SCIENCE & TECHNOLOGY IN SOCIETY

6

ASE

SATIS

ABOUT SATIS

Science and Technology in Society units are designed to be used in conjunction with conventional science courses, particularly those leading to GCSE examinations. Each unit has links to major science topics as well as exploring important social and technological applications and issues.

The units are self-contained and generally require about 2 periods (around 75 minutes) of classroom time. Each unit comprises Teachers' Notes (blue sheets) and Students' materials (white sheets). Full guidance on use is given in the Teachers' Notes accompanying each unit, which also include background information and suggest further resources.

Each SATIS book contains ten units. The units are numbered in a system giving the number of the book followed by the number of the unit within that book. Thus the first unit in the first SATIS book is numbered 101.

In addition to the SATIS books, a general Teacher's Guide to the project is available, giving guidance on some of the teaching techniques involved as well as ideas for further activities.

Many people from schools, universities, industry and the professions have contributed to the writing, development and trials of the SATIS project. A full list of contributors appears in the Teachers' Guide.

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SATIS 6
List of units in this book

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Electricity on Demand

Contents: Decision-making task concerning electricity generation and the use of different types of power stations.

Time: 2 periods.

Intended use: GCSE Physics and Integrated Science. Links with work on electricity generation and transmisson, energy transformation and power.

Aims:

- To complement prior work on electricity generation and energy changes
- To describe the different types of power stations in use in Britain, and their relative advantages and disadvantages
- To show the planning and decisions that have to be made to ensure a reliable and economic supply of electricity on demand
- To provide opportunities to practise skills in planning and decision-making.

Requirements: Students' worksheets No. 601. Scissors.

The unit is in two parts.

Part 1 gives information on electricity generation, with particular reference to the North West Region of the CEGB.

Part 2 is a decision-making task in which students plan which power stations to use at different times in order to generate sufficient electricity at an economic price.

Background information

In part 1 a certain number of simplifications have been made. Some of the power stations can in fact run on more than one type of fuel — for example, Padiham can use oil or coal. For simplicity only one fuel cost is given.

At some stations there are sets of equipment which use gas turbines. These are very expensive to run but in difficult situations they can be used to 'top up' the system. The gas turbines can be used in an emergency to start up the power stations themselves. The combined capacity is only 0.2 per cent of total capacity.

In Part 2 it is probably best if students work in pairs. With able students, teachers may wish to withhold Figure 11, which gives help with the answer.

Students should not find it hard to arrange power stations in order of cost to meet the demand. The most difficult part of the task is using the pumped storage capacity in the most cost-effective way, since it is difficult to quantify how much capacity is spare. Most students will do this approximately, by eye, but some may realize that the quantity of available spare energy is given by the area above the graph (the shaded area in Figure 11). For simplicity it is assumed that the pumped storage stations are 100 per cent efficient — in other words, they convert all the stored energy back into electricity. Their efficiency is in fact about 85 per cent, so this is not a bad approximation.

Further resources

Understanding Electricity, the educational service of the electricity supply industries, has a wide range of resource materials available which relate to electricity generation and distribution. Catalogue from: Understanding Electricity, Electricity Council, 30 Millbank, London SW1P 4RD. These resource materials include *Power Package,* a computer simulation of electricity generation and supply.

The Granada TV series *Physics in Action* includes two very useful programmes relating to electricity generation and supply, which can be recorded off-air for school use. Transmission times can be found in the ITV for Schools programme schedule.

Acknowledgements Figure 1 supplied by the Electricity Council; Figure 2 is reproduced by permission from *Science* by Graham Hill and John Holman (Nelson); Figures 3, 5 and 7 supplied by CEGB: Figure 4 supplied by the United Kingdom Atomic Energy Authority.

ELECTRICITY ON DEMAND

Part 1 Generating electricity

When you turn an electric switch, you expect an instant supply of electricity, at a constant voltage. You also expect the electricity to be cheap.

The Central Electricity Generating Board (CEGB) has the job of generating electricity in England and Wales. The CEGB is split up into regions (Figure 1). In this unit we will be concerned with the North West Region.

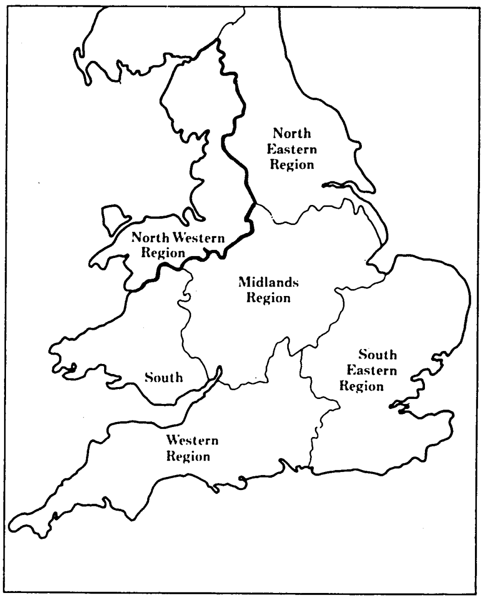

Figure 1 Regions of the CEGB

Electricity comes from a mix of different types of power station. In the North West Region, these are:

Nuclear
Coal
Oil
Hydro-electric
Pumped storage.

