COMMISSION OF THE EUROPEAN COMMUNITIES
DIRECTORATE-GENERAL FOR AGRICULTURE

AGRICULTURAL STUDIES

Consumption of energy in agriculture in the European Community

STUDY P. 219

FOR OFFICIAL USE ONLY

December 1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

FOREWORD

This study has been undertaken in the framework of the study programme of the Directorate General for Agriculture of the Commission of the European Communities.

The report was prepared by the ECONOMIST INTELLIGENCE UNIT (EUROPE) S.A., Avenue Louise, 137, Boîte 5, B-1050 Brussels.

The Division "Reports, studies, statistical information, documentation" of the Directorate-General for Agriculture participated in the work.

Original language : English

The present study does not necessarily reflect the views of the Commission of the European Communities in this area and in no way anticipates the Commission's future attitude towards this matter.

INTRODUCTION

The EIU undertook a study for the European Commission in 1974 on the implications of the energy crisis for Community agriculture. At the request of the European Commission, the EIU has undertaken the present study which was conceived as an updating and elaboration of the earlier study.

The earlier study provided statistical data for 1972 or 1973, depending on the sources used : the description and analysis of energy utilisation was essentially static. In the present study, the EIU has endeavoured to trace the trends in the period since 1972/73, depending on the availability of statistical data, and to identify energy utilisation in agriculture by source of energy, sector of activity and by region.

The first chapter provides a summary of the main findings of this study. More detailed reports for the Member States of the Community (excluding Greece) are contained in the subsequent chapters. The summary chapter contains a series of tables which are made up from data extracted from the national studies. The tables and accompanying commentary have been designed to provide an outline of the information in the main dimensions of the subject of the study :

- agriculture's share of national energy consumption
- energy input to agriculture, both direct and indirect
- direct energy input by fuel type
- consumption of petroleum-based fuels
- indirect energy
- direct energy input by application.

In most instances, it has been possible to provide comparable data for the countries of the Community, and in this respect the present study has produced more comparative data than did the earlier study undertaken in 1974.

The EIU is of the opinion that the data set out in the summary tables are broadly comparable. In the commentary which precedes each table, attention is drawn to situations where comparisons are implicitly made between figures which are incorporated in a table but which are not directly comparable with figures relating to other countries, because of differences in methods of evaluation.

To make broad spectrum comparisons in the Summary, categories have been grouped to overcome the problems of comparison arising from Member States adopting different definitions to categorise fuels and their uses. Again, the EIU is of the opinion that such categories provide an overall picture of energy utilisation which is comparable in outline if not in every detail.

The sources of information approached by the EIU in the course of the study are identified in the Appendix on Sources of Information. The EIU has preferred certain sources on the grounds that the data they provide are more comprehensive and reliable : these preferred sources have been used in compiling the summary tables contained in this report.

Where the EIU felt that it could put forward reasonable estimates to fill gaps in data available from recognised sources, this has been done. EIU estimates are placed between brackets.

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY - SUMMARY REPORT

CONTENTS

.../...

CONTENTS Page

Abbreviations and Symbols

The main abbreviations used in the report are explained below :

Kilo	: 10^3
Mega	: 10^6
Giga	: 10^9
Tera	: 10^{12}
Tonne	: metric tonne
Ha	: hectare
m2	: square metre
m3	: cubic metre
l	: litre
Hl	: hectolitre
TOE	: tonne oil equivalent = 10^7 Kcal
Kw	: Kilowatt
KWH	: kilowatt-hour
MWH	: megawatt-hour
GWH	: gigawatt-hour
J	: joule = 0.2388 Cal
MJ	: megajoule = 238.8 Kcal
GJ	: gigajoule = 238,800 Kcal
Cal	: calorie
Kcal	: kilocalorie
Tcal	: teracalorie
GER	: gross energy requirement
ESD	: energy specific demand
Eo	: energy necessary to obtain raw product
Et	: energy necessary for transformation
Cp	: calorific value of losses
Cf	: calorific value of final product
Cs	: calorific value of by-products
FU	: food unit (feed value of 1 kg of barley)
DERV	: diesel engine road vehicle (fuel)
SMD	: Standard-Man-Days

ADAS	: Agricultural Development and Advisory Service	(UK)
AI	: Agricultural Institute	(IRL)
BSL-ESB	: Electricity Supply Board	(IRL)
CBS	: Centraal Bureau voor de Statistiek	
CEREN	: Comité d'Etudes et de Recherches Economiques sur l'Energie	(FR)
CNEEMA	: Centre National d'Etudes et d'Expérimentation de Machinisme Agricole	(FR)
CPP	: Comité Professionnel du Pétrole	(FR)
CRISP	: Centre de Recherche et d'Information Socio-Politique	(BELG.)
DEF	: Danske Elvaerkers Forening	(DK)
DL	: De Danske Landboforeninger	(DK)
DS	: Danmarks Statistik	(DK)
EFGF	: Electricité de France Gaz de France	(FR)
ENEL	: Ente Nazionale Energia Elettrica	(IT)
ENI	: Ente Nazionale Idrocarburi	(IT)
ERL	: Energy Resources Limited	
ETSU	: Energy Technology Support Unit	(UK)
EUROSTAT	: Statistical Office of the European Communities	
FAO	: Food and Agriculture Organisation	
FMA	: Fertiliser Manufacturers' Association	(UK)
Groupe EDEN	: Groupe Interdisciplinaire Ecologie, Développement et Energétique	(FR)
IAM	: Institut für Agrarpolitik und Marktlehre	(FRG)
IEA	: Institut Economique Agricole	(BELG.)
INS	: Institut National de Statistique	(BELG.)
INSEE	: Institut National de la Statistique et des Etudes Economiques	(FR)
ISTAT	: Istituto Nazionale Statistica	(IT)
LEI	: Landbouw-Economisch Instituut	(NL)
MAFF	: Ministry of Agriculture, Fisheries and Food	(UK)
NBST	: National Board for Science and Technology	(UK)
NFU	: National Farmers Union	
NIAE	: National Institute of Agricultural Engineering	
OECD	: Organisation for Economic Cooperation and Development	
PTOM	:	

SB	:	Statistisches Bundesamt	(FRG)
SER	:	Service d'Economie Rurale	(BELG.)
UKASTA	:	United Kingdom Agricultural Supply Trade Association	(UK)
UMA	:	Utenti Motori Agricoli	(IT)
UNACOMA	:	Unione Nazionale Costruttori Macchine Agricole	(IT)
WRR	:	Wetenschappelijke Raad voor het Regerings-beleid	(NL)

...	:	not available
n/a	:	not applicable
-	:	nil or marginal

Conversion Factors

For ease of comparison, in the national studies quantities are expressed in units appropriate to an energy source and in a standard unit. Energy is expressed in terms of tonnes oil equivalent (TOE) : a tonne oil equivalent being equal to 10^7 kilocalories. In the summary chapter energy inputs are expressed in tonnes oil equivalent.

In converting to tonnes oil equivalent, the EIU has adopted the conversion factors applied by the Organisation for Economic Cooperation and Development (OECD) in compiling the statistics published in Energy Balances, and the national conversion factors commonly used, as appropriate. The differences between the OECD and the national conversion factors are small, the OECD conversion factors are generally accepted as a standard, and they are set out below for reference.

Gas is expressed in Tcal, gross calorific value, and the following factors are used to convert gross Tcal to net tonnes oil equivalent :

	TOE net/Tcal gross
Natural gas	91.7
Town gas/coal gas	91.7

Electricity in final consumption is converted into tonnes oil equivalent at

10^9 kilowatt-hours (KWH) = 0.086 MTOE

The primary energy equivalent of electricity is converted into tonnes oil equivalent at

1 kilowatt-hour (KWH) = 0.222×10^{-3} TOE

Solid Fuels, Crude Oil and Petroleum Products are converted from physical units into net tonnes oil equivalent by applying the following OECD factors :

	TOE net/tonne
Solid Fuels	
Hard coal (anthracite and bituminous)	0.70
Lignite	0.20

	TOE net/tonne
BKB	0.48
Coke oven coke	0.67
Gas coke	0.67
Patent fuel	0.70
Crude Oil and Petroleum Products	
Crude oil	1.007
Liquefied petroleum gas	1.140
Gasoline, naphtha	1.073
Kerosene, gas/diesel oil, fuel oil, jet fuel	1.045
Residual fuel oil	0.969
Non-energy products (other than naphtha)	0.950

Appropriate National Conversion Factors

For the UK, Italy and Germany, Solid Fuels, Crude Oil, and Petroleum Products are converted by applying the following factors.

1) Germany (Ministry of Economic Affairs)

Solid Fuels :	TOE net/tonnes
Hard coal (applied to t.c.e.)	0.70
Patent fuel	0.75
Coke oven coke	0.68
Gas coke	0.67
Brown coal	0.19
B.K.B.	0.48
Liquid Fuels :	
Crude petroleum	1.010
L.P.G.	1.096
Motor gasoline	1.040
Kerosene	1.020
Gas/diesel oil	1.020
Residual fuel oil	0.980
Naphtha	1.040
Other non-energy fuels	0.930

Note : The data used for hard coal in Germany is already converted into coal equivalent and is therefore not the same as the figures expressed in metric tonnes published in "Energy Statistics 1974-1978".

The conversion factors listed above relate to fuels in final consumption. The Institute for Farming Policy and Marketing (Institut für Agrarpolitik und Marktlehre) has used conversion factors which take into account total energy input, including energy expended in producing the energy product available for final consumption. The conversion factors applied by the Institute for Farming Policy and Marketing are set out below :

Electricity

1000 KWH = 14.4 10^3 MJ

Solid fuels and petroleum products

Coal	: tonne	: 32.6 10^3 MJ
Gas/diesel oil	: 1,000 litres	: 43.3 10^3 MJ
Lubricants	: 1,000 litres	: 46.6 10^3 MJ

These conversion factors can be used to convert primary energy equivalents into tonnes oil equivalents.

2) Italy (Italian Ministry of Industry)

Solid Fuels	TOE net/tonne
Hard coal imported	0.740
Hard coal indigenous	0.3657
Lignite	0.250
B.K.B.	0.430
Coke oven coke	0.700
Gas coke	0.640
Liquid Fuels	
Crude oil	1.000
L.P.G.	1.100
Gasoline	1.050
Kerosene	1.030

	TOE net/tonne
Gas/diesel oil	1.020
Residual fuel oil	0.980
Naphtha	1.040
Petroleum coke	0.830
Lubricants, bitumen, paraffin waxes, others	0.5506

3) United Kingdom : (Department of Energy)

	TOE net/tonne
Solid Fuels	
Hard coal	0.6640
Coke oven coke	0.6362
Patent fuel	0.6362
Liquid Fuels	
Crude oil	1.0226
LPG	1.1263
Gasoline	1.0650
Kerosene	1.0556
Gas/diesel, distillate fuel oil	1.0344
Residual fuel oil	0.9849
Non-energy products	1.0349

The following factors were used to convert original units of liquid fuels into tonnes before conversion into tonnes oil equivalent, where necessary :

	Litres/tonne
White spirit	1,280
Burning oil (including vaporising oil)	1,260
Derv fuel	1,185
Gas oil	1,185
Marine diesel oil	1,175
Fuel oil - light	1,075
Fuel oil - medium	1,055
Fuel oil - heavy	1,035

Furthermore, conversion factors commonly used in Denmark, France and Ireland differ from the conversion factors adopted by OECD for the following categories of fuels :

	Denmark	OECD
Light fuel oil	35.9 MJ/litre equivalent to 0.858 TOE/litres '000	1.045 TOE/tonne
DERV fuel	36.8 MJ/litre equivalent to 0.879 TOE/litres '000	1.045 TOE/tonne
Gasoline	31.6 MJ/litre equivalent to 0.755 TOE/litres '000	1.073 TOE/tonne
Residual fuel oil (heavy fuel)	40.6 MJ/kg equivalent to 0.97 TOE/tonne	0.969 TOE/tonne
Liquid petroleum gas	46 MJ/kg equivalent to 1.099 TOE/tonne	1.14 TOE/tonne

	France	OECD
Solid fuels except wood	0.667 TOE/tonne	Several factors according to type of fuel
Wood	0.14 TOE/m3	None provided
Residual fuel oil	1 TOE/tonne	0.969 TOE/tonne
Gas/diesel oil	835 10^{-6} TOE/litre	1.045 TOE/tonne
Gasoline	735 10^{-6} TOE/litre	1.073 TOE/tonne
Propane and butane	11.05 10^{-4} TOE/kilo	None provided

Data on consumption of petroleum products obtained from the Comité Professionnel du Pétrole have been converted from tonnes of product into tonnes oil equivalent by applying OECD conversion factors. The returns made by the Comité Professionnel du Pétrole are very comparable to the statistics compiled by OECD. As the OECD statistics are expressed in tonnes oil equivalent, it seems appropriate to convert the Comité's figures expressed in tonnes into tonnes oil equivalent by using the same conversion factor.

	Ireland	OECD
Liquefied petroleum	1.1263 TOE/tonne	1.14 TOE/tonne
Kerosene	1.0556 TOE/tonne	1.045 TOE/tonne
Gas/diesel oil	1.0344 TOE/tonne	1.045 TOE/tonne
Residual fuel oil	0.9849 TOE/tonne	0.969 TOE/tonne

Data on consumption of petroleum products derived from data prepared by the Agricultural Institute were converted from volume units into calorific units by applying Irish conversion factors.

SOURCES OF INFORMATION : A COMMENT.

The main sources of information used by the EIU in compiling the statistical data presented in the national studies are listed in appendix 2.

Major problems in evaluating the consumption of energy in agriculture are:

- the diversity of sources and the wide variances between the figures put forward by sources
- the absence of comprehensive and regular evaluations of the consumption of energy in agriculture, derived from surveys which have the specific objective of measuring energy consumption in agriculture
- the lack of a generally accepted definition of the activities which constitute the agricultural sector, and the identification and isolation of energy uses for professional agricultural purposes and energy uses for private household purposes on the farm
- the lack of a generally accepted definition of those products and activities which should be taken into account in assessing indirect energy inputs to agriculture, and the diversity of methods followed in evaluating indirect energy contents of products and services.

A problem presented by much of the documentary material on the subject of energy use in agriculture is that the material treats the efficiency of energy in sectors of agriculture, rather than detailing actual national consumption of energy in agriculture. Thus 'energy budgets' are given for particular crops or categories of livestock, but methods of producing a given item vary so much from one farm and one year to another that grossing up from individual energy budgets to arrive at national energy consumption is frequently misleading and invalid. Also, energy budgets or energy inputs are calculated in various ways. For example, some give the energy value of fuel used in different field operations separately; others include this in their evaluation of each stage of cultivation and harvesting, making comparison of the constituents difficult. Again, some energy inputs are calculated on the basis of a tonne of output, others per hectare of land used.

A further difficulty exists in that authors frequently refer to one another's calculations in their own papers, and it is not always possible to identify the origin of certain data.

The best informed persons approached by the EIU were aware of the main sources of data on energy consumption but few were able to comment in any detail on the methodology and calculations which lay behind the findings. Moreover, while respondents were often familiar with national sources of data on energy consumption in agriculture, they were rarely aware of attempts made in other countries to measure energy inputs to agriculture: this situation does not facilitate international comparisons.

A prime source of comparative international data on energy consumption in agriculture is the OECD statistics published in Energy Balances and Energy Statistics. The value of OECD statistics is that they allow the identification of national consumption of energy and of consumption in agriculture on a comparative basis, and also provide a historical series which allows the tracing of trends.

While OECD statistics on energy consumption are reliable at the aggregate national level, the breakdown of national totals to identify energy consumption by end-use sectors is subject to a wide margin of error. OECD breaks down estimates of aggregate national consumption of energy by type of fuel so as to identify the main consuming sectors and sub-sectors of the economy. Adjustments have to be made to align consumption with estimates of production, foreign trade and changes in stocks. Consequently, it is believed that the margin of error in evaluating consumption in agriculture, which is a relatively small end-use sector, can be appreciable.

OECD statistics on energy consumption in agriculture are often partial in that they cover only a limited range of fuels. For example, OECD statistics exclude the use of natural gas in the Netherlands, are limited to petroleum products for Belgium and to electricity for Ireland.

For these reasons, OECD statistics often diverge from national sources. Criticism of the coverage and reliability of OECD statistics is made in the national studies.

In each national study, the EIU has identified the sources which have been used in assessing the situation.

The companies and organisations approached by the consultants are listed in alphabetical order by country in appendix 1.

STRUCTURE OF AGRICULTURE

As a background to the analysis of energy consumption in agriculture, the structure of the agricultural sector has been sketched in terms of area under cultivation, number of holdings, number employed and contribution to the national economy.

Salient features of agriculture in the European Community have been the contraction of the area cultivated, and the decline in the number of holdings and share of the active population finding employment in agriculture, forestry and fishing.

Table 1.1 shows that in the period 1975 to 1978 the area cultivated contracted by 1 to 2 per cent in most countries. Ireland is the exception: in the five-year period from 1970 to 1975 the area under cultivation in Ireland is believed to have increased by some 12 per cent, with the increase being most evident in the area devoted to permanent pasture and meadow.

The number of agricultural holdings fell by 6-7 per cent in most countries in the period 1975-1978. The reduction in the number of holdings was particularly marked in Belgium (-8 per cent) and Luxemburg (-11 per cent), but the number of holdings fell by only 4 per cent in the United Kingdom.

A particular feature of agriculture in Italy is the large number of small holdings. The area under cultivation in Italy is some 50 per cent smaller than the area cultivated in France, but the number of holdings is nearly twice as great. Only 2 per cent of Italian farms are of over 50 hectares but these farms account for a third of the total area under cultivation.

The average size of farms ranges from 66 hectares in the United Kingdom to 6-7 hectares in Italy. In the period 1975-1978 the average size of holding increased by 6-7 per cent in most countries, but by only 3 per cent in the United Kingdom and by as much as 16 per cent in Ireland in the period 1970-1975.

The proportion of the active population engaged in agriculture varies appreciably, from 24 per cent in Ireland to 3 per cent in the United Kingdom and Belgium. Agriculture provides employment for some 9 per cent of the active population in France and Denmark; for some 6 per cent in Germany, the Netherlands and Luxemburg.

Agriculture's contribution to the national economy (1) in terms of gross value added at factor cost in 1979 ranged from 14 per cent for Ireland to some 2 per cent for Germany, Belgium and the United Kingdom:

- Belgium	2.4 per cent
- Denmark	4.7 per cent
- France	4.7 per cent
- Germany FR	2.1 per cent
- Ireland	13.7 per cent
- Italy	7.5 per cent
- Luxemburg	2.8 per cent
- Netherlands	3.7 per cent
- United Kingdom	2.2 per cent.

(1) Source : EUROSTAT - AGRICULTURAL ACCOUNTS.

Table 1.1

Structure of Agriculture

Country	Year	Area Cultivated (ha '000)	Number of Holdings[a] ('000)	Average Size of Holdings (ha)	Population Engaged in Agriculture[b] (%)
Belgium	1975	1,462	106	13.8	3.6
	1978	1,433	97	14.8	3.2
Denmark	1975	2,936	130	22.6	9.8
	1978	2,927	122	24.0	9.0
France	1975	29,426	1,209	24.3	10.2
	1978	29,150	1,126	25.9	9.1
Germany FR	1975	12,462	905	13.8	7.4
	1978	12,305	844	14.6	6.5
Ireland	1970	4,732	267	17.7	
	1975	5,325	260	20.5	24.0
Italy	1970	16,807	2,173	7.7	18.5
	1975	16,097	2,053	7.8	16.8
	1977[c]	16,517	2,634	6.3	14.7
Luxemburg	1975	132	6	22.0	6.1
	1978	130	5	25.9	5.6
Netherlands	1975	2,074	144	14.4	6.6
	1978	2,038	134	15.2	6.2
United Kingdom	1975	17,451	272	64.2	2.7
	1978	17,163	260	66.0	2.7

a of 1 hectare and over; b agriculture, forestry and fishing; c Istituto Nazionale Statistica

Source: Eurostat - Yearbook of Agricultural Statistics 1980

AGRICULTURE'S SHARE OF NATIONAL DIRECT ENERGY CONSUMPTION (OECD)

Statistical data compiled by OECD, and published in Energy Balances of OECD Countries and in Energy Statistics, provide a common source which attempts to record and compare consumption of energy in the countries of the European Community. OECD statistics also provide an historical series which can be used to trace trends both in national and agricultural consumption of energy.

The EIU considers that OECD statistics on national consumption of energy are reliable and a valid source of comparative data. The statistics on energy consumption in agriculture are less reliable for the reasons given in the chapter on Sources of Information. Moreover, in some instances OECD provides only a partial coverage of energy consumption in agriculture: data on Belgium are confined to petroleum products, data on Ireland are confined to electricity for 1977 and 1978, and data on the Netherlands exclude natural gas.

In the analysis of the relative importance and trend in consumption of energy in agriculture, the EIU has drawn on OECD data in the first instance, and used other sources either for supplementary data or as an alternative and, in the view of the EIU, more reliable measure.

The EIU suggests that the share of national consumption of direct energy taken up by agriculture in the Member States is as follows:

Belgium	2-3 per cent
Denmark	5-6 per cent
France	3-4 per cent
Germany FR	2-3 per cent
Ireland	5-6 per cent
Italy	2-3 per cent
Luxemburg	0.5-1 per cent
Netherlands	4-6 per cent
United Kingdom	1-2 per cent
EUR 9	2-3 per cent.

The trend in the input of energy to agriculture in the five-year period 1973-1978 has been assessed in terms of average annual rates of increase or decrease in the period:

Belgium	+ 3 per cent
Denmark	- 3 per cent
France	+ 2 per cent
Germany FR	+ 4 per cent
Ireland	+ 7 per cent
Italy	+ 4 per cent
Luxemburg	+3-4 per cent
Netherlands	+ 4 per cent
United Kingdom	- 4 per cent.

Tables 1.2 and 1.3, set out at the end of this chapter, provide a comparative summary of statistical data extracted from OECD sources referring to national consumption of direct energy and consumption of direct energy in agriculture.

The statistics should be interpreted in the light of the commentary which precedes the tables. Comment is made, country by country, on the scope and reliability of OECD statistics and other sources as bases for assessing the position of agriculture within the context of national energy requirements and for determining trends.

Belgium

OECD statistics on consumption of energy in agriculture are partial in that they are confined to petroleum products. Moreover, OECD puts consumption of petroleum products far lower than the two sources which are preferred by the EIU - E. Van Hecke and J.P. Lebailly. OECD statistics are used to illustrate the share of national energy consumption accounted for by agriculture and the trend in consumption.

On the basis of OECD statistics, it is estimated that agriculture accounts for about 2 per cent of total national energy consumption, with agriculture taking up about 3 per cent of national consumption of petroleum products. Estimates based on data compiled by E. Van Hecke would raise agriculture's share of total national energy consumption to close on 3 per cent.

Between 1973 and 1978, consumption of petroleum products in agriculture rose from 461,000 TOE to 527,000 TOE, an increase of 14 per cent, equivalent to an average annual rate of increase of 3 per cent.

Denmark

OECD statistics on consumption of energy in agriculture take into account petroleum products and electricity (since 1974). OECD puts consumption of energy in agriculture appreciably higher than the two sources preferred by the EIU - S. Rasmussen and Danmarks Statistik. The main reason for this variance appears to be inclusion of household consumption on the farm in OECD statistics.

From OECD statistics it is estimated that agriculture accounts for close on 8 per cent of total national energy consumption, with agriculture taking up rather more than 8 per cent of national consumption of petroleum products. On the basis of data compiled by Danmarks Statistik, the share of national energy consumption attributable to agriculture (excluding household farm consumption) is of the order of 5 per cent.

Between 1973 and 1978, OECD shows consumption of energy in agriculture remaining constant at 1,250,000 TOE. In the same period, Danmarks Statistik records a decline of 13 per cent in energy consumption for professional agricultural purposes to 826,000 TOE.

France

OECD data on consumption of energy in agriculture takes into account petroleum products and electricity. OECD puts consumption of petroleum products in agriculture in 1977 at some 30 per cent below the estimates of the two sources preferred by the EIU - Ministry of Agriculture and Centre National d'Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA).

OECD statistics show agriculture accounting for 2 per cent of total national energy consumption in 1978, with agriculture taking up 3 per cent of national consumption of petroleum products. On the basis of data obtained from the Ministry of Agriculture and CNEEMA relating to 1977, agriculture's share of total national energy consumption would have been 3-4 per cent in 1977.

Between 1973 and 1978, OECD shows consumption of energy in agriculture rising by 9 per cent to 3,159,000 TOE, equivalent to an average annual growth rate of 2 per cent.

Germany FR

OECD statistics show agriculture accounting for close on 1 per cent of national energy consumption in the period 1973 to 1978. This is considered to be a serious underestimation of the share of national energy consumption attributable to agriculture.

If OECD statistics are a reliable measure of national energy consumption, OECD's assessment of energy input to agriculture is believed to be far too low. If direct energy consumption in agriculture as measured by the Institut für Agrarpolitik und Marktlehre (IAM) is compared with OECD's evaluation of national energy consumption, agriculture's share is seen to be 2.5 per cent in 1978. This is believed to be a more reliable indication of the relative importance of input of direct energy to agriculture.

IAM shows that between 1973 and 1978 direct energy consumption in agriculture rose by some 25 per cent, an average annual rate of growth of 4.5 per cent. OECD statistics show no growth in energy consumption in agriculture in the period. The EIU suggests that the trend which emerges from IAM statistics is the more reliable.

Ireland

OECD cannot be used as a source for determining agriculture's share in national energy consumption or for tracing trends in consumption of energy in agriculture, as the data on agriculture compiled by OECD are confined to electricity in 1977 and 1978.

Data obtained from the Agricultural Institute (AI) can be used to evaluate the share of agriculture in national energy consumption in 1974 and 1978:

	1974 (TOE '000)	1978 (TOE '000)
National energy consumption (OECD)	5,700	6,440
Agriculture (AI)	290	377
- share %	5	6

The evaluation of energy consumption in agriculture in 1974 and 1978 by the Agricultural Institute also provides an indication of the trend in consumption of energy in agriculture. In the four years, consumption increased by 30 per cent, equivalent to an annual growth rate of 7 per cent.

Italy

Statistics compiled by OECD and by the Ministry of Industry are close in their evaluation of the consumption of energy in agriculture.

Both sources show agriculture accounting for 2 per cent of national energy consumption in 1978, and agriculture's share has remained steady in the period 1973-1978.

Between 1973 and 1978, OECD shows consumption of energy in agriculture rising from 1,940,000 TOE to 2,310,000 TOE, an increase of 19 per cent equivalent to an average annual rate of growth of 3.5 per cent.

The growth in consumption of energy in agriculture recorded by the Ministry of Industry for the same period is somewhat lower, from 1,940,000 TOE in 1973 to 2,168,000 TOE in 1978, an increase of 12 per cent. The Ministry of Industry puts consumption of energy in agriculture at 2,362,000 TOE in 1979: an increase in consumption of 22 per cent in six years is equivalent to an average annual rate of growth of 3.3 per cent.

Luxemburg

OECD statistics are the only source available from which to determine the consumption of energy in agriculture, and the source is considered to provide a reliable assessment of the situation, at least in recent years, even though OECD identifies only the use of petroleum products and electricity in agriculture.

Agriculture's share of national energy consumption is relatively low at under 1 per cent: in 1978 agriculture's share of total national consumption is estimated at 0.6 per cent, with agriculture taking up 1 per cent of national consumption of petroleum products.

In the period 1973-1978, OECD statistics show energy consumption in agriculture rising from 13,000 TOE to 21,000 TOE, an increase of 62 per cent. Most well-informed observers discount this trend, and attribute the apparent growth to massive underestimation of energy input to agriculture prior to 1977. In the five years from 1973 to 1978, energy consumption in agriculture is likely to have increased by 15-20 per cent, equivalent to an annual growth rate of 3-4 per cent.

Netherlands

Natural gas accounts for close on 46 per cent of national energy consumption. In 1973, natural gas was the second largest source of energy after petroleum products, accounting for 39.6 per cent of total energy consumption. In 1978, natural gas was the largest single source of energy, accounting for 45.6 per cent of total energy consumption: petroleum products had fallen to second place with a 42 per cent share.

As far as agriculture is concerned, OECD statistics are partial and their use is limited by the fact that consumption of natural gas in agriculture is not broken out separately. As a consequence, the OECD statistics show agriculture accounting for a share of national energy consumption of no more than 0.6 per cent to 0.8 per cent in the period 1973 to 1978. If consumption of natural gas in agriculture is taken into account, the share rises to 4-6 per cent of national energy consumption.

OECD figures show that in the period 1973 to 1978 consumption of petroleum products and electricity in agriculture rose by 21 per cent, equivalent to an average annual rate of growth of 4 per cent.

United Kingdom

OECD and the Department of Energy compile detailed statistical series on energy consumption in agriculture, which are very comparable, although the Department of Energy (Energy Statistics) gives a slightly higher value for energy consumption in agriculture.

Agriculture's consumption of energy has fallen in recent years, and agriculture's share of national energy consumption has also declined, if only marginally. Department of Energy statistics give agriculture a 1.4 per cent share of national energy consumption in 1973: the Department of Energy and OECD are agreed that agriculture's share had fallen to 1.2 per cent in 1978.

Consumption of all fuel sources in agriculture declined between 1973 and 1978, with the exception of electricity. Department of Energy statistics show consumption falling from 2,216,300 TOE in 1973 to 1,839,500 TOE in 1978, a decline of 17 per cent equivalent to an annual rate of decline of 4 per cent.

Table 1.2

National Direct Energy[a] Consumption and the Share Attributed to Agriculture, 1978

Country	Solid Fuels TOE (mn)	Solid Fuels Per cent	Petroleum Products TOE (mn)	Petroleum Products Per cent	Gas TOE (mn)	Gas Per cent	Electricity TOE (mn)	Electricity Per cent	National Total TOE (mn)	National Total Per cent	Agriculture TOE (mn)	Agriculture Per cent
Belgium	6.10	16.9	19.12	53.0	7.27	20.2	3.56	9.9	36.05	100	0.53	1.5
Denmark	0.81	5.1	13.15	83.0	0.10	0.6	1.79	11.3	15.86	100	1.25	7.9
France	13.48	9.3	97.28	66.9	17.54	12.1	17.03	11.7	145.33	100	3.16	2.2
Germany FR	20.09	10.0	124.73	62.2	29.48	14.7	26.24	13.1	200.54	100	1.80	0.9
Ireland	1.50	23.3	4.18	64.9	0.08	1.3	0.67	10.5	6.44	100	(0.08)[b]	(1.3)
Italy	5.90	5.6	66.65	63.1	20.26	19.2	12.81	12.1	105.61	100	2.31	2.2
Luxemburg	1.51	42.3	1.44	40.3	0.33	9.2	0.30	8.4	3.57	100	0.02	0.6
Netherlands	1.69	3.1	22.84	42.3	24.60	45.6	4.82	8.9	53.95	100	(0.43)[c]	(0.8)
United Kingdom	20.20	13.7	72.65	49.2	34.42	23.3	20.35	13.8	147.62	100	1.77	1.2
EUR 9 total	71.28	10.0	422.04	59.0	134.08	18.7	87.57	12.3	714.97	100	(11.35)	1.6

a direct final consumption; b electricity only; c excluding natural gas

Source: OECD - Energy Balances 1980

Table 1.3

Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978
(TOE '000 and per cent shares)

	Belgium	Denmark	France	Germany	Ireland	Italy	Luxemburg	Netherlands	United Kingdom	EUR 9 Total
1973										
Total (TOE '000)	461	1,252	2,911	1,849	279	1,940	13	352	1,790	10,847
of which:										
- petroleum products	461	1,252	2,814	1,326	208	1,830	13	352	1,700	9,956
- electricity	...	...	97	523	71	110	...	...	...	(801)
- solid fuels	...	...	...	...	...	...	...	...	90	(90)
Share of agriculture in national consumption (%)										
All fuels	1.2	7.7	2.0	0.9	5.1	1.9	0.3	0.7	1.2	1.5
Petroleum products	2.2	8.7	2.7	1.0	5.4	2.6	0.8	1.4	2.1	2.2
Electricity	...	...	0.6	2.0	11.0	1.0	...	...	...	...
Solid fuels	...	...	...	...	...	...	...	...	0.3	...
1976										
Total (TOE '000)	408	1,227	2,885	1,893	247	2,070	14	337	1,680	10,761
of which:										
- petroleum products	408	1,083	2,770	1,326	167	1,900	9	310	1,330	9,303
- electricity	...	144	115	567	80	160	5	27	310	(1,408)
- solid fuels	...	...	...	...	...	...	...	...	40	(40)
- gas	...	...	...	...	...	10	...	...	...	(10)
Share of agriculture in national consumption (%)										
All fuels	1.2	7.8	2.1	1.0	4.6	2.1	0.4	0.6	1.2	1.6
Petroleum products	2.1	8.0	3.0	1.1	4.5	2.7	0.7	1.3	1.9	2.2
Electricity	...	9.4	0.8	2.3	13.9	1.3	1.8	0.6	1.6	(1.7)
Solid fuels	...	...	...	...	...	...	...	...	0.2	...
Gas	...	...	...	...	...	0.1	...	...	...	...

(continued)

Table 1.3 (continued)

Uses of Direct Energy in Agriculture by Fuel Type, 1973, 1976 and 1978
(TOE '000 and per cent shares)

	Belgium	Denmark	France	Germany	Ireland	Italy	Luxemburg	Netherlands	United Kingdom	EUR 9 Total
1978										
Total (TOE '000)	527	1,253	3,159	1,805	82	2,310	21	426	1,770	11,353
of which:										
- petroleum products	527	1,090	3,036	1,216	...	2,110	15	396	1,400	(9,790)
- electricity	...	163	123	589	82	190	6	30	350	(1,533)
- solid fuels	...	...	...	...	...	...	...	...	20	(20)
- gas	...	...	...	...	...	10	...	...	...	(10)
Share of agriculture in national consumption (%)										
All fuels	1.5	7.9	2.2	0.9	1.3	2.2	0.6	0.8	1.2	1.6
Petroleum products	2.8	8.3	3.1	1.0	...	3.2	1.0	1.7	1.9	(2.3)
Electricity	...	9.1	0.7	2.2	12.2	1.5	2.0	0.6	1.7	(1.8)
Solid fuels	...	...	...	...	...	...	...	...	0.1	...
Gas	...	...	...	...	...	...	...	...	...	...

Source: EIU calculations on data from OECD - Energy Balances 1980

DIRECT AND INDIRECT CONSUMPTION OF ENERGY IN AGRICULTURE

In determining direct and indirect energy consumption in agriculture, the EIU has looked to the recognised national sources of information There are no more than one or two organisations or individuals in each country who have undertaken comprehensive surveys into the consumption of energy in agriculture, and the majority of these surveys are essentially static, referring to the situation in the year selected for the exercise.

The main surveys are relatively recent, and describe the situation in 1977 or 1978. Given the moderate pace of change in the utilisation of energy in agriculture, it seems reasonable to compare data drawn from two consecutive years. Moreover, the margin of error inherent in such an exercise is far greater than variations in energy utilisation from one year to the next.

The Summary chapter serves to bring together the findings of the most reliable and complete surveys on direct and indirect consumption of energy in agriculture. Other sources of information are identified in the national studies.

The EIU has taken the findings of the more comprehensive surveys as being the most reliable. These surveys were undertaken with the specific objective of evaluating energy inputs to agriculture, whereas other sources of information are partial, in that they deal with a particular fuel or activity, or treat agriculture as a residual category. For a number of countries, it has been possible to compare the findings of two or more surveys which are sufficiently close to be considered as confirmatory.

The EIU has put forward estimates to fill gaps in the findings where it was felt that a meaningful figure could be estimated. The EIU would not claim that these estimates are more than a broad indication of the true value.

A particular problem encountered in assessing direct energy consumption in agriculture is the extent to which household consumption of energy on the farm has been identified and excluded. In all countries this has been attempted, but the degree of sucess is uncertain. It has been especially difficult to identify private and professional use of petrol and diesel oil.

A valuable source of data on direct energy consumption is the farm accounts which are prepared for their members by professional organisations representing farmers. Another useful source is the claims for the refund of excise duties and other taxes levied on certain fuels. For reasons of confidentiality, these sources were not available to the EIU. The European Commission collects and analyses farm accounts, but again these could not be made available to the consultants.

Few attempts have been made to evaluate indirect energy inputs to agriculture. The energy containing products which have been the subject of greatest attention are fertilisers.

There is considerable confusion on the definition and measurement of indirect energy.

- There is little agreement on the products and services which should be taken into account.

- The products themselves are often difficult to appraise, in particular the volume/area of farm buildings, the rate of use and depreciation of agricultural machinery, and the incidence of transport

- Methods of evaluating indirect energy contents are various. It is usual to refer to a recognised authority, often British, French or American, and make ad hoc adjustments to allow for local conditions.

Indirect energy consumption is an area of uncertainty where a wide margin of error must be accepted. The persons interviewed by the consultants were often unaware of the detailed work which went into assessments of indirect energy, and they were reluctant to criticise sources which were put forward as the best or only source of information on the subject. Few respondents could comment critically on comparisons with other countries.

Table 1.4, set out at the end of this chapter, has been compiled to show in a comparative form the extent of direct and indirect energy consumption in agriculture in Member States. The evaluations were made for 1977 or 1978, and the sources of the data are identified in the table.

Where possible, information obtained from two sources is provided to illustrate the extent to which one confirms the other.

The statistical data are broadly comparable across the nine countries, but should be interpreted in the light of the comments which precede the table.

Direct energy accounts for 20-30 per cent of total direct and indirect energy consumption in five countries:

- Belgium
- Ireland
- Italy
- Luxemburg
- United Kingdom.

The comparatively low share of 20 per cent attributed to direct energy in Luxemburg is suspect, as the evaluation of indirect energy is an estimate arrived at by the EIU and may well be on the high side.

The importance of direct energy input rises to 38 per cent of total energy input in Denmark. Indirect energy consumption in the form of the energy content of agricultural machinery, farm buildings and transport and services provided by third parties, was excluded in the survey of indirect energy input undertaken by S. Rasmussen. The EIU has partially filled the gap by estimating the energy content of agricultural machinery.

The relatively low share of indirect energy in Germany is partly attributed to the exclusion of animal feedstuffs, other than imported feedstuffs, from the evaluation of indirect energy input.

Data provided on the Netherlands are very approximative: the high share of direct energy (46 per cent) probably reflects the importance of horticulture, but estimates of indirect energy consumption are very tentative.

Belgium

Comprehensive studies on energy consumption in agriculture (direct and indirect energy) have been undertaken by J.P. Lebailly and E. Van Hecke. Lebailly's evaluations are based on averages for the three years 1974-1976, and Van Hecke's analysis relates to 1977.

The findings of the two studies are broadly similar. Direct electricity consumption accounts for much of the difference between the evaluations of total direct energy input, with Lebailly putting annual consumption 19 per cent higher than Van Hecke. Lebailly and Van Hecke are broadly in agreement in their estimates of total indirect energy consumption, although they diverge in the breakdown of indirect energy by source of input, particularly in their respective evaluations of the indirect energy content of agricultural machinery.

Direct energy consumption accounts for some 25-30 per cent of total energy consumption in agriculture, and petroleum products account for 80 per cent of direct energy input.

The findings of both studies are set out in detail in the chapter on Belgium. In the Summary Chapter comment is restricted to the findings of Van Hecke as this is the more recent of the two studies.

Denmark

At the request of the EIU, Danmarks Statistik carried out an analysis of energy consumption in agriculture based on national input/output data. The analysis is confined to direct energy input, but provides an historical series for the period 1967 to 1978. While an important source of data, the findings of the analysis should be treated with caution as they are the outcome of rational calculations and not of statistical returns relating specifically to the agricultural sector.

The most comprehensive study of energy input to agriculture is that undertaken by S. Rasmussen. The study is static, referring to 1978, but direct and indirect inputs are evaluated. S. Rasmussen based his analysis of direct energy consumption on data extracted from farm accounts and on data obtained from the Danish Energy Board.

Danmarks Statistik and S. Rasmussen are close in their estimates of direct energy consumption in 1978 - 826,000 TOE and 759,000 TOE respectively. Danmarks Statistik includes consumption of petrol (motor gasoline) for private purposes, and direct consumption of energy for fur production, bee rearing, forestry and agricultural services. Rasmussen confined his analysis to arable cultivation, livestock rearing and horticulture.

OECD's estimate of total direct energy consumption in agriculture in 1978 is 52-65 per cent greater than the figures put forward by S. Rasmussen and Danmarks Statistik. It is assumed that the difference is largely accounted for by the inclusion of private and household energy consumption in the OECD statistics. If Rasmussen's estimates of direct energy consumption for professional and household purposes are aggregated, the total of 1,234,000 TOE in 1978 comes very close to the figure put forward by OECD for total direct energy consumption in agriculture.

S. Rasmussen puts indirect energy consumption at 1,060,000 TOE in 1978 but this estimate takes into account only fertilisers, agrochemicals and feedstuffs. The EIU has estimated that the energy content of agricultural machinery used in 1978 could be of the order of 200,000 TOE.

France

Studies undertaken by the Ministry of Agriculture and by the Centre National des Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA) provide a detailed analysis of energy input to agriculture. The analyses are confined to a single year but are recent - 1977. The study undertaken by CNEEMA is the more complete in that its scope covers both direct and indirect energy consumption.

The findings of the Ministry of Agriculture and of the CNEEMA for 1977 are broadly similar, evaluating direct energy consumption in agriculture at close on 5 million TOE. A significant difference between the findings of these two studies lies in the evaluation of the consumption of electricity: this is largely due to the use of different conversion factors in expressing electricity in terms of tonnes oil equivalent.

Germany FR

The Institut für Agrarpolitik und Marktlehre (IAM) has undertaken a detailed study on direct and indirect energy consumption in agriculture. For ease of comparison, the EIU has converted direct energy expressed in primary consumption to final consumption.

Direct energy consumption at 43 per cent of total energy input to agriculture is high in comparison to other countries, where direct energy takes a 20-30 per cent share of total energy input.

The apparently high share of total energy input attributed to direct energy is probably due to an underestimation of indirect energy input. The IAM has confined its evaluation of the energy content of animal feedstuffs to imported feedstuffs alone, arguing that some 50 per cent of feedstuffs consumed in Germany are produced on the farm.

Ireland

The studies undertaken by the Agricultural Institute (AI) provide a detailed analysis of direct and indirect energy input to agriculture. The studies refer to two years - 1974 and 1978. In both years, direct energy consumption was estimated to account for 26 per cent of total energy input to agriculture, a proportion which is close to the norm for the European Community.

Italy

There are two sources of statistical data on direct consumption of energy in agriculture - the Ministry of Industry and OECD. The analysis provided by the Ministry of Industry is the more detailed but the two sources are broadly in line.

Indirect energy consumption has been estimated by the EIU, taking into account fertilisers, agro-chemicals, animal feedstuffs and agricultural machinery.

Luxemburg

Data presented by OECD are the main sources of information on consumption of direct energy in agriculture, and the origin of the data processed by OECD is the Ministry of Energy. OECD statistics identify petroleum products and electricity only, but these fuels would account for well over 90 per cent of direct consumption of energy in agriculture. Respondents at the Ministry of Agriculture accepted OECD statistics as being reliable for recent years - since 1977.

Estimates of indirect energy consumption in agriculture are tenuous, and are made up of an estimate of the energy content of fertilisers arrived at by Energy Research Limited, and the EIU's estimate of the energy content of feedstuffs and agricultural machinery.

The relative importance of direct energy - 20 per cent of total direct and indirect consumption - appears low, but this may be more apparent than real as when dealing with small quantities the effect of statistical error is magnified.

Netherlands

There is a lack of reliable statistical data on direct consumption of energy in agriculture. The margin of error in estimates of direct energy consumption is probably wide, but some reassurance can be drawn from the closeness of estimates put forward by OECD, Landbouw-Economische Instituut (LEI) and Wetenschappelijke Raad voor het Regeringsbeleid (WRR). The EIU is of the opinion that the data prepared by WRR is the closest to reality.

It appears that little attempt has been made to assess indirect energy consumption in agriculture.

United Kingdom

The official sources of statistical data on direct consumption of energy in agriculture are the OECD statistics on the Energy Balances of Member States, and the Digest of United Kingdom Energy Statistics. The latter is produced by the Department of Energy, which also prepares the energy balances presented by the OECD; the two sources provide comparable figures.

Dr. D.J. White has undertaken studies on the use of direct and indirect energy in agriculture. In these studies, data on direct energy consumption derived from the Digest of United Kingdom Energy Statistics have been expressed in terms of primary energy equivalents. As it is more customary to express direct energy in terms of final consumption, the EIU has brought together estimates of direct energy arrived at by OECD and the Department of Energy with the evaluation of indirect energy consumption calculated by Dr. White.

The relative importance of direct energy consumption, at 25 per cent of total direct and indirect energy consumption in agriculture, is in line with the situation found in other Member States of the Community.

Table 1.4

Direct and Indirect Consumption of Energy in Agriculture

Country	Main Sources of Data	Year	Direct Energy TOE '000	%	Indirect Energy TOE '000	%	Total TOE '000	%
Belgium	J.P. Lebailly	1974-76	970	30	2,297	70	3,267	100
	E. Van Hecke	1977	911	28	2,382	72	3,293	100
Denmark	S. Rasmussen	1978	759	38	(1,260)	62	(2,019)	100
	Danmarks Statistik	1978	826	-	...	-	...	-
France	Ministry of Agriculture	1977	5,023	-	...	-	...	-
	CNEEMA[a]	1977	4,900	36	8,800	64	13,700	100
Germany FR	IAM[b]	1977	(4,380)	43	5,887	57	(10,267)	100
Ireland	Agricultural Institute	1974	290	26	830	74	1,120	100
		1978	377	26	1,086	74	1,463	100
Italy	Ministry of Industry	1978	2,168	22	(7,751)	78	(9,919)	100
	OECD	1978	2,310	23	(7,751)	77	(10,061)	100
Luxemburg	OECD	1978	21	20	(85)	80	(106)	100
Netherlands	WRR[c]	1977	2,600	46	(2,981)	53	(5,581)	100
United Kingdom	OECD/D.J. White	1978	1,777	25	5,466	75	7,243	100
	Department of Energy/ D.J. White	1978	1,839	25	5,466	75	7,305	100
EUR 9 total		1977/78[d]	(17,955)	33	(35,698)	67	(53,653)	100

a CNEEMA: Centre National d'Etudes et d'Expérimentation de Machinisme Agricole; b IAM: Institut für Agrarpolitik und Marktlehre; c WRR: Wetenschappelijke Raad voor het Regeringsbeleid; d estimate of annual consumption based on national totals for 1977 or 1978

Source: As identified in the table and EIU estimates in brackets

DIRECT ENERGY CONSUMPTION BY TYPE OF FUEL

It is evident from the breakdown of direct energy consumption by type of fuel that petroleum products predominate in all countries, with the exception of the Netherlands where natural gas accounts for over 80 per cent of direct energy input to agriculture. In other Member States, petroleum products represent 80-90 per cent of direct energy input.

Belgium

Petroleum products, solid fuels and natural gas are grouped into a single category by E. Van Hecke, and represent energy inputs to animal rearing, horticulture and the powering of tractors and farm machinery.

Fuel consumption has been assessed on the basis of farm accounts prepared by the Belgische Boerenbond, from claims for refund of excise duty levied on fuel oil, and from information provided by gas distribution companies.

It is estimated that of the 750,000 TOE classified by Van Hecke under the heading 'fossil fuels' some 48,000 TOE are natural gas utilised in horticulture. Petroleum products account for close on 80 per cent of direct energy input to agriculture.

Denmark

S. Rasmussen shows that in 1978 petroleum-based fuels accounted for 90 per cent (682,000 TOE) of direct energy consumption in agriculture.

The main usage sector is horticulture which takes up 51 per cent of petroleum-based fuel supplies to agriculture, mainly for the heating of glasshouses.

Electricity, which accounted for 10 per cent of energy consumption in agriculture in 1978, is mainly used to power ventilation systems in the rearing of animals.

France

Petroleum products are estimated to account for over 80 per cent of direct energy consumption in agriculture: the Centre National d'Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA) puts the share of petroleum products at 89 per cent in 1977, while the Ministry of Agriculture puts the share of petroleum products at 83 per cent in the same year. The figure of 175,000 TOE shown under gas comprises mainly liquefied petroleum gas, and its inclusion in the category of petroleum products would increase the relative importance of that category to over 90 per cent of all direct energy inputs.

The category of 'other' fuels consists mainly of coal and wood. It is the practice in some countries to treat wood as a 'non-commercial' source of energy, and to exclude non-commercial fuels from evaluations of energy input.

Germany FR

Petroleum products account for 85 per cent of direct energy input to agriculture, and electricity takes a somewhat higher share than in most other countries at 11 per cent. Close on 2 per cent of direct energy is attributed to lubricants which are classified under the 'other' category in Table 5.

Ireland

The values arrived at by the Agricultural Institute for direct consumption of energy are reasoned estimates for the whole country based on partial data and observations on energy consumption in selected samples of farms. The input of petroleum-based products is made up of four categories of fuel: DERV fuel for powering tractors, fuel oil for heating animal rearing premises, heavy fuel oil for heating glasshouses and liquefied petroleum gas. Petroleum products account for over 90 per cent of direct energy input to agriculture.

The Agricultural Institute has assessed electricity consumption, in terms of final consumption, at 21,000 TOE in 1974 and 32,000 TOE in 1978, an increase of over 50 per cent. These estimates are based on observations which show a steady increase in the use of electricity as farming has become increasingly mechanized, in particular with the wider use of cooling and refrigeration equipment and of electrically powered pumps.

Italy

The main fuels used in agriculture are petroleum products which account for 90 per cent of direct energy input. Electricity accounts for 9 per cent of energy input: in the period 1972 to 1978 the consumption of electricity doubled.

Luxemburg

In 1978, direct consumption of petroleum products and electricity in agriculture was put at 21,000 TOE, equivalent to 0.6 per cent of total national consumption. Petroleum products are credited with

71 per cent of the total, and this would seem to be a low estimate although it is generally accepted as being realistic.

Netherlands

In recent years, natural gas has accounted for 80-90 per cent of direct energy consumed in agriculture.

It is evident that natural gas has increased in importance as a source of energy, both at the national level and in agriculture. On the basis of the WRR estimates, natural gas accounted for 81 per cent of energy consumed in agriculture in 1977, and data obtained from the Ministry of Agriculture show natural gas with a share of 76 per cent in 1978.

United Kingdom

The main energy source for agriculture is petroleum fuels, which accounted for nearly 80 per cent of direct energy consumption in the 1970s. Three-quarters of this is taken up by gas/diesel oil. Solid fuels account for less than 2 per cent at present (4.3 per cent in 1972) and electricity makes up the remainder with a share of about 20 per cent.

Table 1.5

Direct Energy Consumption in Agriculture by Type of Fuel

Country	Year	Petroleum Products TOE '000	%	Gas TOE '000	%	Electricity TOE '000	%	Solid Fuels TOE '000	%	Other[a] TOE '000	%	Total TOE '000	%
Belgium	1977	(702)	77	(48)	5	161	18	...	-	...	-	911	100
Denmark	1978	682	90	...	-	77	10	...	-	...	-	759	100
France	1977	4,355	89	175	4	310	6	...	-	60	1	4,900	100
Germany FR	1977	(3,706)	85	...	-	(505)	11	(90)	2	(79)	2	(4,380)	100
Ireland	1978	345	92	...	-	32	8	...	-	...	-	377	100
Italy	1978	1,962	90	12	1	194	9	...	-	...	-	2,168	100
Luxemburg	1978	15	71	...	-	6	29	...	-	...	-	21	100
Netherlands	1977	400	15	2,100	81	100	4	...	-	...	-	2,600	100
United Kingdom	1978	1,474	80	...	-	345	19	20	1	...	-	1,839	100
EUR 9 total	1977/78[b]	(13,641)	76	(2,335)	13	(1,730)	9	(110)	1	(139)	1	(17,955)	100

a including solid fuels and lubricants; b estimate of annual consumption based on national totals for 1977 or 1978

... not available or not significant

Source: As identified in Table 4 and EIU estimates in brackets

DIRECT CONSUMPTION OF PETROLEUM PRODUCTS

The preceding table (Table 1.5) has served to highlight the predominance of petroleum products in all Member States, with the exception of the Netherlands.

In Ireland, Italy and Denmark petroleum products account for at least 90 per cent of direct energy consumption in agriculture. In France, Germany, Belgium and the United Kingdom the share of direct energy input taken up by petroleum products lies between 80 and 90 per cent.

In Table 1.6 petroleum products are broken down into five sub-categories to show the importance of particular petroleum-based fuels.

Belgium

The breakdown of the 702,000 TOE of petroleum products consumed in 1977 by type of product has been estimated with reference to the relative importance of products identified by OECD.

Denmark

Residual fuel oil is the largest category of petroleum-based fuels, accounting for 56 per cent of total consumption of petroleum products in agriculture. This reflects a situation where horticulture takes up 51 per cent of petroleum-based fuels for the heating of glasshouses.

Tractors and machinery used for the preparation of the soil account for 17 per cent of consumption of petroleum-based fuels in agriculture.

France

The Centre National d'Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA) puts the direct consumption of petroleum-based fuels (diesel oil, heavy fuel oil and petrol) at 6-7 per cent higher than does the Ministry of Agriculture. The CNEEMA makes an allowance for petrol consumption by collective organisations, an item which the Ministry of Agriculture excluded. The CNEEMA has redistributed consumption of oil products, giving far greater importance to heavy fuel oil. Whereas the Ministry of Agriculture assumed that consumption of oil by collective organisations could be classified as consumption of diesel oil, the CNEEMA is of the opinion that heavy fuel oil accounted for a high proportion of the total.

The 3,130,000 TOE shown under the heading 'diesel oil' in Table 1.6 can be further broken down between 2,930,000 TOE of domestic grade diesel oil and 200,000 TOE of diesel-engine road vehicle fuel.

Germany FR

The Institut für Agrarpolitik und Marktlehre (IAM) identifies two categories of petroleum-based fuels - petroleum products, mainly for heating, and fossil fuels for powering tractors and machinery.

Petroleum products for heating make up the largest category of energy, accounting for 61 per cent of all petroleum-based fuels and for 52 per cent of all direct energy consumption. Consumption has increased year by year, except for a fallback in 1974.

Consumption of fossil fuel for machinery accounted for 33 per cent of all direct energy consumption in 1977, and for 39 per cent of consumption of petroleum-based fuels.

Ireland

The most important single category of direct energy is diesel fuel for tractors. Consumption of diesel fuel in 1978 was assessed on the basis of information on average consumption per tractor extracted from the 1978 Farm Management Survey, and on an estimated tractor park of 120,000 units: the calculation resulted in an estimated input of DERV fuel for tractors of 232,000 TOE for 1978, an increase of 38 per cent on 1974.

The second largest category of petroleum products is heavy fuel oil for heating. On the basis of sample observations, national consumption of heavy fuel in the heating of glasshouses was assessed at 63,000 TOE in 1974. For 1978, input of heavy fuel for heating glasshouses was estimated at some 53,000 TOE, a decrease of 16 per cent.

Fuel for heating animal rearing premises is mainly used in oil-fired central heating systems installed in pig breeding units. A problem encountered here is that it has not been possible to assess separately input for farming purposes and input for heating domestic premises. The estimates of 33,000 TOE of fuel input for heating farms (excluding glasshouses) in 1974 and 49,000 TOE in 1978 include both the use of fuel for pig breeding and for domestic use.

Although accounting for a small part of energy input, liquefied petroleum gas has become more widely used since 1974. The Agricultural Institute has put input of liquefied gas to agriculture at 5,000 TOE in 1974 and 11,000 TOE in 1978, an increase of 120 per cent.

Italy

Petroleum products represent 90 per cent of direct energy input to agriculture. Of these, diesel oil accounts for 72 per cent and fuel oil for 15 per cent. The upward trend in consumption of diesel oil was broken only in 1975. While fuel oil is the second largest source of energy input to agriculture, consumption has remained very steady.

Agriculture's share of national consumption of diesel oil has tended to decline, but agriculture's share of diesel oil consumption is relatively high at about 6 per cent.

Luxemburg

Residual fuel oil was the most important source of direct energy input in agriculture in 1978: 11,000 TOE of residual fuel oil accounted for 52 per cent of direct energy input in agriculture, and for 2.4 per cent of total national consumption of residual fuel oil. Consumption of residual fuel oil in agriculture doubled since 1976 when OECD recorded consumption in agriculture for the first time.

Small amounts of kerosene continue to be used in agriculture, although usage has fallen and OECD has not recorded consumption in agriculture since 1974 when 1,000 TOE were consumed. Motor gasoline consumption in agriculture is also low, and OECD last recorded consumption in 1973 when 2,000 TOE were consumed.

Netherlands

Petroleum products account for a relatively low share of direct energy input to agriculture compared with other countries - 15 per cent in the Netherlands compared with 70-90 per cent in other Member States. This is due to the predominance of national supplies of natural gas as an energy source.

United Kingdom

By far the largest use of energy in agriculture takes the form of petroleum fuels which account for 80 per cent of total direct energy consumption in agriculture. The most important areas of usage are tractors and self-powered machinery which together account for 50 per cent of consumption of petroleum fuels. The heating of glasshouses would account for 25 per cent of total consumption of petroleum fuels.

Table 1.6

Consumption of Petroleum-based Products

Country	Year	Diesel Oil		Residual Fuel Oil		Kerosene		Motor Gasoline		Gas (LPG)		Total	
		TOE '000	%	TOE '000	%	TOE '000	%	TOE '000	%	TOE '000	%	TOE '000	%
Belgium	1977	(414)	59	(260)	37	(7)	1	(7)	1	(14)	2	(702)	100
Denmark	1978	264	39	380	56	...	-	27	4	11	1	682	100
France	1977	3,130	69	825	18	...	-	400	9	175	4	4,530	100
Germany FR	1977	(1,445)	39	(2,261)	61	...	-	...	-	...	-	(3,706)	100
Ireland	1978	232	67	102	30	...	-	...	-	11	3	345	100
Italy	1978	1,413	72	294	15	40	2	176	9	39	2	1,962	100
Luxemburg	1978	4	27	11	73	...	-	...	-	...	-	15	100
Netherlands	1977	(300)	75	(4)	1	...	-	(48)	12	(48)	12	400	100
United Kingdom	1978	1,128	76	326	22	10	1	10	1	...	-	1,474	100
EUR 9 total	1977/78[a]	(8,330)	60	(4,463)	32	(57)	1	(668)	5	(298)	2	(13,816)	100

a estimate of annual consumption based on national totals for 1977 or 1978

... not available or not significant

Source: As identified in Table 4 and EIU estimates in brackets

INDIRECT ENERGY CONSUMPTION

The problems inherent in attempting an evaluation of indirect energy input to agriculture were commented on in the chapter on Direct and Indirect Consumption of Energy in Agriculture. The problems are essentially associated with definition and methodology.

The EIU has attempted to bring into an evaluation of indirect energy consumption fertilisers, animal feedstuffs, machinery and agrochemicals. It is generally agreed that these are the main items and they are identified in most countries. Fertilisers and animal feedstuffs are by far the main forms of indirect energy, and together account for some 70 per cent of total indirect energy consumption.

Some countries extend the definition to include the energy content of farm buildings, packaging materials, fencing, irrigation, transport and services. These items are grouped in the 'other' category in Table 1·7, but can often be identified more precisely in the national chapters.

Belgium

Indirect energy consumption in the form of fertilisers and animal feedstuffs have been evaluated by the methods put forward by G. Leach, adapted to Belgian conditions by E. Van Hecke.

The energy content of tractors and mobile agricultural machinery was evaluated by applying the conversion factors suggested by the Food and Agriculture Organisation (FAO), but allowance was made for the lighter weight of tractors used on Belgian farms. An arbitrary 20 per cent was added to cover energy expended in the form of repairs and maintenance.

Miscellaneous items include farm buildings, agro-chemicals and maintenance products. The energy content of these has been taken as an arbitrary 10 per cent of total energy input to agriculture.

By comparison with other countries, the importance of animal feedstuffs in total indirect energy consumption seems high. The evaluation of E. Van Hecke is, however, confirmed by J.P. Lebailly who arrives at a figure 12 per cent greater (1,639,000 TOE) as the annual average in the period 1974-1976.

