Global Counsel


# **Falling flat:** lessons from the 2018 UK $CO_2$ shortage

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# Foreword

The summer of 2018 will be remembered for the revival of England's World Cup fortunes. However, as England won through to the semi-finals, the country was running out of $CO_2$. The shortage hit the headlines, with media fixing on an image of the UK running out of beer just at the moment of long-awaited English footballing success.

The potential impacts however went much further. For brewers and bakers, for local operations and global mega-brands, $CO_2$ is a critical input. Few people realise that $CO_2$ plays a role in everything from the production of fresh meat to the modified atmospheric packaging that keeps our salads and baked goods fresh.

The events in the summer of 2018 showed up a lack of resilience in the $CO_2$ supply chain. Effort, ingenuity and extra resources deployed by businesses up and down the country mitigated the impacts of the shortages, but it is important to learn lessons from the crisis for the future.

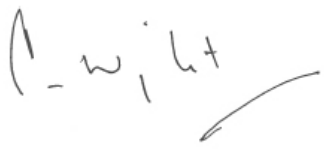
Some have labelled last summer's events as a 'perfect storm', highlighting the unusual set of circumstances experienced by the $CO_2$ chain: the coincidence of outages at production facilities; the heatwave that pushed up demand for drinks and frozen products; and the similar shortages experienced in Europe that curtailed availability of imports into the United Kingdom.

But the 'perfect storm' description risks giving false assurance that the events were a one off, and the impression that nothing can be done. In fact, the events were not entirely unique. Disruptions on a lesser scale have taken place several times in the last decade.

Last summer's events were a wake-up call that we need to make the UK's $CO_2$ chain more resilient. A proper response should have three parts: learning from this summer's shortage; preventing another such shortage happening in the future; and preparing for if it does.

This report forms part of the first step in this process; deepening our understanding about $CO_2$ supply in the UK and what went wrong last summer. The report also concludes with some suggestions for action where the chain can be strengthened.

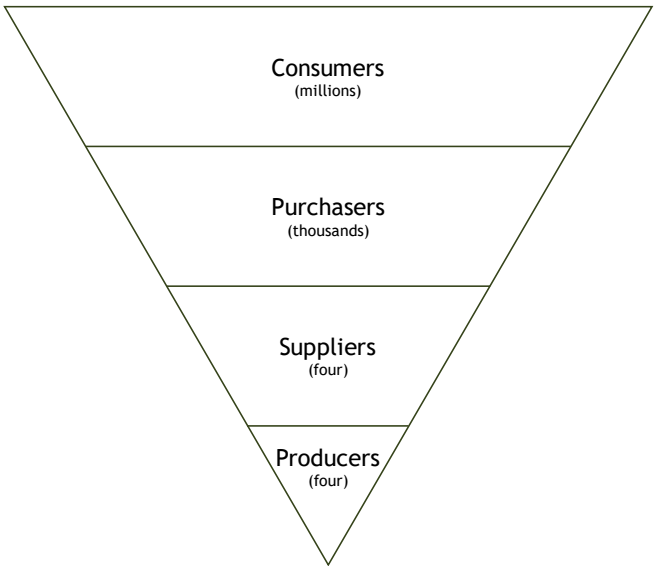
But this is just the beginning. We look forward to working with our members, other sectors, industry and government on steps that can be taken to make the $CO_2$ supply chain more resilient and diverse. That way, we can all be sure of enjoying crumpets for breakfast, chicken salad for lunch and a pint in the evening.



**Ian Wright CBE**
Director General
Food and Drink Federation (FDF)

# Executive summary

$CO_2$ has many users and ubiquitous uses. This summer, a series of events put the UK's $CO_2$ supply chain under severe pressure. Supplies dried up at a time when demand was high. As the events unfolded it became clear there was little understanding of the $CO_2$ chain and only limited contingency planning should the chain break. This report sets out how the UK $CO_2$ chain works, provides an analysis of its structural vulnerabilities and looks at how it might be strengthened.




**$CO_2$ consumers:** although mostly unaware, every single person in the UK is a $CO_2$ consumer. Switching on a light, eating lunch, drinking a beer after work; all reliant on the efficient operation of the $CO_2$ chain.

**$CO_2$ purchasers:** a diverse range of industries and thousands of individual businesses, with the food and drink industry the leading user. A range of businesses from large multinational companies to some of the smallest businesses in the UK with a varying capacity to manage disruption, to improve resilience and to invest in new supply solutions.

**$CO_2$ suppliers:** four multinational non-UK companies. All of whom draw from the same limited sources of $CO_2$. Import capacity delivered through two terminals owned by one of the four suppliers. A tier of secondary suppliers delivering bottled product.

**$CO_2$ producers:** two ammonia plants producing $CO_2$ as a by-product + two bioethanol plants + two import facilities with limited capacity.

## Four main takeaways

**The UK $CO_2$ chain has a structural weakness: the drivers of supply are unconnected to the drivers of demand.** Due to the very low margins on its manufacture, $CO_2$ is only produced in the UK as a by-product of the manufacture of two products with significantly higher value: ammonia and bioethanol. This means that when there is demand for ammonia or bioethanol, there is supply of $CO_2$. But the price differential means that the reverse is not true. When there is demand for $CO_2$, the price is too low to incentivise producers to increase manufacture of ammonia or bioethanol. As a result, the supply of $CO_2$ is detached from demand, creating a significant structural weakness.

**For a commodity that is critical to large parts of UK food supply, the $CO_2$ chain was poorly understood by purchasers, government and the public.** The lack of understanding meant that they did not know what might cause a $CO_2$ shortage and thus when it might occur. Many purchasers did not understand what factors affect the $CO_2$ market and consequently did not foresee that it would be a particularly tight market this year. In particular, there were two supply side factors that impacted on $CO_2$ availability. First, a combination of maintenance and breakdowns reduced production of $CO_2$ in June. Second, production of ammonia, and therefore $CO_2$ as a by-product, has been costlier and less attractive to produce with the high natural gas prices seen over the relevant period.

**Low awareness of the significance of $CO_2$ and the UK's $CO_2$ chain left users underprepared to cope with a $CO_2$ shortage.** Many purchasers first became aware of the shortage when expected deliveries did not arrive. When $CO_2$ suppliers declared force majeure, purchasers did not possess the legal knowledge of under what circumstances force majeure might be justified. Many users did not have contingency plans for dealing with a $CO_2$ shortage.

**In government it is unclear who 'owns' the UK's $CO_2$ problem, or what tools are available to government to address future shortages.** The response to the $CO_2$ shortage was coordinated between Cabinet Office, Defra, BEIS, the Food Standards Agency and other departments. While all played their part in mitigating the impact of the shortage, there was widespread uncertainty among market participants about the roles of each. The Defra-led Food Chain Emergency Liaison Group acted as an important focal point for industries

affected, and as a platform for information sharing. However, government did not intervene more explicitly, citing that it was an issue for the market and recognised the challenge of making the choices that would have been required for prioritisation of supply.

# The UK $CO_2$ market

This summer saw wide parts of Europe experience a critical shortage of $CO_2$. The shortage was most acute in the United Kingdom. Before media reports of shortages of carbon dioxide broke, with its impact on suppliers of meat, beer, poultry and fizzy drinks, $CO_2$ had only featured in the media for its overconcentration in the atmosphere and its contribution to climate change. This summer's events have, however, highlighted its value and usefulness, indeed, that it is an essential for everyday life.

