Structure and Performance of Six European Wholesale Electricity Markets in 2003, 2004 and 2005

Appendix I

DG Comp

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Global Energy Decisions

EU Database Product Specification

Version 1.0

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1. Specification

In the following sections, the Specification summarises the general classes and sub-classes of data that are maintained in the GED database along with the alterations required for the EU study.

1.1. General Resource Data

Power system resources are generators that produce electricity in order to serve hourly load requirements.

1.1.1. Existing Capacity

Our standard database was stripped down to those units for which the utilities had provided information. No information was requested from utilities with less than 250MW of generation and so these units, along with any units under 25MW which were not reported, were excluded from the simulations for the purposes of the study[1].

1.1.2. Plant Retirements

In all cases the data provided by the utilities was used to identify plant retirement dates.

1.1.3. New Build

In all cases the data provided by the utilities was used to identify plant online dates.

1.1.4. Ownership

Jointly-owned units were treated as unified whole units for the purposes of modelling. Characteristics were usually taken from the station's primary owner and/or operator, although in a few cases the characteristics were blended from among owner-specified numbers.

1.1.5. Mothballed Units

Mothballed units were treated as fully unavailable during their period of mothballing.

1.2. Thermal Resource Data

1.2.1. Heat Rates

Below is a description of the methodology behind the heat rates used in the GED database. For the purposes of the EU study these same heat rate curves were mapped to the characteristics provided by the utilities.

[1] There were a number of exceptions to this as companies/units that were considered to be potentially price setting units (peaking units) wereincluded in the simulations for the purpose of the study.

The utilities provided a maximum winter capacity and a heat rate relevant to this point. The heat rate curves in the GED database, the origins of which are detailed below, were then scaled so that the top point represented the maximum capacity and heat rate provided by the utility. Where data was not provided by the utilities GED base data was used. All heat rates and heat rate curves are derived based on age, technology and size of the unit.

In several instances, operating prices for nuclear units were given in €/MWh produced. In these cases, the heat rate was set to a unity factor of 1,000 to convert the given price into an operating price.

Heat Rate Methodology

Actual data on unit efficiencies was discovered for a significant minority of units in the integrated zone. This information was used to update the full load heat rate, and heat rate curves for those units.

Heat Rate curves are derived form the full load heat rate using standard shapes derived from Global Energy's world-wide database of plant performance data. Common shapes are shown in the table below with heat rates changing at 25, 50, and 75% of full load:

Unit Type	***Heat Rate 1***	***Heat Rate 2***	***Heat Rate 3***
CC	1.788	1.195	1.102
GT	1.504	1.095	1.029
ST	1.276	1.061	1.010

Table 1-1 Full Load Heat Rate Multipliers

For those units for which efficiency data could not be obtained, a full load heat rate was set by comparison with similar units in Europe or from Global Energy's world-wide database of plant performance data. As above, heat rate curves were derived from the full load heat rate. These units were updated en masse – with all units for a country, or country and fuel type being updated in a single batch.

Some example full-load heat rates are given in

Table 1-2. Note that all heat rates are given as higher heating value (HHV).

Type of Station	***Full Load Heat Rate (GJ/GWh)***
Open Cycle GT	15,493
Large Steam Turbine plant	10,732
New CCGT	7,200

Future CCGT	6,830

Table 1-2: Example of Full Load Heat Rates

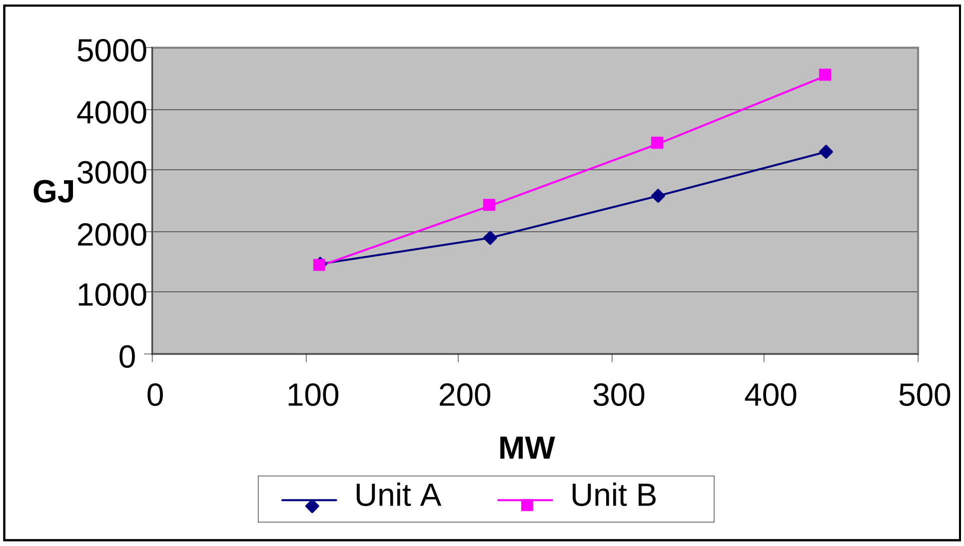

Figure 1: Sample Heat Rate Curves

1.2.2. Outage Rates

All hourly actual outages were provided by the utilities and fed into the model via HXML integration.

