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Combined Cycle Gas Turbine Power Stations in England: An Historical Overview

Wayne D Cocroft

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COMBINED CYCLE GAS TURBINE POWER STATIONS IN ENGLAND

An Historical Overview

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SUMMARY
This report provides a brief overview of natural gas-fired Combined Cycle Gas Turbine (CCGT) power stations in England. The majority date from the early 1990s and are associated with the deregulation of the electricity industry at that date and the so-called 'dash for gas' to quickly provide generation capacity for new companies entering into the energy market. Today, natural gas provides about 40% of the fuel used in United Kingdom power stations to generate electricity (BEIS 2019, 65). The main body of research for this report was completed in early 2020, however, given fluctuations in the energy market and plant obsolescence information on individual plant can quickly become outdated.

CONTRIBUTORS
This report was compiled by Wayne Cocroft. Ground photography was by James Davies and aerial photography by Damian Grady and David MacLeod.

ARCHIVE LOCATION
No archive was produced as part of this project. The photographs used in the report are mostly available from the Historic England Archive.

DATE OF RESEARCH
Desk based research was mainly undertaken between winter 2019 and spring 2020 with minor revisions in summer 2021

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INTRODUCTION

This report provides a brief overview of natural gas-fired power stations in England. The majority date from the early 1990s and are associated with the deregulation of the electricity industry at that date and the so-called 'dash for gas' to quickly provide generation capacity for new companies entering into the energy market. Today, natural gas provides about 40% of the fuel used in the United Kingdom's power stations to generate electricity (BEIS 2019, 65).

Previous reports have addressed other late 20th century power stations; nuclear power stations (Cocroft 2006) and coal and oil-fired power stations (Clarke 2015 and 2015a). These reports were primarily written for historic environment professionals, few of whom will have knowledge of these stations. Guidance on the recording of coal and oil-fired power stations has also been issued (Historic England 2016). Historic England has also been working with the Nuclear Decommissioning Authority to develop a recording strategy for their decommissioned facilities.

Research for this report was completed in early 2020, however, it is recognised that given fluctuations in the energy market and plant obsolescence information on individual plants can quickly become outdated.

HISTORY

Technologically, the possibility of using natural gas to generate electricity was opened up by development of the Irish and North Sea oil and gas fields from around 1970. During the following decades there was a gradual increase in demand for natural gas for electricity generation (Le Fevre 2015, 5). The marked growth in the use of natural gas as a fuel for electricity generation was stimulated by the privatisation and deregulation of the electricity industry that started in November 1990. At this time regulatory changes made by the European Union and United Kingdom also eased restrictions on the use of natural gas for power generation. In turn greater competition in the market encouraged the construction of new stations by independent power producers (Pearson and Watson 2012, 12). In comparison with other sources of energy natural gas stations were comparatively quick and cost effective to build as they avoided the high capital costs and long construction phases of nuclear and the requirements for complex fuel handling infrastructure needed for coal. There were also environmental benefits as natural gas stations produce 50%-60% less carbon dioxide and fewer sulphur emissions than equivalent coal and oil-fired stations, although leakage during extraction and transportation also has detrimental effects on the environment.

Prior to privatisation there had been developing interest in the new technology of Combined Cycle Gas Turbine (CCGT) generator plant (see below). The first CCGT station connected to the national grid at Roosecote, Cumbria, was operational by 1991 and over the next decade 34 CCGT and Open Gas Cycle Turbine (OGCT) stations were completed. Although the growth of this industry sector was checked by the 1997 Review of Energy Sources for Power Generation which recognised the possible threats to diversity and security of supply if too much reliance was placed on gas (Pearson and Watson 2012, 18-9). A small number of the stations operate as Combined Heat and Power (CHP) plants where heat is used in industrial processes or for domestic and commercial heating. Today there are 42 operational CCGT and OGCT plants in England, just six of which were completed in the last decade, five have also been mothballed or demolished (BEIS 2019). For the foreseeable future natural gas will remain as an important fuel source for electricity generation and several new stations plants have approval or are under construction.

PREVIOUS RESEARCH

As described above previous research has been concentrated on coal and oil-fired, and nuclear power stations. No comparable historic analysis has been undertaken into the significance of the more recent gas-fired stations.

In 2015, the then Historic England Historic Environment Intelligence team produced a short 'Horizon scan' on gas-fired power stations. At least 14 gas-fired power stations have been recorded by Historic England by low oblique photography, notably those plants that share locations with coal and oil-fired stations. Limited external ground photography was also taken of Didcot B in 2012 and 2013.

THREAT

The operational life of a gas-fired station is estimated to be around 20 to 30 years, so within the next few years most of the early stations will be reaching the end of their design lives. However, in several cases stations have been subject to mid-life upgrades, so while the outward appearance of the stations may appear relatively unaltered most of the original plant may have been replaced.

