Industrial decarbonization and energy efficiency through AI

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We are the only company dedicated to the AI transformation of foundation materials

We are pushing the boundaries of machine learning and artificial intelligence in the production of cement and other foundational materials. Our goal is to enable the transformation of the industry to meet the decarbonization challenges.

Our team

We have built the best interdisciplinary team – with expertise in: AI, industrial processes, mathematics, computational chemistry, innovation, organisation change, software engineering and product development.

David Boyd
CCO

David has held senior leadership roles in digital transformation for global listed corporations.

He previously founded Boyd & Associates, a management consultancy and established a boutique M&A consultancy.

David has received multiple awards from the Royal Academy of Engineering.

Bob Gregory
Head of Engineering

Widely-recognized leader in the cloud-based software engineering community for the past 20+ years.

Bob has co-authored multiple technical writings, and the leading book on Architecture Patterns in Python.

Previously chief architect at Cazoo, one of the most successful British startups of the past decade and was also lead software architect at Made.com and Huddle.

Dr Nantas Nardelli
Senior Research Scientist

Nantas is an expert in machine learning and reinforcement learning with a PhD in Machine Learning from Oxford University.

Prior to Carbon Re, Nantas worked in research roles at DeepMind, Facebook AI Research, Microsoft Research and Five AI, among others.

Nantas led and shipped large-scale machine learning projects all the way to production, and has led the revitalization of multi-agent reinforcement learning approaches.

Santiago Ruest Teran
VP Sales

Santiago has over 20 years in the cement industry, including 8 years with Holcim in North and South America, 8 years with ThyssenKrupp in Europe and South America and 4 years globally with FLSmidth.

Dr Aidan O'Sullivan
CTO & Co-founder

Pioneer in application of AI-to-energy systems.

Professor in AI & Energy at UCL, and Fellow of Alan Turing Institute.

Programme Chair in AI and Climate Change at UNESCO's International Research Center on AI.

PhD from Imperial College and Postdoc from MIT.

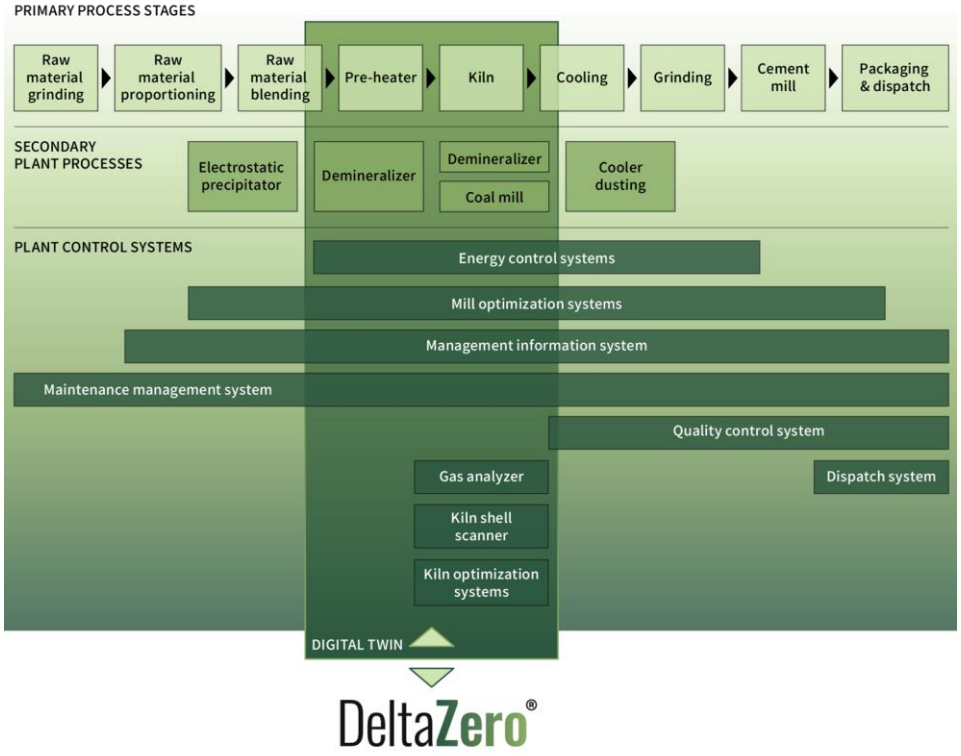
Unlocking the value in your data

Why is this possible now? Why didn't we do it before?

