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DG ENERGY

European Coal resources: a geographical database and map of EU coal basins including potential sources of coal bed methane based on a harmonised typology

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Final report

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List of abbreviations

AAPG	American Association of Petroleum Geologists
AMM	Abandoned Mine Methane
AS	Australian Standards
ASTM	American Society for Testing and Materials
BGR	Germany Federal Institute for Geosciences and Natural Resources
CBM	Coalbed Methane
CBNG	Coalbed Natural Gas
CIS	Commonwealth of Independent States
CMM	Coal Mine Methane
CMMI	Council of Mining and Metallurgical Institutions
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
CRS	Coordinate Reference System
CSM	Coal Seam Methane
daf	Dry, ash-free basis
DG	Directorate-General
DIN	Deutsches Institut für Normung
DS	Data Specification
ECOSOC	United Nations Economic and Social Council
EFTA	European Free Trade Association
EGRC	Expert Group of Resource Classification
EIA	US Energy Information Administration
EU27	European Union of 27 member states
EuCoRes	European Coal Resources (acronym for this project)
EUOSME	European Open Source Metadata Editor
EURACOAL	The European Association for Coal and Lignite
GCV	Gross Calorific Value
GDMB	Gesellschaft Deutscher Metallhütten- und Bergleute
GIS	Geographical Information System
GISCO	Geographical Information System at the Commission
GOST	Gosudarstvennyy Standart (Russian)
GUI	Graphical User Interface
IAEA	International Atomic Energy Agency
ICCP	International Committee for Coal and Organic Petrology
IEA	International Energy Agency
IMM	Institution of Mining and Metallurgy
IMO3	Institute of Materials, Minerals and Mining
INSPIRE	Infrastructure for Spatial Information in the European Community
InterEnerStat	Working Group on Energy Statistics
IRES	International Recommendations for Energy Statistics
ISO	International Organisation for Standardization
JORC	Joint Ore Reserves Committee

kcal	Kilocalorie
kg	Kilogram
km	Kilometre
km^2	Square kilometre
m	Metre
mD	Millidarcy
MJ	Mega joule
mmf	Mineral matter free basis
MPa	Mega Pascal
NEA	Nuclear Energy Agency
NI	National Instruments Canada
NWECB	Northwest European Cenozoic Basin
OECD	Organisation for Economic Co-operation and Development
PERC	Pan European Reserves and Resources Reporting Committee
PGI	Polish Geological Institute
PIIP	Petroleum Initially In Place
PRMS	Petroleum Resource Management System
RAG	German hard coal industry
RWTH	Rheinisch-Westfaelische Technische Hochschule
SADL	Spatial application division Leuven
SPE	Society of Petroleum Engineers
SPEE	Society of Petroleum Evaluation Engineers
$std.m^3$	Standard cubic metre
t	Ton
UK	United Kingdom
UML	Unified Modelling Language
UN-ECE	United Nations Economic Commission for Europe
UNFC	United Nations Framework Classification
UNSTATS	United Nations Statistical Division
USA	United States of America
USBM	United States Bureau of Mines
USGS	United States Geological Survey
USSR	Union of Soviet Socialist Republics
VAM	Ventilation Air Methane
VCBM	Virgin Coalbed Methane
vol%	Volume percentage
VR	Vitrinite Reflectance
WCA	World Coal Association
WEC	World Energy Council
WPC	World Petroleum Council
wt%	Weight percentage
XML	Extensible Mark-up Language

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Introduction

This document is the final report of the EuCoRes (European Coal Resources) project, continuing from December, 22nd 2011 until November, 22nd 2012.

To give a good overview of the project, the document is built-up in a classic manner: there are (1) the original objectives, (2) the general approach, (3) the achieved results, and (4) the final conclusions.

Additionally to this report, the on-line project presentation is accessible through the project web site: http://ec.europa.eu/energy/coal/eucores.

Context

This project should be placed in the wider context of the increasing global demand for energy. Especially in rapidly industrialising and developing economies, energy security concerns become ever more important.

The requirements are high: energy must be readily available, affordable and be proven a reliable source of power, not only short-term but also for future generations. This implies a necessity for a wide range of energy sources, now and into the future, each with their own advantages. This provides security to an energy system by allowing flexibility in meeting instantaneous and long-term needs.

Fossil fuels, among which coal and coalbed methane (CBM), still play a very important role in the energy supply today. Coal is an important energy source for the steel and cement industry, and for electricity production in Europe. Almost one third of the power generated in the EU27 is coal-based.

The production of primary energy from fossil fuels decreased significantly in the EU27 in the last decade. Supplies of raw materials have become exhausted and/or producers now consider the exploitation of limited resources uneconomical. Consequently, the EU27 has become more dependent on import of these resources. However, this import dependency is for coal the lowest of all fossil fuels. Moreover, the unconventional exploitation of coal seams (*e.g.* CBM production, underground Coal Gasification) opens perspectives for improving the EU27's security of energy supply and it has the added advantage of a lower carbon emission.

Taking this all into consideration, a good knowledge of the energy potential and thus of the conditions and geographical location of the main coal resources throughout Europe is required for future policy making. This information serves as a tool for decision making on the potential extraction of coal and CBM. Assembling data on coal and CBM resources and reserves is a first step in this process of decision making.

1 Project objectives

This project fits in a wider scope that aims at securing the energy supply in Europe. For this, an assessment of the potential of the EU27's resources of coal (lignite and hard coal) as well as coalbed methane (CBM) must be carried out.

The scope of the project is to assimilate data on coal and coalbed methane in a structured manner, i.e. based on a harmonized classification and typology.

This data collection will be presented in a digital geographic database with descriptive and spatial information of all (available) existing coal deposits covering the main coal basins in Europe.

Coal deposits will be differentiated by coal type, based on a proposed common classification, and contain information on coal or CBM resources (chapter 3.1).

For this, the following steps are required:

1. A collection and **evaluation of the existing** data sources and an evaluation of different classification schemas in relation to coal deposits including the potential sources of coalbed methane in the EU and relevant neighbouring countries;
2. **Formulation of a common classification and terminology** for coal typology and for CBM reservoirs for Europe taking into consideration existing (national and international) methodologies and classifications. The proposed common typology will be evaluated throughout an organised workshop for coal experts.
3. The common classification will be integrated in the **database model** and the collected data will be fitted into the model.

The combined result of the different deliverables will serve as reliable starting point for future studies or consultations in this field.

The final database is not definite, but its status can be updated as future changes can have a profound influence. Examples of such changes are an increasing knowledge of existing basins/deposits, availability of data with higher quality, improved exploitation feasibility due to technological progress or due to change of economic conditions, extensions of the model for different energy sources *e.g.* shale gas, *etc*.

2 General approach

In order to be able to organise and plan the work in the project 4 different 'tasks' were defined:

1. Task 1: Evaluation of existing data sources and classification schemes
2. Task 2: Formulation of a common classification and terminology
3. Task 3: Creation of a geographical database
4. Task 4: Production of maps

The project was carried out in close collaboration between the partners of the consortium SADL (expertise in the field of database modelling) and RWTH Aachen University (expertise in the field of coal).

Multiple work meetings at regular time intervals were organised to ensure the communication between the different stakeholders (DG ENER, SADL, RWTH) and to oversee the progress of the project. Apart from the kick-off meeting (January, 20th 2012), 6 additional progress meetings (February, 27th 2012; April, 2nd 2012; April, 26th 2012; July, 18th 2012; September, 7th 2012 and October, 18th 2012) were held in order to report the progress to the Commission and to make important decisions for the continuation of the project (*e.g.* planning of the workshop).

Table 1 (page 12) gives an overview of the timetable for the identified activities for the 8 months project duration as presented at the beginning of the project. This timing had to be revised mainly due to the difficulties to lay hands on existing data sources. This had its implications on the progress of tasks 1 and 2.

The proposal of the common classification and terminology was evaluated on a workshop (see http://ec.europa.eu/energy/coal/eucores/eucores_workshop_en.htm) for national coal experts organised on May, 29th (T+5) back to back with the 8th Coal Dialogue (organised jointly by the Commission and EURACOAL). Slight revisions had to be made based on the findings from the workshop.

Meanwhile, in order to keep on track with the schedule, it was decided not to wait for the evaluation of the existing data sources in order to start the creation of the geographical database. This was not the ideal situation since the external data sources were finally used to feed the database. An analysis of existing data would have made this process easier.

In the first place the attention was focused on the most important coal producing countries of the European Union, countries where coal production was abandoned for a longer period were considered as less important. Countries without known resources were not taken into account.

The content of the resulting database is described in higher detail in the chapter 3.2. The database is a first attempt to gather harmonized coal and CBM resource information on European scale. It can be extended with new and more detailed information whenever this becomes available.

In the chapter *Project achievements* the work is described in more depth. It is not described in order of the tasks stated above, but more as a logical sequence for the reader (and more in line with the deliverables).

Table 1 – Project timetable

	Scheduled deadline Deliverables	T+1	T+2	T+3	T+4	T+5	T+6	T+7	T+8
TASK 1: Evaluation of existing data sources & classification schemes									
Analysis requirements	T+2	■	■						
Analysis s. data& literature on existing classifications	T+4	■	■	■	■				
Documentation	T+7		■	■	■	■	■	■	
TASK 2: Formulation of common classification and terminology									
Analysis and prepare workshop	T+5	■	■	■	■	■			
Workshop	T+3		■	■					
Workshop post-processing	T+4			■	■				
Documentation	T+8			■	■	■	■	■	■
TASK 3: Creation of a geographical database									
creation of conceptual and logical datamodel	T+4			■	■				
implementation of physical data model	T+5				■	■			
feed database and verify consistency	T+6				■	■	■		
generate INSPIRE compliant metadata	T+7					■	■	■	
reiteration of entire process	T+5					■			
create symbology using modelbuilder tools	T+8					■	■	■	■
create customised tools	T+6					■	■		
delivery and installation of database	T+8								■
Documentation	T+8					■	■	■	■
TASK 4: Production of Maps									
analysis of mapping requirements	T+7						■		
creation of map templates	T+8							■	■
create and deliver maps.	T+8							■	■
Project Management									
Kick-off Meeting	T+1	■							
Interim meeting	T+3			■					
final project meeting	T+7							■	
management / Quality Control project	T+8	▨	▨	▨	▨	▨	▨	▨	▨
Inception report	T+1	■							
Interim report	T+3			■					
Final Project Report inc. draft	T+8							■	■

3 Project achievements

This chapter presents the project achievements. It is built around the four major themes described in the tender: (i) a common classification and terminology, (ii) data collection and interpretation, (iii) a geographic database, and (iv) a set of maps. Each of these themes is described in a separate section.

Next to these four themes, two additional sections are included. One section is dedicated to the workshop that was organised in order to get expert feedback on the project. Another section gives a brief overview of the metadata fiches. These describe country specific metadata, as an elaboration of the INSPIRE discovery profile 'lineage' metadata element.

This chapter's contents:

All sections follow the same structure: first the objectives and the approach are outlined, followed by an in-depth presentation of the results.

Remark: *For organising all the publications, reports and other referenced documents (see References on page 137), a* ***reference management system*** *(EndNote) is being used, with references and/or hyperlinks to articles and/or websites.*

3.1 Formulation of a common classification and terminology

In order to formulate a suitable, internationally harmonized classification and terminology for the EuCoRes database, first a range of national and international **coal classification systems** that are in use in EU countries have been evaluated. Additionally, an evaluation and review of national and international classification and reporting systems for coal and coalbed methane **resources and reserves** has been performed.

This chapter's contents:

3.1.1 Objective

The first objective was to evaluate the **coal classification systems and definitions** that are used by government organisations, coal industry and academia to differentiate coals by rank and coal quality throughout the EU. The purpose of this study was to help understand and identify differences in classification and terminology that are used for coal in the Europe and finally, to allow the formulation of a common classification and terminology that can be used in the EuCoRes database to compare coal, coalbed methane and their respective resources and reserves.

The second objective was the evaluation of systems and schemes that are used throughout the EU to define classify and report **resources and reserves** of coal and coalbed methane. The aim of this study was to identify differences in the definition and classification of resources and reserves used by coal industry, government organisations, geological surveys and institutions that report energy statistics in the EU. Furthermore, methodological differences in the assessment of resources and reserves and the applied parameters and cut-off values for the delimitation of resource and reserve quantities were identified to evaluate to which degree reported resource and reserves figures are comparable in the EU. Results of the evaluation of different national and international resource classification and reporting systems were used to identify a simple and harmonized system that can be used for the EuCoRes database, which allows a maximum of comparability of resource and reserve figures in the EU.

3.1.2 Approach

For the evaluation of coal classifications and coal resource/reserve classification systems used in EU countries, **a survey** was sent to national geological surveys, government institutions, coal industry, mining associations and universities. Additionally, a **literature review** of national and international coal and coal resource classification systems was performed and **experts** from international scientific organisations such as the International Commission of Coal Petrology or the expert groups of the United Nations Economic Commission for Europe were consulted. Based on results of this survey and review, a summary of existing classification systems and terminologies that are used in the EU and internationally was compiled and a first harmonized classification and common terminology for coal classes and resource / reserve classes for coal and coalbed methane was formulated. The summary and proposed classification were distributed to national coal experts and institutions of the EU countries, who were also invited to an international **workshop**, which was organised to present the project and critically discuss and review the proposed harmonized classification and common terminology. The proposal was then updated according the findings of the workshop.

3.1.3 Result

Coal classification

Results of the review of coal classification systems used on a national and international level in the EU (see section 3.1.3.1) show that currently many different scientific and technological classifications are used in Europe. Scientific coal classifications use different coal rank parameters to classify coals according to their degree of coalification into low rank, medium rank and high rank coals. The most widely accepted coal rank parameter that can be used over a wide range is the reflectance of vitrinite. Other frequently used parameters are the volatile matter yield, the gross calorific value or the bed moisture content. National coal classification systems use different terminologies or codes for the individual rank classes.

To harmonize these systems, several international classification systems were created that allow mapping of coal rank classes between different national systems. The most detailed classification of coals according to commercial parameters can be achieved by the UN-ECE 1988 codification system. However, the complex nature of this system, it's limitations towards coal rank classification and comparability of coals from different coal provinces (*e.g.* Gondwana, Laurasia) and the fact that after more than 20 years it is still not widely used, indicate that a less complex system such as the ISO 11760 is more useful for the classification of European coals.

The ISO 11760 also represents the latest and scientifically most accurate classification for coals by rank and also includes classification parameters for coal grade and type. The ISO was also developed to allow good comparison with the UN-ECE classification and thus also the US (ASTM), German (DIN), Australian (AS) and Russian (GOST) classification. This classification system can also be extended to include commercial parameters, such as those used in the UN-ECE 1988 codification system.

Next to scientific coal classifications, a range of technological classification systems exist that classify coals according to their utilization properties. These classifications use properties that are important for metallurgical coals (coking properties) steam coals (grindability, heating value) and other traded coals. Classification and coal quality parameters frequently used for coal trade are the gross calorific value, proximate analysis results (ash yield, moisture content, volatile matter yield), coking properties (coke strength, maximum fluidity, *etc.*), and elemental composition, *e.g.* sulphur content.

Results of the review of coal classification systems were used for the formulation of a simplified and harmonized classification system which can be used in the EuCoRes database. Furthermore, a list of important coal rank and coal quality parameters was compiled with the aim to include this information in the metadata of the database. Finally, a harmonized terminology and classification for coal rank classes was proposed and reviewed during and after the workshop (see chapter 3.3 page 66).

Resource / reserve classification

Results of the review of resource/reserve classifications used internationally and specifically in EU countries for coal and coalbed methane (see section 3.1.3.2) show that currently, no internationally recognized method exists for the categorization and quantification of coal resources. Instead, numerous guidelines and classification systems exist that exhibit significant differences between individual countries but also within the national framework. The classifications differ in terms of:

- concepts, *e.g.* geologic, economic or deposit concepts;
- terminology, *e.g.* different use and definition of the terms 'resource' and 'reserve';
- definition of coal classes, *e.g.* hard coal, brown coal, lignite, *etc*.

Differences in commodity type result in different classification systems that are used for coal and for coalbed methane. Coal resources are often classified using classification systems that are equal or comparable to systems that are used for the assessment and reporting of solid mineral commodities such as the CRIRSCO template. Coalbed methane resources are often assessed using different systems that are designed for the classification of petroleum resources such as the petroleum resource managements system (PRMS).

Furthermore, no uniform method exists for the delimitation of the volume of a coal deposit that is under consideration for the resource classification. Instead, different parameters and limiting values (cut-off values) *e.g.* for coal quality, depth, seam thickness, *etc*. are used.

The international UNFC 2009 classification system provides the only versatile and harmonised classification system that can be used to report and compare resources and reserves for coal as well as associated gas (coalbed methane). This system has already been mapped to several other international and national classification systems that are used in Europe *e.g.* Poland, Turkey, Russia and other CIS countries (Niec, 2010; Ersoy, 2010; Kavun and Denisov, 2005). However, the UNFC 2009 as well as other classification systems such as the CRIRSCO or PRMS do not provide standardised parameters for the resource and reserve estimation. Knowledge of the methodology, key parameters and cut-off values that were used for the resource assessment of individual coal deposits is therefore of utmost importance.

Based on the results from the review of resource/reserve classification systems it was decided to include quantities of coal and CBM resources/reserves according to the individual (national) classification and typology of EU countries in the EuCoRes database. If mapping from the national system to the international UNFC classification is available, resource and reserve information can be included according to the code system of the UNFC in parallel to the national classification, to allow a maximum in harmonization.

Until a harmonized international resource classification system such as the UNFC is applied in all EU countries and standardised parameters and guidelines are available for the resource assessment and reporting of coal and CBM resources, a sound comparison of coal and CBM resources in Europe will be difficult, if not impossible.

3.1.3.1 Results of the literature study on scientific and technological coal classification

Coal (definition)

Coal is defined according to ISO 11760 as a "carbonaceous sedimentary rock largely derived from plant remains with an associated mineral content corresponding to an ash yield less than, or equal to 50% by mass (dry basis)".

The border between peat and brown coal is most commonly placed at a bed moisture or total moisture content of more than 75 wt% (ash-free basis) (Teichmüller and Teichmüller, 1979; UN-ECE, 1998; ISO 11760).

Different parameters are used to define the border between brown coal and bituminous coal, *e.g.* bed moisture more than 8-10 wt%, (ash-free basis) (Patteisky and Teichmüller, 1960) or a calorific value of 5700 kcal/kg (24 MJ/kg) (moist, ash-free basis) (UN-ECE, 1956; UN-ECE, 1998) or by a vitrinite reflectance of 0.4% (ISO 11760).

Principles of Coal classification

Coals show a wide variation in composition and in chemical and physical properties. This variation occurs on different scales, *e.g.* within a coal seam, between coal seams within a coal basin, between coals from different coal basins as well as between coals from different coal provinces. Due to this complex and heterogeneous nature of coal, a comparison of coals on a global scale is difficult.

The purpose of a coal classification system is to differentiate coals according to their physical and chemical properties, which can then be used to evaluate the quality and the (economic) value of the individual coals for different utilisation purposes. Coal classification also provides information on specific coal properties that can be used as cut-off values for the estimation of coal resources and reserves (*e.g.* ash yield, calorific value, total sulphur content).

Many different coal classification systems have been developed in individual coal basins and countries. Coal can be classified according to different **scientific properties**, *e.g.* elemental composition, and physical and chemical properties, or according to **commercial properties** that control the market value of coal for coal utilization purposes such as combustion or carbonisation, *e.g.* coking or caking properties, calorific value, washability, grindability, water content, *etc*.

The use of a commercial classification system is not recommended because commercial coal classifications often do not have strict definitions (*e.g.* soft- hard coking coal) and also because commercial categories are rather arbitrary and can change according to economic circumstances and thus "it can be the case that coals that might be considered as belonging to one of these categories at a given time, can be sold under a different category when the supply-demand balance changes" (Cook and Diessel, 2010).

Coal classification is generally based on **specific coal properties that show systematic variation**. Van Krevelen (1993) divided these coal properties into extrinsic and intrinsic properties.

Extrinsic coal properties depend on the amount and type of inorganic (mineral) matter. Classification based on extrinsic properties determines the coal **grade** and is mostly based on the ash yield (as wt% on a dry basis) or the mineral matter content, determined microscopically (as vol%). However, microscopic determination of mineral matter is difficult, especially for small particles and thus ash yield is the most widely used parameter. Coal grade is controlled by the depositional environment (facies). Higher amounts of inorganic matter decrease the heating value and coking properties of coal and thus decrease the commercial value.

Intrinsic properties are properties of the organic matter, which are inherited from the original plant organic matter and it changes during early biochemical coalification (peat formation). The organic matter **type** of coal is most frequently analysed by organic petrographic methods using reflected light microscopy of discrete coal particles. This method distinguishes between three major groups of microscopically recognizable organic materials, so called maceral groups. These maceral groups are vitrinite (termed huminite for brown coals), inertinite and liptinite (formerly termed exinite), according to the classification of the International Committee for Coal and Organic Petrology (ICCP), based on the Stopes-Heerlen System (Table 2). The petrographic composition (relative proportion of maceral groups) of coal determines the coal type.

Table 2 – Maceral groups used for petrographic coal classification by type (organic matter)

Maceral Group (brown coal)	characteristic	Typical origin
Vitrinite (huminite)		Lignin and cellulose of plant cell walls
Liptinite (formerly termed exinite)	Hydrogen-rich	Hydrogen-rich plant remains such as spores, pollen, waxes and fats
Inertinite	Oxygen-rich	Same plant substances as of vitrinite and liptinite that were altered during early stage of coalification, *e.g.* charring caused by forest fires

Intrinsic coal properties undergo systematic changes during the diagenetic and catagenetic stage of the coalification process. These transformations are mainly controlled by temperature, time and to a lesser degree by pressure. The degree of coalification determines the coal **rank**. Coal rank, coal grade and coal type are generally independent and can be used on orthogonal axes for coal classification. Several coal properties show systematic variation with increasing coal rank (Table 3 page 20 and Figure 1 page 20).

Most coal classifications are classifications of coal by rank, because most of the observed variation of coal properties is rank related. However, the parameters that are used for coal rank classification systems can differ. Most common parameters are the chemical (elemental) composition, the volatile matter yield, the specific energy (calorific value) and the reflectance of vitrinite macerals. For low-rank coals the specific energy is also influenced by coal grade and type and thus the bed moisture (*in-situ* moisture, total moisture content) or moisture holding capacity (equilibrium moisture) is commonly used as an additional parameter for rank classification (van Krevelen, 1993).

Vitrinite reflectance is a microscopically measured parameter that was introduced by McCartney and Teichmüller in 1972 and which is now the most widely accepted and applied rank parameter in coal science. Vitrinite reflectance is measured in oil immersion on randomly selected vitrinite macerals (usually 100 measurements per coal) and reported as average value (% Rrm). High rank coals such as anthracites show an increasing anisotropy of vitrinite reflectance, which requires additional measurements of the minimum and maximum reflectance.

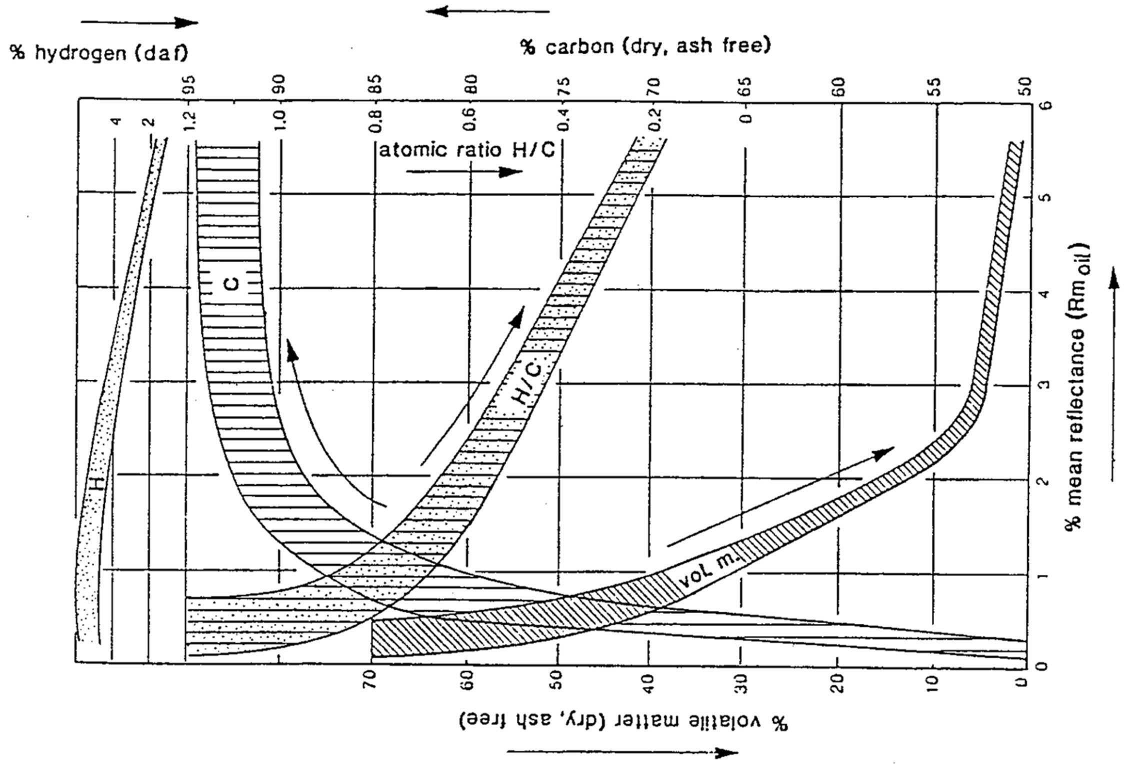


Figure 1 – Variation of different coal properties with coal rank (vitrinite reflectance) (Teichmüller and Teichmüller, 1979).

Table 3 – Coal properties commonly used for coal classification by rank (Cook and Diessel, 2010)

Coal property	Unit, reference base	Analytical method	Trend with increasing coal rank	Classification system
Vitrinite reflectance	%	Microscopy	increases	DIN, UN-ECE 1998, ISO 11760
Total carbon content	wt%, dry ash-free	Ultimate analysis	increases	Regnault (1837), Seyler (1901)
Oxygen content	wt%, dry ash-free	Ultimate analysis	increases	
Hydrogen content	wt%, dry ash-free	Ultimate analysis	decreases	
Volatile matter yield	wt%, dry ash-free	Proximate analysis	decreases	ASTM
H/C atomic ratio	-	Ultimate analysis	decreases	
Specific energy (calorific value)	kJ/kg or kcal/kg or btu/lb, moist, ash-free	Proximate analysis	Falls to mid bituminous range, then rises	ASTM, UN-ECE 1998
Bed moisture (total moisture content)	wt%, dry ash-free	Volumetric or Gravimetric	Rises to mid bituminous range, then falls	UN-ECE 1998

Comparison of national and international coal classification systems

The US ASTM coal classification system uses the specific energy (calorific value) as rank discriminating parameter for low rank coals and additionally the volatile matter yield for high rank coals (volatile matter yield below 31%). The German DIN classification system uses the reflectance of vitrinite macerals as a primary rank parameter (Figure 3 page 23).