Electricity supply and the National Grid

All Britain's power stations are linked into the National Grid (Figure 2). This is a network of power lines that feeds electricity to all parts of the country. Electricity is moved around at 400 000 volts, 275 000 volts and 132 000 volts. It is transformed to lower voltages for use by the consumer.

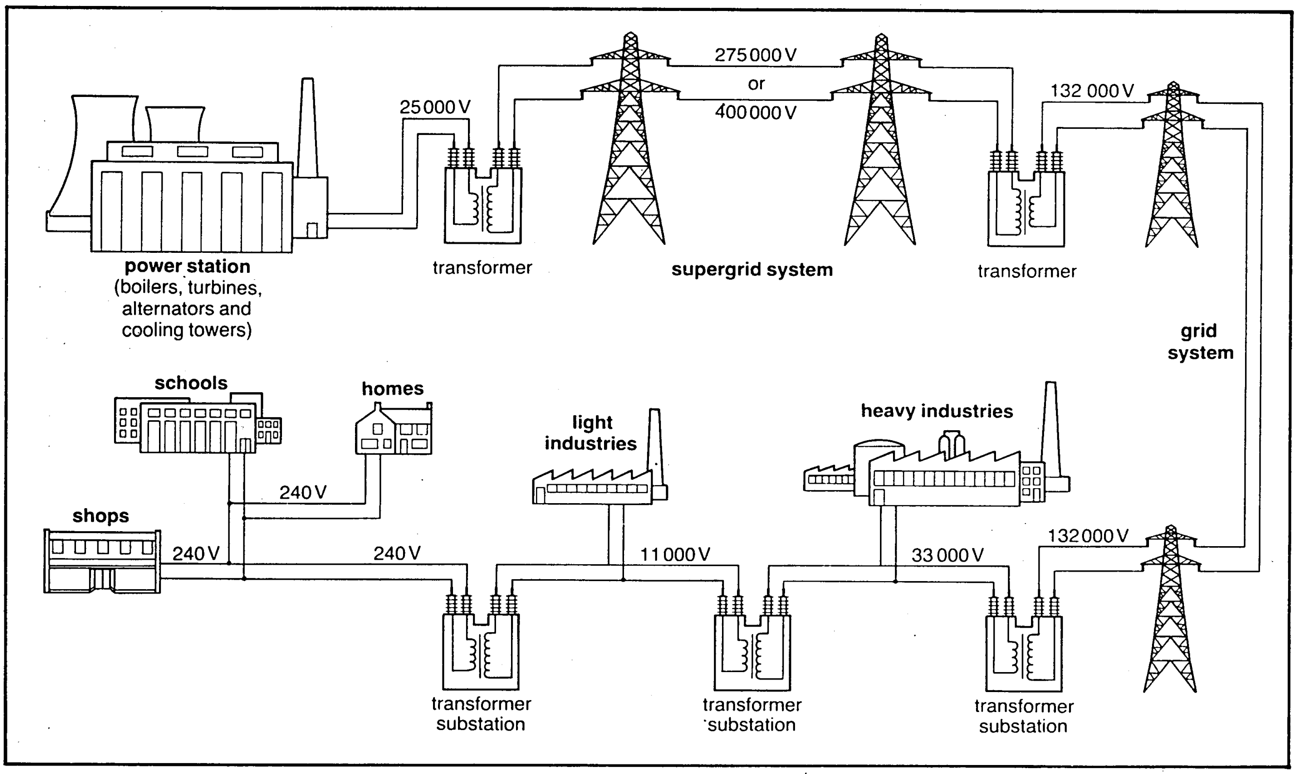

Figure 2 The National Grid

The CEGB must supply electricity on demand. It tries to do so at the lowest possible cost. Each power station produces electricity at different costs and in different quantities. When demand for electricity is low, only the cheapest power stations need be used. The more expensive power stations are only used when demand is high. In Part 2 of this unit you will make decisions on which power stations to use at different times.

The Regional Control Centre tells each power station when to operate and feed electricity into the Grid. There are times when the North West Region has to help other regions which may be short of power. At other times the North West Region may use excess power from other regions. This is controlled by a National Centre. As a general rule, though, the North West Region is fairly self-sufficient and able to look after its own electricity demand.

