CHAPTER 11

SERVICES FOR GAS, ELECTRICITY, FUEL AND POWER AUTHORITIES

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11.1 Introduction

11.1.1 This market includes all services connected with the storage and distribution of gas, the generation and transmission of electricity including nuclear, coal or oil-fired power stations, wind-driven, wave and solar generation of power, and the land-based extraction of gas, oil, coal and peat. Marine extraction of gas and oil forms the offshore oil and gas market sector and is discussed in chapter 15.

11.1.2 The supply of electricity and services to consumers by Regional Electricity Companies is included in this market sector but the sale of appliances by gas and electricity showrooms is properly part of the retail sector (chapter 8).

11.2 Organization of the gas industry

11.2.1 British Gas PLC is responsible for the distribution and supply of natural gas to domestic and industrial users throughout mainland Britain. The country is divided into twelve semi-autonomous British Gas Regions made up of one for Scotland, one for Wales and ten covering England (see map at Annex A). Arrangements for the supply of gas in Northern Ireland are the responsibility of Belfast City Council.

11.2.2 Supplies of natural gas come primarily from the gas fields in the North Sea and Morecambe Bay, though liquified natural gas (LNG) is imported via a tanker terminal at Canvey Island. Supplies from fields in the North Sea come on shore at St. Fergus (Grampian), at Easington (Humberside), Theddlethorpe (Lincs) and at Bacton (Norfolk). A terminal at Barrow receives gas from the Morecambe field. From the entry points and tanker-terminal the gas is distributed by means of the National Gas Transmission System, a network of large diameter pipelines driven by compressor stations and thence to consumers via local networks within each Region. Gas movement is controlled via pressure differentials along the line.

11.2.3 Both the rate of production of North Sea gas and bulk supply to the Regions are the responsibility of Central Control at British Gas Headquarters at Hinckley. Supply to the customer is the responsibility of the Regions each of which has its own Regional Control Centre. Production offshore normally proceeds at a steady rate. Although in an emergency, production platforms may be able to vary the rate of extraction within a few hours, this is expensive and British Gas has a contractual obligation to give 12 hours notice of a change in the rate of input at the terminals. Although a certain amount of storage of bulk supplies may be made in LNG storage plants, in salt cavities and by packing of gas in the pipelines, the prediction of consumer demand ("sendout") which is highly weather dependent, is of considerable importance to Controllers. In particular the Central Controllers must determine by 1800 LCT each day the amount of gas to order from the producers for the following day.

11.2.4 An important element of the organization is the Energy Research Station (ERS) at Newcastle. This unit is concerned with the development of national demand prediction models which make optimum use of weather information, based on regression analysis. It acts in an advisory rather than regulatory capacity to the Regions, but its influence over the years has brought about both a considerable measure of standardization of demand prediction methods using numerical techniques of statistical regression analysis.

11.2.5 The short-term forecasting of the demand, which is sensitive to weather forecast information, is coordinated within British Gas by the Short-Term Forecasting Panel, which consists of representatives of each of the Regions, of ERS and Central Control. The panel meets annually with representatives of the Office to discuss service performance and requirements.

11.3 Prediction of gas sendout, and control of the grid

11.3.1 The METGAS forecast format developed by ERS (see section 11.5) is designed as direct input to numerical demand prediction models run by British Gas, although there is still a considerable measure of "man–machine mix" (as in the Office) in the process of demand prediction especially at the Regions. The most important forecasts are those issued at 1530 LCT, on the basis of which each Region prepares its own estimate of demand for the following gas day ("Gas day" is the 24-hour period commencing at 0600 LCT). These Regional estimates are sent to Central Control where they are summed to produce a national figure and compared with independent predictions of total national sendout. After resolving any inconsistencies, Central Control at 1800 LCT give notice to North Sea producers of the requirements for the following day.

11.3.2 The grid system is continuously monitored both at Central Control and at Regional Control Centres. The intermediate forecasts and actuals issued 4 times per day as part of the METGAS service are an essential part of this monitoring process as a guide to possible remedial action. Demands above predicted levels lead to a fall of pressure in the grid and although pressures can be allowed to vary between 3.5×10^6 and 7×10^6 Newtons per square metre, if the minimum pressure is approached the security of the system is threatened because of the risk of explosions. Conversely, unexpectedly low demand causes an increase of pressure. Up to a point this "linepacking" is a useful means of temporary storage, but if pressure becomes too high, gas has to be let out of the system at the terminals which is uneconomic and wasteful. A measure of control can also be achieved by using compressors to increase the rate of flow of gas through the grid.

11.3.3 There are also other ways of achieving a cushion against varying or unexpected demands. A limited amount of gas may be stored in gasholders and there are a small number of liquefaction plants. Gasholder stocks are primarily intended as a buffer to deal with the anticipated diurnal variations in demand, but the liquefaction process is so lengthy that stored supplies are exhausted more quickly than they can be replenished. Thus neither provides a satisfactory means of handling significant errors in sendout prediction.

11.3.4 As noted in paragraph 11.3.1, Central Control and the Regions have their own independent methods of demand prediction but all of them require weather information as a major input. Most Regions, as well as British Gas Central Control, use computer-based regression techniques to link temperature to demand, but there are varying amounts of manual adjustment. Several Regions use the computer output only in an advisory capacity. Most techniques convert actual and forecast temperatures into "effective temperature". This is a single quantity for the whole "gas day" (0600–0600 LCT). Minor variations exist between Regions in the formula used but it usually takes the form

$$\text{effective temperature } E_D = aT_D + (1 - a)\,E_{D-1}$$

where T_D is the mean temperature over gas day D and a is a constant. T will be based on a mix of actual and forecast temperatures as available, either a straight arithmetic mean of 2-hourly or maximum/minimum values or weighted towards the daytime period. The standard (LRS) value of a is 0.5 but some regions use 0.6. Sometimes T_{D-1} is substituted for E_{D-1}. This formula thus takes into account the dependence of demand on previous as well as current temperature levels, recognizing, among other factors, lags in the thermal response of buildings. Other meteorological factors are usually taken into account subjectively, though wind is often used quantitatively to reduce effective temperature by means of a "chill factor".

11.3.5 The shape of the diurnal curve of gas demand varies from Region to Region being dependent on the mix of domestic and industrial consumers. Domestic demand shows very large diurnal variations whereas industrial demand is less variable. Regions dominated by the domestic demand (e.g. South Eastern and North Thames) are especially sensitive to weather variations. In Regions with a greater proportion of industrial customers (e.g. East Midlands) the diurnal curve is flatter and the weather sensitivity lower.

11.3.6 The same differences can be seen in the variation in demand between winter and summer. The growth of domestic central heating by gas in the 10 years to 1985 led to a fivefold increase in the winter demand, with almost no effect on summer demand levels. This is not to say that weather forecasts, especially of temperature, are not important in summer. Plant and line maintenance are normally carried out in summer so that the industry's capacity to supply gas is often severely reduced and an unusually cold spell leading to high demand can place a severe strain on the system. Nevertheless most demand-forecasting models recognize a fall-off in dependence of demand on temperature above an effective temperature of 14 °C.

11.3.7 Demand within a Region also depends on the geographical distribution of consumers. Weather forecasts are usually based on a single reference station in the Region but the weather there may not always be representative of the Region as a whole. Because of the statistical procedures used in demand forecasting this is allowed for partially in the correlations, and no attempt should be made to bias temperatures to be more representative. The effect will be greater where the population is more evenly distributed across a Region (e.g. Southern) than where it is concentrated close to the reference station (e.g. North Thames). Some Regions request routine additional information to adjust for such variations (see section 11.6).