By contrast, the energy content of fertilisers appears to be low in comparison with other countries. E. Van Hecke and J.P. Lebailly arrive at broadly comparable estimates, and a third evaluation of the energy content of fertilisers based on a study by Energy Research Limited (ERL) tends to confirm the estimates of Van Hecke and Lebailly, even though the estimates based on ERL data are some 13-15 per cent lower than those of Van Hecke and Lebailly.

Denmark

Indirect consumption of energy in agriculture in Denmark is comparatively low at 62 per cent of total energy consumption. S. Rasmussen did not take into account indirect energy consumption in the form of agricultural machinery, farm buildings and transport and services provided by third parties.

The EIU has made a broad estimate of the indirect energy content of agricultural machinery, which is put at 200,000 TOE in 1978.

Fertilisers account for the largest indirect input to agriculture, representing 55 per cent of indirect energy and 34 per cent of total energy taken up by agriculture. S. Rasmussen's estimate of indirect energy input from fertilisers is close to an estimate of 676,000 TOE (1978/79) arrived at by Energy Research Limited.

France

The Centre National d'Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA) estimated total indirect energy consumption at 8.8 million TOE in 1977, of which the largest item was fertilisers accounting for 44 per cent (3.9 million TOE) of total indirect energy input.

Confirmation of this estimate can be found in an earlier and separate study undertaken by the Groupe Interdisciplinaire Ecologie, Développement et Energétique (Groupe EDEN). The Groupe EDEN evaluated indirect energy consumption in agriculture at 8.7 million in 1975, of which the main constituents were:

- fertilisers	3,880,000 TOE
- feedstuffs	1,898,000 TOE
- agro-chemicals	500,000 TOE
- machinery	961,000 TOE
- buildings	955,000 TOE
- others	552,000 TOE.

The 'others' category includes such items as packaging materials and fencing, and the energy consumed in their utilisation, and irrigation. These are items which are not usually taken into account when evaluating indirect energy input.

A third confirmation of the importance of fertilisers as a source of indirect energy input to agriculture comes from Energy Research Limited which puts the energy content of fertilisers at 4,037,000 TOE in 1978/79.

Germany FR

The Institut für Agrarpolitik und Marktlehre (IAM) has evaluated consumption of energy in agriculture for the period 1970 to 1978, although the evaluation of indirect energy input in 1978 was only partial, in that no evaluation was made of the energy content of agricultural machinery. In the period 1970 to 1977, indirect consumption of energy in agriculture has increased by 12 per cent, compared with a 40 per cent increase in direct energy consumption.

IAM takes into account four items when evaluating indirect energy input to agriculture - fertilisers, agricultural machinery, imported feedstuffs, and agro-chemicals. Of the four items, fertilisers is the most important, accounting for 52 per cent of total indirect energy input.

Agricultural machinery is defined to include tractors and self-propelled machinery powered by engine fuel.

The IAM's evaluation of the indirect energy content of animal feedstuffs is limited to imported feedstuffs. This procedure tends to depress the evaluation of indirect energy consumption in Germany in comparison with other countries. Imported feedstuffs are believed to account for some 45 per cent of overall consumption of feedstuffs, but of the remaining 55 per cent only 3 per cent takes the form of processed feedstuffs. The greater part of animal feedstuffs of German origin is unprocessed agricultural produce.

Certain items which are considered as having an indirect energy input in some countries are excluded from IAM's analysis: these are agricultural buildings, maintenance products and packaging materials.

Ireland

According to the Agricultural Institute, the values for indirect consumption of energy in the form of fertilisers and feed processing are more reliable than other estimates of indirect energy consumption. These two items together account for about 50 per cent of indirect energy input in agriculture. Two sub-categories are grouped in the category 'animal feedstuffs' identified in Table 1.7 :

- feed processing 37,000 TOE
- imported feedstuffs 163,000 TOE.

The values for feed processing are broad estimates based on observations of energy input to milling, grinding and pelleting of feeds and to feed grain drying.

The estimates of the energy content of imported feedstuffs, machinery, buildings and transport and services are regarded as broad estimates derived from the parameters for indirect energy consumption in agriculture established by recognised authorities. It should be noted that account is taken of imported feedstuffs.

The Agricultural Institute's estimate of the indirect energy content of fertilisers is largely confirmed by separate evaluations made by Energy Research Limited which put the energy content of fertilisers at 515,000 TOE in 1978/79.

Italy

The EIU could find no source which has systematically attempted to measure indirect energy input to agriculture. The EIU has collected data on the consumption and utilisation of the main categories of products which constitute a source of indirect energy. It must be accepted that the evaluations put forward by the EIU are broad estimates based on aggregate values for fertilisers, animal feedstuffs, plant protection products and agricultural machinery.

Luxemburg

The indirect energy content of fertilisers has been reliably estimated at 25,000 TOE in 1978. The EIU has estimated the energy content of agricultural machinery (tractors, harvesters and mechanical hoes) at 20,000 TOE in 1978. Total indirect energy consumption is broadly assessed at 85,000 TOE, and animal feedstuffs is treated as a residual category.

Netherlands

The EIU could find few sources of data on indirect usage of energy in agriculture. The leading agricultural and economic research institutes have not undertaken such work systematically. The Landbouwstatistiek Department of the Centraal Bureau voor de Statistiek confirmed that no systematic attempt had yet been made to evaluate indirect energy consumption in agriculture.

Fertilisers are likely to be an important source of indirect energy consumption in agriculture, and may account for around 50 per cent of total indirect energy input. It is reliably estimated that the energy content of fertilisers in 1978 was equivalent to 751,000 TOE.

United Kingdom

Indirect consumption of energy in agriculture has been evaluated by Dr. D.J. White for a number of years, 1978 being the most recent.

The values for fertilisers are the most reliable, and account for about 41 per cent of indirect energy used in agriculture. The values given for transport and services, chemicals and miscellaneous uses were derived by G. Leach for 1968 and have not been updated. The figures for machinery, buildings and feedstuffs are open to question on the grounds of methodology, and may well be revised by Dr. White and his colleagues.

The data for feedstuffs exclude imported products and those made on the farm itself.

Table 1.7

Indirect Energy Consumption in Agriculture

Country	Main Source of Data	Year	Fertilisers TOE '000	%	Animal Feedstuffs TOE '000	%	Agro-Chemicals TOE '000	%	Machinery TOE '000	%	Other TOE '000	%	Total TOE '000	%
Belgium	E. Van Hecke	1977	392	17	1,464	61	...	-	197	8	329[a]	14	2,382	100
Denmark	S. Rasmussen	1978	693	55	341	27	26	2	(200)	16	...	-	(1,260)	100
France	CNEEMA	1977	3,900	44	1,800	20	600	7	1,300	15	1,200[b]	14	8,800	100
Germany FR	IAM	1977	3,077	52	1,286	22	66	1	1,458	25	...	-	5,887	100
Ireland	Agricultural Institute	1978	496	46	200	18	...	-	195	18	195[c]	18	1,086	100
Italy	EIU	1978	(4,081)	53	(2,550)	33	(706)	9	(414)	5	...		(7,751)	100
Luxemburg	EIU	1978	(25)	29	(40)	47	...	-	(20)	24	...	-	(85)	100
Netherlands	EIU	1978	751	25	(2,000)	67	(30)	1	(200)	7	...	-	(2,981)	100
United Kingdom	D.J. White	1978	2,228	41	1,254	23	203	4	950	17	831	15	5,466	100
EUR 9 total		1977/78[d]	(15,643)	44	(10,935)	31	(1,631)	4	(4,934)	14	(2,555)	7	(35,698)	100

a including agro-chemicals and buildings; b including buildings and miscellaneous items; c including buildings, transport and services; d estimate of annual consumption based on national totals for 1977 or 1978

Source: As identified in the table and EIU estimates in brackets

DIRECT ENERGY CONSUMPTION BY USAGE

By grouping usage sectors into broad categories, it is possible to compare the relative importance of the uses made of energy in a number of countries. This has been done in Table 18 in which consumption of direct energy is broken down to identify three major sectors of use:

- heating in animal rearing and drying of crops
- horticulture
- machinery and power.

Heating in animal rearing includes ventilation and energy expended in controlling the environment of rearing units.

Machinery includes tractors and self-propelled agricultural machinery, and powered equipment used in dairy farming such as milking equipment and milk-cooling equipment.

Belgium

In evaluating direct consumption of fossil fuels in agriculture, Van Hecke has taken into account three inputs - heating in animal rearing, heating in horticulture, and the consumption of fuel and lubricants by tractors and other agricultural machinery. The EIU has broken down an aggregate figure for consumption of electricity (161,000 TOE) between the three major areas of energy usage.

Horticulture accounts for the major part of direct energy consumption in agriculture, taking up 42 per cent of direct input of energy.

This situation is explained by the importance of cultivation under glass. Between 1973 and 1977, the consumption of light and heavy fuel oil in the heating of glasshouses declined from 374,350 TOE to 302,990 TOE, a fall of 19 per cent. In the same period, the area under glass rose marginally from 11,457,537 square metres to 11,515,937 square metres.

Animal rearing accounts for about 26 per cent of direct energy input, mainly in the form of heating. Fuel and lubricants for powering agricultural machinery account for about 32 per cent of direct energy consumption.

Denmark

Horticulture accounts for 40-50 per cent of direct energy input to agriculture, taking up an estimated 350,000 TOE in 1978. Agricultural machinery is defined as including tractors and machinery used in the preparation of the soil and harvesting, and machinery used in dairy farming. This category accounts for some 40 per cent of direct energy consumption.

Heating is defined to include heating and ventilation in animal rearing, and drying of grain on the farm. These activities account for 10 per cent of direct energy input.

France

Estimates based on data obtained from the Ministry of Agriculture show that fuel for tractors and self-propelled machinery, and electricity used as power to drive agricultural machinery comprise the largest usage category, accounting for 70 per cent of direct energy input to agriculture.

Heating, comprising mainly heating and ventilation in animal rearing and grain drying, takes up about 20 per cent of direct energy input.

Germany FR

The data on which to base an estimate of direct energy consumption by usage sector is scant. It is reasonable to assume that fuel and electricity used to power agricultural machinery accounts for 40-50 per cent of total direct energy input to agriculture.

Ireland

In its analyses of the studies which it conducted on energy consumption in agriculture in 1974 and 1978, the Agricultural Institute arrived at broad estimates of the consumption of petroleum-based fuels and electricity by main usage sectors.

The share of DERV fuel for tractors in total demand for petroleum-based fuels in direct consumption in agriculture would have risen from some 63 per cent to about 67 per cent between 1974 and 1978, from 168,000 TOE to 232,000 TOE.

The second largest category of demand for petroleum-based fuels is made up of heavy oil used for heating glasshouses; this category accounts for about 15 per cent of petroleum-based fuels, equivalent to 53,000 TOE in 1978. The total area under glass in Ireland is estimated at 180 hectares, of which 120-140 hectares are heated.

Fuel to provide heating on pig-breeding farms would account for another 14 per cent of total input of petroleum-based fuels to agriculture. However, a large proportion, which could be as high as 50 per cent according to some respondents, is probably accounted for by heating for domestic purposes.

Electrical machinery used in crop and livestock farming accounts for some 94 per cent of consumption of electricity for agricultural purposes. The main uses of electricity are in dairy farming where electricity is used for powering milk coolers. Consumption of electricity by farms cultivating crops under glass is relatively small and is equivalent to close on 6 per cent of all electricity consumed for agricultural purposes.

Luxemburg

Of total direct energy consumption in agriculture of 21,000 TOE in 1978, OECD provides a breakdown which identifies

gas/diesel oil	4,000 TOE
residual fuel oil	11,000 TOE
Electricity	6,000 TOE.

It can be assumed that gas/diesel oil and electricity are used mainly to power agricultural machinery, although the share of total direct energy consumption (48 per cent) thereby attributed to machinery and power appears relatively low.

Residual fuel (52 per cent) is treated as being used in heating and drying.

Netherlands

Horticulture accounts for some 80-90 per cent of direct energy consumed in agriculture, and the heating of glasshouses accounts for over 90 per cent of energy used in horticulture. In 1980, there were 28,700 holdings engaged in horticulture, of which 42 per cent with cultivation mainly under glass. The number of horticultural holdings has declined by 22 per cent since 1971, but the number of holdings cultivating under glass has fallen by only 15 per cent.

Since the 1960s, there has been a marked increase in the number of natural gas burning installations in horticulture. The Dutch Government has been prepared to cover the cost of installing natural gas equipment, as part of a general energy programme aimed at encouraging the use of a national fuel and reducing dependence on imported supplies of expensive petroleum products.

United Kingdom

Agricultural machinery and vehicles account for some 50 per cent of direct energy input. Energy used in heating and drying is the second largest usage sector, taking up close on 30 per cent of direct energy input.

Horticulture accounts for 20-25 per cent of direct energy input. In broad terms, the heating of glasshouses accounts for a quarter of direct petroleum fuel input into agriculture, and this fuel represents up to 40 per cent of the costs of producing fruit, vegetables and flowers in glasshouses.

Table 1.8

Direct Energy Consumption by Usage

Country	Year	Heating[a] TOE '000	%	Horticulture TOE '000	%	Machinery and Power TOE '000	%	Total TOE '000	%
Belgium	1977	(240)	26	(380)	42	(291)	32	911	100
Denmark	1978	79	10	350	46	330	44	759	100
France	1977	(980)	20	(490)	10	(3,430)	70	4,900	100
Germany FR	1977	(1,100)	25	(1,280)	29	(2,000)	46	4,380	100
Ireland	1978	(54)	14	(61)	16	(262)	70	377	100
Italy	1978	(434)	20	(100)	5	(1,634)	75	2,168	100
Luxemburg	1978	(11)	52	...	-	(10)	48	21	100
Netherlands		(200)	8	(2,100)	80	(300)	12	2,600	100
United Kingdom	1978	(490)	27	(400)	22	(949)	51	1,839	100
EUR 9 total	1977/78[b]	(3,588)	20	(5,161)	29	(9,206)	51	(17,955)	100

a heating and ventilation in animal rearing and drying of crops; b estimate of annual consumption based on national totals for 1977 or 1978

Source: As identified in Table 1.4 and EIU estimates in brackets

APPENDIX 1 to SUMMARY CHAPTER

SOURCES OF INFORMATION : LIST OF COMPANIES AND ORGANISATIONS APPROACHED BY THE CONSULTANTS

Belgium

- Belgische Boerenbond
- Centre de Recherche et d'Information Socio-Politique
- Faculté des Sciences Agronomiques de l'Etat
- Fédération des Industries Chimiques
- Ford Motor Company (Belgium)
- Institut Economique Agricole
- Institut National de la Statistique
- Katholieke Universiteit Leuven
- J.P. Lebailly
- Ministère des Affaires Etrangères
- Ministère de l'Agriculture
  . Administration des Structures Agricoles
  . Service d'Information
- Professeur E. van Hecke
- Union des Exploitations Electriques en Belgique
- Universiteit Gent

Denmark

- Danmarks Statistik
- Danske Gasvaerker Forening
- Dansk Elvaerkers Forening
- De Danske Landboforeninger
- Det Landøkonomiske Driftbureau
- Energiministeriet
- Energystyrelsen

- Jordbrugsintitut
- Konglige Veterinaer og Landbohojeskole
- Landboorganisationernes Faellesudvalg
- Landbrugets Ekonomiske Statistik Udvalg
- Landbrugsministeriet
- Landbrugsraadet
- Risø Energisystemgruppen

France

- Académie d'Agriculture de France
- Agra
- Centre National d'Etudes et d'Expérimentation de Machinisme Agricole
- Chambre Syndicale Nationale des Fabricants d'Engrais Composés
- Comité d'Etudes et de Recherches Economiques sur l'Energie
- Comité Européen des Groupements de Constructeurs du Machinisme Agricole
- Comité Professionnel du Pétrole
- Compagnie Française des Pétroles
- Compagnie Française des Pétroles Total
- Electricité de France/Gaz de France
- Fédération Nationale de Syndicats d'Exploitants Agricoles
- Institut National de Recherches Agricoles
- Institut National de la Statistique et des Etudes Economiques
- Laboratoire d'Ecologie Générale et Appliquée, Université de Paris VII
- Ministère de l'Agriculture
- Ministère de l'Industrie
- Organisation for Economic Cooperation and Development
- Société Nationale Elf Aquitaine
- Société pour l'Etude et la Diffusion de Documents Economiques et Sociaux
- Sopexa
- Union des Industries Chimiques
- Union Laitière Normande

Germany FR

- Agrarwirtschaft
- Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten
- Bundesamt für Ernährung und Landwirtschaft
- Bundesforschungsanstalt für Landeskunde und Raumordnung
- Bundesforschungsanstalt für Landwirtschaft
- Bundesministerium für Ernährung, Landwirtschaft und Forsten
- Bundeswirtschaftsministerium
- Deutsche Shell
- Institut für Agrarpolitik und Marktlehre
- Institut für Landtechnische Grundlagenforschung der Forschungsanstalt für Landwirtschaft
- Institut für Technik in Gartenbau und Landwirtschaft
- Landwirtschaftsverlag
- Statistisches Bundesamt
- Vereinigung Industrielle Kraftwirtschaft

Ireland

- Department of Agriculture
- Department of Energy
- Economic and Social Research Institute
- Electricity Supply Board
- Irish Central Statistical Office
- Irish Institute for Industrial Research and Standards
- National Board for Science and Technology
- Oak Park Research Centre
- The Agricultural Institute
  - . Headquarters
  - . Kinsealy Station
  - . Carlow Station

Italy

- Ente Nazionale Energia Elettrica
- Ente Nazionale Idrocarburi
- Istituto Nazionale Statistica

- Ministero Dell Industria
- Unione Nazionale Costructtori Macchine Agricole
- Utenti Motori Agricoli

Luxemburg

- Eurostat
- Ministère de l'Agriculture
- Service Central de la Statistique et des Etudes Economiques
- Service d'Economie Rurale

Netherlands

- Centraal Bureau voor de Statistiek
- Landbouw-Economisch Instituut
- Landbouw Hogeschool
- Ministerie van Economische Zaken
- Ministerie van Landbouw en Visserij
- Nationale Raad voor Landbouwkundig Onderzoek
- Nederlandse Stichting voor Energie-onderzoek
- Staatsuitgeverij en -drukkerij
- Unilever

United Kingdom

- Agricultural Engineers' Association
- Agricultural Research Council
- British Agrochemicals Association
- Department of Energy
- Electricity Council, Intelligence Section
- Fertiliser Manufacturers' Association
- Glasshouse Crops Research Institute
- Harwell, Energy Technology Support Unit
- Imperial Chemical Industries
  - . Agricultural Division
  - . Plant Protection Unit
- Institute of Agriculture, Fisheries and Food
  - . Agricultural Development and Advisory Service
  - . Rothampsted Experimental Station

- Institute of Energy
- Monsanto
- National Farmers' Union
- National Institute of Agricultural Engineering
- Open University Energy Research Unit
- Shell International
- Shell UK
- United Kingdom Agricultural Supply Trade Association
- Weed Research Organisation

Among a confusing array of sources - many providing only partial data in terms of prices and activities, and many showing wide variances when attempting to measure similar inputs of energy - the EIU has had to express an opinion on which sources can be considered the most reliable. The selection of preferred sources was made after sounding out the opinions of well-informed persons during an extensive programme of interviews in each country. The criteria for selecting the preferred sources were:

- the data are the findings of surveys which had as their objective the evaluation of energy inputs to agriculture
- the surveys are comprehensive in that they take account of direct consumption of the main fuels, and attempt to assess indirect energy consumption
- the data can be confirmed, at least broadly, by reference to other sources.

The sources which were retained by the EIU are identified below, and it is from these that much of the statistical data which are set out in the tables that follow have been extracted.

Belgium	:	- E. Van Hecke - J.P. Lebailly
Denmark	:	- S. Rasmussen - Jordbrugsinstitut - Danmarks Statistik
France	:	- Ministry of Agriculture - Centre National d'Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA)

Germany FR	:	- Institut für Agrarpolitik und Marktlehre (IAM)
Ireland	:	- Agricultural Institute (AI)
Italy	:	- Ministry of Industry
Luxemburg	:	- OECD
Netherlands	:	- Wetenschappelijke Raad voor het Regeringsbeleid
United Kingdom	:	- Department of Energy - D.J. White.

The EIU has arrived at its own estimates to fill gaps in the data obtained from these sources, with a view to allowing a more comprehensive international comparison. These estimates should be treated with caution; they are broad estimates at the best.

Most of the preferred sources of data have undertaken comprehensive but static studies on the use of energy in agriculture. The studies are, however, relatively recent, referring to 1977 or 1978. The difference in time is not sufficient to invalidate an international comparison, and the situation in 1977 or 1978 is unlikely to have altered significantly since, particularly if allowance is made for an inevitably broad margin of error.

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

BELGIUM

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

BELGIUM

Page

AGRICULTURE IN BELGIUM

The total area under agricultural cultivation was 1,432,000 hectares at the time of the Census of Agriculture held in May 1979. In the seven years since the Census of May 1972, the area under cultivation declined by 6 per cent.

The agricultural sector in Belgium is characterised by a large number of small holdings, although the number is declining: from 1970 to 1978 the number of holdings fell by 32 per cent to 125,600. The average size of holdings has risen from 6.2 hectares in 1959 to 11.5 hectares in 1978. Only 3.1 per cent of the active population is engaged in agriculture, compared with 4.6 per cent in 1970.

Table 2.1

Belgium: Number of Agricultural Holdings[a], 1970-1978

Size of Holding (Hectares)	1970		1977		1978	
	Number	%	Number	%	Number	%
No activity	4,543	2.5	3,458	2.6	3,190	2.5
1 - 5	93,237	50.7	57,308	43.7	53,847	42.9
5 - 10	33,059	18.0	20,911	16.0	19,895	15.8
10 - 15	20,838	11.3	15,621	11.9	15,070	12.0
15 - 20	12,642	6.9	11,106	8.5	10,831	8.6
20 - 30	11,281	6.1	11,510	8.8	11,503	9.2
30 - 50	5,808	3.1	7,552	5.8	7,604	6.1
50 - 100	2,222	1.2	3,040	2.3	3,125	2.5
100 and over	375	0.2	530	0.4	562	0.4
Total	184,005	100.0	131,036	100.0	125,627	100.0

a commercial holdings producing for sale

Source: Institut National de Statistique (INS)

Capital investment in agriculture has increased appreciably from year to year, rising from BF 7,000 million in 1968 to BF 17,000 million in 1978.

Agriculture contributed 3 per cent of Gross National Product (GNP) in 1978, compared with 7 per cent of GNP some 25 years ago. Close on 70 per cent of gross added-value derived from agriculture is attributed to livestock and dairy farming, and this is consequently the sector of agriculture with the highest energy input. The trend towards larger, more mechanised holdings would suggest that demand for energy in agriculture is increasing.

ENERGY COSTS

The cost of inputs to agriculture is analysed annually by the Ministry of Agriculture and the analysis serves to illustrate the increasing burden of the cost of energy and lubricants since 1973. Energy and lubricants accounted for 4.8 per cent of goods and services purchased by farmers in 1972 but sharp rises in 1974, 1978 and 1979 have taken the share of energy and lubricants to 8.9 per cent in 1979. Energy and lubricants now represent the second most important input to agriculture, after feedstuffs (60 per cent) and ahead of fertilisers.

In the seven-year period from 1972 to 1979 covered by Table 2.2, the cost of inputs of goods and services bought in by farmers has risen by 62 per cent from BF. 52,468 million to BF. 84,791 million. In the same period, the cost of energy and lubricants has increased nearly threefold from BF. 2,781 million to BF. 7,546 million.

Table 2 2

Belgium: Purchases of Goods and Services by the Agricultural Sector, 1972-1979

(percentage)

	1972	1973	1974	1975	1976	1977	1978	1979
Plants and seeds	3.8	3.5	3.5	3.7	3.7	4.2	3.8	3.7
Feedstuffs	62.5	66.1	65.7	62.1	63.9	62.7	60.1	60.0
Fertilisers	9.0	7.8	7.7	8.7	8.6	8.3	8.7	8.1
Agro-chemicals	2.1	2.1	2.2	2.7	2.3	2.4	3.0	3.0
Pharmaceuticals	0.9	0.9	1.0	1.0	1.3	1.1	1.3	1.3
Energy and lubricants	5.3	4.8	6.2	6.9	6.6	6.7	7.5	8.9
Cattle	3.0	2.4	1.1	2.3	2.1	2.4	2.4	1.8
Maintenance and repair	5.6	5.3	5.7	5.7	5.1	5.5	6.0	6.0
General costs	7.8	7.1	6.9	6.9	6.6	6.7	7.2	7.2
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Value of total purchases (BF mn)	52,468	62,470	68,439	72,325	81,213	82,984	80,064	84,791

Source: EIU calculations based on data provided by the Ministère de l'Agriculture, Institut Economique Agricole (IEA)

SOURCES AND SUMMARY OF DATA

There are three main sources of data which can be used to evaluate the consumption of energy in agriculture, OECD statistics on the energy balance of member states, and the studies undertaken by Professor E. Van Hecke and by J.P. Lebailly. Of these three sources, only OECD provides a historical series of statistics which can be used to trace trends. Van Hecke's analysis relates to 1977, and Lebailly's evaluations are based on averages for the three years 1974-1976. OECD statistics are, however, partial in that they cover only direct energy consumption in the form of petroleum-based fuels.

Each of the three main sources of data are treated separately in subsequent chapters of this study, but so as to identify the dimensions of the subject at the outset, the main findings of the three sources are compared in Table 2.3.

A comparison of the estimates of energy consumption arrived at by Van Hecke and Lebailly shows that the findings are broadly similar. In an area of uncertainty, the differences can be attributed to methodology.

Lebailly puts direct energy consumption 6 per cent above that of Van Hecke, at 970,000 TOE a year compared with 911,000 TOE. Direct electricity consumption accounts for much of the difference, with Lebailly putting annual consumption 19 per cent higher than Van Hecke.

Lebailly and Van Hecke are broadly in agreement in their estimates of total indirect energy consumption, although, as will be shown later in the study, they diverge in the breakdown of indirect energy by source of input, particularly in their respective evaluations of the indirect energy content of agricultural machinery.

Table 2.3

Belgium: Energy Consumption in Agriculture - Comparative Summary of Data

(TOE '000)

	Lebailly 1974-76 (Average)	Van Hecke 1977	OECD 1972	OECD 1975	OECD 1977	OECD 1978
Direct Energy	970	911	...	...	...	...
of which:						
- Petroleum fuels	743	750	441	409	527	527
- Coal	36		...	...	...	...
- Electricity	191	161	...	...	...	...
Indirect Energy	2,297	2,382	...	...	...	...
Total	3,267	3,293	...	...	...	...

Source: J.P. Lebailly, E. Van Hecke and OECD

Both Lebailly and Van Hecke evaluate direct consumption of petroleum-based fuels far above the figures provided by OECD. Van Hecke's estimate of consumption of fossil energy (mainly petroleum-based fuels) of 750,000 TOE is 42 per cent higher than the figure of 527,000 TOE recorded by OECD in Energy Balances for 1977. Lebailly's estimated average annual consumption of 743,000 TOE for the three years 1974-1976 is 82 per cent above the consumption of petroleum-based fuels recorded by OECD for the same period (408,000 TOE).

On balance, and after discussing the variance with well-informed respondents in Belgium and with respondents representing international organisations, the EIU suggests that the estimates of Van Hecke and Lebailly are closest to reality. The assumptions on which Van Hecke and Lebailly rest their evaluations are explained later in the report.

Table 2.3 shows that direct energy consumption accounts for some 25-30 per cent of total energy consumption in agriculture, and that petroleum-based fuels account for some 80 per cent of direct energy input.

It should be borne in mind that a high proportion of indirect energy utilised in agriculture in Belgium is imported in the form of animal feed-stuffs, fertilisers and agricultural machinery. Belgium is largely dependent on imports for supplies of these products.

OECD DATA: DIRECT CONSUMPTION OF PETROLEUM-BASED FUELS

OECD statistics can be used to determine total energy consumption in Belgium. The data set out in Table 2.4 have been extracted from Energy Balances of OECD Countries 1973-1978, which was published in 1980.

Table 2.4

Belgium: National Energy Consumption[a], 1973-1978

	1973		1976		1977		1978	
	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent
Solid fuels	8.14	21.7	5.92	16.8	5.43	15.6	6.10	16.9
Petroleum products	21.21	56.6	19.22	54.6	18.78	53.8	19.12	53.0
Gas	5.19	13.8	6.81	19.3	7.30	20.9	7.27	20.2
Electricity	2.95	7.9	3.24	9.2	3.38	9.7	3.56	9.9
National total	37.49	100.0	35.21	100.0	34.89	100.0	36.05	100.0
of which:								
Agriculture[b]	0.46	1.2	0.41	1.2	0.53	1.5	0.53	1.5

a direct final consumption

b petroleum products only

Source: Organisation for Economic Cooperation and Development (OECD) - Energy Balances

The share of agriculture in national consumption of direct energy cannot be derived from the partial data obtained from OECD, which only identify consumption of petroleum-based products in agriculture. Some measure of agriculture's share of energy consumption in recent years can be obtained by relating OECD figures for national consumption with figures put forward by Van Hecke and Lebailly for direct energy consumption in agriculture. This comparison shows that agriculture accounts for close on 3 per cent of national consumption of direct energy:

	National Consumption (TOE '000)	Agricultural Consumption (TOE '000)	Share of Agriculture (%)
1974-76 (average)	34,777	970	3
1977	34,890	911	3

Table 2.5 has been compiled from statistical data extracted from Energy Statistics of OECD Countries published by OECD. Although the statistical data are partial, relating only to direct consumption of petroleum-based fuels, and their accuracy is questionable, those figures constitute the only time series which can be taken as indicative of the trend in consumption of energy in agriculture. The studies of Professor E. Van Hecke and J.P. Lebailly are essentially static.

Table 2.5 below shows that in tonnage terms agriculture accounted for 2.8 per cent of Belgian consumption of petroleum and petroleum gas products in 1978. In 1973, agriculture had taken up 2.2 per cent of national consumption of petroleum and petroleum gas.

Since 1973, total national consumption of petroleum products has tended to decline from 20,597,000 tonnes in 1973 to 18,462,000 tonnes in 1978: the trend has not been even, and consumption has stabilised at around 18,500,000 tonnes since 1976.

Demand for petroleum-based fuels in agriculture reached a peak of 450,000 tonnes in 1973, declined in 1974 and remained stable at around 397,000 tonnes until 1977 when consumption rose steeply by 30 per cent to 517,000 tonnes. The level of consumption was maintained in 1978 at 517,000 tonnes, 15 per cent above the level of consumption in 1973.

There is no information on the sulphur content of petroleum-based fuels refined in Belgium or imported, let alone of petroleum-based fuels used in agriculture.

Table 2.5

Belgium: Uses of Direct Energy in Agriculture by Petroleum Product Type, 1973-1978

	Gas	Motor gasoline	Kerosene	Gas/diesel oil	Residual fuel oil	Total[a]
1973						
Agriculture						
- tonnes '000	10	4	4	300	132	450
- TOE '000	11	4	4	314	128	461
National consumption						
- tonnes '000	540	2,573	37	9,247	4,678	20,597
- TOE '000	616	2,761	39	9,663	4,533	21,210
Share of agriculture (%)	1.8	0.2	10.8	3.2	2.8	2.2
1974						
Agriculture						
- tonnes '000	10	3	5	275	104	397
- TOE '000	11	3	5	287	101	407
National consumption						
- tonnes '000	513	2,511	24	8,346	2,933	17,679
- TOE '000	585	2,694	25	8,722	2,842	18,300
Share of agriculture (%)	1.9	0.1	20	3.3	3.5	2.2

(continued)

Table 2.5 (continued)

Belgium: Uses of Direct Energy in Agriculture by Petroleum Product Type, 1973-1978

	Gas	Motor gasoline	Kerosene	Gas/diesel oil	Residual fuel oil	Total[a]
1975						
Agriculture						
- tonnes '000	10	4	4	280	100	398
- TOE '000	11	4	4	293	97	409
National consumption						
- tonnes '000	526	2,769	22	8,255	3,292	16,628
- TOE '000	600	2,971	23	8,626	3,190	18,160
Share of agriculture (%)	1.9	0.1	18.2	3.4	3.0	2.3
1976						
Agriculture						
- tonnes '000	10	5	2	280	100	397
- TOE '000	11	5	2	293	97	408
National consumption						
- tonnes '000	522	2,869	23	8,859	3,533	18,576
- TOE '000	595	3,078	24	9,258	3,423	19,220
Share of agriculture (%)	1.9	0.2	8.7	3.2	2.8	2.1

(continued)

Table 2.5 (continued)

Belgium: Uses of Direct Energy in Agriculture by Petroleum Product Type, 1973-1978

	Gas	Motor gasoline	Kerosene	Gas/diesel oil	Residual fuel oil	Total[a]
1977						
Agriculture						
- tonnes '000	11	4	2	300	200	517
- TOE '000	13	4	2	314	194	527
National consumption						
- tonnes '000	519	2,978	24	8,834	3,288	18,132
- TOE '000	592	3,195	25	9,232	3,186	18,780
Share of agriculture (%)	2.1	0.1	8	3.4	6.1	2.8
1978						
Agriculture						
- tonnes '000	11	4	2	300	200	517
- TOE '000	13	4	2	314	194	527
National consumption						
- tonnes '000	574	3,069	27	8,820	3,368	18,462
- TOE '000	654	3,293	28	9,217	3,264	19,120
Share of agriculture (%)	1.9	0.1	7.4	3.4	5.9	2.8

a Totals for national consumption include petroleum-based fuels not used in agriculture, such as aviation gasoline and jet fuel, and non-energy petroleum products.

Source: EIU calculations based on data provided by Organisation for Economic Cooperation and Development (OECD)

DIRECT AND INDIRECT ENERGY CONSUMPTION

The only detailed analyses of the consumption of energy in agriculture in Belgium are these undertaken by Professor E. Van Hecke, published by the Centre de Recherche et d'Information Socio-Politique (CRISP), and by J.P. Lebailly of the Faculty of Agronomic Science at Gembloux.

EVALUATION BY PROFESSOR E. VAN HECKE

Van Hecke has made a detailed evaluation of the energy input to agriculture in the year 1977. The results of Van Hecke's study were published in the early part of 1980. Van Hecke has evaluated total energy consumption in agriculture in 1977 at 137,888 10^6 MJ which is equivalent to 3.3 million TOE. Direct consumption accounted for 911,000 TOE (28 per cent) and indirect consumption for 2,382,000 TOE (72 per cent).

Table 2.6

Belgium: Energy Consumption in Agriculture, 1977

	MJ 10^6	TOE '000	Per Cent
Direct Energy			
Fossil energy	31,405	750	22.8
of which:			
- heating in animal rearing	9,359	223	6.8
- heating in horticulture	15,576	371	11.3
- fuel and lubricants for machinery	6,470	156	4.7
Electricity	6,697	161	4.9
Total Direct	38,102	911	27.7
Indirect Energy			
Fertilisers	16,425	392	11.9
Animal feedstuffs	61,315	1,464	44.4
Agricultural machinery	8,258	197	6.0
Miscellaneous (buildings, agro-chemicals, maintenance products)	13,788	329	10.0
Total Indirect	99,786	2,382	72.3
Total energy input	137,888	3,293	100.0

Source: Centre de Recherche et d'Information Socio-Politiques (CRISP)

Direct Energy

Direct consumption of fossil fuels and electricity accounts for close on 28 per cent of total energy consumption in agriculture. The use of solid fuel in agriculture is low and is confined to the heating of stables and animal rearing units. The term fossil fuel refers to petroleum products, natural gas and coal which accounted for 750,000 TOE of direct energy consumption in agriculture in 1977, representing 82 per cent of total direct energy consumption.

In evaluating direct consumption of fossil fuels in agriculture, Van Hecke has taken into account three inputs - heating in animal rearing, heating in horticulture, and the consumption of fuel and lubricants by tractors and other agricultural machinery.

Fuel consumption in animal rearing has been assessed on the basis of an extrapolation of data extracted from farm accounts drawn up on behalf of farmers affiliated to the Belgische Boerenbond, the leading agricultural association representing farming interests. The analysis of farm accounts suggests that the average annual consumption of fuel per animal for heating is as follows:

- sows	90 litres
- fattening pigs	33 litres
- laying hens	4 litres
- fattening hens	3 litres
- fattening calves	5 litres
- cows	20 litres

Fuel input in horticulture has been assessed on the basis of claims for the refund of excise duty included in the price of fuel oil paid by horticulturalists cultivating plants and crops under glass. These returns, which are treated as confidential by the fiscal authorities and are not published, support an estimate of aggregate consumption of 82,600 tonnes of gas oil and 244,674 tonnes of heavy fuel oil in 1977.

The consumption of natural gas in horticulture has been assessed from data provided by the gas distributing companies. It was estimated that in 1977 some 48,000 TOE of natural gas were utilised in the horticulture sector.

Estimates based on fiscal returns have been adjusted upwards to allow for farmers who have failed to file claims for the refund of excise duty, and for the small number of farmers who rely on propane and coal for the heating of animal rearing units and glasshouses.

Fuel consumption for the powering of tractors and other farm machinery has again been assessed from farm accounts drawn up by the Belgische Boerenbond. The analysis of farm accounts allowed Van Hecke to arrive at the cost of fuel per hectare, and to differentiate between agricultural regions. The energy units arrived at by this method of evaluation were increased by 5 per cent to take account of consumption of lubricants.

In evaluating the consumption of electricity in agriculture, Van Hecke has again relied on data extracted from farm accounts made available by the Belgische Boerenbond. On average, consumption of electricity is equivalent to 50 KWH per annum per hectare in Belgian agriculture: consumption of electricity has been evaluated on the assumption that 1 KWH is equivalent to 9.7 MJ and that power stations achieve an output yield of 37 per cent. In addition, an allowance is made for consumption of electricity by large users - in animal rearing and in heating glasshouses. The norms used to estimate consumption of electricity in animal rearing are as follows, in terms of placements for animals maintained in a year:

- sows	250 KWH
- fattening pigs	25 KWH
- cows	250 KWH
- fattening calves	107 KWH
- laying hens	2.1 KWH
- fattening hens	1.8 KWH

The norm for glasshouses is 5 KWH a year per square metre.

Horticulture accounts for the major part of direct energy consumption in agriculture, taking up 49 per cent of direct input of fossil fuels. This situation is explained by the importance of cultivation under glass. The heating of glasshouses alone accounted for 41 per cent of direct energy input and for 11 per cent of total energy input in agriculture.

Animal rearing accounts for about 25 per cent of direct energy input, mainly in the form of heating, but takes up the major part of indirect energy consumption in the form of animal feedstuffs.

Fuel and lubricants for powering agricultural machinery account for some 5 per cent of total energy input in agriculture but for 17 per cent of direct energy consumption.

Indirect Energy

Data on the consumption of fertilisers have been converted into energy units following the method used by G. Leach in his study entitled "Energy and Production". A regional analysis of indirect consumption of energy in the form of fertilisers rests on a comparative analysis of expenditure on fertilisers as extracted from farm accounts.

Energy inputs in the production and distribution of animal feedstuffs have been evaluated on the basis of average inputs in the United Kingdom arrived at by Leach. In 1968, Leach calculated that one kilo of animal feedstuffs was equivalent to 9.6 MJ of energy. This energy input is the sum of three energy factors:

- energy consumed in the production of raw materials
- energy consumed in the processing of raw materials into finished feedstuffs
- energy consumed in the transport of imported feedstuffs.

In adapting the figures derived from experience in the United Kingdom to conditions in Belgium, the transport energy factor has been increased to allow for Belgium's greater dependence on imported feedstuffs and raw materials for processing into feedstuffs locally. Moreover, as Leach's calculations are based on 1968 data and as it is generally agreed that there has been an appreciable increase in the consumption of energy in the production of raw materials for animal feedstuffs, Van Hecke has concluded that the energy input in animal feedstuffs consumed in Belgium is of the order of 12 to 13 MJ per kilo of feedstuffs. The calculations made by Van Hecke are based on an average energy input of 12.5 MJ per kilo of feedstuff.

According to the Food and Agriculture Organisation (FAO) the average energy input in the production of agricultural machinery is equivalent to 86.7 MJ per kilo of weight of machinery, and the average weight of tractors and other mobile agricultural equipment in Europe is 8 tonnes. Van Hecke has retained the input factor of 86.7 MJ per kilo, but has concluded that the average weight of tractors and related agricultural machinery used in

Belgium is only 6-7 tonnes. It should be borne in mind that Belgian farms are relatively small in comparison with other European countries.

To the energy inputs required for the production of tractors and other agricultural machinery, 20 per cent of production input has been added to allow for maintenance and repair of the machinery.

Miscellaneous items containing an energy input include buildings, agro-chemicals and maintenance products. Leach has estimated that in the United Kingdom such miscellaneous items account for 10 per cent of total energy input in agriculture, and, in the absence of any other indications, the same estimate has been made in Belgium.

Animal feedstuffs account for 44 per cent of total energy consumption in agriculture. It should be borne in mind, however, that as Belgium is a large importer of animal feedstuffs and of raw materials for processing into feedstuffs, a high proportion of the energy consumed in the production of feedstuffs fed to animals in Belgium is consumed abroad.

Indirect consumption of energy in the form of fertilisers and agricultural machinery represent 12 per cent and 6 per cent respectively of total energy input in agriculture.

EVALUATION BY J.P. LEBAILLY

J.P. Lebailly has attempted to calculate energy consumption in agriculture by applying scientifically established energy input factors to outputs of agricultural produce.

Lebailly has evaluated the consumption of energy in each of the years 1974, 1975 and 1976, and taken the average for the three years so as to even out distortions.

Lebailly has estimated that in the three years from 1974 to 1976 total energy consumption in agriculture averaged 3,267,000 TOE of which 970,000 TOE (30 per cent) were in the form of direct energy consumption, petroleum products accounting for 77 per cent of direct energy consumption.

Table 2.7

Belgium: Energy Consumption in Agriculture 1974-1976

(Annual average)

	10^6 MJ	TOE '000	Per cent
Direct Energy			
Petroleum products	31,100	743	22.7
Coal	1,500	36	1.1
Electricity	8,000	191	5.8
Total Direct	40,600	970	29.7
Indirect Energy			
Fertilisers			
N	13,200	315	9.6
P_2O_5	1,800	43	1.3
K_2O	1,700	41	1.3
Lime	400	10	0.3
Agricultural machinery	5,800	139	4.3
Buildings	4,600	110	3.4
Annual feedstuffs			
- imported	50,600	1,207	36.9
- locally produced	18,100	432	13.2
Total Indirect	96,200	2,297	70.3
Total energy input	136,800	3,267	100.0

Source: J.P. Lebailly, Faculté des Sciences Agronomiques de l'Etat, Gembloux

For fossil energy and electricity input, estimates of consumption in agriculture in value terms have been obtained from the Institut Economique Agricole, and values have been converted to volume units by applying indicative prices ruling at the time for each type of energy.

Information was obtained on consumption of fertilisers, lime and animal feedstuffs from the Institut Economique Agricole, the Institut National de Statistique and from the Ministry of Agriculture.

The park of agricultural machinery was established on the basis of information obtained from the Ministry of Agriculture.

An estimate of the energy required to construct the stock of agricultural buildings was arrived at with the cooperation of the Rural Engineering Department of the Ministry of Agriculture. A twenty-year period has been allowed for the depreciation of farm buildings, and the total indirect input of energy required to construct the stock of farm buildings has been divided by 20 to arrive at annualised values.

The energy conversion factors for petroleum products are those established by F. Bel, Y. Le Pape and A. Mollard in their study of the use of energy in agriculture entitled "Analyse Energétique de la Production Agricole - Concepts et Méthodes".

Coal has been converted into calorific values and 3 per cent has been added to these values to take account of the energy input in the extraction of the coal. The method is that followed by G. Leach and M. Slesser.

The calorific value of electricity has been calculated on the assumption that electricity has been produced by traditional thermal power stations. This assumption is reasonable since in the reference period to which Lebailly's analysis refers - 1974 to 1976 - thermal power stations accounted for 88 per cent of electricity produced in Belgium.

For fertilisers, conversion factors derived by Bel, Le Pape and Mollard have been applied. Lebailly also takes into account the use of lime, and has derived the energy input represented by lime by applying the methodology developed by Leach.

The indirect energy content of agricultural machinery has been arrived at by the method developed by R. Berry and M. Fels.

The indirect energy content of buildings is based on a study of the stock of agricultural buildings in Belgium carried out by Lebailly, and an estimate of the related energy content.

The indirect energy content of animal feedstuffs has been evaluated by applying the methods developed by Leach.

Table 2.8

Belgium: Selected Energy Input Standards Applied by J.P. Lebailly

	MJ per kg	10^4 Kcal per tonne
Petroleum	51.0	1,217.88
Coal	29.7	709.24
Electricity (per GWH)	13.8	329.54
Fertiliser		
- N	75.3	1,798.16
- P_2O_5	13.8	329.54
- K_2O	10.8	257.90
Lime	2.0	47.76
Agricultural machinery	83.7	1,998.76
Animal feedstuffs	3.7	88.36

Source: J.P. Lebailly, Faculté des Sciences Agronomiques de l'Etat, Gembloux

Lebailly has calculated, on the basis of a comparison between fossil energy input and total output of agricultural produce in energy units, that on average 2.41 J of agricultural produce (or 2.41 tonnes oil equivalent of food output) required an input of 1.47 J of fossil energy (or 1.47 tonnes oil equivalent energy) in the period 1974-1976. This relationship shows that one tonne of oil equivalent of fossil energy on average produces 1.64 tonnes of oil equivalent of food energy.

Lebailly calculated the average national annual energy consumption per hectare in the period 1974-1976 at 91,600 MJ per hectare, and average annual energy consumption per person employed in agriculture at 1,013,000 MJ. This is equivalent to 2.19 TOE per hectare and 24.19 TOE per person employed.

COMPARISON OF THE FINDINGS OF PROFESSOR E. VAN HECKE AND J.P. LEBAILLY

A comparison of the estimates of energy consumption arrived at by Van Hecke and Lebailly shows that the findings are broadly similar. In an area of some uncertainty, the differences can be attributed to methodology.

Table 2.9

Belgium: Energy Consumption in Agriculture - Comparison of the Findings of Van Hecke and Lebailly

(TOE '000)

	Lebailly 1974-76 (Average)	Van Hecke 1977
Direct Energy		
Petroleum	743	750
Coal	36	
Electricity	191	161
Total	970	911
Indirect Energy		
Fertilisers	399	392
Lime	10	-
Animal feedstuffs	1,639	1,464
Agricultural machinery	139	197
Buildings	110	329
Miscellaneous (agro-chemicals, maintenance products)	-	
Total	2,297	2,382
Total	3,267	3,293

Source: Professor E. Van Hecke (CRISP) and J.P. Lebailly (Faculté des Sciences Agronomiques de l'Etat)

Lebailly puts direct energy consumption 6 per cent above that of Van Hecke, at 970,000 TOE a year compared with 911,000 TOE. Direct electricity consumption accounts for much of the difference with Lebailly putting annual consumption 19 per cent higher than Van Hecke.

Lebailly and Van Hecke are broadly in agreement in their estimates of indirect energy consumption in the form of fertilisers.

Lebailly estimates indirect energy consumption in the form of animal feedstuffs at 12 per cent higher than Van Hecke.

While Lebailly's estimates tend to be higher than those of Van Hecke for most categories of indirect energy consumption, the balance is restored in the total by Lebailly estimating the indirect energy content of agricultural machinery at 29 per cent below Van Hecke's estimate.

REGIONAL CONSUMPTION OF ENERGY

Eleven agricultural regions are identified in Professor Van Hecke's study: the regions are defined in terms of soil conditions and number of hectares under cultivation. Direct and indirect energy consumption is analysed by region for the year 1977. The regions are identified on the map provided below.

Four regions - Sandy, Sandy-clay, Kempen and Clay - account for 83 per cent of total energy consumption in agriculture, and three of these regions also exceed the national average consumption per hectare.

Average energy consumption (direct and indirect) per hectare is put at 2.26 TOE, of which 0.62 TOE represent direct energy consumption. Three regions exceed the national average in energy consumption, and these regions largely cover the Flemish-speaking region of the country:

Sandy region	5.57 TOE
Kempen	4.43 TOE
Sandy-clay region	2.96 TOE

Four regions fall well below the national average:

Condroz	0.79 TOE
Ardennes	0.71 TOE
Famenne and Fagnes	0.65 TOE
Jurassic region	0.60 TOE

The three agricultural regions with an energy input greater than the national average also have the highest energy inputs per hectare for direct energy and for indirect energy incorporated in fertilisers and animal feedstuffs. The Polders which are situated along the North Sea coast and the Scheldt estuary have a type of agriculture similar to that of other regions of the Flemish-speaking region but holdings tend to be larger and farming less intensive.

The four agricultural regions which cover the Flemish-speaking area of the country - Polders, Sandy, Kempen and Sandy-clay - account for about 75 per cent of total energy consumption in agriculture, but account for only 44 per cent of agricultural land.

By contrast, the five agricultural regions which cover the region south of the River Meuse - Condroz, Haute Ardenne, Famenne and Fagnes, Ardennes, and Jurassic - account for only 9 per cent of total energy consumption but for 28 per cent of the agricultural surface area of the country.

The importance of the Flemish-speaking provinces in the consumption of energy in agriculture is illustrated below by the summary of data extracted from Tables 2.10 to 2.12 to show the share of national consumption accounted for by the four agricultural regions which cover the Flemish provinces:

- agricultural surface area	: 44 per cent
- fossil energy for animal rearing	: 83 per cent
- fossil energy for horticulture	: 98 per cent
- direct fossil energy for powering machinery	: 44 per cent
- electricity	: 70 per cent
- indirect energy in fertilisers	: 54 per cent
- indirect energy in feedstuffs	: 80 per cent
- indirect energy in machinery	: 46 per cent

The diversity of production is more limited in the southern region and most horticultural production takes place in the Flemish-speaking provinces, particularly production under glass.

According to a Commission study of the regional impact of the CAP (Regional Policy series No 21) The Gross Added Value (Agricultural production - intermediate purchased consumer products needed to bring it about) of the Flemish and Wallon area are as follows

GAV / ha 1976 - 1977

Flanders	72,000 BF
Wallonia	26,340 BF

This puts into perspective the high consumption of energy in the Flemish region.

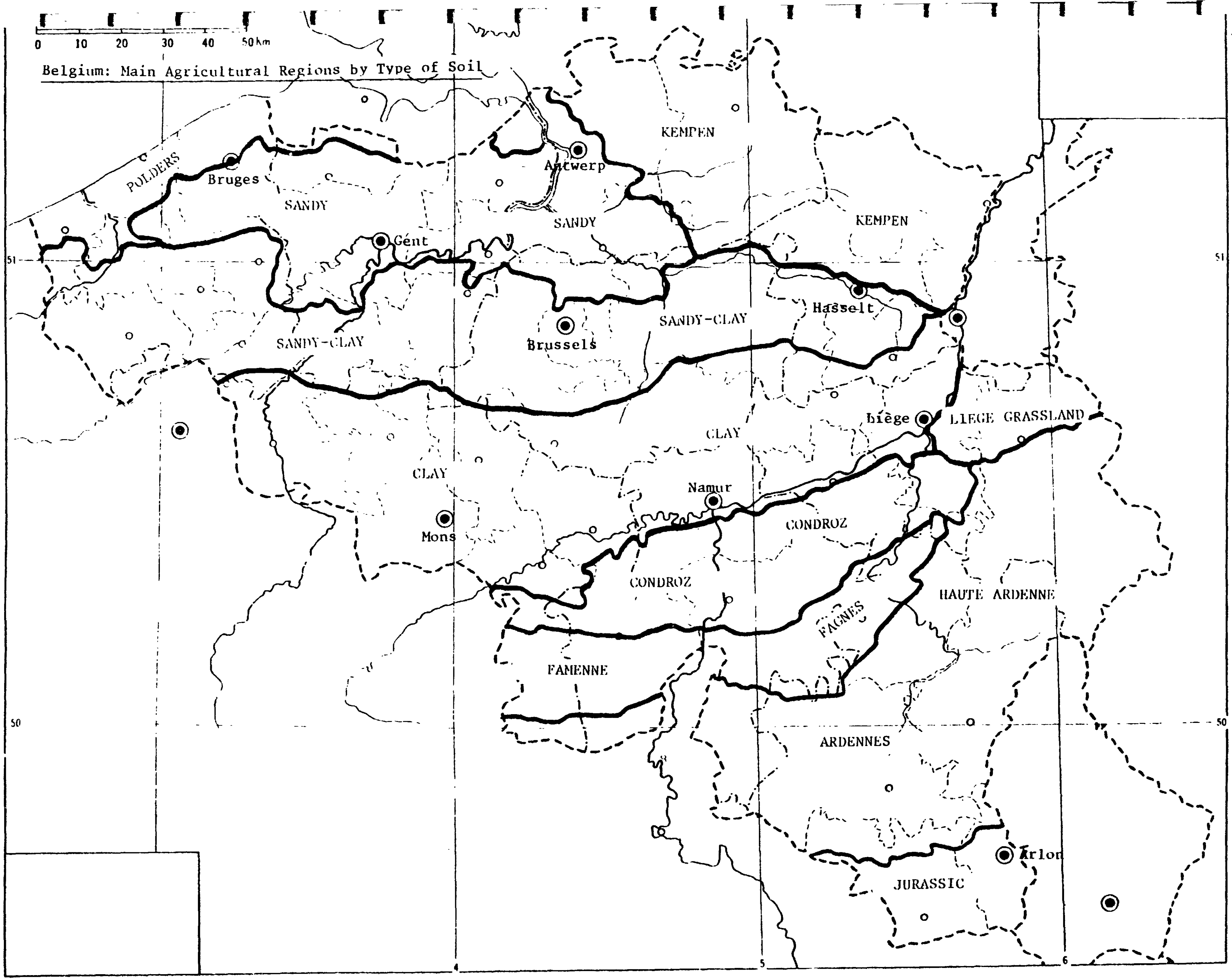
0 10 20 30 40 50 km
Belgium: Main Agricultural Regions by Type of Soil
POLDERS
Bruges
SANDY
Gent
Antwerp
SANDY
KEMPEN
KEMPEN
Hasselt
SANDY-CLAY
SANDY-CLAY
Brussels
Liège
LIEGE GRASSLAND
CLAY
CLAY
Mons
Namur
CONDROZ
CONDROZ
HAUTE ARDENNE
FAGNES
FAMENNE
ARDENNES
Arlon
JURASSIC
51
50
4
5
6

Table 2.10

Belgium: Energy Input in Agriculture by Agricultural Regions, 1977

(10^6 MJ)

	Agricultural area	DIRECT ENERGY					INDIRECT ENERGY				TOTAL
		Fossile Energy				Electricity					
	(ha)	Heating animal sector	Heating horticultural sector	Fuel and lubricants for machinery	TOTAL		Fertilisers	Animal feedstuffs	Machinery	Others[a]	
Polders	70,658	418	161	257	836	290	801	3,061	388	597	5,973
Sandy Region	180,512	2,738	11,080	769	14,587	1,828	2,907	17,685	875	4,209	42,091
Kempen	106,218	1,930	1,004	457	3,391	936	1,640	11,257	512	1,970	19,706
Sandy-clay Region	282,772	2,766	3,087	1,390	7,243	1,622	3,587	17,055	2,028	3,503	35,038
Clay Region	340,513	844	140	1,778	2,762	813	3,901	6,340	2,331	1,794	17,941
Liège Grassland Region	70,834	259	43	236	538	333	628	2,127	346	441	4,413
Condroz	139,953	140	51	578	769	269	1,215	1,240	653	460	4,606
Haute Ardenne	32,008	48	...	161	209	114	365	462	203	150	1,503
Famenne and Fagnes	84,806	68	5	305	378	183	494	707	325	231	2,318
Ardennes	114,446	120	...	411	531	248	670	1,167	452	340	3,408
Jurassic Region	34,497	26	5	127	158	58	217	208	136	86	863
Total - Belgium	1,458,686	9,359	15,576	6,470	31,405	6,697	16,425	61,315	8,258	13,788	137,888[b]

a buildings, agro-chemicals and maintenance products (10 per cent of total input)

b totals do not always add up to national total due to exclusion of some agricultural land not located in specific agricultural regions.

Source: CRISP, Brussels

Table 2.11

Belgium: Energy Input in Agriculture by Agricultural Regions, 1977

(TOE)

	Agricultural area (ha)	DIRECT ENERGY					INDIRECT ENERGY				TOTAL
		Fossile Energy				Electricity					
		Heating animal sector	Heating horticultural sector	Fuel and lubricants for machinery	TOTAL		Fertilisers	Animal feedstuffs	Machinery	Others[a]	
Polders	70,658	9,982	3,845	6,137	19,964	6,925	19,128	73,097	9,265	14,256	142,635
Sandy Region	180,512	65,383	264,590	18,364	348,337	43,653	69,419	422,318	20,895	100,511	1,005,133
Kempen	106,218	46,088	23,975	10,913	80,977	22,352	39,163	268,817	12,226	47,044	470,579
Sandy-clay Region	282,772	66,052	73,717	33,193	172,963	38,733	85,657	407,273	48,429	83,652	836,707
Clay Region	340,513	20,155	3,343	42,459	65,956	19,414	93,156	151,399	55,664	42,841	428,431
Liège Grassland Region	70,834	6,185	1,027	5,636	12,847	7,952	14,997	50,793	8,262	10,531	105,382
Condroz	139,953	3,343	1,218	13,803	18,364	6,424	29,014	29,611	15,594	10,985	109,991
Haute Ardenne	32,008	1,146	-	3,845	4,991	2,722	8,716	11,032	4,848	3,582	35,892
Famenne and Fagnes	84,806	1,624	119	7,283	9,027	4,370	11,797	16,883	7,761	5,516	55,354
Ardennes	114,446	2,866	-	9,815	12,680	5,922	16,000	27,868	10,794	8,119	81,383
Jurassic Region	34,497	621	119	3,033	3,773	1,385	5,182	4,967	3,248	2,054	20,608
Total - Belgium	1,458,686	223,493	371,955	154,504	749,951	159,924	392,229	1,464,202	197,201	329,257	3,292,765[b]

a buildings, agro-chemicals and maintenance products (10 per cent of total input)

b totals do not always add up to national total, due to exclusion of some agricultural land not located in specific agricultural regions

Source: EIU calculations based on data from CRISP, Brussels

Table 2.12

Belgium: Energy Input in Agricultural Regions, 1977

(MJ/ha)

		DIRECT ENERGY				
		Fossile Energy				Electricity
	Agricultural area (ha)	Heating animal sector	Heating horticultural sector	Fuel and lubricants for machinery	TOTAL	
Polders	70,658	5,916	2,279	3,637	11,832	4,104
Sandy Region	180,512	15,168	61,381	4,260	80,809	10,127
Kempen	106,218	18,170	9,452	4,302	31,924	8,812
Sandy-clay Region	282,772	9,782	10,916	4,916	25,614	5,736
Clay Region	340,513	2,479	411	5,221	8,111	2,388
Liège Grassland Region	70,834	3,656	607	3,331	7,595	4,701
Condroz	139,953	1,000	364	4,130	5,494	1,922
Haute Ardenne	32,008	1,500	-	5,030	6,530	3,562
Famenne and Fagnes	84,806	802	59	3,596	4,457	2,158
Ardennes	114,446	1,048	-	3,591	4,639	2,167
Jurassic Region	34,497	753	145	3,682	4,580	1,681
Total - Belgium	1,458,686	6,416	10,678	4,435	21,529	4,591

	INDIRECT ENERGY							TOTAL
		Animal Feedstuffs						
	Fertilisers	Pig sector	Poultry sector	Cattle sector	total	Machinery	Others	
Polders	10,722	26,078	6,358	10,889	43,326	5,491	8,453	83,928
Sandy Region	15,519	61,619	21,743	14,618	97,981	4,847	23,317	232,600
Kempen	14,933	47,142	39,443	19,399	105,985	4,820	18,552	185,026
Sandy-clay Region	12,778	38,931	12,434	9,599	60,312	7,172	12,391	124,003
Clay Region	11,524	9,710	2,570	6,339	18,619	6,845	5,269	52,756
Liège Grassland Region	8,997	12,376	2,178	15,472	30,027	4,885	6,230	62,435
Condroz	9,059	2,245	932	5,686	8,863	4,666	3,291	33,295
Haute Ardenne	11,583	2,707	500	11,242	14,449	6,342	4,696	47,162
Famenne and Fagnes	5,903	1,371	305	6,665	8,342	3,832	2,733	27,425
Ardennes	5,896	2,899	502	6,800	10,202	3,949	2,978	29,831
Jurassic Region	6,328	1,568	749	3,720	6,038	3,942	2,502	25,071
Total - Belgium	11,260	23,361	9,249	9,727	42,337	5,661	9,486	94,861

Source: CRISP, Brussels

Direct energy consumption for heating in horticulture is exceptionally high in the Sandy region, the region where most glasshouses are located. The region accounts for 71 per cent of national consumption of energy for heating in horticulture.