The Russian (GOST 2003), Ukrainian (DSTU 3472 96) and Polish (PN-82/G-97002) coal classification systems use a combination of coal rank parameters (volatile matter yield and vitrinite reflectance) and commercial classification parameters such as the specific energy and coking parameters (*e.g.* Roga Index, Swelling Index).

The coal classification system used by British Coal (1964) for hard coal is widely used in the UK. This classification uses coal rank codes which are assigned for coals using the volatile matter yield as rank parameter and the Gray-King coke type as a technological parameter to classify coking coals (Table 4 page 24).

For commercial coal classification, additionally to grade, type and rank, coal properties that influence the value for coal utilisation in industrial processes *e.g.* carbonisation, combustion, gasification, *etc*. are used. Most important properties are the hardness and grindability of coal which influence the value for pulverised coal combustion and the plasticity and fluidity of coal, which then influence the coking and caking properties of coal. Table 5 page 24 gives an overview of additional coal properties for commercial classification.

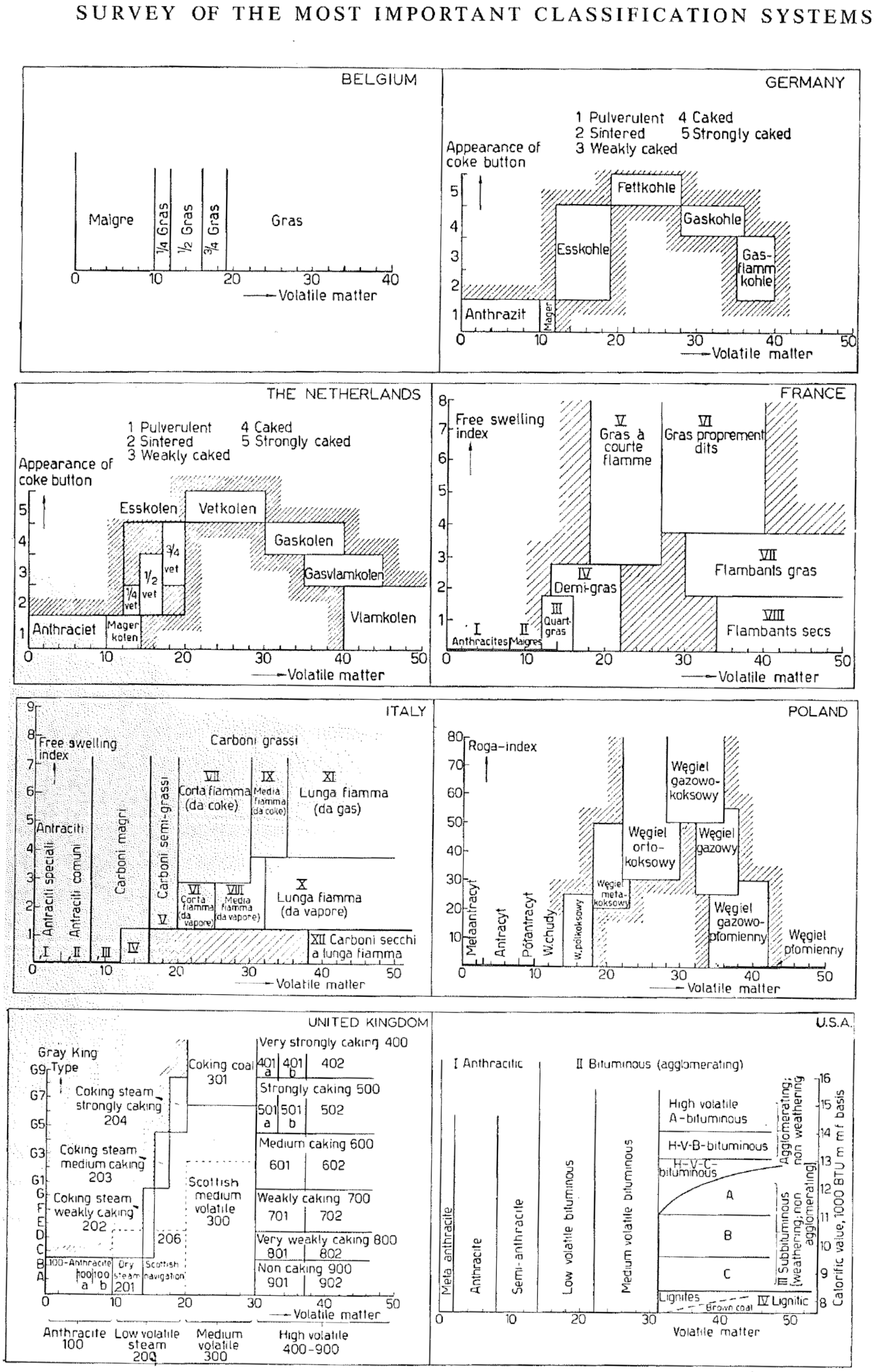
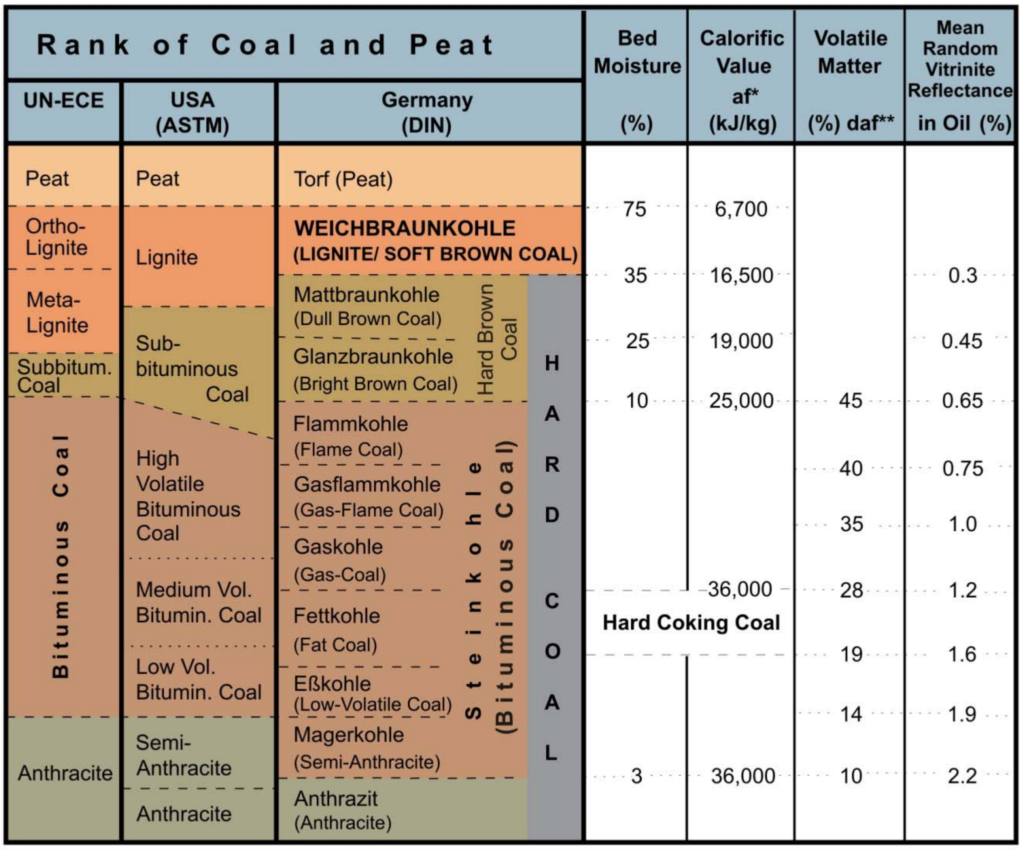


Figure 2 – Comparison of national commercial coal classification systems by van Krevelen (1993).



UN-ECE: Ortho-Lignite max. 15,000 kJ/kg
Meta-Lignite max. 20,000 kJ/kg
Subbituminous Coal max. 24,000 kJ/kg
Bituminous Coal max. mean random vitrinite reflectance of 2 %

USA: Lignite max. 19,300 kJ/kg

* af = ash-free, daf** = dry, ash-free

Figure 3 – Comparison of the German, American and international UN-ECE (1998) coal classification (BGR, 2003)

Table 4 – Coal classification used in the UK (Thomas, 2002)

Coal rank code: Main class(es)	Class	Subclass	Volatile matter (d.m.m.f.) (%)	Gray–King coke type[a]	General description
100			Under 9.1	A	
	101[b]		Under 6.1	A	Anthracites
	102[b]		6.1–9.0	A	Anthracites
200			9.1–19.5	A–G8	Low Volatile steam coals
	201		9.1–13.5	A–C	Dry steam coals
		201a	9.1–11.5	A–B	Dry steam coals
		201b	11.6–13.5	B–C	Dry steam coals
	202		13.6–15.0	B–G	Coking steam coals
	203		15.1–17.0	E–G4	Coking steam coals
	204		17.1–19.5	G1–G8	Coking steam coals
300			19.6–32.0	A–G9 and over	Medium volatile coals
	301		19.6–32.0	G4 and over	Prime coking coals
		301a	19.6–27.5	G4 and over	Prime coking coals
		301b	27.6–32.0	G4 and over	Prime coking coals
	302		19.6–32.0	G–G3	Medium volatile, medium caking or weakly caking coals
	303		19.6–32.0	A–F	Medium volatile, weakly caking to noncaking coals
400–900			Over 32.0	A–G9 and over	High volatile coals
400			Over 32.0	G9 and over	High volatile, very strongly caking coals
	401		32.1–36.0	G9 and over	High volatile, very strongly caking coals
	402		Over 36.0	G9 and over	High volatile, very strongly caking coals
500			Over 32.0	G5–G8	High volatile, strongly caking coals
	501		32.1–36.0	G5–G8	High volatile, strongly caking coals
	502		Over 36.0	G5–G8	High volatile, strongly caking coals
600			Over 32.0	G1–G4	High volatile, medium caking coals
	601		32.1–36.0	G1–G4	High volatile, medium caking coals
	602		Over 36.0	G1–G4	High volatile, medium caking coals
700			Over 32.0	E–G	High volatile, weakly caking coals
	701		32.1–36.0	E–G	High volatile, weakly caking coals
	702		Over 36.0	E–G	High volatile, weakly caking coals
800			Over 32.0	C–D	High volatile, very weakly caking coals
	801		32.1–36.0	C–D	High volatile, very weakly caking coals
	802		Over 36.0	C–D	High volatile, very weakly caking coals
900			Over 32.0	A–B	High volatile, noncaking coals
	901		32.1–36.0	A–B	High volatile, noncaking coals
	902		Over 36.0	A–B	High volatile, noncaking coals

Table 5 – Coal properties and parameter for commercial classification

Coal property	Classification parameter	Analytical method	Relevant industrial coal utilisation
Hardness / Grindability	Hardgrove Grindability Index	ISO 5074	Pulverised combustion
plasticity	Crucible Swelling Number, Roga Index	ISO 501, Roga Test ISO 335	Coking
plasticity	Gray-King Index	Gray-King Essay (Test) ISO 502	Coking
Swelling	Temperature of softening, maximum Dilatation and contraction	Dilatometer test ISO 349	Coking
Fluidity	Plastic properties (Gieseler fluidity)	Gieseler plastometer ISO 10329	Coking
Elemental composition	Nitrogen, Oxygen, Sulphur, Chlorine, Fluorine, Phosphorous	Ultimate Analysis ISO 332, 1994, 351, 352, 587, 622, 11724	Combustion, Coking
Trace Elemental composition	Trace elemental composition	ISO 8983	Combustion, Coking

International coal classification systems

The United Nations Economic Commission for Europe (UN-ECE) initiated an international classification system of hard coals by type (UN-ECE 1956, Figure 4). This mainly commercial coal classification is valid for hard coals which are defined as coals with a calorific value over 5700 kcal/kg (moist, ash-free basis). It uses a three figure code to differentiate coals into class, group and sub-group. Coal class is based on coal rank using the volatile matter yield (wt%, dry ash-free) when it is smaller than 33% and the calorific value for coals with a volatile matter yield higher than 33% (daf). Group and Sub-Group are defined according to the coking properties using the Crucible Swelling Number or Roga Index (Group) and the maximum dilatation or Gray-King coke type (Sub-Group). Disadvantages of this classification are that it is not applicable to low-rank coals, that is limited applicable of some of the coking properties and that there is a lack of a coal type parameter, which makes it unsuitable for comparison of carboniferous and Permian or tertiary coals (van Krevelen, 1993).

International Classification of Hard Coal

GROUPS (determined by coking properties)			CODE NUMBERS										SUBGROUPS (determined by coking properties)		
GROUP NUMBER	ALTERNATIVE GROUP PARAMETERS: Free-swelling index (crucible-swelling number)	Roga index	The first figure of the code number indicates the class of the coal, determined by volatile-matter content up to 33% V. M. and by calorific parameter above 33% V. M. The second figure indicates the group of coal, determined by coking properties. The third figure indicates the subgroup, determined by coking properties.										SUBGROUP NUMBER	ALTERNATIVE SUBGROUP PARAMETERS: Dilatometer	Gray-King
3	>4	>45					435	535	635				5	>140	>G8
						334	434	534	634				4	>50–140	G5–G8
						333	433	533	633	733			3	>0–50	G1–G4
						332 a / 332 b	432	532	632	732	832		2	≤0	E–G
2	2½–4	>20–45				323	423	523	623	723	823		3	>0–50	G1–G4
						322	422	522	622	722	822		2	≤0	E–G
						321	421	521	621	721	821		1	Contraction only	B–D
1	1–2	>5–20			212	312	412	512	612	712	812		2	≤0	E–G
					211	311	411	511	611	711	811		1	Contraction only	B–D
0	0–½	0–5		100 (A / B)	200	300	400	500	600	700	800	900	0	Nonsoftening	A
CLASS NUMBER →			0	1	2	3	4	5	6	7	8	9	As an indication, the following classes have an approximate volatile-matter content of: Class 6 33–41% volatile matter; 7 33–44% " "; 8 35–50% " "; 9 42–50% " "		
CLASS PARAMETERS	Volatile matter (dry, ash-free) →		0–3	>3–10 (>3–6.5 / >6.5–10)	>10–14	>14–20	>20–28	>28–33	>33	>33	>33	>33			
	Calorific parameter →		–	–	–	–	–	–	>13,950	>12,960–13,950	>10,980–12,960	>10,260–10,980			
CLASSES (Determined by volatile matter up to 33% V. M. and by calorific parameter above 33% V. M.)															

Figure 4 – The UN-ECE 1956 commercial international classification of hard coals.

The UN-ECE 1956 classification was replaced by an extended commercial codification system for medium and high rank coals (UN-ECE 1988), which is based upon eight key coal parameters and additional supplementary parameters to divide coals using a 14 digit code (Table 6 page 26).

The UN-ECE 1988 system allows a significantly more detailed classification of coals as compared to the UN-ECE 1956 system. However, major drawbacks are that it is only valid for medium and high rank coals, the coding system is complicated and inertinite is used for the classification of coking coals, which does not allow direct comparison of some Gondwana coals with Laurasian coals (van Krevelen, 1993).

Table 6 – Primary and supplementary parameter for the UN-ECE 1988 commercial coal classification

Primary coal parameters	Classification Purpose
Mean vitrinite reflectance	Rank
Characteristics of the vitrinite reflectogram	Single coal, coal blend differentiation
Maceral group composition	Type
Crucible swelling number	Commercial properties (Coking)
Volatile matter yield (wt.%, dry, ash-free basis)	Rank
Ash yield (wt.%, dry basis)	Grade
Total sulphur content (wt.%, dry, ash-free basis)	Commercial properties (Coking, Combustion)
Gross calorific value (moist, ash-free basis)	Rank
Supplementary parameters	**Standard Method**
Elemental Composition (C, H, O)	ISO 609
Chlorine	ISO 625
Composition of ash	DIN 51729
Dilatation	ISO 349
Friability	ISO 5074
Fusibility of ash	ISO 540
Gray-King index	ISO 502
G-value	DIN 51739
Impurity	ISO 1213
Maximum fluidity	ASTM D 2639
Mineral matter content	ISO 602
Moisture holding capacity	ISO 1018
Nitrogen	ISO 332, 333
Net calorific value	ISO 1928
Phosphorous	ISO 622
Plastometer curve	ASTM D 2639
Plastometer shrinkage	GOST 1186
Preference to dust explosion	No standard
Preference to self ignition	No standard
Reactivity against oxygen	No standard
Resinite content	ISO 7404
Roga index	ISO 335
Sulphur (pyritical, sulphate)	ISO 157
Particle size distribution	ISO 1953
Thickness of plastic layer	GOST 1186
Total moisture	ISO 589
Trace elements	No standard
Vitrinite content	ISO 7404
Washability curve	ISO 923

Additional codification systems were introduced for the classification of low rank coals, *e.g.* the UN-ECE 1957 classification system of brown coals, which uses the total moisture content (wt%, ash-free basis) and the tar yield (wt%, dry ash-free basis) to assign four digit code numbers for different groups. Recently, different national classifications systems were developed for low-rank coals, *e.g.* in Serbia and Poland (Ercegovac et al., 2006; Bielowicz, 2010). Table 7 page 27 shows a comparison of coal parameters used in these classification systems for low-rank coals.

Table 7 – Comparison of classification parameters used for the classification of low-rank coals (modified from Bielowicz, 2010). d = dry, daf = dry, ash-free, maf = moist, ash-free

Classification	UN-ECE (1998)	ISO 11760 (2004)	UN-ECE (2002)	US: ASTM D 388 (2005)	Polish: Kwiecińska, Wagner (1997)	Serbian: Ercegovac, Zivotic, Kostic (2006)	Russian: Jeremin, Boronowiec (1997)	China: GB 16772 (1997)	Polish: PN-91 G-97051
Parameter									
Gross calorific value (maf)	■		■	■			■	■	
Net calorific value					■				■
Random reflectance Ro		■				■		■	
Ash yield (d)	■	■	■		■	■		■	■
Total sulphur (d)			■		■			■	■
Tar yield (daf)					■	■	■	■	
Maceral composition	■	■			■	■	■	■	■
Sand content									■
Volatile matter yield (daf)				■			■	■	
Total moisture		■	■			■		■	
Ash melting point									■

Based upon the Alpern classification system, an international (non-commercial) coal classification has been developed for the United Nations Economic Commission for Europe (UN-ECE), first published in 1995 and revised in 1998. The classification system primarily consists of a rank classification using calorific value for low rank coals and vitrinite reflectance for medium to high rank coals (see Figure 5). Additionally, a petrographic classification based on maceral groups to differentiate coals by type and a classification based on ash yield to different coals by grade are included in this UN-ECE classification. Drawback of this classification system is the use of calorific value for low rank coal, which is also influenced by coal type and grade (Cook and Diessel, 2010).

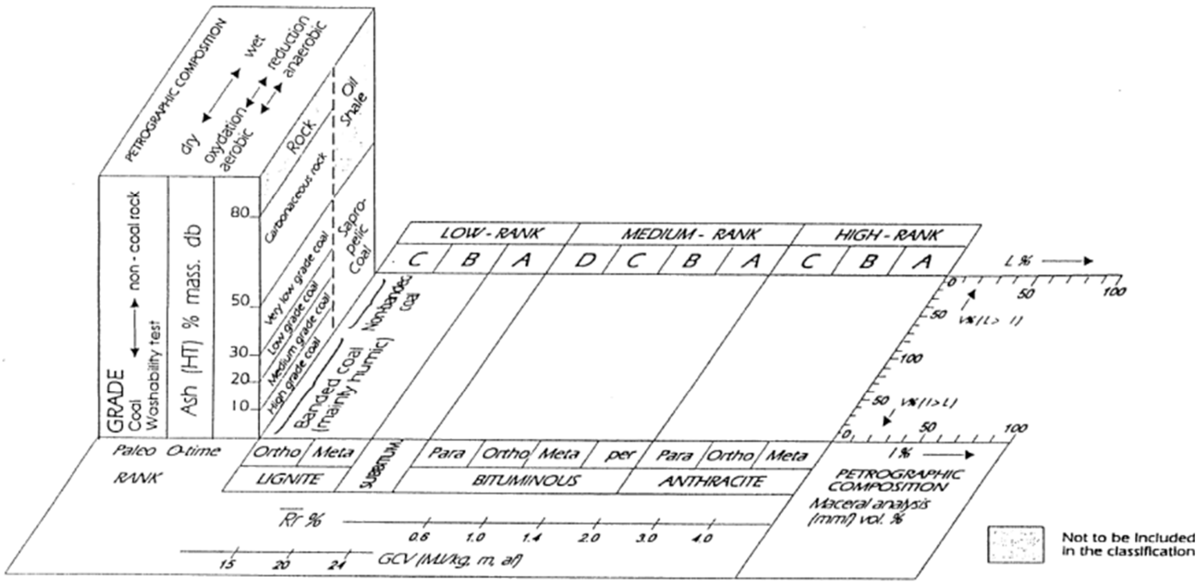


Figure 5 – The UN-ECE 1998 Classification of in seam coals.

The latest international classification system is the ISO 11760 Classification of coals (2005). This scientific classification system represents a simplification and improvement to the UN ECE 1998 system. The main classification of this system is by rank, extending the use of vitrinite reflectance to low rank coals (0.4% to 6%) and using bed moisture rather than calorific value for the lignite/brown coal range (Figure 6). The ease of use of vitrinite reflectance and absence of a need for corrections lead to its use rather than total carbon or volatile matter yield. Coal type is accommodated within 4 categories for vitrinite content because liptinite only occurs in small amounts (<10%) in most coals. Coal quality (grade) is assessed in terms of 5 categories of ash yield. The ISO system also allows for additional descriptors *e.g.* for coking properties. The intention of the ISO classification system is that coals are assessed on their full scientific analysis.

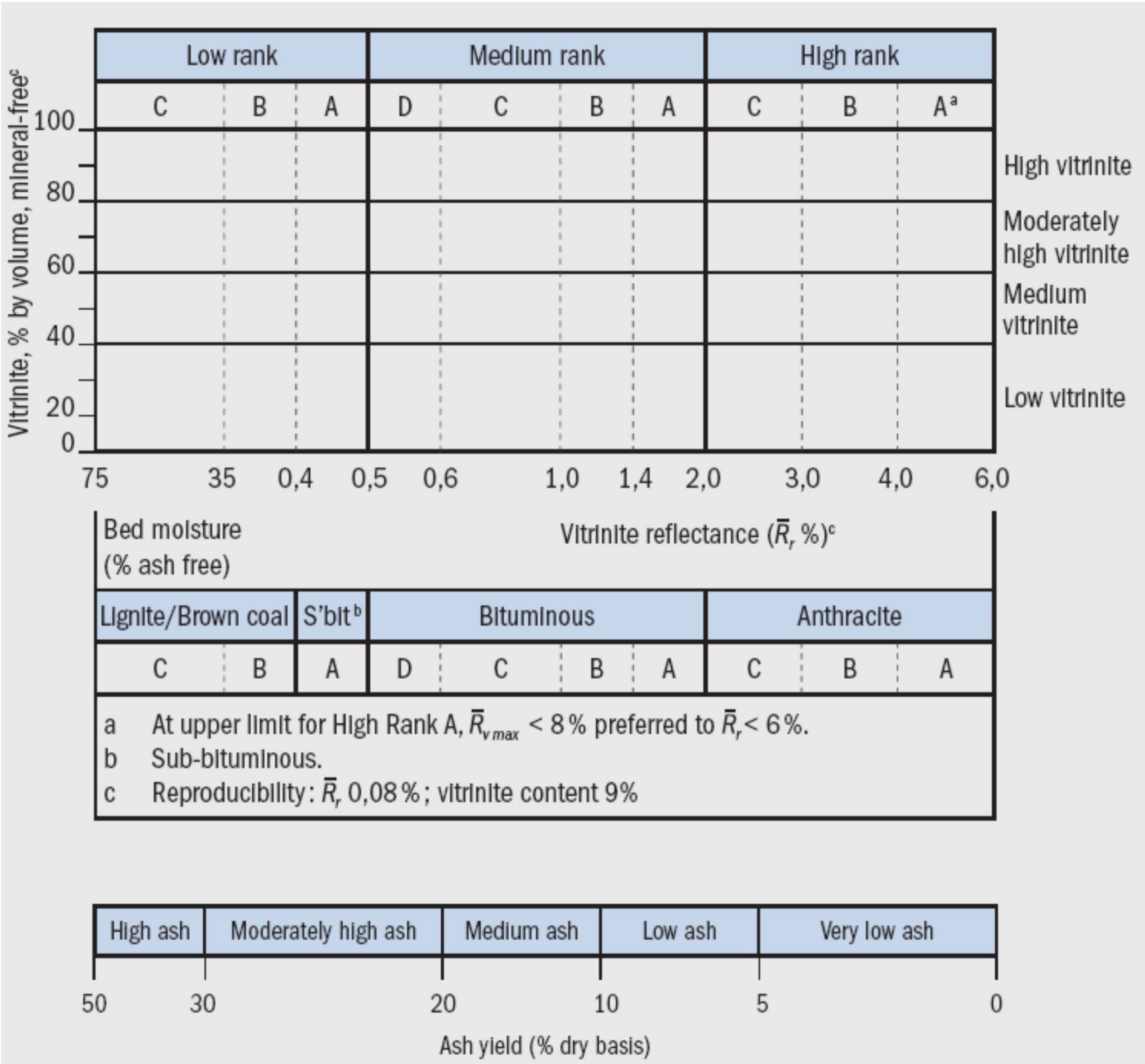


Figure 6 – The ISO 11760 Classification of coals (Pinheiro and Cook, 2005).

Proposed harmonized terminology and sub-division for the reporting of coal resources and reserves

Many different national and international definitions and classifications exist to subdivide coal resources into different classes, *e.g. hard coal*, *brown coal*, *steam coal*, *coking coal*, *etc*. These subdivisions are either based on scientific (physical, chemical, petrographic), technical (heating value, plasticity, swelling index), commercial, or combined parameters. A general overview of the coal subdivisions commonly used as a base for resource and reserve statistics is provided in Figure 7). An example of parameters and definitions for the commercial classification of reported coal resources in Poland is given in Figure 8.

