The Paradox of Smokeless Fuels: Gas, Coke and the Environment in Britain, 1813–1949

PETER THORSHEIM

Department of History
University of North Carolina at Charlotte
Charlotte, NC 28223, USA
Email: pthorshe@email.uncc.edu

ABSTRACT

The contemporary world faces a toxic legacy: environmental contamination caused by past industrial activities. In Britain, a large proportion of the soil and groundwater pollution that occurred during the nineteenth and first half of the twentieth century came from gasworks and coke plants. Paradoxically, many people long viewed them as the answer to the country's pollution problems. Smoke-abatement activists and industry officials argued that gas and coke could be burned without producing the large quantities of particulates and volatile organic compounds that emanated from coal fires. Yet promoters of these 'smokeless fuels' failed to recognise that they did not eliminate environmental problems, but instead shifted them from sites of consumption to those of production. Air pollution declined in many places, but it grew worse in those containing gasworks and coke plants. In addition to displacing pollution geographically, the manufacture of gas and coke displaced it chronologically by creating hazards that would long endure. Today, decades after they ceased production, many of the places where gasworks and coke plants once stood remain contaminated by toxic by-products.

KEY WORDS

Coal, smoke, gas industry, pollution displacement, environmental reform

The construction of the Millennium Dome, built beside the Thames in the Docklands region of London, required one of the largest environmental remediation projects ever attempted. East Greenwich, which served as the focal point for Britain's inauguration of the third millennium, was indelibly shaped by one of the most polluting industrial processes of the previous one: the production

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of gas and coke from coal. Commensurate with the rest of the Dome's budget, the cost of remediation was staggering, and it kept rising as work progressed. By the time the toxic dust had settled, the government had spent £185 million and had excavated 200,000 tons of contaminated soil. Unfortunately, this 'clean-up' did nothing to neutralise the plethora of hazardous substances that permeated the site; it simply dispersed them to landfills across Britain. The transfer of pollution from one location to another and the assumption that it no longer poses a risk to health or the environment can be called pollution displacement. This practice is not limited to contemporary efforts to deal with contamination. On the contrary, pollution displacement played a crucial part in causing and disguising the activities that contaminated East Greenwich, and countless other places where gas and coke were produced.[1]

Although few visible signs of them now remain, virtually every town and city in Britain once contained gasworks, in which coal was transformed into gas, coke, and other by-products. During the nineteenth and early twentieth centuries gas provided the main source of artificial light in Britain, and coke served as an important industrial fuel. Electricity began to supplant gas for lighting purposes in the late nineteenth century, but consumption of gas and coke increased nonetheless as people adopted them as relatively clean-burning alternatives to coal for cooking and heating. By the early 1960s – just before manufactured gas was replaced by natural gas from the North Sea – gasworks in Britain were consuming 22 million tons of coal each year, and coke plants were using even more.[2]

Despite the fact that they were touted as smokeless fuels, the production of gas and coke was an exceedingly dirty process, which damaged the health of workers and nearby inhabitants, and which contaminated the environment with smoke, sulphur, cyanide, heavy metals, and carcinogenic organic compounds. Gas and coke did not eliminate pollution; instead, they displaced it from one environment and group of people to another. In addition to redistributing the burden of pollution spatially and socially, the manufacture of gas and coke also displaced pollution chronologically by bestowing a legacy of persistent toxins on future generations. Sixty-eight former gasworks sites – each of them a potential hazard – have been identified in the London area; in Britain as a whole, at least 2,000 sites exist.[3]

Historians have devoted little attention to the environmental consequences of the gas industry in Britain. Although several studies provide valuable insights into its technological, organisational, and financial aspects, they say practically nothing about its effects on workers or the environment. Such an oversight is not unique to this industry or to studies of Britain. As Christine Meisner Rosen and Christopher C. Sellers recently observed, scholarship in economic and business history has 'tended to treat industrial impacts like pollution as well as most other environmental dimensions of business activity as if they were what economists call "externalities"'. Jeffrey K. Stine and Joel A. Tarr have similarly noted that

historians 'have on the whole neglected not only worker safety but also the environmental consequences of industry and manufacturing'.[4] Historians of air pollution in Britain have displayed a similar propensity to ignore pollution from gasworks and coke plants. Focusing on the serious problem of coal smoke, they have considered how the consumption of gas and coke affected the atmosphere and have overlooked the environmental consequences of their production. Eric Ashby and Mary Anderson, for example, assert that 'London air became cleaner in the first decade of the twentieth century' largely as a result of 'the enterprise of the gas industry'. Although air quality improved in many places as a result of gas and coke, the production of these fuels also created new hazards to human health and the environment.[5]

GAS AND COKE PRODUCTION

The first public gasworks in Britain began operating in 1813. Owned by the Gas Light and Coke Company, it was located in Great Peter Street in Westminster. Gas quickly gained popularity as a source of light in streets, commercial buildings, and private houses; companies soon began producing it throughout Britain. By the middle of the nineteenth century, 760 towns in Britain and Ireland possessed at least one gasworks. All over the kingdom workers dug up streets to lay pipes for gas – London alone contained 2,000 miles of mains by 1850. The amount of coal used by the gas industry rose from just 500,000 tons in 1830 to 10 million tons in 1887. London had by far the largest gas production in Britain throughout the era of manufactured gas. At the beginning of the twentieth century its gas companies consumed approximately 4 million tons of coal each year.[6]

Both coke and gas were created by the 'carbonisation' of coal in retorts that were heated to approximately 1,300° C. The bituminous coal that was often used to heat these ovens produced a great deal of smoke, and fugitive emissions from coal undergoing carbonisation further contaminated the air with a mixture of smoke and foul-smelling vapours. Despite becoming red-hot, the coal did not burn, because the retorts were tightly sealed to keep out oxygen. Instead, the extreme temperatures forced virtually all of the volatile constituents from the coal. In some places, particularly during the nineteenth century, the sole purpose of carbonising coal was to make coke. The 'beehive' coke ovens that dotted Britain's industrial landscape made no attempt to capture the gases and liquids that were driven from coal as it was heated. Parts of northern England became virtually denuded of vegetation as a result of this pollution. In contrast to beehive ovens, 'by-product' coke plants and gasworks produced a wide range of materials in addition to coke.[7]