This report sets out how the UK $CO_2$ chain works, its structural vulnerabilities and why it is subject to disruption, and some proposals for how it might be strengthened. Its content is based on research by Global Counsel and a series of interviews undertaken with participants from across the whole of the $CO_2$ supply chain: producers, suppliers and consumers.

## The use and value of $CO_2$

$CO_2$ is used in a wide range of sectors in the economy, including food and beverages, medicine and energy. For the food and drink industry, the UK's largest manufacturing sector, it is a key resource. Colourless and odourless, it is well suited for use in food and beverages, although supply requires purification to 99% to meet Food Standards Agency (FSA) standards for 'food-grade $CO_2$' for all uses in the industry.

The sector's primary uses of $CO_2$ are:

- To carbonate water, soft drinks and alcoholic drinks such as beer. Many breweries use $CO_2$ to supplement the $CO_2$ produced through fermentation. And it is vital for dispensing drinks and beers in pubs.
- For meat and poultry, where $CO_2$ is used to 'stun' animals prior to slaughter. It is chosen for reasons of animal welfare, safety, cost and reliability.
- For packaging meats, baby foods, fresh foods and baked products, the $CO_2$ extends shelf life - through Modified Atmosphere Packaging (MAP) - with its presence preventing the growth of aerobic bacteria.
- And to keep food fresh in transport, where $CO_2$ is used in the form of dry ice and snow.

$CO_2$ enables the industry to meet the demands and needs of the UK's highly competitive food chain. It is an integral part of the just-in-time production and lean processes that enables the industry to deliver the quality, value and speed that retailers and consumers demand from producers. The industry operates on slim profit margins and strong pressure to reduce costs. To prosper in this challenging environment food and drink producers need reliable and dependable suppliers of key resources like $CO_2$.

## Sourcing $CO_2$

$CO_2$ is naturally produced through biological processes including combustion, fermentation and decomposition. And in some countries $CO_2$ is sourced by extracting it from wells in the ground. Industrial sources of $CO_2$ involve the production and use of hydrocarbons. But as $CO_2$ is a relatively cheap commodity and hydrocarbons such as natural gas are costly, $CO_2$ is sourced as a by-product from the production of other more valuable commodities.

A number of industrial processes emit $CO_2$, but low concentrations and purity levels of the $CO_2$ make them uneconomic sources. The production of ammonia, a key component of fertilisers, does have high concentrations of $CO_2$ and in the UK and elsewhere in Europe it is the primary source of $CO_2$ as an industrial gas.

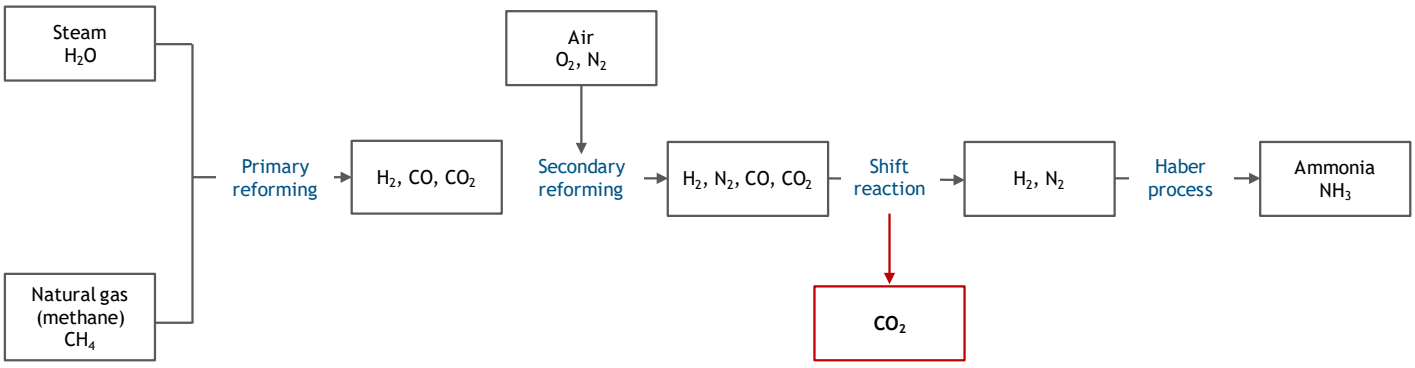



Figure 1: Ammonia production (process simplified)

The production of $CO_2$ from ammonia starts with a hydrocarbon, usually natural gas. First, the natural gas is purified by removing any sulphur. Steam is then added to the natural gas to form hydrogen and carbon monoxide. A catalytic shift conversion is conducted to transform the carbon monoxide into $CO_2$ and more hydrogen. Another shift conversion follows, which separates out the $CO_2$. The $CO_2$ is then captured, purified and liquified.

These processes are carried out at high temperature and pressure. And this means that mechanical parts at production facilities need to be replaced periodically. To facilitate this the plants are shut down to allow this maintenance to be done. These shutdowns take place annually and the ammonia producers schedule them to take place during the summer when demand for fertilisers is at its lowest.

**Bioethanol**

Bioethanol, or ethyl alcohol ($C_2H_5OH$), is produced from a variety of biodegradable feedstocks, usually crops such as corn, wheat or waste crops such as straw. The feedstock undergoes a process of preparation for fermentation, and is then

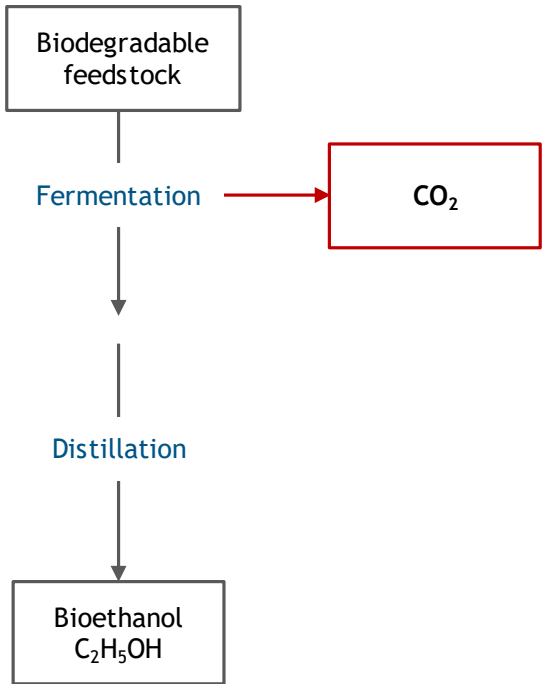



Figure 2: Bioethanol production (process simplified)

heated with water and specific enzymes which bring out the natural sugars in the 'mash'.

The mash then undergoes fermentation in which yeast converts the sugars of the mash into ethanol with $CO_2$ being released as by-product. The ethanol produced by the fermentation is subsequently distilled and purified into usable bioethanol.

