APPENDIX 3 THE SPECIFICATION OF THE ENERGY MODULE

A3.1 Model specification

The module models energy use by fuel user and fuel using the following equations.

Fuel users other than power generation and transport

For most 'fuel users' (see A3.2 below for the elements of this classification), each user's overall energy demand is related to a relevant measure of real activity (eg industry output). The model user enters assumptions for the trend over time in this relationship (so that, for example, a trend towards greater energy efficiency can be entered).

(3.3.1) $FUE_{i,t} = FUEC_{i,t} \times FUY0_{i,t}$

where

FUE(i,t)	energy use by fuel user i in year t (energy units)
FUEC(i,t)	energy use per unit of activity by fuel user i in year t (energy units)
FUY0(i,t)	'activity' indicator for fuel user i in year t (gross output for industries, real household disposable income for domestic use)

For each fuel user, energy demand is then shared out by fuel. The model user enters assumptions for the trend over time in these shares (so that, for example, a trend towards substitution of gas for oil can be entered).

(3.3.2) $FUJ_{i,j,t} = FUJC_{i,j,t} \times FUE_{i,t}$

where

FUJ(i,j,t)	use of fuel j by fuel user i in year t (energy units)
FUJC(i,j,t)	share of fuel j in all energy use by fuel user i in year t

Power generation

Because fuel use in power generation is specific to the characteristics of a small number of stations, these stations are identified explicitly in the model, with assumptions regarding their capacity, load factors (capacity utilisation), and fuel-using characteristics:

(3.3.3) $FUJ_{power,j,t} = \sum_{i}^{NES} (JESC_{i,j,t} \times ESG_{i,t})$

(3.3.4) $ESG_{i,t} = ESGC_{i,t} \times ESC_{i,t}$

where

ESC(i,t)	capacity of power station i in year t (MW)
ESG(i,t)	generation of power from power station i in year t (MWh)
ESGC(i,t)	load factor for power station i in year t (MWh per MW capacity)

FUJ(power,j,t)	fuel use by fuel j in the power generation sector in year t (energy units)
JESC(i,j,t)	fuel use by fuel per unit of electricity generated in power station i in year t (energy units per MWh)
NES	number of power stations identified in the region

Transport

The use of different modes for freight and passenger transport is determined in the Transport module (see Appendix 4). Once the number of vehicle kilometres for each mode of transport is determined, fuel use coefficients are applied to determine the resulting use of each kind of fuel. The model user enters assumptions for the trend over time in these coefficients (so that, for example, a trend towards greater fuel efficiency or substitution of fuels can be entered).

(3.3.7) $TMJ_{i,j,t} = TMJC_{i,j,t} \times TMVK_{i,t}$

(3.3.9) $TFJ_{i,j,t} = TFJC_{i,j,t} \times TFVK_{i,t}$

where

TFJ(i,j,t)	use of fuel j by freight mode i in year t (energy units)
TFJC(i,j,t)	use of fuel j per freight vehicle kilometre in freight mode I in year t
TFVK(i,t)	freight vehicle movements by freight mode i in year t (in vehicle kilometres)
TMJ(i,j,t)	use of fuel j by passenger mode i in year t (energy units)
TMJC(i,j,t)	use of fuel j per passenger vehicle kilometre in passenger mode I in year t
TMVK(i,t)	passenger vehicle movements by passenger mode i in year t (in vehicle kilometres)

TFJ and TMJ are then transferred to the appropriate transport elements in the fuel user classification (eg rail transport) in the variable FUJ.