11.3.8 One important control arrangement to deal with high, unseasonal peaks of demand, especially in winter, is that certain large industrial consumers (who have alternative fuel supplies) pay a slightly reduced rate for their gas on the understanding that on a maximum of 10 days per year, for not more than 24 hours at a time, gas supplies can be withheld. For this to be done, at least 8 hours notice must be given so that reliable forecasts well ahead are essential; once the decision to cease supplies has been made it cannot be cancelled. Pessimistic temperature forecasts are thus to be avoided.

11.4 Importance of meteorological factors

11.4.1 The various control measures described in section 11.3 enable the system to absorb demand prediction errors of up to 5% with little difficulty, but errors of more than 10% cause serious problems. On average errors in meteorological forecasts account for roughly half of the demand prediction errors, the remaining half being due to imperfections in the prediction model itself.

11.4.2 The most important meteorological factor influencing gas demand is temperature. A change of 1 °C in "effective temperature" over the country causes a 4% change in demand on a national basis, but as much as 6% in certain Regions.

11.4.3 A change from a calm day to a windy day with speeds up to gale force leads to an increase in demand of about 6 or 7%. Wind direction appears to be important in some Regions, notably in the south-east of Britain where winds from an easterly point lead to higher gas consumption than with similar temperatures and winds of the same speed from another quarter.

11.4.4 A change from a sunny day to a cloudy day with rain leads to a demand increase of about 5%. Clearly direct solar radiation both warms buildings and has a psychological effect on their occupants. Rain can also have a psychological effect as well as increasing the chill factor.

11.4.5 Errors of 1 °C in effective temperature are significant, and those of 2 °C or more can be very serious. By agreement both British Gas and the Office monitor the incidence of large errors in mean temperature (>3 °C, approximately equivalent to the 2 °C error in effective temperature because of the contribution of actuals to the latter). It should be noted that because large errors are often due to incorrect forecasts of the synoptic evolution, the errors in individual 2-hourly temperatures can be highly correlated and errors in mean gasday temperature of >7 °C can occur. PSP offices responsible for METGAS services should seek to benefit from the results of routine verification. Improvements of as little as 0.1 °C in root-mean-square error and a reduction in the number of large errors will contribute significantly to the benefit derived by British Gas.

11.5 METGAS service

11.5.1 The METGAS service devised by ERS provides, four times per day, the necessary meteorological input for demand prediction by Regional and Central Controllers. Separate METGAS services are provided for 10 of the 12 Regions (Eastern and Southeastern Regions receive copies of the forecast for North Thames) while 8 of these (excluding Northeast and Southwest Regions) are copied to the British Gas computer centre at Hinckley to enable the national demand to be calculated by Central Control.

11.5.2 Each issue contains forecast temperatures at 2-hour intervals and forecast winds at 4-hour intervals for 24 to 36 hours ahead; recent actual temperature and wind data are also given. Twice per day the forecasts include maximum and minimum temperatures up to 72 hours ahead, together with comments. Forecasts and actuals normally refer to one specific meteorological station which is used, as mentioned in paragraph 11.3.7, as a reference point for the Region. The full specification of the service is given in Annexes B to D to this chapter.

11.5.3 Responsibilities for METGAS issues are set out in Annex B to chapter 1 and reiterated in Annex D to this chapter. Messages are sent by telex and provide direct input to British Gas computers. It is therefore of great importance both to adhere to the agreed format and to send clean copy. The issues must also be sent on time, particularly so in the case of the 1530 LCT issue on which the crucial decision for ordering gas from the North Sea producers is based.

11.5.4 Close contact with Regional and National Controllers by the appropriate PSP office is encouraged as part of the METGAS service. Consultation can be originated by either party. Forecasts should be kept constantly under review and early indication that temperature forecasts are going adrift should be given. Precise criteria for amendment (by telephone to Controllers) may be agreed locally.

11.6 Additional services to gas regions, set-up and charging arrangements

11.6.1 Most gas regions require additional information over and above that supplied under the METGAS service; for example temperature data for locations other than the regional reference station are required in several regions, while one or two regions require more comprehensive information. Some of the additional data are supplied as additional items (sections) in the METGAS message. There is also a requirement for forecasts and warnings for the LNG plants and for climatological data for post-hoc investigations and monitoring.

11.6.2 Both MSM–Energy Services and British Gas Central Control must be notified by their respective outstations of any proposed modifications or additions to the service. In general all METGAS services including any local modifications and additions to the messages, plus any other routine data or forecast services for operational use by British Gas will form part of the central contract negotiated between MSM–Energy Services and British Gas Central Control and must be agreed before introduction. Accounts under the central contract will be raised by MSM who will also advise on charges for minor, occasional or temporary services, accounts for which may be raised locally, subject to the agreement of Central Control.

11.7 Organization of the electricity supply industry

11.7.1 The subject of the organization of the electricity supply industry in England and Wales has undergone a significant change. Some of these changes could be altered still further, which in turn could affect some of the services mentioned hereafter.

11.7.2 There is a trade association known as the Electrical Association which has taken over some of the functions of the now defunct Electricity Council. These include administering the Electricity Supply Pension Fund, "generic" marketing of electricity, central wage negotiations and coordination of health and safety advice. The Association is also involved in planning studies.

11.7.3 In England and Wales, the main body of the "old" CEGB has been divided into three: generating companies, national grid, and regional electricity companies (RECs). All require meteorological information to assist in their day-to-day operations.

11.7.3.1 Generating companies The "old" CEGB's generating operations have been split into three parts owned by three new companies. The fossil-fuelled, wind-powered and most of the hydro-electric power stations have been divided between National Power (NP) and PowerGen (PG), whilst the nuclear power stations have been transferred to Nuclear Electric (NE), along with some gas turbine and hydro plant which are associated with the stations for safety purposes. Nuclear Electric remains in the public domain.

11.7.3.2 National Grid The national grid links to French and Scottish networks and two pump-storage power stations, are now owned by the National Grid Company PLC (NGC). The company is owned by the RECs but not controlled by the shareholders. NGC operates the transmission system, co-ordinates the operation of all the major power stations in England and Wales and operates a "trading pool". Each day the generating companies submit bids to the trading pool stating how much electricity each of their power stations will have available every ´hour for the next day and at what price. When setting the pool price NGC makes provision for plant to be held in reserve. Similarly the RECs put their bids into NGC for their energy requirement for the next day. The selling price in the pool will reflect the price paid for the power and the extent of the requirement of the distribution companies. The sale price in the trading pool is reassessed every ´hour depending on demand and supply.

11.7.3.3 Regional electricity companies The 12 area boards have been succeeded by 12 RECs (see Annex E). They are responsible for the operation of their local distribution network and supplying domestic and industrial users. Their industrial customers are not confined to their region. Their retailing and contracting businesses have not been affected by the restructuring. Some of them take a post-facto interest in weather in relation to sales and may seek climat data. Their control in their local grid network may necessitate forecast and warning services.

11.7.4 Regular forecast services are supplied to NGC who distribute them to their Grid Control Area (GCA). NGC at Sudbury House, London EC1, require climat data for long-term planning, and PSP(Land) supply climatological data on a regular basis to some of the distribution companies. Arrangements and charges for these services are matters for PSP(Land), MSM(Energy Services) and the customer concerned. Climatological services to the NGC and power companies are similarly arranged.

11.7.5 The new structure of the Scottish Electricity industry has not changed drastically. There are still two utilities, Scottish Power (SP) and Scottish Hydro-Electric (HE), served meteorologically by Glasgow WC and Aberdeen WC, respectively (see Annex E). Both are responsible for generation and supply of electricity. The nuclear stations remain in the Public domain under the ownership of Scottish Nuclear Ltd. (SNL), who sell their output exclusively to SP and HE. Hydro, coal-fired and oil/gas fired power stations are shared between SP and HE under long-term contracts. The two companies also participate in the trading pool run by NGC, using interconnectors to NGC.