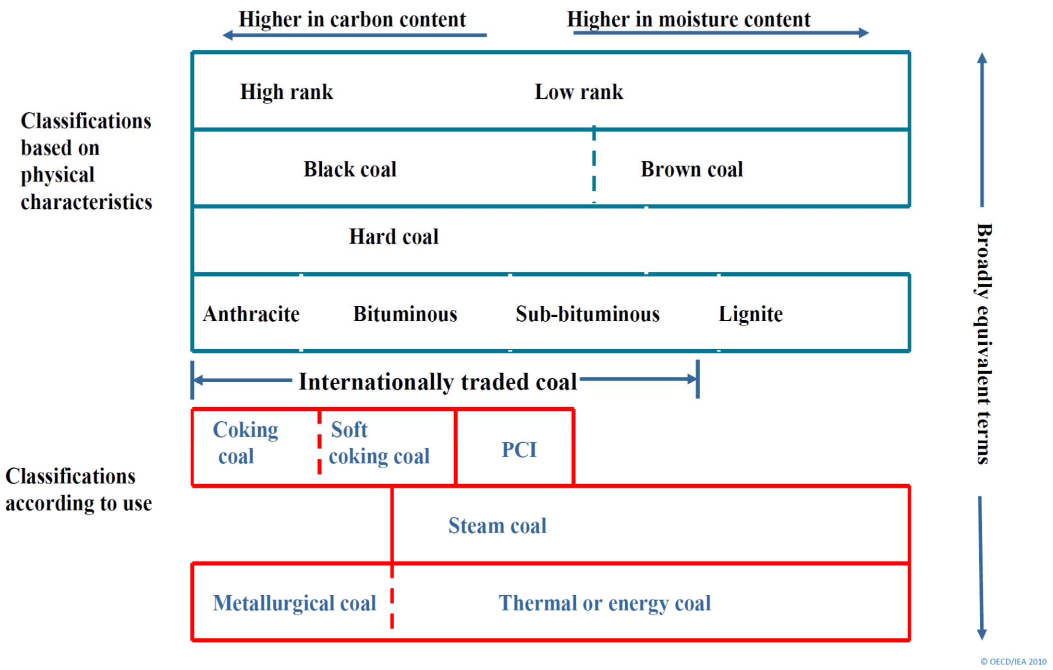


Figure 7 – General overview of commonly used coal classification based on scientific characteristics (coal rank) and commercial characteristics (coal utilization) (Trus, 2010)

COAL CLASSIFICATION

1) **LIGNITE**
calorific value 6.3 – 12.5 MJ/kg/15 MJ/kg (Poland)/ ≥ 17.5 MJ/kg (W Europe)

2) **STEAM COAL**
calorific value 12.5/15.0 MJ/kg (Poland)/ 17.5 MJ/kg (W Europe)
15.0/17.5 – 23.9 MJ/kg subbituminous coal
23.9 – 29.3 MJ/kg hard steam coal
but 25.1 – 26.0 MJ/kg standard steam coal on market
≤ 12 % of ash
≤ 1 % of total sulphur
≤ 8 % of moisture

3) **COKING COAL**
29.3 – 35.1 MJ/kg calorific value
≤ 6.9 % of ash
≤ 0.7 % of total sulphur
≤ 8.0 % of moisture
≤ 8.0 % of volatiles

4) **ANTHRACITE**
≥ 35.1 MJ/kg calorific value
≤ 5.6 % of ash
≤ 0.9 % of total sulphur
≤ 7.9 % of volatiles

Figure 8 – Commercial coal classification parameters used by the Polish Geological Institute (PGI) for the subdivision of hard coal resources (Smakowski et al., 2011)

It is evident that, if different definitions and cut-off values are used to subdivide the volumes of coal resources and reserves, *e.g.* into brown coal and hard coal, the resulting figures are not comparable. To arrive at a reasonably consistent European classification system and still make use of reported resource and reserve figures of different member states and institutions, the coal database has to include (a references to) the national definitions and cut-off values that are used in individual countries for the subdivision into coal classes.

An example of harmonized definitions is provided by the UN International Recommendations for Energy Statistics (IRES). These definitions were developed in cooperation with the Intersecretariat Working Group on Energy Statistics (InterEnerStat), which provides data for the IEA energy statistics report (UNSTATS, 2011). The IRES definition for coal rank classes is mainly adopted from the UN-ECE 1998 classification, subdividing coals into hard coal and brown coal. Hard coal is defined as coal of gross calorific value not less than 5700 kcal/kg (23.9 MJ/kg) on an ash-free but moist basis and with a mean random reflectance of vitrinite of at least 0.6% and comprises bituminous coal and anthracite. Brown coal is defined as non-agglomerating coal with a gross calorific value less than 5700 kcal/kg (23.9 MJ/kg) containing more than 31% volatile matter on a dry, mineral matter free basis and comprises sub-bituminous coal and lignite.

Following discussions at the workshop on 29 May 2012, **the EuCoRes database will define hard coal as coal with mean random vitrinite reflectance larger or equal than 0.45% and/or gross calorific value larger or equal than 20 MJ/kg (moist, ash- free basis). Hard coal comprises of the coal rank classes sub-bituminous coal, bituminous coal and anthracite. Brown coal is defined as low-rank coal with a mean random vitrinite reflectance of more than 0.3% but less than 0.45% and/or a gross calorific value of more than 6.7 but less than 20 MJ/ kg (moist, ash- free basis)** (Table 8 page 31, column 1). Compared to international coal classifications (ISO 11760, UN-ECE 1998) the hard coal class of the EuCoRes database represents low rank coal A, medium rank coal and high rank coal, whereas the class brown coal (lignite) represents low rank coal B and C. Table 8 shows the comparison of the harmonised system with international coal classification systems (UN-ECE, 1998; ISO 11760), the ASTM D388 and the Germany DIN coal classification system.

Considering the high degree of integration, wide acceptance and proven practicability, this classification system is considered the best choice for the EuCoRes database. The proposed terminology and definitions for the EuCoRes database are listed in Table 9 page 32.

Table 10 page 33 shows the relation of coal classes used for the EuCoRes database to coal classes used in international energy reports published annually by the international energy agency (IEA), the world energy council (WEC) and the German Federal Institute for Geosciences and Natural Resources (BGR).

The sub-division of coal resources according to the proposed scheme is primarily based on the coal rank parameters: random vitrinite reflectance (VR) in percentage, gross calorific value (GCV) in MJ/kg on a moist, ash-free basis and bed moisture in percentage. Due to the economic importance of coking coal, hard coals can be subdivided in terms of their technological utilization as 'steam coal' or 'coking coal'.

The database is designed to include resource/reserve information for the principle coal rank classes 'brown coal' and 'hard coal'. Additionally, the coal classes according to utilization of coal as 'steam coal' and 'coking coal' can be included as metadata in the database.

Table 8 – Proposed harmonised coal classification according to coal rank, using vitrinite reflectance (VR) in percentage, gross calorific value (GCV) in MJ/kg and bed moisture in percentage.

<table>
<tr><th rowspan="2">EUC ORES</th><th rowspan="2" colspan="3">ISO 11760 / UN ECE 1998</th><th rowspan="2" colspan="2">ASTM</th><th rowspan="2" colspan="3">DIN</th><th rowspan="2">VR %</th><th>GCV MJ/ kg maf</th><th>GCV MJ/k g maf</th><th rowspan="2">Bed Mois- ture %</th></tr>
<tr><th>UN- ECE</th><th>ASTM</th></tr>
<tr><td>Peat</td><td colspan="3">Peat</td><td>Peat</td><td>Peat</td><td colspan="3">Peat</td><td>< 0.3</td><td></td><td>< 6.7</td><td>≥ 75</td></tr>
<tr><td rowspan="3">Brown Coal (Lignite)</td><td rowspan="5">Low Rank</td><td rowspan="2">C</td><td rowspan="3">Lignite/ Brown Coal</td><td rowspan="3">Lignitic</td><td>Lignite B</td><td rowspan="6">Brown Coal</td><td rowspan="2" colspan="2">Soft Brown Coal</td><td rowspan="4">> 0.3 - 0.4</td><td rowspan="2">< 15</td><td rowspan="2">6.7 – 16.7</td><td rowspan="4">< 75 - ≥ 25</td></tr>
<tr><td rowspan="2">Lignite A</td></tr>
<tr><td>B</td><td rowspan="4">Hard Brown Coal</td><td rowspan="2">Dull Brown Coal</td><td>≥ 15 - 20</td><td>16.7 – 19.3</td></tr>
<tr><td rowspan="11">Hard Coal</td><td rowspan="2">A</td><td rowspan="2">Sub- bituminous Coal</td><td rowspan="2">Sub- bituminous</td><td>Sub- Bituminous C</td><td rowspan="2">≥ 20 - 24</td><td>19.3 – 22.1</td></tr>
<tr><td>Sub- Bituminous B</td><td rowspan="2">Bright Brown Coal</td><td rowspan="3">> 0.4 - 0.65</td><td>22.1 – 24.4</td><td>< 25 ≥ 10</td></tr>
<tr><td rowspan="6">Medium Rank</td><td>D</td><td rowspan="6">Bituminous Coal</td><td rowspan="2">Sub- bituminous / Bituminous</td><td rowspan="2">Sub- Bituminous A / High Volatile C Bituminous</td><td rowspan="9">≥ 24</td><td>24.4 – 26.7</td><td rowspan="9">< 10</td></tr>
<tr><td rowspan="2">C</td><td rowspan="6">Bituminous Coal</td><td colspan="2">Flame Coal</td><td>26.7 – 30.2</td></tr>
<tr><td rowspan="4">Bituminous</td><td>High Volatile B Bituminous</td><td colspan="2">Gas-Flame Coal</td><td rowspan="2">> 0.65 – 1.1</td><td>30.2 – 32.6</td></tr>
<tr><td rowspan="2">B</td><td>High Volatile A Bituminous</td><td colspan="2">Gas Coal</td><td rowspan="6">≥ 32.6</td></tr>
<tr><td>Medium Volatile Bituminous</td><td colspan="2">Fat Coal</td><td>>1.1 – 1.5</td></tr>
<tr><td>A</td><td>Low Volatile Bituminous</td><td colspan="2">Low- Volatile Coal</td><td>>1.5 – 2.0</td></tr>
<tr><td rowspan="3">High Rank</td><td>C</td><td rowspan="3">Anthracite</td><td rowspan="3">Anthracitic</td><td>Semi- anthracite</td><td colspan="2">Semi- anthracite</td><td rowspan="3">> 2.0 – 6.0</td></tr>
<tr><td>B</td><td rowspan="2">Anthracite</td><td rowspan="2">Anthracite</td><td rowspan="2" colspan="2">Anthracite</td></tr>
<tr><td>A</td></tr>
</table>

Table 9 – Terms and definitions for coal used in the EuCoRes database

Brown coal (Lignite)	Low-rank coal with a mean random vitrinite reflectance of more than 0.3% but less than 0.45% and or a gross calorific value of more than 6.7 but less than 20 MJ/ kg (moist, ash- free basis). Brown coal comprises lignite.
Hard coal	Coal with mean random vitrinite reflectance larger or equal than 0.45% and/or gross calorific value larger or equal than 20 MJ/kg (moist, ash-free basis). Hard coal comprises of the coal rank classes sub-bituminous coal, bituminous coal and anthracite.
Sub-bituminous coal	Low-rank coal with a mean random vitrinite reflectance less than 0.6% and equal or greater than 0.45% and or a gross calorific value equal to or greater than 20 MJ/kg but less than 24 MJ/kg (moist, ash- free basis). Sub-bituminous coal will be assigned to the Hard Coal class in the EuCoRes database.
Bituminous coal	Medium-rank coal with a mean random vitrinite reflectance equal or greater than 0.6% and less than 2.0 and a gross calorific value equal or greater than 24 MJ/kg (moist, ash-free basis). Bituminous coals are agglomerating and have a higher volatile matter and lower carbon content than anthracite. They are used for industrial coking and heat generation and household heat generation. Bituminous coal will be assigned to the Hard Coal class in the EuCoRes database.
Anthracite	High-rank coal with mean random vitrinite reflectance larger or equal than 2.0% and gross calorific value larger or equal than 24 MJ/kg (moist, ash- free basis). Anthracite has usually less than 10% volatile matter (dry, ash-free basis), a high carbon content (about 86-98% carbon) and is non-agglomerating. Anthracite is mainly used for industrial and household heat generation. Anthracite will be assigned to the Hard Coal class in the EuCoRes database.
Coking coal	Medium-rank coal that can be used in the production of a coke capable of supporting a blast furnace charge. Coking coals usually have a volatile matter yield between 20% and 30% (dry, ash-free basis). Coking coal will be assigned as an additional utilization class in the metadata of the EuCoRes database.
Steam coal	Hard coal not suitable for coke production. Steam coal will be assigned as an additional utilization class in the metadata of the EuCoRes database.

Table 10 – Comparison of coal classes used in the EuCoRes database with classes used in international resource/reserve reports.

<table>
<tr><th></th><th>EuCoRes</th><th>IEA</th><th>WEC</th><th>BGR</th></tr>
<tr><td rowspan="3">Reported coal classes</td><td>Hard Coal
(GCV ≥ 20 MJ/kg)
• Anthracite
• Bituminous coal
• Sub-bituminous coal</td><td>Hard Coal
(GCV ≥ 23.9 MJ/kg)
• Anthracite
• Bituminous coal</td><td>Bituminous coal (including anthracite)
(No GCV reported)</td><td>Hard Coal
(GCV ≥ 16.5 MJ/kg)
• Anthracite
• Bituminous coal
• Sub-bituminous coal (hard brown coal)</td></tr>
<tr><td rowspan="2">Brown Coal
(GCV < 20 MJ/kg)
• Lignite</td><td rowspan="2">Brown Coal
(GCV < 23.9 MJ/kg)
• Sub-bituminous coal
(GCV 20 – 23.9 MJ/kg)
• Lignite
(GCV < 20 MJ/kg)</td><td>Sub-bituminous coal
(No GCV reported)</td><td rowspan="2">Lignite
(GCV < 16.5 MJ/kg)</td></tr>
<tr><td>Lignite
(No GCV reported)</td></tr>
</table>

3.1.3.2 Results of the literature study on coal resource / reserve classification and reporting

Comparison of national and international resource classification systems

In the early 20th century the Institution of Mining and Metallurgy in London proposed a resource classification, categorizing mineral resources (ore) into three groups according to the degree of risk in estimates. This classification was adopted by Hoover (1909) who, in his book "Principles of Mining" subdivided mineral resources into the groups "proved", "probable" and "prospective". This basic classification of resources according to the degree of geologic certainty has been adopted and continuously modified during the 20th century, resulting in the development of different classification systems. These systems were based on different methodologies by which the classification categories were defined and are often only valid for specific coalfields. Today more than 150 different classifications exist worldwide, which significantly complicate a correlation between coal resources of individual coalfields or countries (Schmidt, 2008).

In the following chapters, classification systems will be described that are most influential for resource classification of coals in Europe today:

- the classification system of the USA (page 34)
- classification systems of the former Soviet Union, Eastern Europe and Germany (page 36)
- international (framework) classification systems (CRIRSCO, SPE-PRMS, UNFC) (page 38)

The classification system of the USA

An important development in resource classification was the consideration of the economic feasibility, in addition to the degree of geologic identification. A result of this development was the resource classification system introduced in the guidelines of the US Bureau of Mines (USBM) and the US Geological Survey (USGS) in 1973. This classification system is displayed as a matrix showing the degree of geologic identification on the horizontal axis and the degree of economic feasibility on the vertical axis (McKelvey diagram) (Figure 9 page 35). The increasing degree of geological information is represented in terms of five different classes: speculative, hypothetical, inferred, indicated and measured. The economic feasibility is differentiated into economic, marginally economic and sub-economic. The US classification system defines the term resource as "A concentration of coal in or on earth's crust in such a form that economic extraction is currently or potentially feasible" and the term reserves as "that portion of the identified coal resource that can be economically and legally mined at the time of delimitation – also referred to as recoverable reserves". Furthermore, the classification defines the term reserve base as "identified coal defined only by physical and chemical criteria such as thickness of coal and overburden, quality, heat values, rank, and distance from points of measurement" (Figure 10 page 35). A revised and expanded version of the US classification system was published in the US Geological Survey Circular 891 in 1983 together with detailed guidelines, descriptions and definitions of coal rank classes and factors for the delimitation of coal resources. Many classification systems in Western countries are based on the same economic geological concept as the US classification system.

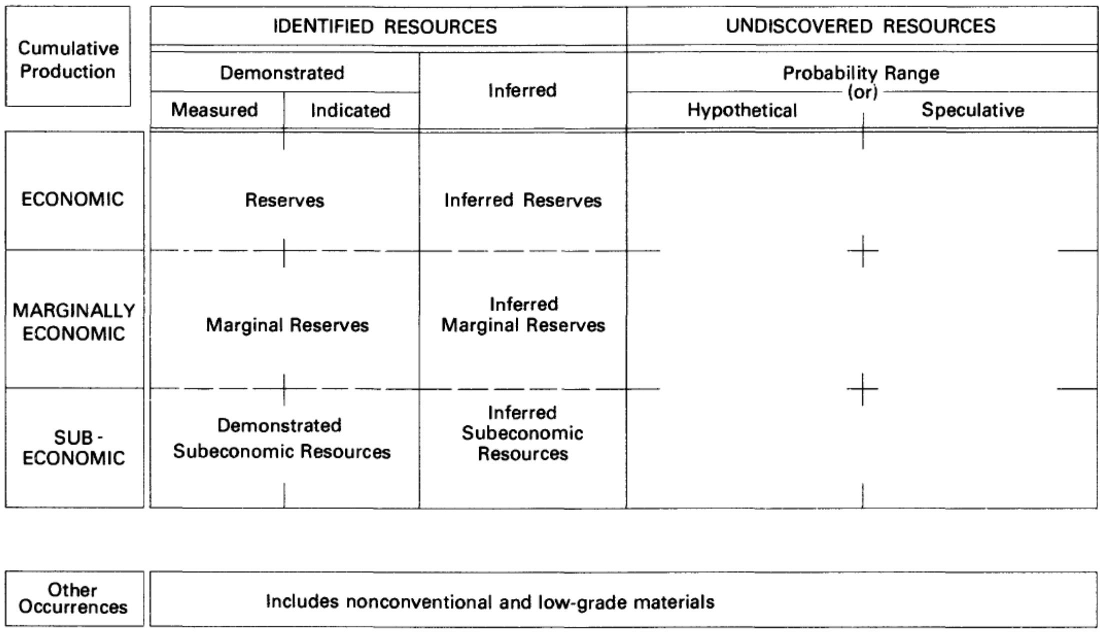


Figure 9 – Coal resource classification system of the USA by degree of geological identification and economic feasibility ("McKelvey diagram"; USGS, 1983).

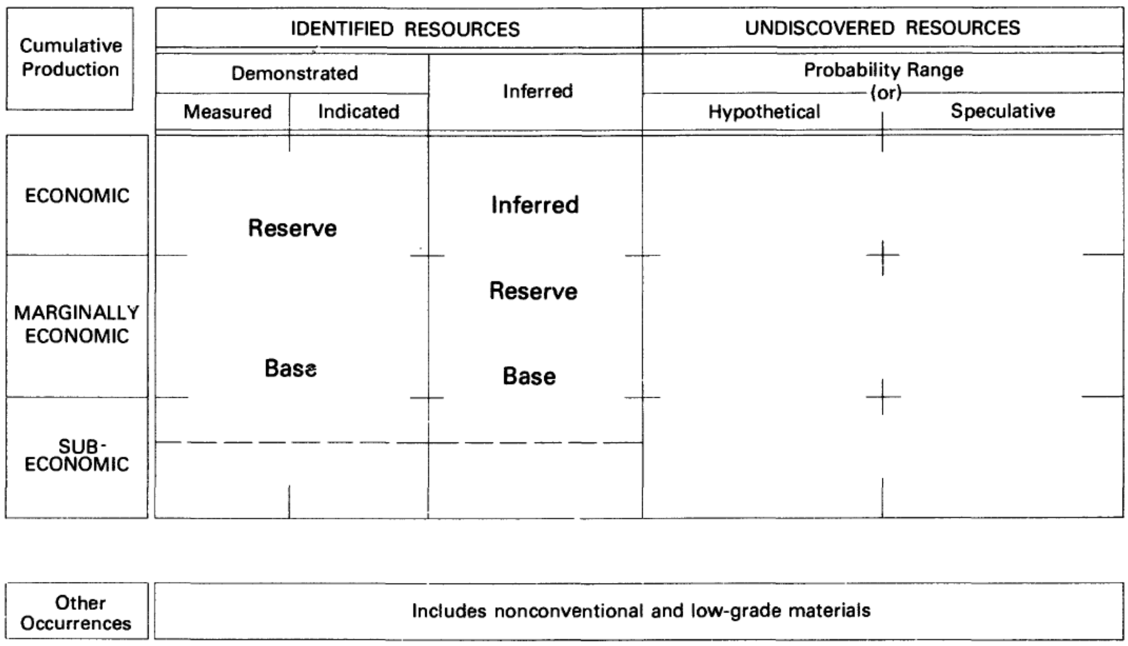


Figure 10 – Format and classification of coal resources by "reserve base" and "inferred reserve base" based on physical and chemical criteria (USGS, 1983).

Classification systems of the former Soviet Union, Eastern Europe and Germany

The resource classification system developed in the former USSR differentiates total resources according to the degree of geologic assurance into five principal classes: A, B, C1, C2 and P (Table 11). Additionally, resources are divided according to the degree of technical/economic feasibility into balance resources and out of balance resources. Unidentified resources are classified as prognostic resources.

Table 11 – Resource classification of the former Soviet Union (after Subelj, 2005).

	Total Resources						
	Degree of knowledge (certainty) and categories						
National Economic Categories	Reserves				Prognostic Resources		
	Exploration		Preliminary estimation		P_1	P_2	P_3
Balance reserves	A	B	C_1	C_2	Resources in explored areas; exploration areas found by prospecting	Resources in areas with known deposits	Resources in areas with no known deposits
Out of balance reserves	a	b	c_1	c_2			

For the delimitation of balance, out of balance and prognostic resources, the geologic complexity of deposits, coal seam characteristics and also physical and chemical criteria such as thickness of coal and overburden and coal quality are considered. Table 12 shows an alignment of the German, US and the former Soviet Union classification systems proposed by Fettweis (1976). Many Eastern European countries use a classification system that is essentially based on the system of the former Soviet Union.

Table 12 – Alignment of the classification systems of the USA, Germany, and the former Soviet Union according to the degree of geologic knowledge (Fettweis, 1976; GDMB, 1959, 1983).

USSR, CIS	Balance (out of balance) reserves	A (a)	B (b)	C1 (c1)	C2 (c2)	P1, P2, P3
(West) Germany (GDMB)	Group I (Group II)	A (a)	B (b)	C1 (c1)	C2 (c2)	(d)
	Confidence level	>90% sicher	70 – 90% wahrscheinlich	70 – 50% angedeutet	50 – 30% vermutet	10 – 30% prognostisch
	Error margin (of 90% confidence level)	±10% (±10%)	±20% (±20%)	±30% (±30%)	±30% (±50%)	- (>±50%)
USA (USBM, USGS)	USBM, USGS	identified				undiscovered
		demonstrated			inferred	hypothetical, speculative
		measured		indicated		

While these classifications and also the German classification are generally comparable with respect to the degree of geologic assurance, different geo-statistical approaches are used to define the degree of geologic assurance. Furthermore, differences exist in parameters and cut-off values used for the delimitation of resources and reserves, which are often specifically defined for individual deposits (*cfr.* Figure 11). Finally, differences exist in the definition of nationally reported "reserves". According to the US system, reserves are the demonstrated (measured and indicated) part of the identified resources that are economic. The proposed alignment in Table 12 page 36 shows that "reserves" according to the German and former Soviet Union systems are represented by the economic group I (Germany) or balance (USSR) resources of the classes A, B and C1. However, not all national reports of coal reserves follow this definition and in some cases (*e.g.* Poland) reserves are defined as the sum of A, B, C1 and C2.

		Germany	**Poland**			**Ukraine** Donetsk basin		**Russia** Kuznetsk basin	
		Hard coal	*Hard coal*			*Hard coal*		*Hard coal*	
			Steam coal	Coking coal	Anthracite	Steam coal	Coking coal	Steam coal	Coking coal
Parameter	unit		reserves (resources)	reserves (resources)	reserves (resources)	reserves (resources)	reserves (resources)	reserves (resources)	reserves (resources)
Max. depth	m	1,500	1,000 (1,000)	1,000 (1,000)	1,000 (1,250)	1,800 (1,800)	1,800 (1,800)	1,800 (1,800)	1,800 (1,800)
Min. net coal thickness	cm	60	100 (60)	100 (60)	(40)	60 / 70 (45)	50 / 55 (45)	100 (60)	70 (50)
Min. seam thickness	cm				100 (60)				
Max. barren partings content in the seam	Mass% Vol.%	50 35		20 (40)	40 (40)			30	30
Max. ash content in raw coal	Mass%					30 / 40 (40)	40 (45)	30 (40)	30 / 40 (50)
Max. barren partings thickness to coal thickness ratio	Vol.%			0.2 (0.4)					
Min. calorific value of coal with barren partings (raw coal)	MJ/kg		15 (12.6)						
Max. ash content in washed coal	Mass%			10 (10)	10 (10)				
Max. volatile matter content	%				10 (10)				
Max. total sulphur content	%	2	2 (unlimited)	1.0 in washed coal	1.0 (unlimited)				

Figure 11 – Cut-off values of various parameters used for hard coal reserve and resource estimations in Germany, Poland, Ukraine and Russia (Schmidt et al., 2007).

The mentioned differences in national coal resource classification systems, different use of cut-off parameters and values and also differences in the definition of "reserves" indicate that an internationally harmonized classification scheme is required for the comparison of coal resources and reserves in Europe.

