Local Energy Centres

Edited by

N. J. D. LUCAS
M.A., Ph.D., C.Eng., M.Inst.F.

Mechanical Engineering Department, Imperial College, London, England

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Contributors

W. E. Baillie, M.I.E.C., M.I.S.M.
Building and Services Manager, Kalamazoo Ltd, Birmingham, UK.

M. V. Casey, M.A., D.Phil.
Senior Engineer, W. S. Atkins & Partners, Epsom, Surrey, UK.

J. H. Chesters, O.B.E., D.Sc., C.Eng., S.F.Inst.F., F.R.S.
Chairman of Watt Committee on Energy, Independent Furnace Consultant.

A. R. B. Cleugh, B.Sc., M.I.Chem.E., A.C.G.I.
Senior Engineer, W. S. Atkins & Partners, Epsom, Surrey, UK.

I. Fells, M.A., Ph.D., C.Eng., F.Inst.F., C.Chem., F.R.I.C.
Professor of Energy Conversion, University of Newcastle upon Tyne, UK.

K. Goldsmith, M.Sc.(Eng.), A.C.G.I., F.I.Mech.E., F.I.E.E.
Managing Director, Londwatt Consultants Ltd, London, UK.

J. Hellemans
Managing Director, Dutch Association of Users of Steamboilers and Prime-movers, Amersfoort, The Netherlands. Vice-President Fédération Internationale des Producteurs Autoconsommateurs Industriels d'Electricité.

R. C. Huxford, F.Inst.F., M.I.H.V.E.
Chief Fuel Technologist, National Coal Board, London, UK.

P. J. Jonas, B.Sc.(Tech.), B.Sc.(Econ.), C.Eng., M.I.E.E., M.I.Mech.E.
Senior Principal Scientific Officer, Economics and Statistics Division, Department of Energy, London, UK.

B. Köhler, D.Sc.
Managing Director, Heat and Power Engineering Division, AB Energikonsult, Stockholm, Sweden.

A. LAWSON, F.I.D.H.A.
Chairman, District Heating Association, UK.

E. MCEWEN, C.B.E., D.Sc., C.Eng., F.I.Mech.E., F.R.S.E., P.P.I.Mech.E.
Visiting Professor, Imperial College, London, Vice-Chairman, Joseph Lucas Ltd, Birmingham, UK.

W. MURGATROYD, M.A.(Cantab.), Ph.D.(Cantab.), M.I.E.E.
Professor of Thermal Power, Imperial College, London, UK.

S. NORDSTRÖM, M.Sc.
Consulting Engineer, Heat and Power Engineering Division, AB Energikonsult, Stockholm, Sweden.

U. NORHAMMAR, M.Sc.
Consulting Engineer, Heat and Power Engineering Division, AB Energikonsult, Stockholm, Sweden.

J. A. O'SHEA, B.E.(Mech. & Elec.), Dr.Ing., M.I.E.E.E.
Managing Director, Integrated Energy Systems Ltd, Preston, Lancs., UK.

R. A. PEDDIE, B.Sc., F.I.E.E., F.I.Mech.E., F.Inst.F.
Chairman, South Eastern Electricity Board, Hove, Sussex, UK. Board Member, Central Electricity Generating Board, London, UK.

E. J. PERRY, C.Eng., M.I.Mech.E., F.I.R.
Chief Engineer, W. S. Atkins & Partners, Epsom, Surrey, UK.

P. D. SPAWFORTH, F.R.T.P.I., R.I.B.A.
Chief Planning Officer, City of Wakefield Metropolitan District Council, Yorks., UK.

J. TATCHELL, B.Sc.(Eng.), A.C.G.I., F.I.E.E.
Energy Adviser, Imperial Chemical Industries Ltd, Agricultural Division, Billingham, Teesside, UK.

F. L. TOMBS, B.Sc., LL.D., C.Eng., F.I.Mech.E., F.I.E.E., F.B.I.N.
Vice-President, Institution of Electrical Engineers, Chairman Designate, Electricity Council, UK.

J. K. WRIGHT, M.A., Sc.D., F.Inst.P., M.I.E.E., C.Eng.
Generation Studies Engineer, Central Electricity Generating Board, London, UK.

Foreword

It is a pleasure as well as an honour to open this conference. It is an extremely important subject and the conference is well timed. I say this with only a minor reservation, because you will have noted that conferences on solar energy tend to take place in the winter and we seem to meet in the summer to discuss heating.

The various studies which have been published on energy demand and supply in the future show that, as a result of population pressure, economic growth and a continuation of the general improvement in the standard of living, the world will run into serious energy problems before the end of the century. In some parts of the world such problems are already pressing.