11.7.6 The Northern Ireland Electricity Board (NIEB) was privatized in April 1992. Three of the four generating power stations are now owned by individual companies. The fourth power station, Colkeeragh, is owned by a management and employment buyout. Northern Ireland Electricity control the electricity grid, distribution and retail sales and will be privatized during the summer of 1993. Weather services are provided from the Belfast International Airport Met.Office.

11.8 Functions of National Grid Control

11.8.1 In the early days of the 132 kV grid system, each GCA was self-contained and itself provided sufficient generating capacity to meet its Area requirements. Since then, however, the need to site large coal-fired power stations near coal fields, and both nuclear and oil-fired stations on the coast has led to construction of the 275 and 400 kV supergrid system which enables large amounts of power to be conveyed to centres of consumer demand. There are also links to the supergrid both from Scotland and from Electricité de France. The existence of the supergrid and its connection introduces great operational flexibility, but clearly very close co-ordination and control are needed.

11.8.2 There are two major functions for NGC, to buy electricity from the power companies and to arrange for all necessary transfers of power from one Area to another and also from Scotland and France. These transfers can sometimes be quite large, for example up to about 6000 MW from the Midlands to southern England at times of winter peak demands. Compared with this, transfers across the English Channel are smaller, with a maximum figure of 2000 (MW), but could increase.

11.8.3 It might be supposed that transfers would be decided purely on the basis of estimated demand and availability but matters are more complicated. The power companies total generating capacity is produced by several dozen power stations of different types scattered over the country and there is a very wide variation in local costs of production. Between the very expensive gas turbines and relatively cheaper nuclear generators, costs differ by a significant factor. Thus it may be much more cost-effective when spare capacity is available to transfer power from one end of the country to the other than to generate it locally using old and inefficient plant. It follows that all GCAs are interdependent and errors in load estimates in one GCA due to incorrect weather predictions may seriously affect another GCA.

11.8.4 A second important responsibility of NGC is to plan the reserve capacity for the country as a whole. Whereas gas can be stored in gasholders and by line packing to provide a cushion against fluctuating demand, electrical power storage is only possible on a modest scale by the use of "pumped storage schemes", i.e. by pumping water into high-level reservoirs from which it can subsequently be drawn to drive hydro-electric turbine generators. To meet unexpected short-term demands there is a "scheduled reserve" of plant from which power can be fed into the Grid within seconds: additional plant is kept on standby and can be brought into use within a few hours. This is totally the responsibility of NGC and is taken into account when buying electricity from the power companies. These reserves have to cover not only weather prediction errors but load estimation errors, plant failures and accidents affecting the transmission system. It is a sobering thought that national scheduled reserves are (1988) normally as little as 1000 MW and that a 1 °C temperature change nationally in winter changes the load by about 450 MW. The importance of weather forecasting is thus self-evident. In difficult weather situations, where doubt exists, controllers can arrange to maintain larger than normal reserves, but to do this unnecessarily is extremely uneconomical. It follows that Controllers must be kept fully informed by Weather Centres about the possibility of significant departures from the forecast.

11.8.5 A third function of NGC is to monitor continuously both voltage and frequency throughout the Grid. If with all reserves in use voltage cannot be maintained, voltage cuts of 3% and later 6% can be imposed. Frequency can be allowed to drift from the normal 50 Hertz (Hz) only down to 49.5 Hz. If these provisions are not enough, load shedding (i.e. power cuts) is inevitable because failure to maintain supplies within the prescribed limits could have serious consequences.

11.8.6 At any given time a proportion of generating plant is always out of commission, e.g. for maintenance, so that the theoretical maximum capacity can never be reached. It might be expected that problems would be most likely to arise in winter when loads are high, but as in the gas industry some of the worst difficulties occur during unseasonably cold weather during summer when a much higher proportion of plant is unavailable because of maintenance.

11.8.7 Over-optimistic forecasts are clearly undesirable, but any element of pessimism built in as a presumed safety factor is equally undesirable. Again as in the gas industry, one of the emergency control measures is that supplies to certain large consumers can be cut off after due warning. If in the event, as a result of a pessimistic forecast, supplies are arbitrarily terminated in this way unnecessarily, vociferous complaints to RECs and NGC may rebound onto the Office.

11.9 Load estimation

11.9.1 The Demand Analysis and Forecasting Section at NGC prepares weekly peak-load estimates for up to 5 years ahead, weekly electrical energy forecasts up to 3 years ahead and estimates in connection with day-to-day operations. The whole process is one of continuous refining and updating in which the Controllers exercise the fine tuning on an hour-to-hour or even minute-by-minute basis. Similarly the power companies and RECs have to prepare long- and short-term forecasts to predict their estimates.

11.9.2 The starting points for load estimation are the normal and average-cold-spell demands which are defined as the loads which would result from standard weather conditions for the time of year. Standard loads are derived from past records of load and weather, the weather effects being modelled by multiple regression methods, continual adjustments being made for changes in consumption over the years. A 'day of the week' factor is applied to take account of social habits. The normal daily load curve, though varying in amplitude and wavelength, usually shows the same recognizable features throughout the year. There is an early morning period of minimum demand centred about 0500 LCT with an extremely rapid rise to the morning peak at about 0830 LCT. After a slight decline there may be a minor peak around midday, followed by an afternoon trough before a peak at 1730 LCT; a darkness peak occurs after sunset followed by a steady decline to the 0500 LCT trough interrupted only by a peak at 0200 LCT resulting from Economy 7 time-switches. Actual patterns vary from GCA to GCA according to the relative proportions of industrial and domestic consumers and differing social habits in various parts of the country, e.g. because of different traditional meal times.

11.9.3 Superimposed on this standard load is a "weather load" and this also varies from GCA to GCA. Meteorological advice is therefore specific to Area Grid Control Centres (GCCs) although sent to NGC. Using the meteorological forecasts each GCC makes its own estimates of demand at various standard points on the normal daily load curve, including information from distribution companies, and passes these to NGC. NGC meanwhile makes separate and independent calculations of national load for the same standard points on the daily curve, and compares these with the sum of the GCA estimates. NGC, using the information from GCC, then estimate how much power to buy from the power companies. They then finalize arrangements for transfers of power between areas at an economical cost.

11.9.4 As described above, demand estimates are given by the standard load plus the weather load (see section 11.10). Additional factors are also taken into account, and although not meteorological, one of these is of some interest. One of the consequences of television as part of our social fabric is that many people are conditioned to do the same thing at the same time; at the end of a popular programme millions of viewers switch on lights and plug in kettles, causing a massive and rapid increase in electricity demand. Controllers have to be prepared for this "TV pickup" effect because it can be extremely large: an increase in national load of 2600 MW in 4 minutes has been recorded, and if spinning reserves were not available for very rapid introduction, load shedding on a very large scale would be inevitable.

11.9.5 The RECs have the task of forecasting three periods of half-hour of the highest electricity demand between November and February (inclusive). These three periods are known collectively as the TRIADS. Each period of exceptionally high demand must be separated by ten clear days from any previous period. NGC bases its charges of usage of their supergrid on the demand in these three periods. Through experience and research the RECs know that the TRIADS are most likely to occur between mid-November and mid-February with the exception of Christmas and the New Year period. They are more likely to be on Monday–Thursday, but not on holidays. Finally, they are likely to occur on dark evenings in the half-hour periods ending between 1700 and 1800, in spells of exceptionally cold weather.

11.10 Meteorological factors affecting demand

11.10.1 It should be apparent from the above that weather factors are of great importance to the electricity industry. Controllers both in the Areas and at NGC take a close interest in the weather, and the Demand Analysis and Forecasting Section is supplied with plotted and hand-drawn charts via MIST and has access to satellite imagery via local reception facilities. The power companies and RECs also have to take into consideration the weather factors.