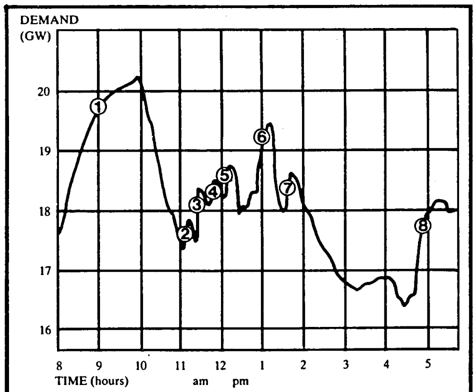

Figure 3 Changes in demand for electricity during Royal Wedding Day, 1981, when Prince Charles married Princess Diana. Notice how the demand jumped after each high point of the wedding, as people left their TVs to switch on kettles, etc:

1 Television scene setting
2 Following bride's arrival at the altar
3 End of solemnisation of matrimony
4 End of prayers
5 Signing registers
6 Return of procession to Buckingham Palace
7 Last appearance on palace balcony
8 After couple left Waterloo Station

Types of power stations

Before trying the decision-making task, you will need some information about the different types of power station.

Nuclear power stations

These make electricity relatively cheaply. They are used to provide the 'base-load' — they run all the time.

There are three nuclear power stations in the North West Region. Their total output is 2500 megawatts.

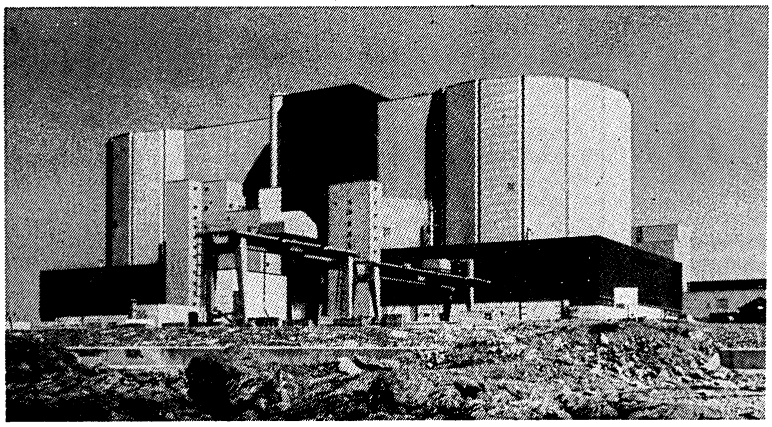

Figure 4 Wylfa nuclear power station

Coal-fired power stations

Before nuclear power stations were built in Britain most of our electricity was generated from coal. The older supply system used many small coal-fired stations each feeding customers in their locality. In the last twenty years large coal-fired power stations have been built. These are often near to Britain's major coal fields.

Generating costs are not as low as for nuclear stations, but usually cheaper than oil stations. The cheapest coal-fired power stations are the big modern ones. Older, smaller coal-fired stations are relatively expensive to run. It is possible to start up and shut down coal-fired stations in a few minutes if their boilers are kept ready at standby.

There are seven coal-fired power stations in the North West Region. Their total capacity is 2471 megawatts.

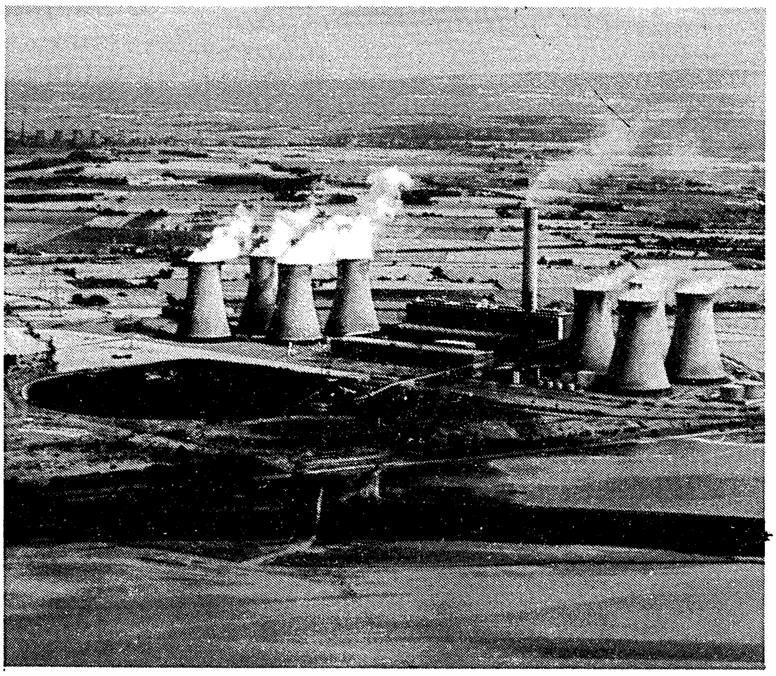

Figure 5 Fiddlers Ferry coal-fired power station

Oil-fired power stations

Britain built several large oil-fired power stations in the late 1960s. At the time they promised low-cost electricity because oil was cheap. Since 1973 the cost of oil has increased dramatically. So now the cost of electricity from this fuel is high. Oil stations are generally only used for peak demand or when other stations are under repair.