Modern plants produce an abundance of data from equipment and IoT sensors but legacy software and operational processes are too static

AI-enabled analytics can help manufacturers exploit this data for massive efficiencies, but it is **hard to implement** and talent is scarce

Delta Zero combines AI and cement production expertise to unlock value and reduce carbon emissions



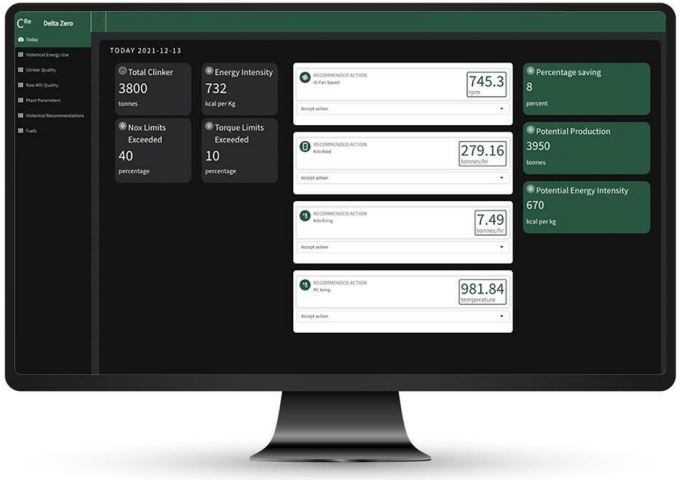
Our solution

Using **state-of-the-art artificial intelligence and machine learning** we:

- **Harness existing industrial data** to produce sophisticated modelling of energy-intensive processes
- **Optimise fuel use**, resulting in immediate reductions in specific heat consumption, with lower costs to manufacturers and lower emissions, **today**
- **Use a variety of AI and ML techniques**, in particular reinforcement learning: a branch of AI particularly well suited to navigating complex environments

Our solution is a repeatable, cloud-based software that is fast to deploy and easy to use

Our platform, Delta Zero Cement, enables substantial cost savings and emissions reduction in cement production