Direct consumption of fossil energy for the heating of animal rearing units is particularly high in the Sandy-clay, Sandy and Kempen regions, both in absolute terms and in consumption per hectare. In absolute terms, these three regions account for 79 per cent of the 223,500 TOE consumed nationally for heating in animal rearing. Intensive animal rearing is concentrated in these three regions where dairy farming is also important.

There are no very marked regional variations in the direct consumption per hectare of energy for the powering of agricultural machinery, the variance being contained within ± 20 per cent. FAO sources suggest that two-thirds of energy consumption accounted for by agricultural machinery is contained in fuel. In Belgium, fuel and lubricants account for some 45 per cent of total direct and indirect energy attributed to agricultural machinery. This situation is explained by the high degree of mechanisation of agriculture in Belgium in relation to the small surface area of holdings: the situation is one of over-mechanisation and under-utilisation of equipment.

CONSUMPTION OF NON-ENERGY PETROLEUM PRODUCTS

The only evaluation of the use of lubricants in agriculture is that made by Professor Van Hecke. On the basis of an analysis of farm accounts kept by the Belgische Boerenbond, it was possible by extrapolation to determine the cost of fuel for agricultural machinery by hectare and by agricultural region. Values were converted to volume by reference to the price of fuel current at the time.

Fuel consumption in the year 1977 was estimated at 149,000 TOE. The consumption of lubricants was assumed to be a function of the consumption of fuel and was put at 5 per cent of the volume of fuel consumed, equivalent to 7,400 TOE in 1977.

CONSUMPTION OF ENERGY IN HORTICULTURE

Consumption of energy for heating in horticulture is the largest single direct energy input in Belgian agriculture. Professor E. Van Hecke evaluates the consumption of fossil energy in horticulture at 371,000 TOE in 1977, equivalent to 41 per cent of direct energy and 11 per cent of total energy consumption in agriculture.

The Ministry of Agriculture compiles a regional breakdown of consumption of light and heavy fuel oil in the heating of glasshouses, by type of produce. The data is extracted from claims for the refund of excise duty levied on fuel, and has been compiled for the years 1973, 1975 and 1977. The data is reproduced in Tables 2.13, 2.14 and 2.15. Crops grown under plastic sheeting and similar coverings are excluded from the statistical series.

Van Hecke used the data referring to 1977 in his analysis of energy consumption in Belgian agriculture, but also took account of consumption of natural gas and allowed for the fact that the statistics compiled by the Ministry of Agriculture are selective in terms of produce and regions.

Between 1973 and 1977, the consumption of light and heavy fuel oil in the heating of glasshouses declined from 374,350 TOE to 302,990 TOE, a fall of 19 per cent. In the same period, the area under glass rose marginally from 11,457,537 square metres to 11,515,937 square metres.

Consumption of fuel oil per square metre remains highest in East Flanders, but the level of consumption has declined from 38.99 10^4 Kcal per square metre in 1973 to 30.5 10^4 Kcal per square metre in 1977. Differences in methods of cultivation and heated areas account for variations between regions in energy input for the cultivation of similar produce.

Table 2.13

Belgium: Usage of Fuels in Heating Glasshouses in Selected Regions, by Type of Produce, 1973

Type of Produce	N° of Units	Total Area under Glass (m2)	Light Fuel-Oil litres	Light Fuel-Oil net 10^4 kcal	Heavy Fuel-Oil[a] litres	Heavy Fuel-Oil[a] net 10^4 kcal	Total Usage litres	Total Usage net 10^4 kcal[b]	Average per m2 litres	Average per m2 net 10^4 kcal
ANTWERP										
Vegetables	199	483,383	4,035,960	4,217,578	9,721,929	8,973,340	13,757,889	13,190,918	28.46	27.29
Tomatoes, Salads	504	3,426,139	6,550,926	6,845,718	108,372,488	100,027,806	114,923,414	106,873,524	33.54	31.19
Cut Flowers	57	191,495	1,795,819	1,876,631	8,269,390	7,632,647	10,065,209	9,509,278	52.56	49.66
Potted Plants	49	93,794	1,662,182	1,736,980	3,394,928	3,133,519	5,057,110	4,870,499	53.91	51.92
Strawberries	53	173,550	1,233,824	1,289,346	2,091,421	1,930,382	3,325,245	3,219,728	19.16	18.55
Others	19	97,492	453,557	473,967	3,583,450	3,307,524	4,037,007	3,781,491	41.40	38.79
Total	881	4,465,853	15,732,268	16,440,220	135,433,606	125,005,218	151,165,874	141,445,438	33.84	31.67
EAST FLANDERS										
Vegetables	196	635,888	5,597,113	5,848,983	11,938,894	11,019,599	17,536,007	16,868,582	27.57	26.52
Cut Flowers	91	205,033	3,097,137	3,236,508	3,383,350	3,122,832	6,480,487	6,359,340	31.60	31.02
Carnations	107	175,307	3,580,547	3,741,672	372,730	344,030	3,953,277	4,085,702	22.55	23.30
Roses	91	243,218	3,701,886	3,868,471	6,754,676	6,234,566	10,456,562	10,103,037	42.99	41.54
Potted Plants	479	1,140,724	17,141,573	17,912,944	56,449,665	52,103,041	73,591,238	70,015,985	64.51	61.38
Azaleas	415	781,030	15,499,261	16,196,728	2,056,085	1,897,766	17,555,346	18,094,494	22.47	23.17
Begonias	189	137,428	3,739,457	3,907,732	407,264	375,905	4,146,721	4,283,637	30.17	31.17
Azaleas-Begonias	68	82,338	2,127,444	2,223,179	228,215	210,642	2,355,659	2,433,821	28.60	29.56
Others	75	167,365	3,850,882	4,024,172	3,086,535	2,848,872	6,937,417	6,873,044	41.45	41.07
Total	1,711	3,568,331	58,335,300	60,960,388	84,677,414	78,157,253	143,012,714	139,117,641	40.07	38.99
WEST FLANDERS										
Vegetables	13	24,725	200,715	209,747	-	-	200,715	209,747	8.11	8.48
Tomatoes, Salads	458	1,425,123	10,452,630	10,922,998	15,123,356	13,958,857	25,575,986	24,881,855	17.94	17.46
Cut Flowers	24	87,101	829,953	867,301	1,981,087	1,868,543	2,811,040	2,735,844	31.27	31.41
Potted Plants	55	136,310	2,026,983	2,118,197	5,290,935	4,883,533	7,317,918	7,001,730	53.68	51.37
Others	137	139,187	3,313,698	3,462,814	919,480	848,680	4,233,178	4,311,494	30.41	30.98
Total	687	1,812,446	16,823,979	17,581,058	23,314,858	21,559,613	40,138,837	39,140,670	22.14	21.57
BRABANT										
Vegetables	27	59,905	690,546	721,620	560,123	516,993	1,250,669	1,238,613	20.87	20.68
Tomatoes, Salads	61	194,164	2,084,181	2,177,969	2,383,916	2,200,354	4,468,097	4,378,323	23.01	22.55
Cut Flowers	141	265,428	7,868,235	8,222,305	3,127,258	2,886,459	10,995,495	11,108,764	41.42	41.85
Potted Plants	78	101,043	3,142,473	3,283,884	2,075,218	1,915,426	5,217,691	5,199,310	51.63	51.46
Carnations	37	102,616	1,345,476	1,406,022	1,142,565	1,054,587	2,488,041	2,460,609	24.24	23.98
Roses	30	99,466	937,657	979,851	3,665,897	3,383,623	4,603,554	4,363,474	46.28	43.87
Grapes	338	769,018	10,895,981	11,386,300	14,794,010	13,654,871	25,689,991	25,041,171	33.40	32.56
Others	17	19,267	745,946	779,513	125,086	115,454	871,032	894,967	45.20	46.45
Total	729	1,610,907	27,710,495	28,957,467	27,874,073	25,727,769	55,584,568	54,685,236	34.20	33.95

a heavy and extra-heavy fuel-oil were converted into litres from kg by multiplying by the coefficient 1.05

b 1 TOE is equivalent to 10^7 Kcal

Source: Ministère de l'Agriculture, Administration des Structures Agricoles

Table 2.14

Belgium: Usage of Fuels in Heating Glasshouses in Selected Regions, by Type of Produce, 1975

Type of Produce	N° of Units	Total Area under Glass (m2)	Light Fuel-Oil litres	Light Fuel-Oil net 10^4 kcal	Heavy Fuel-Oil[a] litres	Heavy Fuel-Oil[a] net 10^4 kcal	Total Usage litres	Total Usage net 10^4 kcal[b]	Average per m2 litres	Average per m2 net 10^4 kcal
ANTWERP										
Vegetables	173	343,521	2,724,803	2,847,419	2,050,275	1,892,404	4,775,078	4,739,823	13.90	13.80
Tomatoes, Salads	508	3,538,781	4,101,228	4,285,783	104,741,168	96,676,098	108,842,396	100,961,881	30.76	28.53
Cut Flowers	40	180,948	741,394	774,757	6,894,469	6,363,595	7,635,863	7,138,352	42.19	39.45
Potted Plants	42	59,114	1,294,782	1,353,047	918,816	848,067	2,213,598	2,201,114	37.44	37.23
Strawberries	57	250,568	713,474	745,580	4,153,148	3,833,356	4,866,622	4,578,936	19.42	18.27
Others	23	86,765	448,152	468,319	2,388,055	2,204,175	2,836,207	2,672,494	32.69	30.80
Total	843	4,459,697	10,023,833	10,474,905	121,145,931	111,817,694	131,169,764	122,292,599	29.41	27.42
EAST FLANDERS										
Vegetables	204	596,233	3,730,457	3,898,327	8,469,355	7,817,215	12,199,812	11,715,542	20.46	19.65
Tomatoes, Salads	10	80,550	23,650	24,714	3,128,422	2,887,533	3,152,072	2,912,247	39.13	36.15
Cut Flowers	208	440,056	4,915,135	5,136,316	7,193,390	6,639,498	12,108,525	11,775,814	27.52	26.76
Potted Plants	462	1,163,988	10,328,543	10,793,327	48,719,710	44,968,292	59,048,253	55,761,619	50.73	47.90
Carnations	46	80,257	1,012,344	1,057,899	430,364	397,226	1,442,708	1,455,125	17.97	18.13
Roses	24	86,339	203,162	212,304	2,840,084	2,621,397	3,043,246	2,833,701	35.24	32.82
Azaleas	355	665,996	9,240,114	9,655,919	2,289,303	2,113,027	11,529,417	11,768,946	17.32	17.67
Begonias	211	172,368	3,235,309	3,380,898	496,493	458,263	3,731,802	3,839,161	21.65	22.27
Azaleas-Begonias	43	55,417	991,527	1,036,146	112,683	104,006	1,104,210	1,140,152	19.92	20.58
Others	79	171,265	1,881,339	1,965,999	2,505,544	2,312,617	4,386,883	4,278,616	25.61	24.98
Total	1,642	3,512,469	35,561,580	37,161,851	76,185,348	70,319,076	111,746,928	107,480,927	31.81	30.60
WEST FLANDERS										
Vegetables	61	202,876	866,102	905,076	1,222,868	1,128,707	2,088,970	2,033,783	10.29	10.02
Tomatoes, Salads	368	1,247,622	4,816,803	5,033,559	12,090,143	11,159,202	16,906,946	16,192,761	13.55	12.98
Sliced Beans	18	83,010	415,882	434,597	1,830,218	1,689,291	2,246,100	2,123,888	27.05	25.58
Potted Plants	51	129,905	1,155,969	1,207,988	4,529,979	4,181,170	5,685,948	5,389,158	43.77	41.48
Others	125	125,341	2,179,615	2,277,698	776,656	716,853	2,956,271	2,994,551	23.58	23.89
Total	623	1,788,754	9,434,371	9,858,918	20,449,864	18,875,224	29,884,235	28,734,142	16.70	16.06
BRABANT										
Vegetables	22	41,190	438,925	458,677	275,703	254,474	714,628	713,151	17.34	17.31
Tomatoes, Salads	63	209,676	1,042,747	1,089,671	2,764,854	2,551,960	3,807,601	3,641,631	18.16	17.37
Cut Flowers	121	212,079	3,559,052	3,719,209	2,793,257	3,578,176	6,352,309	7,297,385	29.95	29.69
Potted Plants	33	66,692	1,190,603	1,244,180	1,069,605	987,245	2,260,208	2,231,425	33.89	33.46
Carnations	14	33,672	336,214	351,344	447,382	412,933	783,596	764,277	23.27	22.70
Roses	31	117,055	742,756	776,188	3,530,586	3,258,731	4,273,342	4,034,919	36.50	34.47
Grapes	255	697,813	4,762,369	4,976,676	10,206,553	9,420,648	14,968,922	14,397,324	21.45	20.63
Others	31	32,027	922,086	963,580	65,152	60,135	987,238	1,023,715	30.82	31.96
Total	570	1,410,204	12,994,752	13,579,516	21,153,092	20,524,302	34,147,844	34,103,820	24.28	23.47

a heavy and extra-heavy fuel-oil were converted into litres from kg by multiplying by the coefficient 1.05

b 1 TOE is equivalent to 10^7 Kcal

Source: Ministère de l'Agriculture, Administration des Structures Agricoles

Table 2.15

Belgium: Usage of Fuels in Heating Glasshouses in Selected Regions, by Type of Produce, 1977

Type of Produce	N° of Units	Total Area under Glass (m2)	Light Fuel-Oil litres	Light Fuel-Oil net 10^4 kcal	Heavy Fuel-Oil[a] litres	Heavy Fuel-Oil[a] net 10^4 kcal	Total Usage litres	Total Usage net 10^4 kcal[b]	Average per m2 litres	Average per m2 net 10^4 kcal
ANTWERP										
Vegetables	207	371,851	3,172,132	3,314,878	2,387,373	2,203,545	5,559,505	5,518,423	14.95	14.84
Tomatoes, Salads	400	3,380,815	4,805,847	5,022,110	98,280,400	90,712,809	103,086,247	95,734,919	30.49	28.32
Cut Flowers	47	209,033	1,402,926	1,466,058	6,309,193	5,823,385	7,712,119	7,289,443	36.90	34.87
Potted Plants	59	96,994	1,596,933	1,668,795	1,815,198	1,675,428	3,412,131	3,344,223	35.18	34.48
Strawberries	112	424,243	1,946,423	2,034,012	7,980,667	7,366,156	9,927,090	9,400,168	23.40	22.16
Roses	11	111,663	127,432	133,166	4,781,694	4,413,503	4,909,126	4,546,669	43.97	40.72
Others	18	126,605	346,109	361,684	4,051,396	3,739,438	4,397,505	4,101,122	34.74	32.39
Total	920	4,721,204	13,397,802	14,000,703	125,605,921	115,934,265	139,003,723	129,934,968	29.45	27.52
EAST FLANDERS										
Vegetables	86	260,022	1,732,214	1,810,164	2,866,642	2,645,910	4,598,856	4,456,074	17.68	17.14
Tomatoes, Salads	82	376,250	1,153,110	1,205,000	7,759,698	7,162,201	8,912,808	8,367,201	23.68	22.24
Cut Flowers	116	256,754	3,179,250	3,322,316	3,630,375	3,350,836	6,809,625	6,673,152	26.52	25.99
Potted Plants	467	1,177,129	11,327,436	11,837,171	50,980,251	47,054,772	62,307,687	58,891,943	52.93	50.03
Carnations	71	123,042	1,683,841	1,759,614	357,008	329,518	2,040,849	2,089,132	16.58	16.98
Roses	81	217,933	1,559,865	1,630,059	5,680,286	5,242,904	7,240,151	6,872,963	33.22	31.54
Azaleas	363	785,968	9,272,166	9,689,413	1,459,812	1,347,406	10,731,978	11,036,819	13.69	14.04
Begonias	162	133,819	2,497,518	2,609,906	743,904	686,623	3,241,422	3,296,529	24.22	24.63
Azaleas-Begonias	67	82,897	1,625,314	1,698,453	133,379	123,109	1,758,693	1,821,562	21.21	21.97
Others	168	170,757	2,883,317	3,013,066	3,055,360	2,820,097	5,938,677	5,833,163	34.78	34.16
Total	1,663	3,584,571	36,914,031	38,575,162	76,666,715	70,763,378	113,580,746	109,338,540	31.69	30.50
WEST FLANDERS										
Vegetables	39	95,555	593,077	619,765	493,173	455,199	1,086,250	1,074,964	11.36	11.25
Tomatoes, Salads	431	1,437,301	6,982,729	7,296,952	12,835,420	11,847,093	19,818,149	19,144,045	13.78	13.32
Cut Flowers	15	44,113	216,656	226,405	1,252,450	1,156,011	1,469,106	1,382,416	33.30	31.34
Potted Plants	42	120,660	964,820	1,008,237	3,297,605	3,043,689	4,262,425	4,051,926	35.32	33.76
Others	119	129,034	2,161,938	2,259,225	1,453,101	1,341,212	3,615,039	3,600,437	28.02	27.90
Total	646	1,826,663	10,919,220	11,410,585	19,331,749	17,843,204	30,250,969	29,253,789	16.57	16.01
BRABANT										
Vegetables	14	37,200	207,349	216,679	627,038	578,756	834,387	795,435	22.42	21.38
Tomatoes, Salads	68	214,738	1,193,653	1,247,367	2,459,938	2,270,523	3,653,591	3,517,890	17.02	16.38
Cut Flowers	117	219,305	3,515,843	3,674,056	1,248,866	1,152,703	4,764,709	4,826,759	21.73	22.01
Potted Plants	71	115,348	2,236,153	2,336,780	2,824,671	2,607,171	5,060,824	4,943,951	43.88	42.86
Carnations	13	25,998	551,237	576,043	44,268	40,859	595,505	616,902	22.91	23.73
Roses	35	127,984	1,131,456	1,182,371	3,078,278	2,841,250	4,209,734	4,023,621	32.98	31.44
Grapes	245	575,687	5,166,211	5,398,690	9,461,439	8,732,908	14,627,650	14,131,598	25.41	24.55
Others	30	67,239	899,494	939,971	721,406	665,858	1,620,900	1,605,829	24.11	23.88
Total	593	1,383,499	14,901,396	15,571,959	20,465,904	18,890,029	35,367,300	34,461,988	25.57	24.91

a heavy and extra-heavy fuel-oil were converted into litres from kg by multiplying by the coefficient 1.05

b 1 TOE is equivalent to 10^7 Kcal

Source: Ministère de l'Agriculture, Administration des Structures Agricoles

CONSUMPTION OF FERTILISERS

Information is available from the Ministry of Agriculture on the use of fertilisers, which can be used to calculate the indirect energy content of fertilisers used in Belgium.

Table 2.16

Belgium: Consumption of Fertilisers, 1972/73 - 1978/79

(tonnes of fertiliser element)

Season	Type of fertiliser N	P_2O_5	K_2O
1972/73	168,843	148,835	187,900
1973/74	165,225	164,680	192,922
1974/75	175,120	148,692	171,250
1975/76	169,485	132,206	138,100
1976/77	176,039	117,922	155,220
1977/78	178,674	80,100	143,644
1978/79	183,657	112,000	160,679

Source: Ministère de l'Agriculture, Administration des Services Economiques

Average application rates in terms of kilos per hectare for the three main categories of fertilisers - nitrogen (N), phosphate (P_2O_5) and potash (K_2O) - are set out in Table 2.17 for the period 1972/73 to 1978/79.

Table 2.17

Belgium: Average Application of Fertilisers, 1972/73 - 1978/79

(kg/ha)

Season	Type of fertiliser N	P_2O_5	K_2O
1972/73	107	95	120
1973/74	107	106	125
1974/75	114	97	112
1975/76	112	86	91
1976/77	117	78	103
1977/78	120	54	96
1978/79	128	78	112

Source: EIU calculations based on data obtained from Ministère de l'Agriculture, Ministère des Affaires Economiques and Institut National de Statistique

The consumption of potash fertilisers per hectare is reputed to be the highest in the European Community, although the rate of consumption has been declining since 1974. Potash fertilisers are used mainly in horticulture.

The indirect consumption of energy represented by the use of fertilisers in Belgium has been calculated on the basis of data obtained from the Ministry of Agriculture and from a study undertaken by Energy Resources Limited (ERL).

Table 2.18

Belgium: Indirect Energy Consumption in the Form of Fertilisers, 1973/74 - 1978/79

(TOE '000)

	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79
Nitrogenous	264	280	271	282	286	294
Phosphates	49	45	40	35	24	34
Potash	33	29	23	26	26	27
Total	346	354	334	343	336	355

Source: EIU calculations based on data obtained from the Ministère de l'Agriculture and ERL

Professor E. Van Hecke and J.P. Lebailly arrived at broadly comparable estimates of the indirect consumption of energy represented by fertilisers. The estimates set out in Table 2.18 based on the study of ERL, are sufficiently close to those of Van Hecke and Lebailly to be considered as a confirmation of their findings, even though the estimates based on ERL data are some 13-15 per cent lower than those of Van Hecke and Lebailly.

AGRICULTURAL MACHINERY

The Ministry of Agriculture compiles statistics of registered agricultural machinery, but does not publish a regional breakdown of the total. The number of tractors in use increased from 92,700 in 1972 to over 100,000 in 1976 but the number has remained steady since then. After tractors, the most numerous categories of heavy equipment are milking machines (45,800 in 1978), milk cooling tanks and sprayers.

Table 2.19

Belgium: Registered Agricultural Machinery in Use, 1973-1978

(units)

	1973	1974	1975	1976	1977	1978
Axle power driven cultivators	7,953	8,152	8,702	9,331	9,458	9,661
Tractors	95,868	95,119	96,907	102,235	102,407	102,296
of which:						
- Tractors using naphtha/ vaporising oil	3,218	2,896	2,969	2,452	2,784	1,921
- Diesel tractors	90,181	92,223	92,419	98,498	98,381	99,189
- Other tractors	2,469	n.a.	1,519	1,285	1,242	1,186
Pick-up balers	17,086	17,536	17,528	18,484	18,879	18,790
Combined harvesters	8,354	8,299	8,378	8,419	8,369	8,327
Self-propelled sugar beet harvesters	1,444	1,206	2,690	3,032	2,997	2,801
Potato pickers and balers	n.a.	n.a.	1,706	1,948	2,046	2,024
Sprayers	20,326	21,082	21,671	22,711	23,747	23,759
Milking machines	49,296	49,760	49,092	48,571	47,449	45,827
Milk cooling tanks	14,040	17,729	22,316	26,226	30,515	34,159
Grain dryers	2,300	2,312	2,467	2,359	2,402	2,383
Other harvesters	n.a.	n.a.	2,184	2,957	3,263	3,597

Source: Ministère de l'Agriculture, Institut Economique Agricole

APPENDIX:
FOOD PROCESSING INDUSTRIES - DIRECT ENERGY CONSUMPTION

Data on the direct consumption of energy in the food processing industries has been obtained from the Ministry of Economic Affairs. Tables have been prepared to show the trend in energy consumption in the period 1974 to 1977 in thirteen food processing industries.

- cereal processing
- bread and pastry
- biscuits
- vegetable processing
- fruit processing
- meat processing
- fish processing
- sugar
- ice-cream

- dairy products
- margarine
- poultry slaughtering

Although this information is not strictly relevant to an appraisal of the consumption of energy in agriculture, it was felt that it could be of interest to persons using this report. For this reason the information is provided as an appendix. It is stressed that none of the data relating to food processing industries has been taken into account when evaluating consumption of energy in agriculture.

Table 2.20

Belgium: Energy Used in the Cereal Processing Industry, 1974-1977

	1974	1975	1976	1977
Coal				
- tonnes	178	72	48	18
- TOE	125	50	34	13
Petrol and vaporising oil				
- hectolitres	17,442	17,669	16,025	6,850
- TOE	18,715	18,991	17,195	18,080
Combustible oil				
- hectolitres	238,813	205,829	195,580	156,346
- TOE	249,560	215,091	204,381	163,382
Coal and natural gas				
- m3 '000	175	199	225	119
- TOE	135	153	173	92
Electricity				
- KWH '000	137,207	157,322	174,177	147,750
- TOE	11,800	13,260	14,979	12,707
Total - TOE	280,335	247,545	236,762	193,044

Source : Ministère des Affaires Economiques and INS

Table2.21

Belgium: Energy Used in the Bread and Pastry Industry, 1974-1977

	1974	1975	1976	1977
Coal and wood				
- tonnes	738	430	529	369
- TOE	517	301	370	258
Petrol and vaporising oil				
- hectolitres	51,066	50,688	49,985	45,829
- TOE	54.794	54,388	53,634	49,175
Gas, diesel and fuel oil				
- hectolitres	190,147	185,238	171,010	169,140
- TOE	198,704	193,574	178,705	176,751
Liquefied gas				
- tonnes	971	1,047	975	723
- TOE	1,107	1,194	1,112	824
Coal gas and natural gas				
- m3 '000	6,038	7,100	7,561	7,700
- TOE	4,651	5,469	5,824	5,931
Electricity				
- KWH '000	23,359	26,412	26,400	26,512
- TOE	2,009	2,271	2,270	2,280
Total TOE	261,782	257,197	241,915	235,219

Source : Ministère des Affaires Economiques and INS

Table 2.22

Belgium: Energy Used in the Biscuit Industry, 1974-1977

	1974	1975	1976	1977
Coal				
- tonnes	83	86	103	31
- TOE	58	60	72	22
Petrol and vaporising oil				
- hectolitres	8,088	7,889	7,274	6,563
- TOE	n.a.	n.a.	n.a.	n.a.
Combustible oil				
- hectolitres	81,368	67,762	57,941	64,359
- TOE	n.a.	n.a.	n.a.	n.a.
Liquefied gas				
- tonnes	2,203	2,415	2,651	2,513
- TOE	2,511	2,753	3,022	2,865
Coal gas and natural gas				
- m3 '000	9,353	11,649	10,199	10,046
- TOE	7,205	8,973	7,856	7,738
Electricity				
- KWH '000	26,280	27,537	27,534	29,110
- TOE	2,260	2,368	2,368	2,503

Source: Ministère des Affaires Economiques and INS

Table 2.23

Belgium: Energy Used in the Vegetable Processing Industry, 1974-1977

	1974	1975	1976	1977
Petrol and vaporising oil				
- hectolitres	2,929	2,616	1,805	1,578
- TOE	3,143	2,807	1,937	1,693
Combustible oil				
- hectolitres	257,958	237,142	191,350	228,415
- TOE	264,566	247,813	199,961	238,694
Liquefied gas				
- tonnes	131	166	123	404
- TOE	149	189	140	461
Coal gas and natural gas				
- m3 '000	-	191	370	401
- TOE		147	285	309
Electricity				
- KWH '000	28,672	32,178	31,033	40,045
- TOE	2,466	2,767	2,669	3,444
TOTAL - TOE	270,324	253,744	205,022	244,601

Source : Ministère des Affaires Economiques and INS

Table 2.24

Belgium: Energy Used in the Fruit Processing Industry, 1974-1977

	1974	1975	1976	1977
Petrol and vaporising oil				
- hectolitres	3,247	2,918	4,156	2,257
- TOE	3,484	3,131	4,459	2,422
Combustible oil				
- hectolitres	60,112	52,114	48,341	46,931
- TOE	62,817	54,459	50,516	49,043
Electricity				
- KWH '000	4,029	3,659	3,976	3,668
- TOE	346	315	342	315
TOTAL - TOE	66,647	57,905	55,317	51,780

Source : Ministère des Affaires Economiques ans INS

Table 2.25

Belgium: Energy Used in the Meat Processing Industry, 1974-1977

	1974	1975	1976	1977
Coal				
- tonnes	183	-	-	-
- TOE	128	-	-	-
Coke				
- tonnes	39	191	153	101
- TOE	26	128	103	68
Petrol and vaporising oil				
- hectolitres	22,106	18,683	16,528	16,065
- TOE	23,720	20,047	17,735	17,238
Combustible oil				
- hectolitres	198,000	171,950	163,990	172,603
- TOE	206,910	179,688	171,370	180,370
Liquefied gas				
- tonnes	443	520	414	378
- TOE	505	593	472	431
Coal gas and natural gas				
- m3 '000	1,777	2,965	2,441	2,708
- TOE	1,369	2,284	1,880	2,086
Electricity				
- KWH '000	47,563	52,317	52,523	59,791
- TOE	4,090	4,499	4,517	5,142
TOTAL - TOE	231,289	200,456	189,680	198,107

Source : Ministère des Affaires Economiques and INS

Table 2.26

Belgium: Energy Used in the Fish Processing Industry, 1974-1977

	1974	1975	1976	1977
Petrol and vaporising oil				
- hectolitres	2,247	2,261	1,557	1,156
- TOE	2,411	2,426	1,671	1,240
Combustible oil				
- hectolitres	19,369	16,263	21,450	15,014
- TOE	20,241	16,995	23,424	15,690
Liquefied gas				
- tonnes	81	56	18	13
- TOE	92	64	21	15
Coal gas and natural gas				
- m3 '000	217	264	320	643
- TOE	167	203	246	495
Electricity				
- KWH '000	7,158	5,847	6,059	6,014
- TOE	616	503	521	517
TOTAL - TOE	23,527	20,191	25,883	17,957

Source : Ministère des Affaires Economiques and INS

Table 2.27

Belgium: Energy Used in the Sugar Industry, 1974-1977

	1974	1975	1976	1977
Coal				
- tonnes	19,174	12,039	9,838	10,489
- TOE	13,422	8,427	6,887	7,342
Coke				
- tonnes	17,190	17,164	16,192	15,619
- TOE	11,517	11,500	10,849	10,465
Petrol and vaporising oil				
- hectolitres	1,498	1,858	4,105	4,030
- TOE	1,607	1,994	4,405	4,324
Combustible oil				
- hectolitres	1,970,961	1,599,584	1,974,650	2,048,705
- TOE	2,059,654	1,671,565	2,063,509	2,140,897
Electricity				
- KWH '000	25,658	26,026	21,225	20,024
- TOE	2,207	2,238	1,825	1,722
TOTAL - TOE	2,088,407	1,695,724	2,087,475	2,164,750

Source : Ministère des Affaires Economiques and INS

Table 2,28

Belgium: Energy Used in the Ice-cream Industry, 1974-1977

	1974	1975	1976	1977
Petrol and vaporising oil				
- hectolitres	19,830	19,558	19,382	15,209
- TOE	21,278	20,986	20,797	16,519
Combustible oil				
- hectolitres	19,542	25,061	26,425	30,324
- TOE	20,421	26,189	27,614	31,688
Electricity				
- KWH '000	28,154	33,289	34,572	30,921
- TOE	2,421	2,863	2,973	2,659
TOTAL - TOE	44,120	50,058	51,384	50,666

Source : Ministère des Affaires Economiques and INS

Table 2.29

Belgium: Energy Used in the Dairy Products Industry, 1974-1976

	1974	1975	1976
Petrol and vaporising oil			
- hectolitres	26,575	13,599	12,642
- TOE	28,515	14,592	13,565
Combustible oil			
- hectolitres	1,376,165	1,286,265	1,333,313
- TOE	1,438,092	1,344,147	1,393,312
Liquefied gas			
- tonnes	-	111	823
- TOE	-	127	938
Coal gas and natural gas			
- m3 '000	15	18	713
- TOE	12	14	549
Electricity			
- KWH '000	141,601	157,034	172,182
- TOE	12,178	13,505	14,808
TOTAL TOE	1,476,857	1,372,385	1,423,217

Source : Ministère des Affaires Economiques and INS

Table 2.30

Belgium: Energy Used in the Margarine Industry, 1974 and 1976

	1974	1976
Combustible oil		
- hectolitres	32,772	31,061
- TOE	34,247	32,459
Electricity		
- KWH	14,521	15,944
- TOE	1,249	1,371
TOTAL TOE	35,496	33,830

Source : Ministère des Affaires Economiques and INS

Table 2,31

Belgium: Energy used in Poultry Slaughterhouses, 1975-1977

	1975	1976	1977
Coke			
- tonnes	202	230	85
- TOE	135	154	57
Petrol and vaporising oil			
- hectolitres	5,719	4,711	2,707
- TOE	6,137	5,055	2,905
Combustible oil			
- hectolitres	46,320	48,255	44,626
- TOE	48,404	50,427	46,634
Liquefied gas			
- tonnes	919	1,731	722
- TOE	1,048	1,973	823
Coal gas and natural gas			
- m3 '000	257	361	326
- TOE	198	278	251
Electricity			
- KWH '000	22,714	27,688	18,952
- TOE	1,953	2,381	1,631
TOTAL - TOE	57,875	60,268	53,051

Source : Ministère des Affaires Economiques and INS

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

DENMARK

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

- DENMARK

AGRICULTURE IN DENMARK

The total land area under agricultural cultivation was 2,899,000 hectares in 1979. In the nine years since 1970, the area under cultivation declined by 2 per cent.

The number of agricultural holdings of one hectare and over in 1978 was 122,264 which was 15 per cent lower than the corresponding figure for 1970. The largest category by size of holdings are farms of 20 to 50 hectares which accounted for 34 per cent of the total number of farms in 1978: farms of 10 to 50 hectares accounted for 61 per cent of the total number.

Table 3.1

Denmark: Number of Agricultural Holdings[a], 1970-1978

Size of Holding (hectares)	1970		1977		1978	
	Number	%	Number	%	Number	%
1 - 5	16,579	11.6	14,416	11.6	13,910	11.4
5 - 10	30,077	21.0	23,152	18.6	22,495	18.4
10 - 20	43,971	30.7	34,343	27.6	33,453	27.4
20 - 50	44,084	30.6	41,784	33.6	41,413	33.8
50 and over	8,689	6.1	10,705	8.6	10,993	9.0
Total	143,400	100.0	124,400	100.0	122,264	100.0

a with 1 hectare and over

Source: Eurostat

An analysis of agricultural holdings by type of holding, prepared by Eurostat, is useful in that it shows the relative importance of arable farming and of livestock rearing. The total number of holdings recorded in the Eurostat surveys of 1970-71 and 1975 differs from the totals set out in the table above in that the surveys of 1970-71 and 1975 took into account farms of under a hectare in size, provided the produce of the farm was marketed.

Arable farming is the main farming activity, with 98 per cent of holdings having arable land and 94 per cent growing cereals in 1975: the proportions were similar in 1970-71, but the number of holdings growing cereals had declined by 10 per cent in the five-year period.

The rearing of pigs and cattle is the second most widespread agricultural activity, and a sector with high energy requirements for lighting, ventilation and heating purposes. In 1975 there were 89,400 farms engaged in pig rearing and 81,600 farms raising cattle. The number of farms rearing pigs had declined by 24 per cent since 1970-71, and the number of farms raising cattle had fallen by 21 per cent.

Pastoral farming is of lesser importance, and the number of farms with permanent pasture is smaller than the number engaged in cattle raising. This situation indicates that Danish cattle farms have to rely to a relatively high degree on animal feedstuffs.

Table 3.2

Denmark: Number of Agricultural Holdings[a] by Type of Activity, 1970/71 - 1975

	1970-71	1975
Total number of holdings	146,000	132,200
- With arable land	142,000	129,600
- With permanent pasture	69,500	57,600
- Growing cereals	136,800	123,800
- Growing potatoes	24,000	16,700
- Growing sugar beet	14,400	14,900
- Growing forage roots and tubers	89,800	66,700
- Growing forage plants	97,800	77,500
- With cattle	103,200	81,600
- With dairy cows	96,400	63,300
- With horses	15,400	17,300
- With pigs	118,400	89,400
- With laying hens	66,600	42,500
- With table fowl	4,300	6,400
- Growing fresh vegetables, melons or strawberries	...	5,900
- Growing ornamental plants	...	2,100

a all holdings marketing their produce

Source: Eurostat - General Survey of Agriculture in 1970/71, and Community Survey on the Structure of Agricultural Holdings 1975

In 1978, close on 9 per cent of the active population was engaged in agriculture, forestry and fishing: in 1975 the proportion had been over 9 per cent. Agriculture is the sixth largest sector of economic activity in Denmark. Agriculture contributed 6 per cent to Gross National Value Added at factor cost in 1976, equivalent to DK 11.4 billion. From 1976 to 1978, Gross Value Added from agriculture rose to DK 15.3 billion, an increase of 34 per cent.

More than 70 per cent of the value of agricultural output of DK 29.8 billion at current prices in 1978 was attributed to livestock and dairy farming. Between 1975 and 1978, the number of pigs being reared increased by 14 per cent in terms of livestock units but the number of cattle declined by 1 per cent.

Table 3.3

Denmark: Number of Livestock, 1975 and 1978

(livestock units '000)

	1975	1978
Cattle	2,439	2,422
Pigs	1,847	2,104
Sheep and goats	6	6
Horses	44	49
Poultry	194	190

Source: Eurostat - Yearbook of Agricultural Statistics

Between 1977 and 1979, the number of cattle fell by 2 per cent in terms of numbers of animals, and the number of pigs rose by 18 per cent.

Table 3.4

Denmark: Number of Selected Livestock, 1977 and 1979

(number of animals)

	1977	1979
Cattle	3,099,000	3,035,000
of which: dairy cows	1,181,000	1,144,000
Pigs	7,925,000	9,342,000
Laying hens	4,507,000	4,859,000
Table poultry	8,398,000	8,400,000

Source: Landbrugsraadet and De Danske Landboforeninger

ENERGY COSTS

The relative burden of the cost of energy to agriculture has remained constant in the period 1973 to 1978 at 5 per cent of the total cost of goods and services purchased by farmers. Energy is the fourth largest input to agriculture in terms of value, following feedstuffs (55 per cent), maintenance and repair of machinery (11 per cent) and fertilisers (11 per cent).

Table 3.5

Denmark: Purchases of Goods and Services by the Agricultural Sector, 1973-1978

(DK million and percentages)

	1973	1976	1977	1978
Value of total purchases	8,810	12,820	13,951	14,755
of which:	%	%	%	%
Feedstuffs	56.6	54.8	56.0	55.0
Fertilisers	9.8	11.8	10.5	10.6
Maintenance and repair of machinery and tools	11.1	10.3	10.5	11.3
Energy	4.7	5.0	4.8	4.9

Source: EIU calculations based on data provided by Eurostat

In the five years to 1978, the cost of goods and services bought in by farmers rose by 67 per cent to DK 14,755 million, an average annual growth rate of 11 per cent. In the same period, the cost of energy to farmers increased somewhat more rapidly at an average annual compound rate of close on 12 per cent to reach DK 723 million in 1978.

In relation to the gross revenue earned by agriculture, energy accounted for 2.2 per cent of revenue in 1973 and for 2.4 per cent of revenue in 1978.

Animal feedstuffs is the main cost item by far, accounting for 57 per cent of total farm purchases in 1973 and for 55 per cent in 1978. In comparison with revenue earned by agriculture, feedstuffs were equivalent to 27 per cent of gross revenue in 1973 and 1978 respectively.

SOURCES AND SUMMARY OF DATA

Five sources have been used to evaluate the consumption of energy in agriculture:

- OECD statistics on the energy balances of member states
- Danmarks Statistik - analysis of energy uses in agriculture, specifically undertaken for the EIU for the purpose of this study, based on national input/output data
- S. Rasmussen and A. Nielsen - study of energy uses in agriculture in 1978
- De Danske Landboforeninger - annual statistics of direct energy consumption in agriculture
- Danske Elvaerkers Forening - consumption of electricity in agriculture

OECD statistics on the energy balances of member states provide an historical series which can be used to trace trends in energy consumption in agriculture. OECD statistics relating to Denmark are based on data obtained from Energystyrelsen, the Danish Energy Board. OECD statistics on energy consumption in agriculture do not differentiate between consumption for farming purposes and household consumption by farmers and their families.

The analysis of energy consumption in agriculture based on national input/output data and undertaken by Danmarks Statistik - the Danish statistical office - provides an historical trend since 1967. These data are not published: they have been calculated on the basis of input/output values of energy products, to which have been applied average prices per gigajoule for petroleum based fuels and per kilowatt for electricity.

OECD and Danmarks Statistik data have their limitations. OECD breaks down estimates of global, national consumption of energy by type of fuel so as to identify the main consuming sectors and sub-sectors of the Danish economy. Moreover, adjustments have to be made to align consumption with estimates of production, foreign trade and changes in stocks. Consequently, it is estimated that the margin of error in evaluating consumption in agriculture, which is a relatively small sector, can be appreciable.

Data obtained from Danmarks Statistik are expressed in calorific content of volumes of energy products, derived from the value of inputs of fuels by applying average prices. Thus, the data are derived through rational calculations, not through statistical returns relating specifically to the agricultural sector. The data provided by Danmarks Statistik exclude consumption of energy by farmers for private and household purposes: consumption of petrol (motor gasoline) for private purposes is, however, included as no clear distinction can be made between professional and private usage of passenger cars and utility vehicles.

A particularly useful source of data is the work undertaken by S. Rasmussen and A. Nielsen between 1977 and 1979, when they were at the Jordbrugsinstitut (Institute of Agricultural Economics). They studied the incidence of energy requirements in agricultural activities, and S. Rasmussen put forward a detailed analysis of energy input to agriculture for the year 1978. The analysis is static, but it has the merit of providing an evaluation of indirect energy inputs to agriculture.

De Danske Landboforeninger, the Danish farmers' union, publishes annual statistics on the direct input of energy to agriculture, excluding horticulture. Although the coverage of the data is partial, the data again provide an historical series.

Danske Elvaerkers Forening, the association of electricity supply companies, compiles statistics of annual consumption of electricity in agriculture.

Each of the 5 main sources of data on energy input in agriculture has been treated separately in subsequent chapters, and the EIU has endeavoured to reconcile variances between the sources and provide an explanation for the differences. A broad comparative summary of the data obtained from the 5 sources is set out in Table 3.6.

Table 3.6

Denmark: Energy Consumption in Agriculture - Comparative Summary of Data

(TOE '000)

	OECD					Danmarks Statistik					S. Rasmussen	De Danske Landboforeninger						Danske Elvaerkers Forening[b]					
	1974	1975	1976	1977	1978	1974	1975	1976	1977	1978	1978	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1974	1975	1976	1977	1978	1979
Direct energy	1,000	1,049	1,227	1,247	1,253	824	829	820	819	826	759	...	...	...	...	...	...	...	...	...	...	...	...
of which:																							
- Petroleum fuels	918	963	1,083	1,098	1,090	724	725	725	726	732	682	...	...	...	...	...	...	...	...	...	...	...	...
- Electricity	82	86	144	149	163	98	102	93	91	92	77[a]	...	...	...	...	...	...	90	91	97	106	109	126
- District heating	-	-	-	-	-	2	2	2	2	2	-	...	...	...	...	...	...	...	...	...	...	...	...
of which:																							
- Agricultural and live-stock production	-	-	-	-	-	-	-	-	-	-	409	363	352	354	397	447	392	85[c]	86[c]	92[c]	100[c]	102[c]	118[c]
- Horticulture	-	-	-	-	-	-	-	-	-	-	350	...	...	...	...	...	...	5[c]	5[c]	5[c]	6[c]	7[c]	8[c]
Indirect energy	...	...	...	...	...	...	...	...	...	...	1,060	...	...	...	...	...	...	...	...	...	...	...	...
Total	...	...	...	...	...	...	...	...	...	...	1,819	...	...	...	...	...	...	...	...	...	...	...	...

a excluding horticulture; b including horticulture, but excluding domestic uses; c electricity only

Source: EIU calculations based on data from Organisation for Economic Cooperation and Development (OECD), Danmarks Statistik, S. Rasmussen, De Danske Landboforeninger and Danske Elvaerkers Forening

OECD figures for total direct energy consumption appear high - 1,253,000 TOE in 1978 - but it must be remembered that OECD includes both consumption for agricultural purposes and consumption for private household purposes.

Danmarks Statistik and S. Rasmussen are close in their estimates of direct energy consumption in 1978 - 826,000 TOE and 759,000 TOE respectively. Danmarks Statistik includes consumption of petrol (motor gasoline) for private purposes, and direct consumption of energy for fur production, bee rearing, forestry and agricultural services.

OECD's estimate of total direct energy consumption in agriculture in 1978 is 52-65 per cent greater than the figures put forward by S. Rasmussen and Danmarks Statistik. It is assumed that the difference is largely accounted for by the inclusion of private and household energy consumption in the OECD statistics. This seems a reasonable conclusion, as S. Rasmussen has estimated consumption of energy for household purposes in the agricultural sector at 475,000 TOE in 1978, excluding farms engaged in horticulture. If Rasmussen's estimates of direct energy consumption for professional and household purposes are aggregated, the total of 1,234,000 TOE in 1978 comes very close to the figure put forward by OECD for total direct energy consumption in agriculture.

OECD and S. Rasmussen differ widely, however, in their estimates of consumption of electricity in agriculture. OECD puts consumption of electricity in 1978 at 163,000 TOE, compared with Rasmussen's estimate of 77,000 TOE for farming purposes and 46,000 TOE for household purposes (123,000 TOE in total).

OECD estimates of electricity consumption in agriculture are also higher than the figures put forward by Danske Elvaerkers Forening. Danske Elvaerkers Forening puts electricity consumption in 1978 at 109,000 TOE for farming purposes plus 39,000 TOE for household purposes, a total of 148,000 TOE. S. Rasmussen and Danske Elvaerkers Forening are, however, close in their estimates of household consumption of electricity on farms.

The EIU has reviewed the findings, based on the five sources identified above, with well informed persons, and concludes that the data compiled by S. Rasmussen and Danmarks Statistik are probably closest to reality.

OECD statistics provide a good indication of total consumption of direct energy consumption in agriculture, aggregating consumption for farming and for household purposes. The breakdown of the total by type of fuel appears to be less reliable, and OECD's estimates of electricity consumption in agriculture appear to be high.

The summary of statistical data presented in Table 3.6 shows that direct energy accounts for some 42 per cent of total energy consumed for agricultural purposes, excluding energy consumed for household purposes on farms. Petroleum-based fuels account for some 90 per cent of direct energy input for agricultural purposes.

OECD DATA: DIRECT ENERGY CONSUMPTION

OECD statistics can be used to determine total consumption of energy in Denmark and consumption of energy by Danish agriculture. The data set out in Table 3.7 have been extracted from Energy Balances of OECD Countries 1973-1978 which was published in 1980.

The OECD statistics on energy consumption show the growing importance of electricity and solid fuels as sources of energy in Denmark. In 1973, electricity and solid fuels accounted for 11.1 per cent of total energy consumption: by 1978, they accounted for more than 16 per cent of total energy consumption. Petroleum products, which are by far the largest source of energy, had fallen to an 83 per cent share in 1978 compared with 88 per cent in 1973.

Another statistical series compiled by OECD and published under the title Energy Statistics provides additional data on energy consumption by type of fuel and by sector of activity. The OECD statistics show agriculture accounting for a share of 7.1 per cent to 7.9 per cent in the period 1973 to 1978. Data extracted from Energy Statistics 1973-1978 (published in 1980) are reproduced in the table below. The fuels identified in the table are those for which there is an entry for agriculture in the original source, and the grand totals shown for national energy consumption are consequently somewhat greater than the totals of the individual fuels shown in the table.

Table 3.7

Denmark: National Energy Consumption[a], 1973-1978

	1973		1976		1977		1978	
	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent
Solid fuels	0.42	2.7	0.48	3.1	0.75	4.7	0.81	5.1
Petroleum products	14.34	88.4	13.55	86.4	13.52	84.4	13.15	83.0
Gas	0.12	0.8	0.11	0.7	0.11	0.7	0.10	0.6
Electricity	1.35	8.4	1.53	9.8	1.64	10.2	1.79	11.3
National total	16.23	100.0	15.68	100.0	16.01	100.0	15.86	100.0
of which:								
Agriculture	1.25	7.7	1.23	7.8	1.25	7.8	1.25	7.9

a direct final consumption

Source: OECD - Energy Balances

Table 3.8

Denmark: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Liquefied gas	Motor gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1973							
Agriculture							
- tonnes '000	92	102	8	730	276	-	-
- TOE '000	105	109	8	763	267	-	1,252
National consumption							
- tonnes '000	273	1,635	179	6,461	3,954	18,896[a]	-
- TOE '000	311	1,754	187	6,752	3,831	1,625	16,230
Share of agriculture (%)	33.8	6.2	4.3	11.3	7.0	-	7.71
1974							
Agriculture							
- tonnes '000	13	73	5	589	212	957[a]	-
- TOE '000	15	78	5	615	205	82	1,000
National consumption							
- tonnes '000	208	1,488	124	5,402	3,308	15,480[a]	-
- TOE '000	237	1,597	130	5,645	3,205	1,331	14,020
Share of agriculture (%)	6.3	4.9	3.8	10.9	6.4	6.2	7.13

(continued)

Table 3.8 (continued)

Denmark: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Liquefied gas	Motor gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1975							
Agriculture							
- tonnes '000	3	38	14	686	193	1,000[a]	-
- TOE '000	3	41	15	717	187	86	1,049
National consumption							
- tonnes '000	165	1,577	120	5,795	3,122	16,240[a]	-
- TOE '000	188	1,692	125	6,056	3,025	1,397	14,290
Share of agriculture (%)	1.6	2.4	12	11.8	6.2	6.2	7.34
1976							
Agriculture							
- tonnes '000	2	31	11	816	190	1,670[a]	-
- TOE '000	2	33	11	853	184	144	1,227
National consumption							
- tonnes '000	181	1,662	125	6,435	3,416	17,847[a]	-
- TOE '000	206	1,783	131	6,725	3,310	1,535	15,680
Share of agriculture (%)	1.0	1.8	8.4	12.7	5.6	9.4	7.83

(continued)

Table 3.8 (continued)

Denmark: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Liquefied gas	Motor Gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1977							
Agriculture							
- tonnes '000	5	29	4	821	205	1,730[a]	-
- TOE '000	6	31	4	858	199	149	1,247
National consumption							
- tonnes '000	184	1,693	108	6,350	3,385	19,082[a]	-
- TOE '000	210	1,817	113	6,636	3,280	1,641	16,010
Share of agriculture (%)	2.9	1.7	3.5	12.9	6.1	9.1	7.79
1978							
Agriculture							
- tonnes '000	5	27	4	820	200	1,900[a]	-
- TOE '000	6	29	4	857	194	163	1,253
National consumption							
- tonnes '000	189	1,767	110	6,339	3,035	20,809[a]	-
- TOE '000	215	1,896	115	6,624	2,941	1,790	15,860
Share of agriculture (%)	2.8	1.5	3.5	12.9	6.6	9.1	7.9

a KWH million; b totals for national consumption include fuels not identified as being used in agriculture by OECD

Source: OECD, Energy Statistics

OECD statistics include consumption of energy for both agricultural purposes and household purposes on the farm. This source is particularly useful as an indicator of the trend in consumption of petroleum-based fuels and electricity.

The most important type of fuel used in Danish agriculture is gas/diesel oil. Consumption of gas/diesel oil increased from 763,000 TOE in 1973 to 857,000 TOE in 1978, a modest increase of 12 per cent. In 1978, agriculture accounted for close to 13 per cent of national consumption of gas/diesel oil, and gas/diesel oil accounted for 68 per cent of energy consumed in agriculture.

Consumption of residual fuel oil in agriculture also accounts for a relatively high proportion of the national total, varying from 6 to 7 per cent a year in the period 1973 to 1978.

OECD figures show that in the period 1973 to 1978 consumption of petroleum products and electricity in agriculture remained static. There was a steep decrease of 20 per cent in 1974, but this was followed by subsequent increases and energy input in 1978 was virtually at the same level as in 1973.

OECD does not identify the consumption of lubricants in agriculture, but non-energy petroleum products are included in the totals for national consumption of energy in Table 8.

While the EIU takes the view that OECD statistics provide a sound indication of consumption of petroleum-based fuels in agriculture, OECD statistics on consumption of electricity appear to be erratic and more difficult to reconcile with other sources. OECD shows consumption of electricity (for agricultural and household purposes) rising from 82,000 TOE in 1974 to 163,000 TOE in 1978, which is equivalent to an average annual rate of growth of 19 per cent.

Statistics obtained from Danske Elvaerkers Forening put agricultural consumption of electricity (including household consumption) at 127,000 TOE in 1974 (55 per cent greater than OECD) and at 148,000 TOE (9 per cent less than OECD) in 1978. The average annual rate of growth derived from statistics compiled by Danske Elvaerkers Forening is 4 per cent.

The EIU takes the view that OECD statistics overstate the rising trend in consumption of electricity in agriculture.

EVALUATION BY S. RASMUSSEN AND A. NIELSEN: DIRECT AND INDIRECT ENERGY CONSUMPTION

From 1977 to 1979, S. Rasmussen and A. Nielsen undertook studies into the use of energy in agriculture, and S. Rasmussen arrived at a detailed analysis of energy input in agriculture for the year 1978, excluding horticulture.

S. Rasmussen based his analysis of direct energy consumption in agriculture on data extracted from farm accounts and on data obtained from the Danish Energy Board.

Estimates of the indirect energy content of fertilisers and pesticides are based on work done by M. and D. Pimentel and by J.L. Sherff in the United States. The energy content of animal feedstuffs has been calculated on the basis of norms for energy input in Danish feedstuffs processing plants. Indirect energy consumption in the form of agricultural machinery, buildings, transport and services by third parties was not taken into account.

S. Rasmussen arrived at separate estimates for direct energy consumption for farming purposes and for household purposes on the farm. Of total direct energy consumption of 884,000 TOE in 1978, 409,000 TOE (46 per cent) was accounted for by inputs for farming purposes.

Table 3.9

Denmark: Direct and Indirect Energy Consumption in Agriculture, excluding Horticulture, 1978

	Tonnes (000)	TOE (000)	Per cent
Direct Energy			
For farming purposes	-	409	21.1
of which:			
- motor gasoline	36[a]	27	1.4
- DERV fuel	300[a]	264	13.5
- light and heavy fuel	35[a]	30	1.5
- liquefied petroleum gas	10	11	0.7
- electricity	900[b]	77	4.0
For household purposes	-	475	24.4
of which:			
- light and heavy fuel	500[a]	429	22.0
- electricity	530[b]	46	2.4
Total Direct Energy	-	884	45.5
Indirect Energy			
Fertilisers[c]	-	693	35.6
of which:			
- nitrogen	373.7	561	28.9
- phosphate	61.4	40	2.1
- potash	147	29	1.6
- lime	1,568	63	3.2
Agro-chemicals[c]	5.4	26	1.4
Animal feedstuffs	-	341	17.5
of which:			
- oil-cake	1,731	154	7.8
- maize	216	23	1.2
- meat and bonemeal	104	21	1.1

(continued)

Table 3.9 (continued)

Denmark: Direct and Indirect Energy Consumption in Agriculture, excluding Horticulture, 1978

	Tonnes (000)	TOE (000)	Per cent
- fishmeal	77	43	2.2
- alfalfa and grass meal	122	23	1.2
- dried beet pulp	35	9	0.5
- skimmed milk powder	37	19	1.0
- compound feeds	3,895	22	1.1
- grain	3,300	27	1.4
Total Indirect Energy	-	1,060	54.5
Total Energy Input	-	1,944	100.0

a litres million; b KWH million; c active ingredient

Source: S. Rasmussen

S. Rasmussen treated horticulture separately, and estimated total direct energy input at 350,000 TOE in 1978. The estimate is based on an average input per square metre under glass of 67.3 Kcal 10^4 or 67.3 TOE per 1,000 square metres under glass.

Consumption of energy in horticulture was excluded from the data calculated by S. Rasmussen for other agricultural sectors, which is set out in Table 3.9. So as to allow a comparison with other sources of data, the EIU has represented the data set out in Table 3.9. to

- exclude household consumption of energy
- include consumption of energy in horticulture

and the data is set out in the following table (Table 3.10). The inclusion of horticulture raises total direct energy consumption to 759,000 TOE in 1978, of which horticulture accounts for 46 per cent.

Table 3.10

Denmark: Energy Consumption in Agriculture, including Horticulture and excluding Consumption for Household Purposes, 1978

	Tonnes (000)	TOE (000)	Per cent
Direct Energy			
Agriculture, excluding horticulture	-	409	22.5
of which:			
- motor gasoline	36[a]	27	1.4
- DERV fuel	300[a]	264	14.5
- light and heavy fuel	35[a]	30	1.6
- liquefied petroleum gas	10	11	0.6
- electricity	900[b]	77	4.2
Horticulture	-	350	19.2
Total Direct Energy	-	759	41.7
Indirect Energy			
Fertilisers[c]	-	693	38.1
of which:			
- nitrogen	373.7	561	30.8
- phosphate	61.4	40	2.2
- potash	147	29	1.6
- lime	1,568	63	3.5
Agro-chemicals[c]	-	26	1.5
Animal feedstuffs	-	341	18.7
of which:			
- oil-cake	1,731	154	8.4
- maize	216	23	1.3
- meat and bonemeal	104	21	1.2
- fishmeal	77	43	2.3

(continued)

Table 3.10 (continued)

Denmark: Energy Consumption in Agriculture, including Horticulture and excluding Consumption for Household Purposes, 1978

	Tonnes (000)	TOE (000)	Per cent
- alfalfa and grass meal	122	23	1.3
- dried beet pulp	35	9	0.5
- skimmed milk powder	37	19	1.0
- compound feeds	3,895	22	1.2
- grain	3,300	27	1.5
Total Indirect Energy	-	1,060	58.3
Total Energy Input	-	1,819	100.0

a litres million; b KWH million; c active ingredient

Source: EIU calculations based on S. Rasmussen

S. Rasmussen and A. Nielsen analysed the energy input required to produce specific agricultural products in Denmark. Energy budgets were calculated for major agricultural products, taking into account recommended inputs of production factors. The energy budgets presented in the following tables should be taken as 'normative' or 'indicative', rather than as average energy inputs by type of crop.