Conditions inside gasworks and coke plants were harsh, unhealthy, and sometimes deadly. An 1878 handbook on gas manufacturing claimed that

gasworks provided 'ample arrangements for the comfort of the stokers'. These reassuring words were belied, however, by warnings that the sulphuric acid fumes that filled the air of retort houses would eat through unprotected iron. Expressing greater concern for damage to property than to people, the book noted that even galvanised nails had to be coated with tar to prevent their being 'rapidly destroyed by the action of the gases and vapours necessarily present in buildings of this description'. Gas workers, in an effort to secure not only better wages and shorter hours but also improved health and safety standards, formed a labour union in 1889. Will Thorne, who organised and led the National Union of Gasworkers and General Labourers, possessed an intimate knowledge of the conditions in gasification plants. When he had worked at the Saltley gasworks in Birmingham, Thorne's job had required him to discharge coke from the ovens. Each time an oven door was opened, a puff of hot gases would burst out and explode into flame as it mixed with oxygen in the air (Figure 1). Describing conditions in the retort house, he recalled, 'The work was hot and very hard. As

FIGURE 1. Troops working in a retort house during a gasworkers' strike in Manchester, 1945. Accession no. 144792. Reproduced with permission from Manchester Central Library.

the coke was drawn from the retort on to the ground, we threw pails of water on it, and the heat, both from the ovens and the clouds of steam that would rise from the drenched coke, was terrific'.[8]

In addition to enduring unpleasant conditions, workers in coke plants and gasworks risked injury and even death from accidents and disease. Records from the South Metropolitan Gas Company reveal the range of injuries to which workers fell victim. Between 1892 and 1896, ten of its employees were killed at work. There were no fatalities the following year, but serious injuries continued to occur. Between November 1896 and December 1897 thirty workers at the company's East Greenwich complex (today the site of the Millennium Dome) missed work because of accidents on the job. These injuries included a severed leg ('taken off by coal crusher'), a lacerated face from being 'pitched headlong from retort charger', mangled fingers and toes, a fractured skull, and numerous burns. Records from the Sheffield United Gas Company tell a similar story. During the late nineteenth century, a serious injury occurred at its Neepsend works approximately once a month.[9]

In addition to the risk of being maimed or killed, gas and coke workers experienced high rates of chronic health problems. A prominent medical expert claimed in 1930 that over half of the 'notifiable cases of cancer' in Britain resulted from exposure to by-products created by the carbonisation of coal in gasworks and coke ovens. One of the most hazardous of these by-products was tar. Despite using goggles and scarves to limit their exposure to it, gas workers frequently suffered from blisters, boils, and warts. Later research revealed that those whose work brought them into close contact with the products of coal carbonisation for over five years suffered from ten times the normal incidence of lung cancer. Writing in 1930 to the head of the Trades Union Congress, a worker in South Wales noted,

> It was with much pleasure that I read in the *Daily Herald* . . . that you intend interviewing the 'Home Secretary' re coke & bye product workers' industrial deceases [*sic*]. A subject in my opinion long overdue. I feel I can claim some knowledge of the terrible manner in which men engaged in the above industry are afflicted. I have worked and passed through some of the worst processes to be found on a bye-product plant for nearly 13 years; and I can assure you that I have suffered terribly and in consequence have lost a considerable amount of time.

He ended by noting that he had been out of work for five months and was 'feeling all the better for it'.[10]

In both public statements and internal operations, the industry assiduously denied that gasification posed any danger to health. *The Gas Bulletin*, a publication of the British Commercial Gas Association, asserted in 1933 that 'people employed in gas works never suffer from headaches, because of the fact that ammonia, a by-product of coal carbonisation, is a cure for this complaint'. Physicians who examined workers faced a potential conflict of interest because

such visits were often arranged and paid for by the employer. Practitioners who made diagnoses that companies disliked were unlikely to receive future referrals. In the case of one South London gas company, a single physician examined numerous employees over a period of many years; in virtually every case, he declared that their illnesses had no connection to their working conditions. When an employee complained in 1947 that working inside the purification equipment was damaging his health, the chief engineer referred him to this doctor, accompanied by a memo in which he made light of the worker's symptoms. Upon examining the man, the physician concluded that the 'pain and vomiting has nothing to do with his work'. After it nationalised the industry in 1949, the government began conducting regular medical examinations of gas workers in an effort to detect health problems before they reached an advanced stage. Thirty employees of the same gasworks were examined in 1954; five of them were diagnosed with cases of eczema, warts, and melanoma.[11]

POLLUTION

In addition to posing considerable hazards to their workers, gasworks filled their neighbourhoods with smoke and foul smells (Figure 2). During the 1820s individuals who lived near the Gas Light and Coke Company's works in Westminster complained that its fumes harmed plants and trees, sullied clothing, tarnished brass and copper, discoloured paint, and impaired their health. Those who were able to move away from the immediate vicinity of this and other gasworks tended to leave. Over time, such localities became occupied almost exclusively by poor and working-class people, who rarely possessed sufficient economic, political, or legal power to challenge polluters' activities. As a London newspaper saw it in 1864, 'Wherever a gas-factory – and there are many such – is situated within the metropolis, there is established a centre whence radiates a whole neighbourhood of squalor, poverty, and disease'. Nearly a century after its beginning the gas industry continued to produce large amounts of air pollution. As the *Lancet* observed in 1904, each time fresh coal was loaded into the retorts of gasworks, 'volumes of thick black smoke' poured into the air.[12]

In contrast to coal combustion, the primary environmental consequence of which was air pollution, the carbonisation of coal directly polluted soil and water as well. As an engineer employed by the Gas Light and Coke Company noted in 1907, many by-products 'long remained in the category of "impurities" which had to be got rid of somehow'. Derivatives that appeared to have no commercial value were often allowed to simply drain into the nearest stream or river. Evidence of water pollution from gasworks can be found as early as 1821, when fish and eels in the Thames were reportedly killed as a result. Although the Gasworks Clauses Act of 1847 barred the industry from discharging liquid effluents directly into watercourses, its impact was limited. Many companies