Stations that have already been lost include the first CCGT station at Roosecote, Cumbria, the large 1875MW station in Teesside, and the 900MW station at Killingholme A, North Lincolnshire (BEIS 2019, 92). Barking Reach, a 1000MW station, is currently being demolished. A feature of the industry in response to changing market conditions is also the mothballing of plant. At present stations at Derwent and Keadby are mothballed (BEIS 2019, 92), while the station at King's Lynn has recently been brought back into operation.

Where stations were designed to provide base loads to the grid changing economic conditions and competition from renewables may also hasten the closure of other stations (Evans 2017). Other factors threatening these plants include measures to reduce carbon emissions, poor energy efficiency in the older plants, rising gas prices, and concerns about fuel security.

The relatively large numbers of owners with a diverse portfolio of stations in an industry where changes of ownership are frequent will make the monitoring of potential closures a time-consuming task. This will be further complicated by the practice of mothballing stations, which in some instances is a prelude to closure and elsewhere a temporary measure until more favourable market conditions appear.

LOCATION

Gas-fired power stations may be located anywhere there is a piped gas supply and therefore they are widely distributed across the country in urban, industrial and rural settings. Two of the smaller combined heat and power stations are in London, one as a district power plant in Tower Hamlets and another in a basement below Imperial College. Other stations are located adjacent to oil and coal-fired stations, or on their sites, where they can link into existing grid connections (Figure 1). Amongst the gas fired stations there is a marked diversity of installed capacity ranging from a small neighbourhood plant of just 1 MW to the largest plant rated at 1,772 MW. In comparison most of the large 1960s coal and oil-fired power stations were rated at 2000MW.

Figure 1. Cottam, Nottinghamshire, Uniper Development Centre, in the foreground the low Combined Cycle Gas Turbine station is partly obscured by trees and to the rear it is dominated by the now decommissioned coal-fired power station. Photographer James Davies © Historic England DP249360

TECHNOLOGY

Natural gas used in England's gas-fired power stations is mainly supplied by the offshore fields in the Irish and North Seas. The amount of gas produced by these fields is in decline and supplies are supplemented through interconnectors to European sources and liquefied gas imported by tanker vessels. Small amounts of natural gas are also available from colliery methane, gases emitted from landfill sites and onshore wells producing so-called sour gas; a gas with a high hydrogen sulphide content.

In the natural gas stations, there are two principal types of generator plant in operation. In the early 1990s the deregulation of the electricity market also coincided with the introduction of more efficient Combined Cycle Gas Turbine (CCGT) power plants. In this type of unit, a gas and a steam turbine are used together to generate up to 50 per cent more electricity from the same fuel than in a traditional simple-cycle plant. In operation the otherwise waste heat from the gas turbine is directed to the Heat Recovery Steam Generator (HRSG) which in turn creates steam from the gas turbine exhaust heat and delivers it to a steam turbine to produce additional power. Most CCGT plants operate at between 50% and 60% efficiency, and newer plants may exceed these figures. In Open Cycle Gas Turbines (OCGT) the exhaust gases from the turbine are exhausted directly to the atmosphere with a corresponding loss of potential energy. OCGT plants operate at around 40% efficiency (Araner 2018). They may, nevertheless, be chosen as they are cheaper, installed where space is limited, or in cases where the primary need is for back-up facilities that can be quickly brought on-line.

A single conventional gas-fired steam generation station remains in operation on the former ICI Wilton site, Redcar, Middlesbrough.

ARCHITECTURE

Combined Cycle Gas Turbine stations generally have relatively small footprints and compared to coal-fired plants have the important advantage of not requiring large coal stock yards and associated handling infrastructure.

Most of the stations are architecturally undistinguished comprising open plant and typically steel-framed buildings clad in pressed steel sheeting (Figures, 2, 3, 4). There are few colour finishes on their buildings and most are bare metal or given off-white or light grey tints. In instances where colour is used light blue is the most favoured. As many are sited within existing industrial sites few exhibit any landscape design to mitigate their visual impact or to provide a more pleasant working environment. Where landscaping has been undertaken it usually doesn't extend beyond grassed areas with some screen planting in the immediate vicinity of the plant.