Table 3.11

Denmark: Energy Inputs in Grain Production, 1977-1978

(Input per hectare)	Quantity	Kcal 10^4
DERV fuel	77 litres	68
Heating fuel oil	43 litres	37
Electricity	43 KWH	4
Nitrogen fertiliser	110 kg[a]	165
Phosphate fertiliser	20 kg[a]	13
Potash fertiliser	50 kg[a]	10
Lime	500 kg[a]	20
Agro-chemicals	1.4 kg[b]	7
Seeds	180 kg	14
Total	-	338
Yield per hectare	4,300 kg	
Energy input per 100 kg of grain		7.86

a fertiliser element; b active ingredient

Source: S. Rasmussen and A. Nielsen

Table 3.12

Denmark: Energy Inputs in Fodder Beet Production, 1977-1978

(Input per hectare)	Quantity	Kcal 10^4
DERV fuel	210 litres	185
Nitrogen fertiliser	170 kg[a]	255
Phosphate fertiliser	40 kg[a]	26
Potash fertiliser	200 kg[a]	40
Lime	500 kg[a]	20
Agro-chemicals	7.5 kg[b]	36
Seeds	6 kg	3
Total	-	565
Yield per hectare	10,000 FU[c]	
Energy input per 100 FU[b]		5.65

a fertiliser element; b active ingredient; c FU = feed unit (feeding value of 1 kg of barley)

Source: S. Rasmussen and A. Nielsen

Table 3.13

Denmark: Energy Inputs in Grass Production for Silage, 1977-1978

(Input per hectare)

	Quantity	Kcal 10^4
DERV fuel	153 litres	135
Electricity	576 KWH	50
Nitrogen fertiliser	320 kg[a]	480
Phosphate fertiliser	40 kg[a]	26
Potash fertiliser	200 kg[a]	40
Lime	500 kg[a]	20
Seeds	12 kg	2
Total	-	753
Yield per hectare	6,500 FU[b]	
Energy input per 100 FU[a]		11.58

a fertiliser element; b FU = feed unit (feeding value of 1 kg of barley)

Source: S. Rasmussen and A. Nielsen

Table 3.14

Denmark: Energy Inputs in Grass Production for Grazing, 1977-1978

(Input per hectare)

	Quantity	Kcal 10^4
DERV fuel	33 litres	29
Electricity	576 KWH	50
Nitrogen fertiliser	150 kg[a]	225
Phosphate fertiliser	25 kg[a]	16
Potash fertiliser	50 kg[a]	10
Lime	500 kg[a]	20
Seeds	12 kg	2
Total	-	352
Yield per hectare	6,500 FU[b]	
Energy input per 100 FU[a]		5.42

a fertiliser element; b FU = feed unit (feeding value of 1 kg of barley)

Source: S. Rasmussen and A. Nielsen

Table 3.15

Denmark: Energy Inputs in Cattle Rearing, 1977-1978

(Input per cow with young stock)

	Quantity	Kcal 10^4
DERV fuel	16 litres	14
Electricity	329 KWH	28
Grain	665 kg	52
Processed feedstuffs	1,180 kg	150
Fodder beet	2,270 FU[a]	128
Grass	2,460 FU[a]	164
Straw	1,160 kg	3
Total	-	539
Yield: milk	5,222 kg	
meat	199 kg (slaughter weight)	
Energy input: per 100 kg of milk		10.3
per 100 kg of meat		271

a FU = feed unit (feeding value of 1 kg of barley)

Source: S. Rasmussen and A. Nielsen

Table 3.16

Denmark: Energy Inputs in Pig Rearing, 1977-1978

(Input per 17.7 bacon pigs)

	Quantity	Kcal 10^4
Fuel oil	50 litres	43
DERV fuel	11 litres	10
Electricity	567 KWH	49
Grain	5,000 kg	393
Processed feedstuffs	1,090 kg	196
Straw	950 kg	3
Total	-	694
Yield	1,230 kg meat at slaughter weight	
Energy input per 100 kg of meat		56.4

Source: S. Rasmussen and A. Nielsen

Table 3.17

Denmark: Energy Inputs in the Rearing of Broiler Hens, 1977-1978

(Input per 100 broilers)

	Quantity	Kcal 10^4
Fuel oil	11 litres	9
Electricity	36 KWH	3
Feed	320 kg	37
Total	-	49
Yield: 106 kg of meat at slaughter weight		
Energy input per 100 kg of meat		46.2

Source: S. Rasmussen and A. Nielsen

Table 3.18

Denmark: Energy Inputs in Egg Production, 1977-1978

(Input per 100 hens)

	Quantity	Kcal 10^4
DERV fuel	2 litres	2
Fuel oil	12 litres	10
Electricity	530 KWH	46
Feed	5,185 kg	600
Total	-	658
Yield	1,480 kg of eggs	
Energy input per 100 kg of eggs		44.5

Source: S. Rasmussen and A. Nielsen

Table 3.19

Denmark : Summary Table - Energy Inputs for specific agricultural products

Product. (1977-1978)	Input Kcal 10^4 per unit of production			per unit of product	
Grain	388	per hectare		7.86	per 100 kg
Fodder Beet	565	"		5.65	per 100 FU a
Grass silage	753	"		11.58	per 100 FU a
Grazing	352	"		5.42	per 100 FU a
Cattle Rearing	539	cow + calf	- milk	10.3	per 100 kg
			- meat	271	per 100 kg
Pig rearing	694	per 17.7 bacon pigs		56.4	per 100 kg
Broiler Hens	49	per 100 hens		46.2	per 100 kg
Egg production	658	per 100 hens		44.5	per 100 kg

EVALUATION BY DANMARKS STATISTIK: DIRECT ENERGY CONSUMPTION

A somewhat different picture of direct energy consumption in agriculture emerges from the input/output analysis undertaken by Danmarks Statistik at the request of the EIU.

For the purpose of this exercise, agriculture was defined to include arable cultivation, livestock breeding, horticulture, landscape gardening, fur production, bee rearing, hunting, agricultural services as provided by farming contractors, forestry and logging. Fishing and related activities are excluded.

The analysis is confined to uses of energy for farming purposes, but it was not possible to make a distinction between farming and private consumption of motor gasoline: motor gasoline used for private purposes is therefore included.

District heating, which appears as a category in the following table, describes a local central heating system which may use coal or oil as a fuel.

Total direct energy input in 1978 was put at 826,000 TOE, 9 per cent higher than the figure arrived at by S. Rasmussen (759,000 TOE). It must be borne in mind, however, that S. Rasmussen's definition of the agricultural sector (cultivation, livestock rearing and horticulture) was more limited, and private consumption of motor gasoline was excluded.

The figures put forward by Danmarks Statistik are lower than those produced by OECD in Energy Balances and Energy Statistics. An explanation for the difference was given earlier in the report: OECD figures include but Danmarks Statistik exclude household consumption of energy on the farm.

EVALUATION BY DE DANSKE LANDBOFORENINGER: DIRECT ENERGY CONSUMPTION

De Danske Landboforeninger compiles statistics on direct consumption of energy in agriculture, excluding horticulture. The most recent figures available relate to the 1979/80 season, and historical data for the period 1969/70 to 1979/80 are set out in the following table. The statistics compiled by De Danske Landboforeninger are confined to agricultural uses of energy and therefore exclude household consumption of energy on the farm.

Table 3.20

Denmark: Direct Energy Consumption in Agriculture, excluding Horticulture, 1969/70 - 1979/80

(TOE '000)

1969/70	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80
386	363	352	354	397	447	392

Source: De Danske Landboforeninger

The figure for direct energy input for the season 1977/78 recorded by De Danske Landboforeninger is very comparable to the estimate of direct input to agriculture, excluding horticulture, arrived at by S. Rasmussen for the year 1978 (409,000 TOE).

AGRICULTURAL DEMAND FOR ELECTRICITY

The Danish association of electricity supply companies, Danske Elvaerkers Forening, provided the EIU with statistics of direct consumption of electricity in agriculture, relating to the period 1972 to 1979. The statistics are broken down to identify separately consumption of electricity for arable cultivation and livestock rearing, for horticulture and for household uses on the farm. In 1979, household consumption accounted for 24 per cent of total electricity consumption in the agricultural sector.

The EIU has converted the statistics of Danske Elvaerkers Forening, which are expressed in kilowatt-hours, into tonnes oil equivalent to facilitate comparison with other sources. The data set out in the following table show that consumption of electricity has increased in all sectors of agriculture but particularly in horticulture where consumption rose sharply from 1976 to 1979 by 60 per cent to reach 8,000 TOE.

Table 3.21

Denmark: Use of Electricity in Agriculture by Sector, 1972-1979

(TOE '000)

	All crops and livestock	Horticulture	Household use	Total
1972	86	5	36	127
1973	88	5	38	131
1974	85	5	37	127
1975	86	5	37	128
1976	92	5	38	135
1977	100	6	39	145
1978	102	7	39	148
1979	118	8	39	165

Source: EIU calculations on unpublished data obtained from Danske Elvaerkers Forening

Statistics compiled by Danske Elvaerkers Forening tend to put consumption of electricity in agriculture somewhat lower than do OECD statistics (Energy Statistics) for recent years (since 1976). Whereas Danske Elvaerkers Forening puts electricity consumption in agriculture, including household consumption, at 148,000 TOE in 1978, OECD puts the figure at 163,000 TOE, 10 per cent higher.

It is interesting and reassuring that Danske Elvaerkers Forening and S. Rasmussen are close in their estimates of household consumption of electricity on the farm. Danske Elvaerkers Forening puts the amount at 39,000 TOE in 1978, and S. Rasmussen suggests a figure some 18 per cent higher at 46,000 TOE.

S. Rasmussen puts electricity consumption for agricultural purposes, excluding horticulture, at 77,000 TOE in 1978. This is appreciably lower (25 per cent less) than the figure of 102,000 TOE put forward by Danske Elvaerkers Forening.

AGRICULTURE'S SHARE OF ENERGY CONSUMPTION

Consumption of energy in agriculture has increased in absolute terms, and agriculture's share of national consumption of energy has risen moderately if household consumption of farms is taken into account.

The following table shows that agricultural and farm household consumption of energy accounted for 7-8 per cent of national consumption in 1978 (OECD). Consumption of energy for professional agricultural purposes was of the order of 5-6 per cent of national energy consumption (Danmarks Statistik), and the share taken up by agriculture seems to have stabilised in recent years at marginally above 5 per cent.

Table 3.22

Denmark: Share of Agriculture in National Consumption of Energy, 1973-1978

(per cent of national consumption)

	1973	1974	1975	1976	1977	1978
Based on OECD						
Petroleum products	8.7	7.6	7.8	8.0	8.1	8.3
Electricity	...	6.2	6.2	9.4	9.1	9.1
Total	7.7	7.1	7.3	7.8	7.8	7.9
Based on Danmarks Statistik						
Petroleum products	6.0	6.0	5.9	5.4	5.4	5.6
Electricity	5.7	7.4	7.3	6.1	5.5	5.1
Total	5.9	5.9	5.8	5.2	5.1	5.2
Based on Danske Elvaerkers Forening						
Electricity	5.7	6.8	6.5	6.3	6.5	6.1

Source: EIU calculations, based on OECD, Danmarks Statistik and Danske Elvaerkers Forening data.

ENERGY CONSUMPTION BY TYPE OF FUEL AND USAGE

Petroleum-based fuels are the main source of energy used in Danish agriculture. The study by S. Rasmussen provides some guidance on the use of petroleum-based fuels and other fuels in agriculture.

S. Rasmussen shows that in 1978 petroleum-based fuels accounted for 90 per cent (682,000 TOE) of direct energy consumption in agriculture. The main usage sector is horticulture which takes up 51 per cent of petroleum-based fuel supplies to agriculture, mainly for the heating of glasshouses. Tractors and machinery used for the preparation of the soil account for 17 per cent of direct consumption of petroleum-based fuels in agriculture.

Electricity, which accounted for 10 per cent of energy consumption in agriculture in 1978, is mainly used to power ventilation systems in the rearing of animals: ventilation accounted for 40 per cent of electricity consumption in 1978.

Table 3.23

Denmark: Direct Energy Consumption in Agriculture by Type of Fuel, 1978

	TOE '000	Per cent
Motor gasoline	27	3.6
DERV fuel	264	34.8
Light and heavy fuel	380	50.1
Liquefied gas	11	1.4
Electricity	77	10.1
Total direct energy input	759	100.0

Source: S. Rasmussen

Table 3.24

Denmark: Direct Energy Consumption in Agriculture, by Type of Fuel and Use, 1978

(TOE '000)

	Petroleum-based fuels	Electricity	Total
Soil preparation	113	-	113
Harvesting	96	-	96
Other fieldwork	83	-	83
Drying of grain (on the farm)	10	2	12
Heating in animal rearing	30	2	32
Irrigation	-	5	5
Ventilation in animal rearing	-	30	30
Lighting	-	5	5
Milk-cooling	-	8	8
Milking	-	5	5
Greenhouses	350	-	350
Other	-	20	20
Total direct energy input	682	77	759
Domestic consumption for household use	429	46	475

Source: EIU calculations based on S. Rasmussen

CONSUMPTION OF FERTILISERS

In 1978, fertilisers accounted for 38 per cent of all energy consumed in agriculture (direct and indirect), and for 65 per cent of indirect energy consumption. Nitrogenous fertilisers accounted for over 80 per cent of indirect energy input represented by fertilisers.

Information is available from De Danske Landboforeninger on the use of fertilisers, which can be used to calculate the indirect energy content of fertilisers used in Denmark. Average application rates in terms of kilos per hectare for the three main categories of fertiliser - nitrogen (N), phosphate (P_2O_5) and potash (K_2O) - are also provided in the tables which follow.

Denmark is known to use a higher concentration of fertiliser per hectare than most other Community countries, and the usage of nitrogenous fertiliser is particularly high. While the application of phosphate and potash fertilisers has been reduced or remained constant since the early 1970s, increasing quantities of nitrogen are being used.

Table 3.25

Denmark: Consumption of Fertilisers, 1972/73 - 1978/79

(tonnes '000 of fertiliser element)

	Type of fertiliser				Change on previous year (%)
	N	P_2O_5	K_2O	Total	
1972/73	329	143	203	675	
1973/74	365	155	216	736	+ 9.0
1974/75	300	114	160	574	-22.0
1975/76	339	129	171	639	+11.3
1976/77	350	135	167	652	+ 2.0
1977/78	374	141	177	692	+ 6.1
1978/79	379	136	173	688	- 0.6

Source: De Danske Landboforeninger

Table 3.26

Denmark: Average Application of Fertilisers, 1972/73 - 1978/79

(kg/ha)

	Type of fertiliser					
	Denmark			European Community		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1972/73	111	48	68	56	50	45
1973/74	124	53	74	60	50	48
1974/75	102	39	55	57	40	40
1975/76	117	44	58	62	40	39
1976/77	120	46	57	65	43	43
1977/78	180	48	109	68	45	44
1978/79	187	44	115	...	...	...

Source: De Danske Landboforeninger

The energy content of fertilisers has been evaluated on the basis of consumption statistics and data from a study undertaken by Energy Resources Limited (ERL).

Table 3.27

Denmark: Indirect Energy Consumption in the Form of Fertilisers, 1972/73 - 1978/79

(TOE '000)

	Nitrogen	Phosphates	Potash	Total
1972/73	526	43	35	604
1973/74	584	47	37	668
1974/75	480	34	27	541
1975/76	542	39	29	610
1976/77	560	41	28	629
1977/78	598	42	30	670
1978/79	606	41	29	676

Source: EIU calculations based on data obtained from De Danske Landboforeninger and ERL

S. Rasmussen arrived at very comparable estimates for indirect energy consumption represented by fertilisers, even though his estimate of indirect input from nitrogenous fertilisers in 1978 is 6 per cent lower than that based on the study by ERL.

AGRICULTURAL MACHINERY

The joint economic and statistical department of Landbrugsraadet and De Danske Landboforeninger compiles statistics of registered agricultural machinery.

Tractors are by far the most numerous, and the number of tractors in use has risen from 135,000 in 1964 to 185,000 in 1979, an increase of 37 per cent. The park of combined harvesters has declined steadily from 41,000 units in 1977 to 39,000 units in 1979.

Table 3.28

Denmark: Registered Agricultural Machinery in Use, 1964-1979

(units)

	1964	1977	1978	1979
Agricultural tractors	135,000	186,000	185,000	185,000
Combined harvesters	16,000	41,000	40,000	39,000
Irrigation systems	...	12,000	14,000	15,000
Grain driers	...	...	34,000	35,000

Source: Annotated Statistics 1980 - Landbrugsraadet and DL

As a broad estimate, the EIU suggests that the indirect energy content of agricultural machinery could be of the order of 200,000 TOE on an annual basis.

CONSUMPTION OF ENERGY IN AGRICULTURE IN
THE EUROPEAN COMMUNITY

FRANCE

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

- FRANCE

Page

AGRICULTURE IN FRANCE

The total area under cultivation was 29,150,000 hectares in 1978. In the eight years since 1970, the area under cultivation declined by 2 per cent.

The agricultural sector in France is characterised by a concentration of medium to large holdings, although the number of holdings is declining: from 1970 to 1978 the number of holdings fell by 21 per cent to 1,126,000. The average size of holdings has risen from 17 hectares in 1960 to 25.9 hectares in 1978. A little over 9 per cent of the active population is engaged in agriculture and fisheries, compared with over 10 per cent in 1975.

Table 4.1

France: Number of Agricultural Holdings, 1970-1978

Size of Holdings (Hectares)	1970		1977		1978	
	Number	%	Number	%	Number	%
1 - 5	325,671	22.9	228,000	19.8	221,000	19.6
5 - 10	250,466	17.6	174,000	15.2	169,000	15.0
10 - 20	354,826	25.0	252,000	21.9	243,000	21.6
20 - 50	369,610	26.0	352,000	30.6	347,000	30.8
50 and over	120,351	8.5	143,000	12.5	146,000	13.0
Total	1,420,924	100.0	1,149,000	100.0	1,126,000	100.0

Source: Eurostat

Net value added at factor cost generated by agriculture has increased moderately by 3-4 per cent from year to year, rising from FF 59.7 billion in 1973 to FF 72.5 billion in 1978.

More than 45 per cent of the value at current prices of agricultural production is attributed to cereals and vegetables and these are consequently the sectors of agriculture with the highest energy inputs.

ENERGY COSTS

An analysis of the cost of inputs to agriculture, undertaken by the Institut National de la Statistique et des Etudes Economiques, serves to illustrate the increasing burden of the cost of energy since 1975. Energy is not treated separately in this analysis but is included in a category grouping fuels and repairs.

Direct energy and repairs accounted for 15.4 per cent of purchases of goods and services in 1975, equivalent to a value of FF 6,800 million. By 1979, the proportion had risen to 16.2 per cent and the absolute cost had increased by 73 per cent to FF 11,800 million. In relation to the gross revenue earned by the agricultural sector, energy and repair costs combined were equivalent to 5.8 per cent of revenue in 1975 and 6.8 per cent of revenue in 1979.

Animal feedstuffs is the main cost item by far, accounting for 34 per cent of total purchases in 1975 and 1979. In comparison with revenue earned by agriculture, feedstuffs were equivalent to 13 per cent of gross revenue in 1975 and 14 per cent in 1979.

Table 4.2

France: Purchases of Goods and Services by the Agricultural Sector, 1975-1979

	1975		1978		1979	
	FF mn	Per cent	FF mn	Per cent	FF mn	Per cent
Animal feed	14,900	33.8	22,200	35.1	24,900	34.1
Fertilisers	9,000	20.4	12,300	19.5	14,500	19.9
Fuel and repairs	6,800	15.4	9,800	15.5	11,800	16.2
Crop protection	2,900	6.6	4,300	6.8	4,900	6.7
Building maintenance	1,400	3.2	2,100	3.3	2,400	3.3
Veterinary expenses	1,900	4.3	2,600	4.1	3,000	4.1
Other goods	4,800	10.9	6,200	9.8	7,200	9.9
Other services	2,400	5.4	3,700	5.9	4,300	5.9
Total	44,100	100.0	63,200	100.0	73,000	100.0

Source: Institut National de la Statistique et des Etudes Economiques, Comptes de l'Agriculture de la Nation

SOURCES AND SUMMARY OF DATA

There are six sources of information which have been used to evaluate the consumption of energy in agriculture:

- OECD statistics on the energy balance of member states
- Electricité de France Gaz de France (EFGF) statistics on electricity input in agriculture
- Comité Professionnel du Pétrole (CPP) statistics on the consumption of petroleum products in agriculture
- Ministry of Agriculture: study of direct energy input in 1977
- Centre National des Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA): study of direct and indirect energy input in 1977
- Groupe Interdisciplinaire Ecologie, Développement et Energétique (Groupe EDEN): study of direct and indirect energy input in 1975.

OECD, the Comité Professionnel du Pétrole and Electricité de France Gaz de France provide historical series of statistical data which can be used to establish trends. The statistics are, however, partial: OECD statistics refer to petroleum-based fuels and electricity; CPP statistics are confined to petroleum products; EFGF statistics are confined to electricity.

The studies undertaken by the Ministry of Agriculture and by the Centre National des Etudes et d'Expérimentation de Machinisme Agricole provide a detailed analysis of energy input in agriculture, but the analysis is confined to a single year - 1977.

The study undertaken by the Groupe EDEN refers to a single year, 1975, but is useful in that it attempts to evaluate indirect energy inputs in agriculture.

Each of the six main sources of data on energy input in agriculture has been treated separately in subsequent chapters, and the EIU has endeavoured to reconcile the variances between the sources and provide an explanation for the differences. A broad comparative summary of the data obtained from the six sources for the period 1975-1979 is set out in Table 4.3.

The last three sources (Ministry of Agriculture, CNEEMA and EDEN) are the most detailed and are considered separately later on in the report.

Table 4.3

France: Energy Consumption in Agriculture - Comparative Summary of Data

(TOE '000)

	Group EDEN	Ministry Agriculture	CNEEMA	OECD				CPP					EFGF					
	1975	1977	1977	1975	1976	1977	1978	1975	1976	1977	1978	1979	1974	1975	1976	1977	1978	1979
Direct energy	7,231	5,023	4,900	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
of which:																		
- Petroleum fuels	6,678 (petroleum fuels, coal and wood)	4,185	4,530	2,667	2,770	2,862	3,037	2,861	2,991	3,037	3,220	3,135	...	...	...	...	...	...
- Coal		17	60 (coal and wood)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
- Wood		43		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
- Electricity	553	778	310	106	115	109	123	...	...	...	...	...	349	377	414	421	458	484
Indirect energy	8,746	...	8,800	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	15,977	...	13,700	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Source: EIU calculations based on data from Groupe Interdisciplinaire Ecologie, Développement et Energétique (EDEN), Ministère de l'Agriculture, Centre National d'Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA), Organisation for Economic Cooperation and Development (OECD), Comité Professionnel du Pétrole (CPP), and Electricité de France Gaz de France (EFGF)

The findings of the Ministry of Agriculture and of the CNEEMA for 1977 are broadly similar, evaluating direct energy consumption in agriculture at close on 5 million TOE. A significant difference between the findings of these two studies lies in the evaluation of the consumption of electricity: this is largely due to the use of different conversion factors in expressing electricity in terms of tonnes oil equivalent.

The difference between direct energy input as evaluated by the Groupe EDEN for 1975 and the estimations of the Ministry of Agriculture and of the CNEEMA for 1977 is wide: Groupe EDEN puts direct consumption in 1975 at 7.2 million TOE which is 44-48 per cent higher than estimates for 1977 put forward by the Ministry of Agriculture and the CNEEMA. The difference is again partly due to methodology, the Groupe EDEN expressing amounts in terms of Gross Energy Requirement.

OECD and the CPP are close in their respective estimates of the direct consumption of petroleum fuels, and the variances are largely accounted for by the categorisation of fuels.

There is, however, a very wide disparity between OECD and CPP figures and the estimates of direct consumption of petroleum-based fuels put forward by the Ministry of Agriculture and the CNEEMA. The study undertaken by the Ministry of Agriculture arrived at an estimate of direct consumption of petroleum-based fuels in 1977 of 4,185,000 TOE, which is 46 per cent higher than the OECD figure of 2,862,000 TOE and 38 per cent higher than the 3,037,000 TOE recorded by the CPP. The CNEEMA estimated direct consumption of petroleum-based fuels at 4,530,000 TOE in 1977, which is 58 per cent greater than the OECD figure and 49 per cent greater than the CPP figure.

After reviewing the findings with well informed persons, the EIU is inclined to accept the findings of the Ministry of Agriculture and of the CNEEMA as being closest to reality, although no clear conclusions emerged from the discussions. The fact that the data put forward by the Ministry of Agriculture and the CNEEMA are the findings of studies specifically related to agriculture tends to add confidence to the figures which have emerged from the studies.

The summary of statistical data presented in Table 4•3 shows that direct energy consumption accounts for some 45 per cent of total energy consumed in agriculture. Petroleum-based fuels account for some 85-90 per cent of direct energy input.

OECD DATA: AGRICULTURE'S SHARE OF DIRECT ENERGY CONSUMPTION

OECD statistics compiled to show the energy balance of member states can be used to determine broad trends in consumption of selected fuels in agriculture, and to show the share of total fuel consumption accounted for by agriculture. The scope of the analysis based on OECD statistics is however limited by the partial nature of the data relating to energy consumption in agriculture, which are confined to petroleum products and electricity. Nevertheless, petroleum products and electricity account for well over 90 per cent of direct energy consumed in agriculture.

Table 4·4

France: National Energy Consumption[a], 1973-1978

	1973		1976		1977		1978	
	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent
Solid fuels	18.37	12.5	14.42	10.5	13.51	9.8	13.48	9.3
Petroleum products	103.66	70.8	92.87	67.8	91.97	67.1	97.28	66.9
Gas	11.21	7.7	14.52	10.6	15.75	11.5	17.54	12.1
Electricity	13.15	9.0	15.14	11.1	15.93	11.6	17.03	11.7
National total	146.40	100.0	136.96	100.0	137.16	100.0	145.33	100.0
of which:								
Agriculture	2.91[b]	2.0	2.89[b]	2.1	2.97[b]	2.2	3.16[b]	2.2

a final consumption

b petroleum products and electricity only

Source: Organisation for Economic Cooperation and Development (OECD) - Energy Balances

Between 1973 and 1975, total national consumption of energy declined by 9 per cent from 146.4 million TOE to 132.9 million TOE, but from 1976 to 1978 consumption rose steadily, to reach 145.3 million TOE, 9.3 per cent more than in 1975. Agriculture has accounted for about 2 per cent of national consumption of energy.

A more detailed analysis of the uses of petroleum products and electricity in agriculture is provided in Energy Statistics compiled by OECD. Data for the six years 1973 to 1978 are presented in the following tables. Data relating to 1978 were published by OECD in 1980.

Apart from a pause in 1975 when consumption fell by 6 per cent, consumption of energy in agriculture has increased in the five-year period by 8.5 per cent to reach 3.2 million TOE in 1978. The share of energy taken up by agriculture has increased marginally from 2 per cent to 2.2 per cent.

Gas/diesel oil is by far the largest category of fuel used in agriculture, and input of 2,526,000 TOE in 1978 account for 80 per cent of total energy input in agriculture. In the five-year period, consumption of gas/diesel oil has decreased marginally, although the trend in consumption has been rising from the low level of 2,336,000 TOE in 1975. Consumption of residual fuel oil increased year by year from 1973 to 1978, when consumption of 316,000 TOE was 97.5 per cent greater than in 1973, making this the second largest category of fuel accounting for 10 per cent of the total.

Table 4.5

France: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Liquefied gas	Gas/diesel oil	Residual fuel oil	Non-energy products[a]	Electricity	Total[c]
1973						
Agriculture						
- tonnes '000	109	2,421	165	-	1,129[b]	-
- TOE '000	124	2,530	160	-	97	2,911
National consumption						
- tonnes '000	2,235	45,657	23,542	10,108	179,562[b]	-
- TOE '000	2,548	47,712	22,812	9,603	15,442	146,400
Share of agriculture (%)	4.9	5.3	0.7	-	0.6	2.0
1974						
Agriculture						
- tonnes '000	102	2,420	214	-	1,201[b]	-
- TOE '000	116	2,529	207	-	103	2,955
National consumption						
- tonnes '000	1,988	39,849	20,849	7,234	161,248[b]	-
- TOE '000	2,266	41,642	20,196	6,872	13,867	139,340
Share of Agriculture (%)	5.1	6.1	1.0	-	0.7	2.1

(continued)

Table 4.5

France: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978 (continued)

	Liquefied gas	Gas/diesel oil	Residual fuel oil	Non-energy products [a]	Electricity	Total [c]
1975						
Agriculture						
- tonnes '000	94	2,235	231	-	1,238 [b]	-
- TOE '000	107	2,336	224	-	106	2,773
National consumption						
- tonnes '000	2,297	37,785	18,139	7,027	161,910	-
- TOE '000	2,619	39,485	17,577	6,676	13,924	132,920
Share of agriculture (%)	4.1	5.9	1.3	-	0.8	2.1
1976						
Agriculture						
- tonnes '000	102	2,300	258	-	1,341 [b]	-
- TOE '000	116	2,404	250	-	115	2,885
National consumption						
- tonnes '000	2,376	38,250	19,886	5,386	176,071 [b]	-
- TOE '000	2,709	39,971	19,270	5,117	15,142	136,960
Share of agriculture (%)	4.3	6.0	1.3	-	0.8	2.1

(continued)

Table 4.5

France: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978 (continued)

	Liquefied gas	Gas/diesel oil	Residual fuel oil	Non-energy products[a]	Electricity	Total[c]
1977						
Agriculture						
- tonnes '000	124	2,350	273	-	1,273[b]	-
- TOE '000	141	2,456	265	-	109	2,971
National consumption						
- tonnes '000	2,465	37,633	19,282	5,246	181,181[b]	-
- TOE '000	2,810	39,326	18,684	4,984	15,582	137,160
Share of agriculture (%)	5.0	6.2	1.4	-	0.7	2.2
1978						
Agriculture						
- tonnes '000	170	2,417	326	1	1,432[b]	-
- TOE '000	194	2,526	316	1	123	3,160
National consumption						
- tonnes '000	2,676	40,913	18,652	5,310	198,057[b]	-
- TOE '000	3,051	42,754	18,074	5,045	17,033	145,330
Share of agriculture (%)	6.4	5.9	1.7	-	0.7	2.2

a excluding naphtha; b million kwh; c totals for national consumption include petroleum-based fuels and other fuels not used in agriculture

Source: EIU calculations based on data provided by Organisation for Economic Co-operation and Development (OECD)

OECD statistics are taken as an indicator of the trend in demand for fuel in agriculture. While the EIU takes the view that OECD statistics understate the consumption of petroleum-based fuels and electricity in agriculture by a broad margin, there are few sources which can be used to trace historic trends. There is no reason to question the trend revealed by OECD statistics for petroleum-based fuels, even though they consistently understate the absolute quantities of energy consumed in agriculture. The upward trend in electricity consumption is probably more pronounced than shown by OECD statistics. Statistics obtained from Electricité de France Gaz de France show that consumption of electricity in agriculture rose from 349,000 TOE in 1974 to 458,000 TOE in 1978, which is equivalent to an average annual rate of growth of 7 per cent.

Table 4.6

France: Growth in Demand for Energy in Agriculture, 1974-1978

(per cent increase on previous year by volume)

	1974 (%)	1975 (%)	1976 (%)	1977 (%)	1978 (%)	Average annual growth (%)
Petroleum-based fuels	+1.3	-6.5	+3.9	+3.3	+ 6.1	+1.5
Electricity	+6.4	+3.1	+8.3	-5.1	+12.5	+4.5
Total	+1.5	-6.2	+4.0	+3.0	+ 6.4	+1.7

Source: OECD - Energy Balances

DIRECT AND INDIRECT ENERGY CONSUMPTION

EVALUATION BY THE MINISTRY OF AGRICULTURE

The Ministry of Agriculture undertook a detailed study of direct consumption of energy in agriculture in 1977. The findings of the study were published in 1979.

Total direct consumption of energy in agriculture in 1977 was estimated at 5,023,000 TOE for farming purposes, and the consumption of energy by farmers and their families for private domestic purposes (household consumption) was put at 4,124,000 TOE. The scope of the study was confined to direct energy consumption.

Table 4.7
France: Ministry of Agriculture - Direct Energy Consumption in Agriculture, 1977

	For farming purposes		For household purposes
	TOE '000	Per cent	
Diesel oil	3,599	71.7	1,106
Heavy fuel oil	175	3.5	34
Petrol (gasoline)	301	6.0	n.a.
Liquefied gas	110	2.2	188
Electricity	778	15.4	689
Coal	17	0.3	187
Wood	43	0.9	1,910
Total direct energy input	5,023	100.0	4,124

Note: Figures on household purposes add up to a total of 4,114,000 TOE. The EIU has however reproduced the figure published by the Ministry, i.e. 4,124,000 TOE

Source: Ministère de l'Agriculture - Sous-direction des Synthèses Statistiques et des Revenus (SDSSR)

Petroleum-based fuels accounted for 83 per cent of total direct energy consumption in 1977.

In evaluating direct consumption of energy in agriculture, the Ministry of Agriculture has taken into account two categories of farming enterprise - independent farm units and collective or cooperative organisations including agricultural contractors.

Energy consumption by independent farm units has been evaluated on the basis of a large-scale sample survey among 10,000 farmers. Energy consumption by collective organisations was evaluated from data provided by the CNEEMA.

Consumption of petroleum-based fuels by collective organisations was taken to be diesel oil, although heavy fuel oil and liquefied gas are used in the drying of grain. The data provided by the CNEEMA did not allow for a more detailed breakdown of consumption of petroleum-based fuels by collective organisations. The estimates prepared by the CNEEMA are based on calculations relating to the park of agricultural equipment, the areas under cultivation and technical norms for fuel consumption.

The sample survey among farmers allowed the Ministry of Agriculture to collect data on the consumption of energy on farms for domestic household uses. The data did not, however, allow for a reliable estimate of consumption of petrol (gasoline) for household needs.

Table 4.8

France: Direct Energy Consumption in Agriculture by Type of Fuel and Use, 1977

(TOE '000)

	Diesel oil	Petrol	Heavy fuel	Sub-total	Elec-tricity	Liquefied gas	Coal	Wood	Total
Independent farm units	2,599	301	175	3,075	578	110	17	43	3,823
of which:									
Heating	318	-	174	492	248	110	17	43	912
of which:									
- animal rearing	44	-	11	55	209	97	1	33	396
- glasshouses	212	-	152	364	22	9	14	1	410
- drying	62	-	11	73	17	4	2	9	106
Power (excluding commercial vehicles	2,188	92	-	2,280	329	-	-	-	2,609
of which:									
- tractors and self-propelled machinery	2,154	64	-	2,218	-	-	-	-	2,218
- other	34	28	-	62	329	-	-	-	391
Commercial vehicles	93	209	-	302	-	-	-	-	302
Collective use (except drying)	300	...	...	300	...	...	...	...	300
Collective drying	700	...	...	700	200	...	...	...	900
Total direct energy input	3,599	301	175	4,075	778	110	17	43	5,023
Domestic consumption for household use	1,106	...	34	1,140	689	188	187	1,910	4,124

Source: Ministère de l'Agriculture and CNEEMA

Fuel for powering machinery and tractors (but excluding commercial vehicles) accounts for 52 per cent of direct energy consumption for farming purposes, and this is by far the largest of the main usage categories. Tractors and self-propelled machinery alone account for 44 per cent of direct energy consumption. The dominance of this category is explained by the importance of cereal, potato and beet cultivation in France, and the mechanisation of viticulture.

The drying of grain by cooperatives accounts for about 18 per cent of direct energy input, mainly in the form of petroleum-based fuels, and the share of energy taken up in drying rises to 20 per cent if energy consumption by farm units is also taken into account.

Horticulture accounts for some 8 per cent of direct energy consumption, mainly in the form of heating glasshouses. The share rises to 45 per cent of energy used for heating purposes.

EVALUATION BY THE CNEEMA

The CNEEMA evaluation of energy consumption in agriculture in 1977 is largely based on data obtained from the sample survey of farmers conducted by the Ministry of Agriculture, and the study can therefore be seen as an interpretation and extrapolation of the findings of the sample survey. The CNEEMA had independently evaluated the energy consumption of agricultural cooperatives and other collective organisations.

The CNEEMA has estimated total direct energy consumption in agriculture at 4,900,000 TOE, with petroleum-based fuels accounting for 93 per cent of the total. While the CNEEMA evaluation of total direct energy consumption in agriculture in 1977 is close to the evaluation made by the Ministry of Agriculture (-2.5 per cent), there are wide variances for some categories of fuel.

Table 4.9

France: CNEEMA - Direct Energy Consumption in Agriculture, 1977

	TOE '000	Per cent
Diesel oil (domestic)	2,930	59.8
Diesel oil (diesel engine road vehicle fuel)	200	4.1
Heavy fuel	825	16.8
Petrol	400	8.2
Liquefied gas	175	3.6
Electricity	310	6.3
Other	60	1.2
Total direct energy input	4,900	100.0

Source: Centre National d'Etudes et d'Expérimentation de Machinisme Agricole (CNEEMA)

The CNEEMA puts direct electricity consumption at 310,000 TOE, 60 per cent below the figure arrived at by the Ministry of Agriculture. This difference is more apparent than real, and is due to the application of different conversion factors. The CNEEMA takes into account electricity consumed by independent farm units and collective organisations, as does the Ministry of Agriculture, but the CNEEMA converts electricity into tonnes oil equivalent by applying the factor adopted by OECD for electricity in final consumption (10^9 KWH= 0.086 TOE million), whereas the Ministry of Agriculture converts electricity into tonnes oil equivalent by applying a primary energy conversion factor (1 KWH = 0.222×10^{-3} TOE).

On a final consumption basis, electricity consumption equivalent to 578,000 TOE (primary), as reported by the Ministry of Agriculture as consumption by independent farm units, would reduce to 224,000 TOE (final consumption). Again on a final consumption basis, the 200,000 TOE (primary) consumed by collective organisations reduce to 80,000 TOE (final consumption). The Ministry of Agriculture's estimate of electricity consumption on the basis of electricity in final consumption would be of the order of 304,000 TOE, 2 per cent below the figure suggested by the CNEEMA.

The CNEEMA admits that it has found it difficult to estimate consumption of liquefied gas, but takes the view that the Ministry of Agriculture has understated consumption by as much as 60 per cent.

The CNEEMA puts the direct consumption of petroleum-based fuels (diesel oil, heavy fuel oil and petrol) at 6-7 per cent higher than does the Ministry of Agriculture. The CNEEMA makes an allowance for petrol consumption by collective organisations, an item which the Ministry of Agriculture excluded. The CNEEMA has redistributed consumption of oil products, giving far greater importance to heavy fuel oil. Whereas the Ministry of Agriculture assumed that consumption of oil by collective organisations could be classified as consumption of diesel oil, the CNEEMA is of the opinion that heavy fuel oil accounted for a high proportion of the total.

The CNEEMA has assessed indirect energy consumption in agriculture at 8,800,000 TOE in 1977, of which the largest input category is made up of fertilisers which account for 44 per cent.

Table 4.10

France: CNEEMA - Indirect Energy Consumption in Agriculture, 1977

	TOE '000	Per cent
Fertilisers	3,900	44.3
Feedstuffs	1,800	20.5
Equipment	1,300	14.8
Agro-chemicals	600	6.8
Miscellaneous materials	1,200	13.6
Total indirect energy input	8,800	100.0

Source: CNEEMA

EVALUATION BY GROUPE EDEN

The Groupe Interdisciplinaire Ecologie, Développement et Energétique (Groupe EDEN) made a detailed study of energy input in agriculture in 1975. The findings of the study were not published. The study is of considerable interest as it is one of the rare comprehensive attempts to evaluate indirect energy consumption in agriculture.

The Groupe EDEN puts total energy consumption in agriculture at 16 million TOE in 1975, of which direct consumption accounted for 7.2 million TOE (45 per cent) and indirect consumption for 8.8 million TOE (55 per cent).

The findings of the Groupe EDEN study cannot be compared directly with those of the studies conducted by the Ministry of Agriculture and the CNEEMA, as the basis of evaluation of direct energy input adopted by the Groupe EDEN is that of Gross Energy Requirement (GER).

Table 4.11

France: Groupe EDEN - Energy Consumption in Agriculture, 1975

	TOE '000	Per cent
Direct Energy		
Fossil energy in GER[a] terms	6,678	41.8
of which:		
- tractors and machinery	3,570	22.3
- transportation	530	3.3
- dehydration	408	2.6
- drying of cereals	280	1.8
- heating in horticulture	560	3.5
- heating in animal rearing	360	2.3
Electricity in GER[a] terms	553	3.5
Total direct input	7,231	45.3

(continued)

Table 4.11

France: Groupe EDEN - Energy Consumption in Agriculture, 1975 (continued)

	TOE '000	Per cent
Indirect Energy		
Fertilisers	3,880	24.3
Animal feedstuffs, excluding imported products	1,508	9.4
Imported animal feedstuffs	390	2.4
Agricultural machinery	961	6.0
Buildings	955	6.0
Agro-chemicals	500	3.1
Packaging materials and fencing	345	2.2
Irrigation	207	1.3
Total indirect input	8,746	54.7
Total energy input	15,977	100.0

a Gross Energy Requirement

Source: Groupe Interdisciplinaire Ecologie, Développement et Energétique (Groupe EDEN)

Direct Energy

Energy consumption is expressed in terms of Gross Energy Requirement (GER) which is defined to include the following elements:

$$GER = Eo + Et + Cf + Cs + Cp$$

when

- Eo = energy required to obtain the raw product (i.e. crude oil)
- Et = energy required for transformation (i.e. refining)
- Cf = calorific value of final product (i.e. petrol)
- Cs = calorific value of by-products (i.e. tar)
- Cp = calorific value of losses (i.e. burned gases)

Direct consumption of fossil fuels and electricity, at 7,231,000 TOE in 1975, accounts for 45 per cent of total direct and indirect energy consumption in agriculture, as evaluated by the Groupe EDEN. The use of solid fuel is low and is confined to the heating of stables, of animal rearing enclosures and of glasshouses, and to the drying of crops. The term fossil fuels is used by the Groupe EDEN to cover petroleum-based fuels, coal and wood: these accounted for 6,678,000 TOE (GER basis) in 1975, representing 92 per cent of total direct energy consumption.

In evaluating direct consumption of fossil fuels, the Groupe EDEN identifies six main usage sectors:

- tractors and other agricultural machinery
- commercial vehicles and cars used for farming purposes
- dehydration of crops
- drying of crops
- heating in horticulture
- heating in animal rearing.

Fuel consumption in powering tractors and agricultural machinery has been assessed on the basis of data obtained from the Comité Professionnel du Pétrole (CPP), an association representing petroleum interests.

Fuel consumption by commercial vehicles and cars has been estimated on the basis of data obtained from the Centre d'Etudes et de Recherches Economiques sur l'Energie (CEREN). The data provided by the CEREN related to 1970 when consumption was put at 360,000 TOE. The data were extrapolated by the Groupe EDEN allowing for an average annual increase of 8.2 per cent. The growth rate is equivalent to the increase in vehicle utilisation reported by the Institut National de la Statistique et des Etudes Economiques (INSEE) in a study on consumption trends in the period 1959-1974.

Consumption of diesel oil in the dehydration of crops has been assessed from data provided by the CNEEMA. It was estimated that in 1973 some 0.23 TOE was used per tonne of dehydrated product. The Groupe EDEN took into account the trend towards a reduction in energy input per tonne of dehydrated product.

Fuel consumption for the drying of grain, mainly maize and wheat, has been assessed on the basis of data provided by the CNEEMA.

Fuel input in animal rearing has been estimated on the basis of information relating to 1970 obtained from the CEREN. The data led to an estimate of 320,000 TOE of diesel oil, liquefied gas and solid fuels, but the Groupe EDEN adjusted this figure upwards to take into account the increase in the number of animals between 1970 and 1975.

Electricity input was based on statistics of electricity consumption compiled by Electricité de France.

Tractors, farm machinery and equipment used in dehydration and drying account for the greater part of direct energy consumption in agriculture, taking up 64 per cent of direct input of fossil fuels. This reflects the importance of cereals, potatoes, beet and viticulture in French agriculture. Machinery in this wider sense accounted for 58 per cent of direct energy input and for 27 per cent of total energy input in agriculture.

Transportation (commercial vehicles and cars) accounts for about 7 per cent of direct energy input.

Fuel for heating purposes in horticulture and animal rearing accounts for some 6 per cent of total energy input in agriculture, and for 13 per cent of direct energy consumption.

Indirect Energy

The Groupe Eden and the CNEEMA have both attempted to assess indirect input in agriculture, and they come to very similar evaluations:

- Groupe Eden 8,746,000 TOE in 1975
- CNEEMA 8,800,000 TOE in 1977

Groupe EDEN has evaluated indirect energy consumption at 8,746,000 TOE in 1975, which would be equivalent to 55 per cent of total energy consumption in agriculture in that year.

Fertilisers account for 44 per cent of indirect energy consumption (3,880,000 TOE), and agricultural chemicals for 6 per cent (500,000 TOE). The energy content of fertilisers and agro-chemicals has been assessed by applying the method of G. Leach and M. Slesser.The CNEEMA estimated indirect energy consumption at 8.8 million TOE in 1977, with fertilisers again accounting for 44 per cent (3.9 million TOE).

Ministry of Agriculture statistics show that in the period 1970 to 1979 consumption of fertilisers rose by about 2.5 per cent a year from 4,632,000 tonnes in 1970/71 to 5,618,000 tonnes in 1978/79. Since 1975/76 consumption has increased year by year, but the statistics show a sharp fall in consumption of 20 per cent in 1974/75. The sharp rise in the price of phosphates is the cause of the very modest increase in consumption of phosphate-based fertilisers in the same period, an increase of 1 per cent a year on average from 1,815,000 tonnes in 1970/71 to 1,950,000 tonnes in 1978/79.

Table 4.12

France: Consumption of Fertilisers, 1972/73-1978/79

(tonnes '000 of fertiliser element)

	Type of fertiliser				
	N	P2O5	K2O	Total	Change on previous year (%)
1972/73	1,649	2,097	1,636	5,382	+ 8.2
1973/74	1,833	2,168	1,826	5,827	+ 8.3
1974/75	1,555	1,711	1,390	4,656	-20.1
1975/76	1,708	1,664	1,315	4,687	+ 0.7
1976/77	1,815	1,796	1,494	5,105	+ 8.9
1977/78	1,832	1,840	1,558	5,230	+ 2.4
1978/79	1,978	1,950	1,690	5,618	+ 7.4

Source: Ministère de l'Agriculture

The energy content of fertilisers has been evaluated on the basis of consumption statistics and data from a study undertaken by Energy Resources Limited (ERL).

Table 4.13

France: Indirect Energy Consumption in the Form of Fertilisers, 1973-1979

(TOE '000)

	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79
Nitrogen (N)	2,933	2,488	2,733	2,904	2,931	3,165
Phosphates (P_2O_5)	650	513	499	539	552	585
Potash (K_2O)	310	236	224	254	265	287
Total	3,893	3,237	3,456	3,697	3,748	4,037

Source: EIU calculations based on data on fertiliser consumption and Energy Resources Limited.

The Groupe EDEN and the CNEEMA arrived at broadly comparable estimates of the indirect consumption of energy represented by fertilisers. The estimates set out in the previous table (based on the study of ERL) are sufficiently close to those of the Groupe EDEN and of the CNEEMA to be considered as a confirmation of the separate findings, even though the estimate for 1975 based on ERL data is some 11-12 per cent lower than the estimate of the Groupe EDEN.

The other main input to agriculture which represents an appreciable form of indirect consumption of energy is animal feedstuffs. The Groupe EDEN estimated the energy content of feedstuffs in 1975 at 1.9 million TOE, accounting for 22 per cent of indirect energy consumption. The CNEEMA put the energy content of feedstuffs in 1977 at 1.8 million TOE, 21 per cent of indirect energy consumption.

The indirect energy content of animal feedstuffs was evaluated on the basis of calorific values established by C. Chatfield and P. Brouk. The Groupe EDEN took into account local production of feedstuffs and foreign trade to arrive at "apparent consumption" in France. The indirect energy content of imported feedstuffs was evaluated following the method of G. Leach.

The energy content of packaging materials and fencing and the energy consumed in their utilisation and erection has been estimated on the basis of inputs calculated by R. Carillon in 1975.

In evaluating the energy content of agricultural buildings, input factors calculated by R. Carillon have again been used. The average energy content of masonry has been taken as 3.3 GJ kg^{-1} and of steel structures as 56.1 GJ kg^{-1}. Groupe EDEN also made an allowance for the extraction and transport of raw materials on the basis of a study by G. Leach. Total energy input was evaluated on the basis of statistics on agricultural buildings made available by the Ministry of Agriculture and Ministry of Equipment. Buildings accounted for a similar amount of indirect energy, 955,000 TOE or 11 per cent.

Agricultural machinery was defined to include machinery and replacement components. R. Berry and M. Fels estimated that in the United States energy specific demand (ESD) amounted to 83.67 GJ per tonne weight of a car. Groupe EDEN arrived at an ESD of 75 GJ per tonne for tractors and agricultural machinery used in France, allowing for the particular characteristics of machinery used on French farms.

Agricultural machinery was estimated to represent an energy input of 961,000 TOE, or 11 per cent of total indirect energy input in 1975.
The CNEEMA estimated that equipment used on farms in 1977 represented an energy input of 1.3 million TOE.

Energy consumed in the irrigation of farm land proved difficult to evaluate. In 1973, D. Pimentel calculated that one acre of maize irrigated by one foot of water per season was equivalent to an ESD of 905 10^3 Kcal. The Groupe EDEN used this factor to evaluate energy consumed in irrigating farms, since maize is the most important crop requiring irrigation in France in terms of area under cultivation. The Ministry of Agriculture provided data on the area of irrigated land in France and Groupe EDEN calculated the total indirect input of energy required to irrigate the area on the assumption that the area was under maize, giving 207 000 TOE.

Agro-chemicals, comprising insecticides and herbicides, were the only other important category of indirect input of energy. This was put at 500,000 TOE in 1975, equivalent to 6 per cent of indirect energy consumption.

Table 4.14

France: Agricultural Consumption of Petroleum Products by Main Product Types, 1973-1979

(tonnes oil equivalent '000)

	Agricultural demand[a]		Total demand	
	Volume	%	Volume	Share of agriculture (%)
1973				
Petrol	160	5.2	17,059	0.9
Paraffin	1	0.1	2,101[b]	-
Diesel oil	2,530	82.5	48,586	5.2
Residual fuel oil	160	5.2	37,689	0.4
Lubricants	93	3.0	1,039	9.0
Liquefied gas	124	4.0	3,073	4.0
Total	3,068	100.0	109,547	2.8
1974				
Petrol	143	4.7	16,407	0.9
Paraffin	1	-	2,096[b]	-
Diesel oil	2,529	82.5	42,374	6.0
Residual fuel oil	207	6.8	37,732	0.5
Lubricants	67	2.2	998	6.7
Liquefied gas	116	3.8	3,039	3.8
Total	3,063	100.0	102,646	3.0
1975				
Petrol	129	4.5	17,185	0.8
Paraffin	1	0.1	2,140[b]	-
Diesel oil	2,336	81.6	40,212	5.8
Residual fuel oil	224	7.8	31,876	0.7
Lubricants	64	2.3	924	6.9
Liquefied gas	107	3.7	2,951	3.6
Total	2,861	100.0	95,288	3.0

(continued)

Table 4.14

France: Agricultural Consumption of Petroleum Products by Main Product Types, 1973-1979 (continued)

(tonnes oil equivalent '000)

	Agricultural demand[a]		Total demand	
	Volume	%	Volume	Share of agriculture (%)
1976				
Petrol	124	4.1	18,076	0.7
Paraffin	1	-	2,293[b]	-
Diesel oil	2,420	80.9	42,052	5.8
Residual fuel oil	250	8.4	36,084	0.7
Lubricants	80	2.7	996	8.0
Liquefied gas	116	3.9	3,044	3.8
Total	2,991	100.0	102,545	2.9
1977				
Petrol	111	3.7	18,316	0.6
Paraffin	1	-	2,412[b]	-
Diesel oil	2,474	81.5	41,199	6.0
Residual fuel oil	265	8.7	31,173	0.9
Lubricants	77	2.5	1,013	7.6
Liquefied gas	109	3.6	3,081	3.5
Total	3,037	100.0	97,194	3.1
1978				
Petrol	107	3.3	18,971	0.6
Paraffin	1	0.1	2,563[b]	-
Diesel oil	2,526	78.4	44,222	5.7
Residual fuel oil	316	9.8	31,607	1.0
Lubricants	76	2.4	926	8.2
Liquefied gas	194	6.0	3,297	5.9
Total	3,220	100.0	101,586	3.2

(continued)

Table 4.14

France: Agricultural Consumption of Petroleum Products by Main Product Types, 1973-1979 (continued)

(tonnes oil equivalent '000)

	Agricultural demand[a]		Total demand	
	Volume	%	Volume	Share of agriculture (%)
1979				
Petrol	97	3.1	19,093	0.5
Paraffin	1	-	2,784[b]	-
Diesel oil	2,518	80.3	42,616	5.9
Residual fuel oil	196	6.3	32,138	0.6
Lubricants	76	2.4	957	7.9
Liquefied gas	247	7.9	3,516	7.-
Total	3,135	100.0	101,104	3.1

a petroleum products used in agriculture

b including jet fuel and white spirit

Source: EIU calculations based on data supplied by the Comité Professionnel du Pétrole (CPP)

While the statistics compiled by the CPP and OECD are broadly in line in evaluating the amount of petroleum-based fuels taken up by agriculture, the CPP consistently allocates somewhat higher amounts to agriculture. OECD statistics do not specifically allocate petrol or paraffin to agricultural uses, whereas these are identified by the CPP.

OECD seems to understate the input of non-energy petroleum products in agriculture, indeed these are identified for the first time in 1978 when consumption in agriculture is put at 1,000 TOE. The CPP statistics have the merit of recording consumption of lubricants separately, and in the period 1973 to 1979 annual consumption has ranged from 64,000 TOE in 1975 to 93,000 TOE in 1973, although in more recent years consumption has levelled off at 76,000 TOE a year.

The trend in consumption of petroleum products in the period 1973 to 1979, as illustrated by the CPP statistics, is traced in Table 4.15. Consumption of petroleum products increased by 2 per cent in the six years to 1979, and the main feature of the trend has been its stability at a level of some 3 million TOE, with a low point of 2.9 million TOE in 1975 and a peak of 3.2 million TOE in 1978.

Diesel oil is by far the main petroleum product consumed in agriculture, accounting for 78-83 per cent of annual consumption of petroleum products in the six years to 1979.

Agriculture takes up about 3 per cent of national consumption of petroleum products, and the share has been consistently held over the past five years.

AGRICULTURAL DEMAND FOR PETROLEUM PRODUCTS

The Comité Professionnel du Pétrole (CPP) publishes statistics on the consumption of petroleum-based fuels and lubricants in agriculture. The most recent figures relate to 1979, and historic data for the period 1973 to 1979 are set out in Table 4.12. Consumption in agriculture is compared with total consumption, but the comparison is confined to petroleum-based fuels and lubricants which are used in agriculture. These products account for 85-90 per cent of total petroleum products identified by the CPP.

For ease of comparison, the EIU has converted volumes expressed in units appropriate to a particular product into tonnes oil equivalent. The conversion factors used in this exercise are those applied by OECD, and this has the further advantage of allowing comparison with the OECD statistics quoted earlier in this report.

Table 4.15

France: Consumption of Petroleum Products in Agriculture, 1973-1979

		1973	1974	1975	1976	1977	1978	1979
Petrol :	tonnes '000	149	134	120	116	103	100	90
	TOE '000	160	143	129	124	111	107	97
Paraffin :	tonnes '000	1	1	1	1	1	1	1
	TOE '000	1	1	1	1	1	1	1
Diesel oil :	tonnes '000	2,421	2,420	2,235	2,316	2,367	2,417	2,410
	TOE '000	2,530	2,529	2,336	2,420	2,474	2,526	2,518
Residual fuel oil :	tonnes '000	165	214	231	258	273	326	202
	TOE '000	160	207	224	250	265	316	196
Lubricants :	tonnes '000	98	70	67	84	81	80	80
	TOE '000	93	67	64	80	77	76	76
Liquefied gas :	tonnes '000	109	102	94	102	124	170	217
	TOE '000	124	116	107	116	109	194	247
Total petroleum products :	tonnes '000	2,943	2,941	2,748	2,877	2,949	3,094	3,000
	TOE '000	3,068	3,063	2,861	2,991	3,037	3,220	3,135
French consumption of petroleum products according to CPP :	tonnes '000	116,487	109,777	100,809	109,299	103,959	109,693	110,644
French consumption of petroleum products according to OECD :	TOE '000	103,660	94,950	89,870	92,870	91,970	97,280	n.a.
Agriculture's share of petroleum products (%)		3.0	3.2	3.2	3.2	3.3	3.3	

Source: EIU calculations based on data supplied by CPP and provided by OECD

COMPARISON OF SOURCES OF DATA ON CONSUMPTION OF PETROLEUM PRODUCTS

There are four sources of statistical data on consumption of petroleum products in agriculture and the variances between the data are often wide and difficult to reconcile. The use of different conversion factors would not have had an appreciable effect on the amounts expressed in tonnes oil equivalent.

The statistics compiled by the CPP and OECD are broadly in line for the main product categories and in total. The differences were the subject of comment earlier in this chapter. The CPP statistics are particularly useful in that they provide a detailed breakdown by product type and a historical series. The CPP and OECD put consumption of petroleum products in agriculture at around 3 million TOE a year in recent years.

The CNEEMA, using its own data and data provided by the Ministry of Agriculture, has undertaken a detailed evaluation of energy consumption in agriculture in 1977, and puts direct consumption of petroleum products 50 per cent higher at 4.5 million TOE.

The Ministry of Agriculture, using similar data to that available to the CNEEMA, has estimated consumption of petroleum products at 4.2 million TOE in 1977.

A comparison of the data obtained from the four sources for the year 1977 is set out below in terms of tonnes oil equivalent :

	CCP (000 TOE)	OECD (000 TOE)	CNEEMA (000 TOE)	Ministry of Agriculture (000 TOE)
Diesel oil	2,474	2,456	3,130	3,599
Residual fuel oil	265	265	825	175
Petrol	111	-	400	301
Paraffin	1	-	-	-
Liquefied gas	109	141	175	110
Lubricants	77	-	-	-
Total	3,037	2,862	4,530	4,185

From discussions with persons concerned with compiling and interpreting these data, it clearly emerges that the margin of error is appreciable. This applies to both the methodology adopted by the Ministry of Agriculture and the CNEEMA and to the evaluation of agriculture's share of total consumption of petroleum products as estimated by the CPP and OECD, bearing in mind that agriculture accounts for only 3 per cent of total national consumption.

The CNEEMA may have overestimated the consumption of diesel oil in powering farm machinery by applying utilisation factors which overstate actual usage of machinery.

If consumption of diesel oil in agriculture had been as high as 3.1 million TOE in 1977, agriculture's share of total national consumption would have been of the order of 8-10 per cent, depending on whether CPP or OECD statistics were taken to represent the national total. This seems by all accounts too high a share for agriculture, and the EIU suggests that consumption of diesel oil in agriculture in 1977 is likely to have been of the order of 2.6 - 2.9 million TOE.

By the same reasoning, consumption of 825,000 TOE of residual oil in 1977 would have given agriculture a share of over 4 per cent of the national total. This is generally considered to be too high and the EIU suggests that consumption of residual oil in agriculture did not exceed 300,000 TOE in 1977.

Although the CPP statistics probably underestimate agricultural consumption of petroleum products, they are considered to provide a sound indication of trends and of the relative importance of product categories.

AGRICULTURAL DEMAND FOR ELECTRICITY

Electricité de France Gaz de France (EFGF) has evaluated consumption of electricity in agriculture at 3.1 billion KWH in 1972 and at 5.63 billion KWH in 1979, following a steady increase year by year in the intervening period. Demand for electricity in agriculture is increasing at a pace comparable with that for overall demand for electricity, and between 1975 and 1979 demand from agricultural users rose by 28 per cent, an average annual rate of growth of 6 per cent.

Table 4.16

France: Electricity Consumption in Agriculture, 1972-1979

	KWH (billion)	TOE ('000)
1972	3.10	267
1973	3.67	316
1974	4.06	349
1975	4.38	377
1976	4.81	414
1977	4.90	421
1978	5.33	458
1979	5.63	484

Source: EIU calculations based on data from Electricité de France Gaz de France (EFGF) - Division Clientèle Courante

The EFGF statistics of electricity consumption in agriculture include electricity consumed on farms for both agricultural and household uses. Rising demand is a feature of a greater degree of mechanisation of agriculture and improved comfort of farms.

There were approximately 1.1 million agricultural holdings in France in 1979, but EFGF statistics record only 818,000 agricultural subscribers to public electricity supplies. The difference is accounted for farmers with other activities which have been classified in other subscriber categories. The classification of farms in subscriber categories other than agriculture provides at least a partial explanation for the variances between the four evaluations of electricity consumption in agriculture in 1977:

EFGF	421,000 TOE	-	professional and household
Ministry of Agriculture	301,000 TOE	-	professional
	260,000 TOE	-	household
CNEEMA	310,000 TOE	-	professional
OECD	109,000 TOE	-	professional

Of the 818,000 agricultural subscribers in 1979, 805,000 were receiving low tension power. Of these, 721,000 had contracts corresponding to installed capacity of more than 3 KW, but some 10 per cent of these had an effective installed capacity of 3 KW or less. The remaining 84,000 subscribers had contracts for installed capacity of 3 KW or less.

Farms with an effective installed capacity of over 3 KW had installed power capacity of 6-20 KW for the greater part.

The relatively large number of farms with installed capacity of 3 KW or less (156,000 farms) would not be able to use professional electrically powered equipment, and only a limited range of household electrical equipment.

In 1979, 12,782 agricultural subscribers were connected to a medium tension power supply. Despite their relatively small number, medium tension subscribers accounted for 27 per cent of total consumption of electricity in agriculture.