There are two oil-fired power stations in the North West Region. Their combined capacity is 1100 megawatts.

Hydroelectric power (HEP) stations

In some parts of the world with high rainfall, hydroelectric power stations provide very cheap electricity. In the North West Region of the CEGB there are only a few small hydroelectric power stations, in North Wales. Their combined capacity is 104 megawatts.

Pumped storage

The North West Region has two **pumped-storage schemes** which are the envy of the rest of the world. They provide a way of storing electrical energy when demand is low, ready to use when demand is high.

Figure 6 illustrates how the scheme works.

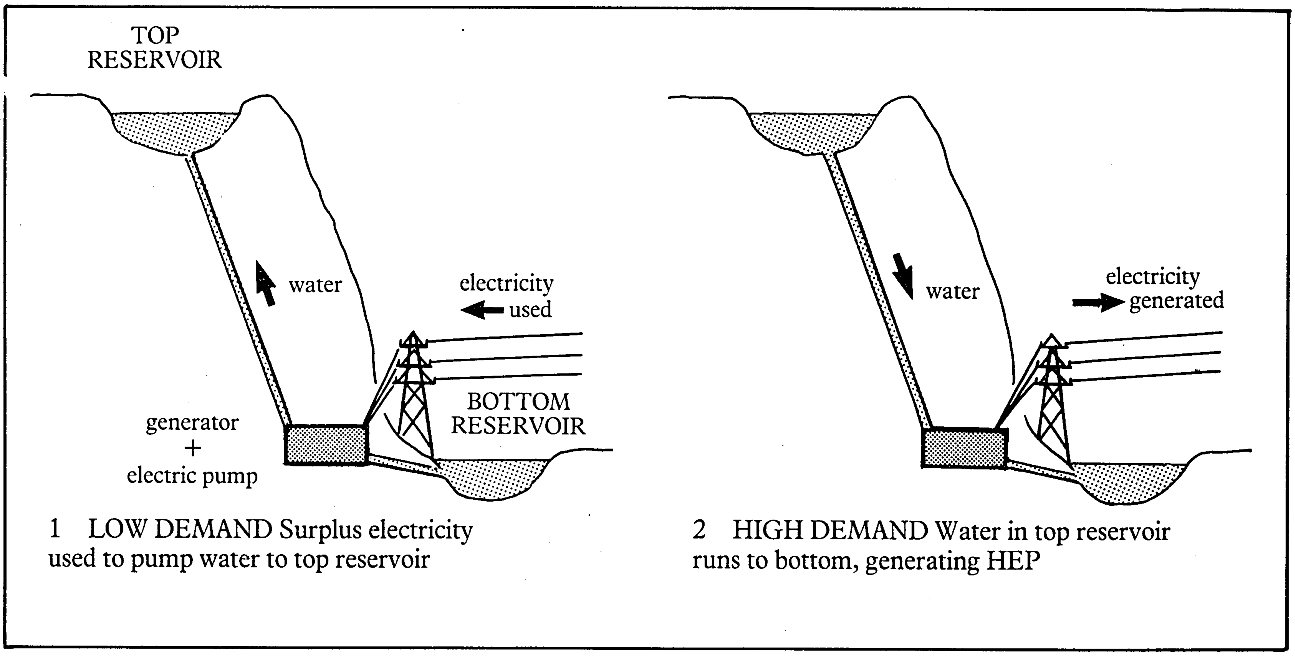

Figure 6 Pumped storage

At low demand times, there is spare electricity from other power stations. This is usually during the night. This electrical energy is used to pump water to the top reservoir. In this way energy is stored as gravitational potential energy. When demand is high, extra electricity is needed. The potential energy is converted back to electrical energy by allowing the water to flow back down, driving the generators.

There are two pumped-storage stations in the North West Region, both in the mountains of Snowdonia. The bigger of the two is at Dinorwig. The top reservoir at Dinorwig takes 5 to 6 hours to fill. When it is full, Dinorwig can generate 1800 megawatts for up to 5 hours. The combined capacity of the two pumped-storage stations is 2160 megawatts.

