Historic England

Gasworks and Gasholders

Introductions to Heritage Assets

Summary

Historic England's Introductions to Heritage Assets (IHAs) are accessible, authoritative, illustrated summaries of what we know about specific types of archaeological site, building, landscape or marine asset. Typically they deal with subjects which lack such a summary. This can either be where the literature is dauntingly voluminous, or alternatively where little has been written. Most often it is the latter, and many IHAs bring understanding of site or building types which are neglected or little understood.

Gas works, or sites where gas was manufactured by thermally decomposing fossil fuels and stored in gasholders, were one of the most ubiquitous and widely distributed industrial complexes of the 19th and 20th centuries. Frequently constructed on the edges of urban areas, close to their customers and adjacent to rivers, canals and railways - reflecting both the inability of the early works to transmit gas over large distances and the reliance on a supply of coal – meant that gasworks and gasholders had a considerable visual impact on the landscape. Beginning with the formation of the Gas Light and Coke Company in London in 1812, coal gas manufactured at gasworks in towns, cities and on private estates was transmitted via England's first energy networks before first nationalisation (1949) and the conversion to natural gas (from 1967), brought about the end of the industry and the clearance of many sites of gas manufacture. In 2020, the physical remains of the manufactured gas industry again face the threat of clearance as the gas networks' programme of gasholder decommissioning and demolition releases former gasworks sites for residential and commercial redevelopment.

This document provides an overview of our understanding of coal gasworks and their attendant low-pressure gasholders, with a particular focus on the building types which survive in part or in full across the country. It provides a brief historical background and chronology of the development of the manufactured gas industry from its origins in the 1790s, through the formation of the industry (1800-1820), its subsequent expansion (1820-1860), regulation (1860-1890), modernisation and rationalisation (1890-1949), nationalisation (1949) and adoption of natural gas (1949-1967). This is followed by an introduction to the process

Front cover:
The Cheltenham Gas Light & Coke Company works from the air in 1938. Formed in 1818, the company moved to a larger site formed by the junction of Gloucester Road and Tewkesbury Road. Photographed shortly after the company was acquired by the Severn Valley Gas Corporation, the late-19th century offices (centre, foreground) survive along with much of the gasworks' wall. The gasholders (left) and retort houses (centre, background) were demolished and the majority of the site is now occupied by a Tesco supermarket.

of manufacturing gas and summaries of the development of the various buildings (including gasholders) which were historically associated with gasworks. These summaries detail their function, construction, materials, main components, architectural treatment and associated landscapes.

This guidance note has been written by Matthew Bristow and Sebastian Fry.

It is one of several guidance documents that can be accessed at HistoricEngland.org.uk/listing/selection-criteria/listing-selection/ihas-buildings/

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Contents

1 Introduction

Public gasworks can broadly be defined as sites where gas was manufactured from fossil fuels and stored at low-pressure before being transmitted to consumers via a network. For the most part, manufactured gas refers to gas released by heating coal in a sealed vessel called a Retort in a process known as Carbonization. Gas was also manufactured using a different process known as Gasification which converted coal to gas without the formation of coke as an intermediate, from oil and, from the early 20th century via the water gas process. It is however the production of gas via Carbonization which is most generally associated with English gasworks and has led to manufactured gas often being referred to as 'coal gas', or more frequently as 'town gas' due to the fact that by the mid-19th century, every town with a population of over 10,000 people, had a gasworks. In addition to these town gasworks, smaller village works and the far larger publically owned municipal gas undertakings in major English cities, private gasworks were also constructed to provide power to country houses and estate villages and to light large industrial complexes such as mills and railway works. The earliest surviving gasworks buildings in England all date from the early 19th century during the period of the gas industry's establishment (Figure 1). They include: the visible remains of the gasworks at Dolphinholme worsted mill, Lancashire (built in 1811 with additions of 1820), the gasworks buildings at Warwick (1822), the retort house at Gas Street basin, Birmingham (1822) and gasholder No. 2 at the Imperial Gaslight and Coke Co. works, Fulham (1829-30). The expansion of the industry during the 19th century saw the wide proliferation of gasworks and despite manufactured gas being replaced by natural gas from 1967, the physical remains of the gas industry are widely distributed across the country.

Most numerous and instantly recognisable of the surviving structures are the gasholders which were originally constructed to store the coal gas manufactured at the gasworks to allow for fluctuations in demand. Dating from the early 1800s, they allowed for variations between the rate of gas production and consumption and were to be found on the majority of sites of gas manufacture irrespective of the scale of the works. Gasholders are sometimes erroneously referred to as gasometers, a name derived from the French 'gazometre', a laboratory gas vessel which measured the volume of gas. Gasholders evolved from small structures utilising counterweights and stanchions to guide the gas bells, to the enormous metal-framed structures which have had such a profound impact on the British landscape. At the start of the 21st century, more than 600 low-

Figure 1: The surviving tank of a gasholder built in about 1820 at Dolphinholme worsted mill by the pioneering gas engineer, Samuel Clegg. The location of the stanchions which formerly supported the bell remains clearly visible, while the large stone counter-weight is a unique survival.
© Matthew Bristow

pressure gas holders remained in use in England, many surviving the transition to natural gas and remaining in use, with their associated gasworks being partially or fully cleared to form holder stations.

Historic England recognises the important role town gasworks and sites of small-scale gas manufacturing played in meeting the nation's energy needs, their technological interest and wider landscape impact. Building on the studies from English Heritage's Monuments Protection Programme of the late 1990s, a summary overview was commissioned on the history of the manufactured gas industry (Russell 2020), available through the Historic England 'Research Report' series and Guidelines for the evaluation and recording of England's former gasworks and redundant gasholders (2019) published. These publications support a growing body of industry specific literature and detailed site records produced during the redevelopment of former gasworks sites. Historic England's Selection Guide on Infrastructure: Utilities and Communication (2017) sets out the current designation thresholds of gasworks buildings and gasholders, to which this introduction provides an additional factual overview.

2 Historical background and chronology

The manufactured gas industry effectively began in the 1790s with the pioneering work of the Scotsman William Murdoch and the Frenchman Phillip Lebon, who developed experimental plant to produce gas from coal and wood respectively. From 1777, Murdoch was employed by renowned engineers Boulton & Watt where he continued his experiments with gas illumination, successfully managing in 1792 to light his house and office in Redruth, Cornwall. Whilst working at Boulton & Watt's Soho foundry – the first gas lit factory in the world - Murdoch was assisted by Samuel Clegg who had joined the company as an apprentice engineer in 1798 before leaving in 1805 to set-up as a rival gas engineer. At this time, prompted by the Salford industrialist George Lee, Boulton & Watt promoted Murdoch's gas light to the owners of large mills and factories, keen to replace the dim light offered by candles with the attendant risk of accidental fire which they brought. Between 1805 and 1816, Boulton & Watt installed private gasworks at 20 mills and factories before retreating from the market providing gas plant, leading to the retirement of Murdoch. Clegg too had successfully installed gas lighting plant at a number of mills, whilst in addition successfully experimenting with wet lime purification and installing the first operational wet lime purifier at his gasworks at Stonyhurst College, Preston, in about 1811. While Murdoch and Clegg had concentrated their efforts on installing gas plant to light a single establishment, the German, Frederick Winsor, in a continuation of Lebon's work, looked towards wider applications for gas lighting. In 1808 he lit both sides of Pall Mall demonstrating the public application of gas light and in 1809 a Bill was put before parliament for the incorporation of a gas light company. It was hotly debated but received Royal Assent in April 1812 and resulted in the formation of the Gas Light and Coke Company (GLCC). In December 1812, the GLCC appointed Samuel Clegg as a deputy engineer and he worked on the construction of their first (ultimately unsuccessful) gasworks, located on a wharf at Cannon Row, Westminster which was quickly succeeded by larger works located between Great Peter Street and Horseferry Road. While at the GLCC, Clegg devised a circular design of gasholders which became widely adopted thereafter and developed the first gas meter and gas governor to monitor and regulate supply. He also consulted on a number of gasworks around the country which were providing a public supply, amongst them notable works at Bristol, Birmingham, Warwick and Fulham.