International resource classification systems

The CRIRSCO classification

To assure a standardized level of competence and transparency among internationally reported mineral resources, an international standard and guideline and reporting template was developed by the Council of Mining and Metallurgical Institutions (CMMI), representing mining and metallurgical institutions of the US, Australia, Canada, the UK and South Africa. The guideline is based on the Australasian Code for Reporting of Mineral Resources and Ore Reserves (JORC code). The international reporting template for the public reporting of exploration results, mineral resources and mineral reserves of the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) of the CMMI is widely used for the classification and reporting of mineral resources/reserves, including coal. CRIRSCO can be correlated to the classification of the Institution of Mining and Metallurgy (IMM) and the Code for reporting of mineral exploration results, mineral resources and mineral reserves (IMO3) that are/were used in the UK for coal resource classification. It is also correlated to the Canadian National Instrument standard (NI 43-101) which is used for the classification of coal resource in Europe, *e.g.* by the Norwegian Geological Survey. In Europe the “Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves” of the Pan European Reserves and Resources Reporting Committee (PERC) is used as a guideline for the reporting of mineral resources and reserves, including coal. The PERC code draws from and is consistent with the CRIRSCO reporting template. The CRIRSCO system divides resources according to the degree of geologic assurance into *inferred*, *indicated* and *measured*, similar to the US classification and further discriminates mineral reserves from mineral resources according to “modifying factors” that consider the technological and socio-economic feasibility (mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors). Undiscovered (potential) resources are reported in the class Exploration Results (Figure 12).

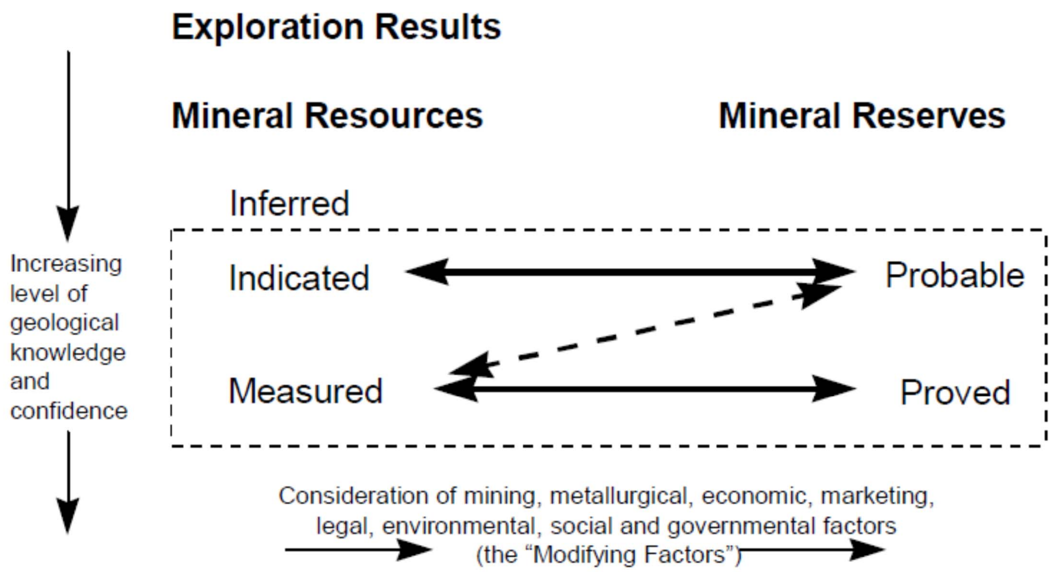


Figure 12 – General relationship between Exploration Results, Mineral Resources and Mineral Reserves of the CRIRSCO system (ICMM, 2006).

The SPE-PRMS classification

In contrast to solid mineral resources that are extracted from deposits, petroleum resources are produced from accumulations in reservoirs. This fundamental difference resulted in a different terminology used for petroleum resource classification. For the international classification and reporting of petroleum resources the Petroleum Resources Management System (PRMS) was developed by the Society of Petroleum Engineers (SPE), the World Petroleum Council (WPC), the American Association of Petroleum Geologists (AAPG) and the Society of Petroleum Evaluation Engineers (SPEE). The PRMS is designed to be suitable for the classification of conventional and unconventional accumulations of liquid or gaseous hydrocarbons, including coalbed methane (CBM). The system provides guidelines and definitions for the classification and reporting and represents a common reference for the international petroleum industry. The PRMS uses a classification according to the degree of geologic assurance into three classes (proved, probable and possible) and additionally divides the total petroleum initially in place (PIIP) according to the chance of commerciality, similar to the USGS classification (Figure 13). For undiscovered (prospective) resources values for the low, best and high estimate are reported.

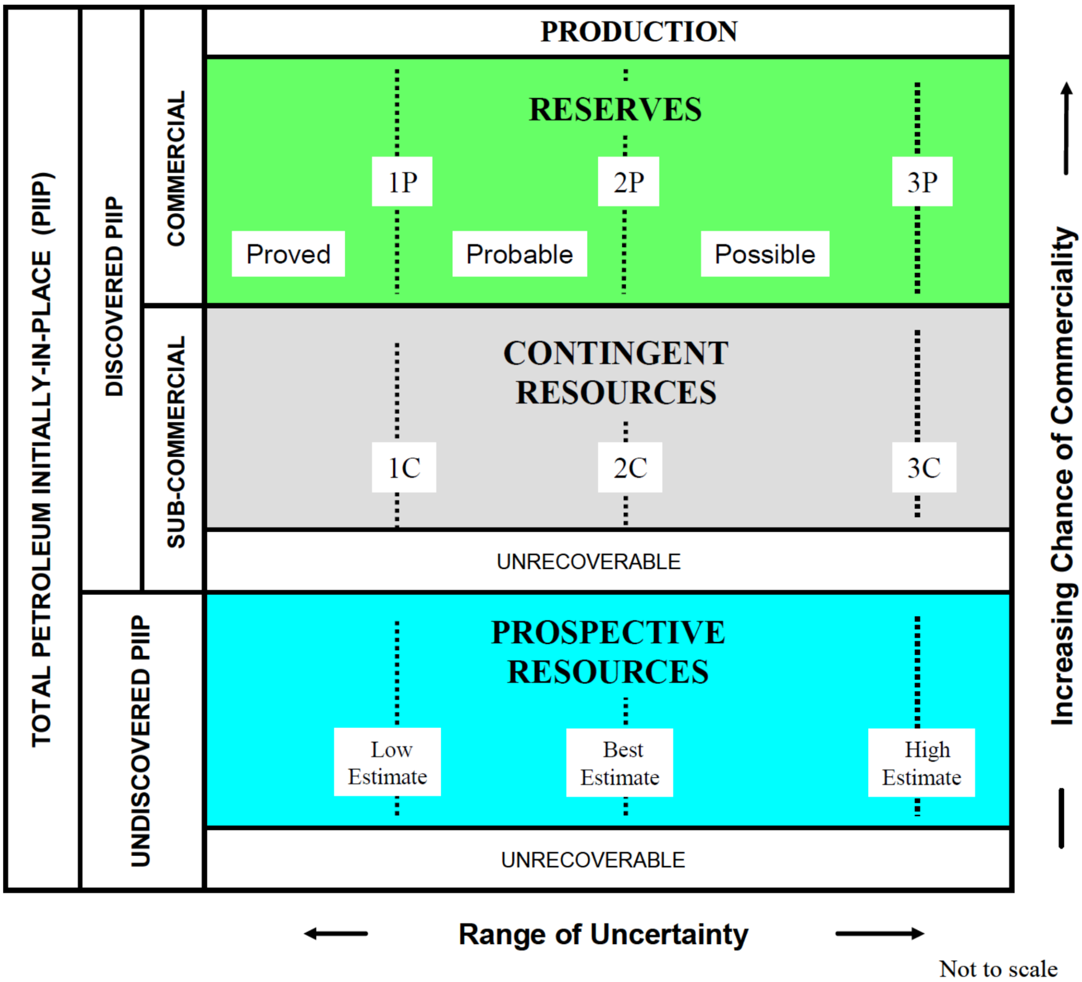


Figure 13 – Resource classification of the Petroleum Resource Management System (PRMS) (SPE, AAPG, WPC, SPEE 2008).

The UNFC classification

Parallel to the developments of the CRIRSCO and SPE-PRMS classification systems, an international framework classification was developed for the United Nations Economic Commission for Europe (UN-ECE). The aim of this initiative was to create a simple and user-friendly classification system that is suitable for solid minerals and energy resources. Based upon a classification of the German Geological Survey (BGR) in 1991, the United Nations Economic Commission for Europe (UN-ECE) developed the United Nations Framework Classification for Reserves and Resources of Solid Fuels and Mineral Commodities" (UNFC). The UNFC was adopted by the UN Economic and Social Council (ECOSOC) 1997 and recommended for worldwide application. Since then, the UNFC was continuously developed and tested worldwide. In 1999 the UN-ECE and CMMI agreed to integrate their respective definitions resulting in a set of joint UN CMMI definitions. In 2001 extension of the UNFC to energy resources was decided with the aim of a harmonization of the classification with the Petroleum Resources Management System (PRMS). Furthermore the UNFC was harmonized to the classification of the IAEA/NEA uranium group.

The latest UNFC classification is the United Nations Framework Classification for Energy and Mineral Reserves and Resources (UNFC 2009), representing an internationally applicable scheme to report fossil energy and mineral resources and reserves, including coal and coalbed methane. The UNFC 2009 classification system differentiates reserves and resources in a **three dimensional system** according to major categories that are essential for commercial production (economy, feasibility and geology). The first set of categories (E) is used to establish the **economic viability** of the project according to social and economic conditions, market price, legal, regulatory, environmental and contractual conditions. The second set (F) is used to define the **feasibility** of a project according to the status and maturity of developments and mining projects that range from early exploration to extraction and selling of a commodity. The third set of categories (G) is used to define the level of confidence in the **geological knowledge** and potential recoverability of the quantities. A detailed description of categories and sub-categories is provided in the UNFC 2009.

The classification uses a three digit code that is assigned in the order of E, F, G according to the number of each category. For example the combination of the categories E2, F2 and G1 would give the UNFC code 221. The UNFC can be used in a two or three dimensional way to illustrate different classes, which are defined by combinations of categories or sub-categories (Figure 14 page 41, Table 13 page 42). Combination of all sets of categories would theoretically lead to 48 different classes. However, only 14 classes are practically used because some combinations of sub-categories would lead to conflicting information and thus are excluded. For example the UNFC class 114 would mean that a project contains commercial quantities of coal that are being produces, but the geologic knowledge of its presence is poor, *e.g.* only estimated based on indirect evidence, which in practice is very unlikely. One major difference of the UNFC is that it strictly avoids the use of the terms "reserve" and "resource" that are used in most existing classifications such as the CRIRSCO and PRMS. The intention of the terminology of the UNFC was to avoid any ambiguity caused by materially different meanings of the terms reserve and resource as they are used in industry and public domain.

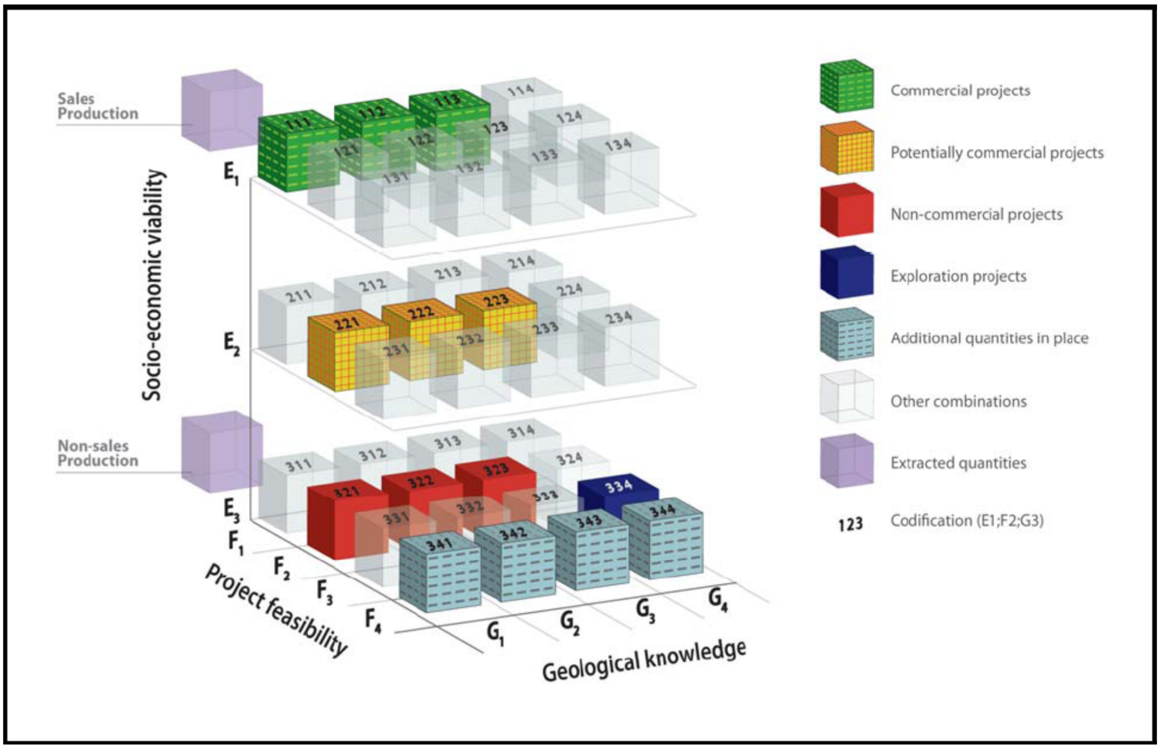


Figure 14 – Three dimensional view of the UNFC 2009, illustrating categories as x,y, and z axis and including examples of different classes (UNFC 2009).

Table 13 Two dimensional view of the UNFC 2009 showing different classes according to categories and sub-categories.

Total Commodity Initially in Place	Extracted	Sales production							
		Non-sales Production							
	Class			Sub-class	Categories	Definition	Sub-Category	Sub-Category Definition	
					E		F		G
	Known Deposits	Future recovery by **commercial** development projects or mining operations	Commercial Projects	On Production	1	Extraction and sale has been **confirmed** to be economically viable.	1.1	Extraction is currently taking place.	1,2,3
				Approved for Development	1		1.2	Capital funds have been committed and implementation of the development project or mining operation is underway.	1,2,3
				Justified for Development	1		1.3	Sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development project or mining operation.	1,2,3
		Potential future recovery by **contingent** development projects or mining operations	Potentially Commercial Projects	Development Pending	2	Extraction and sale is **expected** to become economically viable in the foreseeable future.	2.1	Project activities are ongoing to justify development in the foreseeable future.	1,2,3
				Development on Hold	2		2.2	Project activities are on hold and/or where justification as a commercial development may be subject to significant delay.	1,2,3
			Non-Commercial Projects	Development Unclarified	3.2	Extraction and sale is **not expected** to become economically viable in the foreseeable future or evaluation is at **too early stage** to determine economic viability.	2.2		1,2,3
				Development Not Viable	3.3		2.3	There are no current plans to develop or to acquire additional data at the time due to limited potential.	1,2,3
		Additional quantities in place associated with **known** deposits			3.3		4		1,2,3
	Potential Deposits	Potential future recovery by successful **exploration** activities	Exploration Projects	No sub-classes defined	3.2		3		4
		Additional quantities in place associated with **potential** deposits			3.3		4		4

Correlation (mapping) between CRIRSCO, SPE-PRMS and the UNFC classification system

The UNFC 2009 is constantly developed and maintained by the Expert Group of Resource Classification (EGRC) of the UN-ECE Committee on Sustainable Energy. The EGRC also provides specifications on the application of the UNFC that provide information and guidelines on the mapping between UNFC classes and other classification systems such as CRIRSCO and SPE-PRMS. The alignment to other classification systems can be done in a two-dimensional form (Figure 15).

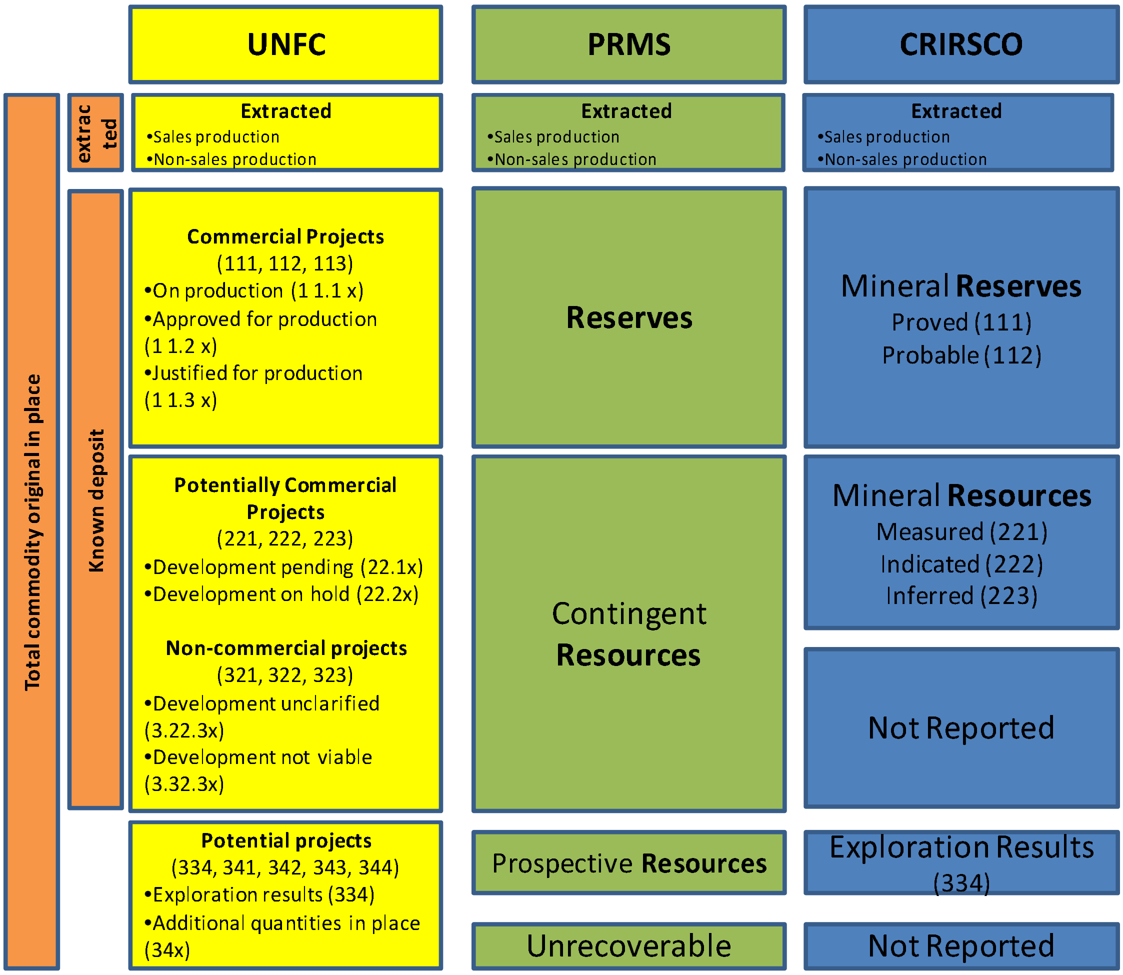


Figure 15 – Two dimensional illustration of the UNFC 2009 and the relationship to the CRIRSCO and PRMS classification system (modified after Ross, 2012). Numbers in brackets represent the codification according to UNFC.

To avoid language confusion and international applicability, the UNFC uses a numerical code and further avoids the use of the terms “reserves” and “resources”. The UNFC can be applied directly as a classification system or as a harmonization tool that is applied in addition to a primary (national) classification. To improve the alignment of the UNFC to national classification systems, the categories E and F can be divided into further sub-categories. This allows an internationally harmonized comparison of resources and reserves that are either directly classified according to the UNFC, mapped from a national classification system or one of the other international systems (CRIRSCO, PRMS). Since the early development in the 1990’s the UNFC has been tested internationally in numerous case studies for coal including Germany, Greece, Hungary, Poland, Russian Federation, Slovenia, Turkey, Ukraine and the USA (Ersoy, 2005). Table 14 page 44, Table 15 page 45 and Figure 16 page 44 provide examples for the mapping from national classification systems to the UNFC.

Table 14 – Matrix used to align the Russian resource classification system to the UNFC (Kavun, 2005).

UN Framework Classification		Detailed Exploration	General Exploration	Prospecting	Reconnaissance
	National System (Russia)	Degree of geological assurance			
		A + B	C1	C2	Speculative estimates (P1, P2, P3)
Feasibility Study	Technical/economic justification of cut-off limits	Proved Reserves **111**			
		Feasibility Resources **211**			
Prefeasibility Study	Technical/economic report and justification of preliminary cut-off values	Probable Resources **121 + 122**			
		Prefeasibility Resources **221 + 222**			
Geological Study	Geologic/economic evaluation	Measured Resources **331**	Indicated Resources **332**	Inferred Resources **333**	Reconnaissance Resources **334**

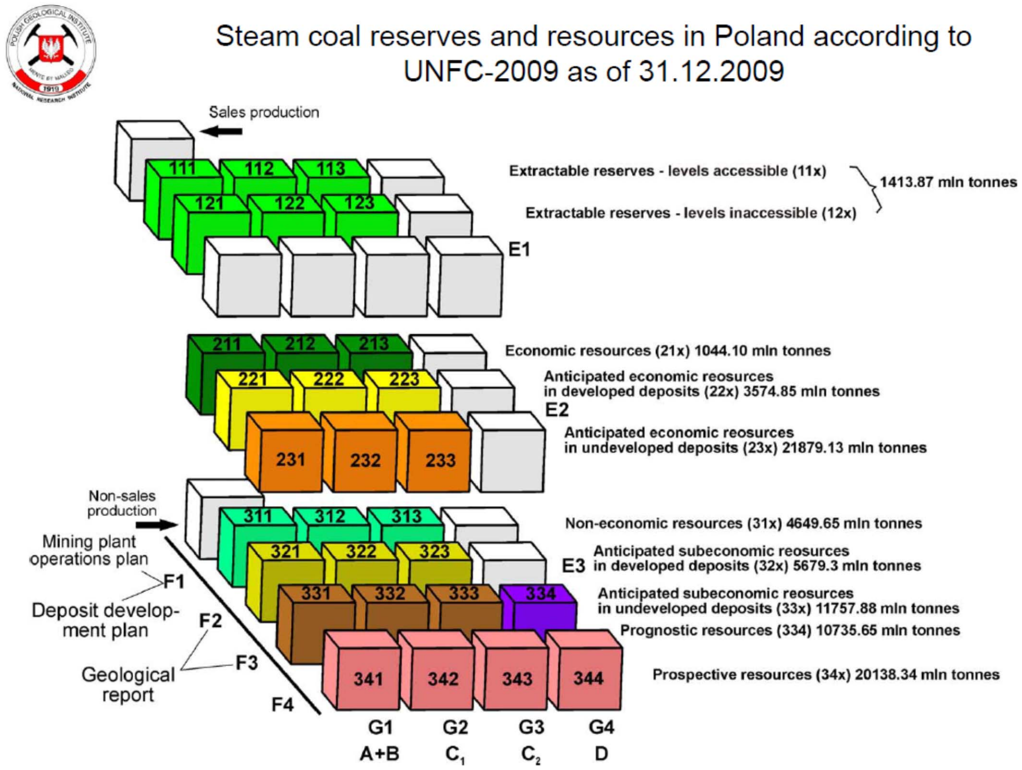


Figure 16 – Three dimensional view of the UNFC 2009, illustrating the use of sub-class combinations to map steam coal reserves and resources from the Polish system to the UNFC (Smakowski et al., 2011)

Table 15 – Comparison of the Czech Republic reserve and resource classification with the UNFC and CMMI classification (from Czech Geological Survey, Geofond). *geological reserves reduced by amount of prospective mining losses.

Code of the UNFC category	Proposed designation of the UNFC category	CMMI category	Czech categories
111	Proved Mineral Reserve	Proved Mineral Reserve	part of exploitable part * of explored economic reserves
121 + 122	Probable Mineral Reserve	Probable Mineral Reserve	part of exploitable part * of explored economic reserves
123		Inferred Mineral Resource	prospected economic reserves
211	Feasibility Mineral Resource	Measured Mineral Resource	part of explored potentially economic reserves
221 + 222	Prefeasibility Mineral Resource	Indicated Mineral Resource	part of explored potentially economic reserves
223		Inferred Mineral Resource	prospected potentially economic reserves
331	Measured Mineral Resource	Measured Mineral Resource	part of explored potentially economic reserves
332	Indicated Mineral Resource	Indicated Mineral Resource	part of explored potentially economic reserves
333	Inferred Mineral Resource	Inferred Mineral Resource	prospected potentially economic reserves + part of P_1
334	Reconnaissance Mineral Resource	not available	P_2 + P_3+ part of P_1

Proposed harmonized terminology of coal and classification system for coal and CBM

The following section provides information on the proposed terminology and classification to be used in the European coal resource database for coal and coalbed methane resources and reserves, based on a review of national and international resource classification systems and terminology and definitions used in resource classifications, industry guidelines and energy resource reporting.

Proposed classification system for coal and coalbed methane resources and reserves

With respect to the development of an international resource database, the UNFC represents the only universally acceptable and internationally applicable scheme for the classification and reporting of coal and CBM reserves and resources. The long period of testing of the UNFC for coal resource and reserve classification in numerous international case studies further emphasizes its applicability for the EuCoRes database.

By integration of the UNFC classification system into the EuCoRes database, a reference is provided that allows comparison of the amount of coal that is defined as resource or reserve in individual EU countries. In addition to the UNFC, the database will also include the original, national classification system on resources and reserves.

Most national classification systems and international energy statistics such as the annual reports by the International Energy Agency (IEA) of the Organisation for Economic Co-operation and Development (OECD), the World Energy Council (WEC) or the annual report on reserves, resources and availability of energy resources by the Federal Institute for Geosciences and Natural Resources (BGR) use the terms "resources" and "reserves". To improve comparability to international energy statistics, the EuCoRes database uses the term "reserve" for the sum of the UNFC classes 111, 112, 113 and 121, 122, 123. The term "resource" will be designated to the sum of all remaining UNFC classes.

The UNFC and CRIRSCO classifications represent method based systems, which means they provide templates and guidelines for the classification of resources and reserves according to defined categories. They do not provide specific and universally applicable variables or cut-off values for the practical resource and reserve estimation. In Europe the PERC code provides general guidelines and an ethical code for "competent persons" who are responsible for the preparation of public reports of a company's exploration results, mineral resources and mineral reserves estimates. Apart from a checklist and guidelines of reporting and assessment criteria for the preparation of reports on exploration results, resources and reserves, the PERC code does not provide specific key variables or cut-off values for the assignment of economic, feasibility and geologic categories. It is up to the "competent person" to define a set of variables and parameters for this purpose. In practice, definition of such key parameters and cut-off values are provided by national governments or institutions, *e.g.* by the Commission of Mineral Resources as an advisory body to the Ministry of Environment in Poland (Niec, 2010), or by local Industry guidelines, *e.g.* the RAG Guideline 1/82 in Germany (Schmidt, 2008). To allow comparison of individual coal resources and reserves between different coal fields and different countries, not only a harmonized and widely applicable classification system such as the UNFC is required, it is also necessary that with each report on exploration results, resources and reserves a detailed description of the set of key parameters and cut-off values used for the report is provided. A comparison of different cut-off values used to differentiate reserves and resources of hard coal in different countries is provided in Table 16 and Figure 17 page 48.