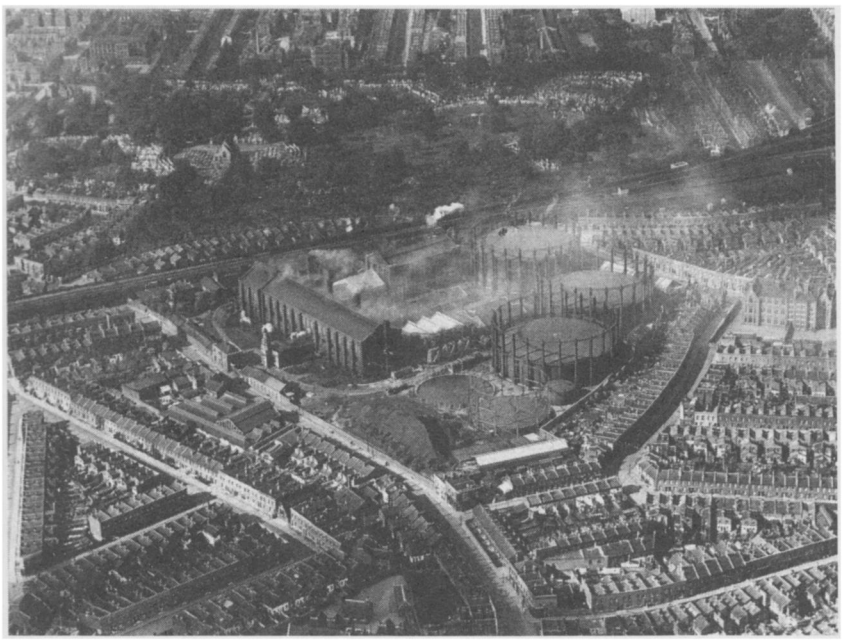

FIGURE 2. Smoke from the Great Central Gasworks drifts over houses in Poplar, Greater London, 1924. 65.3 POP, negative 92/29. Reproduced with permission from London Metropolitan Archives.

dealt with such wastes by pouring them into holding ponds, from which they could seep into groundwater or 'accidentally' overflow into nearby streams or rivers. Solid wastes were often used to fill in low-lying areas, polluting not only the soil, but frequently the air and water as well. During the 1930s, six decades after gasification ceased there, 6,000 gallons of coal tar were removed from the soil beneath the former works of the Gas Light and Coke Company in Westminster. Fittingly, this site became the headquarters in 1971 for the Department of the Environment. Eventually, many wastes were re-used instead of being buried or poured away. For example, the slaked lime used to absorb impurities from gas was often sold as an agricultural fertiliser. Yet the re-use of waste materials from gasworks and coke plants often meant that toxic substances simply entered the environment via different pathways.[13]

Aware that its activities were degrading the environment, the gas industry worked hard to shield itself from the risk of lawsuits. In 1843, the owners of a brewery located at Earl Street and Horseferry Road in Westminster (Figure 3)

FIGURE 3. Gas Light and Coke Company Works in Westminster, 1869. Note its proximity to houses, schools, and a brewery. Detail from the 1869 Ordnance Survey Map of London, RM 21\XLIII SE. Reproduced with permission from London Metropolitan Archives.

complained that their wells had become contaminated 'by the draining and passing of water and liquor of a deleterious nature from the . . . Gas Light and Coke Company in Peter Street'. As a result, the brewery could no longer use its own well water to make beer. The gas company, anxious to avoid a civil suit, paid the brewers £500 compensation in exchange for an indemnity against all past and future damage. Three years later, the company paid £790 to the owners of another

neighbouring property in a similar agreement. Although these sums were substantial, lawsuits could prove even more expensive. Such a case arose in Scotland during the first years of the twentieth century when the brewing firm James Muir and Son sued the Edinburgh and Leith Gas Commissioners for £10,000 in damages. The judge in the case ruled that pollution from the city-owned gasworks had contaminated the claimant's well 'to such an extent as to make it absolutely unfit for brewing purposes'. As compensation, he ordered the gas company to pay the brewery £3,730 plus legal expenses.[14]

People who lived near gasworks faced not only contaminated air and water, but also the risk of injury in the event of an accident. Leaking gas could cause suffocation or explosion, and accounts of such events appeared with disconcerting frequency in newspapers and magazines. A large explosion at the Nine Elms Gasworks in the London borough of Battersea killed nine people in 1865. According to a contemporary account, 'People nearly a mile off were thrown violently down, and persons who were in houses and streets adjacent to the works received severe burns'. Shortly after this accident, an anonymous letter to the *Times* urged the removal of gasworks from densely populated districts. The writer argued that this would not only limit casualties in the event of an explosion, but would also reduce the number of people who had to endure the habitual stench of gas production. For despite 'every precaution it is impossible to produce gas on a large scale without contaminating the surrounding atmosphere with offensive, if not noxious effluvia. Gasworks are a positive and unmistakable nuisance to all whose olfactory nerves are not smitten with paralysis'.[15]

The environmental impact of individual gasworks increased during the economic boom of the 1850s and 1860s, spurred not only by rising demand, but also by technological developments that allowed gas companies to achieve large economies of scale in both production and distribution. In 1867, two years after the explosion at Nine Elms, the Gas Light and Coke Company purchased a marshy site along the north bank of the Thames in East Ham, where it built the mammoth Beckton gasworks, once the largest in the world. This installation consumed vast amounts of coal, and the gas that it produced flowed to central London through gas mains that were four feet in diameter. Another huge gasworks in London was the South Metropolitan Gas Company's complex in East Greenwich (Figure 4). In the early years of the twentieth century it consumed 2,200 tons of coal each day and produced 23 million cubic feet of gas. Alarmed by the company's proposal to expand it, a nearby resident complained in 1902 that unless 'some new process by which gas can be produced without filling the atmosphere with dust and dirt' were discovered, 'the beneficent influences of Blackheath and Greenwich Park will be counteracted'.[16]

As a result of these changes, the pollution that occurred during carbonisation became increasingly concentrated in areas where land was cheap and residents lacked influence. The experience of living in such a place made a deep

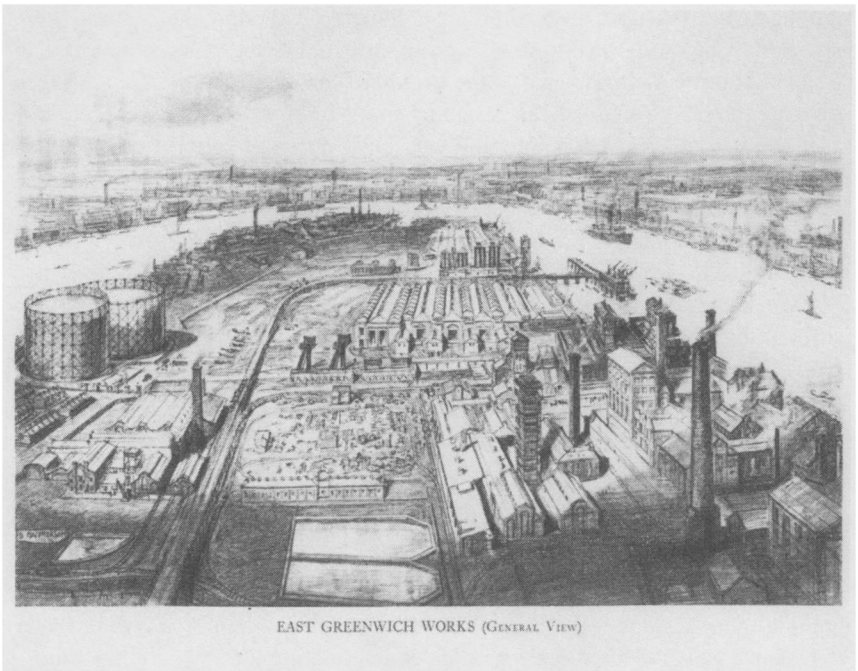

FIGURE 4. East Greenwich Gasworks, c. 1924. From *A Century of Gas in South London*, 1924. Reproduced with permission from Transco plc.