The formation of the GLCC and the adoption of gas light at large mills and factories acted as the catalyst for the rapid and wide growth of the manufactured gas and gas lighting industries. This was most keenly felt in London which by 1850 was supplied by 13 gas undertakings, amongst them the South Metropolitan Gas Light and Coke Company, the great rival to the GLCC south of the Thames. The period from 1820 to 1860 also saw a great increase in the geographical spread of gas undertakings and new works and by 1830, 200 towns in England and Scotland had gas undertakings formed by individual acts of parliament. The period of expansion also saw gas production and the provision of gas lighting move out of the cities in a chronological 'trickle down' process. In the 1820s, gas lighting was the preserve of towns and cities with populations over 10,000 people but by the 1830s, this had extended to towns with populations between 4,000 and 10,000, with small towns of between 2,500 and 4,000 people receiving gas supplies in the 1840s. By the 1850s, the continued expansion of the industry was characterised less by the establishment of new companies and more by the expansion of existing works or the addition of new works by an existing company in order to extend its area of supply, leading to the major London companies operating numerous sites. In 1860, following years of unchecked competition across the capital, the Metropolis Gas Act was passed which assigned each of the London companies a monopoly of supply over a defined district or region. It also recognised the rights of the consumer by providing for the independent testing of gas quality, purity and pressure, a clause which was extended to the entire country in the 1871 Gasworks Clauses Act.

The gas produced at works across the country and conveyed by the first gas networks had a considerable technological and cultural impact. Primarily used for public, non-domestic lighting, gas fundamentally changed the character of England's towns and cities and from the 1840s began to alter domestic life through advances in the lighting of dwellings and from the 1860s, through the wider use of gas for cooking. New non-lighting applications for gas saw gas consumption treble between 1875 and 1920 as the industry experienced another period of considerable growth. This growth in demand was met by organisational and technological improvements to the manufactured gas industry. The 1875 Public Health Act gave local authorities the power to purchase and amalgamate local gas companies to form municipal gas undertakings. These powers were readily adopted and the number of municipal gas undertakings formed had reached 148 within five years of the act and 306 by 1912. Contemporary technological innovations included the development of inclined and vertical retorts, the latter (introduced in the early 20th century) was capable of continuous operation through the use of mechanical equipment to charge the retort with coal and remove coke. Gasholder design also advanced in order to address the need to store ever greater quantities, resulting in the first 4-lift gasholder, constructed by the South Metropolitan Gas Light and Coke Co. in 1888 (Figure 2). This period also saw the introduction of the flying lift (an additional lift which rose above the gasholder frame) and spiral guided gasholders, the first of which was constructed in 1889-90 at Northwich, Cheshire.

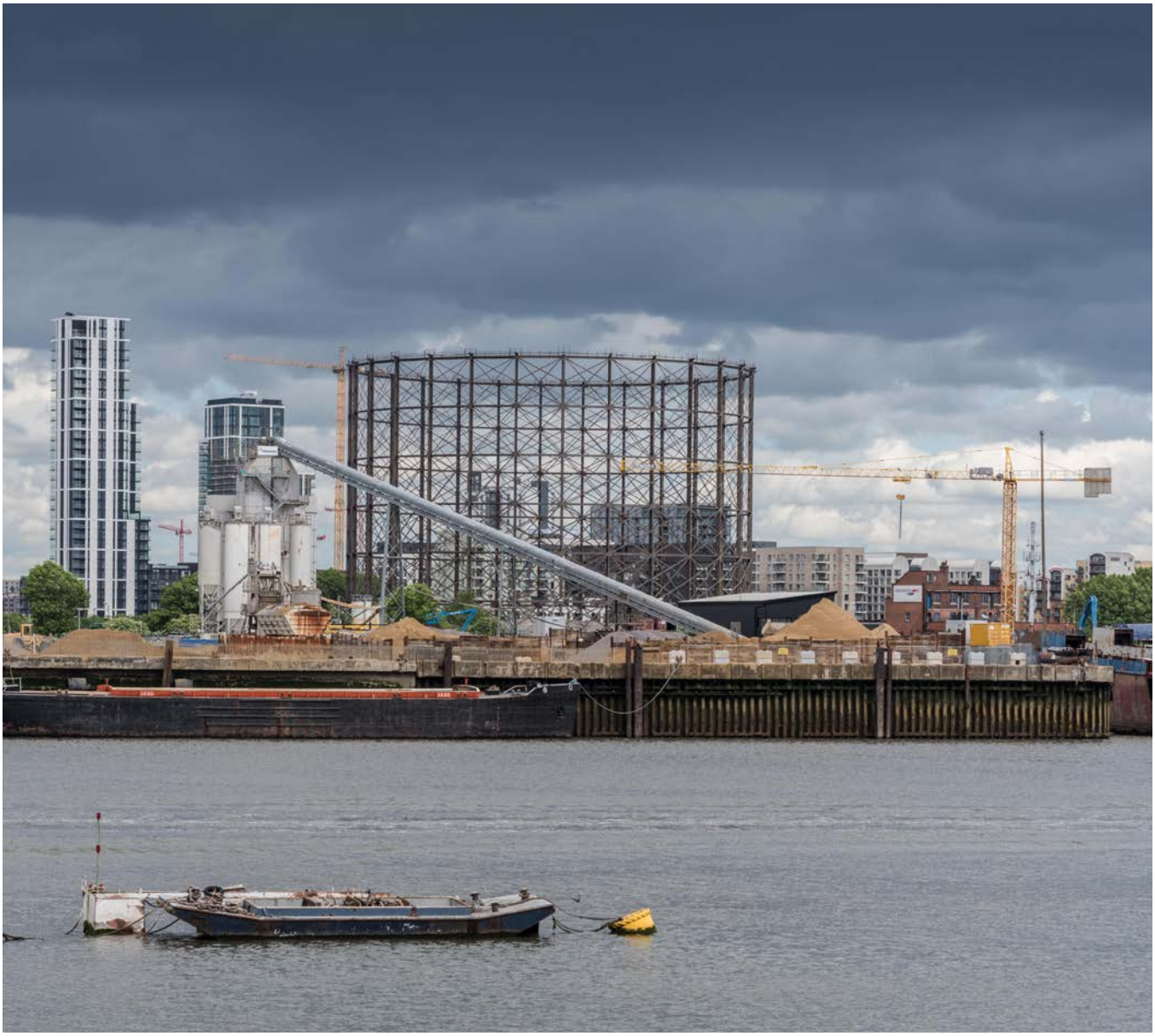

Figure 2: Gasholder No. 1 at the South Metropolitan Gas Company's (SMGC) East Greenwich gasworks in 2017. The largest of the gasworks constructed and operated by the SMGC, they opened on 30th July 1887 and both gasholders (at the time of their respective construction) were the largest in the world. Gasholder No. 1 was built to designs by Sir George Livesey and claims the distinction of being the world's first 4-lift gasholder. [DP182568]

Though production increased to meet wartime demand, expansion of the industry was checked by the First World War which saw skilled staff leave for the Front and materials diverted for fuel and munitions manufacture. Following the cessation of hostilities, the manufactured gas industry entered a period of consolidation and rationalisation, with many small companies either going bankrupt or having to amalgamate in order to survive. This process of consolidation was formalised by the 1920 Gas Regulation Act and characterised by the purchasing of small town and village gas works by the large town and city undertakings. It gathered pace in the 1930s with the 'Holding Company' movement which saw 242 gas undertakings enter into joint operation under 18 larger umbrella companies, of which the biggest was the GLCC. The inter-war years saw little in the way of major technological change, although continuous vertical retorts became well established and carburetted water gas plant was installed on many of the larger sites. In 1927, the first waterless gasholders – built to a German design – were constructed in Britain, although their introduction was not widespread.