Table 16 Cut-off values of various parameters used for hard coal reserve and resource estimations in Germany, Poland, Ukraine and Russia (Schmidt et al., 2007).

		Germany	**Poland**			**Ukraine** Donetsk basin		**Russia** Kuznetsk basin	
		Hard coal	*Hard coal*			*Hard coal*		*Hard coal*	
			Steam coal	Coking coal	Anthracite	Steam coal	Coking coal	Steam coal	Coking coal
Parameter	unit		reserves (resources)	reserves (resources)	reserves (resources)	reserves (resources)	reserves (resources)	reserves (resources)	reserves (resources)
Max. depth	m	1,500	1,000 (1,000)	1,000 (1,000)	1,000 (1,250)	1,800 (1,800)	1,800 (1,800)	1,800 (1,800)	1,800 (1,800)
Min. net coal thickness	cm	60	100 (60)	100 (60)	(40)	60 / 70 (45)	50 / 55 (45)	100 (60)	70 (50)
Min. seam thickness	cm				100 (60)				
Max. barren partings content in the seam	Mass% Vol.%	50 35		20 (40)	40 (40)			30	30
Max. ash content in raw coal	Mass%					30 / 40 (40)	40 (45)	30 (40)	30 / 40 (50)
Max. barren partings thickness to coal thickness ratio	Vol.%			0.2 (0.4)					
Min. calorific value of coal with barren partings (raw coal)	MJ/kg		15 (12.6)						
Max. ash content in washed coal	Mass%			10 (10)	10 (10)				
Max. volatile matter content	%				10 (10)				
Max. total sulphur content	%	2	2 (unlimited)	1.0 in washed coal	1.0 (unlimited)				

Here cut-off values are reported for different parameters that are defined by the local geology of the coal deposit, such as depth, thickness and dipping of coal seams, as well as parameters for coal quality such as calorific value, ash yield, volatile matter yield and sulphur content, which can be obtained from coal classification. Some of these parameters show significant variation between different countries, *e.g.* the maximum depth of commercial coal mining is set to 1000 m for Poland, 1500 m for German hard coal deposits and to a significantly greater depth of 1800 m for the Ukraine (Schmidt et al., 2007).

Hard Coal	Country	max. depth (m)	min. coal thickness (m)	max. sulphur content	min. calorific value (MJ/kg)	max. amount of impurities
	Poland	1000 (1250)	0.6, 1.0, (1.5)	2%	15 (12.5)	
	Germany	1500	0.6, 1.0	2%	25	35, 50 vol.%, wt.%
	UK	1200	1.5			
	US	6000ft 1800m	14 in. 0.35 m		24.4	

Brown Coal (surface mining)	Country	max. depth (m)	min. seam thickness (m)	stripping ratio	min. calorific value (MJ/kg)	maximum ash yield (%)
	Poland	350	3	12	6.5	
	Germany	450	2 - 3		6.7	30
	US	150 (40)	0.75		6.6	33

CBM	Country	depth range (m)	min. coal thickness (m)	min. gas content (m^3/t)	min. distance to mines	min. distance to major aquifers and faults
	UK	200 - 1200	0.4	1 (7)	500 horizontal 150 above 50 below	100

Figure 17 – Example of cut-off parameter and values reported for the delineation of resources and reserves in different countries. Numbers in brackets are applied to reserves. Source: Smakowski and Paszcza 2010, Ersoy, 2005, Schmidt et al., 2008, LfLUG Sachsen, USGS, 1983, Jones et al., 2004.

All of these parameters influence the feasibility of a potential development project. The geological knowledge is defined by the German hard coal industry (RAG) according to the degree of exploration based on the horizontal and vertical distance to the current coal extraction, the density of bore hole data (boreholes/km²) and the availability and distance to seismic data (Schmidt, 2008). In Germany and Poland different categories for the 90% confidence level of geologic knowledge are used, based on the admissible error of estimate (Schmidt, 2008; Niec, 2010). These categories can be mapped to the geologic axis of the UNFC (Figure 18 page 49).

Stage of prospecting/exploration	UNFC	CRIRSCO	POLAND		
			Resources/ reserves categories		admissible error limit for resources/ reserves (at 0,9 confidence level)
Reconnaissance	G4	Exploration results	D		>40%
Prospecting	G3	Inferred	C	C_2	30-40%
General exploration	G2	Indicated/ probable		C_1	20-30%
Detailed exploration and exploitation planning	G1	Measured/ proved	B		10-20 %
			A		<10%

Figure 18 – Categories for admissible error of estimate used for resource/reserve classification in Poland (Niec, 2010).

The assessment of the economic and commercial viability of a coal deposit strongly depends on local and national factors, such as government subsidiaries, socio-economic conditions, environmental regulations, cultivation and building development and infrastructure. These factors can also change over time resulting in changes of the commercial viability, independent of the geologic knowledge and technological feasibility.

Recent studies proposed a set of common parameters definitions and cut-off values for an internationally harmonized classification of hard coal resources, specifically the use of three depth intervals (0 – 600 m; 600 – 1200 m; 1200 – 1800 m) and a minimum coal thickness of 0.6 m (Schmidt et al., 2007; Thielemann and Schiffer, 2012) (Figure 19 page 50).

However, until such standardized parameters are widely accepted, the parameters and cut-off values that were applied in individual countries for the delimitation and sub-division of coal and CBM quantities should be included in the metadata of the EuCoRes database to improve the comparability of resource and reserve figures throughout the EU. Additional information on coal quality can also be included in the database in form of metadata.

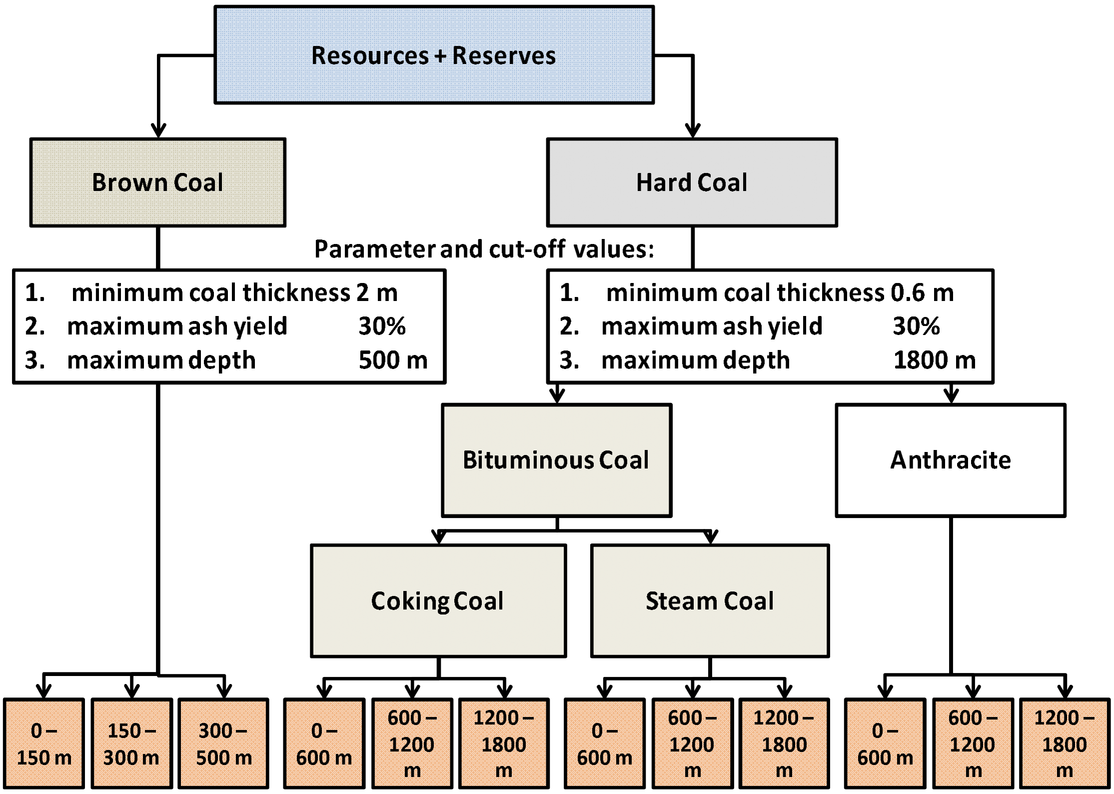


Figure 19 – Proposed sub-division of coal resources and reserves using harmonised parameter and cut-off values (modified from Schmidt et al., 2007 and Thielemann and Schiffer, 2012).

Assessment and reporting of coalbed methane (CBM) resources and reserves

For coalbed methane (CBM) no internationally harmonized terminology exists. Most commonly CBM is used to describe methane recovery from un-mined coal seams. In Australia for CBM the term coal seam methane (CSM) is used, in the US sometimes the term coalbed natural gas (CBNG) is used. In some countries, *e.g.* Poland and the UK, the term CBM is used for methane in un-mined "virgin coal seams" (VCBM) and also other coal related methane such as coal mine methane (CMM) and abandoned mine methane (AMM).

For the EuCoRes database the term CBM is used to describe natural gas associated with un-mined or un-mineable coal seams. Gas extraction associated to mining operations (CMM, AMM, ventilation air methane (VAM)) is not considered.

Coalbed methane is currently produced in commercial quantities in the US, Canada, Australia, China and other countries. In Europe several exploration activities for CBM are carried out, however, commercial production is still not realized and the amount of recoverable CBM resources is not or only poorly quantified and mapped. Consequently, large uncertainties associated with CBM resource and reserve estimates remain.

The EuCoRes database will include CBM resource estimates (gas initially in place) and, if available, information on economically recoverable CBM volumes in Europe. Similar to coal resources, the UNFC will be applied as a harmonization tool to improve the international comparability of CBM resource information. Additionally, information on the method used for the assessment of CBM resources/reserves (*e.g.* volumetric, material balance, production data analysis (PDA), reservoir simulation), as well as parameters and cut-off values used for delineation of CBM resources (*e.g.* depth, coal thickness, gas content, distance to active mining regions, aquifers and faults) can be included in the database. If available, information on critical factors that influence the gas content and commercial production of CBM such as coal rank, moisture content, permeability, cleat system, sorption parameter, gas composition, *etc.* can also be included in the database.

3.2 Data collection and interpretation

This chapter's contents:

3.2.1 Objective

The overall objective of this task was to make an evaluation of the existing sources and classifications of data relating to coal deposits including potential sources of coalbed methane (CBM) in the EU based on data residing in national geological surveys, data which industry partners are willing to share and other published data.

The principle questions to be answered in this task were:

Where are the main coal and coalbed methane resources in the EU?
How much coal and CBM is available for Europe's sustainable energy supply?

To answer these questions, countries with significant geologic coal resources had to be identified. Secondly those countries which currently have an active coal production industry and consequently possess economic quantities of coal reserves had to be identified.

3.2.2 Approach

Before data collection could be initiated, a list of European countries that could be relevant for the coal resource database was created. While the project is primarily aiming at the evaluation of coal resources in the EU27, the list of potential countries also included candidate countries and neighbouring non-EU countries of Europe.

In a second step, those countries with abundant geologic coal resources had to be identified. For this purpose a literature review of European coal geology was carried out, to identify when and where deposition of coal bearing sediments took place in Europe. Geological information on the European coal basins has been collected with regard to spatial distribution, seam thickness and distribution of coal rank.

In a third step, countries which have abundant geologic coal resources and an active coal production industry were identified by a review of international energy and coal production statistics. It was generally assumed that countries with abundant hard coal resources also have a potential for coalbed methane resources. Coalbed methane is an unconventional gas resource which is not widely produced in commercial quantities in Europe and consequently CBM production data are not yet included in international energy statistic reports for Europe. The approach to identify countries with CBM resources in Europe was aimed at the evaluation of the status of exploration and development of CBM projects in Europe.

After European countries with coal resources were identified, a list of potential data providers was created. This list included all national geological surveys of the relevant countries, as well as industry contacts, provided by the European Association for Coal and Lignite (EURACOAL). In a first informative letter which introduced the project and also included a call for data and cooperation, geological surveys, coal industry and additionally, government institutions responsible for coal and coalbed methane licensing as well as national experts in coal science and coal resource assessment at different European universities were addressed. Attached to this call for data was a detailed list of relevant information for the EuCoRes database, which was compiled from the structure and information of other coal quality and coal resource databases, *e.g.* by the USGS or the UK Coal Authority.

If no information or reply for a country was received, the call for data was extended to other contacts, if the responsible institutions or persons that could provide information for the project could not be identified or addressed in the first call for data.

After the workshop a second call for data was issued, which now put emphasis on the "core data" that are required to form the basis of the information for each country (*e.g.* spatial information of coal basins and deposits, quantitative information on resources and reserves).

Parallel to contacting data providers in the relevant countries, literature and archive data were compiled, analysed and documented under the key aspects “coal resources” and “CBM potential”.

3.2.3 Result

3.2.3.1 Overview of the coal geology and resources in the European Union and neighbouring countries

The following section provides a brief overview of the coal geology in Europe, which was mainly compiled from literature (Ziegler, 1990; Thomas, 2002 and McCann, 2008).

Geologic coal deposits in Europe are of Paleozoic (Carboniferous), Mesozoic (Jurassic, Cretaceous) and Tertiary (Palaeogene, Neogene) age. Significant hard coal deposits are associated with marine influenced to continental sediments that were deposited in the Variscan Foreland Basin during the Late Carboniferous. The tropical climate during the Late Carboniferous promoted coal formation which resulted in numerous, widespread but often thin coal seams in large parts of Europe. Additional to deposits of the Variscan Foreland, coal bearing sediments were deposited in intramontane basins of the Variscan Foldbelt, which was located to the south of the Foredeep. The intramontane basins are significantly smaller than coal basins associated with the Variscan Foredeep. Sediments of the intramontane basins show a non-marine character, associated coal seams exhibit higher thickness but laterally less continuity than coals of the Variscan Foredeep. Most economic hard coal production in Europe takes place in the Late Carboniferous coal basins. Figure 20 shows a schematic distribution of coal bearing deposits in Europe during the Late Carboniferous (Westphalian).

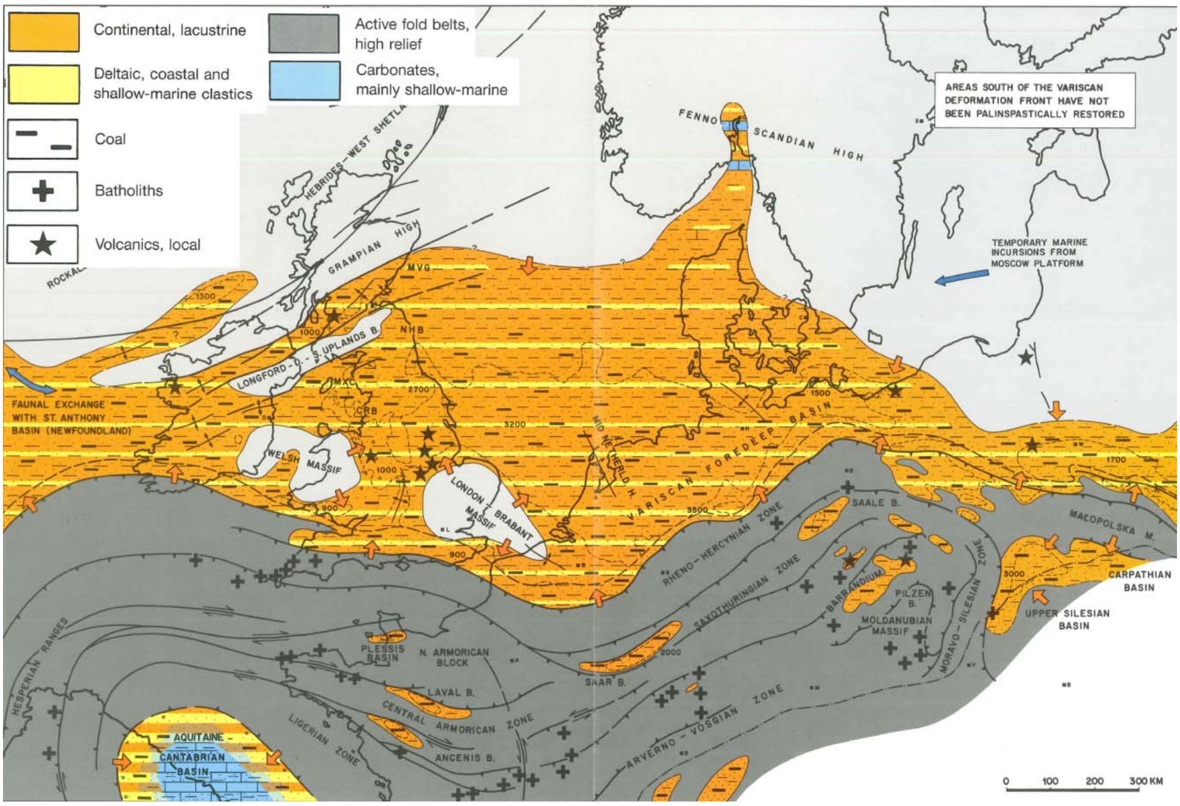


Figure 20 – Palaeogeographic map of the Upper Carboniferous (Westphalian) of central Europe, illustrating the distribution of coal bearing sediments associated with the variscan foredeep (northern part) and the variscan foldbelt (southern part). Modified from Ziegler (1990).

Mesozoic coals of Jurassic age are associated with smaller deposits in southern Europe, mainly in Austria, Hungary and Poland. The coal seams were only mined for local use in the past. Cretaceous coals are associated with deposits in northern Germany (Wealden coal) and smaller deposits in Austria (Gosau coal) and Hungary (Ajka Basin). These coals were also mined in the past and most commercial extraction has stopped.

Significant brown coal deposits are associated with Tertiary sedimentation in the Northwest European Cenozoic Basin (NWECB), which hosts the world's largest lignite production. Major coal deposits are located in Germany and Poland. Smaller discrete deposits occur in rift basins (Poland, Czech Republic), in the foreland of the Alps (Germany and Austria), in intramontane basins of the Alps, Carpathians and Dinarides (Slovenia, Slowakia, Former Yugoslavia) and the Pannonian Basin (Austria, Hungary, Slovenia, Slovakia, Former Yugoslavia). Tertiary coals are mostly of low rank (brown coal), locally they have reached higher ranks (hard coal). Coal deposits accumulated in fluvial, lacustrine or delta plain environments where coals of high thickness and variable ash contents were formed. Tertiary brown coals are mostly produced for local electricity generation.

Figure 21 and Figure 22 illustrate the stratigraphic position of hard coal deposits of Carboniferous age (ca. 360 – 300 Ma bp) and brown coal deposits of Tertiary age (Paleocene to Pliocene, ca. 65 – 2.5 Ma bp) in Europe.

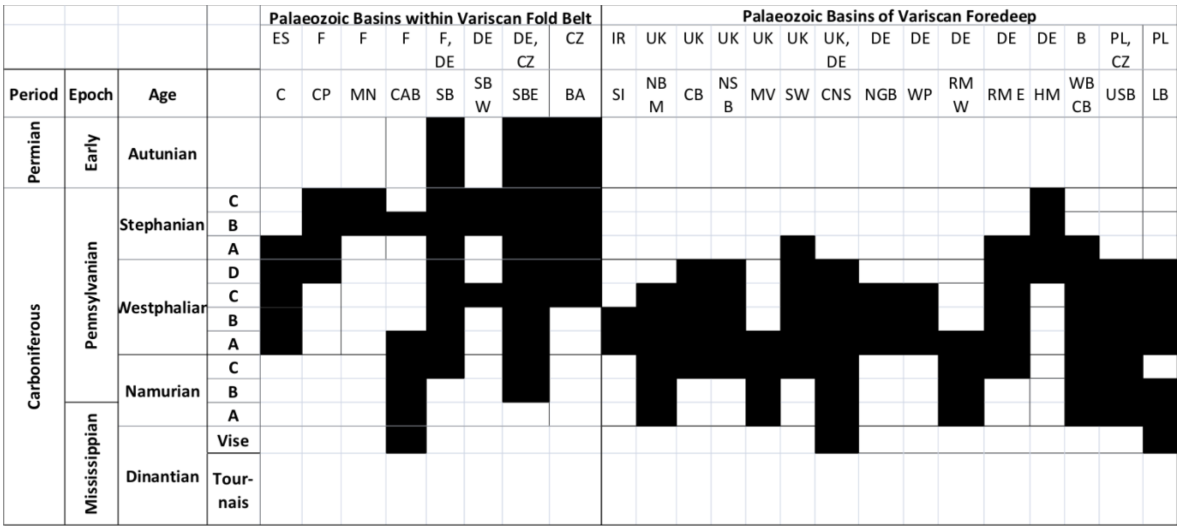


Figure 21 – Stratigraphic position of Carboniferous coal bearing formations in Europe. Simplified from Ziegler (1990) and McCann (2008). C = Cantabria, CP = Central Pyrenees, MN = Montagne Noir, SB = Saar-Lorraine Basin, SBW = Saxothuringian Basin (west of Elbe line), SBE = Saxothuringian Basin (east of Elbe line), BA = Barrandium, SI = Southern Ireland, NBM = North flank of Brabant Massif, CB = Craven Basin, NSB = Northumberland Solway Basin, MV = Midland Valley, SE = South Wales Basin, CNS = Central North Sea, NGB = Northern German Basin (Rügen, Hiddensee, Mecklenburg), WP = Western Pommerania, RMW = Rhenish Massif west, RME = Rhenish Massif east, HM = Harz Mountains, WB CB = West Brabant, Campine Basin, USB = Upper Silesian Basin, LB = Lublin Basin

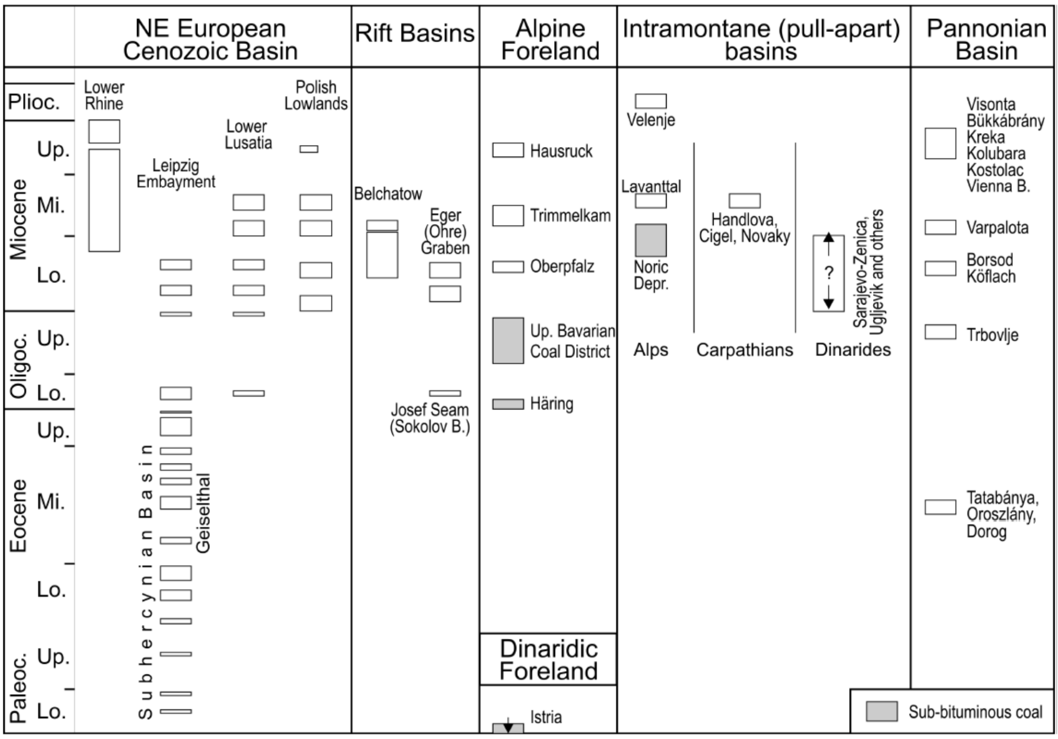


Figure 22 – Stratigraphic position of Tertiary brown coal deposits in Europe (from McCann, 2002).

Geologic information indicates the presence of brown coal and hard coal deposits in many European countries. Carboniferous hard coals are mostly located in the central and northern part of Europe, whereas brown coals of Tertiary age are abundant in Poland, Germany and the south-eastern part of Europe. Figure 23 and Table 17 give an overview of coal deposits in Europe. Reference to major coal deposits which are shown as numbers in Figure 23 are provided in Table 17.

