few countries.

DESNZ aims to support the DAC market as a greenhouse gas removal technology through a proposed 15-year contract for difference (CFD). However, until CO₂ storage becomes readily accessible, DAC-S will be limited to applications like building materials innovation, where CO₂ can be permanently mineralised. These markets are limited in scale, hindering large-scale DAC-S deployment until the T&S infrastructure is established. Biogenic CO₂ remains the main competitor for DAC-S, thus any CFD must offer a premium for DAC-based removals to incentivise its adoption. Delivery of CDRs into the Emissions Trading Systems (ETS) would also provide much-needed liquidity. MZT welcomes the intention of the Government to integrate GGRs into the UK Emissions Trading Scheme (ETS) to provide much needed confidence, transparency, and liquidity into the market for removals

The utilisation market presents another potential catalyst for DAC. The e-fuels sector is a key market, and aligning incentives between the Department for Transport (DfT) and DESNZ could stimulate DAC under the sustainable aviation fuel (SAF) mandates. This could enable DAC to scale ahead of the T&S infrastructure development. We see the close connection in these markets in the United Airlines offtake deal with Hierloom.

DAC is capital expenditure intensive, but technologies are expected to become more efficient over time. Capital incentives, similar to those in Canada, could be more effective for the DAC industry and potentially reduce the need for long-term revenue guarantees.

When T&S infrastructure is available at scale, DAC-S can scale to meet the market demand. The UK can lead the European CO₂ storage industry, providing a competitive advantage. For DAC-S to succeed, the DAC industry needs access to abundant, affordable, and clean power.

DAC has few geographical constraints, allowing it to be located near planned wind farms, providing power producers with a baseload offtake without needing extensive grid connections. Electrochemical DAC, such as ours, can optimise production with intermittent power loads, minimising curtailment and maximising value for renewable providers. The UK Government can support the DAC (and e-fuels) industry by providing guarantees to support large behind-the-meter energy parks with good access to the T&S network, creating an ideal end-to-end solution to establish the UK as a leading DAC-S jurisdiction.

Our DAC plants are designed for remote operation, minimising physical intervention. Job creation will primarily come from feedstock suppliers and CO₂ users. DAC supports additional offshore wind farm development and the e-fuels and e-chemicals industries, which have the potential for significant employment. As the UK becomes competitive in DAC, other CO₂ conversion technologies, including chemicals and complex materials, will be attracted to the UK. While it is too early to quantify job creation in the carbon-to-value sector, abundant DAC is essential to attract these businesses. These industries are likely to be centred around offshore energy parks, fostering growth across various UK regions.

For Mission Zero, the progress and success achieved along Phase 2 has resulted in a healthy commercial domestic pipeline of our DAC technology before 2028. This is healthily distributed across use cases like building materials, sustainable aviation fuels, and direct sequestration. Even today, a second instance of Mission Zero's DAC has been delivered to another UK client for SAF production, made possible by the learnings and increase in TRL achieved through Phase 2. This pipeline is significant as in each of these cases, the very real prospect of Mission Zero's DAC as a carbon-negative raw material is the keystone technology enabling these downstream environmentally positive technologies and projects to be viable within the UK in the near term. In the very near future, CO₂ from the DRIVE pilot plant will be used in OCO's process to create carbon negative building aggregate. OCO's existing process creates carbon negative building aggregate using CO₂ from biogenic sources. With our collaboration, their carbon source will expand to include DAC-produced carbon as well. By enabling the proliferation of such end-users as OCO and beyond, we are well on track to achieve the benefits proposed.

8 Assessment of the potential rollout for the technology once successfully commercialised

Following the completion of the DRIVE project, the next phase of commercialisation will focus on multi-kilotonne-per-annum (ktpa) plants, with an initial emphasis on mineralisation and industrial CO₂ users. These early deployments will serve as a bridge to larger-scale sequestration projects. Achieving multi kilo tonne scale will require multiple Front-End Loading (FEL) engineering studies to refine the detailed design and techno-economic feasibility, targeting Final Investment Decisions (FIDs) in 2027.

8.1 Scaling Strategy and Cost Reduction

The development of our next generation product will be a key step in enabling cost-effective rollout. At the 1 ktpa scale, our next generation product is expected to achieve costs of \$350/tCO₂, with further reductions targeted through:

- Supplier optimisation: Sourcing more cost-effective membranes, contactors, and auxiliary components.
- Technical improvements: Increasing electro dialysis current density, optimising kinetics in the contactor, and reducing system complexity.
- Material and chemical efficiency: Using cheaper, more durable materials and extending chemical lifetimes to lower OPEX.

These optimisations will be critical to bridging the cost gap for large-scale sequestration projects, where further economies of scale will drive cost reductions

8.2 Key Enablers and Barriers to Deployment

The successful rollout of DAC at scale will depend on overcoming several challenges:

- Energy Access: Securing cheap, reliable, and green electricity is critical.
- Supply Chain Resilience: The DRIVE project has expanded MZT's supplier network, particularly in the UK, Europe, the US, and China, providing greater flexibility and shorter lead times for future deployments.
- Operational Uncertainty: Long-term OPEX remains a key unknown, particularly the lifetime of membranes, chemicals, and component failure rates. These will be closely monitored in DRIVE operations to refine future cost projections.
- Policy and MRV: Measurement, Reporting, and Verification (MRV) is essential for establishing DAC as a credible carbon removal solution. MZT will seek to align with the

most rigorous MRV frameworks to ensure high integrity in both voluntary and compliance markets.

8.3 Project Objectives Review

Our original project objectives included the following:

- To develop, design, build and operate an electrochemical, heat-free direct-air capture system.
 - We have successfully delivered an early commercial demonstration of our direct-air capture process. It is a system with a large degree of automation. DRIVE is a ~ 200x scale-up compared to our lab-scale integrated pilot.
- Develop a robust techno-economic understanding and life-cycle assessment of the technology.
 - We have developed a much greater techno-economic understanding of the technology developed at the DRIVE site. This has informed our budgeting for future projects and our plans for the next generation of our product. Our life-cycle assessment of the technology is still underway and not yet fully complete.
- Integrate the direct-air capture process into OCO's mineralisation process.
 - We completed the pipebridge and integration of our process into OCO's CO₂ vessel. We also delivered CO₂ into the vessel, however we fell short having aggregate being produced within the project timelines. The image below shows the buffer vessel where gaseous CO₂ will be stored before being injected into the OCO process building.

Figure 8: CO₂ buffer vessel and integration with OCO



9 Appendix: Photos of the completed DRIVE site









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