11.10.2 The meteorological elements found to affect demand are similar to those affecting demand for gas namely, temperature, wind speed, cloud, visibility and precipitation. In this case the cloud, visibility and precipitation, as well as modifying the heating demand, affect directly the daylight illumination level and thus the lighting demand.

11.10.3 All buildings have a thermal capacity depending on thermal insulation and thus show a lag in responding to ambient temperature and radiation. To take account of this, long-term demand estimates use an "effective temperature" which is determined by weighting the forecast temperatures towards the actual temperatures a day previously. This is one reason that Controllers require actual as well as forecast temperatures, but the effect fortunately serves to minimize rapid changes in temperature. Actual weather is also used to update the demand forecasting models to track trend growth and changes in seasonality.

11.10.4 Wind produces a cooling effect which appears to vary with the square root of the wind speed and in a linear way on the temperature difference from a reference level. This wind effect operates by draught driven air changes within buildings.

11.10.5 Forecasts of cloud, visibility and precipitation are weighted and combined to produce a daylight illumination index; these elements are of no significance during the hours of darkness. However, precipitation does also appear to have one independent effect apart from being an indicator of thicker cloud; presumably because it tends to keep people indoors, it does influence the evening peak demand.

11.10.6 The sensitivity of national demand to weather changes, which varies with time of day, day of week and season, is illustrated by the following figures (1988) which apply to winter weekday afternoons:

a. Temperature The response of demand to changing temperature is non-linear (approximated by a section of a cubic curve, with negative slope below the minimum at about 20 °C and positive slope at higher temperatures). The gradient is such that a fall in temperature from 2 °C to 1 °C increases demand by about 400 MW.

b. Wind At 2 °C an increase in wind speed from 5 to 15 knots increases demand by about 700 MW.

c. Cloud A change in cloud from nil to full cover on a dry day increases demand by 1000 MW. A change from no cloud to overcast with rain implies an increase in demand of about 1800 MW which underlines the importance of cloud during the daylight period. The sudden onset of day darkness due to a large convective storm over a city can have a dramatic effect on local demand, and Area Controllers should be kept fully informed about such developments. Anticyclonic gloom by day can similarly lead to unusually high demand and warning of this should be given whenever possible.

11.10.7 Another meteorological factor of considerable importance is the Lightning Risk. This is a routine item in all forecasts (see section 11.11). The current risk is normally displayed prominently in all Control Rooms and is used when authorizing maintenance work on power lines. If the forecast risk is low, men may be working on the lines and a lightning strike even some distance away could be instantly fatal. Amendments of lightning risk must therefore always be sent **AT ONCE** direct to GCAs.

11.11 Routine daily forecasts to NGC controllers

11.11.1 The responsibilities of CS offices for forecast information and advice to Grid Controllers are indicated in Annex B to chapter 1 and highlighted at Annex F to this chapter. As noted in paragraph 11.9.3 all forecasts refer to GCAs but the method of transmission is centralized, all bulletins being passed in a rigid standard format and time schedule to Bracknell (TC) for collation and onward transmission by a computer link from COSMOS to NGC where they are automatically compiled on a computer database to be accessed by both the GCAs and National Control. In the event of an emergency the operation of the Grid may be transferred to a standby Control Centre. The National Control Engineer in these circumstances will notify the (TC) supervisor who will arrange for forecasts to be telexed to the Grid Control Centres. Similar direct transmission is introduced in the event of a communications failure at Bracknell (BRACKDIM or BRACKOUT) (see chapter 5). Although there is a standard format for all routine issues, individual GCAs can have minor additions to suit local circumstances and load estimation techniques.

11.11.2 Seven routine issues are made each day according to the schedule indicated in Annex G to this chapter. The times of issue have been chosen to fit into a tight schedule of demand estimation at Control Centres and to allow for automatic collation at Bracknell. It is essential that messages are sent on time. Failure to do this means major disruption of the planning structure at the NGC. Cumulative "lateness" graphs are received monthly from NGC and distributed for information to the office involved. Major delays will require investigation.

11.11.3 The overall design of the service incorporates the concept of a rolling programme of load estimation in which forward estimates are refined as the forecast period approaches. The first operational (as opposed to planning) look at weather follows the 1015 issue of day-ahead forecasts covering the period 0600 to 2100 next day. These forward estimates are later followed by preliminary and final forecasts, each for a 3-hour period; in some cases revised forecasts are also inserted between the two latter, giving 3 or 4 attempts. The actual reports, in particular those involving temperature, are used in determining the effective temperatures (see paragraph 11.10.3), and short-term model updating. Since the NGC demand forecasts relate only to the major turning points (cardinal points) on the demand curve information is not required presently for a period overnight. (This may change as prediction methods are revised.)

11.11.4 For each 3-hour forecast period the elements included are as detailed in Annex H. The format has been devised for decoding by the NGC computer systems and should be strictly adhered to. It is to be laid out as illustrated in Annex I.

11.11.5 The Lightning risk as noted in paragraph 11.10.7 is of vital importance and should be given in accordance with the conventions set out in Annex J. Note that for completeness Annex J details the full "Lightning Risk, Thunderstorm Level and Thunderstorm Risk" scheme, which is of concern also to Defence Services (DS) customers. These risks apply to different and overlapping periods from those used in the quantitative forecasts (see Annex G). Each GCA is interested in lightning anywhere within its own Area, but at NGC the messages are used primarily in assessing risk on the 400/275 kV supergrid lines connecting Areas. Every attempt should be made to be as precise as possible in these assessments, indicating both the expected and timing of the Lightning Risk. For example, a forecast in the form "4 becoming 2 after 2300 except near the south coast" would be useful. Lightning Risk is sent direct to GCAs as well as within the collated bulletins.

11.11.6 The Outlook is included in three issues (see Annex G). Minimum temperatures are included on a separate line.

11.11.7 Actual reports for the reference station in each GCA should include temperature, wind speed and direction, cloud (as in Annex H for forecasts), precipitation and visibility.

11.11.8 In the light of the background information given in sections 11.8 to 11.10 it is evident that controllers have to monitor the system continuously and take action at once when excessive loads develop. They are in a position where new information can be absorbed and acted upon almost immediately, and it follows that they must be kept fully in the picture about unexpected weather developments. Forecast amendments should be sent via Bracknell to NGC, but over and above this, forecasters at responsible CS offices should initiate telephone calls to controllers to discuss any difficulties or adverse risks that develop. In particular, LWC, prompted when necessary by CFO, should originate calls to NGC, when any unexpected large-scale developments occur which indicate the need for major amendment to the day-ahead forecasts issued at 1730 LCT.

11.12 Weekend forecasts to NGC controllers

11.12.1 In addition to the forecasts detailed in section 11.11, special weekend forecasts are issued at 1015 on Fridays. These forecasts should include:

a. Maximum and minimum temperatures for Saturday, Sunday and Monday.

b. A general commentary on the weather for Saturday, Sunday and Monday.

c. Spot forecasts of temperature, wind speed and total cloud cover at 1100 and 1800 LCT on Saturday and Sunday and at 0900 and 1800 LCT on Monday.

11.12.2 Forecasts will be based on the routine medium-range guidance produced by CFO (charts and GSD) amended as necessary in Synoptic Reviews; see chapter 4. CFO medium-range (T+48, 72, 96, 120 hour) charts are also received at NGC National Control.

11.12.3 Arrangements will be agreed with NGC for the extension of this weekend guidance by additional days to cover Public Holiday weekends and to cover mid-week Public Holidays (e.g. Christmas). Responsible offices will be notified by MSM–Energy Services.

11.13 Other forecasts and warnings for NGC

11.13.1 Weekly planning forecasts LWC send to NGC National Control each Wednesday, a planning forecast codifying expected developments for the following week. These forecasts are used on a trial basis in place of climatological data ("Average Cold Spell" see paragraph 11.9.2) to revise safety limits on available reserves and include estimates of confidence levels.