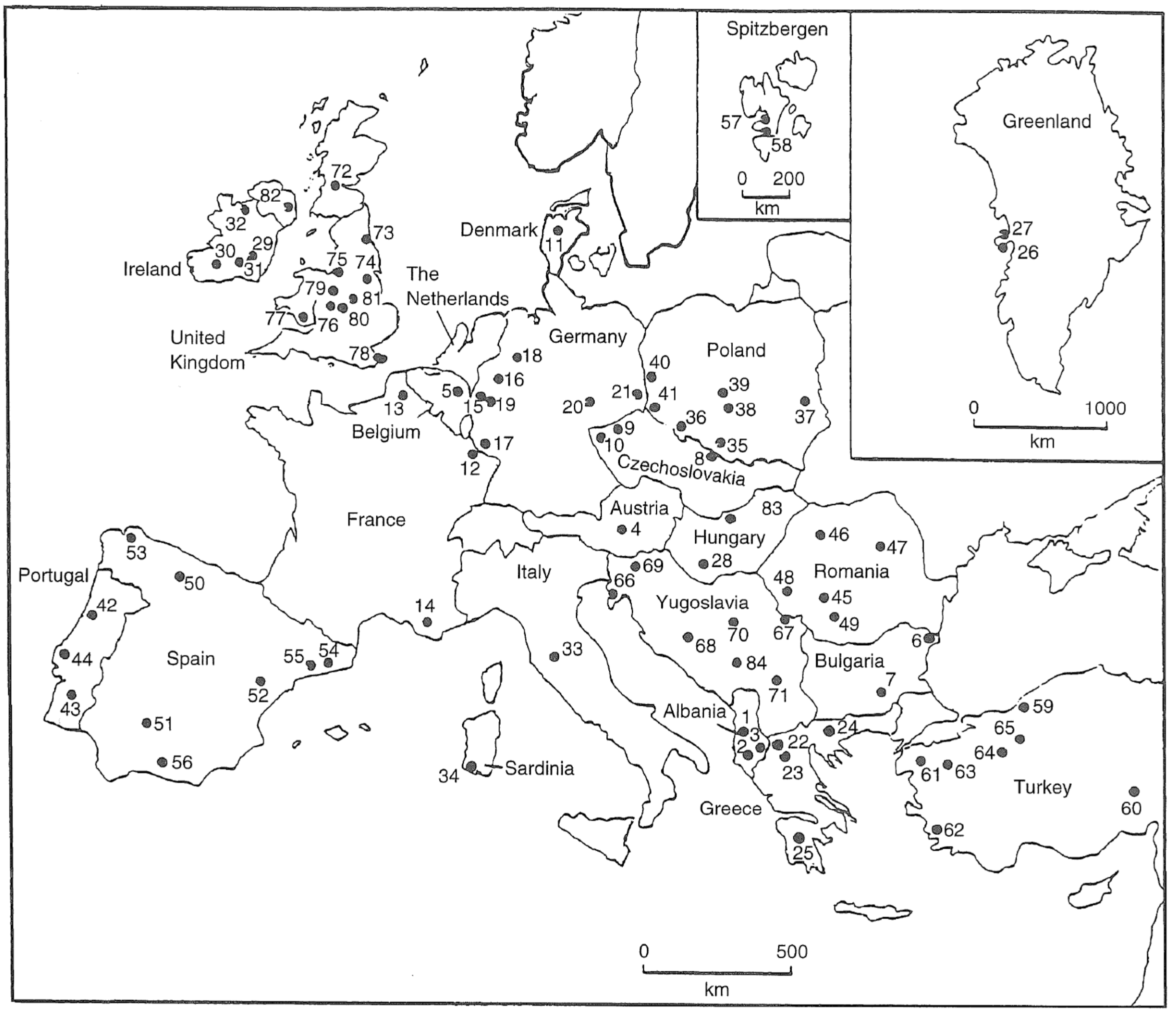


Figure 23 – Coal deposits of Europe. From Thomas (2002).

Table 17 – List of European coal deposits by country. Locations of major coal deposits are shown in Figure 23 (bracketed numbers in this table). After Thomas (2002) and McCann (2008).

Country name	Coal Deposit (Brown Coal)	Coal Deposit (Hard Coal)
Austria	West Styria (4), Häringen, Herzogenburg-Krems, Trimmelkamm, Hausrück, Langau, Noric Depression, Frohnsdorf, Leoben, Lavanttal, Wies, Köflach, Tauchen, Brennberg, Zillingsdorf	Gresten, Lunz, Grünbach
Belgium		Wallonian Basin, Kempen/Campine Basin (5)
Bulgaria	Dobruja (6), Maritsa (7)	
Czech Republic	Bohemian Basin (9), Sokolov (10),	Ostrava-Karvina (8), Bohemian Basin, Lower Silesian Basin, Rosice-Oslavany
Denmark	Herning (11)	
France		Lorraine (12), Nord et Pas de Calais (13), Provence (14), Sincey, Blancy, St. Etienne, La Mure, Lons-le-Saunier, Ronchamps, St. Hippolyte
Germany	Lower Rhine Basin (19), Mitteldeutschland (20), Lausatia (21), Borken, Subhercynian Basin, Geiselthal, Oberröblingen-Amsdorf, Upper Bavaria, Wetterau, Rhön, Hoher Meißner	Aachen (15), Ruhr Basin (16), Saar (17), Ibbenbüren (18), Baden Baden, Stockheim, Manebach, Ilfeld, Wettin, Zwickau-Ölsnitz, Freital, Doberlug, Osnabrück, Barsinghausen
Greece	Florina-Amyndaeon (22), Ptolemais (23), Serrae (24), Megalopolis (25)	
Hungary	Mecsek (28), Visonta-Bukkabrany (83), Oroslany, Tatabanya, Torony, Varpalota, Borsod	Ajka, Mecsek
Ireland		Leinster (29), Kanturk (30), Slieveardagh (31), Connaugh (32)
Italy	Valdarno (33)	Sulcis (34), La Thuile
Netherlands		Winterswijk
Poland	Belchatow (38), Konin (39), Lausitz (40), Turow (41)	Upper Silesia (35), Lower Silesia (36), Lublin (37), Zawiercie, Lysa Gora
Portugal		Sao Pedro da Cova (42), Cabo Mondego (43), Rio Maior (44)
Romania	Jiu (45), Almas (46), Comanesti (47), Banat (48), Oltenia (49)	
Slovakia	Senovo, Dubranji, Novaky, Upper Nitra Basin, Nograd	
Slovenia	Istra (66), Trans-Sava (69), Secovlje, Zasavje, Velenje, Kocevje, Globoko, Zabukovica	
Spain		Leon (50), Puertollano (51), Teruel (52), Garcia Rodriguez (53), Calaf (54), Mequinenza (55), Arenas del Rey (56)

Country name	Coal Deposit (Brown Coal)	Coal Deposit (Hard Coal)
United Kingdom	Northern Ireland (82)	Scotland (72), Northeast England (73), Yorkshire-Nottinghamshire (74), Lancashire-North Wales (75), English Midlands (76), South Wales (77), Kent (78), North and South Staffordshire (79), Warwickshire (80), Leicestershire (81)
Croatia	Pregrada, Rasa Valley, Konjscina, Ivanec. Pokupsko, Ludbreg, Bilogra, Posavje	
Serbia (incl. Kosovo)	Dobra (67), Kolubara (70), Kosovo (71), Kostolac (84)	
Turkey	Elbistan (60), Canakkale (61), Mugla (62), Bursa (63), Ankara (64), Cankiri (65)	Zonguldac (59)
Albania	Tirane (1), Teplene (2)Korce (3)	
Bosnia Herzegovina	Sarajevo-Zenica (68), Kamengrad, Banja Luka, Stanari, Tesanj, Gracanica, Kreka-Tuzla, Banovici, Ugljevik	
Norway		Longyearbyen (57), Svea (58)

3.2.3.2 Evaluation of energy statistics for Europe and documentation of country specific information

Evaluation of international energy statistic reports, *e.g.* by the International Energy Agency (IEA), the World Coal Association (WCA) or the Germany Federal Institute for Geosciences and Natural Resources (BGR), can be used to identify which European countries are currently producing coal and how much reserves are estimated for these countries.

The evaluation of geologic information and energy statistics for Europe shows that of the 27 EU member states, only 19 countries have abundant geologic coal deposits and resources. Annual hard coal production is reported for 9 of these countries. The following seven EU member states have a hard coal production that exceeded 1 Mt:

Poland, United Kingdom, Germany, Czech Republic, Spain, Romania and Bulgaria.

Brown coal deposits occur in 17 of the 27 EU countries. Brown coal production was reported for nine countries in 2011. Most of the EU brown coal production and resources are associated with deposits in Germany and Poland. Significant brown coal resources are also found in southeast Europe. All EU member countries with reported coal resources were contacted in the course of the data collection for the *EuCoRes* database. Additionally, the data collection was extended to include EU candidate countries such as Serbia or Turkey, which possess significant brown coal reserves. In case of coal basins or deposits of the EU that cross borders to neighbouring countries, the data collection was extended to include these countries. A list of European countries is provided in Table 18 (page 63), which provides information on coal resources, reserves, coal production and the status of data loading in the database.

Based on the evaluation of the geologic distribution of coal deposits in Europe and the evaluation of energy statistics, countries that can be included in the database were selected. European countries for which no coal resources are known or reported were not included in the database. All EU 27 countries for which coal production is reported and which thus possess coal resources and reserves are included in the database. Austria and Sweden were not included in the database because no coal reserves are reported, they do not possess significant hard coal resources and no coalbed methane resources or exploration activities are reported for these countries. Belgium, France, Ireland and the Netherlands are included in the database, even though no significant coal reserves are reported, but their remaining hard coal resources are associated with potential coalbed methane resources.

For most of the non-EU countries which have significant coal resources and are adjacent to the EU, only very limited information was available and only Serbia could be included in the database.

Table 19 provides an overview of the quality and availability of data for the countries that are loaded in the EuCoRes database.

For each country included database, a document was prepared which provides an overview on coal deposits and coal production. These **country profile** documents also summarize information on the national coal classification system and the classification and assessment of coal resources and reserves. If available, information on coalbed methane was also included in the country profiles. What follows is a description of **the structure of these country profiles**.

Section 1: Economy

This section provides information on the current economic situation with regard to coal mining and coalbed methane industry. Furthermore the aim of this section is to compare the national coal and CBM production in an international context, to evaluate the importance and significance of the countries industry in the European Union. The information is based on information from international energy reports, *e.g.* International Energy Agency (IEA), World Coal Association (WCA), US Energy Information Administration (EIA) or the Germany Federal Institute for Geosciences and Resources (BGR). Additionally, country specific economic information are included, if available.

Section 2: Coal Geology - Hard Coal

This section gives a general and simplified overview of the geology and stratigraphy of the country's main hard coal basins and deposits. Furthermore an overview of coal rank and quality is given.

Section 3: Coal Geology - Brown Coal

This section gives a general and simplified overview of the geology and stratigraphy of the country's main brown coal basins and deposits. Furthermore an overview of coal rank and quality is given.

Section 4: Coalbed Methane

This section gives a general overview of coalbed methane accumulations, associated with the country's coal deposits. It also describes the status of exploration and other activities related to coalbed methane. Furthermore, information on gas contents and relevant reservoir parameters for CBM accumulations are summarized, if available.

Section 5 and 6: Resource/reserve information

This section provides information on the country's resources and reserves with respect to coal and coalbed methane. It gives an overview on the resource and reserve assessment in the country and provides information on the methodology and classification that is used. Results from the latest resource assessments as well as a summary of resource estimate of the past are provided, if available. This section also includes information on the institutions and organizations that are responsible for coal resources, resource estimations and licensing for mining and coalbed methane exploration and production. Additionally, this section provides information on the national coal classification. The section is sub-divided into:

Resource information – Hard Coal
Resource information – Brown Coal
Resource information – Coalbed methane (CBM)
Resource/reserve assessment and classification

References

This section provides a list of references that were used for the creation of the country profile documentation and of any further literature references or material that was provided for the country or available from public sources.

3.2.3.3 Result of data collection

Contacted persons and organizations in Europe mostly indicated interest and support of the database project. However, requested data for the project were only in few cases directly available. Response to the call for data and the open discussion round during the workshop indicated that for many countries, the required information on coal resources and coal quality are not readily available and information could not be compiled in time for the project. For these countries information was extracted and compiled from publicly available reports or scientific literature. To provide general information on the location of coal deposits of countries for which no digitized spatial information was available, polygons or point data (x-y coordinates) of coal basins, coal deposits and mining areas were created by roughly digitizing available information *e.g.* from analogue maps or satellite images.

Table 18 provides an overview of coal resources and reserves, as well as production in European countries. An extra column represents the status of the data loading and is divided into the following three categories:

- **no known resource** indicates countries that do not possess significant geological coal resources and thus were not included in the data collection.
- **no data** indicates countries for which no data or information for the database was provided or collected from literature. This data is either not available or could not be compiled or provided by the national geological survey because it is not readily available in digital form.
- **available data loaded** indicates countries that either provided data or where data could be compiled from published reports. All data made available was assimilated and loaded into the database. Table 19 gives an overview of the general status of the data collection for these countries. This status is indicated for 4 themes: coal resource/reserve information; coal quality information; spatial information; coalbed methane information.

For each of these themes in Table 19, the status is described using the following terms:

- **no data** indicates countries for which no data or information for the database was provided or collected from literature. This data is either not available or could not be compiled or provided by the national geological survey without financial support because it is not readily available in digital form.
- **partial** indicates countries that did provide general information or referred to reports or other documents from which data needed to be extracted and digitized. It also indicates countries for which information was only available for some individual coal deposits or coal basins or countries that could only provide a specific type of information but critical core data was missing.
- **reports (survey, university, company, coal authority)** indicates information that is reported by the national geological survey, national research institutes or universities, coal producing companies or national coal authorities. These reports were either directly provided for the database or are publicly available.
- **literature** indicates information that was compiled from scientific literature such as journal articles, scientific books, compilations (*e.g.* coal atlases) or conference contributions

- spatial data is further described by the following terms:
  - **point/polygon** data refers to the type of data either available/provided or digitized
  - **provided** refers to spatial data that was available or provided in digital form
  - **digitized** refers to the remaining countries for which spatial information was roughly digitized based on maps from reports or literature

For most of the European countries that provided coal resource information, the mapping to the harmonized classification system of the UNFC 2009 was not available or not complete. Detailed information on the applied resource classification system was also not frequently available. However, harmonized resource / reserve information can be included in the database whenever it becomes available in the future.

Table 18 – Overview of coal production and resources in the EU27 and other European countries. Resource, reserve and production information from BGR (2012) "Annual Report Reserves - Resources and Availability of on energy resources 2011"

Country	code	EU27 member?	hard coal production [Mt]	brown coal production [Mt]	hard coal resources + reserves [Mt]	brown coal resources + reserves [Mt]	status of data loading
Austria	AT	yes	**0**	**0**	**0**	**333**	no data
Belgium	BE	yes	**0**	**0**	**4100**	**0**	available data loaded
Bulgaria	BG	yes	**2.2**	**27.2**	**4112**	**4574**	available data loaded
Cyprus	CY	yes	**0**	**0**	**0**	**0**	no known resources
Czech Republic	CZ	yes	**11.2**	**43.9**	**9946**	**16627**	available data loaded
Denmark	DK	yes	**0**	**0**	**0**	**0**	no known resources
Estonia	EE	yes	**0**	**0**	**0**	**0**	no known resources
Finland	FI	yes	**0**	**0**	**0**	**0**	no known resources
France	FR	yes	**0.3**	**0**	**160**	**114**	available data loaded
Germany	DE	yes	**14.1**	**169.4**	**82921**	**77000**	available data loaded
Greece	GR	yes	**0**	**56.5**	**0**	**6430**	available data loaded
Hungary	HU	yes	**0**	**9.1**	**5351**	**7717**	available data loaded
Ireland	IE	yes	**0**	**0**	**40**	**0**	available data loaded
Italy	IT	yes	**0.1**	**0**	**610**	**29**	available data loaded

Latvia	LV	yes	**0**	**0**	**0**	**0**	no known resources
Lithuania	LT	yes	**0**	**0**	**0**	**0**	no known resources
Luxembourg	LU	yes	**0**	**0**	**0**	**0**	no known resources
Malta	MT	yes	**0**	**0**	**0**	**0**	no known resources
Netherlands	NL	yes	**0**	**0**	**3247**	**0**	available data loaded
Poland	PL	yes	**76.7**	**56.5**	**176738**	**228183**	available data loaded
Portugal	PT	yes	**0**	**0**	**3**	**66**	available data loaded
Romania	RO	yes	**2.2**	**27.7**	**2446**	**9920**	available data loaded
Sloviakia	SK	yes	**0**	**2.4**	**19**	**1061**	available data loaded
Slovenia	SI	yes	**0**	**4.4**	**95**	**656**	available data loaded
Spain	ES	yes	**8.8**	**0**	**4231**	**319**	available data loaded
Sweden	SE	yes	**0**	**0**	**5**	**0**	no data
United Kingdom	UK	yes	**18.4**	**0**	**187071**	**1000**	available data loaded
Croatia	HR	acceding	**0**	**0**	**0**	**300**	no data
F Y R O M[1]	MK	candidate	**0**	**6.8**	**0**	**632**	no data
Iceland	IS	candidate	**0**	**0**	**0**	**0**	no known resources
Montenegro	IS	candidate	**included in Serbia**				no data
Serbia[2]	RS	candidate	**0.1**	**45.4**	**855**	**31012**	available data loaded
Turkey	TR	candidate	**2.6**	**70**	**1190**	**12114**	no data
Albania	AL	potential candidate	**0**	**<0.05**	**0**	**727**	no data
Bosnia Herzegovina	BA	potential candidate	**0**	**11**	**630**	**4182**	no data
Norway	NO	no	**1.9**	**0**	**78**	**0**	no data
Ukraine	UA	no	**75**	**0**	**81045**	**0**	no data

[1] FYROM = Former Yugoslav Republic of Macedonia
[2] includes Kosovo

Table 19 Information on the status of data loading of countries with significant coal resources.

Country name	code	Resource/reserve information	Coal quality information	Spatial information	CBM information
Belgium	BE	no data	literature	partial, digitized	no data
Bulgaria	BG	no data	literature	point data, digitized	no data
Czech Republic	CZ	reports (survey)	literature	provided + digitized	literature
France	FR	no data	no data	digitized (general location)	no data
Germany	DE	reports (survey)	literature	provided + digitized	literature
Greece	GR	partial, reports (university)	reports (university), literature	point data, provided (university)	no data
Hungary	HU	reports, literature	literature	digitized (from reports, literature)	reports, literature
Ireland	IE	reports (survey)	reports (survey)	digitized (from analogue maps)	no data
Italy	IT	partial, literature	literature	digitized (from literature)	no data
Netherlands	NL	literature	no data	digitized (from literature)	literature
Poland	PL	reports (survey)	literature	reports (survey)	reports (survey)
Portugal	PT	reports (university)	reports (university)	general point data, digitized	no data
Romania	RO	partial (1 basin), reports (company)	partial (1 basin), reports (company), literature	general location, digitized (from analogue map)	no data
Sloviakia	SK	literature, reports	literature	general point data, digitized	no data
Slovenia	SI	partial (1 basin), literature	partial (1 basin), literature	general localtion, digitized	no data
Spain	ES	reports (survey), old data	reports (survey), literature	digitized (from analogue maps)	reports, literature
United Kingdom	UK	reports (survey + coal authority)	reports (survey)	provided (survey)	reports
Serbia[3]	RS	reports (university)	reports (university)	point data, provided (university)	no data

[3] includes Kosovo

3.3 Workshop

3.3.1 Objective

The EuCoRes project aims at providing policy makers, stakeholders and the public with a comprehensive overview of Europe's coal resources including potential sources of coalbed methane (CBM). In this perspective there is a need for a common classification and terminology for coal and CBM as well as for a harmonised database model. The latter should allow the mapping of different data sources to the common classification and terminology.

The purpose of the workshop was to present the work in development concerning the common classification and the harmonised data model to the Member States and stakeholders with the aim to verify the proposals and to test peer acceptance for the envisaged common classification and terminology.

3.3.2 Approach

Possible participants for the EuCoRes workshop were mobilized through several channels:

- The workshop date was set one day before the 8th Coal Dialogue meeting, organised jointly by the Commission and the European Association for Coal and Lignite (Euracoal). The invitation was thus also send to the members of Euracoal.
- The National Coal Expert Group was summoned by the Commission.
- A list of connections of the consortium was contacted.

An invitation was sent to these stakeholders, including the agenda, and an outline of the project. Documentation on the proposal for terminology and classification, and on the database model were provided to registered participants prior to the workshop.

The workshop was also published on the EuCoRes website at
http://ec.europa.eu/energy/coal/eucores/eucores_workshop_en.htm.

3.3.3 Result

The workshop was held on Tuesday, 29th May 2012, at 14h, in room 1B of the Albert Borschette Conference Centre, Rue Froissart 36, 1040 Brussels.

The programme

14:00 – 14:30	Registration
14:30 – 14:45	**Welcome and introduction to EuCoRes project** Presentation by Mr Michael Schütz, Policy Officer, DG Energy
14:45 – 15:15	**Presentation of proposal for coal typology and classification of resources and reserves based on evaluation of existing typologies and classifications** Mr Philipp Weniger, Post-graduate Researcher, Institute of Geology and Geochemistry of Petroleum and Coal, RWTH Aachen University **Mode of reporting resources and reserves in Poland on Coal, Lignite and Coal Bed Methane** Prof. Dr Marek Nieć Mineral and Energy Economic Research Institute, Polish Acad. Sciences, Kraków
15:15 – 15:45	**Presentation of proposed database model** Mr Stijn Keijers, Senior consultant and Ms Ann Crabbé, Junior consultant, Spatial Applications Divison, K.U.Leuven
15:45 – 16:15	Coffee break
16:15 – 17:30	**Discussion and feedback on proposals** Chair: Michael Schütz, Policy Officer, DG Energy Non-exhaustive list of issues to be discussed: • Feasibility of proposed typology and classification in relation to existing systems used for coal in Europe. • Appropriateness of typology, classification and database model for inclusion of coalbed methane. • User friendliness of database: Does it provide easily accessible, useful information to policy makers and stakeholders? Does it allow future updating, improvement and possible extension (*e.g.* to shale gas)? • Filling the database: Which data is available in Europe and how could data inclusions be facilitated to the benefit of stakeholders?
17:30 – 18:00	**Summary and concluding remarks** • Mr Philipp Weniger, Post-graduate Researcher, Institute of Geology and Geochemistry of Petroleum and Coal, RWTH Aachen University • Mr Stijn Keijers, Senior consultant, Spatial Applications Divison, K.U.Leuven • Mr Michael Schütz, Policy Officer, DG Energy

Documentation & Website

This website page contains the following information and documentation:

- A brief introduction to the probject and statement of purpose (see 3.3.1)
- The programme (pdf)
- A bundle of the given presentations (in pdf, see list above), including a summary of the round of comments
- *Terminology and classification for the EUCORES Database*: the updated version of the background documentation on terminorligy and classification.
- *Database Model*: the updated version of the background documentation on the database model.
- A summary of the EuCoRes workshop, presented at the the CoalDialogue the next day
- Information on the venue

Round of comments

The most important part of the workshop was the round of comments. The general scope of the open discussion round was to get feedback on the presented work and to find answers on following topics (amongst others):

- Feasibility of the proposed typology and classification in relation to existing systems used for coal in Europe.
- Appropriateness of the typology, classification and database model for inclusion of coalbed methane.
- User friendliness of the database: easily accessible and useful information for policy makers and stakeholders? Does it allow updating, improvement and possible extension (*e.g.* to shale gas)?
- Which data is available in Europe and how could data inclusions be facilitated to the benefit of stakeholders?

A full summary of the round of comments is available through the website. The outcome was taken into consideration and updated versions of *Terminology and classification for the EUCORES Database* and *Database Model* were made available on the website.

Outcome

The **attitude** towards the project is very positive in general. However there are a few remarks: input delivery is expensive and time-consuming, sometimes even interpretation is necessary and a direct instentive is missing.

The **proposed typology and classification** was found acceptable, provided a few chages: coal rank and utilization were disjoint and their definitions restated more clearly, and the threshold to distinguish between brown coal and hard coal, based on GCV was changed from 24 MJ/kg to 20 MJ/kg.

The idea of distinguishing between *core data* and *extensions* in the **database model** was welcomed.

3.4 Geographical database

De data that is collected and classified under chapters 3.1 and 3.2 is transformed into a set of GIS features and descriptive tables and entered into an ArcGIS File Geodatabase. This chapter covers the entire process of creating a database, filling it with data, using the data and keeping the database up to date.

This chapter's contents:

Objective states the exact goals of this theme. Approach 'briefly explains the steps undertaken in order to reach these goals. Result presents the project achievements related to this theme. The latter can also be considered as a user manual.

3.4.1 Objective

The invitation for tender specifies the following:

“The creation of a geographical database of the coal deposits in the EU differentiated by coal type on the basis of the proposed common classification with further differentiation and details, where feasible. The data should allow for ease of comparison and be broken down by coal basin and by country. It should include information about which areas are being actively mined, which are in the closure process and which are already planned mining areas for the future. Main information like the depth and the calorific content of deposits should be indicated. Furthermore, estimates for the gas reservoir of the coal deposits should be given by using the existing data and information from coaliferous basins including active and abandoned mines. The data on CBM should be included in the geographical database and should comprise parameter classes like gas content, permeability, natural fracturing, pressure and further characteristic reservoir properties. In case of insufficient data, estimates should be given, based on the available data and level of geological knowledge. “

The database should fulfill following requirements:

(a) use the coal classification system proposed in chapter 3.1 *Formulation of a common classification and* terminology of this report
    a. the subdivision of coal in classes (hard coal, brown coal) and sub-classes
    b. the classification of resources and reserves according to the UNFC system
(b) include the data specifications described in the request for tender (*e.g.* information on mining activity, coal deposit information like depth and calorific content, and CBM information like gas content, permeability, natural fracturing, pressure)
(c) be compliant with INSPIRE Data Specifications, taking into account that the DS for INSPIRE of the annex II and III themes are still under development
(d) be based on the available content of the existing data sources that are collected in the frame of this project
(e) be extendible for more details or new objects in the future

3.4.2 Approach

The first step in the development is the **creation of the database model** (or 'schema'). This is done by means of the Sparx Systems Enterprise Architect software package (see chapter 3.4.3.4), which is used for the visual modelling in UML (Unified Modelling Language) on the one hand, and the physical implementation of the database in ArcGIS on the other hand.

The database model is based on two application schemas by INSPIRE: Mineral Resources[4] and Energy Resources[5]. For now, the work on the data specifications is still on-going and the documents used here are the draft guidelines.

The **Mineral Resources** schema is built around two main object types:

(a) **earth resource** identifies observable or inferred phenomena, required to classify economic and sub-economic earth resources (*i.e.* natural material like coal);
(b) **mining feature** represents a conceptual feature that exists in the world and corresponds with either a mine or a mining activity, locatable and identifiable in time and/or space.

The **Energy Resources** schema covers both renewable as non-renewable resources. Evidently only the latter are used here. A **non-renewable resource** is defined as a natural resource, which cannot be produced, grown, generated or used on a scale which can sustain its consumption rate, due to long-term formation. These resources exist in a fixed amount, or are consumed much faster than that nature can replenish them. This data type has two sub-types: solid fossil fuels and hydrocarbons.

The database schema is described in general in the first chapter (3.4.3.1). The next chapter (3.4.3.2) contains the feature catalogue, which is a collection of details and definitions on all the objects and features, their attributes and their associations with other features. Chapter 3.4.3.3 shortly presents the GISCO database and the data that is included from the GISCO database into the EuCoRes database. This concerns 'reference' data like country boundaries, European cities, *etc*.