impression on Robert Roberts, growing up in Salford in the early twentieth century. Although his neighbourhood contained several sources of air pollution, including a brickworks and an iron foundry, he considered the local gasworks – which filled the air with thick smoke and a terrible stench – to be the worst offender. On the other side of the class divide, the scientist Walter Hepworth Collins suggested that poor people did not object to living near gasworks because they possessed crude sensibilities. Addressing a meeting of the Sanitary Institute in 1890, he asserted that gasworks were typically 'situated at the lowest accessible level, and, particularly in the case of old works, are surrounded by cottage or other property of an indifferent character; the adjacent neighbourhood being tenanted usually by the lower labouring class, whose sense of smell would not appear to be of a cultivated or refined type'. Indignant in the face of such attitudes, Roberts wrote, 'Our own streets stood immediately under the gasworks in the path of prevailing winds. Sometimes the air stank abominably for days on end. But very few questioned the right of industry to ruin our health and environment; in pursuit of profit the poor were expendable'.[17]

Although local authorities often turned a blind eye to pollution from gasworks and other industries, this was not always the case. In 1899 the Garston Urban District Council notified the Liverpool United Gas Light Company that its operations were causing 'pollution of the atmosphere by the escape of offensive odours'. Frustrated by the company's failure to correct the problem, the council took it to court in 1901. Testifying at the trial, one resident complained that as a result of the gasworks, his family 'had suffered from acute headaches, pains in the stomach, and abdomen, causing sickness and nausea and sometimes choleric pains. He had had to shut his windows to keep out the smells'. Another testified that the smell had once so permeated his house that he had 'vomited nearly all night'. He concluded by complaining that 'the neighbourhood was not really fit for anyone to live in'.[18]

Interestingly, the main source of the council's complaint was not the smoke and vapours produced during carbonisation, but the smells that entered the air as sulphur compounds and other impurities were removed from gas. Although manufactured gas was cleaner than coal, it was far from pristine. Gas lights imparted a sharp odour to the air of rooms in which they were used, and many people complained that they injured houseplants and deposited a sooty residue on ceilings. Legislation gradually forced gas companies to reduce the level of impurities in the gas they sold, and many companies – hoping to encourage greater consumption – sought to achieve a higher standard of purity than the law required. Yet cleaner gas for the consumer often led to dirtier conditions at and near gasworks. Purification did not eliminate contaminants from gas; it simply concentrated them. According to the allegations brought by the Garston council, the gas company's scrubbers produced a stream of liquid with 'an abominable stench', as did the iron oxide and slaked lime that were used in another stage of the purification process (Figure 5). The solicitor representing the company admitted that 'gas works did give off effluvia' and 'disagreeable smells', but he argued that they caused no harm. Going further, he put on the stand a consulting engineer who claimed that the smell complained of was actually beneficial, since it was 'practically that of napthaline [*sic*], which was a powerful antiseptic and disinfectant'. Recognising that it would be foolhardy to rely solely on such a claim, he argued that the crucial question was not whether the firm had caused damage, but whether they had 'done what they reasonably could to prevent the business injuring the neighbourhood'. The magistrates who heard the case failed to reach a consensus, and the company was declared not guilty.[19]

Although its representatives frequently claimed to be doing everything possible to minimise its detrimental effects, the gas industry was slow to invest in cleaner technology unless doing so would directly benefit its bottom line. Two innovations began to transform the process of coal carbonisation in the years around 1900. The first of these were automated methods of stoking retorts with coal and discharging coke after carbonisation. In an 1894 report to the Birming-

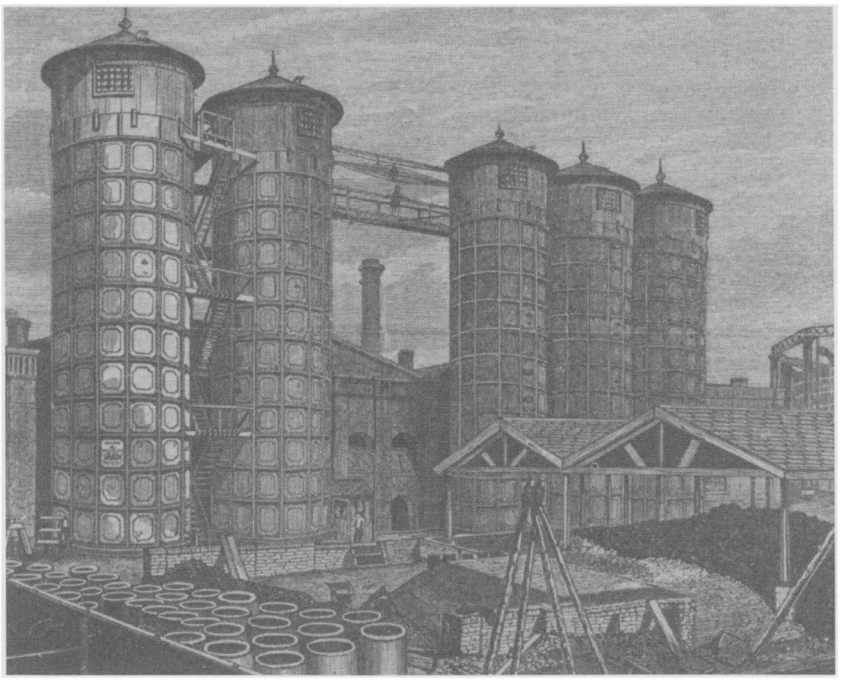

FIGURE 5. Gas scrubbers, Nine Elms Gasworks, London, c. 1870. From Newbigging and Fewtrell, *King's Treatise*, vol. 1 (see n. 7).