1.2.3. Unit Dynamics

Minimum Capacity (MW) - The minimum stable generation provided by the utilities was used. Where this was not provided GED base data was used (which assumes minimum capacity is 40% of the maximum capacity for most of the plant types)

Minimum Up Time (hrs) – This was entered on a unit type basis (See Table 1-3) unless a unit specific value was contained within GED base data.

Maximum Down Time (hrs) - This was entered on a unit type basis (See Table 1-3) unless a unit specific value was contained within GED base data.

Run Up Rates (MW/hr) - This was entered on a unit type basis (See Table 1-3) unless a unit specific value was contained within GED base data.

Type of Station	*MINUP_HRS*	*MINDOWN_HRS*	*RUNUP_% Max Cap*
CC_ALLSIZE	*8*	*8*	*0.50*
DIESEL_ALLSIZE	*1*	*1*	*0.50*
FOSSIL_COAL_ALLSIZE	*12*	*12*	*0.33*
FOSSIL_GAS_ALLSIZE	*12*	*16*	*0.50*
FOSSIL_LIGNITE_ALLSIZE	*12*	*16*	*0.33*
FOSSIL_OIL_ALLSIZE	*12*	*16*	*0.50*
GEO_ALLSIZE	*1*	*1*	
GT_ALLSIZE	*2*	*1*	
IGCC_ALLSIZE	*24*	*16*	*0.50*
JET_ALLSIZE	*1*	*1*	
MULTITURBINE_ALLSIZE	*8*	*16*	
NUC_ALLSIZE	*168*	*0*	*0.10*

Table 1-3 Standard Min Up/Down and Run Up Rates for Common Unit Types

Ramp Up and Ramp Down Rates (MW/hr) in the UK - For each plant in the UK the Ramp Up and Ramp Down Rates are listed in the Custom field of the Thermal Table. These values are obtained by the BM Reports web site. The variables RampUp and RampDown identify the rates (MW/hr) whereas RampUpPoints and RampDownPoints (MW) describe the inflection points in multi-segment piece-wise linear Ramp Up/Down Rates. An example is shown below:

RampUp	[v3]	300	12	300
RampUpPoints	[v3]	177	180	485
RampDown	[v3]	300	24	3510
RampDownPoints	[v3]	234	240	485

1.2.4. Operating Costs

Variable non-fuel operation and maintenance costs were standardized by unit type, to allow comparability among generators despite accounting differences. In particular, the reply to the variable o&m question in the 2006 Questionnaire returned by newcomers to the study at that stage, were not used, in order to put the new units on an equal footing with the base of existing units, for which the question was not separately asked.

1.2.5. Start-up Costs

Start-up costs were provided by the utilities. If a differentiated figure was provided for “hot” and “cold” starts, these were entered with the hours provided. If no hours were provided, we assumed a hot start was anything less than 8 hours of downtime, while a cold start was greater than 72 hours. A start after a number of hours in between hot and cold start hours was interpolated from the figures provided.

1.2.6. Emissions

Below is a description of the methodology behind the unit CO_2 emission rates used in the GED database. For the purposes of the EU study the appropriate unit type factors derived from the methodology below were used in conjunction with the unit specific heat rates provided by the utilities. Average monthly CO_2 prices (€/tonne), taken from EEX, were entered into the emission basins of the countries being studied.

To determine an emission rate, either a reported emission rate or the combination of actual emissions and plant generation were required. In the case of 2005, actual generation data would be sufficient – as total CO_2 emissions could be identified from the Community Independent Transaction Log (CITL). Even so, only a very small number of data points (<30) across the integrated zone could be found – either for individual units or stations.

This means that Global Energy has had to develop a methodology to assign rates to the vast majority of units based on the rather limited data points available. It is anticipated that as more companies complete their reporting for 2005, the number of data points should increase – and at this point CO_2 rates will be reviewed.