The manufactured gas industry was further retarded by the Second World War, with the increased aerial bombardment of the British Isles and the strategic importance of the gas industry to the war effort, ensuring that the Second World War took a greater toll on the gas industry than the First World War. Nationalisation of major infrastructure was a priority for the post-War Labour government and following the nationalisation of the coal industry in 1945 and the railways in 1947, the post-war Labour government passed the Gas Act of 1948, nationalising the 1,064 local gas undertakings and vesting them in twelve area gas boards. Nationalisation continued the drive towards a rationalised and concentrated industry and between 1949 and 1958, the number of gasworks nearly halved from 1,050 to 536 as the industry battled to remain viable through technological innovation and developments in gas produced from oil. Faced with the rising cost of coal rendering the production of town gas uneconomical, following the discovery of natural gas under the North Sea in 1965, the UK gas network underwent a massive process of conversion between 1967 and 1977. Coal gas stopped being utilised in favour of natural gas transported under high pressure in pipes, resulting in the immediate redundancy of much gas manufacturing equipment and the clearance of many traditional gasworks sites. Still required for the storage of natural gas, many historic gasholders were retained and gasworks converted to gasholder stations. The industry was re-privatised in 1986 and in 1999, TransCo, the then operator of the national pipeline and storage system, announced the intended demolition of most of its stock of 630 gasholders. Though this threat did not immediately materialise, the facility for high-pressure storage of gas within mains pipelines had rendered all low-pressure gasholders redundant and the devolved networks have begun programmes to demolish them and redevelop the sites, in many cases, removing with the gasholders the last physical vestiges of the manufactured gas industry.

2.1 Manufacturing process and gasworks buildings

For the most part, gas was produced from coal, delivered to the gasworks by river, canal and later rail and held in a Coal Store. Gas was released from the coal by carbonization in a sealed vessel called a retort which was heated by a furnace. Multiple retorts heated by one furnace were known as an oven, while multiple linked ovens were called a Retort Bench (Figure 3). The retorts were contained within the Retort House, which formed the core of all gasworks and which evolved from single-storey buildings, often vernacular in character containing horizontally arranged retorts, to far taller buildings with characteristic wall ventilation which housed inclined retorts and vertical retorts developed in the late-19th century. Gas left the retorts via the ascension pipe and hydraulic main, the latter using water to collect hot tar and ammonia which was continuously drawn off through a Tar Tower to Liquour Tanks (for the ammonia) and Tar Wells or Tar Tanks. Having acted as primary condensers, the gas left the hydraulic main via the Foul Main which further cooled it and conveyed it via an Exhauster, which kept the gas flowing, into the Condensor which removed further tar and

Figure 3: The horizontal retorts and ascension pipes in the retort house at Fakenham gasworks, the only complete example of a town gasworks in England. © Historic England Archive, BB93/10504

ammonia. The gas then passed through a purification process to remove the remaining residual tar and ammonia, firstly through Tar Washers and Tower Scrubbers and then Box Purifiers; iron boxes filled with dry lime or iron oxide which removed hydrogen sulphide and hydrogen cyanide from the gas. Between 1885 and 1922, Cyanogen Plant was installed at some larger gas works in order to recover the by-product Cyanogen for use in dying and printing, whilst the First World War prompted a concerted effort to recover Benzole which could be utilised in the manufacture of explosives, leading to the construction of dedicated Benzole Plant. The purified gas was not immediately distributed to customers and was stored adjacent to the production and purification plant in Gasholders (Figure 4).

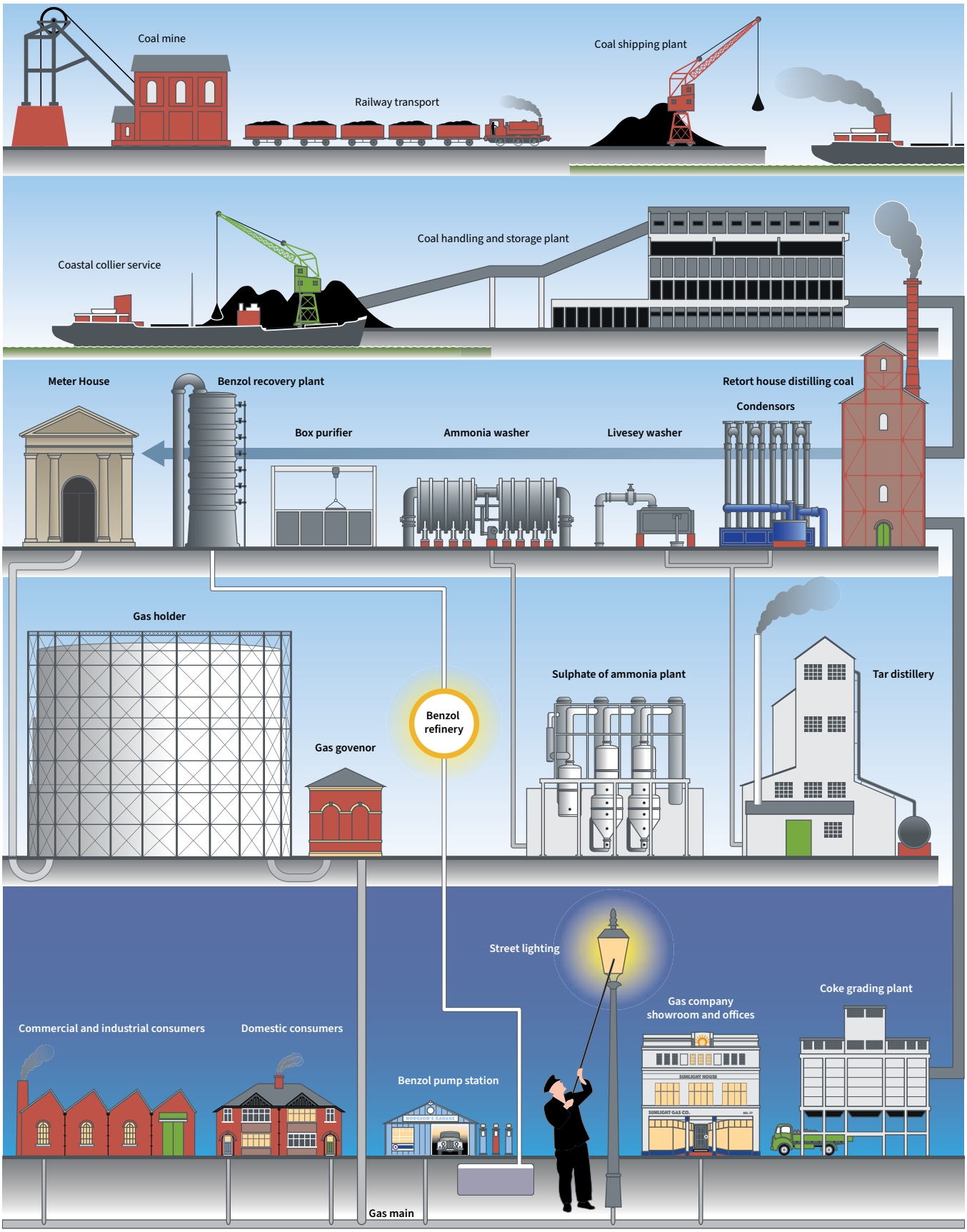

Figure 4: A schematic, general overview of the gas manufacturing process.
© Historic England based on an illustration by Professor Russell Thomas

Gasholders are one of the most instantly recognisable features of a former gasworks. The most distinctive visual element is the guide frame; a circular metal structure comprising a frame of vertical columns or standards (metal uprights) and horizontal girders, sometimes with diagonal bracing between the two. Those with columns may be referred to as 'column-guided holders' and those with standards as 'frame-guided holders'. The guide frame supported the gas vessel or bell, essentially an upturned open-ended metal vessel, within a circular tank of water that made a gas-tight seal. It rose as it was filled or fell as it was emptied of gas. The tank could be constructed of metal, standing entirely above ground, or of stone, brick (waterproofed by puddle clay), or concrete, set partially or completely into the ground. A bell was usually formed of a wrought-iron structure covered in metal sheeting, which went up or down on guide rollers that ran against rails fixed to the guide frame (Figure 5). The top of the bell was the crown which was covered in metal sheeting supported either by metal trusses or ribs fixed to the inside of it (a 'trussed crown'), by girders ('girder stiffened') or by a rest frame built in the tank (an 'untrussed crown'). Gasholders were increasingly built with telescopic bells in the later 19th century, although this had been invented as early as 1824. These possessed a bell that telescoped with multiple lifts: as the bell rose under pressure a U-shaped rim (the 'cup') in the lift above engaged with an inverted U-shaped rim (the 'grip') on the lift below and carried it with it. Extremely tall gasholders with as many as six lifts were eventually built in England, and in 1888 a flying lift was also introduced whereby the top lift rose up above the guide frame.