11.13.2 Services to Nuclear Electric power stations in the event of a release of radioactive materials are discussed in chapter 22.

11.13.3 Ice accretion/adhesion warning criteria Ice accretion on overhead power lines may occur either because of wintry precipitation or due to supercooled water droplets impinging upon cables whose surface temperature is below 0 °C. In the case of precipitation the effects of wind speed, temperature and humidity are critical. Normally the snow or freezing rain should persist for at least one hour. The following table shows some likely relationships between wind, temperature and precipitation which will give rise to cable pylon icing.

Wind speed (knots)	*Air temp. range (°C)*	*Precipitation*
Around 15	cable around 0	freezing rain
Around 15	cable around 0	Supercooled water droplets (low stratus/freezing fog)

(NB. A wet-bulb temperature just below freezing may enhance the accretion effect.)

20–25	0 to +0.5	Moderate snow
25–30	0 to +2.0	Heavy snow
30–40	+0.5 to +2.0	Moderate snow/sleet

(NB. Relative humidities above 90% will greatly increase the likelihood of ice accretion)

>40	—	danger of cable clash, with or without precipitation

It should also be noted that there is a danger of cable clash (due to whiplash) when sudden warming occurs and melting snow/ice falls from the cables. This is likely to occur at temperatures above the ranges given above. Amendments should be issued if icing is expected when not previously forecast **OR** forecast but not now expected.

11.14 Administrative arrangements for services to NGC

11.14.1 BD(Sales), through MSM–Energy Services, is responsible for all negotiation with NGC Headquarters about general arrangements and services. Minor additions, and details of telephone consultancy with Area Controllers, are matters for local agreement. Dealings with RECs are handled by WCs, liaising as necessary with MSM–Energy Services.

11.14.2 CFO supply copies of daily medium-range forecasts (GSDs) to NGC by telex.

11.14.3 NGC also receive in two bulletins daily, of 12 SYNOPs extracted automatically in (TC).

11.14.4 CS Admin in consultation with (F&S) prepare and submit accounts covering:

a. Routine daily forecast bulletins.

b. Products provided via MIST.

c. CFO telex issues of medium-range guidance.

d. Extended-range forecast weekly from LWC.

e. SYNOP bulletins from (TC).

Any other services may be arranged and billed locally but MSM–Energy Services should be informed when additions are proposed or services discontinued.

11.15 Services for other electricity authorities

11.15.1 Services to SHE, SP and NIES, if required, will be discussed and agreed locally by Commercial Manager Glasgow WC and Belfast, respectively. However, MSM–Energy Services should be kept fully informed of these services and consulted on aspects concerning charges. Accounts will be submitted locally.

11.15.2 Any service required by SHE will be discussed and agreed by Commercial Manager Aberdeen, consulting MSM–Energy Services as necessary. Accounts will be submitted locally.

11.15.3 Responsibilities for the 12 RECs in England and Wales are set out in Annex B to chapter 1. Any services required will be discussed and agreed locally, with advice from MSM–Energy Services as necessary. In particular, certain RECs require warning of snow accretion on overhead (11 kV) power lines. A forecasting technique for such warnings is available in LWC Memorandum No. 23 by J.S.Foot. Charges for these services will be determined using the appropriate cost-plus, and accounts will be locally raised.

11.15.4 Budget warmth Several RECs operate heating schemes for sheltered housing for old people under the label "Budget Warmth". The heating is controlled by the companies who therefore require an indication of temperatures in the relevant areas where the housing is located. Services for each board are provided by the CS office responsible who will raise charges according to a centrally agreed formula based on the number of locations, and a standard estimate of the staff time involved.

11.16 Services for the coal industry

11.16.1 British Coal is responsible for the extraction of coal from surface and underground workings throughout Great Britain. The primary requirements for meteorological information are for warning services of large pressure falls which may lead to a dangerous build up of gases in the underground workings, warnings of the conditions likely to cause condensation and brake slippage on pit winding gear and for forecasts of severe weather in winter which may cause problems in the surface transport of coal. Services are negotiated and accounts raised locally using the national price list agreed with British Coal HQ, Doncaster.

11.16.2 Warnings of pressure falls Warnings of impending large falls of pressure are issued by participating WCs according to the following criteria:

a. Sharp Falls of between 4 and 8 hectopascals in 3 hours.

b. Very sharp Falls in excess of 8 hectopascals in 3 hours.

The warnings are transmitted normally to British Coal's Regional Rescue Centres but also to individual collieries depending on the service negotiated.

BRITISH GAS REGION BOUNDARIES

METGAS SERVICE SPECIFICATION

		Included at (LCT)
A	Reference station	All times
B	Date	All times
C	Time of issue	All times
D	Actual temperatures	All times
E	Forecast temperatures	All times
F	Actual wind speed and direction	All times
G	Forecast wind speed and direction	All times
H	Day 2 Maximum	0800, 1530
I	Night 2 Minimum	0800, 1530
J	Day 3 Maximum	0800, 1530
K	Night 3 Minimum; Day 4 Maximum	1530
L	General comments first 24 hours	0800, 1530
M	Temperature comments whole period	0800, 1530
N	Wind comments for second 24-hour period	0800, 1530
O	General comments for second 24-hour period	0800, 1530

Notes

1. The style of reference station name and details of message headings etc. will be as agreed locally.

2. Date (Item B) will be in the form 21/6/89 or 21-6-89.

3. Time of issue (Item C) should be one of the standard issue times (see Annex C) and NOT the time of origin of the forecast. The date (Item B) entered on the 0001 issue should be that appropriate for this time and not the date on which the forecast was prepared. All times are LCT.

4. All temperatures (Items D and E) should be in °C, using two figures, with 50 added for negative values.

5. Winds (Items F and G) should give all wind speeds first in knots, using two figures, followed by all wind directions using the 16-point compass. A calm should be entered as 0 in the speed block, followed by "CALM" in the direction block. To avoid confusion with error identification procedures, wind directions of E should always be written in full, i.e. EAST; for other directions compass points will suffice, e.g. NW, NNW.

6. The day maximum and night minimum entries (Items H, I, J and K) refer to the periods 0900 to 2100 and 2100 to 0900 GMT respectively. Note that in the 1530 issues, the Day 2 maximum and Night 2 minimum are included despite the fact that these values are, or may be, bracketed by the 2-hourly temperature figures.

7. General comments (Items L and O) should be used to describe cloudiness and precipitation during the first and second 24-hour periods in simple terms as used in radio forecasts for the general public. Approximate times of onset and cessation of precipitation should be given under Item L but not under Item O. For example under Item L "Bright at first, general rain (1400-2000) then mostly clear", or under Item O "Dry with sunny periods by day but rain later."

8. Despite the amount of temperature data included under earlier items, the comments under Item M are regarded as most important in amplification of forecast values over the next 3 days. In particular, an indication of confidence should be given, and risk of values <u>lower</u> than forecast should always be stated. For example: "Mild south-westerly airstream well established; little risk of colder weather", or "Cold outbreak continuing, with possibility of even colder weather by Day 3", or "Generally warm, but temperature fluctuations of 5 °C may occur in heavy showers during Days 1 and 2".

9. Item N is intended to provide a rough outlook for wind, using normal descriptive terms for speed and a general direction. For example: "Fresh south-westerly".