Table 4.17

France: Demand for Medium Tension Electricity in the Agriculture, 1972-1979

	1972	1973	1974	1975	1976	1977	1978	1979
Number of agricultural consumers	9,252	9,990	10,512	10,951	11,388	12,187	12,637	12,782
Power installed (KW)	587,584	688,265	738,849	790,073	832,451	901,218	927,221	961,668
Average power installed (KW)	63.51	68.9	70.29	72.15	73.10	73.95	73.37	75.24
Consumption - 10^3 KWH	960,442	1,078,895	1,154,322	1,187,961	1,285,239	1,247,843	1,398,789	1,502,505
Consumption - TOE	82,598	92,785	99,272	102,165	110,531	107,314	120,296	129,215
Average annual consumption (KWH)	103,809	107,997	109,810	108,480	112,859	102,391	110,690	117,549
Average annual consumption (10^4 Kcal)	8,927	9,288	9,444	9,360.2	9,706	8,806	9,519	10,109
Annual utilisation (hours)	1,634	1,615	1,562	1,504	1,544	1,385	1,509	1,562

Source: EIU calculations on information supplied by Electricité de France Gaz de France, Division Clientèle Courante

Average electricity consumption of farms connected to low tension supplies of electricity was 5,130 KWH in 1979, an increase of 23 per cent since 1976. Taking into account subscribers to medium tension supplies, average consumption increased from 5,615 KWH in 1976 to 6,888 KWH in 1979.

ENERGY CONSUMPTION BY USE

PETROLEUM PRODUCTS

In an analysis of the findings of the study which it conducted in 1978, the Ministry of Agriculture arrived at estimates of the consumption of diesel and heavy oil and of petrol by main usage sectors. These three fuels account for over 80 per cent of direct energy consumption in agriculture.

Table 4.18

France: Agricultural Consumption of Petroleum-Based Fuels by Usage Sector, 1977

(TOE '000)	Diesel oil	Heavy fuel oil	Petrol
Heating	318	174	-
of which:			
Animal rearing	44	11	-
Glasshouses	212	152	-
Drying of grain	62	11	-
Power (excluding commercial vehicles)	2,188	-	92
of which:			
Tractors and self-propelled machinery	2,154	-	64
Other	34	-	28
Commercial vehicles	93	-	209
Sub-total independent farm units	2,599	175	301
Collective use, except drying	300	...	...
Collective use, drying	700	...	...
Total agricultural use	3,599	175	301
Domestic consumption for household use	1,106	34	...

Source: Ministère de l'Agriculture, Sous-direction des Synthèses Statistiques et des Revenus

Tractors and self-propelled machinery account for some 54 per cent of total demand for petroleum products in direct consumption in agriculture. A study undertaken by an oil company suggests that in 1972 the share of petroleum-based fuels taken up by tractors and machinery was somewhat higher at 58 per cent.

Consumption of petroleum-based fuels for agricultural purposes and for household purposes on farms was put at 5,215,000 TOE in 1977, and household consumption accounted for 22 per cent of the total. The private study referred to in the previous paragraph suggests that in 1972 the share of household consumption was lower at 18 per cent. The increase would be accounted for by an improvement in the equipment and comfort of farms.

ELECTRICITY

The survey conducted by the Ministry of Agriculture also served to identify the consumption of electricity by main usage sectors. The EFGF can provide detailed statistics of electricity consumption by agricultural subscribers but has not analysed the data by usage.

Table 4.19

France: Agricultural Consumption of Electricity By Usage Sector, 1977

(TOE '000 primary energy equivalent)

Heating	248
of which:	
Animal rearing	209
Glasshouses	22
Drying of grain	17
Electrical machinery	329
Sub-total independent farm units	578
Cooperative drying	200
Total agricultural use	778
Domestic consumption for household use	689

Source: Ministère de l'Agriculture - Sous-direction des Synthèses Statistiques et des Revenus

Electrical machinery accounts for some 42 per cent of consumption of electricity for agricultural purposes. The main applications of electrical machinery are in dairy farming and in irrigation. In dairy farming, electricity is used for heating and for powering milking machines and milk coolers: in 1977 there were 380,000 milking machines in use.

Household consumption of electricity on farms is relatively high and is equivalent to close on 90 per cent of the amount consumed for agricultural purposes.

OTHER ENERGY SOURCES

The survey conducted by the Ministry of Agriculture in 1977 identified the consumption of propane, butane, coal and wood by main sector of usage which are all related to heating. The greater part of liquefied gas and wood consumed in agriculture is used in providing heating for the rearing of animals. The small quantity of coal taken up by agriculture is used mainly to heat glasshouses.

Table 4.20

France: Agricultural Consumption of Liquefied Gas, Coal and Wood By Usage Sector, 1977

(TOE '000)

	Liquefied gas	Coal	Wood
Heating in animal rearing	97	1	33
Heating of glasshouses	9	14	1
Drying of grain	4	2	9
Total	110	17	43
Domestic consumption for household use	188	187	1,910

Source: Ministère de l'Agriculture, Sous-direction des Synthèses Statistiques et des Revenus

ENERGY CONSUMPTION BY TYPE OF CROP AND ACTIVITY

Data on the use of energy by type of crop or agricultural activity is fragmentary.

The most important fuel in agriculture is diesel oil, particularly for powering tractors and self-propelled machinery. The Ministry of Agriculture has calculated the consumption of diesel oil per hectare for different types of farms, excluding consumption of fuel for diesel engine road vehicles (DERV).

Table 4.21

France: Annual Consumption of Diesel Oil for Selected Crops and Activities, 1977

	Litres per hectare	10^4 Kcal per hectare
General agriculture	107	94
Horticulture	1,257	1,103
Arable land and cattle	96	84
Cattle and arable land	89	78
Cattle-milk	80	70
Cattle-meat	52	46
Cattle-milk and meat	87	73
Cattle, pigs and poultry	97	85
Pigs	154	135
Poultry	324	284
Fruit	156	137

Source: EIU calculations based on data provided by Ministère de l'Agriculture - Sous-direction des Synthèses Statistiques et des Revenus

The heating of glasshouses is the second largest usage of diesel oil, although a long way behind the powering of tractors and self-propelled machinery. The consumption of diesel oil in the heating of glasshouses is of the order of 212,000 TOE.

The average electricity consumption of selected types of electrical machinery is shown in Table 4.20.

Table 4.22

France: Consumption of Electricity by Selected Types of Electrical Machinery, 1981

Beef and milk production	
Water heaters	100-150 KWH/cow/year
Milk coolers	18-25KWH/litre milk cooled
Calf rearing	
Space heaters	50-60 KWH/calf
Water heaters	40-50 KWH/calf
Pig rearing	
Space heating	15-25 KWH/weaned piglet

Source: Information supplied by Electricité de France Gaz de France - Division Clientèle Courante

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

FEDERAL REPUBLIC OF GERMANY

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY - FEDERAL REPUBLIC OF GERMANY

AGRICULTURE IN THE FEDERAL REPUBLIC

The total area under agricultural cultivation was estimated at 12,260,500 hectares in 1979. In the nine years from 1970 to 1979, the area under cultivation declined by 3 per cent.

In the same period, the number of agricultural holdings of 1 hectare and over fell by 25 per cent to 816,300 in 1979. The average size of holding increased from 9.3 hectares in 1960 to 15 hectares in 1979.

Table 5.1

Germany: Number of Agricultural Holdings, 1970-1979

Size of Holding (hectares)	1970 Number	1970 %	1978 Number	1978 %	1979 Number	1979 %
1 - 2	154,800	14.3	112,100	13.3	105,300	12.9
2 - 5	251,000	23.2	169,100	20.0	161,200	19.6
5 - 10	232,700	21.5	161,200	19.1	154,100	18.9
10 - 15	158,200	14.6	110,100	13.0	106,000	13.0
15 - 20	109,600	10.1	84,000	10.0	81,300	10.0
20 - 30	104,100	9.6	105,000	12.4	104,000	12.8
30 - 50	53,400	4.9	73,000	8.7	74,200	9.1
50 - 100	16,300	1.5	24,900	3.0	25,900	3.2
100 and over	3,000	0.3	4,200	0.5	4,300	0.5
Total	1,083,100	100.0	843,600	100.0	816,300	100.0
Under 1	63,800	-	57,400	-	55,000	-

Source: Statistisches Bundesamt (SB), Bundesministerium für Ernährung, Landwirtschaft und Forsten

Agriculture and fisheries provided employment for about 6 per cent of the active population in 1979, compared with 8.5 per cent in 1970.

Agriculture contributed 2 per cent to Gross Domestic Product (GDP) in 1978, compared with 5 per cent some twenty years ago. Close on 70 per cent of the total value of agricultural output is derived from livestock and dairy farming.

Gross capital investment in agriculture has increased appreciably from year to year, rising from DM 7,882 million in 1976 to DM 10,414 million in 1979.

ENERGY COSTS

The cost of inputs to agriculture is analysed annually by the Ministry of Food, Agriculture and Forestry, and the analysis serves to illustrate the increasing burden of the cost of energy since 1977.

Energy accounted for 14.7 per cent of expenditure by farmers on goods and services in 1979, equivalent to a value of DM 4,765 million, compared with 13.4 per cent in 1976. Energy is now the second highest cost factor, following feedstuffs (36 per cent) but ahead of fertilisers (13 per cent).

In the three years from 1976 to 1979, the cost of goods and services bought in by farmers rose by 17 per cent from DM 27,600 million to DM 32,412 million. In the same period, the cost of energy to farmers rose by nearly 30 per cent from DM 3,700 million to DM 4,765 million.

Table 5.2

Germany: Purchases of Goods and Services by the Agricultural Sector, 1976-1979

(percentage)

	1976	1977	1978	1979
Plants and seeds	2.3	2.2	2.6	2.6
Feedstuffs	37.2	37.6	36.0	35.9
Fertilisers	14.2	14.1	13.5	13.3
Agro-chemicals	2.4	2.5	2.7	2.6
Energy	13.4	13.1	13.3	14.7
Cattle	0.3	0.4	0.4	0.4
Maintenance and repair of buildings	4.2	4.3	4.3	4.0
Maintenance and repair of machinery	13.3	13.2	14.0	13.6
General costs	10.3	10.2	10.6	10.1
Agricultural taxes	0.3	0.3	0.3	0.3
Miscellaneous	2.1	2.1	2.3	2.5
	100.0	100.0	100.0	100.0
Value of total expenditures (DM mn)	27,600	29,340	29,491	32,412

Source: EIU calculations based on data provided by Bundesministerium für Ernährung, Landwirtschaft und Forsten

SOURCES OF DATA

There are three sources of data which have been used in assessing the consumption of energy in agriculture:

- OECD statistics on the energy balances of member states
- Institut für Agrarpolitik und Marktlehre (IAM) which has undertaken a detailed study on direct and indirect consumption of energy in agriculture
- Bundeswirtschaftsministerium (Ministry of Economic Affairs) which compiles statistics on the consumption of electricity in agriculture.

All three sources provide a historical series of data which can be used to trace trends. The IAM can provide data going back to 1880, but the EIU has confined the period covered by this report to 1970 and subsequent years.

OECD statistics are partial in that they cover direct consumption of gas/diesel oil and electricity only. The data compiled by the Bundeswirtschaftsministerium only cover electricity, but a regional breakdown by State (Land) is available.

Each of these three sources are treated separately in subsequent chapters but, so as to identify the dimensions of the subject at the outset, the main findings of the three sources are compared in the table below. Comparison between the three sources, where they overlap, is awkward because the IAM expresses energy in units of primary consumption[1] whereas OECD expresses energy in units of final consumption.[2] The EIU has converted statistics on consumption of electricity provided by the Bundeswirtschaftsministerium into tonnes oil equivalent by applying conversion factors used by OECD, and this seems an acceptable approach as OECD is supplied with

(1) Primary energy is that measured at source, eg coal & oil in the ground; electricity is thus expressed in terms of the energy used to produce it, not in terms of KWH consumed.

(2) Energy in the form it is finally consumed in.

data on energy consumption in the Federal Republic by the Bundeswirtschaftsministerium.

In the comparative table, the EIU has attempted to overcome this problem by converting IAM values to units of final consumption: to avoid confusion, units of primary and final consumption are shown side by side.

There is a second reason for variances between sources. The IAM has endeavoured to exclude household consumption of energy on the farm for non-agricultural purposes: OECD and Bundeswirtschaftsministerium statistics for electricity consumption include both farming and household consumption.

Table 5.3

Germany: Energy Consumption in Agriculture - Comparative Summary of Data

(TOE '000)	Petroleum Fuels		Coal		Electricity		Lubricants		Total Direct Energy		Total Indirect Energy
	Primary	Final	Primary	Final	Primary	Final	Primary	Final	Primary	Final	Primary
Institut für Agrarpolitik und Marktlehre											
1970	2,994	2,479	202	182	1,477	369	99	56	4,772	3,086	5,248
1971	3,578	2,963	185	94	1,568	392	100	57	5,431	3,506	5,204
1972	3,646	3,019	175	157	1,683	421	116	72	5,620	3,669	5,181
1973	3,961	3,280	187	168	1,778	445	116	72	6,042	3,965	5,026
1974	3,691	3,056	132	119	1,794	449	116	72	5,733	3,696	5,204
1975	4,077	3,376	104	94	1,853	463	116	72	6,150	4,005	5,372
1976	4,146	3,433	98	88	1,908	477	94	71	6,246	4,069	5,827
1977	4,476	3,706	100	90	2,020	505	105	79	6,701	4,380	5,887
1978	5,238	4,336	94	85	2,112	528	105	79	7,548	5,028	...
OECD											
1973		1,326				523					
1974		1,306				528					
1975		1,346				545					
1976		1,326				567					
1977		1,275				575					
1978		1,216				589					
Bundeswirtschaftsministerium											
1972						495					
1973						523					
1974						528					
1975						545					
1976						563					
1977						575					
1978						614					
1979						624					

Source: (indicated on table)

The three sources provide estimates of the consumption of electricity, and the estimates are close enough to be confirmatory. In the period 1973 to 1978, IAM puts electricity consumption at 2,867,000 TOE, 14 per cent under the figure recorded by OECD for the same period (3,327,000 TOE). The Bundeswirtschaftsministerium's figure for consumption of electricity in agriculture in the same period is 3,348,000 TOE, which is 1 per cent higher than OECD's figure.

Estimates of consumption of petroleum-based fuels are put forward by IAM and OECD, but the figures are wide apart. In the period 1973 to 1978, IAM puts consumption at 21,187,000 TOE, which is 172 per cent greater than OECD's aggregate figure for the period of 7,795,000 TOE. It has been suggested that OECD data on petroleum-based fuels are limited to diesel engine road vehicle fuel (DERV).

It is generally accepted that the detailed analysis made by IAM is the most complete and reliable source of information on energy consumption in agriculture. The analysis shows that direct energy input, expressed in terms of primary consumption, accounts for 48-55 per cent of total energy consumption in agriculture, and that petroleum-based fuels account for 63-69 per cent of direct energy input. Expressed in terms of final consumption, direct energy input accounts for 37-44 per cent of total energy consumption in agriculture.

ENERGY SOURCES - OECD DATA

OECD statistics compiled to show the energy balance of member states can be used to determine trends in total national consumption of energy by type of fuel, and the share taken up by agriculture. The data set out in Table 4 has been extracted from Energy Balances of OECD Countries 1973-1978, which was published in 1980.

The OECD statistics of energy consumption show that national consumption has fluctuated around a level of 200 million TOE a year in the period 1973 to 1978, with consumption in 1978 being 1.6 per cent lower than in 1973. Petroleum products accounted for 62 per cent of total energy consumption in 1978, and their share has declined marginally since 1973. Gas has taken a larger share of energy consumption, and in 1978 accounted for close on 15 per cent of the total.

OECD statistics show agriculture accounting for close on 1 per cent of national energy consumption in the period 1973 to 1978. This is considered to be a serious understatement of the share of national energy consumption attributable to agriculture.

If OECD statistics are a reliable measure of national energy consumption, OECD's assessment of energy input to agriculture is believed to be far too low. If direct energy consumption in agriculture as measured by the Institut für Agrarpolitik und Marktlehre is compared with OECD's evaluation of national energy consumption, agriculture's share is seen to be 2.5 per cent in 1978. This is believed to be a more realistic indication of the relative importance of input of direct energy to agriculture.

Table 5.4

Germany: National Energy Consumption[a], 1973-1978

	1973		1976		1977		1978	
	TOE (mn)	%	TOE (mn)	%	TOE (mn)	%	TOE (mn)	%
Solid fuels	28.92	14.2	22.21	11.7	20.26	10.7	20.09	10.0
Petroleum products	129.60	63.6	118.33	62.1	117.55	62.0	124.73	62.2
Gas	22.77	11.2	25.61	13.4	26.61	14.0	29.48	14.7
Electricity	22.48	11.0	24.46	12.8	25.12	13.3	26.24	13.1
National total	203.78	100.0	190.60	100.0	189.55	100.0	200.54	100.0
of which:								
Agriculture	1.85	.91	1.89	.99	1.85	.98	1.80	.90

a direct final consumption

Source: OECD - Energy Balance

Another statistical series compiled by OECD and published under the title 'Energy Statistics' provides a similar but more detailed breakdown on energy consumption by type of fuel and by sector of activity. Although the data on consumption of energy in agriculture are partial, in that they are confined to direct consumption of petroleum-based fuels and electricity, they provide a time series which illustrates trends and which can be compared with more complete data provided by the IAM.

OECD statistics reproduced in Table 5.5 provide a breakdown of total energy consumption in agriculture as shown in aggregate in Table 5.4 Consumption of gas/diesel oil and electricity in agriculture totalled 1,805,000 TOE in 1978, of which gas/diesel oil accounted for 67 per cent.

Consumption of gas/diesel oil in agriculture reached a peak of 1,346,000 TOE in 1975, but subsequently declined to around 1,200,000 TOE a year. Consumption of gas/diesel oil in agriculture declined by 8 per cent between 1973 and 1978. There is reason to doubt whether the OECD statistics include all types of gas/diesel oil, and it has been suggested that the OECD figures include diesel engine road vehicle fuel (DERV) only.

Consumption of electricity in agriculture has been increasing steadily from 523,000 TOE (6,084 million KWH) in 1973 to 589,000 TOE (6,850 million KWH) in 1978, an increase of 13 per cent. Agriculture has accounted for about 2 per cent of national electricity consumption in the period.

Table 5.5

Germany: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Gas/ diesel oil	Electricity	Total[a]
1973			
Agriculture			
- tonnes '000	1,300	6,084[b]	-
- TOE '000	1,326	523	1,849
National consumption			
- tonnes '000	63,627	309,286[b]	-
- TOE '000	64,900	26,599	203,780
Share of agriculture (%)	2.0	2.0	0.9
1974			
Agriculture			
- tonnes '000	1,280	6,139[b]	-
- TOE '000	1,306	528	1,834
National consumption			
- tonnes '000	55,491	269,447[b]	-
- TOE '000	56,601	23,172	196,110
Share of agriculture (%)	2.3	2.3	0.9
1975			
Agriculture			
- tonnes '000	1,320	6,339[b]	-
- TOE '000	1,346	545	1,891
National consumption			
- tonnes '000	55,866	262,439[b]	-
- TOE '000	56,983	22,570	183,890
Share of agriculture (%)	2.4	2.4	1.0

(continued)

Table 5.5 (continued)

Germany: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Gas/ diesel oil	Electricity	Total[a]
1976			
Agriculture			
- tonnes '000	1,300	6,594[b]	-
- TOE '000	1,326	567	1,893
National consumption			
- tonnes '000	59,978	284,386[b]	-
- TOE '000	61,178	24,457	190,600
Share of agriculture (%)	2.2	2.3	1.0
1977			
Agriculture			
- tonnes '000	1,250	6,683[b]	-
- TOE '000	1,275	575	1,850
National consumption			
- tonnes '000	59,056	292,123[b]	-
- TOE '000	60,237	25,123	189,550
Share of agriculture (%)	2.1	2.3	1.0
1978			
Agriculture			
- tonnes '000	1,192	6,850[b]	-
- TOE '000	1,216	589	1,805
National consumption			
- tonnes '000	62,788	305,069[b]	-
- TOE '000	64,044	26,236	200,540
Share of agriculture (%)	1.9	2.2	0.9

a totals for national consumption include petroleum-based fuels not identified as being used in agriculture, such as liquefied gas, gasoline, jet fuel, kerosene, residual fuel oil, and non-energy petroleum products, and solid fuels and gas; b million KWH

Source: EIU calculations based on data provided by OECD

DIRECT AND INDIRECT ENERGY CONSUMPTION - INSTITUT FÜR AGRARPOLITIK UND MARKTLEHRE DATA

The only detailed study of consumption of energy in agriculture in the Federal Republic of Germany is that undertaken by the Institut für Agrarpolitik und Marktlehre (IAM). The IAM has evaluated consumption of energy in agriculture for the period 1970 to 1976, and the findings were published by Landwirtschaftsverlag in 1979. The Ministry of Agriculture subsequently asked the IAM to update the study, and the series has been extended to 1977 and 1978, although no evaluation was made for indirect energy consumption in the utilisation of agricultural machinery in 1978. The findings relating to 1977 and 1978 have not been published but were made available to the EIU by the Institute.

The IAM has calculated all its evaluations of energy inputs to agriculture in terms of primary energy.

Total energy consumption in agriculture increased from 10.02 million TOE in 1970 to 12.59 million TOE in 1977, an increase of 26 per cent. Total consumption increased year by year, with the exception of a break in the trend in 1974 when consumption fell by 1 per cent compared with the previous year to 10.94 million TOE.

Table 5.6

Germany: Direct and Indirect Consumption of Energy in Agriculture, 1970-1978

	Direct		Indirect		Total
	TOE '000	%	TOE '000	%	TOE '000
1970	4,772	48	5,248	52	10,020
1971	5,431	51	5,204	49	10,635
1972	5,620	52	5,181	48	10,801
1973	6,042	55	5,026	45	11,068
1974	5,733	52	5,204	48	10,937
1975	6,150	53	5,372	47	11,522
1976	6,246	52	5,827	48	12,073
1977	6,701	53	5,887	47	12,588
1978	7,548	...	...	...	...

Source: IAM

Direct consumption of energy increased by 40 per cent from 1970 to 1977 to reach 6.7 million TOE. The rise in direct consumption has been continuous, except for a break in the trend in 1974. Indirect consumption has increased more slowly, by 12 per cent in the period, and the trend has been irregular: indirect consumption decreased by 4 per cent between 1970 and 1973, but rose by 17 per cent from 1973 to 1977.

Reflecting these variances, direct consumption has increased in relative importance from 48 per cent of total consumption in 1970 to 53 per cent in 1977.

A detailed breakdown of the components of direct and indirect energy, as identified by the IAM, is provided in the following table.

Table 5.7

Germany: Energy Consumption in Agriculture, 1970-1978

	Direct Energy[a]						Indirect Energy					
	Coal	Petroleum products	Fossil fuel for machinery	Lubricants for machinery	Elec- tricity	Total	Agricul- tural machinery	Import- ed feed- stuffs	Ferti- lisers	Agro- chemi- cals	Total	Total Energy Input
1970												
MJ 10^6	8,427	56,294	69,107	4,142	61,848	199,818	57,134	46,644	113,927	2,067	219,772	419,590
TOE '000	202	1,344	1,650	99	1,477	4,772	1,364	1,114	2,721	49	5,248	10,020
Per cent	2.0	13.4	16.5	1.0	14.7	47.6	13.6	11.1	27.2	0.5	52.4	100.0
1971												
MJ 10^6	7,749	79,637	70,253	4,194	65,650	227,483	58,853	42,366	114,676	1,997	217,892	445,375
TOE '000	185	1,901	1,677	100	1,568	5,431	1,405	1,012	2,738	49	5,204	10,635
Per cent	1.7	17.9	15.8	1.0	14.7	51.1	13.2	9.5	25.7	0.5	48.9	100.0
1972												
MJ 10^6	7,309	85,340	67,375	4,839	70,474	235,337	55,783	40,986	118,094	2,114	216,977	452,314
TOE '000	175	2,037	1,609	116	1,683	5,620	1,332	979	2,820	50	5,181	10,801
Per cent	1.6	18.8	14.9	1.1	15.6	52.0	12.3	9.1	26.1	0.5	48.0	100.0
1973												
MJ 10^6	7,822	98,542	67,375	4,839	74,462	253,040	55,783	40,986	111,385	2,301	210,455	463,495
TOE '000	187	2,352	1,609	116	1,778	6,042	1,332	979	2,660	55	5,026	11,068
Per cent	1.7	21.2	14.5	1.1	16.1	54.6	12.0	8.8	24.0	0.6	45.4	100.0

(continued)

Table 5·7 (continued)

Germany: Energy Consumption in Agriculture, 1970-1978

	Direct Energy[a]						Indirect Energy					
	Coal	Petroleum products	Fossil fuel for machinery	Lubricants for machinery	Elec-tricity	Total	Agricul-tural machinery	Import-ed feed-stuffs	Ferti-lisers	Agro-chemi-cals	Total	Total Energy Input
1974												
MJ 10^6	5,522	87,427	67,158	4,839	75,139	240,085	55,534	41,400	118,687	2,299	217,920	458,005
TOE '000	132	2,087	1,604	116	1,794	5,733	1,326	989	2,834	55	5,204	10,937
Per cent	1.2	19.0	14.7	1.1	16.4	52.4	12.1	9.0	25.9	0.6	47.6	100.0
1975												
MJ 10^6	4,346	103,296	67,461	4,839	77,587	257,529	55,770	47,840	119,051	2,299	224,960	482,489
TOE '000	104	2,466	1,611	116	1,853	6,150	1,332	1,142	2,843	55	5,372	11,522
Per cent	0.9	21.4	14.0	1.0	16.1	53.4	11.6	9.9	24.6	0.5	46.6	100.0
1976												
MJ 10^6	4,103	105,981	67,678	3,935	79,891	261,588	55,859	56,820	129,013	2,299	243,991	505,579
TOE '000	98	2,530	1,616	94	1,908	6,246	1,334	1,357	3,081	55	5,827	12,073
Per cent	0.8	20.9	13.4	0.8	15.8	51.7	11.0	11.2	25.5	0.6	48.3	100.0
1977												
MJ 10^6	4,202	113,576	73,870	4,395	84,571	280,614	61,047	53,866	128,869	2,756	246,538	527,152
TOE '000	100	2,712	1,764	105	2,020	6,701	1,458	1,286	3,077	66	5,887	12,588
Per cent	0.8	21.5	14.0	0.9	16.0	53.2	11.6	10.2	24.4	0.5	46.8	100.0

(continued)

Table 5.7 (continued)

Germany: Energy Consumption in Agriculture, 1970-1978

	Direct Energy[a]						Indirect Energy					
	Coal	Petroleum products	Fossil fuel for machinery	Lubricants for machinery	Elec-tricity	Total	Agricul-tural machinery	Import-ed feed-stuffs	Ferti-lisers	Agro-chemi-cals	Total	Total Energy Input
1978												
MJ 10^6	3,932	145,471	73,870	4,395	88,430	316,098	(61,000)	57,224	129,234	3,038	(250,500)	(566,598)
TOE '000	94	3,474	1,764	105	2,112	7,548	(1,457)	1,367	3,086	73	(5,983)	(13,531)
per cent	0,7	25,6	13,0	0,8	15,6	55,8	10,8	10,1	22,8	0,5	44,2	100

a primary energy

Source: IAM

DIRECT ENERGY

Direct energy consumption has accounted for 48-55 per cent of total energy consumption in agriculture in the period 1970 to 1977, according to the evaluation made by the IAM. In 1978, direct energy consumption was put at 7,548,000 TOE, 58 per cent greater than in 1970.

The use of coal and other solid fuels in agriculture is low at 94,000 TOE in 1978, and in the period 1970 to 1978 consumption fell by 53 per cent. Coal accounted for just over 1 per cent of direct energy consumption in 1978, and its use is confined to the heating of stables and other animal rearing premises.

The term petroleum products is used by the IAM to describe petroleum-based fuels other than fuel for machinery. This is the largest category of energy in direct consumption, accounting for 46 per cent of direct energy consumption in 1978. Consumption increased from 1,344,000 TOE in 1970 to 3,474,000 TOE in 1978, an increase of 158 per cent. Consumption has increased year by year, except for a fall back of 11 per cent in 1974. Since 1971, consumption of petroleum-based fuels used for heating has surpassed petroleum-based fuels used for powering machinery.

Over the period 1970 to 1978, consumption of 'fossil fuel for machinery', or engine fuel, increased from 1,650,000 TOE to 1,764,000 TOE, an increase of 7 per cent, to account for 23 per cent of direct energy consumption. Consumption of engine fuel has increased at a slower pace than overall direct consumption of energy, and in 1970 engine fuel had accounted for 35 per cent of total direct energy consumption.

Electricity has accounted for about 30 per cent of direct energy consumption in the period 1970 to 1978. Consumption rose by 43 per cent in the period to reach 2,112,000 TOE in 1978.

Table 5.8

Germany: Direct Consumption of Energy in Agriculture, 1970-1978

(TOE '000 - primary consumption)

	1970	%	1971	%	1972	%	1973	%	1974	%	1975	%	1976	%	1977	%	1978	%
Coal	202	4	185	3	175	3	187	3	132	3	104	2	98	2	100	2	94	1
Petroleum products	1,344	28	1,901	35	2,037	36	2,352	39	2,087	36	2,466	40	2,530	40	2,712	40	3,474	46
Fossil fuel for machinery	1,650	35	1,677	31	1,609	29	1,609	27	1,604	28	1,611	26	1,616	26	1,764	26	1,764	23
Lubricants	99	2	100	2	116	2	116	2	116	2	116	2	94	2	105	2	105	2
Electricity	1,477	31	1,568	29	1,683	30	1,778	29	1,794	31	1,853	30	1,908	30	2,020	30	2,112	28
Total	4,772	100	5,431	100	5,620	100	6,042	100	5,733	100	6,150	100	6,246	100	6,701	100	7,548	100

Source: IAM

In evaluating direct consumption of fossil fuels in agriculture, the IAM has taken into account three inputs - heating by coal, heating by petroleum-based fuels, and use of petroleum-based fuels to power tractors and other agricultural machinery.

Fuel consumption in heating has been assessed on the basis of energy input in megajoules derived from returns on expenditure on coal and combustible petroleum fuels in agriculture, as provided by the Ministry of Agriculture. The analysis of energy input figures suggests that average annual consumption of fuel for heating per hectare was as follows in 1978:

- coal	298 MJ or 7.1 Kcal 10^4
- combustible petroleum fuel	11,021 MJ or 263 Kcal 10^4

Fuel input for the powering of tractors and other farm machinery has been assessed on the basis of estimates of consumption of engine fuel by farmers. These data are published by the Ministry of Agriculture, and provide the following estimates of aggregate consumption of diesel engine road vehicle fuel (DERV) in agriculture:

1970	1,596 million litres
1971	1,622 million litres
1972	1,556 million litres
1973	1,556 million litres
1974	1,551 million litres
1975	1,558 million litres
1976	1,563 million litres
1977	1,706 million litres
1978	1,706 million litres

The consumption of lubricants in agriculture has also been evaluated from data provided by the Ministry of Agriculture. It is estimated that the utilisation of lubricants in agriculture was as follows during the period 1970-1978:

1970	60,000 tonnes
1971	61,000 tonnes
1972	78,000 tonnes
1973	78,000 tonnes
1974	78,000 tonnes
1975	78,000 tonnes
1976	76,000 tonnes
1977	85,000 tonnes
1978	85,000 tonnes

Electricity consumption in agriculture has again been evaluated from data compiled by the Ministry of Agriculture. It is estimated that the input of electricity to the agricultural sector was as follows during the period 1970-1978:

1970	4,295 million KWH
1971	4,559 million KWH
1972	4,894 million KWH
1973	5,171 million KWH
1974	5,218 million KWH
1975	5,388 million KWH
1976	5,548 million KWH
1977	5,873 million KWH
1978	6,141 million KWH

Statistics set out in Tables 5.7 and 5.8 make it evident that petroleum-based fuels account for the major part of direct consumption of energy in agriculture. In 1978, consumption of petroleum-based fuels of 5,238,000 TOE accounted for 69 per cent of total direct energy input. This situation is explained by the importance of animal rearing in German agriculture, and by the relatively high incidence of mechanisation.

Lubricants for agricultural machinery is a small item and accounts for 1-2 per cent of direct energy input.

INDIRECT ENERGY

Indirect energy input to agriculture, as defined by the IAM, has accounted for about half of all energy consumed in agriculture (direct and indirect energy) in the period 1970 to 1978, with the proportion tending to decline marginally. In 1977, the most recent year for which complete comparative data are available, indirect energy accounted for 47 per cent of total energy consumption in agriculture. Between 1970 and 1977, indirect consumption of energy rose by 12 per cent to reach 5,887,000 TOE.

Of the four items identified by IAM in its breakdown of indirect energy input, fertilisers is by far the most important accounting for 52 per cent of total indirect energy input in 1977. Consumption of energy in the form of fertilisers has increased by 13 per cent from 1970 to 1978 to reach 3,086,000 TOE.

Agricultural machinery and imported animal feedstuffs each account for 20-25 per cent of indirect energy consumption. Consumption of energy in the form of agricultural machinery reached 1,458,000 TOE in 1977, an increase of 7 per cent over 1970. Imported feedstuffs accounted for 1,286,000 TOE in 1977 (1,367,000 TOE in 1978), an increase of 15 per cent over 1970.

Agro-chemicals account for a relatively low indirect input of energy to agriculture, representing about 1 per cent of total indirect energy input.

Table 5.9

Germany: Indirect Consumption of Energy in Agriculture, 1970-1978

(TOE '000 - primary consumption)

	1970	%	1971	%	1972	%	1973	%	1974	%	1975	%	1976	%	1977	%	1978
Agricultural machinery	1,364	26	1,405	27	1,332	26	1,332	27	1,326	25	1,332	25	1,334	23	1,458	25	...
Imported feedstuffs	1,114	21	1,012	19	979	19	979	19	989	19	1,142	21	1,357	23	1,286	22	1,367
Fertilisers	2,721	52	2,738	53	2,820	54	2,660	53	2,834	54	2,843	53	3,081	53	3,077	52	3,086
Agro-chemicals	49	1	49	1	50	1	55	1	55	1	55	1	55	1	66	1	73
Total	5,248	100	5,204	100	5,181	100	5,026	100	5,204	100	5,372	100	5,827	100	5,887	100	...

Source: IAM

The IAM estimates the average energy content of fertilisers as equivalent to 80 MJ per kilo of pure nitrogen (N), 14 MJ per kilo of pure phosphate (P_2O_5), and 9 MJ per kilo of pure potash (K_2O). The IAM has used these factors to evaluate indirect energy input derived from usage of fertilisers.

Indirect energy consumption in the form of agricultural machinery is evaluated on the basis of data on the consumption of fuel and lubricants used to power the machinery. A coefficient of 0.78 is applied to consumption of engine fuel and lubricants to arrive at an estimation of indirect energy represented by machinery used on farms.

The Food and Agriculture Organisation (FAO) in its publication "The State of Food and Agriculture" takes the view that indirect energy input in the form of the utilisation of machinery is equivalent to 52 per cent of aggregate consumption of engine fuel and lubricants, but the IAM has raised FAO's coefficient by 50 per cent as it believes that a coefficient of 52 per cent underestimates the true level of indirect energy consumption.

The energy content of imported animal feedstuffs has been evaluated by applying an energy consumption ratio of 4.6 MJ 10^3 per 'corn unit'. The corn unit is a norm which expresses the net energy value of agricultural produce in proportion to the net energy value of corn: the corn unit is equivalent to the net energy value of 100 kg of corn. In terms of corn units, 45 per cent of the consumption of aninal feedstuffs in the Federal Republic is accounted for by imported products. Of the remaining 55 per cent, only 3 per cent takes the form of processed feedstuffs. The greater part of animal feedstuffs of German origin is unprocessed agricultural produce, and its energy content has already been accounted for under other categories of energy input such as engine fuel, lubricants, fertilisers and agro-chemicals.

The energy content of agro-chemicals is estimated to be 100 MJ per kilo of pure active ingredient.

Certain items, such as buildings, maintenance products and packaging materials, which can be considered as representing an indirect energy content, are excluded from the IAM's analysis.

AGRICULTURAL DEMAND FOR ELECTRICITY: EVALUATION BY THE BUNDESWIRTSCHAFTS-MINISTERIUM

The Bundeswirtschaftsministerium (Ministry of Economic Affairs) has analysed electricity consumption in agriculture by state (Land) for the period 1972 to 1979. The 10 states are identified in the map provided at the end of this chapter.

Four states, Bayern, Niedersachsen, Nordrhein-Westfalen and Baden-Wurttemberg, account for over 80 per cent of electricity consumption in agriculture. Three states Bayern, Niedersachsen and Nordrhein-Westfalen accounted for two-thirds of electricity consumption in agriculture in 1979.

The Bundeswirtschaftsministerium puts consumption of electricity in agriculture at 7,261 million KWH or 624,000 TOE in 1979, a 26 per cent increase compared with consumption in 1972, and consumption has increased year by year in the intervening period.

The figures compiled by the Bundeswirtschaftsministerium for electricity consumption in agriculture are very comparable to the statistics published by OECD: the largest difference occurs in 1978 when the Bundeswirtschaftsministerium figure of 614,000 TOE is 4 per cent greater than the OECD figure. The estimates of electricity consumption in agriculture put forward by IAM are somewhat lower, and this is due to the fact that IAM excludes consumption of electricity for household purposes on the farm: for 1978 the Bundeswirtschaftsministerium puts electricity consumption 16 per cent above the figure put forward by IAM.

The Bundeswirtschaftsministerium and OECD are wider apart in their estimates of total electricity consumption in the Federal Republic, but the variance is not great and is of the order of 7-9 per cent. This is due to methodological differences.

The statistical series obtained from the Bundeswirtschaftsministerium show that consumption of electricity in agriculture has increased at a slower pace than has total national consumption of electricity, and agriculture's share of the total has fallen marginally from 2.16 per cent in 1972 to 2.08 per cent in 1979. OECD data show agriculture increasing its share of total national consumption of electricity from 1.97 per cent in 1973 to 2.25 per cent in 1978, but again the orders of magnitude between the two sources are close.

Table 5.10

Germany : Consumption of Electricity 1972-1979

	Agricultural KWH million	consumption TOE' 000	All use KWH million	total consumption TOE' 000	Agriculture as proportion of total %
1972	5,758	495	266,574	22,925	2,16
1973	6,084	523	288,225	24,787	2,11
1974	6,139	528	296,268	25,479	2,07
1975	6,339	545	289,643	24,909	2,19
1976	6,541	563	312,393	26,866	2,09
1977	6,683	575	319,563	27,482	2,09
1978	7,135	614	333,618	28,691	2,14
1979	7,261	624	348,953	30,010	2,08

CONSUMPTION OF FERTILISERS

Information compiled by the Ministry of Agriculture on the consumption of fertilisers was used by the IAM to calculate estimates of indirect energy consumption in agriculture.

Statistics obtained from the Ministry of Agriculture show that consumption of fertilisers in the period 1972 to 1979 rose by about 1 per cent a year from 3,240,000 tonnes in 1972/73 to 3,440,000 tonnes in 1978/79. The trend has however been erratic. Growth in consumption has been greatest for nitrogenous fertilisers, with an average increase of 2 per cent a year over the period.

Table 5.11

Germany: Consumption of Fertilisers, 1972/73 - 1978/79

(tonnes '000 of fertiliser element)

	Type of fertiliser				Change on
	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Total	previous year (%)
1972/73	1,189	903	1,148	3,240	
1973/74	1,101	917	1,163	3,181	- 1.8
1974/75	1,201	877	1,171	3,249	+ 2.1
1975/76	1,228	780	1,099	3,107	- 4.4
1976/77	1,323	887	1,195	3,405	+ 9.6
1977/78	1,325	873	1,183	3,381	- 0.7
1978/79	1,354	908	1,178	3,440	+ 1.7

Source: Bundesministerium für Ernährung, Landwirtschaft und Forsten, Statistisches Bundesamt (SB)

Average rates of application, in terms of kilos per hectare, for the three main categories of fertilisers - nitrogen, potash and phosphate - are set out in the following table.

Table 5.12

Germany: Application of Fertilisers, 1972/73 - 1978/79

(kg/ha)

Season	Type of fertiliser Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)
1972/73	88	67	85
1973/74	82	68	87
1974/75	90	66	88
1975/76	92	59	83
1976/77	100	67	90
1977/78	100	66	90
1978/79	103	69	89

Source: Bundesministerium für Ernährung, Landwirtschaft und Forsten, SB

The IAM evaluated indirect energy consumption in the form of fertilisers at 3,100,000 TOE in recent years, representing somewhat over 50 per cent of total indirect energy consumption.

Table 5.13

Germany: Indirect Energy Consumption in the Form of Fertilisers, 1970-1978

(TOE million)

Total indirect energy consumption in agriculture		Fertilisers - Energy content	
Year	TOE million	TOE million	Per cent
1970	5.2	2.7	52
1971	5.2	2.7	53
1972	5.2	2.8	54
1973	5.0	2.7	53
1974	5.2	2.8	54
1975	5.4	2.8	53
1976	5.8	3.1	53
1977	5.9	3.1	52
1978	-	3.1	-

Source: IAM

The energy content of fertilisers used in Germany has also been evaluated on the basis of consumption statistics and of data provided for by Energy Resources Limited (ERL).

Table 5.14

Germany: Indirect Energy Consumption in the Form of Fertilisers, 1973-1979

(TOE '000)

	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79
Nitrogen (N)	1,761	1,922	1,965	2,117	2,120	2,166
Phosphates (P_2O_5)	275	263	234	266	262	272
Potash (K_2O)	198	199	187	203	201	200
Total	2,234	2,384	2,386	2,586	2,583	2,638

Source: EIU calculations based on data on fertiliser consumption and Energy Resources Limited.

Both evaluations arrive at broadly comparable findings, given the necessarily tentative nature of the exercise, and they can be considered as confirmatory even though findings based on ERL are some 14-17 per cent below those of the IAM.

CONSUMPTION OF NON-ENERGY PETROLEUM PRODUCTS

The Ministry of Agriculture has evaluated the use of lubricants in agriculture, and the Ministry's figures were taken up by IAM in its analysis of energy inputs to agriculture.

The consumption of lubricants is a function of the use of agricultural machinery and therefore of the consumption of fuel to power the machinery. During the period 1972 to 1979, input of lubricants to agriculture was of the order of 5 to 7 per cent of the consumption of fuel, in terms of tonnes oil equivalent.

Table 5.15

Germany: Consumption of Lubricants, 1970-1978

(TOE '000 - primary consumption)

1970	1971	1972	1973	1974	1975	1976	1977	1978
99	100	116	116	116	116	94	105	105

Source: IAM

There was a sharp fall in consumption of lubricants in 1976, when consumption of 94,000 TOE was 5 per cent less than in 1970 and 19 per cent less than in 1975. Consumption recovered by 12 per cent in 1977 and has remained stable at 105,000 TOE.

CONSUMPTION OF ENERGY IN AGRICULTURE IN
THE EUROPEAN COMMUNITY

IRELAND

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY - IRELAND

AGRICULTURE IN IRELAND

Statistical data on the number and size of agricultural holdings in Ireland are not as complete and up-to-date as the data available of the agricultural sector in some other Community countries. The latest figures available relate to 1975, when 260,000 farms of one hectare or more were recorded.

The total area under cultivation was estimated at 5,325,000 hectares in 1975. In the eight-year period between 1967 and 1975, the area under cultivation is believed to have increased by 12 per cent. The expansion has been most evident in the area devoted to permanent pasture and meadow.

Table 6.1

Ireland: Number of Agricultural Holdings[a], 1967, 1970 and 1975

Size of Holding (hectares)	1967 Number	%	1970 Number	%	1975 Number	%
1-5	55,700	20.6	54,604	20.5	44,912	17.3
5-10	59,500	22.0	56,435	21.1	47,256	18.2
10-20	82,500	30.3	81,544	30.5	80,875	31.1
20-50	58,500	21.6	59,439	22.3	67,725	26.0
50 and over	14,800	5.5	14,912	5.6	19,315	7.4
Total	271,000	100.0	266,934	100.0	260,083	100.0

a with one hectare and over

Source: Eurostat

Farms are fairly evenly distributed among the size categories identified in Table I, with farms of 10 to 20 hectares accounting for a third of the total number, but the largest farms with 50 hectares or more accounted for only 7 per cent of the total number of farms in 1975. From 1967 to 1975, the number of holdings fell by 4 per cent, but the average size of holdings increased from 17.1 hectares in 1967 to 20.5 hectares in 1975.

In 1978, 22.2 per cent of the active population was engaged in agriculture, forestry and fishing: in 1975, the proportion had been over 24 per cent. Net value added by agriculture, at factor cost, has increased steeply from year to year at current prices, from IR£ 400 million in 1973 to IR£ 900 million in 1978. Agriculture contributed 19 per cent to gross national value added at factor cost in 1977, equivalent to IR£ 900 million, and agriculture's relative contribution to gross national value added was of the order of 19 per cent in the second half of the 1970s.

More than 85 per cent of the value of agricultural output, IR£ 1.6 billion at current prices in 1978, is attributed to livestock and dairy farming. According to the EC-Survey on the Structure of Agricultural Holdings in 1975, 99 per cent of farms had pasture and grazing land in agricultural use; cattle rearing was an activity of 92 per cent of farms, but only 5 per cent of farms grew vegetables or strawberries for marketing.

Table 6.2

Ireland: Number of Agricultural Holdings by Type of Activity, 1970/71 and 1975

	1970/71	1975[a]
Total	275,100	228,000
- with arable land	239,000	161,900
- with permanent pasture	258,200	226,200
- growing cereals	131,600	99,200
- growing potatoes	155,800	121,900
- growing sugar beet	17,300	11,300
- growing forage roots and tubers	79,700	51,000
- growing forage plants	228,000	91,400
- growing vegetables or strawberries	12,500	12,300
- with cattle	227,600	209,400
- with dairy cows	108,600	127,500
- with sheep	65,300	53,500
- with horses	68,500	64,300
- with pigs	67,900	26,500
- with laying hens	159,100	124,400

a owners and tenants: holdings cultivated by the same owner or tenant are treated as one unit

Source: Eurostat - General Survey on Agriculture in 1970/71, and Community Survey of the Structure of Agricultural Holdings in 1975

While the number of holdings rearing pigs declined by 61 per cent between 1970/71 and 1975, the pig population rose between 1975 and 1978 by 32 per cent in terms of livestock units. Pig rearing has become more intensive, and pig breeding units have become important consumers of oil fuel for heating purposes.

Table 6.3

Ireland: Numbers of Livestock, 1975 and 1978

(livestock units '000)

	1975	1978
Cattle	4,946	4,809
Pigs	212	280
Sheep and goats	271	253
Horses	110	92
Poultry	106	110

Source: Eurostat - Yearbook of Agricultural Statistics

ENERGY COSTS

The relative burden of the cost of energy to agriculture increased in the period 1973 to 1976 from 6 to 8 per cent of the total cost of goods and services purchased by farmers, but the proportion fell in 1978 to 7 per cent.

Table 6.4

Ireland: Purchases of Goods and Services by the Agricultural Sector, 1973 and 1976-1978
(IR£ million and percentages)

	1973	1976	1977	1978
Value of total purchases	202	377	492	586
of which:	%	%	%	%
- Feedstuffs	47.9	43.5	45.8	44.8
- Fertilisers	20.8	23.4	20.3	23.1
- Maintenance and repair of machinery and tools	4.2	4.8	4.9	5.6
- Energy	6.0	8.2	7.8	7.1

Source: EIU calculations based on data provided by Eurostat

In the five years to 1978, the cost of goods and services bought in by farmers rose by 190 per cent to IR£ 586 million, an average annual growth of 24 per cent. In the same period, the cost of energy to farmers increased from IR£ 12.1 million to IR£ 41.6 million in 1978, equivalent to an average annual increase of 28 per cent.

Ireland is reputed to use a lower concentration of fertiliser per hectare than most other Community countries, and the usage of nitrogenous fertilisers is relatively low. While the application of phosphate fertilisers has declined since 1970, increasing quantities of nitrogen are being used.

SOURCES AND SUMMARY OF DATA

There are three sources of information which have been used to evaluate the consumption of energy in agriculture:

- OECD statistics on the energy balances of member states
- Electricity Supply Board (BSL-ESB) estimates of electricity input in agriculture
- Agricultural Institute (AI) studies on direct and indirect energy input in agriculture in 1974 and 1978, undertaken on behalf of the National Board for Science and Technology (NBST).

Statistical series compiled by OECD and the Electricity Supply Board provide historical data which can theoretically be used to establish trends. The data, however, are partial. OECD statistics have not included consumption of petroleum-based fuels in agriculture since 1977. BSL-ESB estimates are confined to electricity. Moreover BSL-ESB data are broad estimates based on consumption of electricity in regions defined as 'rural areas'. Consumption of electricity in rural areas includes agricultural, industrial and residential consumption, and the BSL-ESB has arrived at consumption for agricultural purposes by making assumptions which allow the exclusion of industrial and residential consumption from the total.

The studies undertaken by the Agricultural Institute provide more detailed analyses of energy input in agriculture. The analyses cover direct and indirect energy input, and refer to two years - 1974 and 1978.

Each of the three main sources of data on energy input in agriculture has been treated separately in subsequent chapters, and the EIU has endeavoured to reconcile the variances between the sources and provide an explanation for the differences. A broad comparative summary of the data obtained from the three sources for the period 1974-1980 is set out in Table 6.5.

Table 6.5

Ireland: Energy Consumption in Agriculture - Comparative Summary of Data
(TOE '000)

	Agricultural Institute		OECD					BSL-ESB						
	1974	1978	1974	1975	1976	1977	1978	1974	1975	1976	1977	1978	1979	1980
Direct energy	290	377	231	233	247	...	...	...	...	...	...	...	...	...
of which:														
- Petroleum fuels	269	345	155	157	167	...	...	...	...	...	...	...	...	...
- Electricity	21	32	76	76	80	80	82	16	17	19	20	23	26	26
Indirect energy	830	1,086	...	...	...	...	...	...	...	...	...	...	...	...
Total	1,120	1,463	...	...	...	...	...	...	...	...	...	...	...	...

Source: EIU calculations based on data from the Agricultural Institute (AI), Organisation for Economic Cooperation and Development (OECD) and Bord Soláthair an Leictreachais - Electricity Supply Board (BSL-ESB)

There is a large variance between the findings of OECD and BSL-ESB on consumption of electricity. OECD evaluates electricity consumption in agriculture at around 80,000 TOE a year, but the BSL-ESB puts consumption at 16,000-23,000 TOE a year in the period 1974 to 1978. The evaluation of electricity input to agriculture by the Agricultural Institute is closer to the estimates put forward by the BSL-ESB, but the Agricultural Institute's evaluation is some 30-40 per cent higher. It should be recalled that BSL-ESB data are broad estimates based on overall electricity consumption in rural areas.

The difference between direct energy input as evaluated by the Agricultural Institute and the estimates put forward by OECD are quite large. The Agricultural Institute puts direct consumption in 1974 at some 300,000 TOE which is 26 per cent higher than the figure for 1974 put forward by OECD. Whereas the Agricultural Institute puts consumption of petroleum fuels in 1974 at 269,000 TOE which is 74 per cent greater than the figure arrived at by OECD, the Agricultural Institute's estimate of electricity consumption is far lower - 21,000 TOE compared with 76,000 TOE suggested by OECD. The Agricultural Institute's estimate of electricity consumption is reasonably close to that put forward by the BSL-ESB of 16,000 TOE.

After reviewing the findings with well informed persons, the EIU is inclined to accept the findings of the Agricultural Institute as being closest to reality, although no clear conclusions emerged from the discussions. The fact that the data derived from the Agricultural Institute are the findings of studies specifically related to agriculture tends to add a measure of confidence to the figures which have emerged from the studies.

The summary of data presented in the previous table shows that direct energy consumption accounts for some 26 per cent of total energy consumed in agriculture. Petroleum-based fuels account for over 90 per cent of direct energy input.

OECD DATA: DIRECT ENERGY CONSUMPTION

OECD statistics can be used to determine total energy consumption in Ireland. The data set out in Table 6.6 have been extracted from Energy Balances of OECD Countries 1973-1978, which was published in 1980.

Table 6.6

Ireland: National Energy Consumption[a], 1973 and 1976-1978

	1973		1976		1977		1978	
	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent
Solid fuels	0.92	16.9	1.08	19.9	1.18	20.3	1.50	23.3
Petroleum products	3.88	71.2	3.69	67.9	3.94	67.6	4.18	64.9
Manufactured gas	0.10	1.9	0.08	1.5	0.08	1.4	0.08	1.3
Electricity	0.54	10.0	0.58	10.7	0.62	10.7	0.67	10.5
National total	5.45	100.0	5.43	100.0	5.82	100.0	6.44	100.0
of which:								
Agriculture	0.28	5.12	0.25	4.55	0.08[b]	1.37	0.08[b]	1.27

a final consumption; b electricity only

Source: Organisation for Economic Cooperation and Development (OECD) - Energy Balances

The trend since 1973 has been for national consumption of energy to increase, from 5,450,000 TOE in 1973 to 6,440,000 TOE in 1978. The trend has not been consistent, however, and a decrease in national energy consumption was recorded by OECD in 1975 when consumption fell by 7 per cent over the previous year. Over the five-year period, energy consumption have risen by 18 per cent, comparing 1973 and 1978: this is equivalent to an average annual increase of 3 per cent.

On the basis of data obtained from the Department of Energy on primary energy input in Ireland, the National Board for Science and Technology (NBST) has made a calculation of national energy consumption in the period 1973-1978. For the period 1973-1977, this calculation shows slight differences compared with OECD figures, and these variances may be attributed to differences in factors used to convert energy volume data to tonnes oil equivalent, and to differences in methodology. For 1978, however, the NBST arrives at a total consumption figure of 5,860,000 TOE which is 9 per cent lower than the OECD figure (6,440,000 TOE). According to the NBST, OECD has overestimated national consumption of petroleum products by 340,000 TOE.

Table 6.7

Ireland: National Energy Consumption as Calculated by National Board for Science and Technology, 1978

(TOE '000)

	NBST Assessment	OECD Assessment
Solid fuels	1,100	1,500
Petroleum products	3,840	4,180
Manufactured gas	240	80
Electricity	680	670
Total	5,860	6,440[a]

a rounded up

Source: National Board for Science and Technology (NBST) and OECD

Based on the figures obtained from NBST for 1978, energy consumption over the five-year period 1973-1978 has risen by only 7.5 per cent: this is equivalent to an average annual increase of 1.5 per cent.

The statistics provided by OECD in Energy Balances do not identify the utilisation of energy in agriculture. Another statistical series compiled by OECD and published under the title "Energy Statistics" provides additional data on energy consumption by type of fuel and sector of activity. As far as agriculture is concerned, the OECD statistics are partial and their use is limited by the fact that consumption of petroleum products in agriculture has not been identified for 1977 and 1978. Moreover, the series of figures on residual fuel oil input in agriculture appears to follow a bizarre pattern with consumption of 19,000 TOE in 1973 falling to zero in 1974 and being of 12,000 TOE in 1975 and 1976 respectively.

OECD statistics show agriculture accounting for 4-5 per cent of national energy consumption in the period 1973 to 1976. Agriculture's share of energy consumption falls to a little over 1 per cent in 1977 and 1978, but this fall is a reflection of the partial nature of OECD statistics which record only electricity consumption in agriculture for 1977 and 1978.

Relevant data extracted from Energy Statistics 1973-1978 are reproduced in the following table. The fuels identified in the table are those for which there is an entry for agriculture in the original source, and the grand totals shown for national energy consumption are consequently far greater than the totals of the individual fuels identified in the table.

Table 6.8

Ireland: Energy Consumed in Agriculture and Share of Agriculture in National Energy Consumption, 1973-1978

	Kerosene	Gas/Diesel Oil	Residual Fuel Oil	Electricity	Total
1973					
Agriculture					
- tonnes '000	8	173	20	827[a]	-
- TOE '000	8	181	19	71	279
Total national consumption					
- tonnes '000	131	1,089	1,187	7,472[a]	-
- TOE '000	137	1,138	1,150	643	5,450[b]
Share of agriculture (%)	5.8	15.9	1.6	11.0	5.12
1974					
Agriculture					
- tonnes '000	7	142	-	883[a]	-
- TOE '000	7	148	-	76	231
Total national consumption					
- tonnes '000	124	1,038	1,353	6,311[a]	-
- TOE '000	130	1,085	1,311	543	5,700[b]
Share of agriculture (%)	5.4	13.6	-	14.0	4.05

(continued)

Table 6.8. (continued)

Ireland: Energy Consumed in Agriculture and Share of Agriculture in National Energy Consumption, 1973-1978

	Kerosene	Gas/Diesel Oil	Residual Fuel Oil	Electricity	Total
1975					
Agriculture					
- tonnes '000	-	139	12	880[a]	-
- TOE '000	-	145	12	76	233
Total national consumption					
- tonnes '000	129	1,025	1,083	6,143[a]	-
- TOE '000	135	1,071	1,049	528	5,310[b]
Share of agriculture (%)	-	13.5	1.1	14.4	4.39
1976					
Agriculture					
- tonnes '000	-	148	12	925[a]	-
- TOE '000	-	155	12	80	247
Total national consumption					
- tonnes '000	84	1,058	1,057	6,697[a]	-
- TOE '000	88	1,106	1,024	576	5,430[b]
Share of agriculture (%)	-	14.0	1.2	13.9	4.55

(continued)

Table 6.8 (continued)

Ireland: Energy Consumed in Agriculture and Share of Agriculture in National Energy Consumption, 1973-1978

	Kerosene	Gas/Diesel Oil	Residual Fuel Oil	Electricity	Total
1977					
Agriculture					
- tonnes '000	-	-	-	930[a]	-
- TOE '000	-	-	-	80	80
Total national consumption					
- tonnes '000	115	1,157	1,136	7,250[a]	-
- TOE '000	120	1,209	1,101	623	5,820[b]
Share of agriculture (%)	-	-	-	12.8	1.37
1978					
Agriculture					
- tonnes '000	-	-	-	950[a]	-
- TOE '000	-	-	-	82	82
Total national consumption					
- tonnes '000	113	1,335	1,005	7,797[a]	-
- TOE '000	118	1,395	974	670	6,440[b]
Share of agriculture (%)	-	-	-	12.2	1.27

a KWH million; b totals for national consumption include petroleum-based fuels not used in agriculture such as liquefied gas, aviation and motor gasoline and jet fuel, non-energy petroleum products and solid fuels

Source: EIU calculations based on data from OECD

Even though the OECD statistics are incomplete as far as agriculture is concerned, they provide an indication of the trend in consumption of electricity in agriculture. There were increases in the consumption of electricity in 1974, 1976 and 1978 when consumption reached 82,000 TOE compared with 71,000 TOE in 1973. In 1978, agriculture accounted for over 12 per cent of national consumption of electricity.

Consumption of gas/diesel oil in agriculture also accounts for a relatively high proportion of national consumption, varying between 14 and 16 per cent a year in the period 1973 to 1976.

OECD statistics do not identify consumption of non-energy petroleum products in agriculture, but these are included in the totals for national energy consumption.

OECD statistics cannot be taken as an indicator of the recent trend in fuel consumption in agriculture, because data on petroleum-based fuels, which constitute the most important source of energy in agriculture, have not been identified in 1977 and 1978. In the period 1973-1976, the EIU takes the view that consumption of petroleum-based fuels in agriculture is understated.

As regards electricity, consumption in agriculture seems to be overstated consistently. Moreover, the upward trend is probably more pronounced than that shown by OECD statistics. According to estimates from the BSL-ESB, consumption of electricity in agriculture rose from 16,000 TOE in 1974 to 23,000 TOE in 1978, which is equivalent to an average annual growth of 9 per cent. Data obtained from the Agricultural Institute and the National Board for Science and Technology show that input of electricity to agriculture rose from 21,000 TOE in 1974 to 32,000 TOE in 1978, which is equivalent to an average annual growth of 11 per cent.

EVALUATION BY THE AGRICULTURAL INSTITUTE : DIRECT AND INDIRECT ENERGY CONSUMPTION

At the request of the National Board for Science and Technology, the Agricultural Institute has attempted to evaluate the use of direct and indirect energy in agriculture. A task force made up of members of the Institute and of the Board was formed for this purpose in 1976 and in 1979, and assessments of energy consumption were made for two years, 1974 and 1978. It is intended to repeat the exercise in a year or so and to evaluate direct and indirect consumption of energy for the year of 1981.

The values arrived at for direct consumption of energy are reasoned estimates for the whole country based on partial data and observations on energy consumption in selected samples of farms. The input of petroleum-based products is made up of four categories of fuel: DERV fuel for powering tractors, fuel oil for heating animal rearing premises, heavy fuel oil for heating glasshouses and liquefied petroleum gas.