Gasholders provided both a storage buffer between production and supply and the requisite mains pressure which was monitored and maintained by the station meter and station governor held at the gasworks in the Meter House. In addition to the buildings housing the plant for production, purification, storage and metering of the gas, many larger gasworks also contained ancillary structures such as Company Offices, Research Laboratories and Stores and were often enclosed by a perimeter wall with a controlled point of entry.

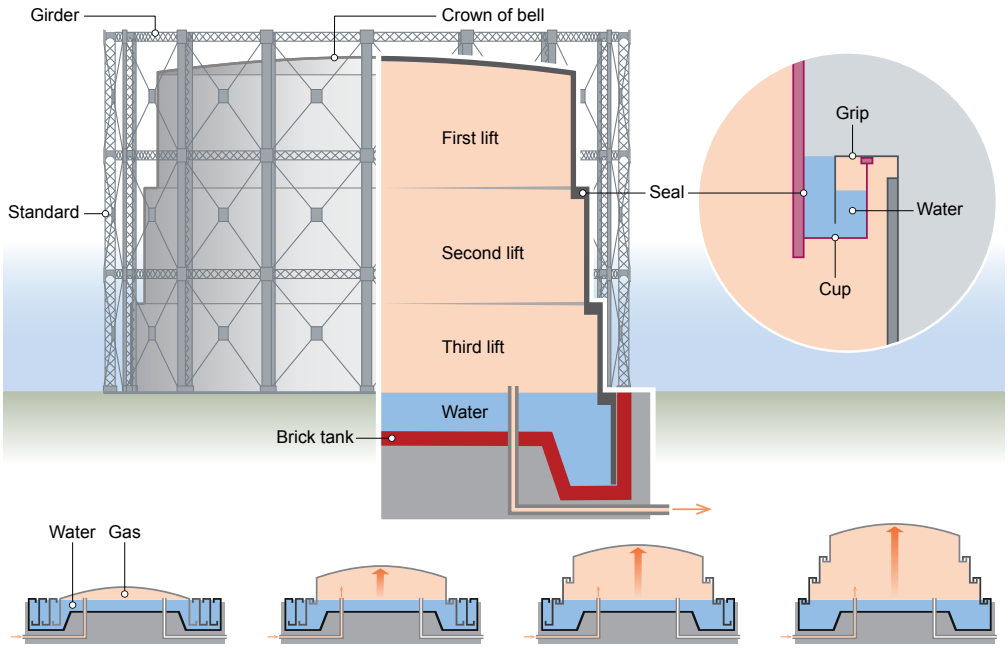

Figure 5: Diagram of a water-sealed gasholder showing the various components including the standards (uprights) and girders of the guide frame, the telescopic bell and the water tank.

3 Development of the building type

Each stage of the gas manufacturing process had dedicated structures (listed above) which survive in part or in full on a number of former gas manufacturing sites around the country, both large-scale town and municipal works and in small country house and village works. The physical character and way in which each of the gasworks' structures developed over the life of the manufactured gas industry are detailed separately below, with primacy given to the gasholders which prior to the demolition programmes instigated by the gas networks in 2015, survived in the greatest number and display the greatest variety of design. The only surviving example of a complete town gas works is preserved as the Fakenham Museum of Gas in Local History, although a number of relatively complete small town works survive around the country they are devoid of all of their plant and converted into light industrial or commercial use.

3.1 Gasholders

The gasholder had its origins in the small water-sealed laboratory vessels used by chemists during the late 18th century. Antoine Lavoisier devised the basic form of gasholder in 1782, using an upturned metal vessel, or bell, in a tank of water that made a gas-tight seal. Initially small rectangular bells were used suspended in tanks of water before the cylindrical form developed. One exceptionally early partial survival is a stone gasholder tank built in about 1820 (along with an enclosure wall and counter-weight) at the Dolphinholme Worsted Mill, Lancashire, by the pioneering engineer Samuel Clegg during the infancy of the industry. Enclosing buildings known as 'gasholder houses' were constructed surrounding gasholders in the early 1800s, often with the gas bell slung from a roof beam by a central chain and balance weight (Figure 6). The octagonal brick gasholder houses at Warwick are a unique survival in England (built 1822) but do not contain the original internal equipment; the gasholders themselves (Figure 7). The practice was abandoned in England in the 1820s when it was realised the enclosures increased both the risk and consequences of an explosion when gas leaked into them. Instead gasholders would be located out in the open, taking the basic form outlined above: a gas bell supported by a metal guide frame as it rose or fell within a circular water-filled tank.