De data that is collected and classified under chapters 3.1 and 3.2 are transformed into a set of GIS features and descriptive tables and entered into the **ArcGIS File Geodatabase**. This is explained in the chapters 3.4.3.5 to 3.4.3.7. As an aid for this task, the ArcGIS software offers the possibility to write custom tools, by means of the easy-to-use ModelBuilder application that is part of the ArcGIS software package or by writing integrated Python scripts. To help the user, a set of tools is written to load data into the database (see chapters 3.4.3.6 and 3.4.3.7).

Metadata (see chapter 3.4.3.8) is available as (i) INSPIRE compliant metadata for discovery, based on the ISO 19115 standard and (ii) as a detailed lineage per country, available in the Country Fiches

[4] D2.8.III.21_v2.9 INSPIRE Data Specification on Mineral Resources – Draft Guidelines, INSPIRE Thematic Working Group Mineral Resources (2012-02-24).

[5] D2.8.III.20_v2.9 INSPIRE Data Specification on Energy Resources – Draft Guidelines, INSPIRE Thematic Working Group Energy Resources (2012-02-24).

3.4.3 Result

3.4.3.1 The European Coal Resources database model

A summary of the full database model is given in Figure 24. It will be discussed step-by-step in this chapter. The first part describes general issues of a database model (such as geometric features, naming items and data validation). The second part describes the model itself, with its **division between core features and extensions**.

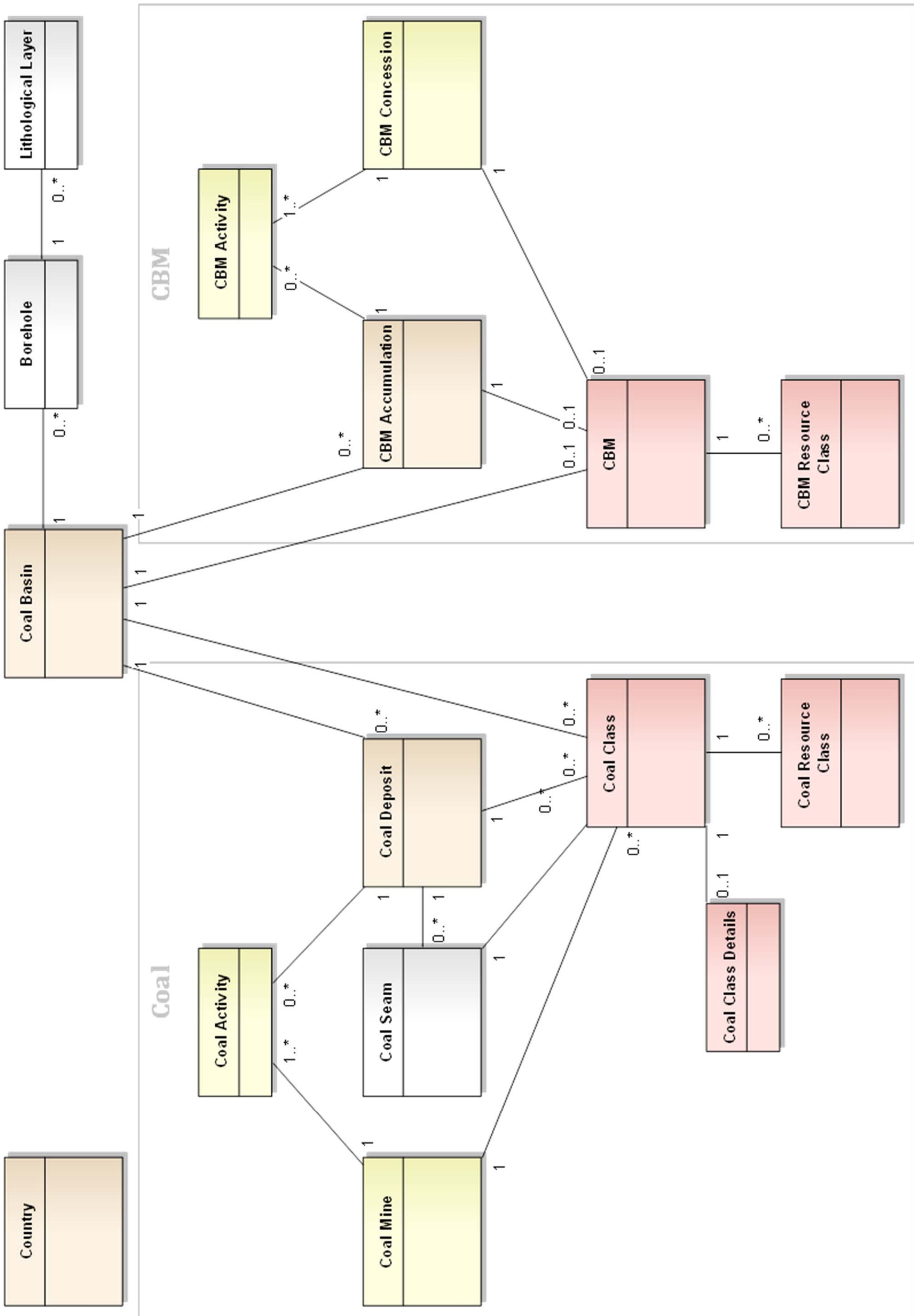


Figure 24 – UML class diagram: Summary of the full European Coal Resources database model (orange – core; yellow and white – extensions; pink – classes and resources). Only object names and relationships are indicated, attributes can be found in the feature catalogue. Multiplicity reads as follows (example for Coal Deposit and Coal Basin): each basin has zero to many deposits, and each deposit belongs to exactly one basin.

Issue 1: dealing with geometry

All tables shown in Figure 24 are **objects or descriptive tables** that only store descriptive information. Geometry information is stored in related **features or geometry tables**. For reasons of simplicity, these tables are left out of the summarizing figure (Figure 24). An overview of all descriptive tables that are related to geometry tables is given in Figure 25. The geometry table is given the same name as the descriptive table, plus a suffix indicating the geometry.

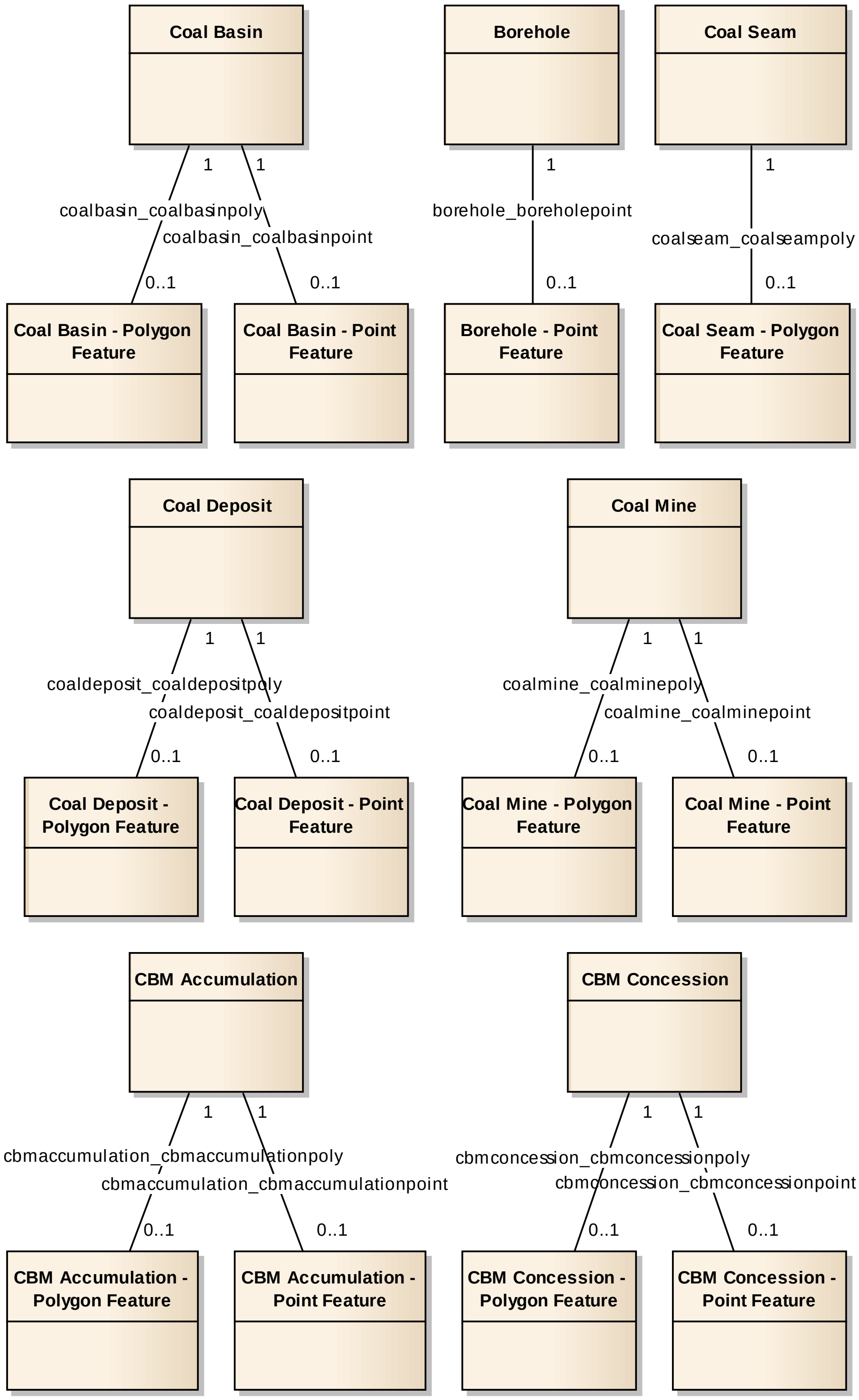


Figure 25 – UML class diagram: Overview of all objects that have a geometry feature related to them

A more detailed example is given for the object **Coal Deposit**. This object has two related features: **Coal Deposit Point** and **Coal Deposit Polygon** (Figure 26). Information on polygons is preferred, but data on point geometry can also be included, in case the former is not available.

The **multiplicity** of 1 at the side of Coal Deposit and 0 or 1 at the side of the geometry feature indicates that each geometry feature is related to exactly one coal deposit object, and that each coal deposit object has 0 or 1 point and/or polygon feature related to it.

The relation is realized by using a primary key *PK_ClassName*, here PK_ CoalDeposit, in the source object and a foreign key *FK_ClassName*, here FK_ CoalDeposit, in the target object.

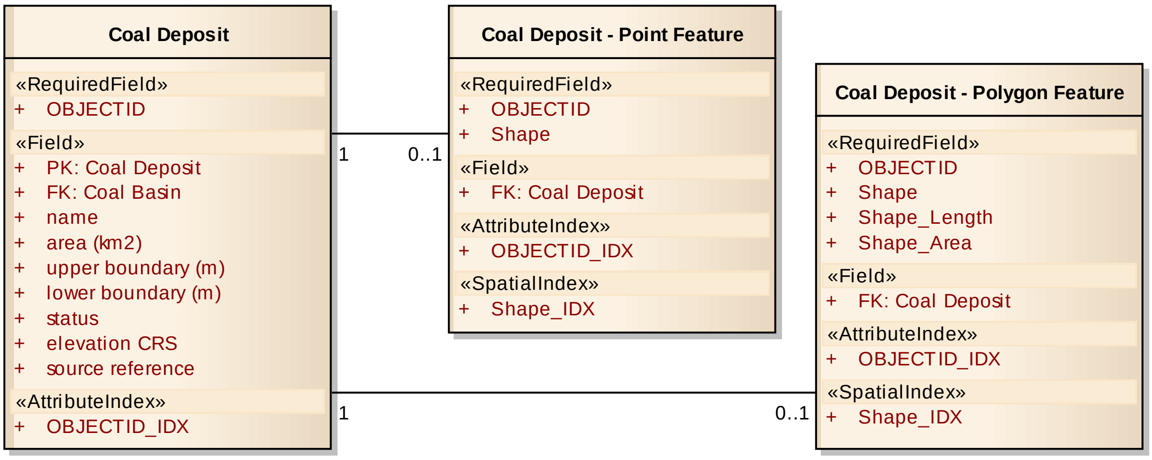


Figure 26 – UML class diagram: Dealing with geometry in de object Coal Deposit.

Notice the ArcGIS system fields: OBJECTID, Shape, Shape_Lenght, Shape_Area, OBJECTID_IDX and Shape_IDX.[6]

[6]The indicated fields – OBJECTID, Shape, Shape_Length, Shape_Area, OBJECTID_IDX and Shape_IDX – are *ArcGIS system fields*. These are attributes and indexes that ArcGIS generates automatically and that are required for internal software processes. However these have no semantic meaning here, and will therefore be omitted from further diagrams and descriptions for reasons of clarity. They are listed in the feature catalogue.

Issue 2: naming of objects, attributes and relationships

The names of objects, attributes and relationships are chosen in a manner that should allow for easy interpretation. Each object and each attribute has two names: the **database name**, which is fixed and bound to strict rules, and an **alias** that can be changed later on and has more possibilities. Relationships only have a database name (here).

Database names can only contain letters, numbers and underscores, but no spaces or other symbols. As they are often made up of different words, each subsequent word starts with an uppercase letter (*e.g.* minSeamThickness). To keep the names clear and understandable, it is best practice to keep them short.

- Classes: The name starts with an uppercase letter, *i.e*. UpperCamelCase (*e.g.* CoalDeposit).
- Attributes: The name starts with a lowercase letter, *i.e*. lowerCamelCase (*e.g.* geologicAge). Exceptions are primary and foreign key fields, which start with their acronyms (PK and FK) and an underscore, *e.g.* PK_CoalBasin.
- Relationships: The name is the concatenation of the two object names, all in lower case, connected with an underscore, *e.g*. coalbasin_coaldeposit.

Aliases can contain all sorts of letters and symbols, including spaces. They are similar to the database names, but with spaces and sometimes with a different order of words or a conjunction in between. They can also be changed afterwards, for which reason units are indicated only here. An example: the alias for ‘upperBoundary’ is ‘upper boundary (m)’.

Aliases are available for object and attribute names, and are preferred in use over database names. In ArcGIS, standard settings show the alias instead of the database name, but this can be changed by the user.

Issue 3: Data validation through code lists

A code list describes a set of possible values for a given attribute. It is a constraint on the value of the attribute. The code list is in fact another table, in which the set of possible values serves as the primary key.

Let us illustrate this with **an example**: The object class **Coal Class** has an attribute *harmonized class*. The value to be filled in for *harmonized class* can only be 'hard coal' or 'brown coal' (*cfr.* chapter 3.1). In order to restrict the user from filling in any other values, he or she can only make a reference (*i.e.* through a foreign key) to the code list **Harmonized Class Value**. This code list contains two primary keys, to which the user can refer, which are 'hard coal' and 'brown coal'.

An overview of all code lists is given in Figure 27.

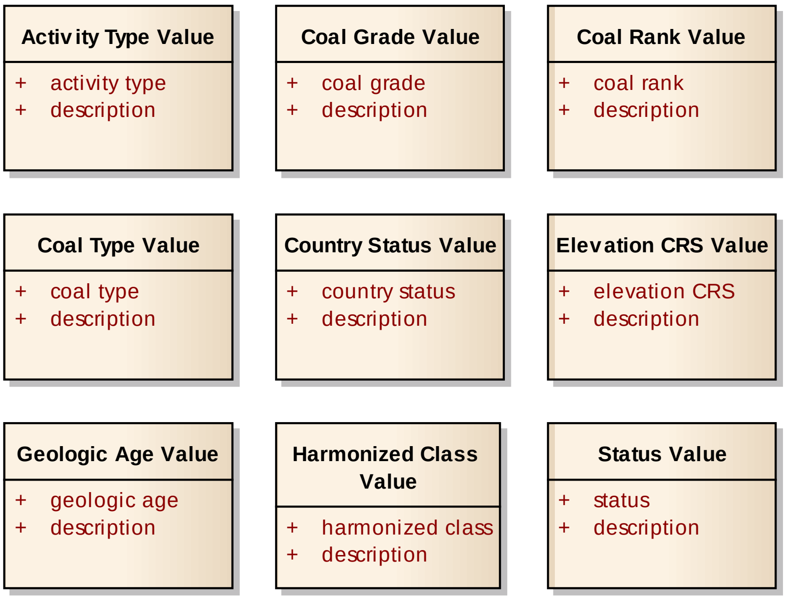


Figure 27 – UML class diagram: Overview of the code lists. The name of the code list is the same as the name of the attributes referring to them, but with the suffix 'Value'.

→ The values for **activity type**, **country status**, **elevation CRS** and **status** are chosen based on available data and internal discussions.

→ Values for **coal grade**, **coal rank** and **coal type** are chosen from the ISO 11760 standard (on classification of coals)[7].

→ **Geologic age** values are chosen based on The Geological Society of America's Geologic Time Scale 2009[8].

→ Values for **harmonized class** are discussed in chapter 3.1 *Formulation of a common classification and* terminology.

[7] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=38898

[8] http://www.geosociety.org/science/timescale/

Core-section of the European coal resources database model

The model (Figure 24) has a dual structure, built around the themes *coal* and *coalbed methane (CBM)*. The core features (Figure 28) are respectively **Coal Deposit** and **CBM Accumulation**, which describe *the phenomena required to classify economic and sub-economic resources*. Directly or indirectly associated we find the following objects:

- **Coal Basin** is the geologic region in which the coal deposit or CBM accumulation is situated.
- **Coal Class** and **CBM** give a description of either the coal class found in the coal deposit or the CBM reservoir found in the CBM accumulation.
- **Coal Resource Class** and **CBM Resource Class** give estimates of the resources. The reported resource classification as well as the mapping to UNFC is included.
- **Country** lists all EU27 countries and other neighbouring countries.

A more complete description of these objects with relations, attributes and data types is given in the feature catalogue (3.4.3.2).

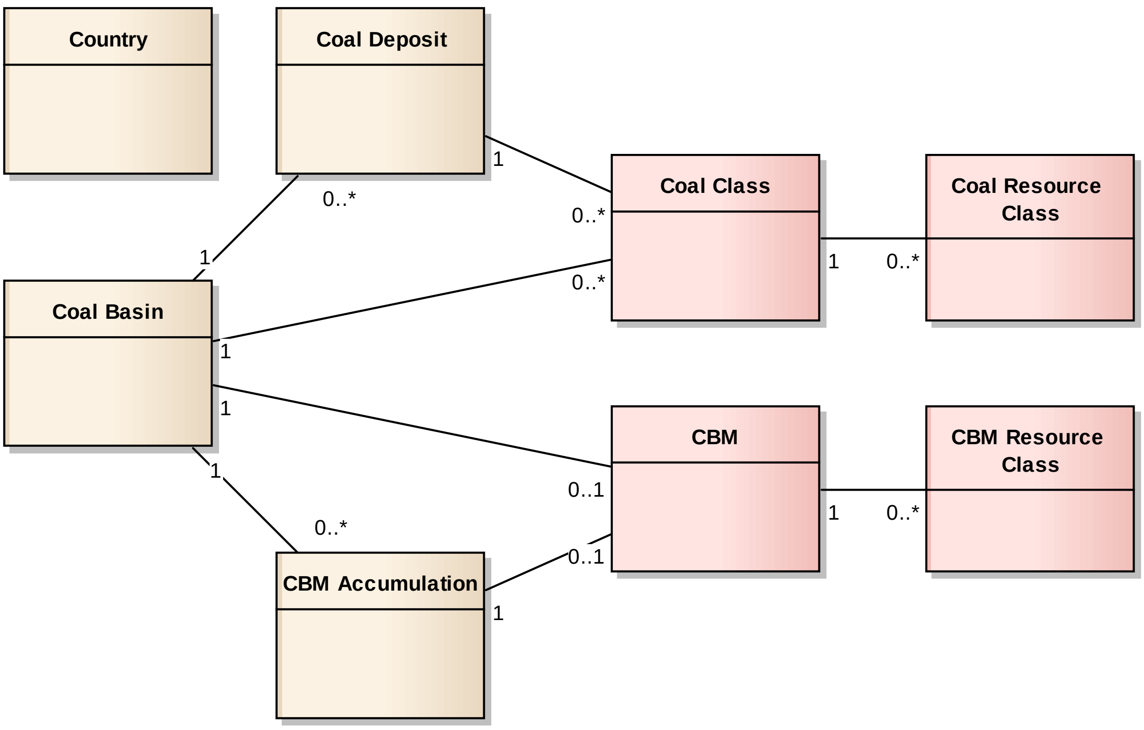


Figure 28 – UML class diagram: Summary of the core European Coal Resources database model

Extensions to the European coal resources database model

The core features describe the principal classes in the database. However more data can be available and useful, such as data on exploitation (mining and concessions), coal class details, boreholes and coal seams. This data can be included in the database through the extensions.

1. Exploitation

Two extra objects are linked to Coal Deposit and CBM Accumulation. In the theme on coal the objects are **Coal Activity** and **Coal Mine**. In the theme on CBM the objects are **CBM Activity** and **CBM Concession**.

A **Coal Mine** is an excavation for the extraction of coal. The Coal Mine and Coal Deposit are linked through **Coal Activity**, which indicates whether the deposit is subject to exploitation, and if so to which type.

This is analogue for the CBM theme. A **CBM Concession** is a terrain that falls under the contractual rights to explore and/or exploit CBM resources. A CBM Concession and CBM Accumulation are linked through **CBM activity**, which indicates whether the accumulation is subject to exploitation, and if so to which type.

It is also possible to link a **Coal Class** to a coal mine and analogue to this, it is possible to link **CBM** data to a CBM concession.

Figure 29 gives an overview of the extra objects on exploitation with all attributes. A more detailed description can be found in the feature catalogue (3.4.3.2).

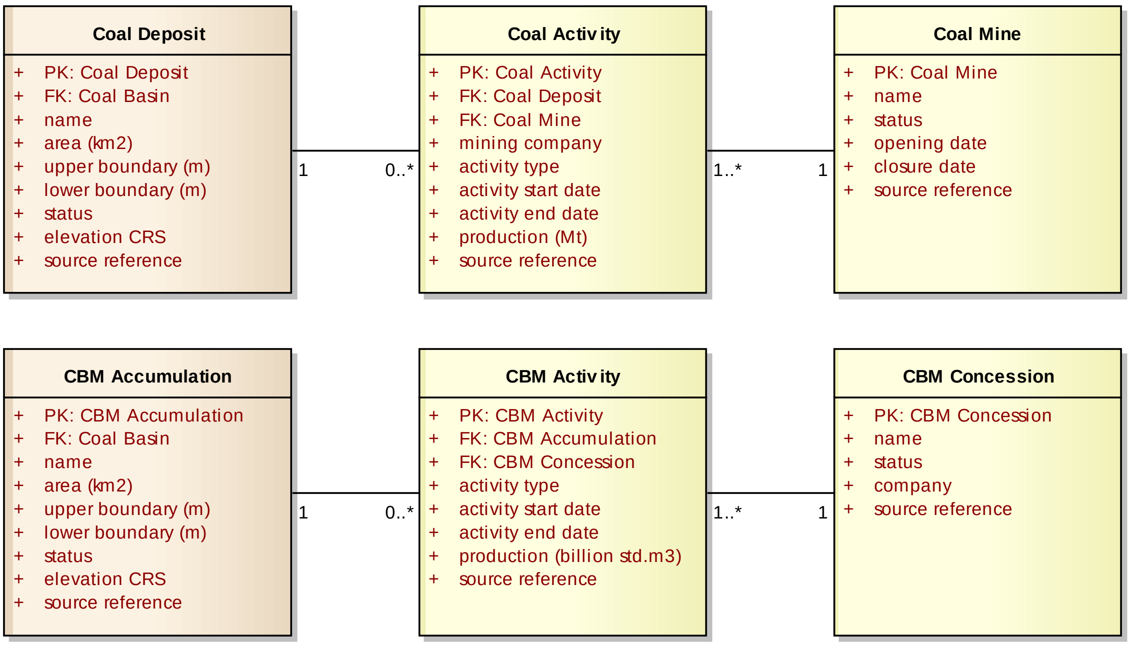


Figure 29 – UML class diagram: European Coal Resources database model – extension on exploitation

2. Classification details

An object is added to the model that gives more details on **Coal Class**. It is a list of parameters that form the basis of the classification (like vitrinite reflectance, bed moisture, ash yield, *etc.*)

Figure 30 gives an overview of the extra object on classification details with all attributes. A more detailed description can be found in the feature catalogue (3.4.3.2).

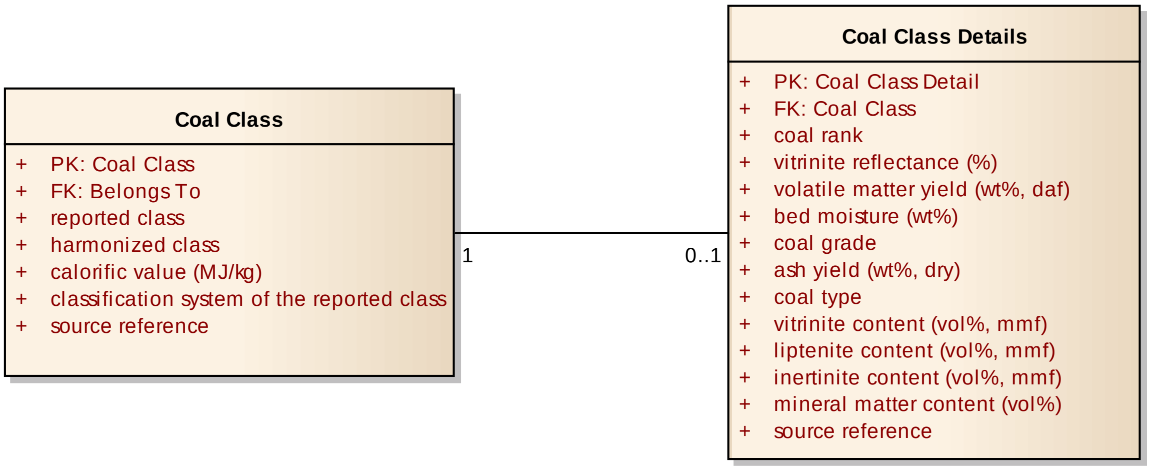


Figure 30 – UML class diagram: European Coal Resources database model – extension on classification details

3. Coal seam

The model also includes the object **Coal Seam**. This object describes the dimensions of individual coal strata in a **Coal Deposit**. With this extension, it is also possible to link **Coal Class** to a coal seam.

Figure 31 gives an overview of the extra object on coal seams with all attributes. A more detailed description can be found in the feature catalogue (3.4.3.2).