ham City Council, the committee in charge of the municipally-owned gasworks claimed that mechanisation would increase the amount of gas produced, improve its quality, lessen workers' exposure to unhealthy and dangerous conditions, and most importantly, save money. Interestingly, the committee's report failed to mention another often-touted advantage of mechanical stoking: that it would reduce the emission of smoke. To raise this issue, the committee would have had to admit that its gasworks produced smoke, something it was extremely reluctant to do. A second major advance was the development of continuously operating vertical retorts. In contrast to the longstanding practice of roasting coal horizontally in small batches, continuous carbonisation was less labour intensive, more energy efficient, and produced less smoke. Despite the economic and environmental advantages of vertical retorts, the cost of replacing existing equipment discouraged gas companies from doing so. Even after World War Two, more than a third of the coal used in British gasworks continued to be processed in horizontal retorts.[20]

CONSUMPTION

Prior to the 1880s virtually all of the gas produced in Britain was used for lighting. Although a variety of gas appliances became available from the middle of the nineteenth century, the public generally regarded cooking and heating with gas to be expensive, ineffective, and possibly dangerous. Few gas companies attempted to dispel this view, confident that they could simply concentrate on supplying gas for lighting purposes. One exception to this occurred in London, where the Crystal Palace District Gas Company began promoting gas as a heating and cooking fuel in 1869. Besides sending each of its customers a pamphlet touting the benefits of gas, it offered to rent out heating and cooking stoves to them.[21]

The gas industry's complacency disappeared abruptly with the emergence of competition from electricity in the late 1870s. Eager 'to keep up with the spirit of the age', several London retailers began experimenting with electric lights in their shops. Not to be left behind, the House of Commons followed suit in 1881. Amid predictions that electricity would soon make gas obsolete, the scientist and entrepreneur Sir Charles William Siemens argued that the gas industry could not survive if it continued to define itself primarily as a purveyor of lighting. 'If gas companies and corporations rightly understand their mission', he declared, 'they will take timely steps to supply . . . heating gas at a greatly reduced cost, the demand for which would soon be tenfold the gas consumption of the present day'. In addition to ensuring continued profits for the industry, he claimed that this would result in 'a radical cure of that great bugbear of our winter existence, a smoky atmosphere'.[22]

Coal smoke was indeed a serious problem. In 1800 about 10 million tons of coal were consumed in Britain. Consumption increased tenfold during the first two-thirds of the nineteenth century, reaching approximately 100 million tons in 1870 and peaking at nearly double that quantity by the onset of World War One. Coal contributed greatly to Britain's economic and political power, but its combustion produced immense quantities of smoke, as well as other, less visible forms of air pollution. Many clean-air advocates shared Siemens's view that the best way to reduce the smoke problem was to substitute gas for coal. Ernest Hart, a prominent public-health reformer and the editor of the *British Medical Journal*, declared in 1883 that 'the ultimate line of progress' lay in the general adoption of gas for heating and cooking. A further advantage of gas, argued some individuals, was that it allowed consumers to avoid contact not only with coal and smoke, but also with the allegedly dirty and ill-mannered workers who were associated with its use. Put another way, smokeless heating and cooking allowed middle- and upper-class householders to alter the social as well as the atmospheric character of their immediate environment. As one member of the Coal Smoke Abatement Society explained in 1903, 'with gas fires the noisy, dirty,

expensive, and alarming [chimney]sweep disappears, as indeed he does with coke and anthracite fires'.[23]

During the second half of the nineteenth century many large towns and cities acquired ownership of gasworks and other utilities. Birmingham, Glasgow, Leeds, and Manchester all had publicly owned gasworks by the late nineteenth century, although in London and Sheffield gas was still supplied by private firms. Advocates of municipal enterprise put forth two reasons for it. First, although most of them supported laissez-faire principles, they believed that monopolies constituted a case of market failure. They argued that given the absence of competition, government intervention was necessary to ensure that gas was supplied to consumers at fair prices and acceptable quality. Second, many questioned the justification for private monopolies to profit from the supply of necessities such as gas. Without the need to generate profits gas could in theory be supplied more cheaply to consumers. Alternatively, profits could be generated as before, but used to 'relieve the rates' (reduce taxes). Many municipalities adopted the latter approach, which disproportionately benefited large property owners. These earnings could be substantial; between 1844 and 1887, Manchester's gas department contributed over £1.3 million to city coffers.[24]

Municipal ownership of utilities affected not only the economic environment of towns and cities, but also the natural environment. Local authorities had responsibility for establishing and enforcing environmental regulations for gasworks and all other industries not under the supervision of the Alkali Inspectorate. Where a local authority profited from an industry that it was supposed to regulate, a clear conflict of interest existed. In Manchester, one resident asserted in 1879 that the municipally owned gasworks was the city's largest single source of smoke. Although free-market critics used such cases to attack what they decried as municipal socialism, private ownership was no guarantee that gasworks would face rigorous scrutiny. City councils and the sanitary committees they appointed were often dominated by businessmen who shielded themselves and their friends from unwelcome intervention.[25]

Although smoke-abatement activists did much to promote gas, they frequently criticised the industry over the issue of pricing. In the 1880s reformers in Manchester urged the city to lower the price it charged. Despite entrenched resistance to their proposal, they long continued to push for cheaper gas. The *Lancet*'s Manchester correspondent predicted in 1894 that the city's air quality would improve dramatically if gas replaced coal as the fuel for heating, cooking, and engine power: 'But the gas committee stands in the way. The price of gas is too high for these purposes, and the committee is reluctant to lower it as the profits are used in aid of the rates'. In 1912 the local branch of the Smoke Abatement League of Great Britain published a pamphlet that sought to turn the city's justifications for expensive gas upside-down. The booklet claimed that 'if

the ratepayers would forego the profit of £50,000 a year which they make on gas ... they would be going a long way towards doing away with the loss of £700,000 a year which is caused by smoke'.[26]

Beginning in the 1880s the gas industry gave substantial financial support to smoke-abatement groups and collaborated with them in sponsoring exhibitions and conferences that promoted both their product and clean air. In 1883 the Gas Light and Coke Company and the South Metropolitan Gas Company each donated £100 to the National Smoke Abatement Institution. The relationship between the gas industry and the smoke-abatement movement grew even closer in subsequent decades. In 1905 the head of the South Metropolitan Gas Company, Sir George Livesey, chaired an air pollution conference sponsored by the Coal Smoke Abatement Society. The promotional arm of the industry, the British Commercial Gas Association, forged close ties with the smoke-abatement movement. Its annual conferences included a section that highlighted the role of gas in clearing the air of smoke from coal fires, and the gas industry continued to give money to antismoke organisations. In return, smoke-abatement groups welcomed advertisements that promoted gas and other 'smokeless' technologies (Figure 6).[27]