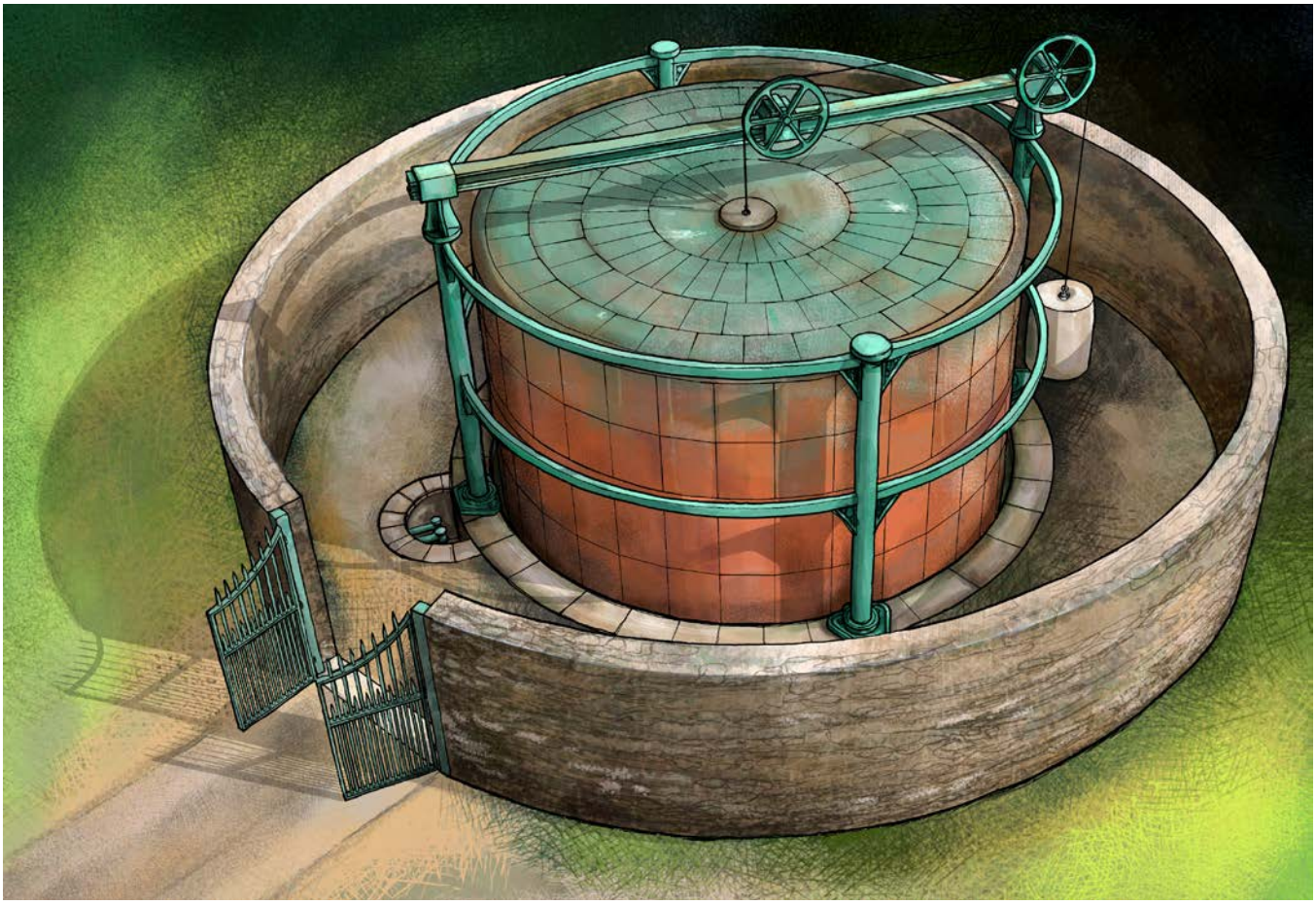

Figure 6 (top): The gasholder at the former Dolphinholme Worsted works as it may have looked in around 1820 after its construction following a major extension of the mill in 1818. The remains of the holder, comprising the circular stone tank, rubble stone wall and counterweight form part of what is thought to be the world's earliest surviving gasworks. © Historic England

Figure 7 (right): The surviving octagonal gasholder houses at the Warwick gasworks, Saltisford. The practice of enclosing gasholders in gasholder houses was abandoned in the 1820s when it was realised that rather than mitigating the risk of explosion, they increased it. [33260_013]

Gasholders with a guide frame of cast-iron columns were predominant until the late C19. Initially these frames comprised just three columns linked by girders. An early alternative for larger gasholders were the use of free-standing cast-iron tripods (without horizontal girders). Indeed the oldest surviving gasholder in the world; the only Georgian example, Gasholder No 2 in Fulham, London, takes this form. Built in 1829-30, it broke new ground in size and capacity, and has remarkable blacksmith-made wrought-ironwork to the bell. Nonetheless, between about the 1840s and 1890s the majority of guide frames came to be composed of a ring of cast-iron columns. These were architecturally-elaborate gasholders with frames first formed of a single tier, or classical order, of columns but subsequently of a double or triple order of columns. Architectural detailing could include: Doric, Ionic or Tuscan capitals, triglyphs and horizontal filigree cast-iron bands. The gasholders of this form built by the Imperial Gas Light and Coke Company were not surpassed in the quality of their ornamentation and include iconic examples at Kings Cross and a unique grouping of seven gasholders at Bromley-by-Bow, London (Figure 8).

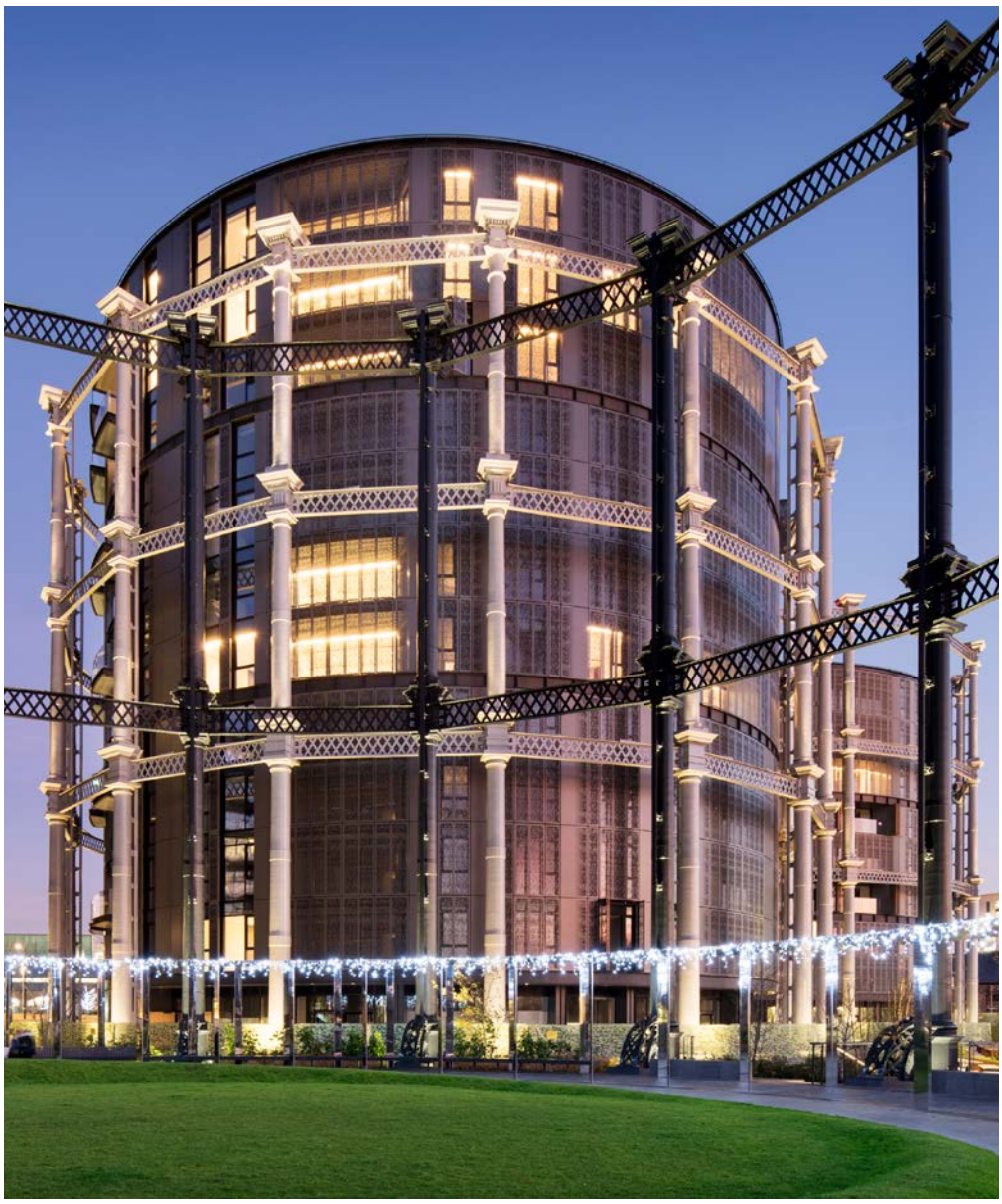

Figure 8: There are four former gasholders at Kings Cross, now surrounding apartments and a park, including three conjoined examples known as the 'Siamese Triplet'. These cast-iron gasholders with classical columns were built in 1879-80 and 1883, although similar gasholders had been built during the mid-19th century. The listed guide frames were dismantled and moved during the construction of the Eurostar terminal at St Pancras Railway Station (the bell and tanks were not retained). [DP220095]

Figure 9: Gasholder No.1 adjacent to The Oval cricket ground, Kennington, London (Built 1877-79 and listed in 2016). Note the wrought-iron lattice standards (uprights), cross girders and diagonal-bracing of the guide frame. The telescopic bell is partially-filled, rising just above the building in the foreground. [DP182564]

The period from the 1870s to the 1890s saw massive changes in the design of gasholder guide frames, including the first standards of wrought-iron (1876) and then steel (c1890). One branch of design combined tapered wrought-iron lattice standards, analogous to buttressing, with an increased number of girder tiers. The most prominent example is Gasholder No 1 at Kennington, London, (constructed 1877-79,) built on a huge scale and in a grandstand setting next to The Oval cricket ground (Figure 9). A second technique, pioneered by the eminent gas engineer George Livesey, was the development of guide frames as cylindrical lattice shells. These had exceptionally thin I-section standards combined with diagonal struts, reducing or omitting the horizontal girders altogether. The revolutionary prototype is Gasholder No 13, Old Kent Road, London; one of the most technologically and structurally innovative gasholders ever built (Figure 10). The world's largest gasholder when erected in 1879-81, it inspired the development of helical or geodesic structures, including a series of distinctive gasholders patented by the engineer Samuel Cutler. These consisted of vertical standards and diagonal triangulated framing without horizontal girders.