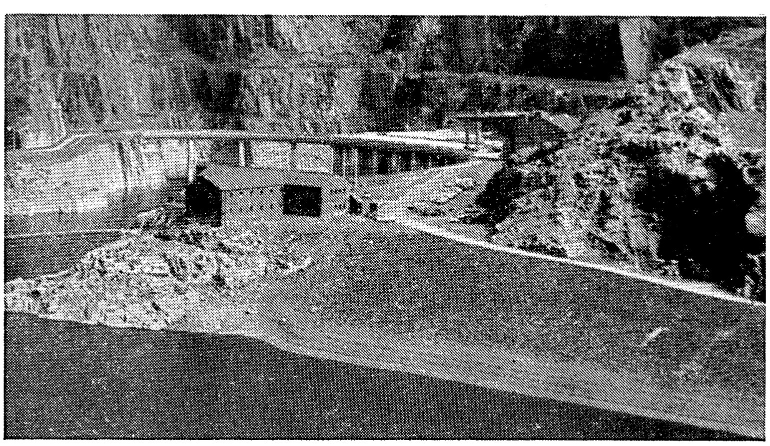

Figure 7 Dinorwig pumped-storage station — the bottom reservoir

Details of power stations in the North West Region

Table 1 gives information about all the stations.

Table 1 Power stations in the North West Region

Name of power station	*Type*	*Normal output /megawatts*	*Fuel cost per megawatt-hour*
Heysham 1	Nuclear	1320	£7.50
Trawsfynydd	Nuclear	380	£7.50
Wylfa	Nuclear	800	£7.50
Agecroft	Coal	215	£18.50
Bold	Coal	160	£21.00
Carrington	Coal	230	£21.00
Fiddlers Ferry	Coal	1700	£20.00
Huncoat	Coal	80	£21.00
Roosecote	Coal	60	£27.00
Westwood	Coal	26	£27.00
Ince B	Oil	1000	£26.00
Padiham	Oil/Coal	100	£26.00
Cwm Dyli	Hydro	5	nil
Dolgarrog	Hydro	25	nil
Maentwrog	Hydro	24	nil
Rheidol	Hydro	50	nil
Dinorwig	Hydro/Pumped-storage	1800	nil*
Ffestiniog	Hydro/Pumped-storage	360	nil*

* For the pumped-storage stations, fuel costs are nil when generating. When pumping water up, fuel costs depend on which other power stations are running.

The location of these power stations is shown on the map in Figure 8.

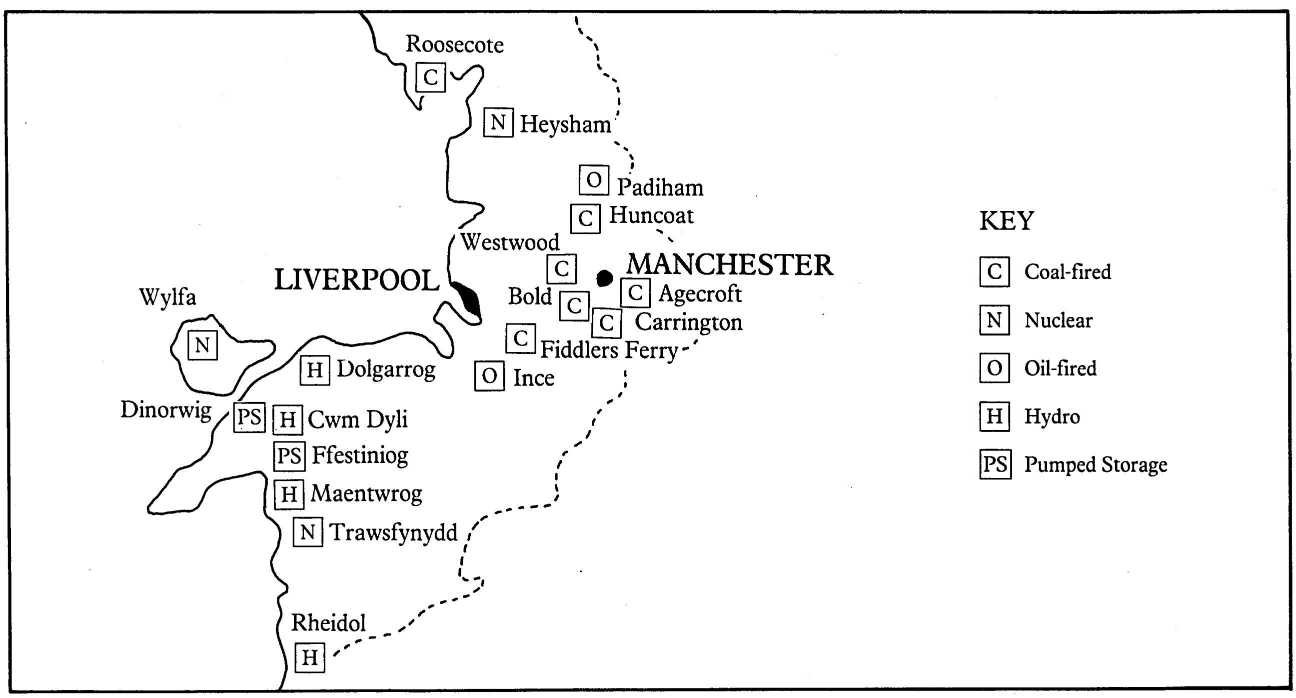

Figure 8 Power stations in North-West Region

Part 2 Task: Deciding which power stations to use

It is best to work on this task in pairs.