**Some key characteristics of $CO_2$**

- **Carbon dioxide is a relatively low value product.** A decade ago, the Competition Commission estimated the value of the UK's $CO_2$ wholesale market as just £15m. According to industry estimates of annual growth rate and prices rising with inflation this market may now be worth somewhere in the region of £25m, but $CO_2$ is not a high value commodity.
- **$CO_2$ has limited commercial sources.** Some countries are able to extract it from the ground. For those without natural sources, the economics of $CO_2$ production mean that it is only commercially viable as a by-product of few industrial processes, notably ammonia and bioethanol production.
- **$CO_2$ is difficult and costly to transport.** $CO_2$ transport takes place either in liquified form or under high pressure. In bulk, this requires both specialized transport – such as specially equipped trucks or ships and import terminals for international trade – and trained drivers to operate the equipment. Transport by road haulage over distances longer than 150 miles is uneconomic at usual market prices.
- **$CO_2$ is difficult and costly to store.** Natural evaporation rates limit the commercial viability of $CO_2$ storage. This time limit varies depending on the particulars of individual storage facilities, but is typically under four weeks. As a result, long term storage is not possible, although some businesses keep shorter term storage on site.

## 'The narrow base': the UK's $CO_2$ chain

The UK $CO_2$ chain supplies goods and services for millions of UK consumers. Between its uses in food and drink, energy, fire safety and medicine almost no person in the UK does not in some way rely on its stable and secure supply. In addition, thousands of companies across these industries acting as purchasers in the chain operate their businesses on the basis of $CO_2$ being available when they need it, at a price they can afford. All of these companies, and the UK consumer, relies on a narrow base of four major suppliers and just a few sources of $CO_2$.

**UK $CO_2$ consumption**

The UK is one of Europe's largest users of $CO_2$. Industry sources estimate annual consumption of around 600kt $CO_2$; around a fifth of Europe's total consumption. It is used across a range of industries in the economy and by businesses from the largest multinational companies to the smallest local businesses.

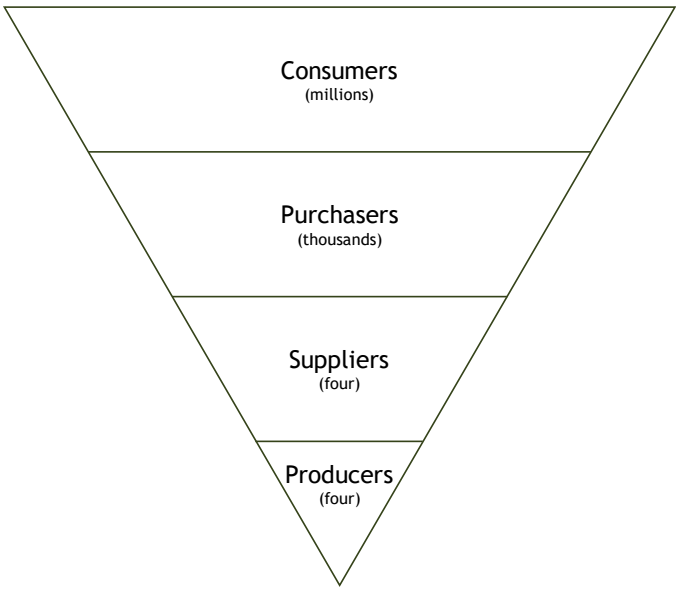



Figure 3: The UK CO2 supply chain

Demand is estimated to be growing at approximately 2-3% a year. Sources of demand growth include its greater use in abattoirs for animal stunning and the rising popularity of bakery products that use $CO_2$ modified atmospheric packaging.

The food and drink industry is by far the largest user of $CO_2$ in the UK. Its accounts for between 50% to 60% of total demand. Beyond food and drink, the biggest demand is in fire suppression and extinguishers (~20%), medical uses (~10%), the energy industry (~10%), and industrial and other uses such as enhanced oil recovery (~10%).

*Sourcing $CO_2$ for the UK market*

Of the 600kt of $CO_2$ the UK consumes:

- Around a fifth is imported, primarily from Scandinavia and the Netherlands;
- A further fifth is sourced as a by-product of bioethanol production;
- And the remaining 60% comes as by-product from the production of ammonia for fertiliser.

The majority of UK-produced $CO_2$ comes as a by-product from the two fertiliser plants, owned by CF Fertilisers, at Ince and Billingham. Between them they are the source of approximately 60% of UK consumption. This concentration of production in a single owner is a joint venture that was established in 2007. That joint venture was investigated by the Competition Commission at the time, who insisted on remedies designed to address a lessening of competition in $CO_2$ supply[1]. Built into $CO_2$ production is a seasonality with less ammonia produced as demand from farmers falls during the summer and a need for closures of plants for maintenance.

The other significant source of $CO_2$ in the UK is bioethanol production. The country's largest bioethanol plant is Ensus at Wilton. On paper, it could be a large producer of $CO_2$, with capacity of up to 250kt a year. However, the market for bioethanol in the UK is very challenging and the plant produces below its capacity. Lack of demand for bioethanol has led the plant to be closed for a number for significant periods since it started operation in 2010.

*UK supply*

For ammonia and bioethanol producers $CO_2$ is a by-product of their business that they sell to industrial gas companies. The industrial gas companies purify the $CO_2$ to the required standard, market it and then supply it to user companies by tankers, or in individual cylinders. One estimate suggested that 75% of UK purchases by volume were delivered in bulk. Bulk liquid $CO_2$ is typically delivered straight from the

1 Competition Commission, Kemira Growhow Oyj / Terra Industries Inc merger inquiry, 11 July 2007

| Name | Location | Owner | Capacity |
|---|---|---|---|
| Billingham Manufacturing Plant | Billingham, Teesside | CF Fertilisers | 400kt |
| Ince | Chester, Cheshire | CF Fertilisers | 120kt |
| Ensus Bioethanol plant | Wilton, Teesside | Ensus | 250kt |
| BOC Bioethanol Plant | Trafford Park, Manchester | BOC (Linde) | 20kt [four 300t CO2 storage tanks] |

Table 1: major UK CO2 producers

liquefaction plant to the end users.

The $CO_2$ is sold through a mixture of contracts and spot sales. And while one interviewee estimated that a few years ago most $CO_2$ (quoted at around three quarters of all supply) was bought on a spot basis rather than through contract, our interviews suggest that the majority of purchasers now contract for $CO_2$ volumes.

The UK has four supply '$CO_2$ majors'. The majors secure supply from a limited range of sources: their own facilities (eg. BOC at Trafford Park), plants that produce $CO_2$ as a by-product (eg. Billingham) and imports.

These companies are:

**Praxair** – the UK market leader with over 40% of sales. A US multinational with a presence in 50 countries, its UK business has a $CO_2$ production site in Wilton based on bioethanol production with an annual capacity of 250 kt, along with long-term agreements to take volume from the $CO_2$ processing plant at Billingham and ownership of the country's two $CO_2$ import facilities.

**BOC (Linde)** – has about a quarter of the UK $CO_2$ market. Opened a $CO_2$ processing facility at the Cargill plant in Manchester in 2017. The company is the UK arm of the world's largest industrial gas company, Linde.

**Air Liquide** – A French multinational founded in 1902, with a presence in 80 countries. Air Liquide has been present in the UK since 2004, providing a range of gases, equipment and services. It owns the liquefaction facility at Ince.

**Air Products** – A US multinational industrial gas and chemicals company, headquartered in Pennsylvania and operating in over 50 countries worldwide.