Fast-growing market presence

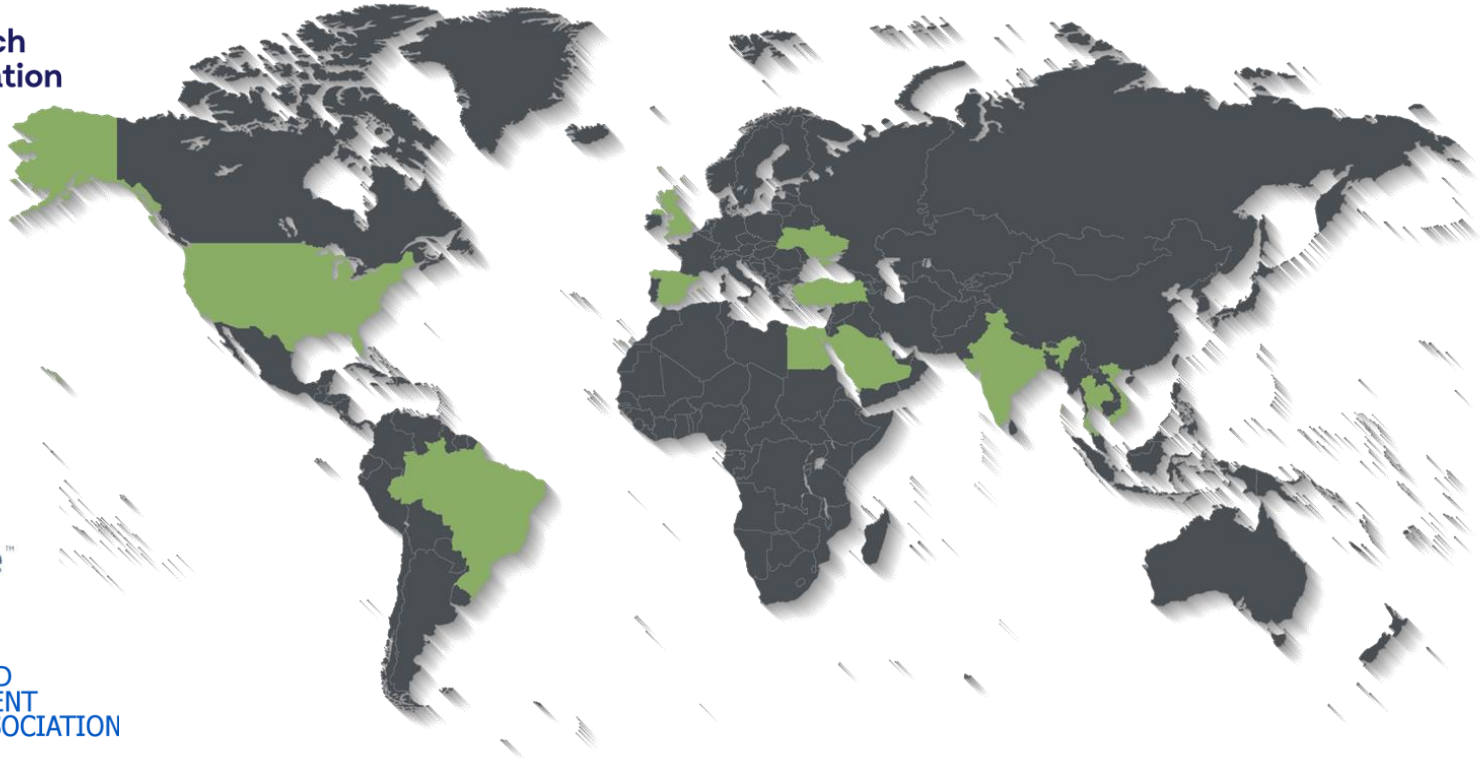
UK Research and Innovation

Materials Processing Institute

decarb connect

Responsible Steel standards & certification

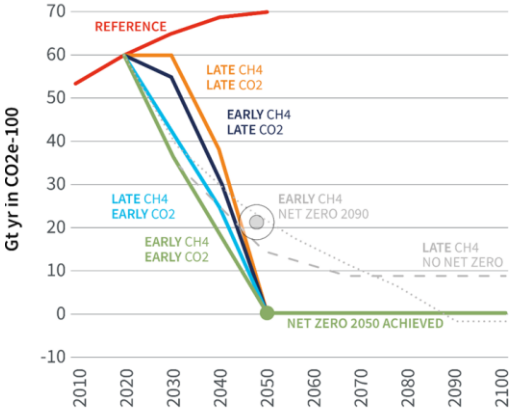
WORLD CEMENT ASSOCIATION

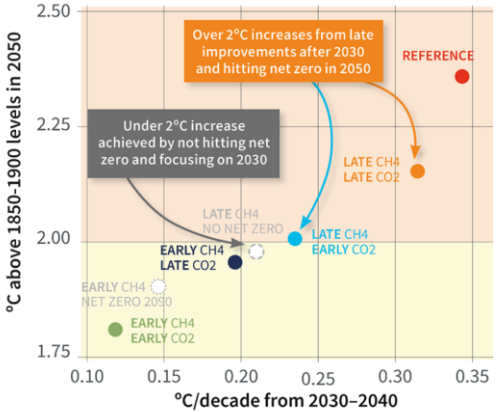


Reductions by 2030 are more important than net zero in 2050

A delay to any significant improvement until 2040 is too late: achieving reductions by 2030 is more important than achieving net zero in 2050.

Research published in Nature in 2021 shows not hitting net zero (but making good progress by 2030) delivers a significantly better result than hitting net zero through a big improvement between 2040 and 2050.





Source: https://www.nature.com/articles/s41598-021-01639-y

Achieving our goals for 2030 are just as important, perhaps more important, than 2050 due to the radiative forcing impact.