METGAS SERVICE SPECIFICATION

SCHEDULE

	Time of issue (LCT)			
	0001	0800	1200	1530
Actual Temperatures	1700,1900 2100,2300	0100,0300 0500,0700	0900,1100	1300,1500
Forecast Temperatures (2-hour steps 01,03,05, etc.)	0100(D1)- 0500(D2)	0900(D1)- 0700(D2)	1300(D1)- 1100(D2)	1700(D1)- 0500(D3)
Actual Wind speed & dir.	1900,2300	0300,0700	1100	1500
Forecast wind speed & dir. (4-hour intervals 03,07,11, etc.)	0300(D1)- 0300(D2)	1100(D1)- 0700(D2)	1500(D1)- 1100(D2)	1900(D1)- 0300(D3)
Day 2 maximum temp	-	Yes	-	Yes
Night 2 minimum temp	-	Yes	-	Yes
Day 3 maximum temp	-	Yes	-	Yes
Night 3 minimum temp; Day 4 maximum temp	-	-	-	Yes
General comments cloud, sunshine, precipitation 1st 24 hours	-	Yes	-	Yes
Temperature comments whole period	-	Yes	-	Yes
Wind comments 2nd 24 hours	-	Yes	-	Yes
General comments cloud, sunshine, precipitation 2nd 24 hours	-	Yes	-	Yes

Notes

1. Amendments are made for temperature only - errors of ± 2 °C generally during the 1st 24 hours only.
2. Temperatures in whole degrees C, using two figures. (For negative values 50 is added and the minus sign dropped.)
3. Wind speed in knots. Wind direction given on 16-point compass.
4. Comments should highlight regional variations and indicate confidence level of forecast.
5. Day maximum and night minimum entries refer to the periods 0900-2100 & 2100-0900 respectively.

METGAS SERVICE RESPONSIBILITIES

British Gas Region	Reference Station	Issuing Office
North Thames (copies to Southeastern & Eastern Gas	London WC	London WC
East Midlands	Nottingham WC	Nottingham WC
West Midlands	Birmingham (Waterworks Rd, Edgbaston)	Birmingham WC
Wales	Cardiff (Wales) Airport	Cardiff WC
Southwest	Bristol (Bristol Weather Centre)	Bristol WC
Northeast	Leeds WC	Leeds WC
Northern	Newcastle WC	Newcastle WC
Scottish	Glasgow Airport	Glasgow WC
Southern	Southampton WC	Southampton WC
Northwest	Manchester Airport	Manchester WC

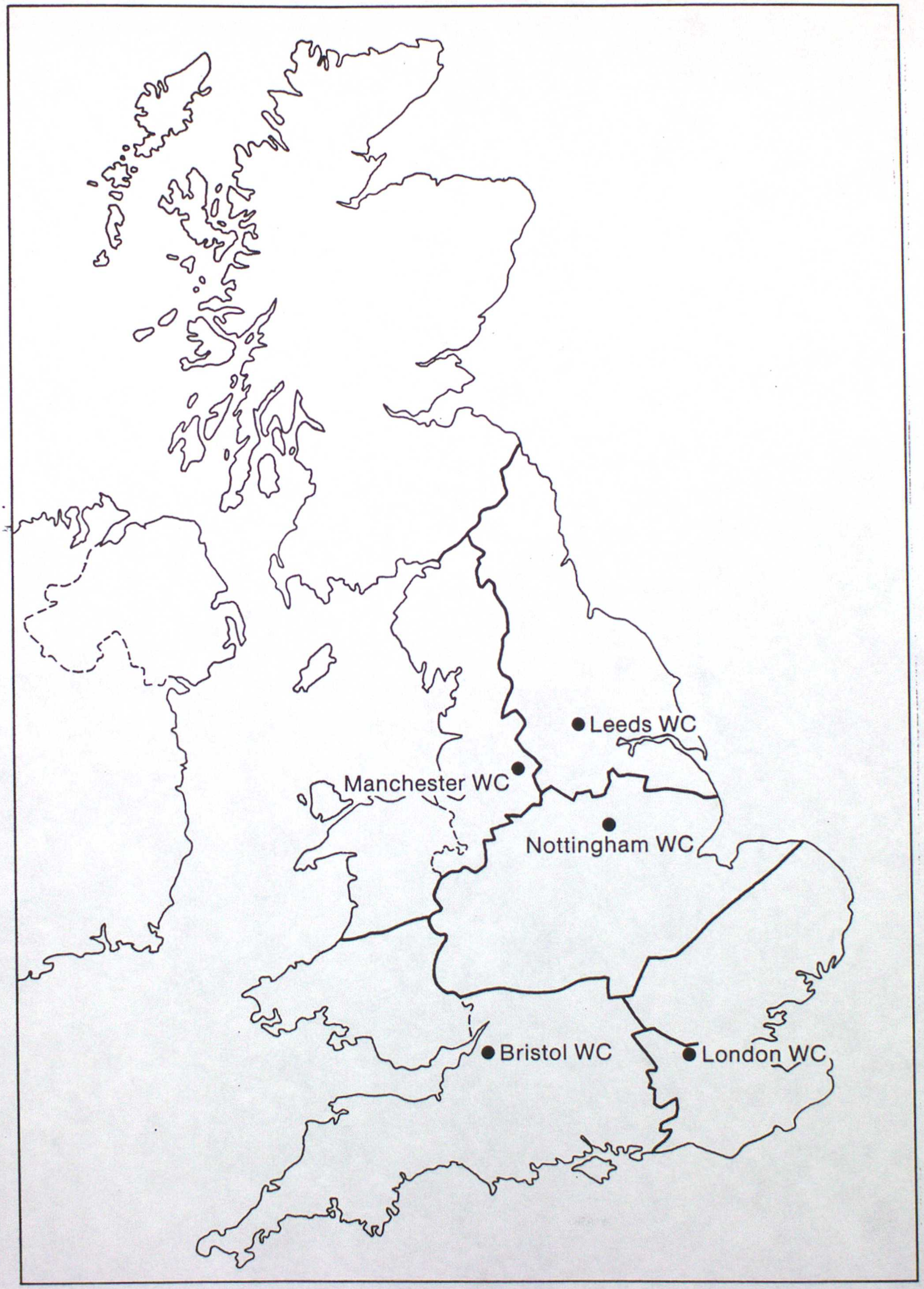
Note

Apart from British Gas Southwest Region and British Gas Northeast Region, all forecasts are copied to Hinckley.

(A.L.1)

THE ELECTRICITY COMPANIES OF ENGLAND, WALES AND SCOTLAND

WEATHER CENTRE AREAS OF RESPONSIBILITY



SPECIFICATION OF SERVICE TO NGC — SCHEDULE OF ROUTINE ISSUES

Time of Issue to NGC	Forecasts Required		Lightning Risk	Outlook	Actuals
	Today	Tomorrow			
0330	0600–0900 0900–1200 1200–1500 1500–1800 1800–2100	—	0400–2100	2100–0900 & Minimum Temp.	0300
0730	0900–1200 1200–1500 1500–1800 1800–2100	—	0730–2100	2100–0900 & Minimum Temp.	0400 0600 0700
1015	1200–1500 1500–1800 1800–2100	0600–0900 0900–1200 1200–1500 1500–1800 1800–2100	1100–2100	—	0800 0900
1315	1500–1800 1800–2100	—	—	—	1000 1100 1200
1600	1800–2100	—	1600–2400	0001–1500 & Minimum Temp.	1300 1400 1500
1730	—	Minimum Temp. 0600–0900 0900–1200 1200–1500 1500–1800 1800–2100	1730–0600	—	1600 1700
2130	—	—	—	—	1800 1900 2000 2100

Notes

1. 1015 issue Friday additional forecasts for Sunday (D+2) and Monday (D+3) in same format as D+1. (Also applies over Christmas and New Year.

2. Grinstead GCA receive additional data from LWC covering temperature at end of each 3-hour period and forecast cloud base in feet.

3. All forecasts passed to National Grid Control via Telecommunications (TC). Lightning Risk forecasts (including amendments) are passed direct to Regional GCAs.