In the market place there are also smaller firms, such as Cellair in Ipswich, who buy their product wholesale from the four major suppliers.

In the food and drink industry, our interviews highlight that users generally have supply relationships with a single supplier. However, overall the market appears to range from long-term contracts and agreed prices to spot transactions and pricing. The prices paid for $CO_2$ among interviewees pointed to bulk users paying significantly less per tonne than smaller users.

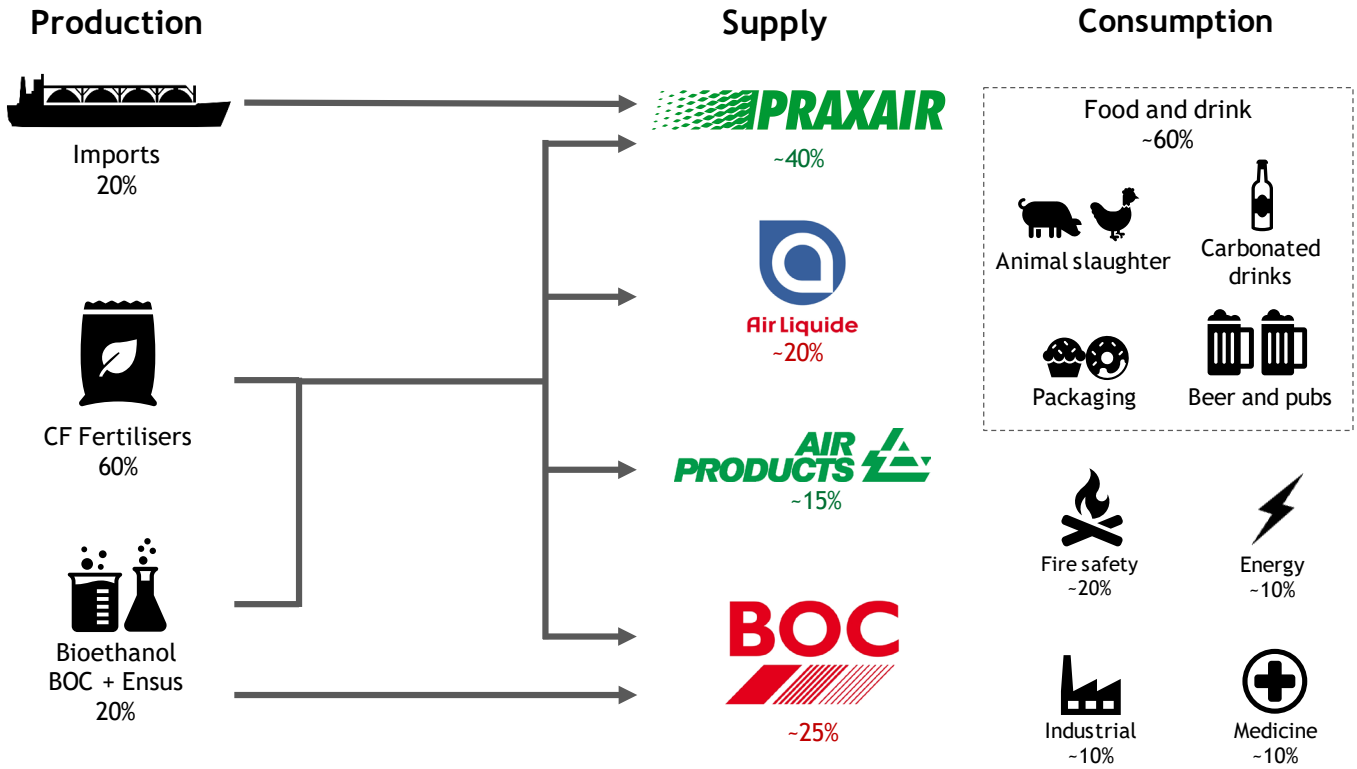



Figure 4: The UK CO2 supply chain
*Percentages are estimates and consequently may not add up to 100%*

**Box 1: Ammonia and bioethanol: markets and production in the UK**

*Ammonia*

$CO_2$ production in the UK is dominated by two plants producing ammonia for ammonia nitrate fertiliser. The result is that $CO_2$ purchasers and consumers are exposed to the market dynamics of fertiliser that are entirely divorced from the UK's needs for $CO_2$. In particular, the fertiliser market is highly cyclical, as demand falls to virtually zero in the winter, peaking during the crop growing season of March, April and May[2].

The largest drivers of $CO_2$ production in this segment of the market are therefore the prices of fertiliser and the key raw input to ammonia production, natural gas. Natural gas accounts for between 70-80% of the cost of producing fertiliser. The significance of the gas price to ammonia production was demonstrated a decade ago in the winter of 2006/7 when UK fertiliser plants suspended production in the face of high gas prices.


During 2018, prices for fertiliser in the UK had recovered from the low levels of the summer of 2017 back to their 2016 peaks of around £250/tonne. At this level however prices remain below the averages of 2011 to 2016 in which prices ranged between £250 and £350/tonne.

In natural gas, the market has experienced a trend of rising prices since the beginning of 2016, despite falling off peaks in the first half of 2017. With dramatically colder weather hitting the UK in March 2018, 'The Beast from the East' storm saw gas prices peak at levels last seen at the end of 2013. Even as the weather improved, the gas price remained high due both to rising Asian demand in the LNG market and residual indexation to the oil price which has been rising since the beginning of 2016 to above $70/bbl in this period.

*Bioethanol*

As with ammonia, $CO_2$ production as a by-product of bioethanol exposes $CO_2$ to set of market drivers unconnected to its own market dynamics. In bioethanol, demand is driven by government policy on renewables and vehicles. Currently the government's Renewable Fuel Transport Obligation (RTFO) requires that almost 5% of fuel at the pump must be sustainable biofuel. The government is proposing

2 Agricultural Industries Confederation, Fertiliser Statistics 2017

to raise this to 9.75% by 2020 but cap the amount of crop-based renewable fuel produced by plants like Wilton.

Since opening, the plant has seen demand for bioethanol register significantly lower than expected – perhaps by as much as half. In consequence the Wilton plant has had periods where it has been uneconomic to operate and has been offline. This performance currently limits bioethanol's value as a dependable source of $CO_2$ in the UK.

# The 2018 supply shortage

In the second week of June, the first signs of a shortage emerged. By the second week of July, $CO_2$ supplies were reported as flowing again to users fairly reliably. The intervening period saw a critical shortage of $CO_2$ in the UK market. The UK has previously experienced $CO_2$ supply disruptions, notably in 2015, however, the 2018 shortage is almost universally considered to have been the most severe in its impacts.

### How the shortage unfolded

A senior figure in the $CO_2$ supply industry describes the summer months as a regular "scramble" to get sufficient $CO_2$ as supply dries up, as fertiliser plants go offline for maintenance, and demand rises as the sun comes out. In 2018, that scramble was significantly more challenging than usual.

On the demand side, a heat wave - average temperatures in the UK were 1.9 degrees higher than seasonal average[3] – combined with the World Cup and England's almost equally unprecedented progress, to produce strong demand for products that require $CO_2$ such as beers and fizzy drinks. With the UK having experienced the hottest May since records began in 1910, drinks producers had already run down inventories – even before the high temperatures of June and July.