The most important single category is DERV fuel for tractors. On the basis of previous research by the Agricultural Institute into the use of DERV fuel for powering tractors (Farm Management Survey) consumption of DERV fuel for tractors was assessed at 163,000 tonnes in 1973, equivalent to 168,000 TOE. This figure can be taken as a reliable estimate of consumption in 1974 as well. Consumption of DERV fuel in 1978 was assessed on the basis of information on average consumption per tractor extracted from the 1978 Farm Management Survey, and on an estimated tractor park of 120,000 units: the calculation resulted in an estimated input of DERV fuel for tractors of 232,000 TOE for 1978, an increase of 38 per cent (see Table 6.12,on page 25).

The second largest category of petroleum products is heavy fuel oil for heating glasshouses. On the basis of sample observations, national consumtion of heavy fuel in the heating of glasshouses was assessed at 64,000 tonnes, equivalent to 63,000 TOE, in 1973. This figure can also be taken as a realistic estimate of consumption in 1974. For 1978, input of heavy fuel for heating glasshouses was estimated at some 53,000 TOE, a decrease of 16 per cent. The total area of heated glasshouses in Ireland is estimated at 120-140 hectares. Though this area has remained fairly static through the 1970s, there has been an important switch from other crops, mainly ornamental potted plant, to the growing of tomatoes, the latter requiring lower temperatures and lower fuel input (see Table 6.12).

Fuel for heating animal rearing premises is mainly used in oil-fired central heating systems installed in pig breeding units. A problem encountered here is that it has so far not been possible to assess separately input for farming purposes and input for heating domestic premises. The estimates of 33,000 TOE of fuel input for heating farms (excluding glasshouses) in 1974 and 49,000 TOE in 1978 include both the use of fuel for pig breeding and for domestic use. Fuel for heating purposes is still a small category, but there has been a significant increase in the past five years in both central heating installations on pig farms and in the use of central heating for domestic purposes (see Table 6.12).

Although accounting for a small part of energy input, liquified petroleum gas has become more widely used since 1974. The Agricultural Institute has put input of liquified gas to agriculture at 5,000 TOE in 1974 and 11,000 TOE in 1978, an increase of 120 per cent.

The Agricultural Institute has assessed electricity consumption, in terms of final consumption, at 21,000 TOE in 1974 and 32,000 TOE in 1978, an increase of over 50 per cent. These estimates are based on observations which show a steady increase in the use of electricity as farming has become increasingly mechanized, in particular with the wider use of cooling and refrigeration equipment and of electrically powered pumps. It is estimated that the consumption of electricity in heating glasshouses in 1978 was of the order of 2,000 TOE, equivalent to 6 per cent of total electricity input to agriculture.

According to the Agricultural Institute, the values for indirect consumption of energy in the form of fertilisers and feed processing are more reliable than other estimates of indirect energy consumption. These two items together account for about 50 per cent of indirect energy input in agriculture. The estimates of the energy content of imported feedstuffs, machinery, buildings and transport and services are regarded as broad estimates derived from the parameters for indirect energy consumption in agriculture established by Dr. D.J. White of the Ministry of Agriculture, Fisheries and Food in the United Kingdom. It should be noted that account is taken only of imported feedstuffs, whereas Dr. D.J. White excluded imported feedstuffs in his assessments of energy consumption in the United Kingdom.

The values for fertilisers were derived by making slight amendments to the conversion factors suggested by G. Leach. The values for feed processing are broad estimates based on observations of energy inputs to milling, grinding and pelleting of feeds and to feed grain drying.

Table 6.9

Ireland: Direct and Indirect Energy Consumption in Agriculture, 1974 and 1978

	1974		1978	
	TOE '000	%	TOE '000	%
Direct Energy	290	25.9	377	25.8
- Petroleum products	269	24.0	345	23.6
- Electricity	21	1.9	32	2.2
Indirect Energy	830	74.1	1,086	74.2
- Fertilisers	326	29.1	496	33.9
- Imported Feedstuffs	230	20.5	163	11.1
- Machinery	122	10.9	195	13.3
- Buildings	76	6.8	115	7.9
- Transport and services	53	4.7	80	5.5
- Feed processing	23	2.1	37	2.5
Total Energy Input	1,120	100.0	1,463	100.0

Source: Agricultural Institute (AI) and National Board for Science and Technology (NBST)

AGRICULTURAL DEMAND FOR ELECTRICITY

A different picture of electricity input to agriculture is provided for by the Electricity Supply Board. The Board compiles statistics on electricity consumption in rural areas, and evaluated consumption of electricity for farming purposes at some 25 per cent of total consumption in rural farming areas. The estimates put forward by the Electricity Supply Board are lower than those derived by the Agricultural Institute, and the reliability of the methodology can be questioned.

There is also variance in total electricity consumption between the data compiled by the Electricity Supply Board and that provided by OECD in Energy Balances. While there is a comparable order of magnitude between the estimates put forward by the Electricity Supply Board and the Agricultural Institute, the OECD statistics put consumption of electricity far higher: the EIU suggests that the broad comparability of the figures put forward by the Electricity Supply Board and the Agricultural Institute lends confidence to the data.

Table 6.10

Ireland: Direct Consumption of Electricity in Agriculture, 1972-1980

	Electricity Consumption in Agriculture		Total Electricity Consumption (All Sectors)		Agricultural Consumption
	KWH million	TOE '000	KWH million	TOE '000	% of total
1972[a]	176	15	5,705	491	3.1
1973	187	16	6,117	526	3.0
1974	184	16	6,412	551	2.9
1975	193	17	6,247	537	3.2
1976	216	19	6,790	584	3.3
1977	238	20	7,351	632	3.2
1978	267	23	7,894	679	3.4
1979	303	26	8,732	751	3.5
1980	305	26	8,687	747	3.5

a April 1972-March 1973

Source: EIU calculations based on Bord Soláthair an Leictreachais/Electricity Supply Board (BSL-ESB) estimates

AGRICULTURE'S SHARE OF NATIONAL ENERGY CONSUMPTION

Not only has agriculture's consumption of energy risen in absolute terms, but agriculture's share of total consumption has also increased, from 5.1 per cent in 1974 to 6.4 per cent in 1978 on the basis of the NBST's assessment of total energy consumption in Ireland, and to 5.9 per cent on the basis of OECD energy statistics.

Agriculture's reliance on petroleum-based fuels is reflected in agriculture's relatively high share of national consumption of these fuels. Based on the NBST's assessment of total national consumption of petroleum-based fuels, agriculture's share amounted to 9 per cent in 1978 when taking the Agricultural Institute's figure for consumption in agriculture. Based on OECD data, the share of agriculture was 8.3 per cent in 1978.

Data extracted from OECD statistics show that agriculture accounted for over 12 per cent of total electricity consumption. However, as stated above, OECD data on input of electricity to agriculture are believed to be too high.

Table 6.11

Ireland: Share of Agriculture in National Consumption of Energy, 1973-1978
(per cent)

	1973	1974	1975	1976	1977	1978
Based on OECD Data						
- Petroleum products	5.4	3.9	4.3	3.1	...	...
- Electricity	11.0	14.0	14.4	13.9	12.8	12.2
Total	5.1	4.1	4.4	4.5	...	...
Based on Agricultural Institute Data						
- Petroleum products	...	6.8	...	...	...	9.0[a]
- Electricity	...	3.9	...	...	...	4.7[a]
Total	...	5.1	...	...	...	6.4
Based on Electricity Supply Board Data						
- Electricity[b]	3.0	2.9	3.2	3.3	3.2	3.4[a]

a based on NBST assessment of total national consumption; b based on BSL-ESB data on total consumption of electricity

Source: OECD, AI and BSL-ESB

ENERGY CONSUMPTION BY USAGE

In its analyses of the studies which it conducted on energy consumption in agriculture in 1974 and 1978, the Agricultural Institute arrived at broad estimates of the consumption of petroleum-based fuels and electricity by main usage sectors. Petroleum-based fuels account for over 90 per cent of direct energy consumption in agriculture.

The share of DERV fuel for tractors in total demand for petroleum-based fuels in direct consumption in agriculture would have risen from some 63 per cent to about 67 per cent between 1974 and 1978, from 168,000 TOE to 232,000 TOE.

The second largest category of demand for petroleum-based fuels is made up of heavy oil used for heating glasshouses; this category accounts for about 15 per cent of petroleum-based fuels, equivalent to 53,000 TOE in 1978. The total area under glass in Ireland is estimated at 180 hectares, of which 120-140 hectares are heated. There are also about 20 hectares under polythene, but this area is not heated. Tomato cultivation under glass has been extended during the 1970s, and tomatoes currently account for close on 90 per cent of the volume output of crops grown under glass.

A survey among a sample of farms growing tomatoes under glass enabled the Agricultural Institute to estimate fuel consumption at about 45 litres per square metre a year. For residual fuel oil, this would be equivalent to 42.5×10^4 kcal per square metre or 425 TOE per hectare. According to the same analysis, annual fuel consumption for foliage pot plants is of the order of 70 litres per square metre. For residual fuel oil, this would be equivalent to 66.2×10^4 kcal per square metre or 662 TOE per hectare.

Because of a steady switch from other crops to tomatoes in cultivation under glass, the input of direct energy to glasshouses has been reduced.

Fuel to provide heating on pig-breeding farms would account for another 14 per cent of total input of petroleum-based fuels to agriculture. However, a large proportion, which could be as high as 50 per cent according to some respondents, is probably accounted for by heating for domestic purposes.

Electrical machinery used in crop and livestock farming accounts for some 94 per cent of consumption of electricity for agricultural purposes. The main uses of electricity are in dairy farming where electricity is used for powering milk coolers. Consumption of electricity by farms cultivating crops under glass is relatively small and is equivalent to close on 6 per cent of all electricity consumed for agricultural purposes.

Table 6.12

Ireland: Consumption of Petroleum Products by Type in Agriculture, 1974-1978

(TOE '000)

	1974	1978
DERV fuel for powering tractors	168	232
Heavy fuel for heating glasshouses	63	53
Central heating (including domestic use)	33	49
Liquefied petroleum gas	5	11
Total	269	345

Source: AI and NBST

Table 6.13

Ireland: Consumption of Electricity in Agriculture by Usage Sector, 1978

(TOE '000)

Crops and livestock	30
Horticulture (glasshouses)	2
Total	32

Source: AI and NBST

CONSUMPTION OF FERTILISERS

Energy contained in fertilisers accounted for 34 per cent of energy used in agriculture in 1978 and was the single most important category of energy input to farming, albeit in an indirect form.

The consumption of all types of fertilisers in agriculture increased by 28 per cent between 1972/73 and 1978/79, but with a sharp drop in consumption in 1974/75 doubtless caused by price rises. Consumption of nitrogen fertilisers rose by 103 per cent during the same period.

Table 6.14

Ireland: Consumption of Fertilisers, 1972/73 - 1978/79
(tonnes '000 of fertiliser elements)

	Types of fertiliser				Change on previous year (%)
	N	P_2O_5	K_2O	Total	
1972/73	130	208	183	521	
1973/74	130	193	181	504	- 3.3
1974/75	133	116	112	361	-28.4
1975/76	153	135	144	432	+19.7
1976/77	167	150	170	487	+12.7
1977/78	230	175	204	609	+25.1
1978/79	264	184	221	669	+ 9.9

Source: Department of Agriculture and Eurostat

Table 6.15

Ireland: Average Application of Fertilisers, 1972/73 - 1978/79 (kg/ha)

	Type of Fertiliser					
	Ireland			European Community		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1972/73	27	43	38	56	50	45
1973/74	27	40	37	60	50	48
1974/75	28	24	23	57	40	40
1975/76	32	28	30	62	40	39
1976/77	34	30	35	65	43	43
1977/78	40	31	36	68	45	44
1978/79	46	33	39	...	...	...

Source: Department of Agriculture and Eurostat

The application of fertilisers per hectare in Ireland is still lower than the average for the European Community, but the increase in the use of nitrogenous fertilisers has been greater in recent years.

The indirect consumption of energy represented by the use of fertilisers in Ireland has been calculated on the basis of data obtained from the Department of Agriculture and from a study undertaken by Energy Resources Limited (ERL).

Table 6.16

Ireland: Indirect Energy Consumption in the Form of Fertilisers, 1972/73 - 1978/79
(TOE '000)

	Nitrogenous	Phosphates	Potash	Total
1972/73	208	62	31	301
1973/74	208	58	31	297
1974/75	213	35	19	267
1975/76	245	41	24	310
1976/77	267	45	29	341
1977/78	368	53	35	456
1978/79	422	55	38	515

Source: EIU calculations based on data obtained from the Department of Agriculture and ERL

The Agricultural Institute arrived at very comparable estimates of indirect consumption of energy represented by fertilisers in 1978 and at broadly comparable estimates for 1974. The estimates set out in the previous table are sufficiently close to those of the Agricultural Institute to be considered as a confirmation of the findings, even though the estimates based on ERL data are some 9-18 per cent lower than those of the Agricultural Institute for 1974.

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

ITALY

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY - ITALY

AGRICULTURE IN ITALY

A feature of the structure of agriculture in Italy is the large number of small holdings. There were 2,634,000 holdings in 1977, more than twice the number of holdings in France. In the same year, the area under agricultural cultivation was 16.5 million hectares, compared with 29 million hectares in France.

Close on 90 per cent of holdings are worked by the owner or tenant and his family, without the assistance of paid agricultural workers. Holdings worked solely by the owner/tenant (direct cultivation) account for some 70 per cent of the area under agricultural cultivation.

The second largest category of holding is that cultivated by paid labourers, but this category accounted for only 7 per cent of holdings and for 25 per cent of the land area under agricultural cultivation. It is in this category that the largest farms are found with the average size of holding for the category being 22.5 hectares.

Table 7.1

Italy: Number and Area of Agricultural Holdings, 1977

Type of Tenure	Holdings		Total Area		Average Size of Holdings (hectares)
	Number	Per cent	Hectares	Per cent	
Direct cultivation by owner/tenant	2,359,334	89.6	11,604,638	70.2	4.92
Cultivation by paid labour	184,665	7.0	4,154,162	25.2	22.50
Metayage[a]	71,293	2.7	608,242	3.7	8.53
Other	18,780	0.7	150,492	0.9	8.01
Total	2,634,072	100.0	16,517,534	100.0	6.27

a farmer pays part of produce or provides services as rent to landowner

Source: ISTAT: Enquiry into the Structure of Agricultural Holdings, November 1977

Holdings of 1-2 hectares accounted for 22 per cent of all holdings in 1975, and this is the largest category of holdings by area cultivated. This category accounted for less than 5 per cent of the total area under agricultural cultivation. Close on 70 per cent of holdings had an area of 5 hectares or less, and they accounted for 20 per cent of the total area under cultivation.

Only 2 per cent of holdings had an area of over 50 hectares, but they accounted for a third of the total area under cultivation.

Table 7.2

Italy: Relative Importance of Holdings by Size, 1975

Size of Holding (hectares)	Per cent of Holdings	Per cent of Area under Cultivation
Up to 1.00	17.6	1.7
1.01 - 2.00	22.4	4.9
2.01 - 3.00	13.7	4.9
3.01 - 5.00	16.1	8.7
5.01 - 10.00	15.7	15.1
10.01 - 20.00	8.1	15.0
20.01 - 30.00	2.4	7.7
30.01 - 50.00	1.7	8.5
50.01 - 100.00	1.1	9.8
100.01 and over	0.7	23.7
no "activity"	0.5	-
Total	100.0	100.0

Source: ISTAT

In 1970, agriculture, forestry and fisheries contributed 8.2 per cent to Gross National Product in terms of value added, agriculture alone accounting for 7.8 per cent. At current market prices, value added attributable to agriculture rose from Lit 4,914 billion in 1970 to Lit 17,842 billion in 1979: in terms of constant 1970 prices, value added attributable to agriculture was Lit 5,440 billion in 1979. Agriculture's share of GNP has declined in the decade to 6.6 per cent in 1979.

The decline in the relative importance of agriculture among economic sectors has been due to a shift of agricultural labourers towards employment in industry and to emigration.

Table 7.3

Italy: Value Added by Agriculture and Contribution to Gross National Product, 1970-1979
(Lit billion)

	Value Added at Current Prices		Value Added at Constant 1970 Prices		Share of GNP at 1970 Prices	
	Agriculture Forestry Fisheries	Agriculture	Agriculture Forestry Fisheries	Agriculture	Agriculture Forestry Fisheries (%)	Agriculture (%)
1970	5,122	4,914	5,122	4,914	8.2	7.8
1971	5,299	5,087	5,148	4,944	8.1	7.7
1972	5,403	5,179	4,767	4,572	7.2	6.9
1973	6,976	6,767	5,101	4,925	7.2	7.0
1974	8,096	7,854	5,196	5,023	7.1	6.8
1975	9,644	9,352	5,369	5,207	7.6	7.4
1976	11,222	10,865	5,149	4,978	6.9	6.6
1977	13,402	12,935	5,123	4,964	6.7	6.5
1978	15,700	15,065	5,303	5,137	6.8	6.6
1979	18,610	17,842	5,620	5,440	6.8	6.6

Source: ISTAT: National Accounts

In 1970, agriculture, forestry and fisheries accounted for 18.5 per cent of the employed labour force, providing employment for 3.6 million persons. By 1979, employment in agriculture, forestry and fisheries had fallen steadily to 2.8 million, corresponding to 13.9 per cent of the national labour force in employment.

Table 7.4

Italy: Employment in Agriculture, Forestry and Fisheries, 1970-1979

	Number Employed (000)	Share of National Labour Force[a] (per cent)
1970	3,605	18.5
1971	3,598	18.5
1972	3,339	17.3
1973	3,242	16.7
1974	3,174	16.0
1975	3,047	15.4
1976	3,020	15.1
1977	2,950	14.7
1978	2,919	14.4
1979	2,840	13.9

a employed labour force

Source: ISTAT: National Accounts

DIRECT ENERGY CONSUMPTION

There are two sources cf statistical data on direct consumption of energy in agriculture - the Ministry of Industry and OECD - and both provide an historical series of data which are indicative of trends. The analysis provided by the Ministry of Industry is the more detailed of the two, but the two sources are broadly in line.

Table 7·5

Italy: Energy Consumption in Agriculture - Comparative Summary of Data

(TOE '000)	Ministry of Industry		OECD	
	1973	1978	1973	1978
Direct Energy	1.940	2,168	1,940	2,310
of which:				
Petroleum products	1,825	1,962	1,830	2,110
Gas	2	12	...	10
Electricity	113	194	110	190
Indirect Energy[a]	...	7,751	...	7,751
Total	...	9,919	...	10,061

a EIU estimate

Source: Ministry of Industry, OECD and EIU estimates

The estimate for indirect energy consumption shown in the table above is a broad estimate arrived at by the EIU. The basis on which the estimate rests is explained in the final chapter of the report. The estimate of indirect energy consumption in 1978 is shown in the table to provide an overall picture of energy input - direct and indirect - in 1978.

MINISTRY OF INDUSTRY DATA

The Ministry of Industry identifies seven sources of energy in statistical series published under the title "Bilanci Energetici Nazionali"(National Energy Balance), and direct consumption of energy in agriculture for farming purposes is identified separately.

Total direct consumption of energy in agriculture has increased from 1,887,400 TOE in 1972 to 2,361,800 TOE in 1979, an increase of 25 per cent over seven years equivalent to an average annual increase of 3.3 per cent. Consumption of energy has increased year by year, with the exception of 1975 when consumption fell by 2 per cent on the previous year due mainly to a fall in consumption of diesel oil.

The main fuels used in agriculture are diesel oil (63 per cent of total energy consumption in 1979), fuel oil (17 per cent), electricity (9 per cent) and petrol (7 per cent).

Consumption of diesel oil increased from 1,173,000 TOE in 1972 to 1,484,100 TOE in 1979, an increase of 27 per cent in seven years. The upward trend in consumption was broken only in 1975 when consumption fell by 5 per cent compared with 1974.

While fuel oil is the second largest source of energy input to agriculture, consumption in 1979 at 392,000 TOE was similar to that recorded for 1972. Consumption during the seven-year period has fluctuated between a high of 441,000 TOE in 1973 and a low of 294,000 TOE in 1978.

Consumption of electricity has more than doubled in the seven years to 1979, to reach 216,500 TOE; an average annual increase of 12 per cent. There was a sharp increase in consumption of electricity in 1977 when the amount taken up by agriculture increased by 16 per cent to 180,300 TOE.

The relative importance of particular fuels consumed in agriculture has altered in recent years, with electricity increasing its share of total input from 5 per cent in 1972 to 9 per cent in 1979, petrol taking an 8 per cent share compared with 6 per cent at the start of the period, and fuel oil and kerosene losing relative importance. Diesel oil maintained its dominant position with 63 per cent of total consumption in 1979, but its share fluctuated between 61 per cent (1973) and 65 per cent (1978).

Table 7.6

Italy: Consumption of Energy in Agriculture by Type of Fuel, 1972-1979
(TOE '000)

	Natural Gas	Electricity	LPG	Petrol	Kerosene	Diesel Oil	Fuel Oil	Total
1972	1.7	99.8	22.0	110.3	88.6	1,173.0	392.0	1,887.4
1973	1.7	112.6	27.5	106.0	73.1	1,178.1	441.0	1,940.0
1974	2.5	122.2	30.8	141.8	81.4	1,315.8	372.4	2,066.9
1975	3.3	142.8	33.0	148.0	64.9	1,244.4	392.0	2,028.4
1976	5.0	155.4	38.5	160.7	47.4	1,264,8	392.0	2,063.8
1977	7.4	180.3	38.5	168.0	45.3	1,382.1	343.0	2,164.6
1978	12.4	193.8	38.5	176.4	40.1	1,412.7	294.0	2,167.9
1979	14.8	216.5	44.0	176.4	34.0	1,484.1	392.0	2,361.8

Source: Ministry of Industry: National Energy Balance

Table 7.7

Italy: Relative Importance of Fuels in Energy Consumption in Agriculture, 1972-1979
(Per cent share of energy input)

	Natural Gas	Electricity	LPG	Petrol	Kerosene	Diesel Oil	Fuel Oil	Total
1972	0.1	5.3	1.2	5.8	4.7	62.1	20.8	100
1973	0.1	5.8	1.4	5.5	3.8	60.7	22.7	100
1974	0.1	5.9	1.5	6.9	3.9	63.7	18.0	100
1975	0.2	7.0	1.6	7.3	3.2	61.4	19.3	100
1976	0.2	7.5	1.9	7.8	2.3	61.3	19.0	100
1977	0.3	8.3	1.8	7.8	2.1	63.9	15.8	100
1978	0.6	8.9	1.8	8.1	1.8	65.2	13.6	100
1979	0.6	9.2	1.9	7.5	1.4	62.8	16.6	100

Source: EIU calculations based on data obtained from Ministry of Industry

OECD DATA

The statistical data provided by OECD in its two publications, Energy Balances and Energy Statistics, are much in line with the data compiled by the Ministry of Industry. The analysis of direct consumption by type of fuel provided by OECD is less detailed, and OECD treats agriculture as a small residual category in what is essentially an analysis of national energy balances.

The data set out in Table 7.8 again serves to show the dominance of petroleum products in direct energy consumption. Although the share accounted for by petroleum products has been declining, petroleum products account for over 90 per cent of direct energy input.

Table 7.8

Italy: Consumption of Energy in Agriculture by Type of Fuel, 1973-1978

	Petroleum Products		Gas		Electricity		Total	
	TOE ('000)	Per cent	TOE ('000)	Per cent	TOE ('000)	Per cent	TOE ('000)	Per cent
1973	1,830	94.3	...	...	110	5.7	1,940	100.0
1974	1,920	94.1	...	...	120	5.9	2,040	100.0
1975	2,140	93.9	...	...	140	6.1	2,280	100.0
1976	1,900	91.8	10	0.5	160	7.7	2,070	100.0
1977	1,980	91.7	...	...	180	8.3	2,160	100.0
1978	2,110	91.3	10	0.5	190	8.2	2,310	100.0

Source: OECD - Energy Balances

AGRICULTURE'S SHARE OF NATIONAL ENERGY CONSUMPTION

Statistics compiled by the Ministry of Industry show that between 1972 and 1979, agriculture accounted for about 2 per cent of national consumption of energy, varying from 1.96 per cent in 1972 to 2.19 per cent in 1979. Over the period, agriculture's share of national energy consumption has increased but only marginally.

While agriculture's share of national consumption of diesel oil has tended to decline, agriculture's share of diesel oil consumption remains relatively high at about 6 per cent.

OECD statistics can also be used to show the relative importance of agriculture in total national consumption of energy. A similar picture emerges to that obtained from a comparison of statistics compiled by the Ministry of Industry, with agriculture accounting for some 2 per cent of national consumption of direct energy, and the share tending to increase very marginally.

Table 7.2

Italy: National Energy Consumption[a], 1973-1978

	1973		1976		1977		1978	
	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent
Solid fuels	6.76	6.7	6.13	5.7	6.01	5.8	5.90	5.6
Petroleum products	70.35	69.7	69.82	65.3	66.36	64.1	66.65	63.1
Gas	13.26	13.1	19.02	17.8	18.89	18.2	20.26	19.2
Electricity	10.59	10.5	11.90	11.1	12.32	11.9	12.81	12.1
National total	100.98	100.0	106.88	100.0	103.57	100.0	105.61	100.0
of which:								
Agriculture	1.94	1.9	2.07	1.9	2.16	2.1	2.31	2.2

a direct final consumption

Source: OECD - Energy Balances

Table 7.10

Italy: Share of Agriculture in National Energy Consumption by Type of Fuel, 1972, 1975, 1977 and 1979
(per cent share)

	Natural Gas	Electricity	LPG	Petrol	Kerosene	Diesel Oil	Fuel Oil	Total
1972	0.02	1.01	1.05	1.00	3.93	6.81	1.54	1.96
1975	0.02	1.32	1.43	1.26	3.10	6.21	1.92	2.05
1977	0.04	1.47	1.58	1.51	2.72	6.31	1.83	2.12
1979	0.08	1.61	1.78	1.38	2.10	5.89	2.11	2.19

Source: EIU calculations based on data obtained from Ministry of Industry

AGRICULTURAL DEMAND FOR ELECTRICITY

The most detailed analysis of energy input to agriculture relates to the use of electricity. Studies undertaken by ENEL, UMA and UNACOMA provide breakdowns by

- region (1973-1979)
- agricultural activity (1977)
- type and size of farm (1973).

CONSUMPTION OF ELECTRICITY BY REGION

ENEL provides a breakdown of electricity consumed in agriculture by region. The most recent data refer to 1979.

The 20 regions are further grouped into four geographical regions:

- North-West
- North-East
- Centre
- South and Islands.

In the period 1973 to 1979, consumption of electricity in agriculture has increased year by year from 1,300,490 MWH to 2,519,000 MWH, an increase of 94 per cent in six years, equivalent to an average annual rate of growth of 12 per cent.

Table 7.11

Italy: Consumption of Electricity in Agriculture by Region, 1973-1979
(GWH)

Region	1973	1974	1975	1976	1977	1978	1979
Piemonte	92	124	106	133	123	143	163
Valle d'Aosta	1	1	0	1	1	1	1
Liguria	21	21	22	25	24	23	28
Lombardia	206	213	280	342	357	406	457
North-West	320	358	408	500	505	573	649
Trentino-Alto Adige	10	21	25	54	65	70	80
Veneto	166	179	201	209	222	238	267
Friuli-Venezia Giulia	22	22	29	34	34	41	50
Emilia Romagna	184	201	310	340	412	443	504
North-East	382	423	565	638	732	792	901
Marche	20	23	24	24	29	32	40
Toscana	63	75	88	150	90	93	105
Umbria	19	20	22	22	29	31	42
Lazio	78	76	91	92	113	116	133
Centre	181	194	225	288	261	272	320
Campania	52	53	55	65	72	74	75
Abruzzi	27	28	19	13	15	16	20
Molise	1	1	3	6	7	8	9
Puglia	69	82	96	86	137	152	154
Basilicata	8	8	8	7	12	15	17
Calabria	26	30	33	36	41	46	44
Sicilia	210	215	216	201	275	263	283
Sardegna	24	28	32	33	40	42	45
South and Islands	418	446	462	447	599	616	647
Italy	1,300	1,421	1,659	1,873	2,097	2,253	2,519

Source: ENEL: Production of Electricity in Italy

Of total national consumption of electricity in agriculture in 1979 of 2,519,000 MWH, the regions of the North-East accounted for 36 per cent, the North-West and South for 26 per cent respectively, and the Centre for 13 per cent. The largest regional consumers of electricity were:

- Emilia Romagna	20 per cent
- Lombardia	18 per cent
- Sicilia	11 per cent
- Veneto	10 per cent.

In these four regions, consumption of electricity in agriculture has increased appreciably in the period 1973 to 1979: in Emilia Romagna and Lombardia consumption has more than doubled, although the increase in Sicilia and Veneto falls below the national average.

CONSUMPTION OF ELECTRICITY BY AGRICULTURAL ACTIVITY

The consumption of electricity in agriculture by type of activity has been analysed by UMA and UNACOMA for the year 1977. Five broad categories of activity are identified

- miscellaneous agriculture, accounting for 73 per cent of agricultural users of electricity and for 45 per cent of consumption
- livestock breeding, accounting for 20 per cent of users of electricity and for 22 per cent of consumption
- forestry, accounting for 1 per cent of users of electricity and for 0.4 per cent of consumption
- activities related to agriculture, accounting for 4 per cent of users of electricity and for 21 per cent of consumption
- development and water resources projects, accounting for 2 per cent of users of electricity and for 12 per cent of consumption.

The diversity of farms and their small size is reflected in the grouping of 73 per cent of agricultural users of electricity into the category of miscellaneous agriculture.

Table 7.12

Italy: Consumption of Electricity in Agriculture by Activity and by Region, 1977

Region	Miscellaneous[a] Agriculture		Livestock Breeding		Forestry		Activities[b] Related to Agriculture		Development[c] and Water Resource Projects		Total	
	Users (number)	Energy (MWH)	Users (number)	Energy (MWH)	Users (number)	Energy (MWH)	Users (number)	Energy (MWH)	Users (number)	Energy (MWH)	Users (number)	Energy (MWH)
Piemonte	30,759	50,737	13,493	42,334	67	432	1,031	15,949	368	13,732	45,718	123,184
Valle d'Aosta	135	246	155	109	5	16	342	263	1	1	638	635
Liguria	15,041	15,230	916	899	10	105	585	3,897	81	3,568	16,633	23,699
Lombardia	43,549	118,760	15,653	142,172	150	575	1,944	62,127	642	33,462	61,938	357,096
North-West	*89,484*	*184,973*	*30,217*	*185,514*	*232*	*1,128*	*3,902*	*82,236*	*1,092*	*50,763*	*124,927*	*504,614*
Trentino-Alto Adige	12,883	35,846	5,320	4,946	9	25	716	22,767	201	1,437	19,129	65,021
Veneto	13,926	72,584	9,859	61,681	67	323	1,771	49,459	889	37,511	26,512	221,558
Friuli-Venezia Giulia	5,765	11,896	2,363	7,779	12	31	1,007	9,736	481	4,312	9,628	33,754
Emilia Romagna	21,056	98,450	11,509	108,221	92	525	3,663	144,548	923	59,868	37,243	411,612
North-East	*53,630*	*218,776*	*29,051*	*182,627*	*180*	*904*	*7,157*	*226,510*	*2,494*	*103,128*	*92,512*	*731,945*
Marche	9,000	13,204	1,473	5,900	23	48	639	9,621	115	635	11,250	29,408
Toscana	31,279	54,348	7,172	20,306	121	711	1,000	10,716	524	3,913	40,096	89,994
Umbria	6,448	14,125	1,296	8,323	10	24	385	5,943	103	826	8,242	29,241
Lazio	20,370	75,367	3,459	9,931	191	910	1,419	7,531	1,136	18,863	26,575	112,602
Centre	*67,097*	*157,044*	*13,400*	*44,460*	*345*	*1,693*	*3,443*	*33,811*	*1,878*	*24,237*	*86,163*	*261,245*
Campania	21,118	43,301	3,288	10,254	365	1,718	1,526	6,652	1,012	10,144	27,309	72,069
Abruzzo	3,794	5,337	5,094	6,307	21	41	286	2,006	381	1,571	9,576	15,262
Molise	1,385	851	313	5,435	3	...	161	687	42	97	1,904	7,070
Puglia	26,614	103,484	4,392	7,418	394	1,592	1,195	14,668	1,391	9,564	33,986	136,726
Basilicata	1,436	5,495	309	901	13	61	117	1,546	109	3,873	1,984	11,876
Calabria	11,498	28,774	1,830	2,607	450	815	996	7,053	626	2,058	15,400	41,307
Sicilia	44,713	182,296	2,198	10,276	31	59	1,373	50,212	658	32,415	48,973	275,260
Sardegna	16,199	22,042	2,032	4,667	11	38	558	5,592	580	7,246	19,380	39,585
South and Islands	*126,757*	*391,582*	*19,456*	*47,865*	*1,288*	*4,324*	*6,212*	*88,416*	*4,799*	*66,968*	*158,512*	*599,155*
Total	*336,968*	*952,375*	*92,124*	*460,466*	*2,045*	*8,049*	*20,714*	*430,973*	*10,263*	*245,096*	*462,114*	*2,096,959*

a mainly cultivation; b mainly transformation and conservation of agricultural produce by cooperative associations; c land reclamation and irrigation

Source: UMA, UNACOMA: Mechanisation of Agriculture in Italy (1979)

CONSUMPTION OF ELECTRICITY BY TYPE AND SIZE OF FARM

ENEL conducted a sample survey in 1973 (September to November) into the activities of farms connected to the main electricity supply. Agricultural activities were classified as either principal or secondary activities.

Close on 36 per cent of farms were engaged in horticulture (defined as the growing of vegetables, legumes, etc.) as a primary (24 per cent) or secondary (11.8 per cent) activity, and the average size of farm was 4.3 hectares. The growing of citrus fruit was the primary activity of 15 per cent of farms and their average size was 5.6 hectares.

Livestock rearing was the primary activity of 16 per cent of farms, and 36 per cent of farms were engaged in livestock rearing as a primary or secondary activity. The 24 per cent of farms raising cattle had an average area of 30.9 hectares, and the 5 per cent of farms raising pigs had an average area of 31 hectares. The largest farms tend to be engaged in livestock rearing and in the cultivation of rice, wheat and maize.

The sample survey conducted by ENEL served to highlight the high consumption of electricity in the regions of Lombardia, Sicilia, Veneto and Emilia Romagna in both absolute and relative terms. Average consumption of electricity per farm was highest in Veneto (12,507 KWH), Molise (8,979 KWH), Emilia Romagna (7,746 KWH) and Lombardia (7,391 KWH). While consumption per farm is high on average in Molise, the region accounts for only 0.1 per cent of electricity used in agriculture.

Table 7.13

Italy: Analysis of Farms[a] by Activity, 1973

Activities	Principal		Secondary		Total	
	Farms[b] (%)	Average[c] Area (Ha)	Farms[b] (%)	Average[c] Area (Ha)	Farms[b] (%)	Average[c] Area (Ha)
Wheat	6.9	36.5	18.2	30.4	25.2	32.1
Maize	3.5	26.2	19.5	27.2	22.9	27.1
Rice	2.2	40.1	0.5	57.9	2.7	43.3
Horticulture (vegetables, legumes, etc.)	24.0	2.3	11.8	8.3	35.8	4.3
Flowers	4.4	2.0	1.1	6.9	5.5	3.0
Pasture and crop rotation	2.3	16.8	17.2	27.4	19.6	26.2
Permanent pasture	2.8	12.3	6.4	26.8	9.2	22.4
Orchards	3.5	20.1	7.8	8.4	11.3	12.0
Vine	9.1	15.2	16.5	20.1	25.5	18.4
Citrus fruit	15.1	5.6	3.6	9.6	18.7	6.4
Olives	1.9	19.0	7.4	28.2	9.3	26.3
Nursery	1.0	4.8	0.5	35.5	1.5	15.1
Other cultivations	2.5	25.3	5.4	37.2	7.8	33.0
Cattle	11.2	30.5	12.8	31.2	24.0	30.9
Pigs	1.6	20.2	3.0	36.2	4.6	31.0
Farmyard animals	2.6	5.0	3.3	14.0	5.9	10.5
Other animal rearing	0.9	30.3	1.1	69.6	2.0	52.5
Production of olive oil by pressing	0.8	23.5	0.9	69.1	1.7	48.0
Production of wine and must	3.4	20.1	5.5	21.7	8.9	21.1
Other transformation activities	0.3	10.7	0.5	65.8	0.7	43.7
Total	100.0	14.7	-	-	-	-

a connected to main electricity supplies; b per cent of total number of farms; c average area of farms

Source: ENEL: Survey into Agricultural Consumption of Electricity, 1973

The survey further showed that 56.2 per cent of farms had an average annual consumption of electricity of 1,000 KWH or less, but these farms accounted for under 5 per cent of electricity used in agriculture. The high concentration of consumption among the largest farms was evident : 14.1 per cent of farms with an average annual consumption of over 5,000 KWH accounted for 76.8 per cent of consumption of electricity in agriculture.

The importance of large, capital intensive farms is again evident in the analysis of consumption of electricity by size of farm in terms of the area of the farm. Average annual consumption of electricity was 3,178 KWH per farm, corresponding to farms of 5 to 20 hectares : farms of 50-100 hectares had an average consumption of 11,503 KWH and farms of over 100 hectares averaged 32,538 KWH a year.

Table 7.14

Italy: Annual Consumption of Electricity and Installed Load by Size of Farm: Survey of Farms Using Electricity[a], 1973

Area (Ha)	Annual Consumption			Installed Load		
	Per cent	Cumulative (%)	Average (KWH)	Per cent	Cumulative (%)	Average (KWH)
No agricultural land	2.8	2.8	11,367	1.4	1.4	9.3
Up to 1.00	15.4	18.2	1,613	16.2	17.6	2.7
1.01-2.00	7.5	25.7	2,435	8.0	25.6	4.2
2.01-3.00	5.9	31.6	3,017	6.8	32.4	5.6
3.01-5.00	5.6	37.2	2,516	6.7	39.1	4.9
5.01-10.00	10.5	47.7	3,412	11.2	50.3	5.9
10.01-20.00	13.8	61.5	4,843	12.8	63.1	7.3
20.01-30.00	5.8	67.3	4,556	6.8	69.9	8.8
30.01-50.00	8.7	76.0	7,594	9.2	79.1	13.1
50.00-100.00	9.6	85.6	11,503	9.9	89.0	19.1
100.01 and over	14.4	100.0	32,538	11.0	100.0	31.5
Total	100.0	-	3,718	100.0	-	6.0

a for farming purposes

Source: ENEL

The levél of ownership of electrically powered agricultural equipment, as revealed by the ENEL survey. The types of farms were identified according to main activity :

- cultivation
- livestock rearing
- transformation of agricultural produce.

The most widely owned electrically powered appliances were

- irrigation pumps	60.2 %
- general purpose pumps	26.2 %
- elevators	15.8 %
- animal feed mixers	14.2 %
- milking machines	10.6 %.

A more recent survey of the input of electricity to agriculture has been undertaken by ENEL. The period of the survey was 1980. The consultants were informed that the findings of the survey have not yet been published and they were led to believe that the analysis of the findings will not be comparable with the 1973 survey.

INDIRECT ENERGY CONSUMPTION

There appears to be no source of information which has systematically attempted to measure indirect energy consumption in Italian agriculture. The EIU has therefore collected data on the consumption and utilisation of the main categories of products which constitute a source of indirect energy, and these data are used later in the chapter as a basis for estimating indirect energy consumption in agriculture.

CHEMICAL FERTILISERS

In the period 1973 to 1978, consumption of fertilisers has fluctuated from one year to another: whereas consumption of nitrogenous and compound fertilisers has tended to increase, consumption of phosphate and potash fertilisers has declined.

In 1978, consumption of nitrogenous fertilisers stood at 1,948,000 tonnes, 9 per cent more than in 1973 although in the intervening period annual consumption had not reached the level of 1973.

Consumption of phosphate fertilisers declined from 1973 to 1976, but recovered in 1977 and remained steady in 1978 when consumption at 814,000 tonnes was 22 per cent below consumption in 1973.

Usage of potash fertilisers declined from 176,000 tonnes in 1973 to 155,000 tonnes in 1978, a reduction of 12 per cent. Only in 1974 did consumption surpass the 1973 level.

The trend in consumption of compound fertilisers has been irregular but has tended to rise in the five years to 1978 when consumption at 2,244,000 tonnes was 26 per cent greater than in 1973.

Table 7·15

Italy: Consumption of Fertilisers, 1973-1978

(tonnes '000 of fertiliser element)

	Nitrogen	Phosphate	Potash	Compounds
1973	1,787	1,050	176	1,783
1974	1,598	947	188	1,759
1975	1,719	769	99	1,754
1976	1,556	684	150	1,899
1977	1,740	828	119	1,836
1978	1,948	814	155	2,244
Per cent change 1978/1973	+9	-22	-12	+26

Source: ISTAT

Table 7.16

Italy: Consumption of Fertilisers by Region, 1978
(tonnes '000)

Region	Nitrogen	Phosphate	Potash	Compounds
Piemonte	152.8	29.0	24.3	260.4
Valle d'Aosta	0.1	-	-	2.5
Lombardia	234.7	52.4	38.6	356.7
Trentino-Alto Adige	17.0	5.1	2.1	38.9
Veneto	237.7	69.7	35.3	329.1
Friuli-Venezia Giulia	68.2	15.8	14.5	80.7
Liguria	6.6	3.3	0.6	16.3
Emilia Romagna	198.1	163.7	17.3	277.8
Toscana	101.5	14.1	2.0	120.8
Umbria	38.7	7.4	0.7	37.6
Marche	80.3	52.3	0.9	63.1
Lazio	95.7	19.1	3.1	108.6
Abruzzi	42.5	60.5	1.2	51.8
Molise	13.5	5.4	0.1	14.9
Campania	193.9	42.4	0.6	74.2
Puglia	210.6	128.1	5.9	128.1
Basilicata	43.4	13.3	0.5	35.9
Calabria	61.7	25.6	0.9	53.5
Sicilia	123.2	103.3	5.9	150.3
Sardegna	27.9	3.3	0.6	42.4
Italy	1,948.1	813.8	155.1	2,243.6

Source: ISTAT

PLANT PROTECTION PRODUCTS

Consumption of plant protection products tended to increase during the 1970's, although consumption of the two major product categories, fungicides and insecticides, fell back in 1978 the most recent year for which official statistics are available. Between 1973 and 1978, consumption of fungicides increased by 14 per cent to 156,787 tonnes, but consumption had reached a peak of 162,267 tonnes in the previous year. Consumption of insecticides increased from 35,800 tonnes in 1974 to 49,186 tonnes in 1978, an increase of 37 per cent, although consumption in 1978 was marginally below that of 1977.

Table 7.17

Italy: Consumption of Plant Protection Products, 1973-1978
(tonnes)

	Fungicides	Insecticides	Weed Killers	Plant Regulators	Integrators	Assisters
1973	137,800	35,800	...	...	...	...
1974	153,100	31,300	...	...	...	...
1975	125,096	35,216	12,938	118	...	...
1976	150,204	43,205	15,990	335	1,676	987
1977	162,267	49,889	17,941	446	2,924	1,231
1978	156,787	49,186	19,078	556	3,493	1,670

Source: ISTAT

Usage of fungicides is highest in the region of Puglia (22 per cent in 1978), Campagnia (10 per cent), Emilia Romagna (10 per cent), Veneto (9 per cent) and Sicilia (8 per cent).

Usage of insectictides is high in Sicilia (15 per cent in 1978), Emilia Romagna (14 per cent) and Campagnia (13 per cent).

Table 7.18

Italy: Consumption of Plant Protection Products by Region, 1978
(tonnes)

Region	Fungicides	Insecticides	Weed Killers	Plant Regulators	Integrators	Assisters
Piemonte	7,201	1,821	5,339	36	115	74
Valle d'Aosta	30	34	5	-	1	-
Lombardia	5,659	3,943	4,752	29	221	48
Trentino-Alto Adige	3,907	1,721	186	21	429	78
Veneto	13,407	5,346	1,701	65	317	134
Friuli-Venezia Giulia	2,584	1,069	574	5	58	30
Liguria	1,678	1,137	40	6	236	20
Emilia Romagna	15,914	6,988	2,153	96	599	476
Toscana	8,704	1,829	708	34	250	98
Umbria	3,182	525	189	12	15	16
Marche	5,641	1,057	516	6	44	30
Lazio	10,080	3,307	702	35	172	72
Abruzzi	5,110	899	113	3	53	15
Molise	641	102	56	-	20	4
Campania	16,230	6,222	257	57	141	104
Puglia	33,966	3,141	923	52	351	158
Basilicata	2,431	392	229	2	56	21
Calabria	4,069	1,331	101	7	35	34
Sicilia	12,636	7,562	345	81	340	240
Sardegna	3,717	760	199	9	40	16
Italy	156,787	49,186	19,078	556	3,493	1,670

Source: ISTAT

ANIMAL FEEDSTUFFS

Consumption of animal feedstuffs increased year by year in the three years to 1979, reaching 9,900,000 tonnes in 1979, 37 per cent more than in 1976. The composition of the total by type of feedstuff has been as follows, on average, over the period:

- poultry feeds	41 %
- cattle feeds	30 %
- pig feeds	23 %
- other feeds	6 %

Table 7.19

Italy: Consumption of Animal Feedstuffs, 1976-1979
(tonnes '000)

1976	1977	1978	1979
7,200	8,100	8,500	9,900

Source: ISTAT

In 1979, three regions accounted for the greater part of consumption of animal feedstuffs:

	Complete compound (tonnes)	Protein concentrate (tonnes)
- Lombardia	2,146,002	180,320
- Emilia Romagna	1,937,777	119,141
- Veneto	1,895,259	119,196

Lombardia is noted for the rearing of calves, pigs, cattle and poultry; Emilia Romagna for pigs, dairy cows and poultry; and Veneto for poultry.

AGRICULTURAL MACHINERY

The park of agricultural vehicles and machinery was established for 1978 by UMA and UNACOMA in a report entitled The Mechanisation of Agriculture in Italy, published in 1979.

Table 7.20

Italy: Park of Agricultural Vehicles and Machinery, 1978

Type	Number	Horse-power	Kilo-watts
Tractors	953,197	44,477,892	32,735,729
Tractor derivates	3,216	52,119	38,360
Combine harvesters	30,589	2,877,024	2,117,490
Motor mowers	393,756	4,025,279	2,962,605
Motor cultivators	304,215	3,461,866	2,547,933
Hoeing machines	300,183	2,136,893	1,572,753
Agro-motors	93,417	1,391,325	1,024,015
Other machinery	103,934	1,275,982	939,123
Miscellaneous motors	300,468	2,740,098	2,016,712
Total	2,482,975	62,438,478	45,954,720

Source: UMA, UNACOMA - The Mechanisation of Agriculture in Italy, Rome, 1979

The trend in the size of the park of powered agricultural machinery has been evaluated by UMA for the period 1970 to 1978 in terms of the number of machines, aggregate horsepower and aggregate consumption of fuel. The analysis is further broken down into four geographical regions. The findings are indexed with 1970 serving as the base year.

Between 1970 and 1978 (the most recent year for which data are available) the park of powered machinery increased by 52.5 per cent to 2,482,975 units. The aggregate horsepower of the park increased by 79.8 per cent reflecting the greater sophistication of the machinery. Fuel consumption rose by a comparatively low factor of 29.3 per cent, reflecting improved efficiency and greater economy in the use of fuel, and consequently fuel consumption per horsepower fell from 36 kg per horsepower in 1970 to 25.9 kg per horsepower in 1978.

UMA compiles statistics of new registrations of self-propelled agricultural machinery. The annual registrations are broken down by type of fuel required to power the engine: tractors, and combine harvesters are, with minor exceptions, powered by diesel oil, and there are signs that diesel engines are being preferred for such machinery as motor mowers, cultivators and mechanical hoes.

Table 7.21

Italy: Park of Powered Agricultural Machinery, 1970-1978

	Park				Fuel Consumption		
Region	Number	Index	Aggregate HP	Index	Tonnes	Index	Kg per HP
1970							
North-West	379,486	100.0	9,066,184	100.0	2,896,670	100.0	32.0
North-East	610,234	100.0	12,711,615	100.0	3,812,257	100.0	30.0
Centre	253,756	100.0	5,754,914	100.0	2,309,947	100.0	40.1
South and Islands	384,455	100.0	7,188,409	100.0	3,470,279	100.0	48.3
Italy	*1,627,931*	*100.0*	*34,721,122*	*100.0*	*12,489,153*	*100.0*	*36.0*
1971							
North-West	396,678	104.5	9,768,289	107.7	3,091,694	106.7	31.7
North-East	634,253	103.9	13,687,366	107.7	3,980,297	104.4	29.1
Centre	275,069	108.4	6,369,144	110.7	2,435,427	105.4	38.2
South and Islands	433,305	112.7	8,106,926	112.8	3,727,844	107.4	46.0
Italy	*1,739,305*	*106.9*	*37,931,725*	*109.2*	*13,235,262*	*106.0*	*34.9*
1972							
North-West	410,493	108.2	10,401,860	114.7	3,164,907	109.3	30.4
North-East	653,810	107.1	14,563,503	114.6	3,905,635	102.4	26.8
Centre	297,125	117.1	6,993,072	121.5	2,400,653	103.9	34.3
South and Islands	487,157	126.7	9,105,340	126.7	4,002,301	115.3	44.0
Italy	*1,848,585*	*113.6*	*41,063,775*	*118.3*	*13,473,496*	*107.9*	*32.8*
1973							
North-West	424,607	111.9	11,095,032	122.4	3,086,015	106.5	27.8
North-East	677,151	111.0	15,605,141	122.8	3,861,883	101.3	24.7
Centre	319,726	126.0	7,646,566	132.9	2,614,795	113.2	34.2
South and Islands	543,440	141.4	10,144,248	141.1	3,837,284	110.6	37.8
Italy	*1,964,924*	*120.7*	*44,490,987*	*128.1*	*13,399,977*	*107.3*	*30.1*

(continued)

Table 7.21 (continued)

Italy: Park of Powered Agricultural Machinery, 1970-1978

	Park				Fuel Consumption		
Region	Number	Index	Aggregate HP	Index	Tonnes	Index	Kg per HP
1974							
North-West	437,452	115.3	11,689,777	128.9	3,625,361	125.2	31.0
North-East	692,935	113.6	16,454,333	129.4	4,419,244	115.9	26.9
Centre	343,185	135.2	8,347,364	145.0	2,649,671	114.7	31.7
South and Islands	595,315	154.8	11,186,384	155.6	4,391,627	126,5	39.3
Italy	*2,068,887*	*127.1*	*47,677,858*	*137.3*	*15,085,903*	*120.8*	*31.6*
1975							
North-West	447,912	118.0	12,320,008	135.9	3,385,805	116.9	27.5
North-East	707,262	115.1	17,274,451	135.9	4,215,448	110.6	24.4
Centre	363,967	143.4	9,003,711	156.5	2,594,534	112.3	28.8
South and Islands	638,301	166.0	12,197,844	169.3	4,486,723	129.3	36.8
Italy	*2,157,442*	*132.5*	*50,796,014*	*146.3*	*14,682,510*	*117.5*	*28.9*
1976							
North-West	464,089	122.3	13,179,992	145.4	3,615,990	124.8	27.4
North-East	729,171	119.5	18,424,436	144.9	4,418,541	115.9	24.0
Centre	388,523	153.1	9,749,838	169.4	2,574,867	111.5	26.4
South and Islands	687,764	178.9	13,315,170	185.2	4,401,382	126.8	33.1
Italy	*2,269,547*	*139.3*	*54,669,436*	*157.5*	*15,010,780*	*120.2*	*27.5*
1977							
North-West	482,132	127.0	14,096,500	155.5	3,715,286	128.3	26.4
North-East	751,760	123.2	19,586,398	154.1	4,666,146	122.4	23.8
Centre	413,149	162.8	10,504,505	182.5	2,823,669	122.2	26.9
South and Islands	736,629	191.6	14,376,488	200.0	4,803,326	138.4	33.4
Italy	*2,383,670*	*146.4*	*58,563,891*	*168.7*	*16,008,427*	*128.2*	*27.3*

(continued)

Table 7.21 (continued)

Italy: Park of Powered Agricultural Machinery, 1970-1978

Region	Park				Fuel Consumption		
	Number	Index	Aggregate HP	Index	Tonnes	Index	Kg per HP
1978							
North-West	497,128	131.0	14,959,780	163.0	3,856,190	133.1	25.8
North-East	774,732	127.0	20,878,785	164.2	4,673,138	122.6	22.4
Centre	433,392	170.8	11,233,023	195.2	2,900,422	125.6	25.8
South and Islands	777,723	202.3	15,366,890	213.8	4,715,406	135.9	30.7
Italy	*2,482,975*	*152.5*	*62,438,478*	*179.8*	*16,145,156*	*129.3*	*25.9*

Source: UMA

Table 7.22

Italy: New Registrations of Self-Propelled Agricultural Machinery, 1973-1978
(units)

	1973	1974	1975	1976	1977	1978
Tractors	50,894	49,395	51,783	62,014	61,368	61,208
of which:						
diesel powered	50,845	49,321	51,740	61,987	61,341	61,179
Combine harvesters	1,574	1,989	2,005	2,241	1,984	2,049
of which:						
diesel powered	1,572	1,986	2,005	2,239	1,980	2,048
Motor mowers	15,413	12,731	10,113	13,591	13,502	12,033
of which:						
petrol powered	8,039	7,959	6,693	9,186	9,112	8,072
diesel powered	2,426	2,513	2,304	3,676	3,866	3,648
kerosene powered	4,948	2,259	1,116	729	524	313
Motor cultivators	24,637	23,047	19,719	22,954	16,917	14,827
of which:						
petrol powered	12,421	12,202	10,970	12,005	7,611	6,525
diesel powered	11,152	10,348	8,399	10,738	9,221	8,361
Mechanical hoes	28,112	27,814	25,588	33,952	36,743	30,072
of which:						
petrol powered	24,408	22,811	20,614	27,411	31,113	25,754
diesel powered	3,050	4,686	4,848	6,438	5,545	4,266
Agricultural motors	5,908	5,766	6,398	8,906	10,062	10,461
of which:						
diesel powered	4,333	4,343	5,146	7,587	8,864	9,454
petrol powered	1,481	1,369	1,222	1,304	1,185	997

Source: UMA

ESTIMATE OF INDIRECT ENERGY CONSUMPTION

The data set out above in this chapter have been used to evaluate indirect consumption of energy contained in

- chemical fertilisers
- plant protection products
- animal feedstuffs
- agricultural machinery.

The year of reference is 1978, as data on these four categories of indirect energy input to agriculture are available for 1978. Data relating to more recent years are not available for all categories of indirect energy input.

Chemical Fertilisers

A tonne of nitrogenous fertiliser is taken to represent an energy content of 15.7×10^6 Kcal (or 1.57×10^7 Kcal which is taken as equivalent to a tonne oil). The 1,948,000 tonnes of nitrogenous fertiliser consumed in agriculture in 1978 would therefore have an indirect energy content of 3,058,000 TOE.

A tonne of phosphate fertiliser is taken to represent an energy content of 1.67×10^6 Kcal (or 0.167×10^7 Kcal which is taken as equivalent to a tonne oil). The 814,000 tonnes of phosphate consumed in agriculture in 1978 would therefore have an indirect energy content of 136,000 TOE.

A tonne of potash fertiliser is taken to represent an energy content of 1.91×10^6 Kcal (or 0.191×10^7 Kcal which is taken as equivalent to a tonne oil). The 155,000 tonnes of potash consumed in agriculture in 1978 would therefore have an indirect energy content of 30,000 TOE.

A tonne of compound fertiliser is taken to represent an energy content of 3.82×10^6 Kcal (or 0.382×10^7 Kcal which is taken as equivalent to a tonne oil). The 2,244,000 tonnes of compound fertiliser consumed in agriculture in 1978 would therefore have an indirect energy content of 857,000 TOE.

The coefficients used to evaluate the energy content of fertilisers are those suggested by G. Leach.

Plant Protection Products

The energy content of plant protection products is taken as 30.59×10^6 Kcal (or 3.059×10^7 Kcal) per tonne. The 230,770 tonnes of plant protection products consumed in agriculture in 1978 would therefore have an indirect energy content of 706,000 TOE.

The coefficient of 30.59×10^6 Kcal is that suggested by G. Leach.

Animal Feedstuffs

The energy content of animal feedstuffs is taken as 3×10^6 Kcal (or 0.3×10^7 Kcal) per tonne. The 8,500,000 tonnes of feedstuffs consumed in 1978 would therefore have an energy content of 2,550,000 TOE.

The coefficient of 3×10^6 Kcal is that suggested by G. Leach.

Agricultural Machinery

'Consumption' of agricultural machinery was tentatively evaluated by the EIU at 200,000 tonnes in 1978 on the basis of new registrations as recorded by UMA. FAO suggests that the energy content of a kilo of agricultural machinery is 86.7 MJ (86,700 MJ per tonne) corresponding to 20.7×10^6 Kcal (2.07×10^7 Kcal). By applying this coefficient, the energy content of agricultural machinery consumed in 1978 is evaluated at 414,000 TOE.

Indirect Energy Consumption

Total indirect energy consumption in 1978 has been evaluated at 7,751,000 TOE, broken down as follows:

	TOE
Chemical fertilisers	
- nitrogen	3,058,000
- phosphate	136,000
- potash	30,000
- Compound	857,000
Plant protection products	706,000
Animal feedstuffs	2,550,000
Agricultural machinery	414,000

Total energy consumption (direct and indirect) in 1978 has been put at 9,919,000 TOE, of which indirect energy accounts for 78 per cent:

- direct energy	2,168,000 TOE
- indirect energy	7,751,000 TOE.

CONSUMPTION OF ENERGY IN AGRICULTURE IN
THE EUROPEAN COMMUNITY

LUXEMBURG

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

- LUXEMBURG

AGRICULTURE IN LUXEMBURG

The total area under cultivation was 130,060 hectares in 1980. In the decade since 1970, the area under cultivation has declined by 4 per cent. The contraction has been most evident in the area devoted to the growing of crops.

The structure of agriculture in Luxemburg is characterised by a high number of relatively large holdings, although the number of holdings is declining. From 1970 to 1978, the number of holdings fell by 28 per cent to 5,002; but the average size of holdings rose from 13.4 hectares in 1960 to 19.4 hectares in 1970 and to 25.9 hectares in 1978.

Table 8.1

Luxemburg: Number of Agricultural Holdings, 1970-1978

Size of Holding	1970		1977		1978	
(Hectares)	Number	%	Number	%	Number	%
1 - 5	1,481	21.3	986	19.0	962	19.2
5 - 10	994	14.3	604	11.6	581	11.6
10 - 20	1,547	22.3	852	16.4	795	15.9
20 - 50	2,619	37.7	2,110	40.5	1,975	39.5
50 and over	298	4.4	649	12.5	689	13.8
Total	6,939	100.0	5,201	100.0	5,002	100.0

Source: Eurostat

In 1978, 5.6 per cent of the active population was engaged in agriculture, forestry and fishing: in 1975 the proportion had been over 6 per cent.

Net value added by agriculture, at factor cost, has increased moderately from year to year, from FLux 2.2 billion in 1973 to FLux 2.6 billion in 1978 at current prices.

Agriculture contributed 4 per cent to gross national value added at factor cost in 1977, equivalent to FLux 3 billion, compared with 6 per cent five years earlier.

More than 80 per cent of the value of agricultural output, FLux 4.7 billion at current prices in 1978, is attributed to livestock and dairy farming. Pasture and grazing land account for 55 per cent of land in agricultural use; arable cultivation accounts for 44 per cent and the balance is made up of vineyards and horticulture.

In comparison with the findings of the Survey of Agriculture 1973, which were summarised in the EIU's earlier report, the Survey for 1980 shows a 10 per cent increase in the number of cattle and a 66 per cent decrease in the number of chickens.

Table 8.2

Luxemburg: Numbers of Livestock, 1973 and 1980

	1973	1980
Cattle	203,738	224,779
Pigs	89,839	79,315
Sheep	3,822	3,570
Horses	1,276	1,601
Chickens	382,963	131,115

Source: Survey of Agriculture - Service Central de la Statistique et des Etudes Economiques (STATEC)

DIRECT ENERGY CONSUMPTION

The data presented by OECD in Energy Balances and Energy Statistics are the main sources of information on consumption of energy in agriculture. OECD processes data supplied by the Ministry of Energy, and produces a series of data in which consumption of petroleum-based fuels and electricity in agriculture are identified.