For each fuel, a basic emission rate (in kg/MWh) was identified for a "reference" unit which burns that fuel and has a known, full load efficiency. Other units were then assigned an emission rate by comparing their full load heat rate with that of the reference unit.

Individual data point with known emission rates were compared with interpolated emission rate assigned, and in each case a very close match was found.

For gas-fired co-generation units, a penalty was applied to their interpolated emission rate to represent CO_2 being produced for heat, rather than power, production. A penalty of 5% was added to units which provide district (or other low-grade heat) and a penalty of 10% to units providing high or intermediate pressure steam. These generic assumptions will need to be reviewed as more data becomes available.

The following table gives the standard emission rates deduced from the data points available:

Fuel	***Emission rate (kg/GJ)***
Natural Gas	50.95
Gas Oil	67.76
Fuel Oil	69.80
Coal	88.21
Lignite	105.79
Blast Furnace Gas	256.00

Table 1-4 Generic Emission Rates

Emission rates in Europe have been implemented as kg/MWh values – this aids comparison with available data.

1.2.7. Commit/Dispatch Status

The must-run status of units was modelled in the manner provided by the generators. If a unit (such as a CHP unit) was explained to be must run during certain months of the year, it was set that way in the model. In all countries except France and Belgium, nuclear units were also considered to be inflexibly dispatched, in other words normally run at maximum available capacity and not available to follow load.

1.3. Hydro Resource Data

Hydro was divided between run-of-river hydro and storage hydro. Since there can be no influencing run-of-river hydro, it was netted off the system for modelling purposes. It was then re-added for the purposes of London Economics' indices.

Storage hydro was modelled by summing all storage units by owning company, and for each month, summing the generation of those units, and finding the minimum and maximum MW level reached in any hour for that month. This was the best proxy available for correct modelling of storage in the absence of hydrological data on the units (cascaded hydro systems, ecological considerations, minimum river flows, fish conservation and agricultural restrictions, etc.).

The model was then allowed to dispatch the aggregated units each month, from minimum to maximum, until the total energy actually produced was reached. In the absence of additional data, this method did not allow us to study any possible effects of moving large amounts of storage hydro energy from month to month.

1.4. Wind Resource Data

Wind was treated in the same manner as run-of-river hydro, as described above.

1.5. Fuels

All fuel prices (cents/GJ) used for the EU study were provided by the utilities. Both a fuel and a fuel group were created and attached to the corresponding power station as indicated by the data provided by the utilities. In cases where small amounts of data were not provided (e.g. No price for March 2004) the missing prices were interpolated from prices at either side of the missing point.

1.6. Economic Parameters

The values in the database are in Euros.

1.7. External Interconnections

All countries were run in isolation and so interconnections have been ignored.

1.8. Daylight Saving Time

It was not possible to tell from the generation figures provided how all companies accounted for the summer time shift. Therefore we standardised on accepting all 26,304 hours (3 years' worth of generation) as given, and simulated 24 hours in each day.

1.9. Reserve contribution

It was impossible to analyse reserves completely, since they are based on system (TSO) load plus local (non-TSO) load, and it was not possible to relate our load to the TSO-provided load. As a proxy, we made the modest assumption of a single requirement of 5% of calculated load, and limited each unit's contribution to 20% of its installed capacity. These assumptions should not have a great effect on price or unit commitment. In fact, raising reserve requirements should lower marginal price.

As a test, we increased the reserve requirement in Belgium to 10% as a stress sensitivity. This resulted in prices mostly staying the same, but dropping in some hours. In the case of Germany, we performed the same test, with the same result in marginal price. The stressed result of the new pricing methodology is that the average price of the most expensive unit rises about 7%. We did not examine whether this was the result of the methodology's effect on the operation of particular generators, or of their having started for reserve purposes.

1.10. Spurious generation and capacity data

When a wild generation figure (contradicting generator characteristics) appears on rare occasions, it has been replaced with a surrounding-hour average. It is presumed to be the result of a measurement error. If a generator's actual generation was consistently above its specified maximum, that maximum was adjusted. The details of this on a per-unit basis are confidential and therefore not included here in order to preserve the extremely high level of confidentiality observed throughout this study.

1.11. Pumped storage modeling

Pumped storage units were modelled in load-levelization mode. Since pumped storage pumping capacity was not separately provided, it was assumed to remain in the same proportion to generating capacity as in the original GED database. Thus if the returned data showed a 10% higher generating capacity than was in the original database, the pumping capacity was assumed to be 10% higher than it was in the original database. Also, if efficiency was provided in the original questionnaire response, that efficiency was used. If not, the efficiency already in the GED database was used.

2. Country Specific Assumptions

This information has been removed for confidentiality reasons.