Figure 2. Didcot B, Oxfordshire, to the rear left, the building in the foreground and the cooling tower were part of the now demolished coal-fired station (2012). Photographer James Davies © Historic England DP159308

A typical Combined Cycle Gas Turbine station comprises a main turbine hall accommodating a gas and steam turbine, generator, and condenser (Figures 2, 3 and 4). Depending on the layout of the site the turbines may be in different structures. Usually adjacent to the turbine hall is a taller building housing the heat recovery steam generator and next to this the exhaust stack. In the Open Cycle Gas Turbine stations, the heat recovery steam generator will be absent. Detached from the turbine hall is the water-cooling system comprising a water treatment plant and cooling

towers. Adjacent to the generators are transformers connected to switching gear, in turn linked to the principal user, such as a factory, or the national grid. Depending on location the switchgear may be open or enclosed within a building. Other buildings include fuel storage tanks, administrative and welfare buildings and workshops.

Figure 3. Deeside Power Station, Flintshire, Wales, power rating 500MW, commissioned in 1994 it is currently being decommissioned. Courtesy of Discovery Museum, Newcastle upon Tyne

1	Gas turbine	2	Heat Recovery Generator Building
3	Steam Turbine Building	4	Administration and Control room
5	Gas Turbine Generator Transformers		
6	Steam Turbine Generator Transformers		
7	400kV Banking Connections	8	Water Treatment Plant
9	Cooling Towers	10	Cooling Water Pump House
11	Standby fuel tanks (not shown)		
12	Workshops, stores, maintenance building		

A selection of images of Combined Cycle Gas Turbine electricity generation stations is presented at the rear of this report.

Figure 4. West Burton, Nottinghamshire, Combined Cycle Gas Turbine station showing its principal components. © Historic England 29953/048 (2016)

SIGNIFICANCE

Technologically, the post 1990 Combined Cycle Gas Turbine electricity generation stations represented a marked improvement in the efficiency of electricity generation. They achieved this by combining two existing technologies gas turbines and steam turbines; neither was new technology; the innovation lay in the grouping of the two technologies. Further refinements in plant design have continued to improve the fuel efficiency of the stations, but with little outward expression in the appearance of the facilities.

Architecturally, the gas fired stations are utilitarian and most comprise open plant and steel-framed buildings clad in pressed steel sheeting.

Politically, the stations reflect the abandonment of the post-war model of a centralised, nationalised power generation and distribution network with its grand schemes of large and often architecturally refined stations. The new deregulated market of the 1990s encouraged smaller electricity supplies represented by the new generation of Combined Cycle Gas Turbine plants that offered a relatively quick and cost-efficient route into this industry.

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NATURAL GAS FIRED POWER STATIONS SELECTED AIR PHOTOGRAPHY

Dam Head Creek, Medway UA, Drax Power Ltd. © Historic England 26477/012 (2009)

Castleford, Wheldon Road, E.On UK. The two chimneys and green tanks mark the position of the power station. © Historic England 28293/031 (2012)

Barkantine Heat & Power, Tiller Road, Tower Hamlets, Open Cycle Gas Turbine located in an Edwardian substation, EDF Energy, marked by the red circle. © Historic England 24453/011 (2006)

West Burton, Nottinghamshire, EDF Energy, rated at 1,332 MW it is one of the country's largest Combined Cycle Gas Turbine stations. To the rear is the 1960s coal-fired station. © Historic England 29953/051 (2016)

West Burton, Nottinghamshire, EDF Energy. © Historic England 29953/048 (2016)

Saltend, Energy Capital Partners, East Riding of Yorkshire. The station is to the left marked by blue buildings and three chimneys. © Historic England 28444/051 (2013)

Fellside, Sellafield, Ponsonby, Cumbria, Fellside Heat & Power. © Historic England 28127/071 (2011)

Coryton, Thurrock UA, Intergen. © Historic England 27948/028 (2014)

Marchwood, New Forest Hampshire, Marchwood Power. The domed structure houses an incinerator. © Historic England 27226/045 (2010)

Didcot B, Vale of the White Horse, Oxfordshire, RWE Npower, note the blackened cooling towers damaged by fire in October 2014. © Historic England 29185/013 (2014)

Great Yarmouth, Norfolk, RWE Npower. © Historic England 29912/052 (2016)

Staythorpe C, Newark & Sherwood, Nottinghamshire, rated at 1,772MW it's the country's largest Combined Cycle Gas Turbine Station, RWE Npower. © Historic England 20907/038 (2009)

Medway, Isle of Grain, Medway UA, SSE. © Historic England 26477/048 (2009)

Cottam, Bassettlaw, Nottinghamshire, bottom left Uniper Development Centre. © Historic England 29953/003 (2016)

Cottam, Bassettlaw, Nottinghamshire, Uniper Development Centre. © Historic England 29953/021 (2016)

Isle of Grain, Medway, Uniper UK, to left is the Combined Cycle Gas Turbine a Combined Heat Power station during construction in 2009. The unit with the shorter chimney is the Open Cycle Gas Turbine plant; the larger oil-fired station has subsequently been demolished. © Historic England 26477/020 (2009)

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