Such energy studies generally enumerate the energy delivered to various sectors, for instance the electricity, gas and fuel oil delivered to homes or factories. A separate item, described as the 'processing losses', gives the difference between this delivered or net energy and the energy in the primary fuel used to generate and deliver the electricity, make and deliver the gas and oil, etc. In case anyone has any difficulty in visualising what is meant by processing losses, they are analogous to what you lose when the government takes the taxes, etc. off your gross pay; the net energy is what ends up in your pocket.

In 1972 in the UK, the processing losses amounted to 29 % of our primary energy consumption or to 1·24 million barrels per day of oil equivalent or 62 million tons of oil equivalent per year, i.e. 60 % of our then imports. In the year 2000 in the UK, these losses might amount to as much as 110 million tons of oil equivalent per year and in the western world the processing losses in 2000 might exceed the net energy used in the world today.

It must be clear to practically everyone that, in the future, as energy becomes more scarce, any process such as electricity generation or making gas or liquid fuel from coal will need to be carefully examined

first to minimise the processing losses and second to approach more closely the thermodynamic limit in which all the free energy in the reaction is made properly available.

I am sorry that Dr Walter Marshall is not here today because to him must go the credit for the initiation of an interesting and comprehensive study of combined heat and power done by a committee under the chairmanship of Dr Wright, who will be speaking to us during the conference.

Many studies have been made of combined heat and power but this is the first which reflects the impact of the new energy outlook—an outlook which is making one Eastern European country consider using nuclear power plants combined with district heating within the confines of its major cities.

Most studies have been at a commercial or large-scale level, with district heating as an extension of a power station. This conference seeks to examine smaller situations. As I said in the W. W. Campbell Memorial Lecture at the Institution of Mechanical Engineers a short time ago, everyone points to the waste heat (public processing losses) from power stations, without realising that by using a premium fuel just to warm water a few degrees they are committing just as wicked a thermodynamic sin—they are producing hidden or private processing losses. Or, using the previous analogy, they are wasting the income which gets to their pockets on tobacco, drink and gambling. To consider what can be done to improve the use of fuel by generating power when heat is needed is one of the objects of this conference outlined in Professor Murgatroyd's introductory paper. The whole objective is to bring together the very many aspects of what may ultimately become as important a network as our present-day systems of large generating stations, namely a system of local energy centres whose conditions of operation and criteria of design and economy will be different and are as yet imperfectly understood.

SIR WILLIAM HAWTHORNE
Churchill College
Cambridge

Preface

This book is about getting the maximum value out of fuel resources; it covers the activities variously known as district heating, combined heat and power and total energy.

It has long been recognised that the processes by which fuel can be converted to power could be adapted to recover the heat which now goes to waste; it is also true, but less widely recognised, that the combustion of premium fuel to produce exclusively low grade heat is a wasteful practice; the efficiencies of processes producing solely heat or solely power have been studied and improved to the neglect of the practice which brings highest added value, i.e. combined heat and power. As a result, much of the plant now installed cannot be adapted to combined heat and power—this applies not only to the giant central condensing power station, but also to the small low pressure industrial boiler.

Along with—and not instead of—the centralisation of power production should go the alternative practice of maximising the value added to fuels in local energy centres.

The aim of this book is to examine the topic of combined heat and power without the usual unproductive conflict which attends the matter. As one might expect in such a controversial matter, it is impossible to completely avoid an adversarial format, but this is inevitable where competing interests are involved. The book certainly serves to identify the principal topics of dissent and I hope that some of the suggestions it includes for encouraging local energy centres will be adopted.

The principal bone of contention is the nature of electricity tariffs. Tariffs for the transfer of electricity contain two elements, a capacity credit and credits for units of electricity generated. The view of the supply industry is that the capacity element will only be paid if the supply is firm, permanent and on peak and the unit price paid will lie

between the producer's costs and the marginal cost to the public supply. In the discussion the electricity supply industry claims that tariffs are not considered by industrialists to be an important constraint on their decisions as to whether or not to install combined heat and power plant.

The opposing view is forcefully put by those who argue that no benefit from the unit price element is owing to the public supply industry because they take no risk. They propose that the electricity supply industries should think not only of a market for kWh but also of a market for kW and that it should think in terms of selling standby capacity to local energy centres. The point is also made that transfer charges are important when schemes involve the sale of large quantities of electricity; this is likely to be the case when diesel engines are used as the prime mover.

The consensus of opinion among the contributors appears to be that there are three separate situations.

(a) Industry pays for and operates the plant itself and takes all the financial risk. In this case there is no reason why the electricity supply industry should benefit and the real rent should go entirely to industry.
(b) Industry pays for plant by government loans made available at interest rates calculated to bring its investment appraisal techniques into line with those of public enterprise. In this case the rent should be shared.
(c) Area Boards construct and operate plant. In this case, which is where the largest opportunities exist, the rent should again be shared for purely practical reasons of providing incentives to both sides.