Figure 10: Gasholder No.13, Old Kent Road, Southwark, London (Built 1879-81 and listed in 2017). With exceptionally thin wrought-iron standards (uprights) linked by girders and diagonal struts this pioneering gasholder essentially forms a three-dimensional cylindrical shell. It inspired the development of helical or geodesic structures. The bell used mild-steel for the first time, and the innovative tank was the deepest then constructed and one of the deepest ever built. [DP182523]

In 1890 the next major development occurred with the construction of the first spiral-guided gasholder. This was a water-sealed gasholder without a guide frame but which had guide rails fitted at a 45 degree angle directly to the tank (but later to each lift) so that as it was filled the gas bell rose in a cork-screw or spiral motion. It was built at Northwich, Cheshire, but has since been demolished. Dispensing with the guide frame made spiral-guided gasholders cheaper to construct, although arguably of less visual interest. They became the predominant form in the 20th century, widely built around the world.

One short-lived introduction was the wire-rope or cable-guided gasholder (circa 1890-1910), which used a system of cables and pulleys to guide the bell of which there are no known surviving examples.

From the 1920s, waterless or dry-seal gasholders were introduced to England from abroad. These followed developments from 1915 in Germany (the 'M.A.N' and 'Klönne' designs) and from 1952 in the USA (the 'Wiggins' design). Essentially they comprised a static cylindrical shell with a piston which moved within it; no water-seal was required. However, dry-seal gasholders were not built in large numbers in this country and the most well-known examples, at Battersea and Southall, were demolished in 2013 and 2018 respectively.

3.2 Retort houses

Gasholders survive in greater number and may be the most instantly recognisable element of a former gasworks, however it was the retort house which lay at the heart of the gasworks and contained the most crucial piece of plant for the manufacture of coal gas: the retort. The retort was the sealed vessel, initially of iron but later of clay in which the coal was heated above a furnace to draw off moisture and release the gas. The arrangement of the retorts dictated the design and appearance of the retort house and can be chronologically summarised as developing from horizontal retorts from the earliest years of the gas industry, through inclined retorts in the second half of the 19th century to vertical retorts in the early years of the 20th century. No inclined or vertical retort houses are believed to survive in England, with the last example - a heavily altered vertical retort house in Newbury, latterly converted to a steel cable factory - demolished in 2017.

Horizontal retort houses covering the entire period of the manufactured gas industry from the 1820s to the 1960s, survive across England and a number have been afforded statutory protection. Those dating from the first half of the 19th century where characteristically wide (around 30 ft (9.14m)), rectangular, single-storey buildings constructed of the most readily available local building material. Though brick was more ubiquitous, examples of stone retort houses survive in south-west and north-east England, while a retort house in the village of Rockingham constructed of ironstone, attests to their construction according to local vernacular traditions. The pitched roofs were typically carried on wrought iron and later steel trusses and variously covered with slate, clay tiles and corrugated iron sheeting. A raised and louvered clerestory running along the length of the roof's apex provided ventilation to the horizontal retort house and was a characteristic feature, irrespective of the scale and overall design of the building (Figure 11). Similarly, ventilation was also required directly

Figure 11: The horizontal retort house and gatehouse at the National Machine Gun Factory, Burton-on-Trent. Characteristic of horizontal retort houses more generally, the gas house (left) at the former machine gun factory, retains both its raised clerestory with louvered windows and its glazed oculus. [DP217067]

Figure 12: The former estate gasworks (later a blacksmiths) built in 1874 to serve Sudbury Hall in Derbyshire. Like many small estate gas works, the Sudbury gasworks were given the architectural embellishments of the other estate buildings, in this case blue brick diaper patterning and Flemish gables. The former retort house (rear) retains its chimney and characteristic clerestory. © Mr Geoffrey R Hood. Source: Historic England Archive

above the retort benches and this was usually provided by open oculi, round openings with brick voussoirs or stone mouldings which were located in the gable walls beneath the apex of the roof. All designs of horizontal and later inclined and vertical retort houses also incorporated a chimney for exhausting waste gases, though those which survived beyond the end of the manufactured gas industry were frequently converted to stores resulting in the loss of their chimneys. Retort houses on private and estate gasworks broadly incorporated all of the features described above, but frequently included greater architectural embellishment or were built to complement the existing buildings of the estate. For example, the gasworks built in 1874 to supply Sudbury Hall and the neighbouring village of Sudbury, Derbyshire incorporate ornate shaped gables and blue brick diaper patterns (Figure 12).

In the 1880s, the design of the horizontal retort house, largely unaltered since the beginning of the century, began to evolve. Before 1880, almost all retort houses were arranged with ground-floor layouts in which the furnaces beneath the retort stack were located below the level of the ground floor. During the 1880s, a stage-floor design was widely adopted in which the retorts where located on a floor strengthened to withstand the weight and extreme heat allowing them to be situated at ground or first floor level. The stage-floor was usually formed of brick or concrete arches strengthened with cast-iron plates and supported by cast-iron columns. Stage-floor retort houses utilised similar construction techniques to purifier houses, making later horizontal retort houses and mid-19th century purifier houses, hard to distinguish (see below). The final evolution of the horizontal retort house was to employ a construction method in which brick panels were built around a steel or concrete frame. This enabled the retort houses to be built taller, a precursor to the automatically charging conveyor-fed vertical retorts of the early 20th century which also employed this brick panel method of construction.

3.3 Purifier houses

The purification of gas was an essential part of the process of producing gas of sufficient quality for lighting. Much of the tar and some of the ammonia contained within manufactured gas was removed in the hydraulic and foul mains immediately after the gas left the retorts, with the remainder of the coal tar drained off into a tar tank or well following the cooling of the gas in condensers, or removed by tar washers. A system of 'wet' lime purification was widely adopted within the industry but, due to issues of disposing of the obnoxious wet lime waste, known as 'Blue Billy', experimentation was undertaken from 1817 to develop 'dry' lime purifiers which passed the gas over slats which held hydrated burnt lime. This process quickly became widespread, especially in cities where it was difficult to dispose of the fouled wet lime material.

'Dry' lime purification and later purification by oxide of iron, took place in large lidded boxes which were usually housed within buildings. The 'dry' process was dusty and purifier houses kept most of that dust in and kept rain water off the lime and later iron oxide when the boxes were being emptied and filled. Initially, 'dry' lime purification did not require purpose-built structures, with redundant, early retort houses converted to house the box purifiers – a task they were well suited to thanks to the ventilation afforded by their characteristic louvered roofs. However, in addition to being dusty and smelly, 'dry' purification was also potentially hazardous. The risk of gas escape and therefore fire was higher during purification than at any other point during the gas manufacturing process and the purification material was susceptible to spontaneous combustion upon exposure to the air. Box purifiers were also exceptionally heavy and reinforced floor surfaces were required where they were housed above ground floor level. As a result, purpose built purifier houses - which incorporated fireproofing measures in their construction, ample ventilation and large openings to allow the installation of the boxes – became fairly typical and widespread between 1850 and 1910.