Imagine you are engineers in the Regional Control Centre. Your job is to make sure enough electricity is generated, at the lowest possible cost.

Look at the graphs in Figures 9 and 10 on the next two pages. They show the expected demand for electricity at different times of day. Figure 9 is for a typical summer day, and Figure 10 is for a typical winter day.

Your task is to plan which power stations to use during each five-hour period. You must choose your power stations to give the lowest cost electricity. At any time you must have a slight surplus over the expected demand. Do the task for the summer first, then for winter.

In Figure 11 an example has been done for you to show the idea.

Figure 12 has blocks to represent the capacities of the different power stations. The blocks are drawn to the same scale as the demand graphs. You can cut out the blocks and place them on the graphs to help with your planning. When you have planned each period, write in the power stations on the graph.

Remember to use the pumped-storage stations. When demand is low, you can use surplus electricity to store energy in them. You can then use this stored energy at high demand times.

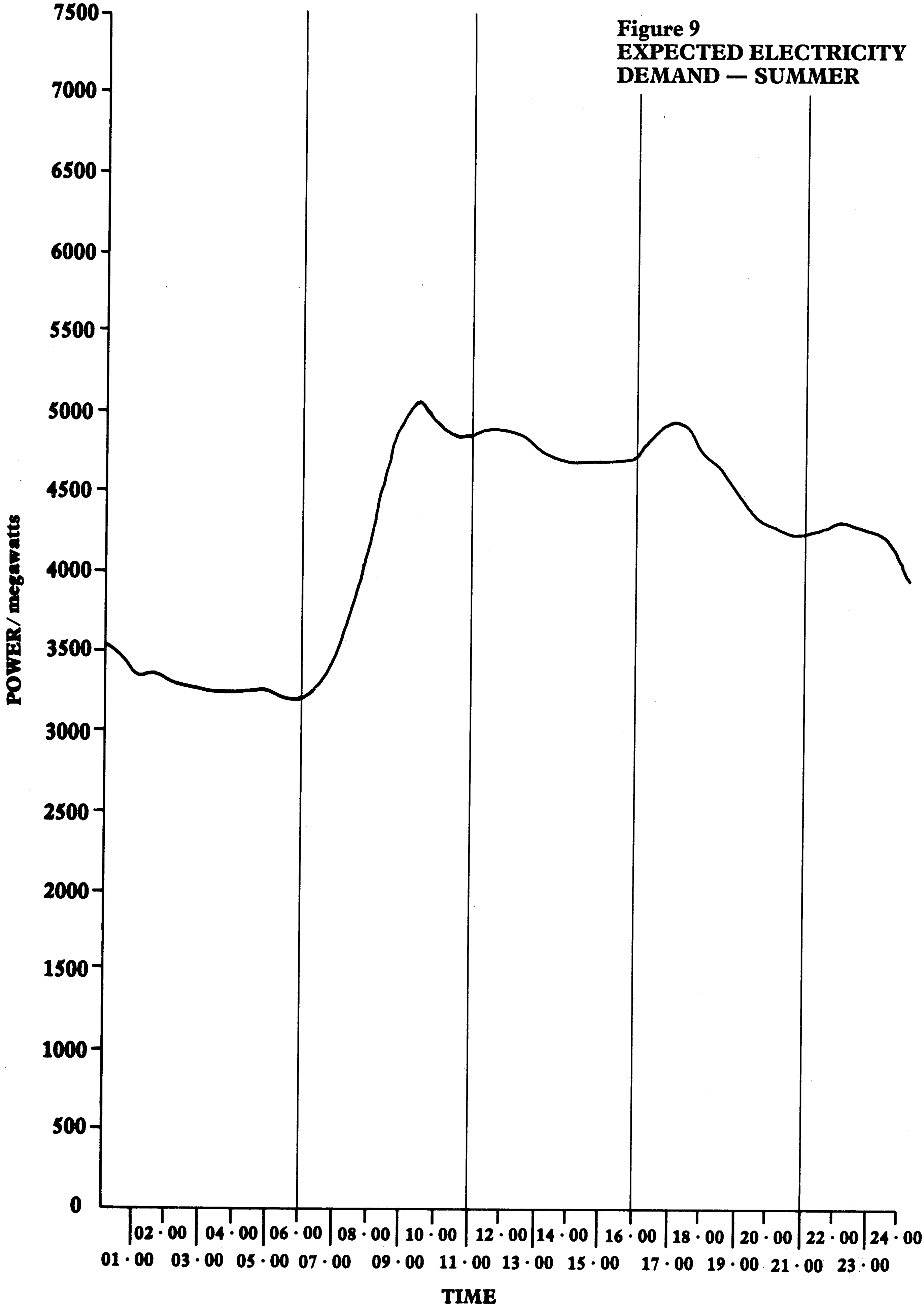

Figure 9
EXPECTED ELECTRICITY DEMAND — SUMMER

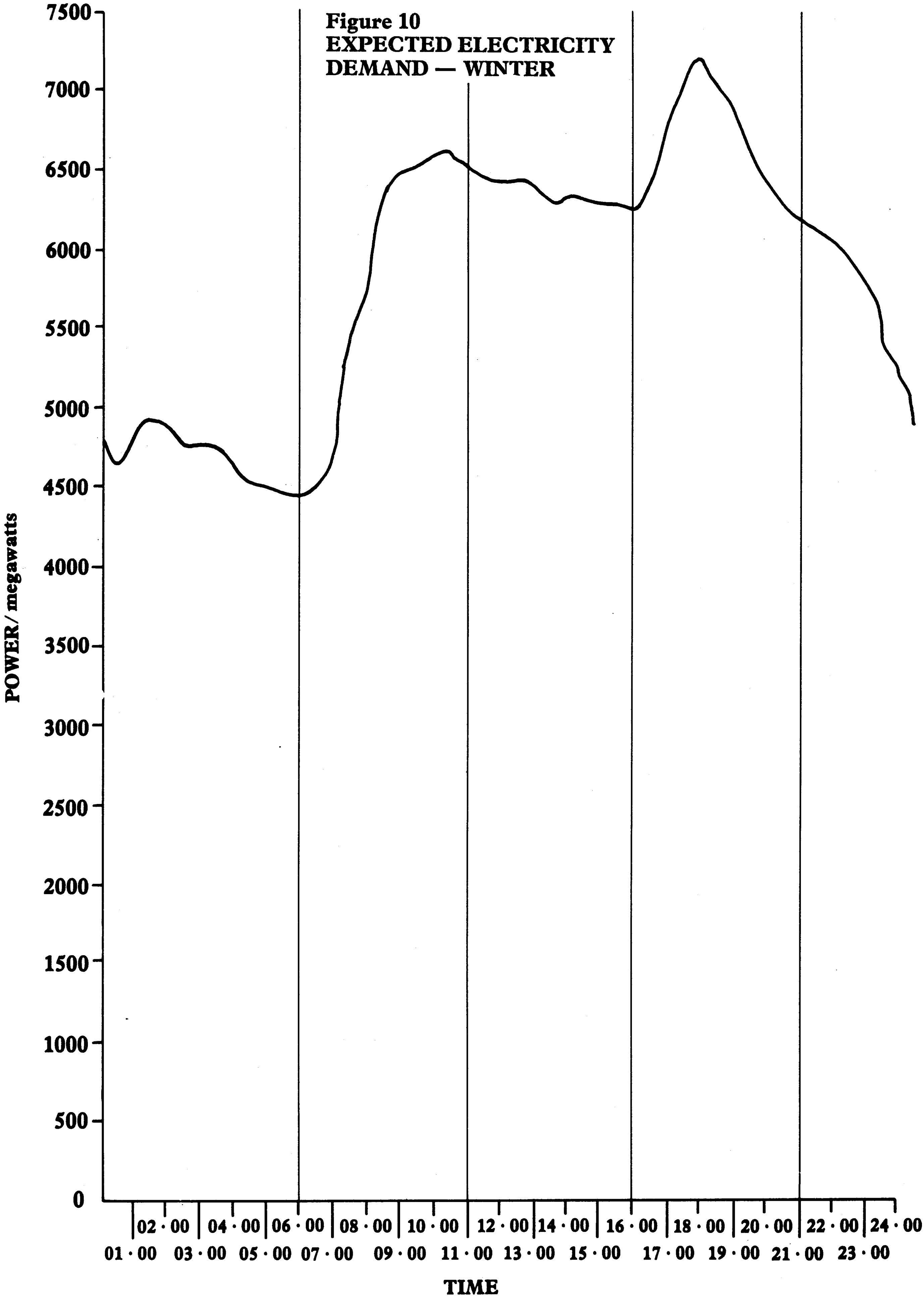
Figure 10
EXPECTED ELECTRICITY
DEMAND — WINTER
POWER/ megawatts
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
02 · 00
04 · 00
06 · 00
08 · 00
10 · 00
12 · 00
14 · 00
16 · 00
18 · 00
20 · 00
22 · 00
24 · 00
01 · 00
03 · 00
05 · 00
07 · 00
09 · 00
11 · 00
13 · 00
15 · 00
17 · 00
19 · 00
21 · 00
23 · 00
TIME