AI is part of the solution

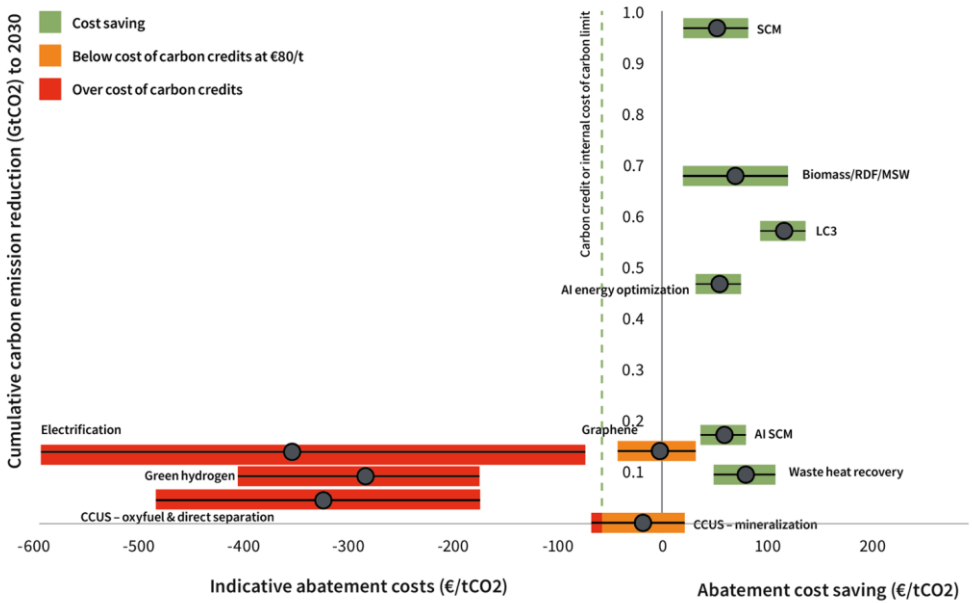
Three groups of technology combined deliver 81% of a total 3.4 gigatonne CO2 opportunity from 2023 to 2030, and reduce operating costs:

1. Substitute Cementitious Materials (SCMs): standard and LC3 (orange)
2. Biomass, RDF and MSW alternative fuels (red)
3. AI improved process controls, covering energy optimization and SCM blending (green)

Extract: "Three technologies to reduce climate change: why cement production between now and 2030 matters to all humanity, and what we can do about it"

Published by Carbon Re
Released February 2023

Indicative carbon emissions abatement costs compared to the cumulative carbon emission reduction potential from 2023 to 2030

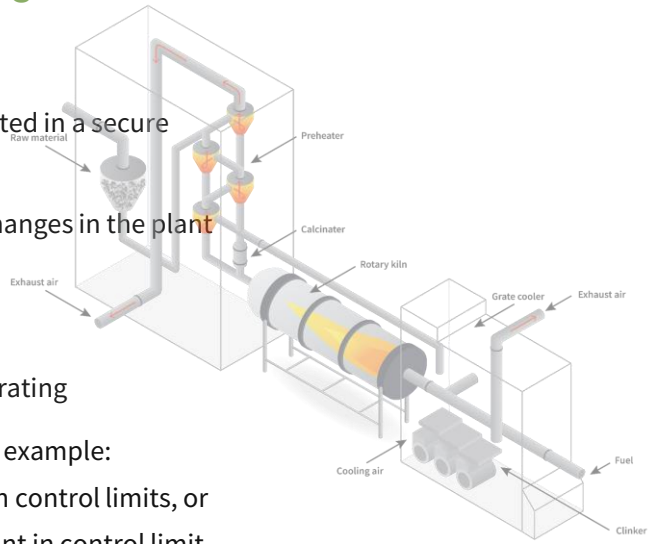


Source: Carbon Re analysis

Introducing Delta Zero

Pyro-processing optimization with artificial intelligence

- Dynamic and live optimization based on live data
- No capital investment, new sensors or new on-premise systems: our platform is hosted in a secure cloud environment, and simply need secure access to the live plant data
- AI models learn how each plant operates from the data: they evolve and adapt to changes in the plant configuration
- Each AI model is a bespoke customized ‘digital twin’ of the plant
- Our recommendations take into account quality metrics and customer defined operating
- Optimizations are defined by each plant and can be changed according to need, for example:
  - Maximize throughput then minimize cost, whilst maintaining quality and plant in control limits, or
  - Minimize cost whilst maintaining throughput, whilst maintaining quality and plant in control limit
- Delta Zero target recommendations and soft sensor data can be directly fed into the Expert Optimizer to optimize production processes