These efforts paid handsome returns. The amount of gas sold in Britain tripled in the three decades preceding World War One as more consumers adopted it for cooking and, to a limited extent, heating as well. Gas cooking began to reach working-class households in the 1890s, following the invention of a coin-operated meter, which allowed customers to pay for gas as they needed it. In 1898 a representative of the gas industry declared that 150,000 'penny-in-the-slot meters' were being used in London and claimed that the Gas Light and Coke Company had leased so many gas stoves that if placed side-by-side they 'would reach from Charing-cross to the West-pier at Brighton and 50 miles back again'.[28]

Co-operation between clean-air groups and the gas industry grew even stronger between the two world wars. Capitalising on this support, the industry increasingly used environmental claims to market gas and coke. Prefiguring much later campaigns to promote 'green' products, one industry expert declared that an individual who heated with gas 'is contributing to remove the nuisance of smoky skies which has for so long disfigured English towns. Gas is the sole practicable cure for this crying evil'. As its leading trade publication explained in 1922, the gas industry, 'both by its service and by its publicity campaigns', was doing much 'to further the cause of Smoke Abatement and Coal Conservation'. The industry received a major boost the following year when the chancellor of the exchequer, Neville Chamberlain, spoke at the opening of a national gas exhibition and praised gas for 'relieving the lungs of the general public'. Shortly thereafter, the executive chairman of the British Commercial Gas Association,

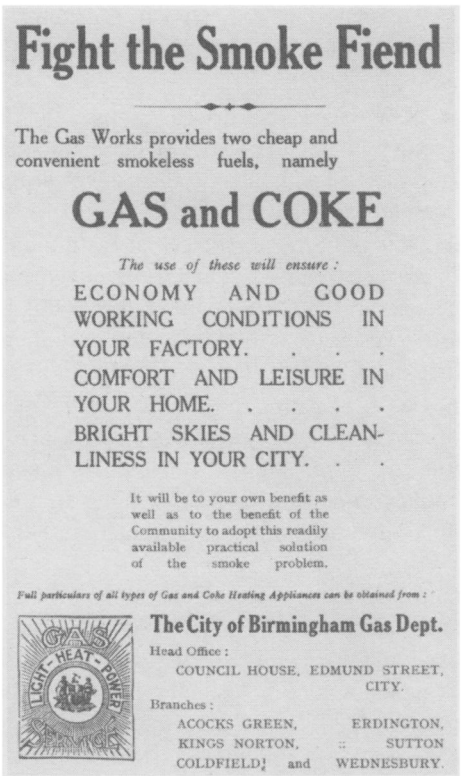

FIGURE 6. Advertisement from the programme of a 1926 smoke abatement exhibition held in Birmingham, organized by the Smoke Abatement League of Great Britain. Accession no. 391200. Reproduced with permission from Birmingham Central Library.

completely overlooking its effects on gas workers and the environment, told attendees at a smoke-abatement conference that gas 'involves no dirt or labour before, during, or after use'.[29]

In 1936 the National Smoke Abatement Society – formed seven years earlier when the London-based Coal Smoke Abatement Society merged with a provincial group, the Smoke Abatement League of Great Britain – organised a major exhibition on air pollution at the Science Museum in London. The exhibition not only demonstrated the harmful effects of coal smoke, but also informed visitors that gas and coke offered the solution. According to the exhibition's official

handbook, 'The Gas Industry has a valuable contribution to make in the reduction of smoke and corrosive substances which enter the atmosphere'. An exhibit lent by the British Gas Federation declared that a million and a half gas cooking stoves and nearly a million gas heaters were in use within Greater London and asserted that they substantially reduced the amount of soot deposited in the metropolis. Another display highlighted the presence in coal of valuable chemicals, which were wasted when coal was burned in the home, but which could be recovered and used productively when coal was processed in gasworks. One year later, the museum granted the British Gas Federation 4,000 square feet of space for a permanent exhibit, which would tell the story of manufactured gas from its origins to the present. In the wake of this activity, the *Gas Bulletin* boasted, 'The gas industry has helped to put Smoke Abatement on the map; and in the process it has achieved for itself no little prestige'. The industry continued to drive home the message that its products were the solution to the smoke problem by sponsoring a documentary film entitled 'The Smoke Menace' in 1937 and a booklet called 'Britain's Burning Shame' the following year.[30]

CONCLUSION

Between its origins in 1813 and its nationalisation in 1949, the gas industry in Britain provided many benefits, including light, heat, convenience, and fewer smoky chimneys from coal-fed stoves and fireplaces. Paradoxically, gas and coke also caused considerable harm to people and the environment. The disadvantages of smokeless fuels, like those of most other energy sources in history, were not evenly distributed. In addition to damaging the health of workers who produced them and filling the air with smoke and acidic vapours, the manufacture of gas and coke polluted the water and soil with highly toxic contaminants. The carbonisation of coal shifted many of the detrimental consequences of energy from places where it was used to those where it was produced, from consumers to workers, and created forms of environmental contamination that will persist far into the future. Yet the belief that gas and coke were clean forms of energy – that they were, in fact, *the* solution to what many people in Britain considered the most pressing environmental problem of the late nineteenth and first half of the twentieth century – blinded many to the detrimental consequences of coal carbonisation and allowed industry to neglect changes that would have reduced the damage it caused to health and the environment. As we search for ways to deal with existing environmental problems and prevent future ones from occurring, we would do well to be wary of choices that might replace one form of pollution with another.

NOTES

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[1] *Guardian* (London), 21 Mar. 1998, 15 Nov. 2001; *Sunday Times* (London), 3 June 2001; Paul Goldberger, 'The Big Top', *New Yorker*, 27 Apr. and 4 May 1998, 151–9. My ideas about pollution displacement have been influenced by the work of many others, particularly Martin V. Melosi, 'Cities, Technical Systems and the Environment', *Environmental History Review* 14 (Spring/Summer 1990): 45–64; John T. Cumbler, 'Whatever Happened to Industrial Waste?: Reform, Compromise, and Science in Nineteenth Century Southern New England', *Journal of Social History* 29 (1995): 149–71; Joel A. Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron, Ohio: University of Akron Press, 1996); Bill Luckin, 'Pollution in the City', in *The Cambridge Urban History of Britain: Volume 3: 1840–1950*, ed. Martin Daunton, 207–28 (Cambridge: Cambridge University Press, 2000).

[2] B. R. Mitchell, *British Historical Statistics* (Cambridge: Cambridge University Press, 1988), 259.