4. Time of issue to TC is between 15 and 29 minutes before time of issue to NGC (from TC). If the forecast is sent earlier than 29 minutes prior to issue to NGC it is rejected by TC. If the forecast is not received by 15 minutes prior to issue to NGC, TC will endeavour to prompt the Weather Centre.

5. All times are LCT.

SPECIFICATION OF NGC SERVICE — FORECAST MESSAGE CONTENT

11H.1 For each 3-hour period: (One value to be "representative of" or "average for" the period, unless otherwise stated.)

Temperatures to be a mean of 4 hourly temperatures in the period, all other elements are forecast for the terminal hour of the period.

a. Temperature in whole degrees Celsius.

b. Wind speed (knots) and direction (16-point compass).

c. Type of precipitation:

ID	Intermittent drizzle	IS	Intermittent snow/sleet
CD	Continuous drizzle	CS	Continuous snow/sleet
RD	Rain and drizzle	HS	Hail showers
IR	Intermittent rain	TS	Thunderstorms
CR	Continuous rain	SH	Showers
WS	Wintry showers	NP	No precipitation

d. Amount of precipitation —

D — Dry	M — Moderate
S — Scattered	H — Heavy
L — Light	

e. Fog F — Yes N — No (visibility ≤ 100 yd).

f. Visibility in yards up to 3500 yards; in miles for 3 miles and above.

g. Number of cloud layers: 0, 1, or 2.
No cloud forecast required if fog is forecast at (e).

h. Cloud amount in oktas.

i. Cloud height: L = Low (below 2000 feet)
M = Medium (2000–5000 feet)
H = High (above 5000 feet)

j. Cloud thickness: TN = Thin (less than 3000 feet)
M = Medium (3000–5000 feet)
TK = Thick (more than 5000 feet)

Note: Actuals are issued in same format.

11H1.2 Lightning risk — scale as specified in Annex J to this chapter and for the period under threat.

1 — Very high
2 — High
3 — Moderate
4 — Low
5 — Nil

11H1.3 Outlook — should be brief and in plain language and specify the period covered.

PROFORMA USED FOR NGC FORECASTS AND EXAMPLE

FXUK88 CCCC YYGGgg

COMPUTER INSTRUCTIONS	FINAL HOUR OF PERIOD	DAY NUMBER	DATE	MONTH	YEAR	LOCATION	3-HOUR AVE TEMP °C	WIND SPEED (KNOTS)	WIND DIRN 16 PT COMPASS	TYPE OF PPN	INTENSITY OF PPN	FOG (F) OR NONE (N)	VISIBILITY YDS (Y) OR MILES (M)	NUMBER OF CLOUD LAYERS	EIGHTHS	HEIGHT OF BASE	THICKNESS OF LAYERS	EIGHTHS	HEIGHT OF BASE	THICKNESS OF LAYER	
WF	0 9																				/
WF	1 2																				/
WF	1 5																				/
WF	1 7																				/
WF	2 1																				/
A	0 3							/													
LR		0400 TO 2100																			
LR		0400 TO 2100																			
OL		2100 TO 0900																			
MIN TEMP																					

Weather comments, where desirable

Notes

1. Under the "computer instructions" column, "WF" stands for weather forecast and "A" for actual, "LR" for lightning risk and "OL" for outlook.
2. Under the "location" column a two-letter entry is made by the issuing WC as follows:- BR (Bristol), LD (Leeds), LN (London), MN (Manchester), NM (Nottingham).
3. Bristol and Nottingham WCs also include a second line for LR (Lightning risk) for PL (Plymouth) and NM (Nottingham) respectively.
4. LWC provides also an extra line of forecast information for East Grinstead GCA - see Appendix A.
5. It is essential that all forecasts are completed using the format as shown in the proforma above and in Appendix A.

Worked example from Bristol WC

```
FXUK 88 EGRR 010200
WF 09 4 01 12 88 BR 07 07  NE NP D N  3M 1 8 L  M       /
WF 12 4 01 12 88 BR 07 10  NE IR L N  4M 2 5 L TN 8 M TK /
WF 15 4 01 12 88 BR 06 10  NE IR L N  4M 2 5 L TN 8 M TK /
WF 17 4 01 12 88 BR 06 12 ENE NP D N  4M 2 5 L TN 8 M TK /
WF 21 4 01 12 88 BR 05 08 ENE NP D N  5M 2 4 L TN 7 M  M /
 A 03 4 01 12 88 BR 03 /
LR BR 0400 TO 2100 3
LR PL 0400 TO 2100 3
OL BR 2100 TO 0900 VARIABLE CLOUD AMOUNTS, MAINLY DRY.
MIN TEMP BR 02

NNNN
```

(A.L.1)

PROFORMA FOR ADDITIONAL LINE DATA, AND EXAMPLE

Indicator East Grinstead	Time at end of period	Indicator (Temperature)	Temperature at end of period (°C)	Indicator (Cloud base)	Cloud base in feet (1st layer)	Cloud base in feet (2nd layer)
G R		T T		C B		

WORKED EXAMPLE FROM LWC

```
FXUK 88 EGRR 010200
WF 09 4 01 12 88 LN 02 05 NNE NP D N  800Y 1 7 L TN        /
GR09 TT 03 CB 200
WF 12 4 01 12 88 LN 05 05 NNE NP D N    3M 1 7 L TN        /
GR12 TT 07 CB 500
WF 15 4 01 12 88 LN 08 08 NNE ID L N    4M 2 2 L TN 8 L  M /
GR15 TT 08 CB 600    1500
WF 17 4 01 12 88 LN 08 10 NNE NP D N    5M 1 8 L  M        /
GR18 TT 07 CB 1800
WF 21 4 01 12 88 LN 07 08   N NP D N    5M 1 7 L M         /
GR21 TT 07 CB 2000
 A 03 4 01 12 88 LN 01 /
LR LN 0400 TO 2100 3
OL LN 2100 TO 0900 MAINLY DRY. CLEAR SPELLS DEVELOPING LATER IN THE
NIGHT.
MIN TEMP LN 03

NNNN
```

ASSESSMENT OF LIGHTNING RISK, THUNDERSTORM LEVEL AND THUNDERSTORM RISK

11J.1 General The requirements for assessing the general threat of lightning strikes in the PS area are different from those affecting customers elsewhere. In the PS area the primary customers (NGC and electricity distribution companies) have an areal coverage requirement (by virtue of power cable network). Elsewhere the customers receiving services from the Office are operating at specific sites with ordnance, aviation fuel or tethered balloons where a short lead-time for the warning is appropriate and thus allows high confidence.

11J.1.1 To cater for these different requirements a unified service of assessing Lightning Risk (LR), Thunderstorm Level (TL) and Thunderstorm Risk (TR) is operated where "thunderstorm" refers to natural electrical discharges from clouds, which are observed as lightning and/or thunder. It does not include induced discharges which may be triggered by aircraft or tethered balloons flying in cloud in certain atmospheric conditions. The full system is set out below.

11J.2 Lightning risk Notification of the expectation of lightning is given always in the form of a single figure assessment, prefixed by the words "Lightning Risk" (or "LR" on copies to NGC via Bracknell) in accordance with the following scale of categories:

Lightning risk Category		Definition
1.	(Very high)	When the probability of cumulonimbus clouds over the area is extremely high. Lightning may or may not have been reported.
2.	(High)	When cumulonimbus clouds over the area are probable.
3.	(Moderate)	When cumulonimbus clouds over the area are improbable.
4.	(Low)	When cumulonimbus clouds over the area are extremely improbable, but "large cumulus" clouds (cumulus mediocris or congestus) are expected.
5.	(Nil)	When cumulonimbus clouds over the area are extremely improbable and any other convective type clouds are not expected to develop beyond the "fair weather" (cumulus humilis) stage.