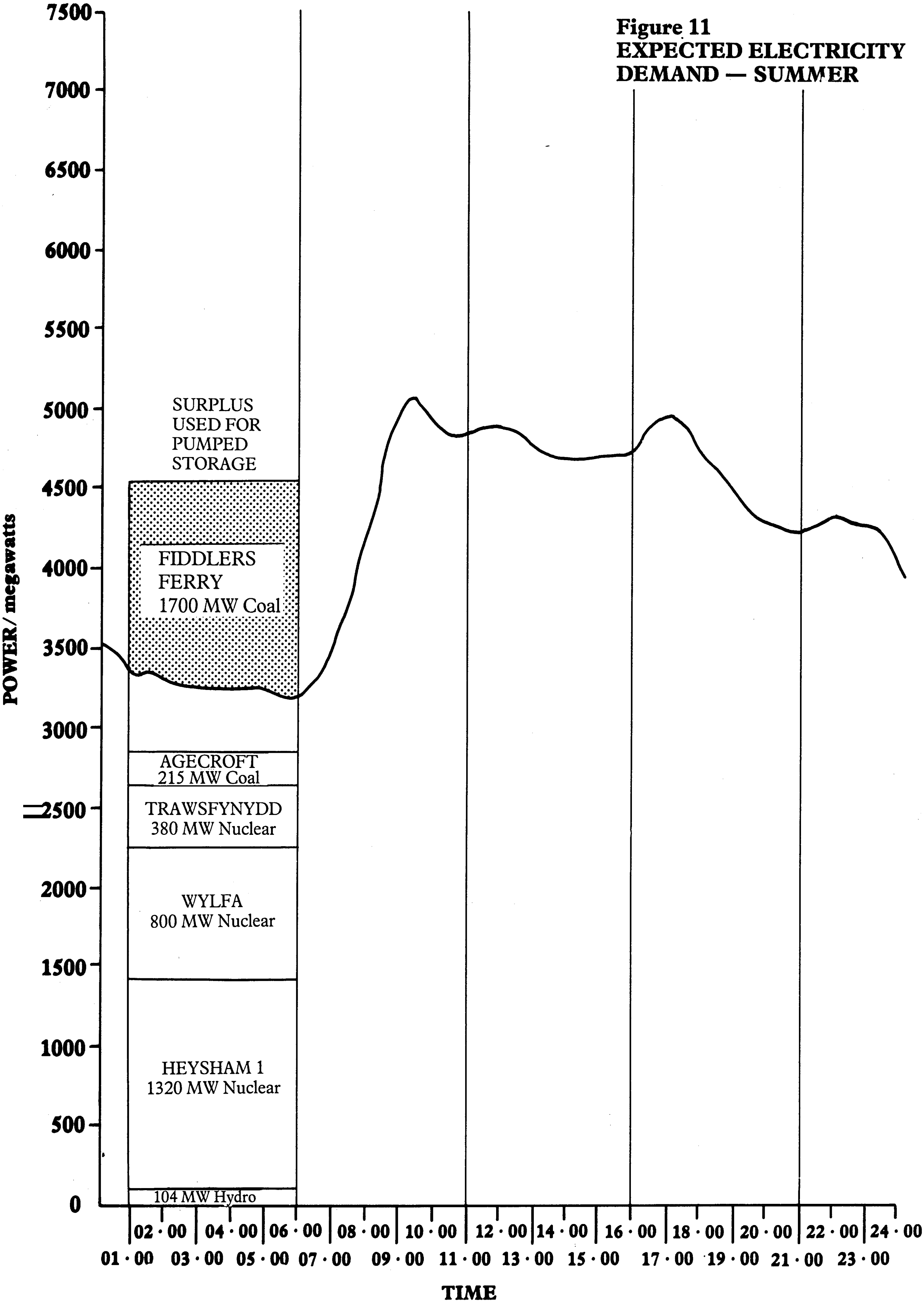
Figure 11
EXPECTED ELECTRICITY
DEMAND — SUMMER
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
POWER/ megawatts
SURPLUS
USED FOR
PUMPED
STORAGE
FIDDLERS
FERRY
1700 MW Coal
AGECROFT
215 MW Coal
TRAWSFYNYDD
380 MW Nuclear
WYLFA
800 MW Nuclear
HEYSHAM 1
1320 MW Nuclear
104 MW Hydro
02·00
04·00
06·00
08·00
10·00
12·00
14·00
16·00
18·00
20·00
22·00
24·00
01·00
03·00
05·00
07·00
09·00
11·00
13·00
15·00
17·00
19·00
21·00
23·00
TIME

Figure 12 Scale blocks to represent power station capacities. Cut them out to help you with the Task.