Table 8.3

Luxemburg: National Energy Consumption[a], 1973-1978

(TOE million)

	1973	1974	1975	1976	1977	1978
Solid fuels	2.12	2.42	1.79	1.69	1.52	1.51
Petroleum products	1.55	1.46	1.25	1.38	1.37	1.44
Gas	0.18	0.26	0.28	0.26	0.29	0.33
Electricity	0.26	0.29	0.27	0.28	0.29	0.30
Total	4.10	4.44	3.58	3.61	3.47	3.57
of which:						
Agriculture	0.01	0.01	0.01	0.01	0.02	0.02

a direct final consumption

Source: OECD - Energy Balances

It is generally agreed that agriculture accounts for well under 1 per cent of national consumption of energy. OECD data show that in recent years the consumption of petroleum-based fuels and electricity in agriculture has been of the order of 10,000-20,000 TOE, equivalent to 0.4-0.6 per cent of national consumption.

Respondents at the Ministry of Agriculture accepted the OECD statistics as being reliable for recent years, but suggested that OECD had underestimated energy consumption in agriculture prior to 1977. In particular, it was argued that OECD had understated agricultural consumption of electricity and residual fuel oil.

Table 8.4 provides a summary of data extracted from Energy Statistics 1973-1978 published by OECD in 1980. The statistics are partial, relating only to direct consumption of petroleum-based fuels and electricity, but they identify both overall national consumption of energy and consumption in agriculture, and provide a time series of data which serves to illustrate the trend.

In 1978, consumption of petroleum-based fuels and electricity in agriculture was put at 21,000 TOE by OECD, equivalent to 0.6 per cent of total national consumption. In 1973, agriculture had taken up 0.3 per cent of national consumption of energy (13,000 TOE), according to the same source, but this figure is generally considered as being too low. OECD does not attribute any significant consumption of electricity to agriculture in 1973, but in 1974 agriculture is shown as taking up 50 million KWH, equivalent to 1.4 per cent of national consumption of electricity. In subsequent years, consumption of electricity in agriculture increased to reach 72 million KWH in 1978, equivalent to 2 per cent of national consumption.

Residual fuel oil was the most important source of direct energy input in agriculture in 1978: 11,000 TOE of residual fuel oil accounted for 52 per cent of total energy input in agriculture, and for 2.4 per cent of total national consumption of residual fuel oil. Consumption of residual fuel oil in agriculture doubled since 1976 when OECD recorded consumption in agriculture for the first time.

Small amounts of kerosene continue to be used in agriculture, although usage has fallen and OECD has not recorded consumption in agriculture since 1974 when 1,000 TOE were consumed. Motor gasoline consumption in agriculture is also low and OECD last recorded consumption in 1973 when 2,000 TOE were consumed.

Table 8.4

Luxemburg: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Motor gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1973						
Agriculture						
- tonnes '000	2	1	10	-	-	-
- TOE '000	2	1	10	-	-	13
National consumption						
- tonnes '000	158	1	604	775	4,222[a]	-
- TOE '000	170	1	631	751	363	4,100
Share of agriculture (%)	1.2	100	1.6	-	-	0.32
1974						
Agriculture						
- tonnes '000	-	1	2	-	50[a]	-
- TOE '000	-	1	2	-	4	7
National consumption						
- tonnes '000	153	1	511	588	3,423[a]	-
- TOE '000	164	1	534	570	294	4,440
Share of agriculture (%)	-	100	0.35	-	1.4	0.16

(continued)

Table 8.4 (continued)

Luxemburg: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Motor gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1975						
Agriculture						
- tonnes '000	-	-	4	-	55[a]	-
- TOE '000	-	-	4	-	5	9
National consumption						
- tonnes '000	180	-	489	454	3,110[a]	-
- TOE '000	193	-	511	440	267	3,580
Share of agriculture (%)	-	-	0.8	-	1.9	0.25
1976						
Agriculture						
- tonnes '000	-	-	4	5	58[a]	-
- TOE '000	-	-	4	5	5	14
National consumption						
- tonnes '000	208	-	507	524	3,310[a]	-
- TOE '000	223	-	530	508	285	3,610
Share of agriculture (%)	-	-	0.75	1.0	1.8	0.39

(continued)

Table 8.4 (continued)

Luxemburg: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Motor gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1977						
Agriculture						
- tonnes '000	-	-	4	9	64[a]	-
- TOE '000	-	-	4	9	6	19
National consumption						
- tonnes '000	228	-	515	480	3,408[a]	-
- TOE '000	245	-	538	465	293	3,470
Share of agriculture (%)	-	-	0.75	1.9	2.0	0.55
1978						
Agriculture						
- tonnes '000	-	-	4	11	72[a]	-
- TOE '000	-	-	4	11	6	21
National consumption						
- tonnes '000	244	-	560	475	3,502[a]	-
- TOE '000	262	-	585	460	301	3,570
Share of agriculture (%)	-	-	0.7	2.4	2.0	0.59

a KWH million; b totals for national consumption include petroleum-based fuels not used in agriculture such as liquefied gas, aviation gasoline and jet fuel, non-energy petroleum products, coal, natural gas and blast furnace gas

Source: EIU calculations based on data from Organisation for Economic Cooperation and Development

The trend since 1973 has been for national consumption of energy to decline, from 4,100,000 TOE in 1973 to 3,570,000 TOE in 1978. The declining trend has not been consistent, however, and increases in national energy consumption were recorded by OECD in 1974, 1976 and 1978 when consumption rose by 3 per cent on the previous year. Over the five-year period, energy consumption has fallen by 13 per cent, comparing 1973 and 1978: this is equivalent to an average annual reduction of 3 per cent.

Consumption of petroleum-based fuels and electricity in agriculture reached a peak of 21,000 TOE in 1978. Consumption in 1978 was 62 per cent higher than in 1973, and three times the amount attributed to agriculture in 1974 by OECD. Persons interviewed by the EIU at SER and STATEC take the view that the trend which emerges from OECD statistics is unrealistic. Dealing with small quantities rounded off to the nearest thousand or million can distort trends, and respondents suggested that the increase in energy input in agriculture over the five years from 1973 to 1978 was probably of the order of 15-20 per cent.

ENERGY COSTS

The relative burden of the cost of energy to agriculture has remained constant in the period 1973 to 1978 at 6-7 per cent of the total cost of goods and services purchased by farmers. Energy is the fourth largest input to agriculture, following feedstuffs (38 per cent), fertilisers (19 per cent) and maintenance and repairs (12 per cent).

Table 8.5

Luxemburg: Purchases of Goods and Services by the Agricultural Sector, 1973-1978

(FLux million and percentages)

	1973	1976	1977	1978
Value of total purchases	1,338	2,029	1,962	1,683
	%	%	%	%
of which:				
Feedstuffs	50.0	51.1	47.9	38.1
Fertilisers	14.3	14.9	16.7	19.0
Maintenance and repair of machinery and tools	10.7	8.5	10.4	11.9
Energy	7.1	6.4	6.3	7.1

Source: EIU calculations based on data provided by Eurostat

In the five years to 1978, the cost of goods and services bought in by farmers rose by 26 per cent to FLux 1,683 million, an average annual rate of growth of 4.7 per cent. In the same period, the cost of energy to farmers increased at the same rate to reach FLux 120 million in 1978.

INDIRECT ENERGY

CONSUMPTION OF FERTILISERS

Information is collected by the Service d'Economie Rurale (SER) on the use of fertilisers in Luxemburg agriculture, and the figures can serve as a basis for estimating the energy content of fertilisers used in Luxemburg. In the 1978/79 season, 28,000 tonnes of fertiliser were used, of which 50 per cent were nitrogenous fertilisers.

Table 8.6

Luxemburg: Consumption of Fertilisers, 1971/72-1978/79

(tonnes '000 of fertiliser element)

	Type of fertiliser		
	N	P_2O_5	K_2O
1971/72	12	8	8
1972/73	12	7	8
1973/74	12	7	8
1974/75	12	7	8
1975/76	14	7	9
1976/77	15	7	8
1977/78	14	7	8
1978/79	14	6	8

Source: Service d'Economie Rurale (SER)

Consumption of fertilisers in Luxemburg is comparatively high, particularly of nitrogen and potash. The application of nitrogen and potash in Luxemburg is some 50-60 per cent greater per hectare than the average for the European Community. Average application rates per hectare for the three main types of fertilisers - nitrogen (N), phosphate (P_2O_5) and potash (K_2O) - in Luxemburg and the European Community are shown in Table 7.

Table 8.7

Luxemburg: Average Application of Fertilisers, 1971/72-1978/79

(kg/ha)

	Type of fertiliser					
	Luxemburg			European Community		
Season	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1971/72	89	59	60	52	47	42
1972/73	88	53	60	56	50	45
1973/74	94	51	58	60	50	48
1974/75	90	50	60	57	40	40
1975/76	104	56	65	62	40	39
1976/77	119	52	64	65	43	43
1977/78	106	50	62	68	45	44
1978/79	107	51	61	...	...	...

Source: EIU calculations based on data obtained from SER and Eurostat

Luxemburg produces phosphate fertiliser but imports other fertilisers, mainly from Belgium.

The indirect consumption of energy represented by the use of fertilisers in Luxemburg has been calculated on the basis of data obtained from the SER and from a study undertaken by Energy Research Limited (ERL). In recent years, usage of fertilisers has represented an indirect energy consumption of 25,000 TOE a year.

If it is assumed that the structure of agriculture in Luxemburg is similar to that found in Belgium, it can be deduced that fertilisers account for 15-20 per cent of total indirect energy consumption in agriculture, and that total indirect energy consumption is of the order of 130,000-160,000 TOE. The relative importance of fertilisers among indirect energy inputs to agriculture is believed to be higher in Luxemburg than in Belgium, probably by about 50 per cent, and the indirect consumption of energy in agriculture in Luxemburg could therefore be of the order of 80,000-100,000 TOE in very round numbers.

Table 8.8

Luxemburg: Indirect Energy Consumption in the Form of Fertilisers, 1971/72-1978/79

(TOE '000)

	Nitrogenous	Phosphates	Potash	Total
1971/72	19	2	1	22
1972/73	19	2	1	22
1973/74	19	2	1	22
1974/75	19	2	1	22
1975/76	22	2	2	26
1976/77	24	2	1	27
1977/78	22	2	1	25
1978/79	22	2	1	25

Source: EIU calculations based on data obtained from SER and ERL

AGRICULTURAL MACHINERY

The Service Central de la Statistique et des Etudes Economiques compiles statistics of registered agricultural machinery. Tractors are normally the most numerous of agricultural machines, and the number in use has risen from 8,000 in 1970 to 9,579 in 1980, an increase of close on 20 per cent. Mechanical hoes have declined steadily from 4,172 units in 1974 to 3,493 units in 1980, and the marked reduction in the number of mechanical milking machines in use reflects both a reduction in the herd of milking cows which numbered 71,183 cows in 1975 but had been reduced to 67,830 cows in 1980 and an increase in the average size of farm holdings.

Table 8.9

Luxemburg: Registered Agricultural Machinery in Use, 1974-1980

(units)

	1974	1975	1976	1977	1978	1979	1980
Agricultural tractors	8,904	9,181	9,270	9,210	9,234	9,368	9,579
Harvesters threshers	1,882	1,873	1,867	1,845	1,893	1,910	1,848
Mechanical hoes	4,172	4,062	3,958	3,853	3,860	3,587	3,493
Presses-gatherers	3,720	3,685	3,632	3,585	3,496	3,428	3,347
Manure loaders	2,975	3,066	3,113	3,110	3,080	3,121	3,082
Mechanical milking machines	4,052	3,962	3,755	3,587	3,373	3,236	3,069
Milk refrigerators	1,787	1,899	1,956	2,050	2,018	1,956	1,952

Source: STATEC, Recensement de l'Agriculture, 1975, 1976, 1977, 1978, 1979, 1980, 1981

The EIU suggests that the indirect energy content of machinery (tractors, harvesters and mechanical hoes) could have been of the order of 20,000 TOE in 1978.

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

THE NETHERLANDS

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY - THE NETHERLANDS

Page

AGRICULTURE IN THE NETHERLANDS

The area under cultivation in the Netherlands was 2.05 million hectares in 1979, a marginal decrease since 1970 when the area under cultivation was 2.1 million hectares.

The number of agricultural holdings of 1 hectare and over in 1978 was 134,377, 18 per cent fewer than in 1970. The largest category by size of holding are farms with 10 to 20 hectares which accounted for 30 per cent of the total number of farms in 1978: farms of 10 to 50 hectares accounted for 52 per cent of the total number.

Table 9.1

Netherlands: Number and Area of Agricultural Holdings[a], 1970-1978

Area (hectares)	1970	1977	1978	% 1978
1 - 5	42,497	33,029	32,473	24,1
5 - 10	39,155	28,889	27,970	20,8
10 - 20	52,079	41,191	39,887	29,7
20 - 50	27,881	30,407	30,444	22,7
50 and over	2,507	3,507	3,603	2,7
Total	164,119	137,023	134,377	100,0

a with 1 hectare and over

Source: Eurostat

An analysis of agricultural holdings by type of holding, prepared by the Centraal Bureau voor de Statistiek (CBS), is useful in that it reveals the relative importance of pasture, arable, horticulture and combined farming. The figures for the total number of holdings cannot be compared directly with those extracted from Eurostat data and reproduced in the table above. The CBS groups holdings according to the number of 'standard agricultural units' which a holding represents, the number of units being related to the degree of intensity of a particular agricultural activity.

Pasture farming remains the main activity, accounting for 64 per cent of holdings in 1980: the proportion was the same in 1971, but the number of holdings with pasture as their main activity has declined by 19 per cent in the decade.

Horticulture is the second most important agricultural activity and a sector with high energy requirements. In 1980 there were 28,700 holdings engaged in horticulture, of which 42 per cent with cultivation mainly under glass. The number of horticultural holdings has declined by 22 per cent since 1971, but the number of holdings cultivating under glass has fallen by only 15 per cent.

Arable farming is of relatively minor importance, and the number of holdings engaged in arable farming is no greater than the number engaged in horticulture in the open.

Agriculture provides employment for 6 per cent of the active population, and accounts for some 4 per cent of the Gross National Product. Agriculture is the sixth largest sector of economic activity in the Netherlands.

Table 9.2

Netherlands: Number of Agricultural Holdings[a] by Type of Activity, 1971-1980

	Total	Pasture	Arable	Horticulture open	Horticulture under glass	Mixed
1971	178,621	114,121	15,420	22,537	14,152	12,391
1975	166,197	108,503	14,510	20,149	12,986	10,049
1978	154,604	99,656	15,944	17,973	12,452	8,579
1979	151,707	97,539	16,107	17,778	12,185	8,098
1980	144,994	92,448	16,715	16,609	12,050	7,172
% 1980	100	64	12	11	8	5

a excluding holdings of less than 10 'standard agricultural units'

Source: Centraal Bureau voor de Statistiek (CBS) -
Landbouwtelling 1971, 1975, 1978, 1979, 1980.

ENERGY COSTS

The Landbouw-Economisch Instituut has estimated the cost of direct energy inputs to agriculture on the basis of a representative sample of farm accounts.

The analysis shows that the cost of energy to Dutch agriculture was of the order of Florins 1,000 million in 1979, and that the cost of energy had doubled in the five years from 1975 to 1979.

Table 9.3

Netherlands: Energy Costs in Agriculture 1975-1979

(Fl million at current prices)

1975	1976	1977	1978	1979	Average annual growth (%)
480	610	675	690	980	19.5

Source: Landbouw-Economisch Instituut Den Haag (LEI)

VOLUME OF DIRECT ENERGY CONSUMPTION

DIRECT ENERGY SOURCES - OECD DATA

OECD statistics can be used to determine the total direct energy consumption of the Netherlands. The data set out in Table 9.4 have been extracted from Energy Balances of OECD Countries 1973-1978, which was published in 1980.

The OECD statistics of energy consumption show the growing importance of natural gas as a fuel in the Netherlands. In 1973, natural gas was the second largest source of energy after petroleum products, accounting for 39.6 per cent of total energy consumption. In 1978, natural gas was the largest single source of energy, accounting for close on 46 per cent of total energy consumption: petroleum products had fallen to second place with a 42 per cent share.

The statistics provided by OECD in Energy Balances do not identify in any detail the utilisation of energy in agriculture. Another statistical series compiled by OECD and published under the title 'Energy Statistics' provides additional data on energy consumption by type of fuel and sector of activity. As far as agriculture is concerned, the OECD statistics are partial and their use is limited by the fact that consumption of natural gas in agriculture is not broken out separately. As a consequence, the OECD statistics show agriculture accounting for a share of national energy consumption of no more than 0.6 per cent to 0.8 per cent in the period 1973 to 1978. If consumption of natural gas in agriculture is taken into account, the share rises to 4-6 per cent of national energy consumption. Relevant data extracted from Energy Statistics 1973-1978 (published in 1980) are reproduced in the Table 9.5. The fuels identified in the table are those for which there is an entry for agriculture in the original source, and the grand totals shown for national energy consumption are consequently far greater than the totals of the individual fuels shown in the table.

Table 9.4

Netherlands: National Energy Consumption[a], 1973-1978

	1973		1976		1977		1978	
	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent	TOE (mn)	Per cent
Solid fuels	1.57	3.2	1.53	2.8	1.47	2.8	1.69	3.1
Petroleum products	24.63	49.6	24.52	45.6	23.00	43.9	22.84	42.3
Natural gas	19.66	39.6	23.26	43.3	23.46	44.7	24.60	45.6
Electricity	3.81	7.7	4.41	8.2	4.51	8.6	4.82	8.9
National total	49.67	100.0	53.73	100.0	52.44	100.0	53.95	100.0
of which:								
Agriculture	0.35	0.7	0.34	0.6	0.35	0.7	0.43	0.8

a direct final consumption

Source: OECD - Energy Balances

Table 9.5

Netherlands: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Liquefied gas	Motor gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1973							
Agriculture							
- tonnes '000	36	20	4	244	32	-	-
- TOE '000	41	21	4	255	31	-	352
Total consumption							
- tonnes '000	475	3,556	1,126	7,303	3,001	51,282[a]	-
- TOE '000	542	3,816	1,177	7,632	2,908	4,410	49,670
Share of agriculture (%)	7.6	0.6	0.3	3.3	1.1	-	0.7
1974							
Agriculture							
- tonnes '000	37	20	2	220	29	272[a]	-
- TOE '000	42	21	2	230	28	23	346
Total consumption							
- tonnes '000	485	3,202	555	5,955	2,431	47,163[a]	-
- TOE '000	553	3,436	580	6,223	2,356	4,056	48,790
Share of agriculture (%)	7.6	0.6	0.3	3.7	1.2	0.6	0.7

(continued)

Table 9.5 (continued)

Netherlands: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Liquefied gas	Motor gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1975							
Agriculture							
- tonnes '000	36	25	-	216	2	318[a]	-
- TOE '000	41	27	-	226	2	27	323
Total consumption							
- tonnes '000	511	3,475	475	6,171	1,788	47,664[a]	-
- TOE '000	583	3,729	496	6,449	1,733	4,099	48,300
Share of agriculture (%)	7.0	1.0	-	3.5	0.1	0.7	0.7
1976							
Agriculture							
- tonnes '000	36	30	-	223	4	313[a]	-
- TOE '000	41	32	-	233	4	27	337
Total consumption							
- tonnes '000	723	3,659	455	7,160	2,301	51,291[a]	-
- TOE '000	824	3,926	475	7,482	2,230	4,411	53,730
Share of agriculture (%)	5.0	0.8	-	3.1	0.2	0.6	0.6

(continued)

Table 9.5 (continued)

Netherlands: Uses of Direct Energy in Agriculture by Fuel Type, 1973-1978

	Liquefied gas	Motor gasoline	Kerosene	Gas/ diesel oil	Residual fuel oil	Electricity	Total[b]
1977							
Agriculture							
- tonnes '000	33	35	-	232	3	324[a]	-
- TOE '000	38	38	-	242	3	28	349
Total consumption							
- tonnes '000	836	3,800	365	6,804	1,621	52,457[a]	-
- TOE '000	953	4,077	381	7,110	1,571	4,511	52,440
Share of agriculture (%)	4.0	0.9	-	3.4	0.2	0.6	0.7
1978							
Agriculture							
- tonnes '000	75	-	-	295	2	348[a]	-
- TOE '000	86	-	-	308	2	30	426
Total consumption							
- tonnes '000	1,204	3,954	364	7,017	1,863	56,014[a]	-
- TOE '000	1,373	4,243	380	7,333	1,805	4,817	53,950
Share of agriculture (%)	6.2	-	-	4.2	0.1	0.6	0.8

a KWH million; b totals for national consumption include fuels not identified as being used in agriculture by OECD, and in particular natural gas

Source: OECD - Energy Statistics

Even though the OECD statistics are incomplete as far as agriculture is concerned, they are a useful indication of the consumption of petroleum products in agriculture. There was a marked increase in the consumption of diesel oil in 1978, which reached 308,000 TOE compared with some 240,000 TOE in preceding years: in 1978, agriculture accounted for over 4 per cent of national consumption of diesel oil.

Consumption of liquefied gas in agriculture is again a relatively high proportion of the national total, varying from 4 to 8 per cent a year in the period 1973 to 1978.

OECD figures show that in the period 1973 to 1978 consumption of petroleum products and electricity in agriculture rose by 21 per cent, equivalent to an average annual rate of growth of 4 per cent.

DIRECT ENERGY CONSUMPTION - WETENSCHAPPELIJKE RAAD VOOR HET REGERINGSBELEID (WRR)

The WRR undertook a detailed analysis of energy consumption in the Netherlands in the year 1977. The analysis was based on data provided by the Centraal Bureau voor de Statistiek and the Dutch Central Planning Office. The scope of the analysis was comparable with that undertaken for 1972 by the Landbouw-Economisch Instituut (LEI).

Table 9.6

Netherlands: Supply and Final Use of Energy in 1972 and 1977

	1972		1977	
	TOE million	Per cent	TOE million	Per cent
1. Total supply for domestic use	55.0	100	63.3	100
Subtract use in energy sector	(11.0)	(20)	(12.6)	(20)
Use of energy in final form	44.0	80	50.7	80
of which:				
- fixed energy	2.3	4	1.6	3
- liquid energy	16.4	30	21.1	33
- natural gas	21.7	39	23.4	37
- electricity	3.6	7	4.6	7
2. Destination by sectors or branches of industry (including losses in transformation)				
Government and private households	18.7	34	15.7	25
Private enterprise	36.3	66	39.3	62
of which:				

(continued)

Table 9.6 (continued)

Netherlands: Supply and Final Use of Energy in 1972 and 1977

	1972		1977	
	TOE million	Per cent	TOE million	Per cent
- agriculture and fisheries	2.3	4	2.6	4
- food processing	2.1	4	1.7	3
- other industry excluding construction	31.9	58	19.1	30
- construction			0.9	1
- services			4.9	8
- transport			5.8	9

Source: Landbouw-Economisch Instituut (1972), Wetenschappelijke Raad voor het Regeringsbeleid (1977)

OECD and WRR statistics on national final consumption of energy by type of fuel are very close, with OECD putting consumption higher by 3 per cent - 52.4 TOE million compared with 50.7 TOE million.

The WRR calculated that agriculture and fisheries took up 2.6 TOE million in 1977, equivalent to 4.1 per cent of total energy supply and 5.1 per cent of energy in final consumption. The WRR breaks down the 2.6 TOE million used in agriculture and fisheries as follows:

- natural gas	2,100,000 TOE
- petroleum products	400,000 TOE
- electricity	100,000 TOE

OECD and WRR data lead to the conclusion that in 1977 some 9 per cent of total consumption of natural gas was taken up by agriculture and fisheries. Moreover, some 80 per cent of energy consumed in agriculture and fisheries was in the form of natural gas.

DIRECT ENERGY CONSUMPTION - MINISTRY OF AGRICULTURE

The Ministry of Agriculture evaluated energy consumption in agriculture in 1973, 1978 and 1979, and arrived at estimates which put consumption of energy far above the estimates arrived at by the OECD, LEI and WRR.

The Ministry of Agriculture puts total energy consumption, excluding electricity, at 3,445,000 TOE in 1973, compared with 2,300,000 TOE estimated by the LEI for 1972. Total consumption is put at 3,470,000 TOE in 1978 by the Ministry of Agriculture compared with 2,600,000 TOE in 1977 as estimated by the WRR.

Table 9.7

Netherlands: Energy Input in Agriculture 1973 and 1978

(TOE '000)

Source of Energy[a]	1973	1978	1979
Natural gas	1,500	2,625	2,467
Residual fuel oil	950	120	331
Motor gasoline	20	40	42
Gas/diesel oil and kerosene	915	625	404
Liquid petroleum gas	60	60	55
Total	3,445	3,470	3,299

a excluding electricity

Source: Ministerie van Landbouw en Visserij

While consumption of energy declined by 4 per cent from 1973 to 1979, the estimates prepared by the Ministry of Agriculture show that consumption of natural gas increased by 64 per cent in the six-year period. Natural gas has replaced residual fuel oil and gas/diesel oil.

There has been a marked increase in consumption of motor gasoline, but this fuel accounted for less than 2 per cent of total energy consumption in agriculture in 1979.

Not only are the Ministry's estimates of total energy consumption in agriculture out of line with estimates arrived at by the LEI and WRR, but the breakdown of the Ministry's totals by type of petroleum products is out of line with OECD statistics. Indeed, the reason for the high estimates put forward by the Ministry is the high figures for consumption of residual fuel oil and for gas/diesel oil. The Ministry's estimates of consumption of natural gas are broadly comparable with the estimate put forward by the WRR. A comparison between the figures put forward by the Ministry and by OECD is set out below: not only do the figures differ but the trends are not consistent.

Table 9.8

Netherlands: Comparison of Estimates of Consumption of Petroleum-Based Fuels in Agriculture, 1973 and 1978

(TOE '000)

	1973		1978	
	OECD	Ministry Agriculture	OECD	Ministry Agriculture
Residual fuel oil	31	950	2	120
Motor gasoline	21	20	...	40
Gas/diesel oil and kerosene	259	915	308	625
Liquid petroleum gas	41	60	86	60
Total	352	1,945	396	845

Source: OECD, Ministerie van Landbouw en Visserij

It is difficult to reconcile such wide differences. Even though respondents felt that OECD tended to understate the amount of energy taken up by agriculture, that alone could not explain the variances.

Some respondents suggested that the Ministry had overstated consumption of petroleum-based fuels, at a time when the possibility of rationing or controlling the allocation of petroleum-based fuels was being considered, so as to ensure that agriculture would receive an adequate allocation of petroleum-based fuels.

The estimates put forward by the Ministry of Agriculture for energy consumption in agriculture in 1979 are in total in line with the estimate for 1978, but there has been a reduction in consumption of gas/diesel oil (-35 per cent) and a marked increase in consumption of light and heavy fuel oil (+176 per cent).

The 1979 figures provided by the Ministry of Agriculture can be further broken down by type of fuel and by activity.

Table 9.9

Netherlands: Direct Energy Input in Agriculture by Type of Fuel[a] and Activity, 1979

(TOE '000)

	Natural gas	Heavy fuel oil	Light fuel oil	Gas/diesel oil, kerosene	Gasoline	LPG	Total
Heating							
Horticulture	2,400	118	85	-	-	-	2,603
Animal rearing	60	-	117	-	-	55	232
Cultivation/drying	7	-	11	-	-	-	18
Transport and machinery							
Horticulture	-	-	-	43	17	-	60
Animal rearing	-	-	-	204	17	-	221
Cultivation	-	-	-	149	8	-	157
Other	-	-	-	8	-	-	8
Total	2,467	118	213	404	42	55	3,299

a excluding electricity

Source: Ministerie van Landbouw en Visserij

DIRECT ENERGY CONSUMPTION - COMPARISON OF SOURCES

There is an evident lack of reliable statistical data on direct consumption of energy in agriculture by type of fuel, by type of farm and by geographical region. Three sources used in the previous report prepared by the EIU, of which two connected with the Landbouwhogeschool (Agricultural Faculty) at Wageningen, are no longer available. This is due to mergers and reorganisations of institutes.

The four sources of data analysed in detail in an earlier chapter of this report are the best sources available, despite shortcomings in coverage and comparative inconsistencies:

- OECD
- Landbouw-Economisch Instituut (LEI)
- Wetenschappelijke Raad voor het Regeringsbeleid (WRR)
- Ministry of Agriculture

The information obtained from these four key sources is summarised and compared in the following table. The margin of error in estimates of energy consumption in agriculture is clearly wide, but some reassurance can be drawn from the closeness of estimates put forward by the OECD, LEI and WRR. The Ministry of Agriculture is out of line with the other sources, except for estimates of consumption of natural gas which has, however, been the main type of fuel in recent years.

In recent years, natural gas has accounted for 80-90 per cent of direct energy consumed in agriculture - say 2.5 million TOE out of a total of 3 million TOE.

Respondents were vague as to whether the figures for direct consumption of energy in agriculture took into account consumption of energy for household purposes. The EIU takes the view that the sources quoted here were unable to make any clear distinction between professional and household use of energy.

Table 9.10

Netherlands: Energy Consumption in Agriculture: Summary of Data, 1972-1978

(TOE '000)

	1972	1973		1977		1978	
	LEI	OECD	Ministry Agriculture	OECD	WRR	OECD	Ministry Agriculture
Natural Gas							
National consumption	21,700	19,660	...	23,460	23,400	24,600	...
Agricultural consumption	...	...	1,500	...	2,100	...	2,625
% of national consumption			7.6		9.0		10.7
Petroleum Products							
National consumption	16,400	24,630	...	23,000	21,100	22,840	...
Agricultural consumption	...	352	1,945	321	400	396	845
% of national consumption		1.4	7.9	1.4	1.9	1.7	3.7
Electricity							
National consumption	3,600	4,410	...	4,511	4,600	4,817	...
Agricultural consumption	...	...	...	28	100	30	...
% of national consumption				0.6	2.2	0.6	

Source: OECD, LEI, WRR, Ministerie van Landbouw en Visserij

It is evident that natural gas has increased in importance as a source of energy, both at the national level and in agriculture. On the basis of the WRR estimates, natural gas accounted for 81 per cent of energy consumed in agriculture in 1977, and the Ministry of Agriculture data show natural gas with a share of 76 per cent in 1978 and 75 per cent in 1979.

DIRECT ENERGY CONSUMPTION IN HORTICULTURE

In the previous report prepared by the EIU, an analysis of energy input in 1970 by type of farm and activity had been made available by the Instituut voor Landbouwtechniek en Rationalisatie at Wageningen. The Instituut voor Landbouwtechniek en Rationalisatie has since been merged with other research institutes but the table which appeared in the previous report is reproduced below because it serves to highlight the importance of horticulture in the consumption of energy in agriculture.

Table 9.11

Netherlands: Energy Input in Agriculture, 1970

(Teracalories)

	Arable production	Cattle and stock breeding	Horticulture
Fuel for:			
i. Tractors	878	1,510	249
ii. Field implements and machinery	457	-	-
Lubricants	40	45	7
Drying operations	80	-	-
Heating (glasshouses etc)	-	-	24,500
Electricity	79	312	827
Horses[a]	486	638	66
Total	2,020	2,505	25,649

a imputed value

Source: Instituut voor Landbouwtechniek en Rationalisatie, Wageningen

Horticulture accounts for some 80-90 per cent of direct energy consumed in agriculture, and the heating of glasshouses accounts for over 90 per cent of energy used in horticulture. Probably for this reason, more data is available on consumption of energy in horticulture.

The Instituut voor Landbouwtechniek en Rationalisatie put consumption of energy in the heating of glasshouses at 2,450,000 TOE in 1970. The LEI puts the amount at 2,563,000 TOE in 1978, a 5 per cent increase in eight years. This comparison confirms the opinions of many respondents that consumption of energy in horticulture had not risen appreciably during the past five years, due to greater efficiency in the use of energy.

Table 9.12

Netherlands: Fuel Used in Heating and Driving Tractors in Glasshouses, 1976-1978

	1976	1977	1978	1976 TOE '000	1977 TOE '000	1978 TOE '000
Natural gas (m3 million)	2,902	2,875	3,216	2,177	2,156	2,412
Residual fuel oil (kg million)	150	213	106	141	200	100
Paraffin (litres million)	57	38	46	45	30	36
Light fuel oil (litres million)	14	21	17	12	18	15
Diesel oil (litres million)	19.5	20.1	20.7	17.1	17.6	18.2
Motor gasoline (litres million)	20.5	20.8	21.3	16.3	16.6	17
Total				2,408.4	2,438.2	2,598.2

Source: LEI and EIU calculations

Consumption of energy in heating glasshouses and in powering tractors and related mechanical equipment used in glasshouses rose from 2,408,400 TOE in 1976 to 2,598,200 TOE in 1978, an increase of 8 per cent but it was reported that consumption was exceptionally high in 1978 due to the early onset of winter. It can be assumed that the diesel oil and motor gasoline identified in the above table were used to power tractors and related mechanical equipment.

The figures for consumption of energy in agriculture put forward by the LEI are in line with figures put forward by the WRR for 1977 and the Ministry of Agriculture for 1978 and 1979, and again show that horticulture takes up some 80-90 per cent of energy consumed in agriculture. Moreover, horticulture accounts for some 90 per cent of natural gas consumed in agriculture, and natural gas accounts for some 90 per cent of energy input in agriculture.

Since the 1960s, there has been a marked increase in the number of natural gas burning installations in horticulture. The Dutch Government has been prepared to cover the cost of installing natural gas equipment, as part of a general energy programme aimed at encouraging the use of a national fuel and reducing dependence on imported supplies of expensive petroleum products.

INDIRECT ENERGY CONSUMPTION

As at the time of the earlier report prepared by the EIU in 1974, the consultants could find few sources of data on indirect usage of energy in agriculture. The leading agricultural economic research institute, the LEI, has not undertaken such work, nor have the oil companies. The Landbouwstatistiek Department of the Centraal Bureau voor de Statistiek confirmed that no systematic attempt had yet been made to evaluate indirect energy consumption in agriculture.

Animal feedstuffs and fertilisers probably account for the greater part of indirect energy input in Dutch agriculture. In Belgium, these two items account for 80-90 per cent of total indirect energy input in agriculture, depending on sources, and the position may be similar in the Netherlands. The relative importance of the two items in Belgium is:

- animal feedstuffs	60-70 per cent
- fertilisers	15-20 per cent

Information on the energy content of animal feedstuffs is partial. The EIU was able to obtain from the CBS a breakdown of production costs of animal feedstuffs for the period 1971-1978, which shows that energy represents 1-2 per cent of the total cost of production. The data set out in the table below refer to plants employing a workforce of 50 persons or more. In the eight-year period, the energy content of the cost of production has risen from 0.75 per cent in 1971 to 1.5 per cent in 1978.

Table 9.13

Netherlands: Cost of Production of Animal Feedstuffs, 1971-1978

	1971		1972		1973		1974		1975		1976		1977		1978	
	Fl million	Per cent	Fl million	Per cent	Fl million	Per cent	Fl million	Per cent	Fl million	Per cent	Fl million	Per cent	Fl million	Per cent	Fl million	Per cent
Total cost	2,058.0	100.0	2,169.1	100.0	2,892.6	100.0	3,349.8	100.0	3,235.2	100.0	3,776.1	100.0	4,398.3	100.0	4,301.8	100.0
of which:																
- Energy	15.7	0.8	15.6	0.7	24.7	0.9	32.7	1.0	38.2	1.2	49.5	1.3	61.6	1.4	63.8	1.5
- Packing	33.5	1.6	36.7	1.7	43.3	1.5	49.7	1.5	57.7	1.8	56.8	1.5	62.0	1.4	54.4	1.3

Source: CBS, Voorburg

The Benelux countries are reputed to use the highest concentration of fertiliser per hectare among Community countries, and the usage of nitrogenous fertiliser in the Netherlands is particularly high. While the application of phosphate and potash fertilisers has been reduced since 1970, increasing quantities of nitrogen are being used.

Table 9.14

Netherlands: Use of Fertilisers on Land under Cultivation, 1973-1979

(kg per hectare)

	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)
1973/74	196	52	59
1974/75	209	44	54
1975/76	218	39	49
1976/77	207	44	54
1977/78	217	42	54
1978/79	217	39	52

Source: Ministerie van Landbouw en Visserij

An indication of the usage of nitrogenous fertiliser on pasture and arable land is provided in the following table. The distinction between large and small farms is made on the basis of the number of standard agricultural units per holding, and the criterion has been modified in the period covered by the Table, 1972-73 to 1977-78. In 1972-73, a large farm was defined as having 103 units or more, for 1974-75 and 1975-76 the number of units was raised to 118 units or more, in 1976-77 the threshold was 123 units and in 1977-78 the threshold was 128 units.

Table 9.15

Netherlands: Nitrogenous Fertiliser Usage on Arable Land and Pasture, 1972-1978

(kg per hectare)

	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
Large Farms						
Arable						
North clay area	123	128	133	138	139	139
Veenkoloniën and North sandy area	162	169	165	181	174	184
Ysselmeer polders and similar	135	130	136	143	142	136
South West clay area	142	141	143	141	149	150
Pasture						
North clay pasture area	199	234	272	285	302	306
North Veen pasture area	175	211	239	244	292	309
West pasture area	152	162	170	180	203	221
North sandy area	252	284	282	301	299	320
East and Central sandy area	217	220	250	249	272	308
South sandy area	256	259	261	277	266	330
Small Farms						
Arable						
Clay areas	124	124	120	144	142	131
Veenkoloniën and North sandy area	160	160	161	159	161	161
Pasture						
Clay and Veen areas	177	177	175	177	207	179
Sandy areas	217	217	218	237	218	239

Source: LEI, Kunstmestverbruik op de LEI-bedrijven

Some 445,000 tonnes of nitrogenous fertiliser were used in 1978-79, compared with 405,000 tonnes in 1970-71, an increase of close on 10 per cent in a decade. About 75 per cent of nitrogenous fertiliser used in the Netherlands is produced locally. Dutch producers of nitrogenous fertiliser are oriented towards foreign markets: of 1,518,000 tonnes produced in 1978-79, 1,235,000 tonnes were exported. Potash fertiliser used in the Netherlands is largely imported.

Table 9.16

Netherlands: Consumption of Fertilisers, 1973-1979

(tonnes '000 of fertiliser element)

	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)
1973/74	412	110	123
1974/75	435	93	113
1975/76	453	81	101
1976/77	430	92	114
1977/78	447	87	111
1978/79	443	81	107

Source: Ministerie van Landbouw en Visserij

The amount of energy represented by fertilisers used in agriculture has been calculated on the basis of data obtained from the Ministry of Agriculture and from the findings of a study undertaken by Energy Research Limited (ERL). The importance of nitrogenous fertiliser as an indirect source of energy is evident.

Table 9.17

Netherlands: Indirect Energy Consumption in the Form of Fertilisers, 1973-1979

(TOE '000)

	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
Nitrogenous	659	696	725	688	715	709
Phosphates	33	28	24	28	26	24
Potash	21	19	17	19	19	18
Total	713	743	766	735	760	751

Source: EIU calculations based on data obtained from the Ministerie van Landbouw en Visserij and ERL (Energy Use in EEC Agriculture and Food Processing)

CONSUMPTION OF NON-ENERGY PETROLEUM PRODUCTS

There is little information on the use of non-energy petroleum-based products in Dutch agriculture. In the previous report, the EIU quoted figures prepared by the Instituut voor Landbouwtechniek en Rationalisatie on the use of lubricants in 1970: the figures are reproduced below for ease of reference.

Table 9.18

Netherlands: Usage of Lubricants in Agriculture, 1970

(Tcals)

Arable farming	40
Animal rearing	45
Horticulture	7
Total	92

Source: Instituut voor Landbouwtechniek en Rationalisatie, Wageningen.

The Ministry of Agriculture estimates that at present annual consumption of lubricants and grease in agriculture and fisheries is of the order of 14,250 TOE (compared with 9,200 TOE in 1970, according to the Instituut voor Landbouwtechniek en Rationalisatie, for agriculture alone).

APPENDIX:

ENERGY CONSUMPTION IN THE AGRO-FOOD INDUSTRY

The Ministry of Agriculture has undertaken research into energy consumption in the agro-food industry, and published findings related to 1978. In that year, total direct energy consumption in the agro-food industry was put at 1,872,000 TOE, of which 73 per cent was accounted for by natural gas. By far the most important sector of the agro-food industry is the dairy sector which takes up 23 per cent of total energy input in the agro-food industry.

Although this information is not strictly relevant to an appraisal of the consumption of energy in agriculture, it was felt that it could be of interest to persons using this report. For this reason the information is provided as an appendix. It is stressed that none of the data relating to food processing industries has been taken into account when evaluating consumption of energy in agriculture.

Table 9.19

Netherlands: Final Use of Energy in the Agro-Food Industry by Sector, 1978

	Light fuels		Heavy fuels		Natural gas		Electricity		Total
	kg mn	TOE 000	kg mn	TOE 000	m3 mn	TOE 000	KWH mn	TOE 000	TOE 000
Slaughterhouses and meat-products	3	3	11	10	135	100	380	32	145
Dairy products	4	4	35	33	475	350	505	43	430
Milling	-	-	-	-	10	7	120	10	18
Margarine and oil	-	-	43	40	120	90	185	16	145
Vegetable and fruit processing	-	-	8	8	70	50	95	8	67
Bread, biscuit and cakes	3	3	3	3	110	80	135	11	100
Cacao, chocolate and confectionery	-	-	3	3	45	33	156	13	50
Animal feedstuffs	18	18	9	8	95	70	560	47	145
Alcohol and distilleries	-	-	-	-	35	25	20	2	30
Beer and malt	-	-	-	-	110	80	190	16	100
Soft drinks	-	-	-	-	30	20	45	4	25
Tobacco	-	-	-	-	25	20	90	8	30
Total	41	41	215	202	1,844	1,366	3,120	263	1,872

- insignificant or unavailable

Source: Ministerie van Landbouw en Visserij

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY

UNITED KINGDOM

1981

CONSUMPTION OF ENERGY IN AGRICULTURE IN THE EUROPEAN COMMUNITY – UNITED KINGDOM

AGRICULTURE IN THE UNITED KINGDOM

The number of farms in the United Kingdom is declining. In 1980, the total number of holdings was about 243,500, 5 per cent fewer than in 1975. The fall in numbers is most marked amongst the smaller full-time enterprises. Half the total number of holdings are capable of providing work for at least one full-time man (i.e. those of 250 standard-man-days (SMD) or more) and these account for over 90 per cent of total agricultural output. Large enterprises of 1,000 SMD, although accounting for only some 12 per cent of the total number, produced about half of total output in 1980. In Northern Ireland and Wales, the output of small-scale farmers is somewhat more important than in other parts of the United Kingdom.

The average area (including rough grazings) of a full-time farm enterprise of 250 SMD or more has risen since 1975 from 111 hectares to 116 hectares. The size of individual enterprises continues to increase. There has been an increase over the last five years in the average area under cereals from 30 to 37 hectares, while the average dairy herd has grown over this period by nearly 28 per cent from 40 to 51 cows. The average size of a beef breeding herd has stabilised at 18 cows, but the average ewe flock has risen to 181 breeding sheep compared with 168 in 1975. The average size of a pig breeding herd has increased from 23 to 34 sows (+48 per cent), while fattening herds reached an average size of 229 in 1980 compared with 161 in 1975.

In Great Britain, 66 per cent of agricultural holdings were wholly or mainly owner-occupied in 1980 compared with 54 per cent in 1960/61. The proportion of the total area held by owner-occupiers increased from 52 per cent in 1960/61 to 58 per cent in 1980. In Northern Ireland virtually all farmers are owner-occupiers.

Table 10.1

United Kingdom: Number of Agricultural Holdings, 1975 and 1980

Size of Holding[a] (Hectares)	1975 Number ('000)	1975 %	1980[p] Number ('000)	1980[p] %
0.1 - 19.9	108.2	42.9	96.9	41.0
20 - 49.9	73.2	29.0	68.0	28.8
50 - 99.9	41.7	16.5	41.5	17.5
100 and over	29.3	11.6	30.0	12.7
Total	252.3	100.0	236.4	100.0
Size of Enterprise[b] (SMD)[c]	**1975 Number ('000)**	**1975 %**	**1980[p] Number ('000)**	**1980[p] %**
Under 250	126.2	49.2	121.7	50.0
250 - 499	56.4	22.0	47.9	19.7
500 - 999	45.8	17.8	44.1	18.1
1,000 and over	28.3	11.0	29.8	12.2
Total	256.8	100.0	243.5	100.0

a excluding holdings with no crops or grass; b including holdings with no crops or grass; c standard-man-days; p provisional

Source: Ministry of Agriculture, Fisheries and Food (MAFF)

Capital investment in agriculture stood at an average of £ 255 million during 1969-1971, in 1976 amounted to £ 663 million and in 1979 to £ 1,018 million. A figure of £ 1,056 million is expected for 1980. At 1975 prices, capital investment increased by 3 per cent between 1976 and 1979, but fell by 10 per cent in 1980 compared with the previous year, owing to decreased spending on plant, machinery and vehicles.

Table 10.2

United Kingdom: Gross Fixed Capital Formation in Agriculture, 1973-1980

(per cent of value)

	1973	1974	1975	1976	1977	1978	1979	1980
Plant, machinery and vehicles	52.5	55.1	60.7	66.1	67.5	63.6	61.8	51.8
Buildings and works	47.5	44.9	39.3	33.9	32.5	36.4	38.2	48.2

Source: MAFF

Agriculture contributed 2.3 per cent of gross domestic product (GDP) in 1980, compared with 2.8 per cent in 1973. Agricultural workers of all kinds represented 2.7 per cent of the total civilian workforce in 1980, as against 2.9 per cent in 1973 and an average of 3.3 per cent during 1967-1969. In quantitative terms, the number of persons engaged in agriculture amounted to 651,000 in 1980, 7.5 per cent fewer than in 1973.

SOURCES OF DATA

The official sources of statistical data on direct consumption of energy in agriculture, and the only ones to provide a historical series of statistics which can be used to trace trends, are the OECD statistics on the energy balance of member states, and the Digest of United Kingdom Energy Statistics. The latter is produced by the Department of Energy, which also prepares the energy balances presented by the OECD; the two sources provide comparable figures, if account is taken of rounding of figures.

A further source of data is the Agricultural Development and Advisory Service (ADAS) which produced a report in 1976 entitled Energy Efficiency in Agriculture, revised in 1981. This source has the limitation of being a static study, but it does provide some information on indirect energy inputs. Other individuals who have written papers that are likewise static in their analyses, and who are quoted in this report, include Dr. D.J. White (MAFF), J.A. Tatchell (formerly ICI), D.A. Lewis (ICI) and G. Sheard (formerly Glasshouse Crops Research Institute). In addition, the Report of the Energy Working Party No 1 was published in 1974 by the Joint Consultative Organisation for Research and Development in Agriculture and Food. A complete list of references consulted appears in the Appendices.

A problem presented by most of the published material on this subject, as far as this report is concerned, is that the material treats the efficiency of energy in sectors of agriculture, rather than detailing actual national consumption of energy in agriculture. Thus many 'energy budgets' are given for particular crops or items of livestock, but methods of producing a given item vary so much from one farm and one year to another that grossing up from individual energy budgets to arrive at national energy consumption is frequently misleading and invalid. Also, energy budgets or energy inputs are calculated in various ways. For example, some give the energy value of fuel used in different field operations separately; others include this in their evaluation of each stage of cultivation and harvesting, making comparison of the constituents difficult. Again, some energy inputs are calculated on the basis of a tonne of output, others per hectare of land used. A selection of the most up-to-date energy budgets is given in the Appendices.

A further difficulty exists in that authors frequently refer to one another's calculations in their own papers, and it is not always possible to identify the origin of certain data.

This report presents first the figures of the OECD and the Digest of United Kingdom Energy Statistics on energy consumption. These statistics cover direct energy only. Following these are figures provided by Dr. White, which include indirect energy inputs and are expressed in terms of primary energy, that is they take account of the energy expended to make the electricity, fuel oil, etc. available to the farm. Insofar as more detailed data allow, each input is discussed in turn in terms of its contribution to agriculture. Most of the information at this level is in terms of primary energy. Finally, energy inputs for different crops and items of livestock are presented in the Appendices.

VOLUME OF DIRECT ENERGY CONSUMPTION

Figures derived from the Digest of United Kingdom Energy Statistics give a slightly higher value for energy consumption in agriculture than those derived from OECD energy balances. The difference is mainly in the petroleum products sector, but in percentage terms is small. Authors have based their works on the Digest figures, and so these have been taken as more representative of the true picture, and have been used to calculate the proportion of each fuel source taken up by agriculture. The statistics are expressed in terms of final energy consumption.

Consumption of all fuel sources in agriculture declined in the 1972-1979 period, with the exception of that of electricity. Electricity consumption was slightly higher in 1979 than in 1972, after falling to a low level in 1976. Total energy usage by agriculture dropped by 13 per cent between 1972 and 1979, compared with a 6.3 per cent rise in national energy consumption during the same period.

The main energy source for agriculture is petroleum fuels, which accounted for nearly 80 per cent of direct energy consumption in the 1970s. Three-quarters of this is taken up by gas/diesel oil. Solid fuels account for less than 2 per cent at present (4.3 per cent in 1972) and electricity makes up the remainder with a share of about 20 per cent.

Table 10.3

United Kingdom: Gross Fixed Capital Formation in Agriculture, 1973-1980

(per cent of value)

	1973	1974	1975	1976	1977	1978	1979	1980
Plant, machinery and vehicles	52.5	55.1	60.7	66.1	67.5	63.6	61.8	51.8
Buildings and works	47.5	44.9	39.3	33.9	32.5	36.4	38.2	48.2

Source: MAFF

Agriculture contributed 2.3 per cent of gross domestic product (GDP) in 1980, compared with 2.8 per cent in 1973. Agricultural workers of all kinds represented 2.7 per cent of the total civilian workforce in 1980, as against 2.9 per cent in 1973 and an average of 3.3 per cent during 1967-1969. In quantitative terms, the number of persons engaged in agriculture amounted to 651,000 in 1980, 7.5 per cent fewer than in 1973.

Table 10.4

United Kingdom: Consumption of Energy in Agriculture, 1972-1979

(TOE '000)

	1972	1973	1974	1975	1976	1977	1978	1979
Solid fuel	91.8	84.9	65.2	45.7	39.0	32.6	19.7	32.6
- Coal	66.4	53.1	39.8	26.6	19.9	19.9	13.3	19.9
- Coke and breeze	25.4	31.8	25.4	19.1	19.1	12.7	6.4	12.7
Petroleum products[a]	1,705.9	1,789.1	1,469.0	1,481.6	1,401.0	1,479.1	1,474.1	1,459.0
- Burning oil	11.1	11.1	10.0	11.1	11.1	11.1	11.1	13.3
- Vaporising oil	43.8	32.9	32.9	21.9	10.8	10.8	10.8	-
- Gas/diesel oil	1,281.6	1,357.6	1,118.5	1,151.3	1,064.4	1,118.5	1,129.4	1,118.5
- Fuel oil	358.1	378.5	306.9	306.9	306.9	337.6	327.3	327.3
Electricity	330.2	342.3	338.8	313.9	311.3	340.6	345.7	353.5
Total	2,127.9	2,216.3	1,873.0	1,841.2	1,751.3	1,852.3	1,839.5	1,845.1

a sum of constituents may not add to total, owing to conversion and rounding; figures were converted to therms, then megajoules and then to TOE

Source: Department of Energy, Digest of United Kingdom Energy Statistics

AGRICULTURE'S SHARE OF NATIONAL ENERGY CONSUMPTION

Not only has agriculture's consumption of energy fallen in absolute terms, but its share in total national consumption has also declined, albeit marginally. In 1972, agriculture took up nearly 1.5 per cent of national consumption of all fuels; in 1979 the figure had fallen to 1.2 per cent. Total national consumption declined in 1974 and 1975 to reach 140.8 million TOE in 1975, but has risen annually since to amount to 155.5 million TOE, an increase of 10 per cent, and marginally higher than the previous peak in 1973.

Agriculture's reliance on petroleum fuels is reflected in the fact that it is for this energy source that agriculture's share of national consumption is the highest, at 2.1 per cent in 1979. Within this sector, gas/diesel oil used in agriculture represents nearly 8 per cent of national consumption.

Table 10.5

United Kingdom: Share of Agriculture in National Consumption of Energy, 1972-1979

(per cent)

	1972	1973	1974	1975	1976	1977	1978	1979
Solid fuel	0.30	0.27	0.23	0.19	0.16	0.14	0.09	0.14
- Coal	0.34	0.27	0.22	0.17	0.14	0.13	0.10	0.14
- Coke and breeze	0.28	0.33	0.30	0.26	0.24	0.18	0.10	0.18
Petroleum products	2.37	2.41	2.17	2.32	2.13	2.21	2.19	2.14
- Burning oil	0.34	0.31	0.32	0.38	0.38	0.38	0.38	0.44
- Vaporising oil	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
- Gas/diesel oil	8.79	8.80	8.03	8.41	7.77	7.81	7.94	7.73
- Fuel oil	1.46	1.59	1.48	1.66	1.66	1.84	1.86	1.85
Electricity	1.87	1.81	1.84	1.72	1.68	1.80	1.79	1.75
Total	1.46	1.45	1.28	1.31	1.21	1.26	1.24	1.19

Source: EIU calculations, based on Digest of United Kingdom Energy Statistics data

DIRECT AND INDIRECT ENERGY CONSUMPTION

EVALUATION BY DR. D.J. WHITE

All other analyses of the use of energy in agriculture have converted the foregoing statistics expressed in terms of final energy consumption into primary energy equivalents, and have by and large included indirect energy usage as well. Dr. D.J. White, who has presented many papers on the subject of energy use and efficiency in agriculture, has provided a series of figures expressed in terms of primary energy input.

According to Dr. White and his colleagues, the values for solid fuel, petroleum and fertilisers show the greatest reliability, and together account for about 50 per cent of primary energy used in agriculture. The values given for transport and services, chemicals and miscellaneous uses were derived by G. Leach for 1968 and have not been updated. The figures for machinery, buildings and feedstuffs are open to question on the grounds of methodology, and may well be revised by Dr. White and his colleagues at a later date.

The data for feedstuffs exclude imported products and those made on the farm itself. It can be argued that an energy equivalent for imported feedstuffs should be included, since it would be necessary for the United Kingdom to grow these feedstuffs itself, were they not otherwise available.

The figures for electricity exclude domestic usage in the farmhouse for household purposes, and are based on an estimate provided by the Central Electricity Council in 1973, attributing 59 per cent of all electricity used in agriculture to purely agricultural purposes. The proportion is now believed to be about 70 per cent, which means that Dr. White's figure for 1978, at least, should be revised to 980,000 TOE of primary energy.

The energy equivalent of fertilisers was computed using energy equivalents of nitrogen, potash and phosphates as calculated by ICI, and multiplying these by the annual consumption of fertilisers.

The utilisation of machinery incurs an expenditure of the energy that was involved in the machine's manufacture and in the production of its constituent materials. Consequently, one can derive an energy equivalent for capital for a particular industry if both total energy consumed in the production of the capital products and the value of the capital products are known. Dr. White used this methodology to compute the values for machinery shown in Table 10.6. The figures for buildings and off-farm feedstuff processing are based on the methods used by G. Leach.

Table 10.6

United Kingdom: Consumption of Primary Energy in Agriculture, 1972-1978

	1972		1973		1974		1976		1978	
	TOE '000	%[a]	TOE '000	%[a]	TOE '000	%[a]	TOE '000	%[a]	TOE '000	%[a]
Direct Energy	2,889	36.4	2,918	33.9	2,586	32.7	2,371	30.9	2,516	31.5
- Solid fuels	107	1.4	98	1.1	76	1.0	41	0.5	26	0.3
- Petroleum	1,927	24.3	2,030	23.6	1,660	21.0	1,583	20.6	1,664	20.9
- Electricity	855	10.8	790	9.2	850	10.8	747	9.7	826	10.4
Indirect Energy	5,051	63.6	5,700	66.1	5,311	67.3	5,298	69.1	5,466	68.5
- Fertilisers	1,839	23.2	1,994	23.1	1,941	24.6	2,058	26.8	2,228	27.9
- Machinery	855	10.8	1,242	14.4	1,001	12.7	960	12.5	950	11.9
- Feedstuffs	1,287	16.2	1,225	14.2	1,206	15.3	1,294	16.9	1,254	15.7
- Chemicals	203	2.6	203	2.4	203	2.6	203	2.7	203	2.5
- Buildings	375	4.7	544	6.3	468	5.9	291	3.8	339	4.2
- Transport and services	389	4.9	389	4.5	389	4.9	389	5.1	389	4.8
- Miscellaneous	103	1.3	103	1.2	103	1.3	103	1.3	103	1.3
Total	7,940	100	8,618	100	7,897	100	7,669	100	7,982	100

a based on unrounded data

Source: Dr. D.J. White, MAFF

EVALUATION BY J.A. TATCHELL AND D.A. LEWIS

A slightly different picture of direct and indirect primary energy inputs into agriculture is presented by J.A. Tatchell and D.A. Lewis. They exclude transport, services and miscellaneous, but include a value for labour, which is the energy used by agricultural workers in their homes and on personal transport. Thus the total is higher than that derived by Dr. White; any other differences are due to the fact that J.A. Tatchell and D.A. Lewis cited rounded figures, as the data are based on Dr. White's work.

Table10.7

United Kingdom: Primary Energy Inputs into Agriculture, 1973

(TOE '000)	Volume	%
Direct Energy	2,913	35.9
- Solid fuel	95	1.2
- Oil	2,030	25.0
- Electricity	788	9.7
Indirect Energy	5,206	64.1
- Fertilisers	2,006	24.7
- Agro-chemicals	191	2.3
- Machinery	1,242	15.3
- Buildings	549	6.8
- Imported feedstuffs	1,218	15.0
Total	8,119	100.0
Indirect Labour	1,600	
Total[a] - Including Labour	9,721	

a based on non-rounded data

Source: J.A. Tatchell and D.A. Lewis, Imperial Chemical Industries (ICI)

J.A. Tatchell and D.A. Lewis went on to derive detailed energy input figures for typical United Kingdom farm types for 1974/75. These are divided into fixed and variable inputs. Fixed energy inputs are common to the whole farming system and can be allocated to each enterprise on the basis of the land area used. Dairy farms are smaller than either general cropping or upland meat farms and are intensively stocked. They require high energy inputs from labour for handling, and from electricity for milking and refrigeration. On general cropping farms, the major requirements are for machinery and fuel oil. Upland meat farms are relatively large, are farmed less intensively and require generally lower energy inputs.

Table 10.8

United Kingdom [a]: Fixed Energy Inputs by Farm Type, 1974/75

(TOE per ha '000)

	General Cropping	Dairy	Upland Meat
Machinery [b]	160.0	119.4	47.8
Fuel oil	164.8	112.3	50.2
Electricity	54.9	117.0	14.3
Labour	74.0	114.6	62.1
Capital [c]	31.1	93.2	50.2
Miscellaneous	14.3	11.9	23.9
Total	499.1	568.4	248.5

a England and Wales only; b purchase and repairs;

c including repairs

Source: J.A. Tatchell and D.A. Lewis

In addition to fixed energy inputs, each farm requires variable energy inputs related to its particular activity. These consist of seed, fertiliser, chemicals, etc. for general cropping farms. Grazing livestock enterprises need seed, fertiliser and chemicals for growing forage, and concentrates, health products and minerals for the animals. The figures in Tables 10.9, 10.10, 10.11 below are averages to take account of different systems.