How it helps our customers

For cement producers, **Delta Zero targets**:

8% ↓
fuel costs

$3m
annual savings per plant

leading to:

20% ↓
fuel emissions

8% ↓
overall cement emissions

With significant advantages:

Zero capex
Fast to set up
Exploit existing data

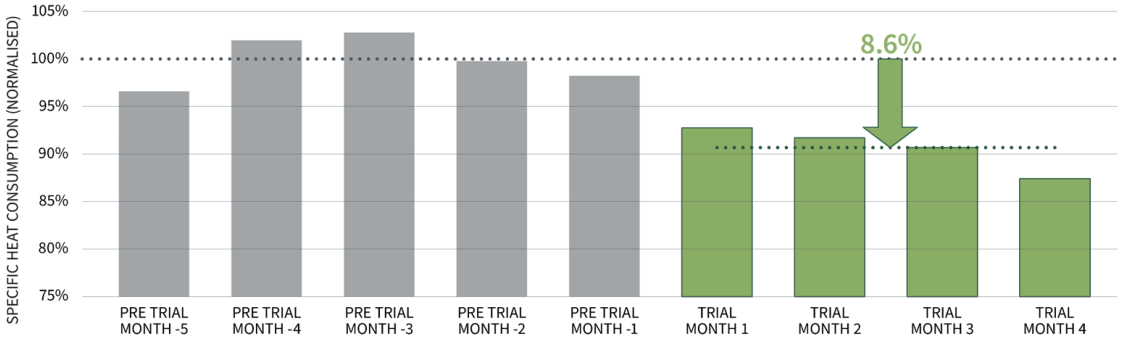
Successful in-plant deployments

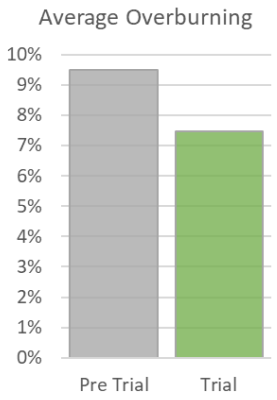
↓8.6%

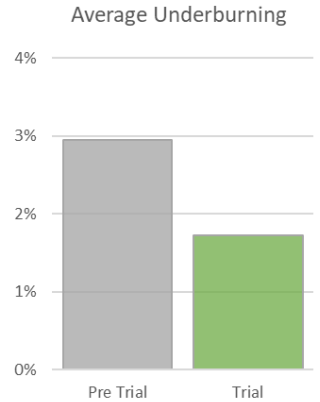
Reduction in specific fuel consumption compared to historic average

↓$3,100,000

In fuel cost savings at typical sized plant







↑~20% profit

For a typical 8-10% margin

↓44,000t CO_2

In emissions reduction at fossil-fuel only plant

↓20%

In overburning of clinker

↓50%

In high free lime clinker


OpenAI
OpenAI
ChatGPT 4.0
Midjourney

A modern machine learning platform

We have built a scalable state-of-the-art machine learning platform

The system architecture of Delta Zero uses cutting edge technology to rapidly develop and deploy our models

Our models react to live plant data

Our models are continually retrained to match actual plant performance

- Our modelling work is not for offline analysis.
- We continually monitor and retrain our models.
- The evolution of each model is to keep it in line with real world plant performance.
- We have a monitoring platform which tests model performance.

This is a world-first

1. Live data streams on plant performance are fed into our statistical models hosted in the cloud.
2. Our models allow us to make predictions of what the plant performance will look like in the future.
3. From these predictions we develop and test different scenarios: what control settings will be the most beneficial.
4. We check the best performing scenarios against plant control limits: e.g. will they produce product with the right quality parameters?
5. The scenario that delivers the best results whilst meeting control limits is sent over the cloud as a recommendation to the Control Room Operator.