On the supply side, across Europe fertiliser and bioethanol plants went offline for maintenance over the summer. The UK's position was exacerbated by breakdowns at key ammonia producers. Across Europe, there is also a suggestion from gasworld, the trade paper that first broke the news of the shortages, that in the face of a combination of high gas prices and competing lower cost stocks of ammonia, producers "prolonged the downtime of the ammonia plants, based on economic grounds."[4]

The combined result of these factors was that by the third week of June suppliers began to inform their customers across the country that supplies would not be arriving. The news was unexpected for most purchasers, and a number of those interviewed report little to no forewarning of supply disruptions before the failure of the expected delivery to arrive. In this period three of the four major suppliers of $CO_2$ declared force majeure on their contracts.

By June 19th, the media began reporting that there was a $CO_2$ shortage. Starting with gasworld, once the scale and impact of the shortage became clear, it began to receive coverage in the national media including the Financial Times, BBC, and a range of other broadsheet and tabloid newspapers. In the subsequent ten days a range of industries and companies affected by the shortage were profiled in the media, notably the beer and pub industry, bakery products, and meat processing.

Almost two weeks later, on July 2nd, $CO_2$ source plants at Billingham and Wilton came back online and started supplying $CO_2$ to the market. However, this coincided with a power outage in Cheshire that knocked out production at the CF Fertiliser plant at Ince. This disruption led Air Liquide to join the other three suppliers in declaring force majeure on some contracts.

By the second week of July, the UK $CO_2$ chain had been restored. This was, however, a gradual process, as suppliers brought volumes back to the UK, but with caveats over the conditionality of supply for some time. Some interviewees reported that it took almost two months to return to normal market conditions and guaranteed supply.

### The impacts of the shortage in food and drink

The disruption to $CO_2$ supply impacted businesses, large and small, across the food and drink industry. Some companies suffered from supply shortages, while others were cut off from supply entirely. Many of those companies that had to go out and secure more supply ended up paying significantly higher prices for their supply than in normal market conditions.

Below, three case studies illustrate the impact.

*Case study 1: Independent family-owned brewery*

The company had been due to receive a $CO_2$ delivery as usual on June 18th, but instead received a letter from their supplier declaring force majeure. They would not receive another delivery for two weeks.

This was the first time that the brewery had experienced interruptions to $CO_2$ supply, although they were aware that others in the past had faced shortages. The brewery typically uses around 5-6 tonnes of $CO_2$ each day using for a variety of uses. These include: a bottling line, kegging and the application of $CO_2$ for top pressure in tanks, cask racking, and filling $CO_2$ for dispense gas in the pubs.

3 https://www.metoffice.gov.uk/climate/uk/summaries/anomalygraphs

4 '$CO_2$ supply position in Europe set to improve', gasworld, Joanna Sampson, 21 June 2018

With little $CO_2$ left in supply, the brewery was forced to stop bottling for nearly three weeks. The small amount of $CO_2$ they had was used to continue a limited supply of keg beers for its own pub estate.

The brewery's efforts to obtain imports of $CO_2$ from Germany were frustrated by the ongoing supply shortage across Europe. In any case, it became clear that securing any $CO_2$ supply available would be obstructed by the lack of certified transport equipment and certified drivers.

For this independent brewery, the impacts were significant. Apart from the negative impact of not having stock on shelves, the brewery bore the costs of additional supply of nitrogen – a more expensive replacement for $CO_2$ - staff costs for days when the bottling lines were not producing and additional pay for overtime work in the warehouses.

*Case study 2: leading UK bakery*

The first sign issues to come arrived at one of the UK's leading bakery companies on June 8th when one of their suppliers advised them that the market was tightening. The next message they received was the declaration of force majeure and communication from their second supplier that supplies were coming under pressure.

Using $CO_2$ at six separate plants for the production and packaging of a range of bakery goods, the interruption was a serious issue. From the July 18th one supplier halted supplies for a period of almost three weeks, while the second supplier managed to maintain some supply, but at a premium to the original contract rate. Two of the four factories producing one of their most popular products had to cease production.

In response, the bakery began to explore contingency measures. This included reducing the $CO_2$ content in their MAP packaging and shortening the shelf life of products. This lessened the pressure somewhat, but caused significant issues with retailers and supply chains for product and ingredients. The company also considered altering the recipe of products to adapt to a lower $CO_2$ atmosphere. However, changes to the recipe required regulatory approval if there was not accompanying changes to the back of pack ingredient listing and labelling, which was not possible under the time pressures.

*Case study 3: Scottish meat processor*

The manager of a large pig abattoir in Scotland first heard about the $CO_2$ shortage on June 16th when speaking with an industry colleague; he was immediately concerned, as the abattoir uses $CO_2$ as a humane method of stunning the pigs. When they contacted their supplier to refill the onsite tank, the response was that there was no supply and the regional office of the $CO_2$ supplier told them that they were at the back of the queue.

The abattoir had no other immediate options for alternative sources of $CO_2$. Further complicating the issue, because the $CO_2$ supplier owned the on-site storage tank, the abattoir could not switch its supplier easily. They also did not have the equipment to switch to electrical stunning.

Operations at the site ceased for two weeks but a proportion of the pigs were moved to other plants in the UK, involving long journeys. There were also some contingency plans for welfare codes on the farms. Eventually, the parent company of the abattoir was able to import $CO_2$ supply from Germany.

For future contingency planning, the manager of the abattoir is now considering producing $CO_2$ themselves, using anaerobic digesters in the area as an alternative source of supply. This would bring the added benefit of a reduction in waste disposal costs. The abattoir is thinking of setting up a working group that would convene every few months to communicate any possible issues and plans regarding $CO_2$ supply.

**Force majeure**

During the shortage, three of the supply companies moved quickly to declare force majeure and to reduce or cut off supplies. The fourth supply major, Air Liquide, following problems at its Ince facility, joined the other three. From our interviews there is a common message of unhappiness with this move by suppliers. A common view among purchasers is that with next to no notice and very little explanation, the supply companies rescinded their contractual obligations. The absence of the supply companies from the media discussion of the shortage added to the view by some that the suppliers were falling short of being good corporate citizens.

Substantively, $CO_2$ users this summer have faced disruption, the need to commit significant management, time, and energy on handling the shortage and additional costs to deal with unreliable $CO_2$ supplies. The supply companies in explanation say that despite extremely short supply, they made their best endeavours to secure $CO_2$ and invoking force majeure enabled them to ensure that contracted customers received at least some supply.

Legal address by users against the suppliers looks unlikely. There appear to be two reasons. First, an acknowledgement that the terms of force majeure clauses in typical contracts are extremely wide, including: strikes and lock outs; breakdown of machinery or other mechanical difficulties; breakdown of vehicles or vessels; and shortage of materials or labour. Prior to this shortage, some purchasers were not aware of the permissiveness of these clauses, or their potential to allow interruption of supply in a wide range of circumstances. However, a number of purchasers argued that the causes of the shortage were foreseeable.