Capacity credits are difficult to assess fairly; there is a clear upper limit defined by the capital charge on a gas turbine or the annual costs of maintaining otherwise obsolete plant. The credits given to industry remain unknown, but it appears that the rates published in CEGB studies for district heating in Peterborough and Battersea are fair and these should be applied also to industry.

It is alleged several times in the book that load matching is an important constraint on the economic viability of local energy centres. The opposing view is that this relates only to quasi-autonomous systems making only small exchanges of power with public supply. On this view the real opportunities lie with systems

involving a large transfer of power such as that proposed by the Midlands Board. This scheme using diesel engines owned by the electricity supply industry who dispose of the electricity and sell steam to industry is the most encouraging development for a long time.

The appropriate degree of competition between public enterprise is another area of discord. In this book one author suggests that it is perfectly proper to zone certain areas of cities for different forms of energy supply and that if this is not done gas will tend to squeeze out district heating from areas in which it might be the cheapest option. This is an interesting proposition which deserves further consideration.

The advantages of the diesel engine are stressed several times. It was agreed that the Energy Paper 20 should have included a treatment of diesels and that diesel engines could have a good potential in industry. This interest is encouraging and it is to be hoped that more attention will be paid to diesels in further studies. The future availability of fuel supplies was alleged to be uncertain but this is not critical. Suitable fuel should be available over the life of a diesel engine installed now; at the end of its life it is reasonable to suppose that new fuels or new prime movers will be available.

The importance of correct energy pricing is stressed throughout the book.

It is evident from the contributions to this book that combined fuel and power is a most valuable contributor to energy supply, especially in industry, where the load factors are higher and the heat using infrastructure less cumbersome than in district heating. But even in the latter case, district heating permits flexibility of fuel use and it appears that it will be competitive with other ways of supplying space heat by the end of the century. This is an aspect of sufficient importance to justify initiatives now which do not necessarily satisfy the strictest of economic criteria.

N. J. D. LUCAS

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W. MURGATROYD

Introduction

We must all be aware of the difficult conditions which for several years have faced electricity utilities, particularly the CEGB. Long construction times for the large stations, compounded by delays in building and commissioning, and by vacillation about fuel policy on the part of the government, are making it almost impossible to produce credible forward plans. There is also a problem of dealing with cyclical changes in demand which take place over a time scale comparable with (or even shorter than) construction times—a potentially unstable situation. This problem was masked for many years by the steady long-term growth in demand, but recently as the growth component has decreased the cyclical changes have become so significant that annual consumption occasionally remains more or less stationary or actually falls. Not only has this exacerbated the CEGB's difficulties, it has also highlighted the problems faced by turbo-generator manufacturers, who are producing a special product in a market which is highly protected internationally and for which there is a worldwide surplus of construction capacity.

In addition to facing these serious difficulties, the utilities have more recently had to contend with the criticism—popularised though not initiated by the energy crisis—that because their generating efficiencies lie between 25 % and 40 %, they reject more energy in the form of unused heat than they produce as electricity. This is true, of course, and the generating authorities are well aware of it.

In the UK, the CEGB have published studies relating to the recovery and sale of heat rejected by modern large steam power stations. From these and other studies it seems clear that although there might be special circumstances in which this is attractive, in the great majority of cases there would be no savings of overall resources.

The most important factors contributing to this conclusion are:

(1) The cost of transmitting, distributing and using the low grade heat energy.
(2) The fact that, to be useful, heat is required at a higher temperature than that rejected by a modern steam power station. If the temperature is raised, either by modifying the turbines or by the use of heat pumps locally, there is a net loss of electricity.
(3) Problems of building up a large and reliable heat load.

On a smaller scale, several groups have made studies of the combined production of electricity with district heating; many of these have been criticised by those who hold different views about the particular constraints, ground rules and costs adopted.

It is my belief that the time has come to adopt a new policy in respect of energy utilisation. We should examine the nation's requirements for heat, light and motive power as a whole and attempt to satisfy the joint need in the way which is most economic in resource use. One aspect of this—and it is only one of many—relates to the joint production of useful heat and electricity, sometimes called combined heat and power (CHP) or, in the USA, co-generation. In making this examination we should bear in mind some basic facts. Heat is an unstandardised commodity: different users require it at different temperatures and in a variety of media; it is relatively costly to transport and distribute and difficult to measure accurately. Electricity is, on the other hand, a highly standardised commodity and is easy to produce and control and measure to the required standards in units of all sizes from a few watts to hundreds of megawatts. A very efficient synchronised transmission network embraces the entire country and there are direct links with other countries.

This suggests that we should discard the notion of the 'waste heat' associated with electricity production and should, instead, and as a matter of policy, consider any local demand for heat as an opportuntiy to generate 'surplus electricity' which, if not required locally, would be supplied to the national grid. Each opportunity should be appraised in terms of its benefit to the nation, and to this end it would be necessary to adopt a uniform set of ground rules for comparing capital and operating costs of local and central generators, as well as a rational tariff for the two-way interchange of