[3] William Byers, Martin B. Meyers, and Donna E. Mooney, 'Analysis of Soil from a Disused Gasworks', *Water, Air, and Soil Pollution* 73 (1994): 1–9; A. O. Thomas and J. N. Lester, 'The Reclamation of Disused Gasworks Sites: New Solutions to an Old Problem', *Science of the Total Environment* 152 (1994): 239–60; Department of the Environment, *Problems Arising from the Redevelopment of Gas Works and Similar Sites*, 2nd ed. (London: HMSO, 1988), esp. 35; Sean Humber, *Gas Works Sites in London: An Investigation into Contaminated Land* (London: Friends of the Earth, 1991), esp. 24–5; Neil S. Shifrin et al., 'Chemistry, Toxicity, and Human Health Risk of Cyanide Compounds in Soils at Former Manufactured Gas Plant Sites', *Regulatory Toxicology and Pharmacology* 23 (1996): 106–16.

[4] Christine Meisner Rosen and Christopher C. Sellers, 'The Nature of the Firm: Towards an Ecocultural History of Business', *Business History Review* 73 (1999): 577–600, quotation from 584; Jeffrey K. Stine and Joel A. Tarr, 'At the Intersection of Histories: Technology and the Environment', *Technology and Culture* 39 (1998): 601–40, quotation from 621. Important works on the history of manufactured gas in Britain include M. E. Falkus, 'The British Gas Industry before 1850', *Economic History Review*, 2d ser., 20 (1967): 494–508; M. S. Cotterill, 'The Development of Scottish Gas Technology, 1817–1914: Inspiration and Motivation', *Industrial Archaeology Review* 5 (1980–81): 19–40; Trevor I. Williams, *A History of the British Gas Industry* (Oxford: Oxford University Press, 1981); Hugh Barty-King, *New Flame: How Gas Changed the Commercial, Domestic and Industrial Life of Britain between 1813 and 1984* (Tavistock, Devon: Graphmitre, 1984); J. F. Wilson, *Lighting the Town: A Study of Management in the North*

West Gas Industry, 1805–1880 (London: P. Chapman, 1991); Mary Mills, 'The Early Gas Industry and Its Residual Products in East London', Ph.D. thesis, Open University, 1995. For an insightful analysis of the environmental consequences of coke production in the US, and of the shifting burden of pollution from one medium to another, see Joel A. Tarr, 'Searching for a "Sink" for an Industrial Waste: Iron-Making Fuels and the Environment', *Environmental History Review* 18 (Spring 1994): 9–34 (republished in Tarr, *Search for the Ultimate Sink*, 385–411).

[5] Eric Ashby and Mary Anderson, *The Politics of Clean Air* (Oxford: Clarendon Press, 1981), quotation from 86. See also Carlos Flick, 'The Movement for Smoke Abatement in 19th-Century Britain', *Technology and Culture* 21 (1980): 29–50; Peter Brimblecombe, *The Big Smoke: A History of Air Pollution in London since Medieval Times* (London: Methuen, 1987), esp. 112; Stephen Mosley, *The Chimney of the World: A History of Smoke Pollution in Victorian and Edwardian Manchester* (Cambridge: White Horse Press, 2001).

[6] Williams, *British Gas Industry*, 9–10; Falkus, 'British Gas Industry', 500 and 504; Mitchell, *British Historical Statistics*, 258; Arthur Silverthorne, *The Purchase of Gas and Water Works, with the Latest Statistics of Municipal Gas and Water Supply* (London: Crosby Lockwood, 1881), 60–6; *Builder* 81 (21 Sept. 1901): 246.

[7] Thomas Newbigging and W. T. Fewtrell, eds, *King's Treatise on the Science and Practice of the Manufacture and Distribution of Coal Gas*, 3 vols. (London: William B. King, 1878–82), esp. 1:109–13; Anthony S. Wohl, *Endangered Lives: Public Health in Victorian Britain* (Cambridge: Harvard University Press, 1983), 214.

[8] Newbigging and Fewtrell, *King's Treatise*, 1:119, 120; Cotterill, 'Gas Technology', 23; Will Thorne, *My Life's Battles* (London: George Newnes, [1925]), 35–7, 51; Giles Radice and Lisanne Radice, *Will Thorne, Constructive Militant: A Study in New Unionism and New Politics* (London: George Allen and Unwin, 1974).

[9] George Livesey, *Report on the First 6 Months' Working of the Accident Fund* (South Metropolitan Gas Company, [1898]), 1–2, 9–11, copy at National Gas Archive, Transco plc [hereafter cited as NGA]; Accident Report Book, Neepsend Works, Sheffield United Gas Company, 1887–1903, NGA [EM] SHD/P/L/2.

[10] Thomas Oliver, 'Coke-Men and By-Products Workers: Their Complaints and Maladies', *British Medical Journal*, 31 May 1930, 992–4; William A. Burgess, *Recognition of Health Hazards in Industry: A Review of Materials and Processes* (New York: John Wiley and Sons, 1981), 196; Barty-King, *New Flame*, 179, 191. Environmental historians have only relatively recently started tracing the effects of pollution back inside the factories from which they emanate. Two excellent examples of this approach are Christopher Sellers, 'Factory as Environment: Industrial Hygiene, Professional Collaboration and the Modern Sciences of Pollution', *Environmental History Review* 18 (Spring 1994): 55–83; and Arthur F. McEvoy, 'Working Environments: An Ecological Approach to Industrial Health and Safety', *Technology and Culture*, 36 supp. (1995): S145-72; Letter to C. Citrene, 31 May 1930, Modern Records Centre, University of Warwick, MS 292/144.5/6.

[11] 'No Headaches in Gas Works', *Gas Bulletin* 22 (1933): 57; NGA BG11/CRG/A/A/78; NGA BG11/SE/ES/CRG/A/X/23.