In appearance, purifier houses of the mid-late 19th century are difficult to distinguish from horizontal retort houses. They were similarly constructed of either brick or local stone depending on the location of the gasworks within England and were broadly-speaking rectangular structures beneath a pitched roof with a louvered clerestory. The gable ends frequently incorporated an open oculus beneath the apex of the roof, a ventilation feature also characteristic of retort houses. Purifier houses can be identified through the absence of an associated chimney, through a characteristic arrangement of external openings comprising arched doorways on the ground floor with round-headed windows above and any surviving evidence of the use of cast-iron in the construction of the first floor. The latter both strengthened the upper floor for the weighty box purifiers but also provided some protection in case of spontaneous combustion. A largely complete purifier house survived at the former Quay Street gasworks, Gloucester until 2017, while two retort houses at Canon's Marsh, Bristol and a warehouse at Ryde, appear to have all been built as purifier houses (Figure 13).

Figure 13: Interior view of the ground floor of the former purifier house at the Gloucester Gaslight Company's first gas works on Quay Street, Gloucester. Constructed in the early 1850s to house dry lime box purifiers, the building was designed to be fireproof and was constructed around two arcades of cast iron columns which carried cast-iron girders and a ceiling of brick jack arches and cast iron plates. It was demolished in late 2017. [DP219975]

3.4 Meter houses and governor houses

The station meter recorded the amount of gas produced by a gasworks after the purification process had been completed and larger works may have had several station meters, each metering separate retort houses. On smaller works, the meter house may have also contained the station governor and the exhauster and pressure register. Like retort and purifier houses, meter houses were usually constructed of either brick or stone depending on the local building traditions of the area and were, in their simplest form, small rectangular buildings with pitched gable roofs which often had tiled interiors to ensure they were kept very clean. However, meter houses were typically the most ornamental building in the gasworks and early examples were given elaborate Neo-classical facades to give the impression of a Roman or Greek temple such as at Kirkland in Cumbria (Figure 14). In cases where the station governor was not housed with the station meter, it was to be found in a separate governor house. The station governor regulated the flow of gas from the gasholders, provided the pressure in the gas mains and was typically the last piece of plant the gas passed through before leaving the gasworks. The station governor remained an integral piece of plant after gas manufacturing ceased and as such, governor houses remained at gasholder stations into

the 21st century. After the gasholders, they are the most visible above-ground structure of the natural gas distribution networks and are generally small to medium sized, single-storey rectangular buildings of brick, stone or glass reinforced plastic panels, with louvered ventilation panels built into the walls.

Figure 14: The façade of the original Kendal Gas Company meter house. Constructed in 1825, the façade comprises a pedimented portico carried on a pair of Tuscan columns and flanked by square corner pilasters and bears the inscription 'EX FUMO DARE LUCEM' which translates as 'Light from Smoke'. The façade was removed from its original gasworks location in 1984 and reconstructed as the west elevation of the extension to the Museum of Lakeland Life and Industry. [DP249853]

3.5 Offices and laboratories

Figure 15: Kelso House, the former offices of the Bath Gas Light and Coke Company, was completed in 1858-59 to designs by the architects Manners and Gill, the latter likely a relation of T. Gill the Chairman of the Directors of the company. Built of local Bath Stone, it is representative of mid-19th century company offices in its relatively modest proportions and its location within the works, forming as it does part of the perimeter of the site and presenting a decorative façade to the street. [DP249936]

The large gas companies required dedicated space from which to deal with administrative tasks related to the operation of the company, which resulted in the construction of purpose-built offices. Initially constructed flanking the entrance to the gasworks, in the early 20th century, offices became increasingly associated with showrooms and sited in town centres, often on the main High Streets. 19th century offices such as the listed examples at Bath and Fulham were generally modest in scale, but with a level of architectural embellishment - typically in the form of neoclassical detailing - indicative of the ambition and growing status of the major gas companies (Figure 15). The consolidation and rationalisation of gas provision brought about by the 1920 Gas Regulation Act, increased the size of the major gas companies, resulting in the construction of larger company offices to accommodate the increased level of administration. During the 1920s, the Gas Light and Coke Co. engaged the then President of the RIBA, Sir Walter Tapper as their consultant architect to design a series of offices and laboratories at their works across north London including Sands End, Fulham and Bow Common Lane. They were built of red brick with

Figure 16: The former laboratory of the Gas Light and Coke Company works at Sands End, Fulham viewed through the frame of gasholder No. 7 during its demolition in 2018. The laboratory was designed by the company's consultant architect, Sir Walter Tapper and completed in 1928. Built in a Neo-Classical style it is characteristic of laboratories and offices built during the 1920s. [DP264697]

stone dressings in refined neoclassical style with the laboratory at Fulham surviving adjacent to the earlier office of 1857. Laboratories were also integral parts of most medium and large gasworks and allowed testing to be undertaken on the gas and by-products produced as companies sought to improve the quality of their supply. At Fulham the laboratory building included an apprentices' school, while some laboratories had associated Test Houses containing calorimeters for testing the gas (Figure 16).

3.6 Showrooms

Initially directly associated with the gasworks but later less so, purpose-built showrooms became more numerous in the final years of the 19th century as gas became increasingly applied to domestic cooking and heating, with the gas companies quick to promote the appliances which

would utilise their supply. During the late 19th century, showrooms were often combined with company offices and situated within the works, presenting a showroom window to the street. However, during the inter-war and post-war years, showrooms were increasingly built away from the gasworks and situated on town High Streets. As commercial rather than industrial structures, their form evolved in line with the architectural tastes of the time with surviving late Victorian red brick examples at Great Yarmouth and Herne Bay, a neo-Tudor showroom in Rainham which matched the style favoured by inter-war pub architects, and striking modernist and Art Deco examples such as SEGAS House in Croydon, Radiant House in Liverpool and on Sandgate Road in Folkestone (Figure 17).

Figure 17: The former showrooms and offices of the Folkestone Gas and Coke Company. Built in the fashionable Moderne style of the inter-war period to designs by the architect John Love Seaton Dahl and completed in 1938, this example is characteristic of the tendency for showrooms to be situated away from the works in High Street locations and to adopt the architectural styles popular in the design of commercial buildings. [DP264589]

Figure 18: The former manager's house and separate showroom at the Bridport Gas Company's works on South Street, Bridport. The works, which operated from 1838 to 1958, was the first in the county and in the late 19th century saw the addition of the manager's house (1872) and a showroom (1899) positioned either side of the entrance to works. [DP249857]

3.7 Managers' houses

In the case of small to medium or early gasworks, a house for the manager of the works was often constructed adjacent to the works entrance. These varied greatly in size and architectural style depending upon the size of the works but do survive in greater number than the buildings of the gasworks they formed part of. Of the surviving examples, Kelso Villa, the house of the Superintendent of the Bath Gas Light and Coke Co, is perhaps the finest but other good examples can be found at Bridport in Devon, Wedmore in Somerset and at Ryde on the Isle of Wight (Figure 18).

3.8 Perimeter walls and works' entrances

In most cases, gasworks were secured around their perimeter by a boundary wall. These walls were generally either constructed of stone or brick depending on the locally available building materials and could include as part of the perimeter the rear elevations of ranges of buildings within the works. Where perimeter walls were constructed of brick, they were often given some visual distinctiveness through the inclusion of recessed panels. Directly associated with the gasworks' walls were the works' entrances. These entrances were almost always fitted with

a wooden or iron gate, sometimes bearing the name of the company, that served to control access to the gasworks and provide security. The entrances themselves varied considerably in form from a basic pair of brick pillars with coping stones or ball finials to far more elaborate monumental archways in fine worked stone (Figure 19). Some gasworks, such as Leicester incorporated a formal gatehouse in the works' entrance which in Leicester's case was a highly ornamented red brick building of 1879 with a striking clock tower. It was also common for the company office or manager's house and showroom to flank the entrance to the works as can be seen in the surviving buildings of the Bridport gasworks.