Table 10.9

United Kingdom[a]: Energy Inputs to Cereal Growing on General Cropping Farms, 1974/75

(TOE per ha '000)

	Spring Barley	Winter Barley	Winter Wheat
Fixed inputs	499.1	499.1	499.1
Variable inputs	188.7	217.3	243.6
- Fertiliser	157.6	200.6	217.3
- Other	31.1	16.7	26.3
Total inputs	687.8	716.4	742.7
Yield (t/ha)	3.86	3.66	4.61
Energy/tonnes '000 (TOE)	179.1	195.8	160.0

a England and Wales only

Source: J.A. Tatchell and D.A. Lewis

Table 10.10

United Kingdom[a]: Energy Inputs to Cash Crops on General Cropping Farms, 1974/75

(TOE per ha '000)

	Sugar from Sugar Beet	Potatoes
Fixed inputs	499.1	499.1
Variable inputs	225.0	585.2
- Fertiliser	183.9	241.2
- Seed	0.5	71.7
- Chemicals	19.1	69.3
- Miscellaneous	21.5	203.0
Total inputs	724.2	1,084.4
Yield (t/ha)	4.5	23.7
Energy/tonnes '000 (TOE)	160.0	45.9

a England and Wales only

Source: J.A. Tatchell and D.A. Lewis

Table 10.11

United Kingdom[a]: Energy Inputs in Milk and Meat Production, 1974/75

(TOE per head '000)

	Dairy		Upland Meat	
	Dairy cows	Fattening beef	Store beef	Store lambs
Fixed inputs	279.4	95.5	57.3	23.9
Variable inputs	554.2	145.8	124.2	21.5
- Forage	269.9	93.2	40.6	16.7
- Concentrates	262.7	47.8	43.0	2.4
- Other	64.5	4.8	40.6	2.4
- Less calf	-43.0	-	-	-
Total inputs	833.6	241.3	181.5	45.4
Head/ha	2.04	5.96	4.3	10.5
Output kg/head	4,820	190.5	149.9	36.3
Energy/tonnes '000 (TOE)	172.0	1,265.9	1,194.2	1,242.0

a England and Wales only

Source: J.A. Tatchell and D.A. Lewis

The figures in the above tables are based on data recorded in "ICI Recorded Farms" which is published annually by ICI's Farming Service.

DIRECT ENERGY CONSUMPTION

AGRICULTURAL DEMAND FOR SOLID FUEL

The direct use of solid fuel in agriculture is small, amounting to 32,600 TOE in 1979 (50,000 tonnes), and accounting for about 0.1 per cent of national consumption of solid fuels. Thirty years ago coal was the dominant fuel for heating glasshouses. Now coal has largely been superseded by fuel oil, but an estimated 7 per cent of glasshouses are still heated by coal. This, plus domestic consumption, accounts for the majority of coal used directly in agriculture. In 1976, 86 hectares, or just under 6 per cent of the total heated glasshouse area in England and Wales was fuelled by coal.

In 1975, there were about 2,700 hectares of glasshouses in the British Isles, of which 2,000 hectares were in England and Wales, 494 hectares in the Channel Isles and 107 hectares in Scotland. The proportions that were heated were 72 per cent in England and Wales, 89 per cent in the Channel Isles and 91 per cent in Scotland. Further details on glasshouses and crops are given in the chapter on petroleum fuels.

AGRICULTURAL DEMAND FOR ELECTRICITY

The only detailed breakdown of direct electrical energy usage on the farm appears in the Report of the Energy Working Party which refers to the period 1973/74. There appear to be no updated figures, except that domestic consumption is now estimated to account for 30 per cent of the total instead of 41 per cent. According to a spokesman from the Farm Electrics Centre, the proportions of electricity consumption as ascribed to agricultural purposes in the following table are still much the same.

Table 10.12

United Kingdom: Use of Electricity in Agriculture by Sector, 1973/74[a]

	Electrical Energy (TKJ)[b]	Primary Energy Equivalent		
		(TKJ)[b]	(TOE '000)	%
All crops	1.47	5.81	138.8	10.7
of which:				
- Grass drying	0.10	0.40	9.5	0.7
- Hay drying	0.26	1.05	25.1	1.9
- Grain drying	1.02	4.00	95.5	7.3
- Potato storage	0.05	0.20	4.8	0.4
- Vegetable storage	0.04	0.16	3.8	0.3
All livestock	5.75	22.60	539.8	41.5
of which:				
- Milk products	3.99	15.70	375.0	28.9
- Feed preparation	0.53	2.08	49.7	3.8
- Environment control	1.21	4.75	113.4	8.7
- Farm waste handling	0.02	0.07	1.7	0.1
Horticulture	0.60	2.38	56.8	4.4
Domestic uses	5.66	22.35	533.8	41.1
Miscellaneous	0.32	1.26	30.1	2.3
Total	13.80	54.40	1,299.3	100.0

a estimated figures
b tera kilo joules

Source: Electricity Council unpublished data

Data published annually by the Electricity Council show that usage of electricity on farms declined in most regions between 1978/79 and 1979/80. The region of highest consumption is the East, followed by the South West, then the East Midlands with the South close behind. In terms of numbers of consumers, Northern Ireland is the most important region with about 34,000 farms supplied with electricity, followed by the South West (32,000), the East (26,000), the Midlands (24,000) and the South and the East Midlands (each with 22,000 farms).

It will be noted that the total in Table 10.13 of some 350,500 TOE in 1979/80 ties up fairly well with the figure in Table 10.4 for total final electrical energy consumption in agriculture in 1979 (353,500 TOE). Consumption declined slightly in most regions in 1979/80 compared with 1978/79.

The data provided in Tables 10.4, 10,12 and 10,13 cannot be compared directly, as in Tables 10.4. and 10.13 electricity is expressed in final consumption,whereas in Table 10.12 electricity is expressed in primary consumption and the total includes domestic use. The total of 1,299,300 TOE in primary consumption would correspond to approximately 500,000 TOE in final consumption. Primary consumption takes account of the energy used in the fossil on nuclear fuel used to obtain the electricity in the first instance, while final consumption only accounts for the energy in the electricity itself.

Table 10.13

United Kingdom: Sales of Electricity[a] to Farms by Region[b], 1978-1980

(TOE)

	1978/79	1979/80	% 1979/80[c]
London	86	86	-
South East	15,136	15,222	1.3
South	31,820	30,272	1.8
South West	33,970	33,884	3.8
East	43,344	41,624	2.1
East Midlands	33,110	30,788	2.0
Midlands	27,950	26,144	1.5
South Wales	14,792	15,222	1.7
Merseyside and North Wales	20,124	19,436	1.5
Yorkshire	27,176	25,284	1.4
North East	17,200	16,856	1.4
North West	24,940	24,080	1.5
Total England and Wales	289,648	278,898	1.6
Northern Ireland	25,714	25,370	5.8
North of Scotland	21,328	20,726	3.0
South of Scotland	25,714	25,542	1.6
Total United Kingdom	362,404	350,536	1.7

a final consumption; b Electricity Generating Board Areas;
c of total consumption in each area

Source: Electricity Council

Apart from the split of electrical energy consumption into agricultural and domestic purposes, there is little up-to-date information available on the different end uses within the agricultural sector.

G.A. Carpenter of the National Institute of Agricultural Engineering (NIAE) provided calculations of the electrical energy used by fans to provide a controlled environment for livestock in the United Kingdom. Chickens, turkeys and pigs were included, and total energy consumed, based on 1974/75 output figures for these categories of livestock, amounted to 35,342 TOE, or some 10 per cent of final electrical energy consumed in agriculture (including domestic usage) in 1975. Full details of the calculation appear in the Appendices.

Dairy farms are one of the largest sectoral consumers of electricity in agriculture, indeed electricity is the most common direct energy input in the farm dairy. A detailed study of electricity consumption in 13 farm dairies with herringbone milking parlours in Devon is currently being undertaken by Seale-Hayne College in cooperation with ADAS, the Electricity Council and the Energy Technology Support Unit (ETSU). This study will establish patterns, peaks, periodicity and totals of energy consumption. Although these data are not yet available, an assessment of the annual average electricity consumption per cow for the various farm dairy processes, in terms of primary energy, is as follows:

	KWH
Milk plant cleaning	160
Milk cooling	110
Vacuum pump operation	55
Lighting	35
Udder washing	25
Space heating	7
Miscellaneous	8
Total	400

Other uses of electricity as direct energy in agriculture are for grain drying, where the input has been estimated by Dr. White at 2,436 MJ/ha or 58.2 TOE/ha '000 annually for winter wheat. It has been shown that the all electric in-store type of drier may use twice as much primary energy to dry a given quantity of grain as do the electrically fanned oil-fired driers of the continuous or in-store types. There can be expected to be some change to the latter system.

AGRICULTURAL DEMAND FOR PETROLEUM FUELS

The largest use of energy in agriculture is in the form of petroleum fuels. The Report of the Energy Working Party, Report No 1, published by the Joint Consultative Organisation for Research and Development in Agriculture and Food, December 1974, gives a breakdown of the use of petroleum fuels in agriculture. The figures were provided by W.G. Chapman (MAFF) who has since moved to New Zealand. It appears that no more recent calculations are available. As the figures include lorries, vans, cars and other vehicles, which are excluded from total figures of direct petroleum consumption in agriculture as provided by the Digest of United Kingdom Energy Statistics, calculations applying the percentages in Table 10.14 below to consumption figures for petroleum in agriculture in other years would not be valid.

Nevertheless it is probably still true that the most important areas of usage are tractors and self-powered machines, accounting for 50 per cent, and glasshouse heating, accounting for 25 per cent of total consumption. It is not known how vehicles, lorries, vans and cars are divided between on and off-farm uses, nor to what extent domestic use may be involved.

Table 10.14

United Kingdom: Use of Petroleum Fuels in Agriculture, 1972/73

(TOE '000 primary energy)	Consumption	%
Tractors and self-powered machines	1,005.6	48.5
Vehicles, lorries, vans, cars	327.2	15.8
Glasshouse heating	520.7	25.2
Heating, drying, lighting	217.4	10.5
Total	2,070.8	100.0

Source: Energy Working Party - Report No 1

Similarly, the Report of the Energy Working Party gave values, from the same source, for the breakdown of petroleum consumption of tractors and self-powered machines by type of product. Livestock includes operations associated with grassland management, the transport of animal feedstuffs and removal of animal wastes. Grassland operations, cereals and roots account for a large share of petroleum consumption by tractors and much of this is thought to be expended in field operations and general farm transport.

Table 10.15

United Kingdom: Petroleum Consumption by Tractors and Self-Powered Machines, by Type of Product, 1974

(TOE '000 primary energy)

	Consumption	Share (%)
Cereals	253.2	25.2
Roots	133.8	13.3
Livestock	575.6	57.2
Horticulture	28.7	2.9
Miscellaneous	14.3	1.4
Total	1,005.6	100.0

Source: Energy Working Party - Report No 1

An exercise carried out at the Aberdeen School of Agriculture involved calculating diesel fuel requirements per hectare of crops for a typical Aberdeenshire farm of 122 hectares of the low-ground, mixed cropping and stocking type.

Table 10.16

United Kingdom: Diesel Fuel Requirements of Different Crops on an Aberdeenshire Farm, 1979

	Litres/ha	TOE/'000 ha
Potatoes	211	184.1
Barley	64	55.9
Swedes	203	177.2
Grazing	6	5.3
Hay	36	31.4
Silage	37	32.3

Source: School of Agriculture, Aberdeen University

In 1979, J.B. Finney presented a paper on fuel use on a typical East Anglian, largely arable farm. Annual usage of diesel oil on such farms was estimated at 80-160 litres/hectare. The breakdown for an all winter wheat farm was given as in Table 10.17 below.

Table 10.17

United Kingdom: Annual Diesel Fuel Use on a Typical East Anglian Arable Farm 1979

(TOE/'000 ha)

	Conventional Cultivation	Direct Drilling
Tractor fuel for crop establishment	42,2	5,1
Tractor fuel for grain carting, spraying, fertiliser spreading and hedging	5,9	5,9
Combine harvester fuel	13,5	13,5
Grain drying - fuel for continuous drier	46,4	46,4
Total	108,0	70,9

Source: J.B. Finney, ADAS

J.B. Finney points out that there are large variations from year to year and from farm to farm, according to the weather, soil conditions, etc. However, annual variations in direct drilling fuel requirements are small. The above table is based on averages of figures taken over several successive years.

Table 10.18 is calculated from Department of Energy statistics and shows the use of gas/diesel and fuel oils according to whether they are used to fuel power units (such as tractors) or driers and heaters. Consumption of gas/diesel oil fell by 12 per cent between 1972 and 1979, mainly as a result of decreased usage for power units. Consumption of fuel oil for power units was the same in 1972 as in 1979, reaching a low point of 34,800 TOE in 1976. In 1979, power units were 95 per cent fuelled by gas/diesel oil; for driers and heaters the split is approximately 50 per cent each way, fluctuating slightly from year to year.

Table 10.18

United Kingdom: Consumption of Gas/Diesel Oil and Fuel Oil, by End-Use, 1972-1979

(TOE '000)[a]	1972	1973	1974	1975	1976	1977	1978	1979
Gas/diesel oil[b]	1264.2	1331.5	1114.2	1149.0	1068.6	1119.6	1130.4	1116.5
- Power units	955.8	967.6	824.2	844.9	823.2	866.6	842.6	804.8
- Driers and heaters	308.4	363.9	290.0	304.1	245.4	253.0	287.8	311.7
Fuel oil	356.0	377.6	318.1	306.9	306.9	337.5	323.2	323.2
- Power units	44.0	45.0	41.9	35.8	34.8	38.9	43.0	44.0
- Driers and heaters	312.0	332.6	276.2	271.1	272.1	298.6	280.2	279.2
Total	1620.2	1709.1	1432.3	1455.9	1375.5	1457.1	1453.6	1439.7

a figures calculated by converting to therms, then to megajoules and then to TOE; b excluding derv fuel (for diesel engined road vehicles)

Source: Digest of United Kingdom Energy Statistics

In broad terms, the heating of glasshouses accounts for a quarter of direct petroleum fuel input into agriculture, and this fuel represents up to 40 per cent of the costs of producing fruit, vegetables and flowers in glasshouses.

As shown in Table 10.19, the total glasshouse area in England and Wales was 2,132 hectares in 1980, 14 per cent higher than in 1972. The proportion that is heated declined, however, from 74 per cent in 1972 to 70 per cent in 1980. The most important regions for glasshouse crops are the East, South East and Yorkshire and Lancashire. At the end of 1980, of the 1,352 hectares that were actually used for horticultural crops, 42 per cent was taken up by lettuces, 10 per cent by tomato and cucumber seedlings, 5 per cent by other vegetables and herbs, 2 per cent by carnations, 16 per cent by chrysanthemums, 4 per cent by roses, freesias and bulbs, 10 per cent by other pot plants and the remainder by strawberries and other plants, seedlings, etc.

Table 10.19

United Kingdom[a]: Heated Glasshouse Area by Region, 1972-1980

(ha)

	1972		1973		1974		1975		1976		1977		1978		1979		1980	
	Total Area	% heated	Total Area	% heated	Total Area	% heated	Total Area	% heated	Total Area	% heated	Total Area	% heated	Total Area	% heated	Total Area	% heated	Total Area	% heated
East	602	77	606	73	608	72	501	74	473	75	453	74	492	73	490	72	507	72
South East	487	79	494	76	497	76	494	77	547	78	524	73	516	73	518	74	529	72
East Midlands	69	73	73	69	65	65	178	67	184	64	189	64	183	65	173	62	190	64
West Midlands	147	68	159	66	147	67	153	65	157	65	161	65	166	66	171	64	179	63
South West	164	74	172	73	172	72	179	70	176	68	191	66	186	66	183	65	187	66
North	38	74	37	72	42	72	42	72	44	71	46	66	46	63	44	64	40	63
Yorkshire and Lancashire	334	66	358	67	398	68	412	70	418	71	427	71	438	72	457	73	457	72
Total England	1,841	74	1,899	72	1,929	72	1,959	72	1,999	72	1,991	71	2,027	71	2,037	70	2,089	70
Wales	31	63	31	68	41	67	42	68	40	68	42	67	36	68	41	69	43	69
Total England and Wales	1,872	74	1,930	72	1,970	71	2,001	72	2,039	72	2,033	71	2,063	71	2,077	70	2,132	70

a England and Wales

Source: MAFF

The figures quoted above for the utilisation of the area under glass are distorted by the fact that they are taken from a census conducted in December. In broad terms, tomatoes are the most important crop, occupying about half of the total area. Tomatoes and vegetables account for 73 per cent of the glasshouse area in England and Wales. Chrysanthemum is the most important ornamental crop.

During the 1970s, the production of tomatoes increased but consumption of fuel oil for heating actually decreased by over a fifth. Growers have been more or less forced by high fuel costs to make their heating systems more effective and efficient. Although it might now be cheaper to heat by coal, oil is cleaner, and the cost of changing to coal-fired equipment is not attractive. Alternative heating systems are being tested, the most notable of which is the £ 3 million Exel tomato complex at Drax power station, officially commissioned in June 1981. This uses reject heat from the power station and is the second such installation in the United Kingdom (on a commercial level), the other being at a whisky distillery near Aberdeen.

Table 10.20

United Kingdom: Oil Consumption in Glasshouses, 1970-1977

(TOE '000)	1970	1971	1972	1973	1974	1975	1976	1977
Light oil	97	122	147	163	128	90	85	83
Fuel oil	372	336	347	346	342	283	264	280
Total	469	458	494	509	470	373	349	363

Source: G.F. Sheard (formerly of the Glasshouse Crops Research Institute)

Table 10.21

United Kingdom: Tomato Output, 1970-1979

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Cropped area (ha '000)	1.02	1.04	1.01	1.02	0.99	0.95	0.95	0.94	0.98	0.96
Output (tonnes '000)	108	109	110	117	121	122	128	123	133	134

Source: Annual Review of Agriculture, MAFF

The energy input per tonne of early tomatoes produced is estimated to have fallen from 2.35 TOE in 1947 to 1.55 TOE in 1977. However, the energy input varies greatly from one area to another, even within the United Kingdom. According to G.F. Sheard, former director of the Glasshouse Crops Research Institute, a long season, early tomato crop on the South coast should use about 562,000 litres of fuel per hectare annually, compared with 674,000 litres per hectare in the Clyde Valley area of Scotland.

The most detailed figures on oil consumption in glasshouses by type of crop were obtained from the Glasshouse Crops Research Institute, and were originally supplied by the Horticultural Crop Consultants of ADAS in liaison with growers and the MAFF Experimental Horticulture stations. As a mixture of oils may be involved, the figures have been left in the original units as supplied.

Table 10.22

United Kingdom: Oil Consumption of Heated Glasshouse Crops in Selected Regions, 1979

(litres '000/0.1 ha)

Crop	Harvest	Region	Energy Use[a]
Early tomatoes	Oct-Nov	South East	48
idem	idem	idem	40
idem	idem	idem	42
idem	idem	idem	22
idem	Oct	Yorks/Lancs	45
idem	idem	idem	25
idem	idem	idem	20.5
Cucumbers	end Sept	South East	27
idem	Sept	Humberside	45
idem	idem	idem	35
idem	idem	idem	26
idem	end Oct	idem	5.6
idem	idem	East	57
idem	mid Oct	idem	51.5
idem	early Oct	idem	54.5
Lettuces	Dec	South East	1.8
idem	Jan	idem	3.6
idem	Feb	idem	6.3
idem	Mar	idem	6.3
idem	Dec	Yorks/Lancs	2.5
idem	Jan	idem	5.0
idem	Feb	idem	7.5
idem	Mar	idem	6.0
Early peppers	Oct	South East	42
Chrysanthemums (spray)	-	South East	42
idem (pot)	-	idem	45
Carnations	-	idem	14-18

a different values for the same crop, harvest time and region result from varying sowing and planting times

Source: Glasshouse Crops Research Institute

SULPHUR CONTENT OF PETROLEUM FUELS

The maximum sulphur content of the various petroleum fuels for oil engines and burners are set out in BS 2869: 1970, which has been amended several times in respect of the sulphur content of the different classes of fuel. The present values are set out in Table 10.23 below, and the British Standard is now in harmony with European Community directives on the subject.

Table 10.23

United Kingdom: Sulphur Content Requirements for Petroleum Fuels

Class of Fuel	Type/Purpose	Maximum Sulphur Content (% by mass)
	Engine fuels	
A1	Automotive diesel-distillate	0.3
A2	General purpose diesel-distillate	0.5
B1[a]	Marine-distillate	1.5
B2	Marine only	1.8
	Burner fuels	
C1	Kerosene type, for free-standing flueless domestic burners	0.04
C2	Kerosene type, for vaporising and atomising burners (flued domestic)	0.2
D	Large atomising burners, domestic and industrial, distillate	0.5
E	Residual or blended fuels for atomising burners, normally requiring preheating before combustion, requiring storage and handling plant with heating facilities. Class H are for special purposes.	3.5
F		4.0
G		4.5
H		5.0

a for use in shipping and power stations only

Source: British Standard 2869: 1970 and amendments

INDIRECT ENERGY CONSUMPTION

FERTILISERS

Fertilisers accounted for 28 per cent of the primary energy used in agriculture in 1978, with nitrogen accounting for over 90 per cent of the total. This is because the manufacture of most nitrogen fertiliser uses large amounts of natural gas, whereas the materials for phosphates and potash-based fertilisers are usually mined as natural products. The energy consumed in fertiliser manufacture rose from 1.8 million TOE in 1972 to 2.2 million TOE in 1978, an increase of some 22 per cent.

The consumption of all fertilisers in agriculture increased by 17 per cent between 1972/73 and 1979/80, with a sharp drop in 1974/75, doubtless caused by price rises. Consumption of nitrogen fertilisers went up by 34 per cent during the same period.

Table 10.24

United Kingdom: Consumption of Inorganic Fertilisers[a], 1972/73 - 1979/80

(tonnes '000 of plant food)

	1972/3	1973/4	1974/5	1975/6	1976/7	1977/8	1978/9	1979/80
Nitrogen								
England and Wales	759.2	783.9	787.5	850.8	879.0	924.0	941.0	1,031.0
Scotland	132.2	139.3	138.6	143.6	145.6	156.0	160.0	156.0
Northern Ireland	55.5	57.1	53.8	64.6	68.0	75.0	85.0	81.0
United Kingdom	946.8	980.3	979.9	1059.0	1092.6	1155.0	1186.0	1,268.0
Phosphate								
England and Wales	372.7	356.6	306.2	315.4	315.8	316.0	321.0	342.0
Scotland	84.7	71.7	69.2	69.4	69.0	72.0	73.0	74.5
Northern Ireland	24.7	20.7	18.0	19.0	21.2	22.0	22.0	23.5
United Kingdom	482.1	449.0	393.4	403.8	406.0	410.0	416.0	440.0
Potash								
England and Wales	332.8	346.6	301.6	322.0	330.1	328.0	330.0	358.0
Scotland	63.2	55.1	58.8	59.4	59.4	63.8	65.0	64.5
Northern Ireland	20.5	18.9	16.4	16.9	19.8	20.2	21.0	21.5
United Kingdom	416.5	420.6	376.8	398.3	409.3	412.0	416.0	444.0

a straights and compounds

Source: Fertiliser Manufacturers' Association (FMA)

Nitrogen is normally applied as a 'straight' N fertiliser, usually as ammonium nitrate (34.5 per cent N), but also as ammonium sulphate (21 per cent N), urea (46.6 per cent N) or liquid ammonia (82.4 per cent N). Nitrogen is also mixed with phosphates and potash into NPK compounds. Nearly all phosphate is applied to the soil in processed form as superphosphate or in compound NPK formulations. The main ingredient is phosphoric acid (H_3PO_4) which is made by reacting phosphate ore concentrates with sulphuric acid. Potash is normally derived from potassium salts that are mined.

The energy equivalents of fertilisers have been calculated by G. Leach and ICI independently for products at the factory gate; G. Leach has added on transport costs to give an energy equivalent of fertilisers as delivered to the farm gate. According to ICI, these figures, although calculated in the early 1970s, are still more or less valid today as there has been virtually no change in the manufacturing processes. G. Leach's figures are slightly higher than ICI's because he uses higher conversion rates for fuels and power. ADAS is not satisfied, however, with the generally accepted energy inputs for fertilisers and is in the process of revising the figures.

Table 10,25

United Kingdom: Energy Inputs for Fertilisers

(TOE per tonnes '000)

Fertiliser	Composition[a] (%)	Bagged: Factory Gate ICI	Bagged: Factory Gate Leach	Bagged: Delivered to Farm G. Leach Product	Bagged: Delivered to Farm G. Leach Element
Ammonium nitrate	34.5 N	606.7	618.6	625.8	1,815.3 N
Urea	46.6 N	879.0	922.0	929.1	1,994.4 N
Liquid ammonia	82.4 N	1,206.2	1,222.9	1,230.0	1,492.8 N
Ammonium sulphate	21.0 N	-	403.7	410.8	1,956.2 N
Diammonium phosphate	18 N: 46 P	-	465.8	472.9	1,827.2 N: 310.5 P
Compounds					
- 15:15:21	15 N: 15 P: 21 K	386.9	386.9	394.1	2,001.6 N: 343.9 P: 198.2 K
- 22:11:11	22 N: 11 P: 11 K	470.5	470.5	477.7	1,925.1 N: 327.2 P: 188.7 K
- 9 :25:25	9 N: 25 P: 25 K	327.2	327.2	334.4	2,078.0 N: 363.1 P: 188.7 K
- 17:17:17	17 N: 17 P: 17 K	418.0	418.0	425.2	1,972.9 N: 334.4 P: 195.9 K
Potassium salts	100 K				215.0 K
Weighted averages					
- Nitrogen	100 N				1,910.8 N
- Phosphate	100 P				334.4 P
- Potash	100 K				215.0 K
Lime (ground limestone)					47.8

A N = nitrogen, P = P_2O_5, K = K_2O

Source: G. Leach Energy and Food Production 1976

Most authors, including Dr. D.J. White, have used average energy content factors for converting quantities of fertiliser into their energy content in terms of tonnes oil equivalent.

Table10.26

United Kingdom: Energy Consumption in Fertiliser Usage, 1972/73 - 1979/80

(TOE '000)	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80
Nitrogen	1,742	1,804	1,803	1,949	2,010	2,125	2,182	2,333
Phosphate	164	153	134	137	138	139	141	150
Potash	83	84	75	80	82	82	83	89
Total	1,989	2,041	2,012	2,166	2,230	2,346	2,406	2,572

Note: energy equivalents used are nitrogen 1.84 TOE/tonne, phosphate 0.34 TOE/tonne, potash 0.20 TOE/tonne

Source: EIU calculations, based on FMA Statistics and Dr. White's conversion factors

These figures are slightly higher than those in Table 10.6 for fertiliser, but not significantly so.

The Survey of Fertiliser Practice is published annually by Rothampsted Experimental Station and permits a breakdown of fertiliser energy use by type of crop, type of farm and geographical region. The scope of the survey is limited to England and Wales. Full calculations have not been carried out for all the above variables, owing to the amount of time required.

Table 10.27

United Kingdom[a]: Energy Input of Fertilisers into Crops by Type of Crop, 1976-1980

(TOE '000)

	1976	1978	1980
Spring wheat	5.0	7.2	9.3
Winter wheat	231.3	250.3	382.9
Spring barley	244.1	214.8	187.9
Winter barley	54.4	73.0	180.4
Spring oats	8.8	4.8	6.5
Winter oats	16.0	12.4	11.4
Other cereals	11.4	4.8	-
Early potatoes	12.0	11.7	7.9
Main crop potatoes	60.0	53.2	45.5
Sugar beet	43.3	58.8	65.1
Mangolds	1.5	0.7	-
Swedes	8.8	3.2	2.0
Turnips		2.9	2.5
Kale and cow cabbage	12.5	9.0	8.1
Rape (stockfeed)	9.8	3.3	2.2
Beans (stockfeed)	0.8	0.8	0.9
Other stockfeed	7.3	4.3	4.4
Peas[b]	1.8	2.3	2.4
Runner and French beans	2.6	0.9	0.7
Broad beans	0.8	2.8	-
Brussels sprouts	9.9	6.3	3.4
Cabbages	6.9	4.0	2.1
Cauliflowers	3.8	3.6	3.7
Carrots	1.4	-	-
Onions	2.6	2.7	1.5
Small fruit	2.0	1.8	1.8
Top fruit	6.7	4.0	6.9
Oil seed rape	12.3	27.3	48.3

(continued)

Table 10.27 (continued)

United Kingdom[a]: Energy Input of Fertilisers into Crops by Type of Crop, 1976-1980

(TOE '000)

	1976	1978	1980
One year leys	12.1	3.5	2.4
2-7 year leys	515.5	484.6	518.5
Permanent grass	409.9	405.2	498.0

a England and Wales; b for human consumption

Source: EIU calculations, based on survey of Fertiliser Practice and conversion factors from Dr. D.J. White

Table 10.28

United Kingdom[a]: Fertiliser Use on Major Tillage Crops by Farm Type, 1979 and 1980

	1979				1980			
	Area	Fertiliser (kg/ha)			Area	Fertiliser (kg/ha)		
	(ha '000)	N	P_2O_5	K_2O	(ha '000)	N	P_2O_5	K_2O
Arable								
Winter wheat	621	134	40	31	698	142	41	34
Spring barley	385	90	36	38	355	89	35	39
Winter barley	187	110	44	37	297	131	43	42
Potatoes	53	206	203	261	57	179	186	255
Sugar beet	138	152	73	167	177	143	70	153
Total[b]	1,702	116	49	57	1,966	124	47	57
Arable-Dairying								
Winter wheat	512	137	51	43	477	148	51	45
Spring barley	546	90	40	40	463	90	39	41
Winter barley	225	119	52	47	299	130	52	47
Potatoes	32	185	196	268	32	199	190	266
Sugar beet	34	159	68	166	35	156	76	172
Total[b]	1,615	114	52	52	1,537	124	53	55
Dairying								
Winter wheat	81	145	53	52	101	143	55	53
Spring barley	162	82	38	41	135	76	37	39
Winter barley	64	107	50	51	78	125	56	53
Potatoes	7	198	205	272	9	192	176	277
Total[b]	376	106	51	55	380	111	53	57
Livestock and Upland								
Winter wheat	55	121	49	42	71	144	57	40
Spring barley	97	80	43	43	111	74	40	39
Winter barley	21	124	57	41	30	128	56	45
Total[b]	221	100	54	48	272	102	57	49

a in England and Wales; b including other crops

Source: Survey of Fertiliser Practice, ADAS

FEEDSTUFFS

According to Dr. White (Table 10.6), feedstuffs accounted for 1.3 million TOE in 1978, or nearly 16 per cent of agriculture's primary energy consumption. Animal feedstuffs are divided into the following main categories:

- Compound feeds consist of a number of different ingredients combined to provide properly balanced diets for all types of stock at every stage of growth and development. Some are designed as supplements to straw, kale, silage, etc.
- Protein concentrates are designed for further mixing before feeding at an inclusion rate of 5 per cent or more. They contain such ingredients as fish meal, meat meal, soya, etc. and are fortified with vitamins and minerals.
- Straights are single feedstuffs of animal or vegetable origin which may or may not have been processed before purchase. Examples are wheat, flaked maize, field beans, groundnut cake and meal, meat meal and soyabean meal.

There are about 475 compound mills in the United Kingdom. Formerly the largest of these were situated close to the deep-water ports (Avonmouth, Hull, Liverpool, London, Glasgow, Belfast). In recent years, there has been a switch of milling capacity to inland areas and smaller ports, closer to livestock production and raw material (cereal) supplies grown in the United Kingdom and shipped from the Continent. In 1979, 70 per cent of output was produced away from the deep-water port areas.

Approximately 10 million tonnes of compound animal feed are manufactured annually in large and small mills throughout the United Kingdom. According to calculations presented in the ADAS/NFU Energy in Agriculture report, a typical modern feedmill of 150,000 tonnes annual capacity, requires a total investment of £ 3 million, of which £ 2 million would be for the building with a 25 year life. The plant and machinery would cost £ 1 million with a 10 year life. The annual cost would therefore be £ 1.2/ tonne of feed manufactured, equivalent to a support energy cost of 64 MJ/tonne.

With the exception of port mills, nearly all raw materials are transported by road to the feedmill and the products are delivered to the farm. The average journey is estimated to be 50 miles (25 miles as raw material and 25 miles as finished product). G. Leach gives the primary energy cost of transport as 6 MJ/tonne-mile, resulting in a total transport energy cost of 300 MJ/tonne.

Table 10.29

United Kingdom: Primary Energy Inputs for Manufactured Compound Feedstuffs

	MJ/tonne	TOE/tonne '000
Buildings and plant	64	1.53
Electricity[a]	540	12.90
Fuel[b]	180	4.30
Raw materials transport	150	3.58
Delivery of feed to farm	150	3.58
Total	1,084	25.89

a 45 KWH/tonne; b 4.5 l/tonne

Source: ADAS/NFU

Some farms have their own mixing plants for feedstuffs. An energy input picture is also presented by ADAS/NFU for such a system. The cost of a 1,000-tonne/year plant is estimated at £ 6,500 without a cuber and £ 10,000 with one. Depreciated over five years and using a support energy conversion value of 53 MJ/£, the support energy costs are 69 MJ/tonne and 106 MJ/tonne respectively. Many farm mixing plants are located on grain-growing farms, thus the energy costs of transport both to and from the feed mill, as shown in the previous table, are reduced. About 80 per cent of the home mix is grain and 20 per cent is bought in protein concentrates, for which the transport costs, using the same method as before, are 30 MJ/0.2 tonne.

Table 10.30

United Kingdom: Primary Energy Inputs for Farm Produced Compound Feedstuffs

	No Cuber		With Cuber	
	MJ/tonne	TOE/tonne '000	MJ/tonne	TOE/tonne '000
Plant	69	1.65	106	2.53
Milling and mixing[a]	240	5.73	240	5.73
Feed movement[b]	12	0.29	12	0.29
Cubing[c]	-	-	240	5.73
Transport	30	0.72	30	0.72
Total	351	8.38	628	15.00

a 20 KWH/tonne; b 1 KWH/tonne; c 20 KWH/tonne

Source: ADAS/NFU

Table 10.31

United Kingdom: Output of Compound Feedstuffs, 1972-1979

(tonnes million)

	1972	1973	1974	1975	1976	1977	1978	1979
Calf starters	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.04
Other calf food	0.40	0.41	0.35	0.33	0.36	0.33	0.39	0.42
Dairy food[a]	-	-	-	-	-	3.71	3.83	4.20
All other cattle food	3.54	3.68	3.44	3.89	4.53	0.57	0.51	0.58
Protein concentrates	0.27	0.25	0.20	0.22	0.21	0.16	0.17	0.16
Total cattle and calf food	4.25	4.38	4.01	4.47	5.15	4.84	4.93	5.39
Pig starters and creep feeds[a]	-	-	-	-	-	0.13	0.15	0.14
Pig breeding food[a]	-	-	-	-	-	0.58	0.68	0.72
All other pig food	2.28	2.54	2.38	1.99	2.27	1.46	1.34	1.40
Protein concentrates	0.23	0.24	0.19	0.16	0.18	0.14	0.13	0.12
Total pig food	2.53	2.80	2.60	2.18	2.45	2.32	2.30	2.38
Broiler chicken food	1.01	1.08	0.99	1.00	1.07	1.05	1.09	1.18
Turkey food	0.36	0.41	0.36	0.29	0.36	0.35	0.36	0.39
Layer food[a]	-	-	-	-	-	1.53	1.57	1.56
All other poultry food	2.35	2.18	2.05	1.97	1.96	0.32	0.34	0.27
Protein concentrates	0.15	0.15	0.10	0.10	0.08	0.07	0.07	0.08
Total poultry food	3.87	3.82	3.50	3.36	3.47	3.35	3.43	3.48
Other compounds[b]	0.20	0.23	0.22	0.22	0.27	0.28	0.30	0.39
Total compounds and concentrates	10.85	11.22	10.34	10.22	11.35	10.80	10.96	11.64

a not distinguished separately prior to 1977; b includes sheep, lamb and horse feeds

Source: United Kingdom Agricultural Supply Trade Association (UKASTA)

In 1979, of all compound feedstuffs produced in the United Kingdom, 46 per cent was cattle and calf food, 20 per cent was pig food, 30 per cent was poultry food and the remainder was for other animals.

The largest input into compound animal feedstuffs used to be barley, but is now followed closely by wheat. Together these accounted for 40 per cent of the raw materials in 1979.

Table 10.32

United Kingdom: Estimated Quantities[a] of Raw Materials Used in the Manufacture of Compound Animal Feedstuffs, 1974-1979

(tonnes '000)

	1974	1975	1976	1977	1978	1979
Wheat	1,764.0	2,383.3	2,206.5	1,932.1	2,065.0	2,367.0
Barley	2,680.2	1,841.2	2,125.6	2,176.5	2,201.0	2,438.3
Maize	1,292.9	1,226.1	1,715.4	1,819.0	1,195.0	1,118.1
Oats	96.8	95.8	106.9	89.8	94.0	80.2
Sorghum	250.6	259.8	271.8	132.5	23.1	32.0
Wheat by-products	1,046.0	1,035.3	1,042.4	1,000.6	1,071.5	1,064.8
Oilseed cake and meal	1,074.4	1,028.4	1,307.8	1,252.1	1,378.6	1,531.0
Animal substances and protein concentrates	590.1	636.7	594.0	558.1	527.2	572.3
Oil and fat	68.1	83.2	89.7	94.2	130.8	123.7
Molasses	377.5	417.5	479.0	443.3	440.0	460.4
Others	1,481.5	1,584.8	1,805.5	1,463.3	2,160.6	2,192.2
Total	10,722.7	10,592.2	11,744.6	10,961.5	11,286.5	11,980.9

a raw material usage does not coincide exactly with production owing to processing time-lag

Source: UKASTA

In 1979, compound feedstuffs represented 73.5 per cent of total purchases of feedstuffs, the remainder being accounted for by cereals, proteins, hay, straw etc.

Table 10.33

United Kingdom: Feedstuffs Consumed in Agriculture, 1975-1979

(tonnes million)

	1975	1976	1977	1978	1979
Compounds	10.22	11.35	10.80	10.96	11.64
Other high energy feeds[a]	3.90	3.70	4.10	3.50	3.60
Low energy bulk feeds[b]	0.40	0.50	0.50	0.60	0.60
Total	14.52	15.55	15.40	15.06	15.84

a cereals, cereal offals, proteins, etc.; b brewers' and distillers' grains, hay, straw, milk by-products, etc., expressed in terms of an equivalent tonnage of high energy feeds

Source: UKASTA

PESTICIDES

Pesticides, listed in Table 6 as chemicals, comprise fungicides, insecticides and herbicides. There are many different products involved, all with varying energy inputs. Usage is, however, relatively small compared to other inputs, and so those who have studied the use of energy in agriculture have relied on approximate averages. A figure of 2.5 TOE/tonne of active ingredient has commonly been used for all types of pesticide but, as the table below shows, some products have energy contents of four times this amount.

Table 10.34

United Kingdom: Energy Inputs to Selected Crop Protection Chemicals

(TOE/tonne of active ingredient)

	Naphtha	Fuel Oil	Natural Gas	Coke	Electricity	Steam	Total[a]
Diuron	2.2	0.1	1.5	-	2.1	0.7	6.5
Atrazine	1.0	0.3	1.6	-	0.9	0.6	4.5
Trifluralin	1.3	0.2	0.3	-	1.4	0.4	3.6
Paraquat	1.8	0.1	1.6	-	3.4	4.0	11.0
2,4 - D	0.9	0.2	-	-	0.5	0.4	2.1
Chloramben	2.2	0.1	0.7	-	1.1	-	4.1
Propanil	1.5	0.1	1.0	-	1.5	1.2	5.3
Propachlor	2.6	0.3	0.7	-	2.0	1.3	6.9
Glyphosphate	0.8	-	2.2	-	5.4	2.4	10.8
Methyl Parathion	0.8	-	0.6	0.1	1.7	0.4	3.8
Carbofuran	3.3	1.1	1.5	-	3.0	2.0	10.8
Carbaryl	0.3	-	1.1	0.6	1.3	0.3	3.7

a may not be sum of constituents owing to rounding of figures during conversion from original units

Source: J.A. Tatchell and D.A. Lewis

A report by the National Economic Development Office (NEDO), published in January 1974, put the annual consumption of pesticides as follows:

herbicides	10,000 tonnes
fungicides	1,200 tonnes
insecticides	1,200 tonnes

J.R. Stansfield suggested that the usage of herbicides was split between crops as follows (1974):

cereals	78 per cent
horticulture	8 per cent
other crops	11 per cent
temporary grass	1.5 per cent
bare fallow	1.5 per cent

J.R. Stansfield estimated that the total usage was 8,300 tonnes annually, somewhat lower than the NEDO figure. In May 1981, a preliminary report on pesticide usage in England and Wales from 1975-1979 by Dr. John Sly was published. This gives an annual consumption of 22,000 tonnes for 1971-1974 and 25,500 tonnes for 1975-1979. Dr. Sly's work is considered the most reliable currently available.

Table 10.35

United Kingdom: Estimated Annual Usage of Pesticides in Agriculture and Horticulture[a], 1971-1974 and 1975-1979

(spray hectares; tonnes of active ingredient)

	1971-1974		1975-1979	
	Area sprayed	Volume of pesticide	Area sprayed	Volume of pesticide
Organochlorine insecticides	148,000	131	146,000	166
Organophosphorus insecticides	845,000	430	975,000	534
Other insecticides, acaricides and molluscicides	93,000	1,286	597,000	907
Seed treatments	3,718,000	565	3,753,000	591
Fungicides	1,895,000	2,400	2,253,000	2,336
Herbicides, defoliants	6,003,000	15,250	7,868,000	19,925
Other pesticides	81,000	2,000	203,000	1,038
Total	12,783,000	22,062	15,795,000	25,497

a England and Wales only

Source: Dr. J.M.A. Sly, MAFF

The usage of all types of pesticides by type of crop shows that cereals received over a third of all pesticide treatments, with other arable crops receiving 42 per cent. Vegetables, orchards and fodder received an average of about five per cent each.

Table 10.36

United Kingdom[a]: Annual Usage of Pesticides in Agriculture and Horticulture, 1975-1979

(spray hectares and tonnes of active ingredients)

Pesticide	Soft fruit 1975		Glasshouse 1976		Hardy nursery stock 1976		Vegetables 1977		Cereals 1977		Other arable crops 1977		Fodder/forage 1979	
	ha	t	ha	t	ha	t	ha	t	ha	t	ha	t	ha	t
Insecticides, molluscicides, acaricides														
Organochlorines	15,902	14.58	3,075	3.01	2,926	3.62	41,278	40.07	813	1.02	40,061	51.07	3,728	5.81
Contact organophosphates	4,875	5.76	4,310	6.06	1,792	2.02	119,511	109.46	6,551	4.20	9,688	6.14	2,341	2.34
Systemic organophosphates	10,275	3.57	1,862	0.72	7,937	2.30	174,663	104.60	287,476	121.84	264,709	106.68	1,512	0.26
Carbamates	2,035	1.22	3,253	6.53	982	1.40	30,406	36.44	269,082	73.91	173,740	158.63	6,267	1.36
Others	1,267	39.85	4,773	9.98	312	17.87	301	0.24	3,011	2.83	6,009	3.37	4,913	4.57
Total	34,354	64.98	17,273	26.30	13,949	27.21	366,159	290.81	566,933	203.80	494,207	325.89	18,761	14.34
Insecticide/fungicide mixtures			738	0.83	3	trace								
Seed treatments			7	trace	3	trace	161,671	64.60	3,272,918	496.88	235,084	8.87	82,974	20.57
Fungicides														
Systemic	12,763	8.19	5,068	7.42	4,505	2.85	24,277	16.05	910,171	461.67	8,985	5.58	23,383	9.69
Mainly against powdery mildews	10,991	13.72	808	0.56	3,336	2.70	194	0.10	2,212	1.66				
Dithiocarbamates	7,851	20.74	13,594	55.03	1,738	3.93	9,556	13.82	28,438	49.19	513,526	770.81	2,329	4.34
Others	19,459	38.23	2,392	33.23	2,460	5.57	7,062	6.00	36,004	56.01	93,861	56.39		
Total	51,064	80.88	21,862	96.24	12,039	15.05	41,089	35.97	976,825	568.53	616,372	832.78	25,712	14.03
Herbicides, defoliants														
Mainly contact	5,791	5.01	135	0.16	3,451	3.46	118,110	280.05	542,560	811.57	297,890	348.17	110,978	38.82
Mainly soil-acting	19,530	70.17	447	1.05	7,369	17.26	262,149	515.81	588,370	1,203.77	501,799	890.66	122,412	179.80
Mainly translocated	3,825	9.30	1	trace	764	2.23	13,087	17.98	3,445,691	5,566.79	85,343	148.66	1,557,032	842.14
Sulphuric acid							2,048	345.29			33,081	8,171.01		
Tar oil														
Total	29,146	84.48	583	1.21	11,584	22.95	395,394	1,159.13	4,576,621	7,582.13	918,113	9,558.50	1,790,422	1,060.76
Growth regulators			904	1.53	42	trace	2,981	10.43	188,136	238.93				
Soil sterilants, fumigants	17	trace	2,013	610.22	153	47.65	203	79.84			208	45.76		
Total treated area	114,581	230.34	43,380	736.33	37,773	112.86	967,497	1,640.78	9,581,433	9,090.27	2,263,984	10,771.80	1,917,869	1,109.70
Area grown	13,123		5,350		6,156		250,702		3,209,331		476,117		5,312,526	

a England and Wales only

(continued)

Source: Dr. J.M.A. Sly, MAFF

Table 10.36

United Kingdom[a]: Annual Usage of Pesticides in Agriculture and Horticulture, 1975-1979 (continued)

(spray hectares and tonnes of active ingredients)

Pesticide	Orchards 1979		Hops 1979		Total	
	ha	t	ha	t	ha	t
Insecticides, molluscicides, acaricides						
Organochlorines	21,551	23.26	16,918	23.42	146,252	165.85
Contact organophosphates	30,305	26.72	10,212	10.20	189,585	172.90
Systemic organophosphates	32,161	12.72	4,923	8.49	785,518	361.18
Carbamates	13,183	22.36	10,586	12.15	509,534	314.00
Others	63,270	513.58	3,539	0.52	87,395	592.81
Total	160,470	598.64	46,178	54.78	1,718,284	1,606.74
Insecticide/fungicide mixtures					741	0.83
Seed treatments					3,752,657	590.92
Fungicides						
Systemic	69,105	33.66	26,460	5.51	1,084,717	550.62
Mainly against powdery mildews	172,077	128.18	3,027	1.34	192,645	148.26
Dithiocarbamates	12,742	29.46	20,657	58.63	610,431	1,005.94
Others	187,707	374.01	16,206	61.79	365,151	631.23
Total	441,631	565.31	66,350	127.27	2,252,944	2,336.05
Herbicides, defoliants						
Mainly contact	16,654	6.84	8,356	11.02	1,103,925	1,505.09
Mainly soil-acting	31,481	46.80	3,983	7.12	1,537,540	2,932.43
Mainly translocated	77,682	116.05	1,761	3.23	5,185,186	6,706.39
Sulphuric acid					35,129	8,516.30
Tar oil			5,977	265.58	5,977	265.58
Total	125,817	169.69	20,077	286.95	7,867,757	19,925.81
Growth regulators	7,770	3.65	803	trace	200,636	254.54
Soil sterilants, fumigants					2,594	783.47
Total treated area	735,688	1,337.29	133,408	469.00	15,795,613	25,498.36
Area grown	42,916		5,706		9,321,927	

a England and Wales only

Source: Dr. J.M.A. Sly, MAFF

AGRICULTURAL MACHINERY

A census of agricultural machinery in use is taken annually by the Ministries and Departments of Agriculture in the different countries comprising the United Kingdom, but not all categories of machinery are covered every year, nor do the countries agree on which items are covered in any one year. Thus it is difficult to form a complete picture for the United Kingdom as a whole at any one point of time. Data for the years 1973 to 1980 are provided in Table 39.

In December 1980, there were 354,500 wheeled tractors in England alone, of which 39 per cent had an output of between 40 KW and 60 KW, and a further 35 per cent had outputs of 25 KW to 40 KW.

There were 45,700 combine harvesters in England in December 1980, of which nearly three-quarters were of less than 80 KW. In addition there were 75,400 balers in use, 260,400 items of portable conveying equipment, 71,400 vans and lorries (73 per cent of which were vans or pick-up trucks) and 310,700 tractor-drawn trailers.

In 1978, the park of root harvesters in England and Wales stood at 45,531 units (59,260 in 1977), that of sowing and planting machines at 105,630 units (120,990 units in 1977); there were 199,432 fertiliser distributors and 74,141 fieldcrop sprayers in use (204,210 and 72,120 respectively in 1977).

Table 10.37

United Kingdom: Agricultural Tractors in Use, 1973-1980

	1973	1974	1975	1976	1977	1978	1979	1980
TRACTORS 7 KW (10hp) AND UNDER								
England	63,000	35,560	...	35,670[a]	14,760	19,358	14,900	11,900
Wales	8,460	3,550	...	4,720[a]	2,230		...	...
Scotland	...	...	814	...	...	...	...	...
Northern Ireland	...	...	1,850	...	...	...	...	...
TRACTORS OVER 7 KW (10hp)								
A - Tracklaying								
England	12,330	...	...	11,430	11,040		...	12,600
Wales	1,210	...	...	850	1,390		...	...
Scotland	...	...	691	...	...	...	...	...
Northern Ireland	...	...		...	...	387,254 ...	...	...
B - Wheeled								
England	290,320	338,210	314,260	312,220	342,320		344,400[a]	342,600
Wales	35,480	45,880	41,340	41,300	46,940		...	...
Scotland	...	...	57,573	...	...	...	...	...
Northern Ireland	...	...	36,900	...	...	...	...	...

a includes tracklaying tractors

Source: MAFF, Department of Agriculture and Fisheries for Scotland and Department of Agriculture for Northern Ireland

Table 10.38

United Kingdom: Sales[a] of Pesticides to Agriculture and Horticulture, 1976-1980

(£ million)

	1976	1977	1978	1979	1980
Herbicides	54.5	69.3	93.6	126.3	116.7
Insecticides	11.9	15.9	15.0	17.7	17.1
Fungicides	8.7	15.0	19.2	32.8	37.3
Total	75.1	100.2	127.8	176.8	171.1

a by members of the British Agrochemicals Association

Source: British Agrochemicals Association (BAA)

NON-ENERGY PETROLEUM PRODUCTS

Lubricating Oils and Greases

The use of lubricating oils and greases in agriculture as a proportion of national consumption has risen from under 3 per cent from 1972-1975 to nearly 4 per cent in 1979. National consumption declined over the period by 7.4 per cent to a little over 1 million tonnes in 1979, whereas agriculture increased its consumption by nearly a third.

Table 10.39

United Kingdom: Use of Lubricating Oils and Grease in Agriculture, 1972-1979

(TOE '000[a])

	1972	1973	1974	1975	1976	1977	1978	1979
Consumption	32.1	35.2	29.0	30.0	34.1	34.1	38.3	42.4
Per cent of national total (%)	2.79	2.87	2.68	2.92	3.26	3.21	3.62	3.98

a final consumption

Source: Digest of United Kingdom Energy Statistics

Other Oil-Based Products

G. Leach quoted a figure from ICI of 21 MJ (0.0005 TOE) as the energy input equivalent of a polythene sack for fertiliser, the capacity of the sack being 50.8 kg. This is equivalent to 410 MJ (0.0098 TOE) per tonne of fertiliser. G. Leach adds on to this a figure to include the operations of the packaging plant, which gives an energy input of 1,040 MJ (0.025 TOE) per tonne.

G. Leach is the only author found to have covered non-energy uses of oil-based products. Most of his evaluations are based on the energy analysis of the 1968 Census of Production, carried out by P. Chapman, and so have to be deflated to give true values for each year. The 1968 figures are as follows:

agro-chemicals	:	692 MJ/£ at factory gate
twine and wire	:	406 MJ/£ (wire industry)
sundries	:	180 MJ/£ for mechanical engineering industries
water	:	9.1 MJ/tonne for piped supply 41.4 MJ/ 1,000 gallons or 295 MJ/£

Some of these inputs are obviously only very indirectly oil-based.

APPENDIX I

ENERGY INPUTS FOR SELECTED PROCESSES, CROPS AND LIVESTOCK

I. Dairy Cow

Forage and concentrates

Silage 1.5 tonne DM/year at 3.85 MJ/kg DM[1]	=	5,775 MJ/cow
Concentrates 1.2 tonne/year at 9.57 MJ/kg	=	11,484 MJ/cow
0.5 tonne/year at 4.5 MJ/kg	=	2,250 MJ/cow
Grazing 1.6 tonne DM/year at 1.57 MJ/kg DM	=	2,512 MJ/cow
Total	=	22,021 MJ/cow

Energy required to produce 1 heifer at 2 years old

Milk substitute 14 kg at 23.93 MJ/kg	=	335 MJ
Concentrates 560 kg at 9.57 MJ/kg	=	5,359 MJ
240 kg at 4.5 MJ/kg	=	1,080 MJ
Forage (1/2 silage, 1/2 grazed) 3,200 kg at 2.77 MJ/kg DM	=	8,864 MJ
Total	=	15,638 MJ

Replacement for cow after 4 years is equivalent to
15,638 : 4 = 3,910 MJ/cow

Energy use in the milking parlour: milk cooling, vacuum pump and hot water heating each contribute 0.1 KWH/gallon of milk.
Energy used in parlour is 0.1 KWH x 3 x 1,075 gallons x 3.6 MJ/KWH x 3.419
= 3,970 MJ/cow

Total Energy Inputs = 29,901 MJ/cow
= 0.714 TOE/cow

---

1 DM = dry matter

The above inputs assume that 70 per cent of concentrates are bought in, with 30 per cent being produced on the farm. A ratio of 3.419 is used to convert electrical energy into its primary equivalent, taking account of thermal efficiency, transmission losses, etc.

II. Winter Wheat

Inputs		MJ/ha	TOE/ha '000
	Fertiliser		
	Nitrogen (N) 150 kg/ha @ 73 MJ/kg =	10,950	261.5
	Phosphate (P_2O_5) 50 kg/ha @ 14 MJ/kg=	700	16.7
	Potash (K_2O) 50 kg/ha @ 8 MJ/kg =	400	9.6
	Manufacture of equipment		
	Field machinery	2,780	66.4
	Drying plant	550	13.1
	Field		
	Field operations	2,471	59.0
	Grain drying	2,436	58.2
	Herbicides	139	3.3
	Seed 175 kg/ha @ 4.51 MJ/kg =	789	18.8
	Total Energy Input	21,215	506.7

These are the inputs required to produce 59,930 MJ/ha of energy output and 495 kg/ha of protein in the form of grain.

III. Spring Barley

Inputs		MJ/ha	TOE/ha '000
Fertiliser			
Nitrogen N 120 kg/ha @ 73 MJ/kg	=	8,760	209.2
Phosphate P_2O_5 50 kg/ha @ 14 MJ/kg	=	700	16.7
Potash K_2O 50 kg/ha @ 8 MJ/kg	=	400	9.6

			MJ/ha	TOE/ha '000
Manufacture of equipment				
Field machinery			2,780	66.4
Drying plant			550	13.1
Fuel				
Field operations			2,471	59.0
Grain drying			2,436	58.2
Herbicides			139	3.3
Seed	175 kg/ha @ 4.81 MJ/kg	=	842	20.1
	Total Energy Input		19,078	455.7

These are the inputs required to produce 46,208 MJ/ha of energy output and 364 kg/ha of protein in the form of grain. It is equivalent to 4.81 MJ/kg of grain produced or 0.115 TOE/tonne.

IV. Silage

Inputs			MJ/ha	TOE/ha '000
Fertiliser				
Nitrogen N	170 kg/ha @ 73 MJ/kg	=	12,410	296.4
Phosphate P_2O_5	80 kg/ha @ 14 MJ/kg	=	1,120	26.8
Potash K_2O	120 kg/ha @ 8 MJ/kg	=	960	22.9
Equipment depreciation				
Tractors	728 MJ/ha x 3 cuts	=	2,184	52.1
Field machinery	496 MJ/ha x 3 cuts	=	1,497	35.8
Silo			3,395	81.1
Fuel	2060 MJ/ha x 3 cuts	=	6,180	147.6
	Total Energy Input		27,746	662.7

These are the inputs required to produce 72,000 MJ/ha of energy output. In terms of volume, the above figures are equivalent to 3.85 MJ/kg DM of silage, or 0.092 TOE/tonne DM.

V. Energy Inputs by Different Cultivation Systems
(MJ/ha)

	Soil and Crop		
	Clay loam winter wheat	Silty loam winter wheat	Clay loam spring barley
Traditional plough system	320 (245)	180 (118)	324 (307)
Shallow (100 mm) plough, combined seedbed preparation and drilling	187 (115)	108 (68)	203 (133)
Chisel plough (125 mm) twice, combined seedbed preparation and drilling	286 (203)	194 (147)	308 (213)
Rotary digger (tines 200 mm, rotor 100 mm), combined seedbed preparation and drilling	176 (117)	144 (88)	201 (156)
Direct drill, preceded by a herbicide	38 (-)	43 (-)	54 (-)

Note: These figures exclude traction losses. They are the result of data gathered over a period of 6 years at the National Institute of Agricultural Engineering. The values in parentheses are for the primary tillage operation. In 1979, 325,000 ha underwent direct drilling, the main crop involved being winter wheat.

VI. Total Energy Inputs for Various Agricultural Products

	Energy Input	
	GJ/ha year	TOE/ha year
Wheat	19.3	0.461
Barley	17.6	0.420
Potatoes	52.0	1.242
Sugar beet	25.2	0.602
Milk	23.6	0.564
Beef (from dairy herd)	10.4	0.248
Pigs	18.0	0.423
Sheep	10.1	0.241

Poultry (eggs)	22.5	0.537
Poultry (broilers)	29.4	0.702
Tomatoes (glasshouse:average)	1,300	31.051

Source: ADAS/NFU

APPENDIX II

ELECTRICAL ENERGY USED BY FANS FOR ENVIRONMENTAL CONTROL OF LIVESTOCK

Assumptions

1. That all poultry are fan ventilated.
2. That half of all pigs are fan ventilated.
3. That the proportion of cattle and calves that are fan ventilated can be ignored.
4. That the installed fan capacity for poultry is based on an average overall figure of $1.57 \times 10^{-3} m^3/s$ kg liveweight (1.5 ft^3/min lb).
5. That the installed fan capacity for pigs is based on an average overall figure of $0.52 \times 10^{-3} m^3/s$ kg liveweight (0.5 ft^3/min lb).
6. That the actual usage over a year is one half of the installed capacity due to low ventilation requirements when the external ambient temperature is low.
7. Populations of pigs and poultry are as follows (based on HMSO 1975) together with average in-house weights.

Class of Livestock	Number (thousands)	Estimated wt per animal (kg)	In-house wt (tonnes)
Laying chicken	38,000	2.0	76,000
Broiler chicken	40,000	1.0	40,000
Rearing chicken	13,000	1.0	13,000
Breeding chicken	4,000	3.2	12,800
Turkeys	5,000	4.5	22,500
Fattening pigs	3,000 *	64.0	192,000
Weaners	3,000 *	20.0	60,000
Boars and sows	400 *	180.0	72,000

* Populations halved to give the numbers housed in fan ventilated buildings.

8. Typical propeller fan power consumptions are:
   630 mm dia. 920 rev/min: 640 W for 2.8 m^3/s of air throughput
   400 mm dia. 1360 rev/min: 250 W for 1.2 m^3/s
   Assume an average of 220 W per m^3/s of air.

Calculations

Total weight of poultry	$= 164{,}300 \times 10^3$ kg
Volume of ventilating air required	$= 164{,}300 \times 1.57\ m^3/s$ $= 257{,}950\ m^3/s$
Total weight of pigs	$= 324{,}000 \times 10^3$ kg
Volume of ventilating air required	$= 168{,}480\ m^3/s$
Total volume of air required for pigs and poultry	$= 426{,}430\ m^3/s$
Average volume of air required over a year	$= 213{,}210\ m^3/s$
Average rate of fan power consumption	$= 213{,}210 \times 220$ W = 46.91 MW
Number of seconds in a year	$= 365 \times 24 \times 3600 = 31{,}536{,}000$
Energy used by fans in a year	$= 46.91 \times 10^6 \times 31{,}536 \times 10^6$ Joule $= 1{,}480 \times 10^{12}$ J $= 1{,}480 \times 10^6$ MJ = 35,350 TOE

APPENDIX III

REFERENCES: ORGANISATIONS CONTACTED DURING RESEARCH

Electricity Council, Intelligence Section
Department of Energy
Institute of Petroleum
Ministry of Agriculture, Fisheries and Food
- Agricultural Development and Advisory Service
- Rothampsted Experimental Station
National Institute of Agricultural Engineering
Weed Research Organisation
Imperial Chemical Industries - Agricultural Division
- Plant Protection Unit
British Agrochemicals Association
United Kingdom Agricultural Supply Trade Association
Shell International
Shell UK
Fertiliser Manufacturers' Association
Agricultural Research Council
National Farmers' Union
Glasshouse Crops Research Institute
Agricultural Engineers' Association
Open University Energy Research Unit
Harwell, Energy Technology Support Unit
Fertiliser Manufacturers Association
Institute of Energy
Monsanto