[12] Thomas Bartlett Simpson, *Gas-Works: The Evils Inseparable from Their Existence in Populous Places...* (London: William Freeman, 1866), 47; 'The Gas', *Illustrated Times*, 5 Mar. 1864, 151, quoted in Lynda Nead, *Victorian Babylon: People, Streets, and Images*

in Nineteenth-Century London (New Haven: Yale University Press, 2000), 94; 'Smoke Prevention at Gas Works (A New Process of Gas Making)', *Lancet*, 12 Mar. 1904, 746.
[13] William Hosgood Young Webber, *Town Gas and Its Uses for the Production of Light, Heat, and Motive Power* (London: Constable, 1907), 56 and 94; Daniel Ellis, *Considerations Relative to Nuisance in Coal-Gas Works . . .* (Edinburgh: John Anderson Jr., 1828), 18–19; Wilson, *Lighting the Town*, 35 and 48; Earle B. Phelps, 'Stream Pollution by Industrial Wastes and Its Control', in *A Half Century of Public Health*, ed. Mazÿck P. Ravenel, 197–208 (New York: American Public Health Association, 1921), 198; Thomas and Lester, 'Disused Gasworks', 240–1. In the US, by-products such as tar and ammonia remained unwanted until the late nineteenth century. See Joel A. Tarr, 'Transforming an Energy System: The Evolution of the Manufactured Gas Industry and the Transition to Natural Gas in the United States (1807–1954)' in *The Governance of Large Technical Systems*, ed. Olivier Coutard, 19–37 (London: Routledge, 1999), esp. 21. For an interesting example of the problems of re-using wastes in another context, see Timothy LeCain, 'The Limits of "Eco-Efficiency": Arsenic Pollution and the Cottrell Electrical Precipitator in the U.S. Copper Smelting Industry', *Environmental History* 5 (2000): 336–51.
[14] London Metropolitan Archives B/NTG/2062, 2066; *Journal of Gas Lighting, Water Supply, &c.*, 4 July 1905, 52.
[15] *Illustrated London News*, 11 Nov. 1865, quoted in Sarah Milan, 'Refracting the Gaselier: Understanding Victorian Responses to Domestic Gas Lighting', in *Domestic Space: Reading the Nineteenth-Century Interior*, ed. Inga Bryden and Janet Floyd, 84–102 (Manchester: Manchester University Press, 1999), 98; *Times* (London), 10 Nov. 1865.
[16] Williams, *British Gas Industry*, 26, 70; *Times* (London), 23 Mar. 1904; *London Argus*, 30 May 1902; *Kentish Mercury*, 31 Jan. 1902.
[17] Walter Hepworth Collins, 'The Alleged Danger to Public Health, Arising from Effluvium Nuisance from Gas Works', *Transactions of the Sanitary Institute* 11 (1890): 112–19, quotation from 113; Robert Roberts, *The Classic Slum: Salford Life in the First Quarter of the Century* (Manchester: Manchester University Press, 1971), 4; Robert Roberts, *A Ragged Schooling: Growing Up in the Classic Slum* (Manchester: Mandolin, 1984), quotation from 133.
[18] *Garston & Woolton Reporter*, 13 Jan. 1900, 2 Mar. 1901.
[19] *Garston & Woolton Reporter*, 2 Mar. 1901.
[20] Webber, *Town Gas*, 40–1; Birmingham City Council, Health Committee, *Minutes*, 10 Dec. 1894, Birmingham City Archives; Williams, *British Gas Industry*, 62–3; Department of the Environment, *Gas Works,* 22; 'The Gas Council Memorandum on Air Pollution', typescript, n.d., Gas Council Records, NGA Roll 152.
[21] Newbigging and Fewtrell, *King's Treatise*, 3:221.
[22] William Henry Preece, 'Gas versus Electricity', *Nature* 19 (23 Jan. 1879): 261–2; Leslie Hannah, *Electricity before Nationalisation: A Study of the Development of the Electricity Supply Industry in Britain to 1948* (Baltimore: Johns Hopkins University Press, 1979), 4; Charles William Siemens, *Science and Industry* (Birmingham, [1881]), 18.
[23] Roy Church, Alan Hall, and John Kanefsky, *The History of the British Coal Industry: Volume 3, 1830–1913: Victorian Pre-Eminence* (Oxford: Clarendon Press, 1986), 19; 'Smoke Abatement', *Builder* 45 (10 Nov. 1883): 635; George Wyld, *Notes of My Life* (London: Kegan, 1903), 106.

[24] Williams, *British Gas Industry*, 10, 27; Robert Millward, 'The Political Economy of Urban Utilities', in *The Cambridge Urban History of Britain: Volume 3: 1840–1950*, ed. Martin Daunton, 315–49 (Cambridge: Cambridge University Press, 2000); Wilson, *Lighting the Town*, 194.

[25] Ashby and Anderson, *Politics of Clean Air*, 42–3, 47; "Proceedings of the Health Section," *Sanitary Record*, n.s., 1 (20 Oct. 1879): 140–41; Millward, 'Political Economy', esp. 328.

[26] 'Manchester', *Lancet*, 28 Apr. 1894, 1099–1100; Smoke Abatement League of Great Britain (Manchester and Salford Branch), *Case against the Levying Contributions. . .* (Manchester, 1912), quoted in Mosley, *Chimney*, 158.

[27] 'Gas Companies and Smoke Abatement', *Builder* 45 (6 Oct. 1883): 470; *Times* (London), 14 Dec. 1905. On the British Commercial Gas Association, see Philip Chantler, *The British Gas Industry: An Economic Study* (Manchester: Manchester University Press, 1938), 32–3; Williams, *British Gas Industry*, 74, 133.

[28] Mitchell, *British Historical Statistics*, 269; Compton Mackenzie, *The Vital Flame* (London: British Gas Council, 1947), 21–3; *Times* (London), 24 Nov. 1898. Yet most people continued to use solid fuels, especially bituminous coal, for heating. When the gas industry was nationalised, gas was providing less than 15 percent of the heat used in British houses. See Barty-King, *New Flame*, 232.

[29] Webber, *Town Gas*, 227; 'Smoke Abatement', *Gas Bulletin* 11 (July 1922): 141; *Times* (London), 18 Sept. 1923; Francis William Goodenough, 'The Fuel of the Future', in *Report of the Smoke Abatement Conference held at the Town Hall, Manchester, November 4th, 5th and 6th, 1924* (Manchester, 1924), 248–54, quotation from 254.

[30] National Smoke Abatement Society, *Smoke Abatement Exhibition Handbook and Guide* (Manchester: National Smoke Abatement Society, 1936), 60; Z Archive, Archives Collection, Science Museum, Z111/8, negs. 8604 and 8609; 'Proposed New Sections', typescript, June 1937, ibid., Z186; Williams, *British Gas Industry*, 74; 'Smoke into Sales', *Gas Bulletin* 28 (Feb. 1939): 32; Timothy Boon, ' "The Smoke Menace": Cinema, Sponsorship and the Social Relations of Science in 1937', in *Science and Nature: Essays in the History of the Environmental Sciences*, ed. Michael Shortland, 57–88 ([Stanford in the Vale]: British Society for the History of Science, 1993), esp. 85.