Figure 19: The classical sandstone arch constructed in c.1826 as the entrance to Beverley gasworks. It is Grade II listed and is the only surviving fragment of the gasworks which ceased production in 1951 but continued as a gasholder station. © Mr Terry Dawson. Source: Historic England Archive

Figure 20: The remaining buildings of the Colne Vale Gas and Drysaltery works in Milnsbridge near Huddersfield. Formed in 1875 as a cooperative venture by local mill owners to establish a larger gas undertaking than the small plants which served each of their mills, the mutual company constructed a sizable works adjacent to the railway viaduct. Surviving in 2019 as a coach hire depot, the large horizontal retort house, complete with characteristic louvered clerestory and oculus, is flanked by single-storey coal and coke stores, a ubiquitous arrangement of which there are few surviving examples.

3.9 Coal and coke stores

To feed the retorts, gasworks required extensive reserves of coal, usually enough to ensure 21 days of maximum production. Damp coal did not carbonize effectively in horizontal retorts, so structures to keep the coal stocks dry were found at gasworks of all scales. Similarly, the coke produced during the carbonization process also required storage prior to its sale to customers or its use in retort furnaces or in the production of water gas or producer gas. These stores took a variety of forms and were constructed from brick, stone or concrete dependent upon their date or their location within the country. The most typical form was for a coal store and a coke store to be built adjoining the retort house as single-storey flanking ranges (Figure 20). To mitigate the risk of the coal spontaneously combusting, the reserves were stacked no higher than 20ft (6m) and as such the most common form of the attached coal store was a single-storey range with a pent roof.

4 Associations

Figure 21: The terraced workers' cottages of the former Leicester Corporation Gas Undertaking works on Aylestone Road, with the clock tower of the works' gatehouse beyond. Constructed in 1879 after the Leicester Corporation pruchased the local gas company, the manager's house in the foreground was constructed in a matching, if more elaborate style, to the rest of the terrace. [DP261721]

Beyond the walls of the gasworks, there are likely to be strong associations with the landscapes and townscapes around the works and with other types of heritage asset. Gasworks were heavily dependant upon the supply of coal, coke and purifying agents such as lime and iron oxide in order to manufacture gas. As such, gasworks sites are frequently directly associated with communications networks, being built on the banks of rivers or canals, adjacent to railways or on the coast where coal could be brought in by sea. Historic infrastructure such as jetties, landing stages, sidings, bridges and coal yards may survive where the gasworks do not, such as the jetty built on the River Thames at Rotherhithe by the South Metropolitan Gas Light and Coke Co. and the skeletal remains of the pier at Beckton. Like other types of large industrial complexes, gasworks relied on a large and locally situated workforce and there are strong associations with workers' housing. Housing constructed by gas companies for their workers survive well and there are notable examples at Leicester on Aylestone Road and in London in the form of Kensal House, completed

in 1936 for the Gas Light and Coke Company to designs by the architect Maxwell Fry (Figure 21). Welfare and social facilities, such as libraries and concert halls were also provided by the gas companies and a fine example survives in the form of the Livesey Memorial Hall in Sydenham. The inability of early gasworks to transmit gas over great distances also means that there are strong and direct associations between gasworks and the estate, village, town or district they supplied, though these associations were lessened by nationalisation and the creation of the British Gas area boards. The gas companies were major employers within communities and as a result there are strong connections between the gasworks and local memorials and sculptures. War memorials detailing the men of a particular company lost during the first and second world wars are relatively numerous with notable examples in Cambridge and at the former Sands End gasworks in Fulham. Similarly, statues honouring the founders or chairmen of the major gas companies can also be found adjacent to former gasworks such as in the case of the statue to Sir George Livesey on Old Kent Road and the statue to Sir Corbett Woodhall on Twelvetrees Crescent adjacent to the former Bromley-By-Bow gasworks.

5 Change and Future

The manufactured gas industry underwent its most substantial period of change in the second half of the 1960s when the national supply was converted from gas manufactured from coal and oil at town gas works to natural gas piped in from the North Sea and imported from overseas. Many gasworks were cleared altogether, though retention of the low-pressure gasholders and the conversion of the gasworks to a holder station was more typical. A number of buildings were afforded statutory protection, but the majority of the buildings associated with gas manufacture, were lost and as a result it is believed that there are no extant examples of inclined or vertical retort houses. The gasholders remained in use throughout the 20th century and survived in large numbers before 2000. Developments in the supply network which allowed the high-pressure storage of gas within mains pipelines finally made gasholders completely redundant and as a result, decommissioning and demolition of the structures has been carried out across the country by the gas networks. The decommissioning and demolition of gasholder stations has released these sites for remediation and redevelopment, posing a threat to structures which had survived from the earlier phase of gas manufacturing. Away from the former large municipal works, smaller town gasworks survive - though usually without their gasholders - in partial or near complete form, converted to light industrial use. Their future is more secure, though development pressure and the increasing appeal of former brownfield sites in urban contexts for conversion to residential use, mean that the future for undesignated historic gasworks buildings, is uncertain.

In 2019, there are fewer than 200 low-pressure gasholders remaining in England, a number which will continue to fall as the gas networks continue their demolition programmes. While the majority of surviving gas manufacturing buildings are not owned by the gas industry, statutory protection has resulted in the retention of a number of significant examples. There are 19 (at January 2020) nationally designated gasholders (and/or guide frames) and more than 100 designations directly related to the manufacture of gas from coal covering all of the building types described above. With an increasing number of former large urban gasworks sites released for redevelopment, the challenge for the future is to find ways to re-use and retain aspects of gas industry heritage, within the constraints presented by historic contamination and the physical shape and proportions of the gasholders. In recent years there have been new and inventive re-uses for historic gasholders, such as the creation of a park and canal-side apartments within the listed guide

frames of the gasholders at King's Cross and a similar scheme proposed for the iconic gasholder at Kennington Oval. Although the preservation of gasholders presents particular challenges, the success of the King's Cross development and numerous successful redevelopments in continental Europe and Australia, have resulted in a greater awareness of the potential for retention of historic gasholders. This has led to the proposed retention and incorporation of both listed and unlisted gasholders in major residential development schemes.

In addition to providing advice to national government about the statutory protection of former gasworks buildings and redundant gasholders and to developers and local authorities through our statutory role in the planning process, Historic England has been photographically recording many of the best surviving examples of gasholders and former gasworks, both from the ground and from the air. This document supplements Historic England recording guidance for gasworks and gasholders to assist the gas networks and other custodians of gas heritage to record, archive and curate the physical and cultural legacy of gasworks and ensure this information is safeguarded for posterity.

6 Further Reading

A detailed overview of the history of the gas industry in England has been commissioned by Historic England and will be available online as part of the Research Reports Series. This provides an overview of the industry, details the physical components of historic gasworks, a gazetteer of gasworks sites in England, a bibliography and a list of manufacturers of gas plant. Part 5 of the report contains the extensive bibliography which details both contemporary industry specific publications and a vast number of regional and national gas histories. A valuable report was also produced by Michael Trueman for the English Heritage Monuments Protection Programme in 1999 and 2002, which was national in scope and similarly provided an overview of the industry followed by a survey of many individual gasworks sites across the country. Gasholders are a relatively specialist area and there is no published work comprehensively covering the history and architecture of these structures in Britain. The most detailed study of gasholders undertaken in England was the London Gasholders Survey carried out by the engineering historian Malcolm Tucker (2000, updated 2014). It provided a typology for gasholders and remains a considerable and highly-regarded achievement. Individual articles have been produced by the Greater London Industrial Archaeology Society (GLIAS) ('Low-pressure gas storage' in London's Industrial Archaeology No.2 (1980)) and the Association for Industrial Archaeology ('Gasholders – the end of an era' in Industrial Archaeology News 172, Spring 2015), among other bodies. Additionally, the increased pace of change has created a growing body of detailed site records produced at the time of gasholder demolition and site clearance, which will become available through county Historic Environment Records and the Archaeology Data Service. Local Study Libraries also hold material on historic sites and their context.

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