Holistic models assessed by engineers

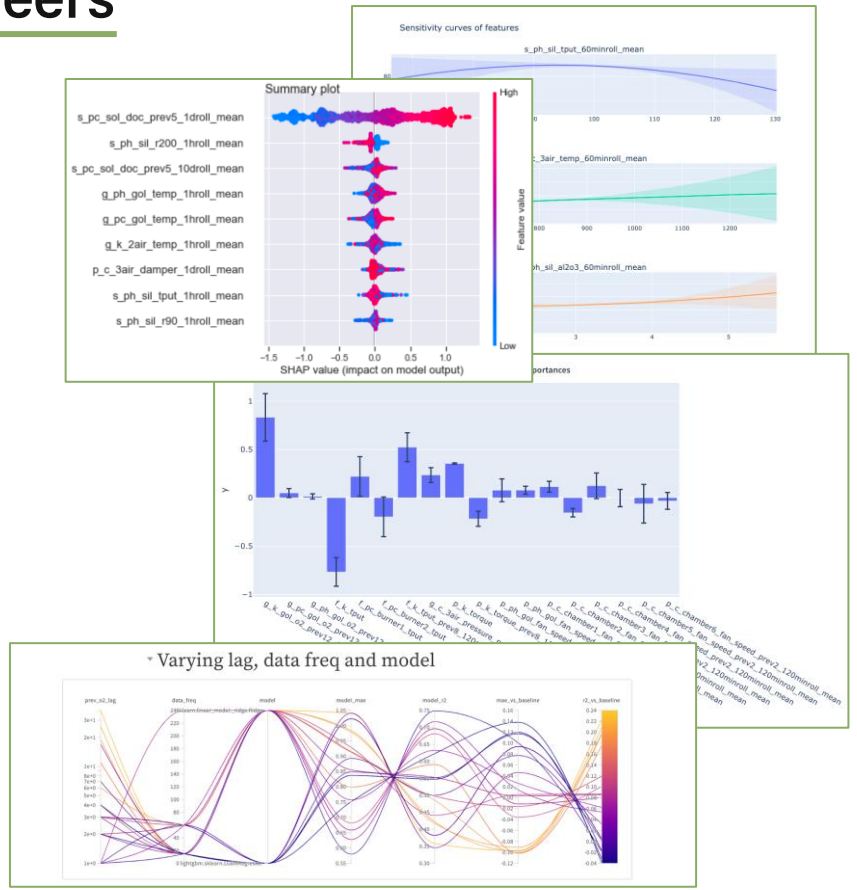
Model baselines are developed and assessed with plant engineers

When building each model, **our process engineers ensure the performance** of each model matches real world plant operations.

We create **a single model** for each of the three main process stages.

- Our models are not single simple relationships between specific variables, they are full models of all variables for each process stage. This allows us to scale our platform quickly.
- We check that the model behaves like a real plant would.
- It is not a ‘physics-based model’, instead it is a model that respects physical laws, chemical reactions and thermodynamics.

We build confidence in each model by reviewing sensitivity curves to key variables and feature importance for each model.



Forecasting product quality

Product quality is a key control parameter for industrial processes

Quality **measures that rely on sampling** and lab testing lead to a **significant control lag** when reacting to changes