11J.2.1 The periods of LR forecasts for NGC are given in Annex G. An indication of timing, where possible, is useful when variations in the threat are expected.

11J.2.1.1 See 'Notes' at the end of this annex on the technical aspects of LR.

11J.3 Thunderstorm Level The term "Thunderstorm Level" (TL) is to be used only in relation to locations at which there is a forecaster on duty. As the word "level" implies, the issue of a TL includes the element of precise local observation which is possible only when a forecaster can monitor developments in the immediate vicinity.

11J.3.1 Notification of a TL is to be given in the form of a single figure assessment, prefixed by the words "Thunderstorm Level", in accordance with the following scale:

Thunderstorm category		Definition
1.	(High)	A thunderstorm is occurring or expected over the site in the immediate future (normally in about 15 minutes).
2.	(Moderate)	Thunderstorms are developing, or have been reported, within 40 km of the site, but are not expected to affect the site in the immediate future.
3.	(Low)	Thunderstorms are not expected.

11J.3.2 A Thunderstorm Level is to be used, whenever possible, to update a thunderstorm warning. A thunderstorm warning is issued whenever thunderstorms are expected in a given area within a specific time ahead. After issuing a thunderstorm warning a forecaster is to monitor local developments and notify the appropriate authorities when the TL becomes 2 and then increase it to 1 if necessary. A TL 1 should be reduced to TL 2 as soon as the immediate threat to the site has passed (for example, when a thunderstorm has crossed the site and moved downwind). Sometimes the TL will fluctuate between categories 1 and 2 until thunderstorm activity within the 40 km radius of the site has ceased.

11J.3.3 It should be noted that the issue of a thunderstorm warning does not necessarily require the immediate issue of a TL 2. There will also be occasions when it will be necessary to notify customers of a TL 1 or TL 2 before issuing a thunderstorm warning. It is expected that the majority of customers will require notification of TL 1 and TL 2 only. TL 3 has been included in the system to satisfy those customers requiring a continuous assessment of the TL.

11J.3.4 Any variation of the procedure described above (for example, where there is a requirement for notification of the onset and cessation of TL 1 only) will be subject to local agreement and written confirmation by the customer authority.

11J.4 Thunderstorm Risk The term "Thunderstorm Risk" (TR) is to be used only in relation to the occurrence of thunderstorms affecting areas or remote sites. (A remote site is defined as a site without a forecaster on duty.) The use of the word "risk" is intended to convey to customers that the assessment has been originated by an off-site forecaster and is thus less precise than otherwise might be expected. This is because forecasters with responsibilities for areas and remote sites do not have the facilities to monitor developments as closely as at their own locations.

(A.L.1)

11J.4.1 It will be noted that customers at some sites (normally Defence Services stations) will receive notification of TL during weekdays when there is a forecaster on duty, but notification of TR at other times when meteorological support is provided by a forecaster at a distant location.

11J.4.2 When applied to remote sites the TR will be an assessment for the area in which the remote site is located. The extent of the area to which the TR refers is left to the discretion of an Officer-in-Charge, but it should not normally exceed that covered by routine issues of Area Forecasts.

11J.4.3 Notification of a TR is given in the form of a single figure assessment, prefixed by the words "Thunderstorm Risk", in accordance with the following scale:

Thunderstorm Risk Category		Definition
1.	(High)	Thunderstorms will* develop/have developed in the area.
2.	(Moderate)	Thunderstorms may** develop in the area.
3.	(Low)	Thunderstorms are not expected in the area.

* The "will" indicates a very high degree of confidence.

** The "may" indicates a degree of uncertainty and implies that thunderstorm activity cannot be discounted entirely.

11J.4.4 A TR is to be used, whenever possible to update a thunderstorm warning in respect of an area or remote site.

11J.4.5 After the issue of a thunderstorm warning the TR is only to be raised to TR 1 when the forecaster considers that thunderstorm activity is imminent. TR 1 may be preceded by the issue of a TR 2 (at the discretion of a forecaster) to warn that the issue of a TR 1 is being considered. A TR 1 should not normally be reduced to a lower category until thunderstorm activity in the area has ceased. However, a forecaster may use discretion to modify a TR for a remote site following direct consultation with the customer to discuss a situation.

11J.4.6 Notification of a TR should normally include an indication of the period of validity. Recipients must be notified of any amendments.

11J.4.7 It should be noted that the issue of a thunderstorm warning does not necessarily require the immediate issue of a TR 2. There will also be occasions when it will be necessary to notify customers of a TR 1 or TR 2 before issuing a thunderstorm warning. It is expected that the majority of customers will require notification only of TR 1 and TR 2. TR 3 has been included in the system to satisfy those customers who may require a continuous assessment of the TR. Assessments of the TR may be included in routine forecasts if requested by a user authority.

11J.4.8 Any variation to the procedures above will be subject to local agreement and written confirmation by the user authority.

11J.5 Use of the LR-TL-TR scheme Offices are to use the LR-TL-TR scheme as follows:

a. Defence Services TL or TR are normally to be used, except in respect to the flying of tethered balloons, where LR is to be used. Any other usage of LR is to be followed after agreement by DS Headquarters.

b. Commercial Services and other non-Defence Service units LR is normally to be used, but TR or TL may be used, on repayment terms, following agreement with the appropriate Headquarters Branch.

c. The periods of LR forecasts for NGC are given in Annex G. An indication of timing, where possible, is useful when variations in risk are expected.

Notes

1. The detailed mechanisms of the separation of electric charges in clouds are still not completely understood, but there is little doubt that they are associated with strong vertical currents and the formation of precipitation. It is probable that the presence of ice crystals within cloud is also an essential condition.

2. The categories of LR are based on the following assumptions:

a. The lightning probability is very high in the presence of a cumulonimbus cloud.

b. The lightning probability is low in the presence of only cumulus mediocris and congestus.

c. The lightning probability is nil in the presence of only cumulus humilis and other non-frontal clouds and, of course, in the absence of cloud.

3. "Lightning risk nil" is not to be used if there are fronts over or approaching the area.

4. The choice between categories 4 and 5 is determined by the likelihood of convective cloud of greater vertical extent than fair weather cumulus.

5. Category 4 LR deals with cumulus mediocris and congestus. Note that:

a. When cloud tops fail to reach the 0 °C level convection may or may not be vigorous, showers may occur but there cannot be any ice crystals. Current theories would suggest, therefore, that the lightning risk would be lower than with cumulonimbus, and in fact experience suggests that the risk is indeed low. However, a discharge and especially an induced charge, cannot be ruled out entirely, especially with deep cumulus congestus producing showers. It is therefore inappropriate to use category 5 in the presence of cumulus mediocris and congestus that fail to reach the 0 °C level.

b. When the cumulus tops are expected to rise above the 0 °C level the forecaster is faced with the problem of deciding whether or not cumulonimbus will develop. If he/she is not confident of this then category 3 should be used.

6. Evidence suggests that the lightning risk is comparatively high in certain wintry weather situations, for example, in a cold north-easterly airstream in which convection over the relatively warm North Sea, although very limited in the vertical, is vigorous enough to give rise to "wintry showers". On occasions the convective nature of this cloud is all too apparent, but on others the main convective cells are masked by a general layer of stratocumulus cloud. These cells are in an environment more favourable for ice crystal development than if they occur in isolation and the tendency to pass into the cumulonimbus stages is enhanced. Warning categories 1, 2 or 3 of LR are appropriate on such occasions. Satellite imagery is helpful. It is emphasized that cumulonimbus clouds do not always have great vertical extent.

7. Forecasters should be aware that in a strong electric field an earthed conductor such as an electricity pylon may experience an electrical discharge where none would have occurred otherwise. It will, however, be impossible to differentiate between induced and natural lightning in forecasting risks.