The treatment of CHP

The impact on projected fuel consumption of the installation of CHP plant has been implemented as follows. Firstly, fuel consumption is estimated on the assumption that the CHP plant is not installed. Secondly, it is assumed that the CHP plant is replacing an existing gas-fired boiler, to deliver the same quantity of heat with the same heat-efficiency. Thirdly, the electricity generated from the plant is assumed to reduce the 'net' electricity consumption from the grid. Under these assumptions, the benefit to GHG emissions of the installation of CHP comes from the reduction in electricity consumption. Since electricity does not produce emissions at the point of consumption, and since the level of the region's power generation is not assumed to be reduced in response to lower consumption of electricity from the grid within the region, this benefit is not recorded in the results as a reduction in the region's GHG emissions, but rather in a reduction in the GHG emissions imputed to the region's electricity consumption.

The user enters assumptions for the level of CHP capacity for each fuel user. These are then multiplied by a load factor (currently assumed to be 70%) and a factor (number of hours in the year divided by 1,000) to convert from MWe of capacity to GWh of electricity generated. The resulting electricity from CHP generation is multiplied by another factor to convert from GWh to million tonnes of oil equivalent and then subtracted from electricity demand in FUJ(i,j,t), to give electricity demand net of that supplied from CHP.

$$(3.3.14)\quad FCHG_{i,t} = 0.7*24*365*FCHP_{i,t}/1000$$

$$(3.3.15)\quad FUJ_{i,electricity,t} = FUJ_{i,electricity,t} - 0.00085985*FCHG_{i,t}$$

where

FCHG(i,t)	electricity generated from CHP by fuel user i in year t (GWh))
FCHP(i,t)	CHP capacity for fuel user i in year t (MWe)
FUJ(i,j,t)	use of fuel j by fuel user i in year t (energy units)

Derived results

The variable FUJ is summed across fuels to give the variable FUE, and across fuel users to give the variable JE:

$$(3.3.10)\quad FUE_{i,t} = \sum_{j}^{NJ} FUJ_{i,j,t}$$

$$(3.3.11)\quad JE_{j,t} = \sum_{i}^{NFU} FUJ_{i,j,t}$$

where

FUE(i,t)	energy use by fuel user i in year t (energy units)
FUJ(i,j,t)	use of fuel j by fuel user i in year t (energy units)
JE(j,t)	use of fuel j in year t (energy units)

A3.2 The Classifications Adopted

The model identifies 50 fuel users and 14 fuels as listed below:

Fuel users

- 1 Power generation
- 2 Other energy transformation
- 3 Energy industries’ own use: electricity generation
- 4 Energy industries’ own use: other
- 5 Basic metals
- 6 Mineral products
- 7 Chemicals
- 8 Pharmaceuticuals
- 9 Mechanical engineering
- 10 Metal goods

- 11 Electronics
- 12 Electrical engineering
- 13 Instruments
- 14 Motor vehicles
- 15 Aerospace
- 16 Other transport equipment
- 17 Food
- 18 Drink
- 19 Tobacco
- 20 Textiles
- 21 Clothing & leather
- 22 Paper, printing & publishing
- 23 Other mining
- 24 Wood & wood products
- 25 Rubber & plastics
- 26 Manufacturing nes & recycling
- 27 Water supply
- 28 Construction
- 29 Air transport
- 30 Rail transport
- 31 Road transport
- 32 National navigation and pipelines
- 33 Domestic use (households)
- 34 Public administration & defence
- 35 Education
- 36 Health & social work
- 37 Retailing
- 38 Distribution nes
- 39 Hotels & catering
- 40 Other transport services
- 41 Communications
- 42 Banking & finance

- 43 Insurance
- 44 Professional services
- 45 Computing services
- 46 Other business services
- 47 Agriculture
- 48 Waste treatment
- 49 Miscellaneous services
- 50 Miscellaneous

Fuels

- 1 Coal and coke
- 2 Motor spirit
- 3 Derv
- 4 Gas oil
- 5 Fuel oil
- 6 Other refined oil
- 7 Gas (natural gas, coke oven gas and town gas)
- 8 Electricity
- 9 Nuclear electricity
- 10 Landfill gas (renewable-obligation)
- 11 Waste (Renewable-obligation)
- 12 Other Renewable-obligation renewables
- 13 Other renewables
- 14 Heat sold