Second, a number of those we interviewed expressed unease with the thought of taking legal action against suppliers. In part, this

### Sector overview of impacts

| | |
|---|---|
| **Carbonated drinks** | ▪ Drinks manufacturers were unable to carbonate their drinks, halting production of numerous brands during a period of peak demand.<br>▪ Even those drinks manufacturers with effective contingency plans in place had to adapt, switching off promotions and deprioritising production of certain lines. |
| **Beer and pubs** | ▪ While breweries were able to continue to brew beer, distribution was badly hit by the impact on bottling and kegging. As a result, breweries had to halt or reduce brewing, bring bottling lines offline and halt kegging meaning that their products could not make it to market.<br>▪ The chain for distribution of smaller $CO_2$ cylinders suffered less disruption than the bulk market. As a result, supply of 'beverage gas', used to power beer systems from cellar to pump/tap, only began to see disruption in the latter weeks of the shortage.<br>▪ As a result of disruption to breweries, some pubs were unable to stock certain brands fully, including John Smith's and Strongbow, during a period of peak demand. |
| **Bakery goods** | ▪ The loss of $CO_2$ deliveries caused interruptions to the supply of some products such as Warburton's crumpets, where $CO_2$ is integral to the production. At one point Warburton's had suspended operations at two of four crumpet factories in the UK.<br>▪ Some companies adapted altering the gas mix in their MAP and reducing the shelf life of the given products. This had the advantage of being an action that companies could take unilaterally, however it required costly changes to supply chains predicated on longer shelf lives of around 8-9 days.<br>▪ Some companies considered altering recipes of given products to allow them to reduce their $CO_2$ usage. However, amending ingredients without matching changes to 'back of pack' ingredient descriptions would have required regulatory approval from the FSA. Although some companies spoke to the FSA about doing so, this was abandoned as an option due to the time required for consultation with the FSA. |
| **Meat producing and processing** | ▪ Meat processing for both chicken and pigs was affected as abattoirs had to move either to use nitrogen – which is more costly – or electric stunning for the slaughter of their animals.<br>▪ The resulting slowing of throughout had significant ramifications for farmers who were unable to take their animals to slaughter. The knock-on impact threatened animal welfare.<br>▪ MAP for meat products was also affected. |
| **Other** | ▪ Food delivery company Ocado was forced to alter its marketing and pricing strategies due to difficulties in supply frozen goods.<br>▪ Fish suppliers struggled to maintain supply due to dry ice shortages, and concerns over cold chain custody. |

was due to existing commercial and personal relationships. However, it was also made clear that purchasers were reluctant to cause disruption in a marketplace where they were constrained in choice to only four suppliers in the market.

**Avoiding the worst**

UK food and drink companies expended a huge amount of energy to limit the impact of the $CO_2$ shortage on the UK consumer. Through adaptation measures, UK companies were able to limit the worst impacts. However, for many – in particular SMEs in the food and drink sector – the financial cost of these measures has been highly significant. In addition, a number of interviewees emphasised that such measures could only be effective for so long and would not have been sufficient had the shortage continued. It appears to be the case that a continuation of the $CO_2$ shortage in the UK for another two weeks could have caused much more significant disruption to businesses and to the lives of British consumers.

## Government response to the shortage

The government appears to have been first alerted to the $CO_2$ shortage by the British Poultry Council reporting to Defra that its member companies were facing significant issues with $CO_2$ supply. Defra responded by convening the Food Chain Emergency Liaison group on June 20th. This brought together relevant food and drink industry trade associations along with BEIS, the Food Standards Agency and the governments in Belfast, Cardiff and Edinburgh. Through the shortage the group held regular conference calls to share information and intelligence. Within government, the Cabinet Office took on the role of co-ordinating across the departments.

Defra is the 'sponsor' department in Whitehall for the food and drink industry. The equivalent sponsorship for $CO_2$ sourcing and supply is less clear. The chemical industry, including fertiliser production, is sponsored by BEIS. And CF Industries – the parent company of CF Fertilisers - is well known as such to BEIS. However, BEIS had no relationship with the industrial gas suppliers and as the shortage developed had to work hard to establish relationships with the four supply majors. Neither CF Industries nor the four supply majors proactively warned the government of shortages.

From our interviews it is clear that those from the food and drink industry who take part in Food Chain Liaison process found it useful. Industry sources are positive about Defra and the FSA's role. In Scotland, the efforts of the Scottish government are also commended. Views from the industry on BEIS are less positive. The department itself felt constrained in its dialogue with the food and drink industry. Once it had established a relationship with the gas supply majors, the commercially sensitive nature of the information being shared with government and a view that supply issues were essentially matters for the 'market', meant that representatives of the food and drink industry were sometimes frustrated at restrictions on government's ability to respond.

**Box 2: Praxair and the use of force majeure**

Praxair, the market leader of the four $CO_2$ supply majors, on its website says:

"As one of Europe's leaders in $CO_2$ production, Praxair is able to provide a reliable supply of $CO_2$ to its customers.

In the UK we have our own production site at Wilton (North), and we also have two ship import terminals in Teesside (North) and Tilbury (South). With a fleet of ships operating in the North Sea we can import sufficient volumes from our other production sites in Europe should there be any issues with any UK sites. Praxair $CO_2$ production sites in Europe - from which can supply the UK and Ireland markets with $CO_2$ by tanker ship - include Porsgrunn (Norway) and Sluiskil (Netherlands).

Praxair have the best proven security of supply within the UK & Ireland market, as we are the only UK & Ireland $CO_2$ supplier with 2 import terminals, and a fleet of ships. This allows us to import additional product quickly from our other European sources".

Praxair's force majeure letter states:

"With the combination of the shutdown of the Ensus plant in Wilton which feeds the Praxair plant with raw gas; the sudden closure of the main UK plant located in Teesside, due to a leak on the ammonia plant, and then a lack of production in Europe Praxair cannot import sufficient stocks to support the UK and Irish customer base."[5]

5 Praxair letter invoking force majeure, 18 June 2018

One issue of contention was whether to give priority to some users for what $CO_2$ supplies were available. Meat and poultry producers, citing animal welfare, wanted government to produce guidance. The independent food regulators, the FSA and FSS (Food Standards Scotland) did issue "to whom it may concern" letters urging suppliers to prioritise animal welfare in making decisions on who to supply (see below). The government itself decided not to offer any guidance – and this was communicated to $CO_2$ suppliers.

The decision not to prioritise appears to have been made by the then-BEIS minister with responsibility for small business. In explanation, BEIS says guidance from government would have had no legal basis, government was not equipped to make decisions on who should receive supplies and it expected supplies to return to normal.

In Scotland, the Scottish government at all levels was engaged, including urging suppliers to greater efforts and putting in place contingency planning for a scenario in which the shortage would have continued. This included emergency relaxation of welfare codes on farms, and of regulatory requirements for the transport of pigs in order to facilitate the redistribution of processing to other plants.

Beyond government, a number of interviewees recognised that constituency MPs were active in attempting to highlight the impact on their constituency businesses.

**The Food Standards Agency**

*Letter on prioritisation*

Dated June 21st, this letter from Jason Feeney, the Chief Executive of the FSA, asked suppliers of $CO_2$ gas to prioritise poultry and pig abattoirs for animal welfare reasons. It stated that $CO_2$ gas is the humane stunning method and there are limited alternatives. It made the case that it would not be viable to keep animals on farms due to the large volumes of animals normally stunned, at 15 million birds and 150,000 pigs a week.