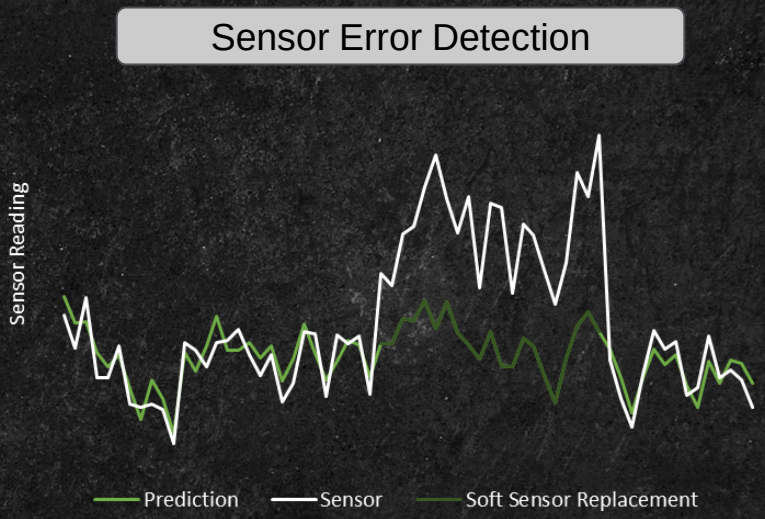
AI **can accurately predict the quality trend**, allowing for **proactive process control** and reduced variation in quality

Detecting sensor error

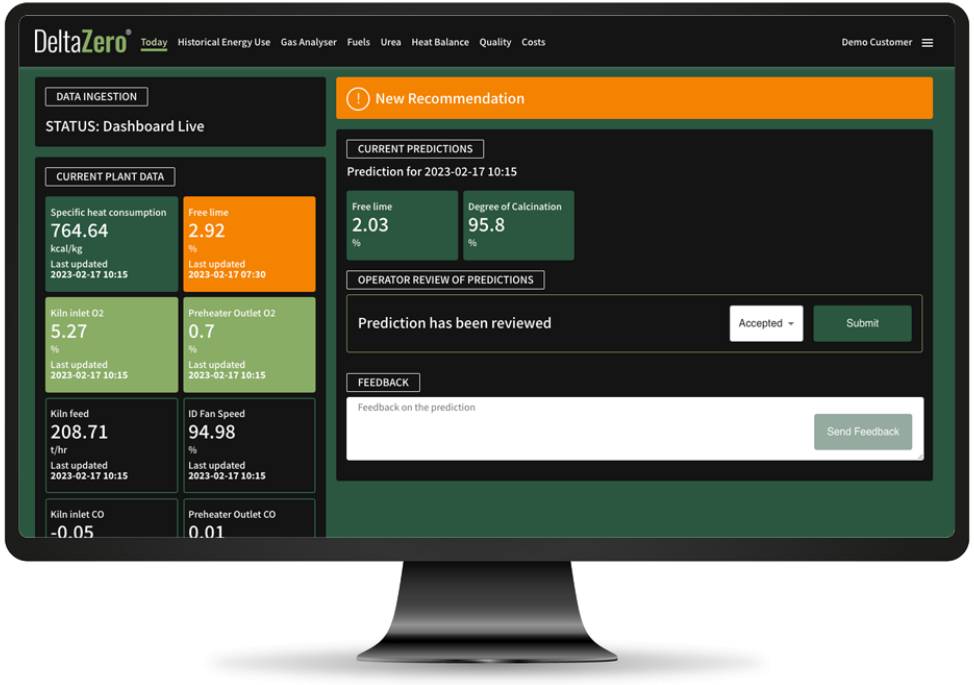
Sensor failure is a common feature of industrial processes, particularly in high temperature, dusty processes

Controlling the plant based on an **inaccurate sensor reading** can lead to **impaired quality,** increased process variation and **higher fuel consumption**

AI **can identify faulty readings** much sooner than a human operator, as well providing an interim **soft sensor replacement** until a physical repair can be made



Open & Closed Loop Integration



6-month research programmes

We are looking for steel producers to act as an industrial partner for two proof-of concept projects, one for Blast Furnace steel production and one for Electric Arc Furnace steel production.

- **Validation of data availability and suitability for our core AI/ML models of the high-temperature material transformation in the furnace**
- **Validation of how our recommendation engine & dashboard will fit within the existing plant production control systems and processes, to confirm our core system architecture and 'human-in-the-loop' structure is suitable**
- **Validation & quantification of fuel reduction opportunities and related emission reductions**
- **Consideration of potential optimisation variables, such as production throughput, fuel cost or specific heat consumption**
- **Identification and assessment of additional limits & control factors, such as NOx emissions, sulphur levels etc**

Join the Carbon Revolution

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