The letter was in part produced out of an exchange between the meat industry, $CO_2$ suppliers and the FSA. After the shortage occurred, some $CO_2$ suppliers told a number of meat producers that a letter from government would give them cover in giving priority to meat processors. In addition, other meat producers proactively asked the FSA to provide some guidance and take a position on prioritisation.

Industry representatives in interviews report member companies as believing the letter had a positive impact on supply to them, although some in the supply industry are more sceptical. Outside of the meat processing industry however, some were critical of the FSA for going beyond its remit and opining on what were essentially commercial issues. And the FSA's citation of animal welfare reasons for its proposed prioritisation were questioned by a few of our interviewees.

*Letter on $CO_2$ purity*

The second FSA letter was provided in response to questions from industry representatives. It stated that in the absence of stocks of food grade $CO_2$, food and beverage companies could substitute it with non-food grade $CO_2$ with no less than 99% per cent purity. In this case however, the systems carrying the $CO_2$ into packaging must be cleaned thoroughly to avoid any build-up of contaminants from the non-food grade $CO_2$. The FSA made clear that this was only a temporary measure and companies must revert back to food grade $CO_2$ as soon as it became available again. In practice it appears to have had no impact through a combination of non-food grade $CO_2$ not being available and the disruption using non-food grade $CO_2$ would involve.

# A perfect storm?

*"A perfect storm is an event in which a rare combination of circumstances drastically aggravates the event. The term is used by analogy to an unusually severe storm that results from a rare combination of meteorological phenomena"*

The phrase 'perfect storm' has been used in parts of the media to describe the $CO_2$ shortage. The outage at CF Fertiliser's plant at Billingham unexpectedly delayed the return to production of the UK's largest $CO_2$ production plant while the company waited on imported parts. On the demand side, coverage highlighted the unusually hot weather, and the World Cup as drivers of increased demand for drinks, beers and meat for the barbeque.

Certainly, 2018 saw a "rare combination of circumstances" in the $CO_2$ chain, but senior government officials nevertheless state that every summer there is similar competition for $CO_2$ supplies. For many among the purchasers in the food and drink sector that we interviewed for this report, this was not their first experience of $CO_2$ supply disruption. Some had experienced up to four disruptions of varying degrees in recent years. While they may not have all had the same widespread consequences, the frequency of supply disruptions highlights both the vulnerability and the importance of the UK's $CO_2$ market.

### The UK's $CO_2$ chain is fragile

In the future, the events which happened this year could well become less rare and consequently cause the fragility of the UK's $CO_2$ chain to be exposed more frequently. The risks of heat waves and other extreme weather events is increasing with climate change; six of the ten hottest summers in the UK have taken place since 2003[6]. The demand for $CO_2$ may grow faster than ammonia production and there will continue to be natural gas price volatility. And depending on the outcome of negotiations, Brexit could raise issues for UK import supply.

In these circumstances, purchasers will be confronted with a dilemma as more alternative sources of $CO_2$ will be needed as part of contingency planning, but they are more costly than current sources. We provide further detail on alternative sources of $CO_2$ in Annex 2.

In our analysis of the summer shortages, we draw four key conclusions:

**The UK $CO_2$ chain has a structural weakness: the drivers of supply are unconnected to the drivers of demand.** Due to the very low margins on its manufacture, $CO_2$ is only produced in the UK as a by-product of the manufacture of two products with significantly higher value: ammonia and bioethanol. This means that when there is demand for ammonia or bioethanol, there is supply of $CO_2$. But the price differential means that the reverse is not true. When there is demand for $CO_2$, the price is too low to incentivise producers to increase manufacture of ammonia or bioethanol. As a result, the UK supply of $CO_2$ is detached from the UK demand, creating a significant structural weakness.

**For a commodity that is critical to large parts of UK food supply, the $CO_2$ chain was poorly understood by purchasers, government and the public.** The lack of understanding meant that they did not know what might cause a $CO_2$ shortage and thus when it might occur. Many purchasers did not understand what factors affect the $CO_2$ market and consequently did not foresee that it would be a particularly tight market this year. In particular, there were two supply side factors that impacted on $CO_2$ availability. First, a combination of maintenance and break downs reduced production of $CO_2$ in June. Second, production of ammonia, and therefore $CO_2$ as a by-product, has been costlier and less attractive to produce with the high natural gas prices seen in recent months.

**Low awareness of the significance of $CO_2$ and the UK's $CO_2$ chain left users underprepared to cope with a $CO_2$ shortage.** Many purchasers first became aware of the shortage when expected deliveries did not arrive. When $CO_2$ suppliers declared force majeure, purchasers did not possess the legal knowledge of under what circumstances force majeure might be justified. Many users did not have contingency plans for dealing with a $CO_2$ shortage. And when users starting taking steps to mitigate the shortages they faced a range of practical problems, for example a shortage of vehicles and drivers to import $CO_2$ from the mainland Europe and to move supplies around the country.

**In government it is unclear who 'owns' the UK's $CO_2$ problem, or what tools are available to government to address future shortages.** The

6 Met Office: https://www.metoffice.gov.uk/climate/uk/summaries/actualmonthly

response to the $CO_2$ shortage was coordinated between Cabinet Office, Defra, BEIS, the Food Standards Agency and other departments. While all played their part in mitigating the impact of the shortage, there was widespread uncertainty among market participants about the roles of each.

The Defra-led Food Chain Emergency Liaison Group acted as an important focal point for industries affected, and as a platform for information sharing. However, the government decided not to intervene more explicitly, judging it to be an issue for the market, and i recognising the challenges of prioritising supply and the possible knock-on effects of such an intervention.

# Proposals

We outline a series of proposals that can be taken by actors across the $CO_2$ chain to improve its resilience.

### Government, parliament and regulators

- Government to consult on, and publish, guidance on policy regarding prioritisation of $CO_2$ supply in times of shortage.
- There should be clearer focus in government on the significance of the UK's $CO_2$ chain and clear lines of departmental responsibility.
- Defra carries out a biennial food chain survey, which includes a range of questions relating to contingency planning and supply chain dependencies. Previous surveys have not specifically referenced $CO_2$, future surveys should.
- Defra Select Committee should launch an inquiry into the $CO_2$ market and its significance for UK food chain security.
- On the supply of $CO_2$, BEIS should also look to survey contingency planning and dependencies. Given the reliance of UK supply on a very limited number of sources it should review how to mitigate risks from maintenance and breakdown to $CO_2$ production, and disrupted imports, particularly if Brexit poses additional threats.
- Government in collaboration with the FSA should produce guidance on handling and responding to $CO_2$ shortages. This should cover the issues of prioritisation and mitigation measures, such as the use of non-food grade $CO_2$ and processing procedures, with particular regard to changing ingredients, MAP gas composition and changes to meat processing.
- The CMA should undertake a sector inquiry into the concentration of the $CO_2$ production and supply markets and the potential impact on UK consumers and UK food chain security.

### Suppliers of $CO_2$

- Suppliers should consider increasing storage capacity for $CO_2$;
- Suppliers should improve communication with purchasers and the public, particularly during period of supply stress;
- Suppliers should proactively search for possible alternative sources of $CO_2$, such as BOC having last year opened its plant at Cargill's Trafford Park site in Manchester.

### Users of $CO_2$

Users of $CO_2$ should review procurement 'best practices' to maximise the resilience of their $CO_2$ supply. Trade associations should lead efforts to produce a $CO_2$ 'purchaser's checklist', outlining steps that can be taken to improve resilience on a company-by-company basis.

These might include:

- Refocusing on relationships with $CO_2$ suppliers;
- Contracting with more than one $CO_2$ supplier;
- Increasing contracted volumes against spot volumes;
- Reviewing contracts with a particular focus on the terms of force majeure clauses;
- Contracting with suppliers for 'virtual stock' – options on additional supply in times of shortage;
- Reviewing current production practices for where $CO_2$ can be safely and cost-effectively replaced with other more secure inputs;
- Putting in place 'Plan B' for future shortages;
- Exploring additional storage options;

### The future of the market: alternative sources of $CO_2$

In the longer term, a number of interviewees are now looking into alternative sources of supply, including investing in their own production facilities. While most consider the upfront capital requirements to be prohibitive for supply of a low margin product such as $CO_2$, there is ongoing work on the possibility of cooperative approaches, for example consortia who might invest in $CO_2$ production.

Alternatively, other companies are now considering smaller scale production where synergies might be found with investment in upgrading existing CHP or anaerobic digestion facilities, or even investing in new plants. For companies in the agribusiness sector in particular, bioethanol plants might offer a range of benefits across waste reduction, energy supply and $CO_2$ supply. Alternative sources are further discussed in detail in Annex 2.

# Annex 1: timeline

| Date | Event |
|---|---|
| **8 June** | First warnings from suppliers to purchasers of "tight market" for $CO_2$ |
| **14-18 June** | Suppliers begin giving notice of supply disruption, ultimately issuing letters invoking force majeure clauses |
| **19 June** | gasworld reports:<br>"It appears the UK is hardest hit – with only one major $CO_2$ plant operating as we go to press. Very reliant on imports from Scandinavia and also the Netherlands – the UK is doubly impacted in that there are limited movements across the Channel due to the plant shut-downs in the Benelux and France limiting product to ship." |
| **20 June** | Wetherspoon's notifies the media that it is monitoring the situation<br>British Pubs & Brewers Association issue a statement<br>1st Defra-initiated FCELG plus conference call held |
| **21 June** | First teleconference between Defra and industry representatives<br>British Poultry Council briefs that the shortage is affecting chicken producers<br>FSA issues letter urging priority from $CO_2$ suppliers for livestock producers<br>UK government says it is "working to find a solution"<br>FDF intervenes, FDF Chief Scientific Officer Helen Munday calls on government "to act with urgency" |
| **25 June** | Heineken announces $CO_2$ shortage leading to some disruption.<br>Coca-Cola announces that it is temporarily stopping some output |
| **26 June** | Impact of shortage spreading, Brechin abattoir shut, Booker rationing distribution of beer and cider; Ocado cutting back on frozen food promotions<br>FSA publishes guidance on non-food safety $CO_2$ being used |
| **28 June** | Pub groups Ei Group and Wetherspoon's announces shortages of certain beer brands: John Smith's and Strongbow<br>Ensus plant at Wilton begins to resume $CO_2$ supply |
| **29 June** | Warburton's suspends crumpet manufacture at two of four factories, "nowhere near" normal production of 1.5m/wk |
| **1 July** | Asda rations sales of fizzy drinks |
| **2 July** | CF Fertiliser plant at Billingham comes back online |
| **3 July** | Power outage at CF Fertiliser plant at Ince delays production resumption. |
| **4 July** | Ince plant restarts fertiliser production |
| **4 July** | Warburton's resumes full production |
| **10 July** | British Poultry Council meeting with members indicates that $CO_2$ supply is back to normal levels, although not guaranteed to continue |

# Annex 2: alternative sources of supply

The summer's events have highlighted the UK's reliance on a narrow set of sources of $CO_2$ and raises the question of whether we should put in place a broader range of sources. As we profile in the first chapter (*The UK $CO_2$ market*), the economics of $CO_2$ as a low-value product makes this a challenge, in particular if new production facilities must compete with offtake from large producers. Nevertheless, organisations are considering investing in their own production facilities, particularly where they were able to benefit from the additional energy generation, or use of organic waste matter (bioethanol).

We profile three potential options for future production.

### Carbon capture and utilisation

Much of the coverage of the shortage commented on the irony of a $CO_2$ shortage amidst efforts to reduce its concentration in the atmosphere. However, with that concentration at around 400ppm, 'stripping' $CO_2$ out of the air would be extremely expensive.

More feasible is carbon extraction through CCU, with carbon capture technologies applied to fossil fuel sources of energy generation and industrial processes, eg. Combined Cycle Gas Turbines. While CCU is technologically proven, the economics of the process are again the issue. Commercial use of the carbon dioxide extracted – rather than simply being stored – could marginally improve the economics of the process. However, where this has been successful elsewhere, the use of carbon dioxide has been in enhanced oil recovery, with the additional cost base covered by the high value oil extraction, rather than the carbon dioxide itself.

### Combined Heat and Power plants (self-production)

CHPs are high efficiency gas driven engines, which utilise both the power and heat generated. Some CHP systems are configured to capture the $CO_2$ in exhaust gases produced by gas combustion, typically used for enriching the atmosphere in greenhouses where higher concentrations of $CO_2$ are beneficial for plant growth. The production of carbon dioxide through CHPs could be done at a larger scale, although the costs of upgrading the $CO_2$ to food grade quality may be prohibitive.

### Bioethanol production expansion

Bioethanol is one of the two existing methods of $CO_2$ manufacture currently in the UK, with the Ensus plant at Teesside one of the major production facilities. Consequent to the $CO_2$ supply disruption, Ensus have highlighted the additional benefits of additional $CO_2$ production as part of their advocacy for changes to the UK government's bioethanol support schemes.

Specifically, Ensus are pushing for the UK to raise the mandated level at which petrol must included in blended biofuels under the Renewable Transport Fuel Obligation (RTFO). The RTFO was recently raised from 4.75% for companies who supply over 450,000 litres a year to 9.75% in 2020 and 12.4% by 2032.

**Case study: Drax pilot**

The carbon capture method is due to be trialled at the UK's largest power plant, Drax in North Yorkshire. While Drax was originally coal-fired, it is in the process of converting its six boilers to be fuelled by biomass. Following the $CO_2$ supply disruption, the company announced a trial with C-Capture, a spin-out from research at the University of Leeds.

The Bioenergy Carbon Capture and Storage project will run for six months, and Drax is in discussions with the British Beer and Pub Association over supply the industry with the captured $CO_2$. In interview Drax CEO Andy Koss suggested that up to 1 tonne of $CO_2$ might be captured everyday – close to the capacity of the UK's biggest $CO_2$ production facility at Billingham - however finding capacity to either use or store the gas might prove to be a bigger challenge.

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### About Global Counsel

Global Counsel advises international investors and businesses on political and regulatory risks in markets around the world. We help investors and companies in a wide range of sectors to anticipate how government policies and regulations will impact on their investment plan or business strategy and to develop and implement responses to these challenges. Global Counsel has offices in London, Brussels and Singapore.

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