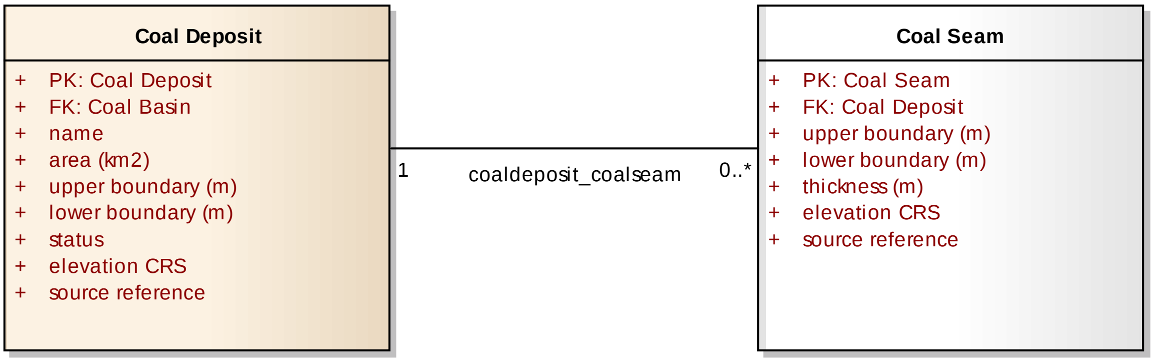


Figure 31 – UML class diagram: European Coal Resources database model – extension on coal seams

4. Boreholes

A borehole is the generalized term for any narrow shaft drilled in the ground, either vertically or horizontally[9]. It has a location, an elevation, a length and a purpose.

Two more objects are described: **Borehole** and **Lithological Layer**. **Borehole** describes metadata on the drilling itself, and includes information on method, purpose and dimensions. Results from drill core analysis are stored in **Lithological Layer**, which stores information on the lithology of the borehole. Each (relevant) layer is described, together with average depth and thickness.

Figure 32 gives an overview of the extra objects Borehole and Lithological Layer with all attributes. A more detailed description can be found in the feature catalogue (3.4.3.2).

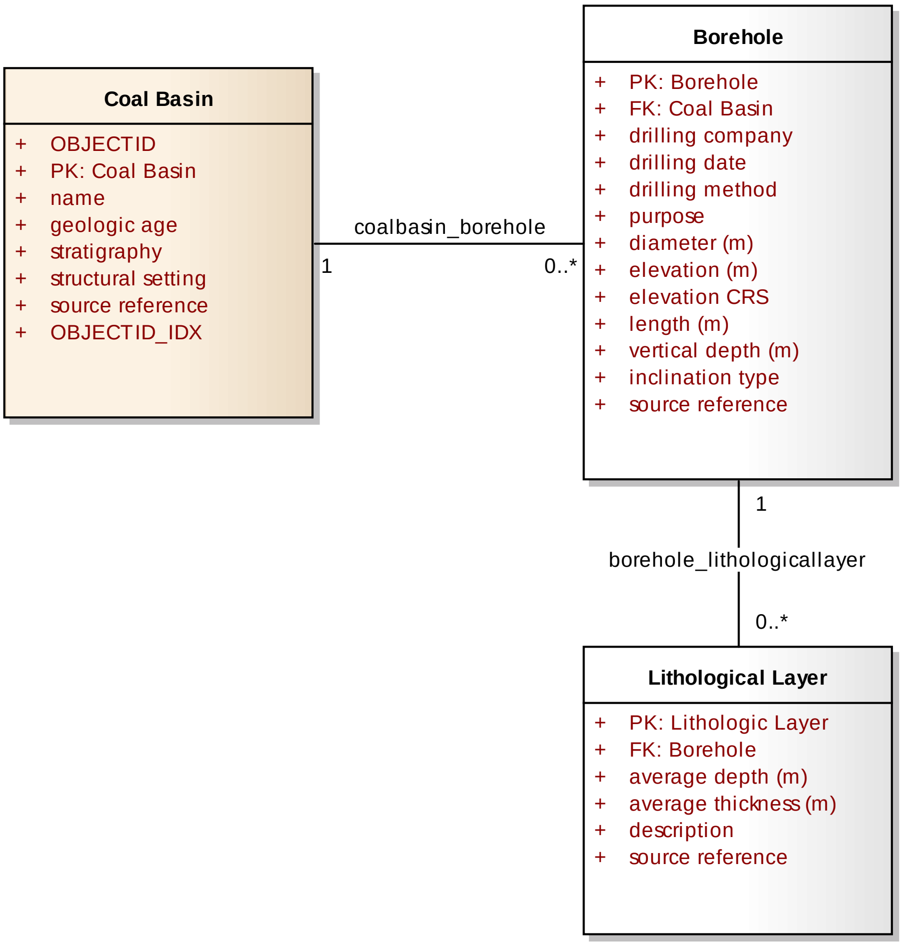


Figure 32 – UML class diagram: European Coal Resources database model – extension on boreholes

[9] D2.8.II.4_v2.9.0 INSPIRE Data Specification on Geology – Draft Guidelines, INSPIRE Thematic Working Group Geology (2012-02-24).

3.4.3.2 Feature catalogue

A feature catalogue is a collection of details and definitions on all the objects, features and code lists, their attributes and their associations with other features. Objects, features and code lists are ordered alphabetically.

Activity Type Value

Database name: ActivityTypeValue
Definition: Code list for activity type: type of activity taking place
Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
activity type *activityType*	esriFieldTypeString	Primary key: uniquely identifies an **activity type**
description *description*	esriFieldTypeString	More elaborate description of the activity type value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
cbmactivity_activitytypevalue	*Multi.:* 0..* *Role:* toCBMActivity *Table:* CBMActivity	Extension -- **ActivityTypeValue** is the code list for the attribute activity type, found in **CoalActivity**
coalactivity_activitytypevalue	*Multi.:* 0..* *Role:* toCoalActivity *Table:* CoalActivity	Extension -- **ActivityTypeValue** is the code list for the attribute activity type, found in **CoalActivity**

Borehole

Database name: Borehole
Definition: Extension -- Descriptive table on boreholes, drilled to explore the coal basin. Includes information on method, purpose and dimensions. Results are stored as **lithological layers**. Geometry information (point) can be found in the feature class **BoreholePoint**.
Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Borehole *PK_Borehole*	esriFieldTypeString	Primary key: uniquely identifies a **borehole**
FK: Coal Basin *FK_CoalBasin*	esriFieldTypeString	Foreign key: references a **coal basin**
drilling company *drillingCompany*	esriFieldTypeString	Company responsible for drilling the borehole
drilling date *drillingDate*	esriFieldTypeString	Date on which the drilling was carried out
drilling method *drillingMethod*	esriFieldTypeString	Method used for drilling
purpose *purpose*	esriFieldTypeString	Purpose for which the borehole was drilled, *e.g.* site investigation, mineral exploration, water resource exploration, *etc.*
diameter (m) *diameter*	esriFieldTypeDouble	Diameter of the borehole shaft, in meter
elevation (m) *elevation*	esriFieldTypeDouble	Elevation of the well head (compromise approach for software that cannot process 3-D GM_point), in meter above sea level (*cfr.* elevation CRS)
elevation CRS *elevationCRS*	esriFieldTypeString	Vertical coordinate reference system (CRS) in

Name: Alias *DB Name*	Data Type	Definition
		which the elevation is measured: values are found in the code list **ElevationCRSValue**.
length (m) *length*	esriFieldTypeDouble	Length of the borehole shaft (not equal to vertical depth, in case the borehole shaft is inclined), in meter
vertical depth (m) *verticalDepth*	esriFieldTypeDouble	Vertical depth of the borehole, in meter below surface level
inclination type *inclinationType*	esriFieldTypeString	Inclination of the borehole shaft, *e.g.* vertical, inclined up, inclined down, horizontal.
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
borehole_boreholepoint	*Multi.:* 0..1 *Role:* hasBoreholePoint *Table:* BoreholePoint	Extension -- Relation between the descriptive part and the geographical representation (as point) of **borehole**
borehole_elevationcrsvalue	*Multi.:* 1 *Role:* hasElevationCRS *Table:* ElevationCRSValue	Extension -- **ElevationCRSValue** is the code list for the attribute elevation CRS, found in **Borehole**
borehole_lithologicallayer	*Multi.:* 0..* *Role:* hasLithologicalLayer *Table:* LithologicalLayer	Extension -- The lithology of a **borehole** core is described per (relevant) **layer**.
coalbasin_borehole	*Multi.:* 1 *Role:* toCoalBasin *Table:* CoalBasin	Extension -- A **coal basin** can be explored by the drilling of **boreholes**

Borehole – Point Feature

Database name: BoreholePoint
Definition: Extension -- Collection of point features that are the geographical representation of a **borehole**. Descriptive information is available in the object class **Borehole**.
Stereotype: «Point»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
FK: Borehole *FK_Borehole*	esriFieldTypeString	Foreign key: references a **borehole** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
borehole_boreholepoint	*Multi.:* 1 *Role:* toBorehole *Table:* Borehole	Extension -- Relation between the descriptive part and the geographical representation (as point) of **borehole**

CBM

Database name: CBM

Definition: Descriptive table on characteristics of the coalbed methane (CBM) reservoirs that are found in a **coal basin** or **CBM accumulation** (Extension: or in a **CBM concession**). The calorific value is also included here.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: CBM *PK_CBM*	esriFieldTypeString	Primary key: uniquely identifies **CBM** characteristics
FK: Belongs To *FK_BelongsTo*	esriFieldTypeString	Foreign key: references a **CBM accumulation** or a **coal basin** (Extension: or a **CBM concession**)
maximum gas content (std.m3/t) *maxGasContent*	esriFieldTypeDouble	Maximum as content, in standard cubic meter per ton of coal
gas composition: CH4 (vol%) *gasComposition_CH4*	esriFieldTypeDouble	Volume percent of CH4
gas composition: C2+ (vol%) *gasComposition_C2*	esriFieldTypeDouble	Volume percent of C2+, *i.e.* higher hydrocarbon gasses (*e.g.* ethane, propane)
gas composition: N2 (vol%) *gasComposition_N2*	esriFieldTypeDouble	Volume percent of N2
gas composition: CO2 (vol%) *gasComposition_CO2*	esriFieldTypeDouble	Volume percent of CO2
gas composition: other (vol%) *gasComposition_other*	esriFieldTypeDouble	Volume percent all gasses except for CH4, C2+, N2 and CO2
calorific value (MJ/kg) *calorificValue*	esriFieldTypeDouble	Gross calorific value, in mega joule per kilogram
porosity (vol%) *porosity*	esriFieldTypeDouble	Porosity of the reservoir, in volume percent
maximum permeability (mD) *maxPermeability*	esriFieldTypeDouble	Maximum permeability of the reservoir, in millidarcy
critical desorption pressure (MPa) *criticalDesorptionPressure*	esriFieldTypeDouble	Critical pressure required to initiate desorption of gas, in mega Pascal
methane sorption capacity (std.m3/t) *methaneSorptionCapacity*	esriFieldTypeDouble	Methane sorption capacity (Langmuir volume), in standard cubic meter per ton of coal
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
cbm_cbmresclass	*Multi.:* 0..* *Role:* hasCBMResClass *Table:* CBMResClass	Estimated quantitative amount of **CBM** for one or several **CBM resource classes**. The local/reported classes and estimates are indicated, as well as the mapping to UNFC.
cbmaccumulation_cbm	*Multi.:* 1 *Role:* belongsTo *Table:* CBMAccumulation	**CBM** can be found in **CBM accumulations**. This information might be missing at this level, hence the possibility to have a multiplicity of 0.
cbmconcession_cbm	*Multi.:* 1 *Role:* belongsTo *Table:* CBMConcession	Extension -- **CBM** can be found in **CBM concession**. This information might be missing at this level, hence the possibility to have a multiplicity of 0.

Association Name	Association Details	Definition
coalbasin_cbm	*Multi.:* 1 *Role:* belongsTo *Table:* CoalBasin	**CBM** can be found in each **coal basin**. This information might be missing at this level, hence the possibility to have a multiplicity of 0.

CBM Accumulation

Database name: CBMAccumulation

Definition: Descriptive table on phenomena that allow the classification of economic and sub-economic **CBM resources**. Geometry information (polygon or point) can be found in the feature classes **CBMAccumulationPolygon** and **CBMAccumulationPoint**.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: CBM Accumulation *PK_CBMAccumulation*	esriFieldTypeString	Primary key: uniquely identifies a **CBM accumulation**
FK: Coal Basin *FK_CoalBasin*	esriFieldTypeString	Foreign key: references a **coal basin**
name *name*	esriFieldTypeString	Name of the CBM accumulation
area (km2) *area*	esriFieldTypeDouble	Area of the CBM accumulation, not necessarily identical to the area as calculated by the geometry features, in square kilometre
upper boundary (m) *upperBoundary*	esriFieldTypeDouble	Average depth of the upper boundary of the CBM accumulation, in meter below sea level (*cfr.* elevation CRS - in case 'from surface level', in meter below surface level)
lower boundary (m) *lowerBoundary*	esriFieldTypeDouble	Average depth of the lower boundary of the CBM accumulation, in meter below sea level (*cfr.* elevation CRS - in case 'from surface level', in meter below surface level)
status *status*	esriFieldTypeString	Status of the coal deposit: values are found in the code list **StatusValue**
elevation CRS *elevationCRS*	esriFieldTypeString	Vertical coordinate reference system (CRS) in which the elevation is measured: values are found in the code list **ElevationCRSValue**.
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
cbmaccumulation_cbm	*Multi.:* 0..1 *Role:* hasCBM *Table:* CBM	**CBM** can be found in **CBM accumulations**. This information might be missing at this level, hence the possibility to have a multiplicity of 0.
cbmaccumulation_cbmaccumulationpoint	*Multi.:* 0..1 *Role:* hasCBMAccumulationPoint *Table:* CBMAccumulationPoint	Relation between the descriptive part and the geographical representation (as point) of **CBM accumulation**
cbmaccumulation_cbmaccumulationpoly	*Multi.:* 0..1 *Role:* hasCBMAccumulationPoly *Table:* CBMAccumulationPolygon	Relation between the descriptive part and the geographical representation (as polygon) of **CBM accumulation**

Association Name	Association Details	Definition
cbmaccumulation_cbmactivity	*Multi.:* 0..* *Role:* hasCBMActivity *Table:* CBMActivity	Extension -- A **CBM accumulation** can be subject to several forms of **activities**: going from exploration over exploitation to abandonment.
cbmaccumulation_elevationcrsvalue	*Multi.:* 1 *Role:* hasElevationCRSValue *Table:* ElevationCRSValue	**ElevationCRSValue** is the code list for the attribute elevation CRS, found in **CBMAccumulation**
cbmaccumulation_statusvalue	*Multi.:* 1 *Role:* hasStatus *Table:* StatusValue	**StatusValue** is the code list for the attribute status, found in **CBM Accumulation**
coalbasin_cbmaccumulation	*Multi.:* 1 *Role:* toCoalBasin *Table:* CoalBasin	A **coal basin** identifies the larger, geologic region in which smaller economic entities - such as **CBM accumulations** - are located.

CBM Accumulation – Polygon Feature

Database name: CBMAccumulationPolygon

Definition: Collection of polygon features that are the geographical representation of a **CBM accumulation**. This feature is meant to point to locations of CBM accumulations of which a polygon delineation is available. If a delineation of the CBM accumulation is not available it will be stored in the feature class **CBMAccumulationPoint**. Descriptive information is available in the object class **CBMAccumulation**.

Stereotype: «Polygon»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
Shape_Length *Shape_Length*	esriFieldTypeDouble	ArcGIS system field
Shape_Area *Shape_Area*	esriFieldTypeDouble	ArcGIS system field
FK: CBM Accumulation *FK_CBMAccumulation*	esriFieldTypeString	Foreign key: references a **CBM accumulation** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
cbmaccumulation_cbmaccumulationpoly	*Multi.:* 1 *Role:* toCBMAccumulation *Table:* CBMAccumulation	Relation between the descriptive part and the geographical representation (as polygon) of **CBM accumulation**

CBM Accumulation – Point Feature

Database name: CBMAccumulationPoint

Definition: Collection of point features that are the geographical representation of a **CBM accumulation**. This feature is meant to point to locations of CBM accumulations of which a polygon delineation is not available. If a delineation of the CBM accumulation is available it will be stored in the feature class **CBMAccumulationPolygon**. Descriptive information is available in the object class **CBMAccumulation**.

Stereotype: «Point»

Attributes

Name: Alias *DB Name*	**Data Type**	**Definition**
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
FK: CBM Accumulation *FK_CBMAccumulation*	esriFieldTypeString	Foreign key: references a **CBM accumulation** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	**Association Details**	**Definition**
cbmaccumulation_cbm accumulationpoint	*Multi.:* 1 *Role:* toCBMAccumulation *Table:* CBMAccumulation	Relation between the descriptive part and the geographical representation (as point) of **CBM accumulation**

CBM Activity

Database name: CBMActivity

Definition: Extension -- Descriptive table that indicates whether a **CBM accumulation** is subject to exploitation, and if so to which type (activity type). Production numbers can also be stored here. Mining activity forms the link between a CBM accumulation and **CBM concession**.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	**Data Type**	**Definition**
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: CBM Activity *PK_CBMActivity*	esriFieldTypeString	Primary key: uniquely identifies a **CBM activity**
FK: CBM Accumulation *FK_CBMAccumulation*	esriFieldTypeString	Foreign key: references a **CBM accumulation**
FK: CBM Concession *FK_CBMConcession*	esriFieldTypeString	Foreign key: references a **CBM concession**
activity type *activityType*	esriFieldTypeString	Type of the activity taking place: values are found in the code list **ActivityTypeValue**
activity start date *activityStartDate*	esriFieldTypeString	Start date of the specified activity
activity end date *activityEndDate*	esriFieldTypeString	End date of the specified activity
production (billion std.m3) *production*	esriFieldTypeDouble	Production numbers related to the given activity and timeframe, in billion standard cubic meter
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	**Association Details**	**Definition**
cbmaccumulation_cbmactivity	*Multi.:* 1 *Role:* toCBMAccumulation *Table:* CBMAccumulation	Extension -- A **CBM accumulation** can be subject to several forms of **activities**: going from exploration over exploitation to abandonment.
cbmactivity_activitytypevalue	*Multi.:* 1 *Role:* hasActivityType *Table:* ActivityTypeValue	Extension -- **ActivityTypeValue** is the code list for the attribute activity type, found in **CoalActivity**

Association Name	Association Details	Definition
cbmconcession_cbmactivity	*Multi.:* 1 *Role:* toCBMConcession *Table:* CBMConcession	Extension -- A **CBM concession** can be subject to several forms of **activities**: going from exploration over exploitation to abandonment.

CBM Concession

Database name: CBMConcession

Definition: Extension -- Descriptive table on the terrain that falls under the contractual right to explore and/or exploit **CBM resources**. A **CBM accumulation** and concession are linked through **CBM activity**. Geometry information (polygon or point) can be found in the feature classes **CBMConcessionPolygon** and **CBMConcessionPoint**.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: CBM Concession *PK_CBMConcession*	esriFieldTypeString	Primary key: uniquely identifies a **CBM concession**
name *name*	esriFieldTypeString	Name of the CBM concession
status *status*	esriFieldTypeString	Status of the CBM concession: values are found in the code list **StatusValue**
company *company*	esriFieldTypeString	Owner of the CBM concession
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
cbmconcession_cbm	*Multi.:* 0..1 *Role:* hasCBM *Table:* CBM	Extension -- **CBM** can be found in **CBM concession**. This information might be missing at this level, hence the possibility to have a multiplicity of 0.
cbmconcession_cbmactivity	*Multi.:* 1..* *Role:* hasCBMActivity *Table:* CBMActivity	Extension -- A **CBM concession** can be subject to several forms of **activities**: going from exploration over exploitation to abandonment.
cbmconcession_cbmconcessionpoint	*Multi.:* 0..1 *Role:* hasCBMConsessionPoint *Table:* CBMConcessionPoint	Extension -- Relation between the descriptive part and the geographical representation (as point) of **CBM concession**
cbmconcession_cbmconcessionpoly	*Multi.:* 0..1 *Role:* hasCBMConcessionPoly *Table:* CBMConcessionPolygon	Extension -- Relation between the descriptive part and the geographical representation (as polygon) of **CBM concession**
cbmconcession_statusvalue	*Multi.:* 1 *Role:* hasStatus *Table:* StatusValue	Extension -- **StatusValue** is the code list for the attribute status, found in **CBM Concession**

CBM Concession – Polygon Feature

Database name: CBMConcessionPolygon

Definition: Extension -- Collection of polygon features that are the geographical representation of a **CBM concession**. This feature is meant to point to locations of CBM concessions of which a polygon delineation is available. If a delineation of the CBM concession is not available it will be stored in the feature class **CBMConcessionPoint**. Descriptive information is available in the object class **CBMConcession**.

Stereotype: «Polygon»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
Shape_Length *Shape_Length*	esriFieldTypeDouble	ArcGIS system field
Shape_Area *Shape_Area*	esriFieldTypeDouble	ArcGIS system field
FK: CBM Concession *FK_CBMConcession*	esriFieldTypeString	Foreign key: references a **CBM concession** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
cbmconcession_cbmconcessionpoly	*Multi.:* 1 *Role:* toCBMConcession *Table:* CBMConcession	Extension -- Relation between the descriptive part and the geographical representation (as polygon) of **CBM concession**

CBM Concession – Point Feature

Database name: CBMConcessionPoint

Definition: Extension -- Collection of point features that are the geographical representation of a **CBM concession**. This feature is meant to point to locations of CBM concessions of which a polygon delineation is not available. If a delineation of the CBM concession is available it will be stored in the feature class **CBMConcessionPolygon**. Descriptive information is available in the object class **CBMConcession**.

Stereotype: «Point»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
FK: CBM Concession *FK_CBMConcession*	esriFieldTypeString	Foreign key: references a **CBM concession** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
cbmconcession_cbmconcessionpoint	*Multi.:* 1 *Role:* toCBMConcession *Table:* CBMConcession	Extension -- Relation between the descriptive part and the geographical representation (as point) of **CBM concession**

CBM Resource Class

Database name: CBMResClass

Definition: Descriptive table on estimates of the CBM resources (gas in place). The reported resource class as well as the mapping to UNFC is included.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: CBM Resource Class *PK_CBMResourceClass*	esriFieldTypeString	Primary key: uniquely identifies a **CBM resource class**
FK: CBM *FK_CBM*	esriFieldTypeString	Foreign key: references **CBM** characteristics
reported resource class *reportedResourceClass*	esriFieldTypeString	CBM resource class as it is reported in the source data. The classification system used is explained in **ReportedClassSystem**.
UNFC code(s) *UNFCCode*	esriFieldTypeString	Mapping of the reported resource class to the UNFC classification system
gas in place (billion std.m3) *gasInPlace*	esriFieldTypeDouble	Estimated amount of gas in place, in billion standard cubic meter
gas in place estimation date *gasInPlaceEstimationDate*	esriFieldTypeString	Date of the estimation of the gas in place
classification system of the reported class *reportedClassSystem*	esriFieldTypeString	Specifications of the classification system of the reported class (references a key in the **EndNote** database)
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
cbm_cbmresclass	*Multi.:* 1 *Role:* toCBM *Table:* CBM	Estimated quantitative amount of **CBM** for one or several **CBM resource classes**. The local/reported classes and estimates are indicated, as well as the mapping to UNFC.

Coal Activity

Database name: CoalActivity

Definition: Extension -- Descriptive table that indicates whether a **coal deposit** is subject to exploitation, and if so to which type (activity type). Production numbers can also be stored here. Mining activity forms the link between a coal deposit and a **coal mine**.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Coal Activity *PK_CoalActivity*	esriFieldTypeString	Primary key: uniquely identifies a **coal activity**
FK: Coal Deposit *FK_CoalDeposit*	esriFieldTypeString	Foreign key: references a **coal deposit**
FK: Coal Mine *FK_CoalMine*	esriFieldTypeString	Foreign key: references a **coal mine**
mining company *miningCompany*	esriFieldTypeString	Company exploiting the coal mine
activity type *activityType*	esriFieldTypeString	Type of activity taking place: values are found in the code list **ActivityTypeValue**.
activity start date *activityStartDate*	esriFieldTypeString	Start date of the specified activity
activity end date *activityEndDate*	esriFieldTypeString	End date of the specified activity

Name: Alias *DB Name*	Data Type	Definition
production (Mt) *production*	esriFieldTypeDouble	Production numbers related to the given activity and timeframe, in megaton
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalactivity_activitytype value	*Multi.:* 1 *Role:* hasActivityType *Table:* ActivityTypeValue	Extension -- **ActivityTypeValue** is the code list for the attribute activity type, found in **CoalActivity**
coaldeposit_coalactivity	*Multi.:* 1 *Role:* toCoalDeposit *Table:* CoalDeposit	Extension -- A **coal deposit** can be subject to several forms of **activities**: going from exploration over exploitation to abandonment.
coalmine_coalactivity	*Multi.:* 1 *Role:* toCoalMine *Table:* CoalMine	Extension -- A **coal mine** can be subject to several forms of **activities**: going from exploration over exploitation to abandonment.

Coal Basin

Database name: CoalBasin

Definition: Descriptive table on geologic regions in which a **coal deposit** or **CBM accumulation** is situated. When no information is available on this level: create a generic (empty) object. Geometry information (polygon or point) can be found in the feature classes **CoalBasinPolygon** and **CoalBasinPoint**.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Coal Basin *PK_CoalBasin*	esriFieldTypeString	Primary key: uniquely identifies a **coal basin**
name *name*	esriFieldTypeString	Name of the coal basin
geologic age *geologicAge*	esriFieldTypeString	Relates the coal bearing sediments of the coal deposit to time: values are found in the code list **GeologicAgeValue**
stratigraphy *stratigraphy*	esriFieldTypeString	Specifies the distribution, deposition, and geologic age of sedimentary rocks
structural setting *structuralSetting*	esriFieldTypeString	Description of the sedimentary environment and the structural geologic setting
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalbasin_borehole	*Multi.:* 0..* *Role:* hasBorehole *Table:* Borehole	Extension -- A **coal basin** can be explored by the drilling of **boreholes**
coalbasin_cbm	*Multi.:* 0..1 *Role:* hasCBM *Table:* CBM	**CBM** can be found in each **coal basin**. This information might be missing at this level, hence the possibility to have a multiplicity of 0.
coalbasin_cbmaccu mulation	*Multi.:* 0..* *Role:* hasCBMAccumulation *Table:* CBMAccumulation	A **coal basin** identifies the larger, geologic region in which smaller economic entities - such as **CBM accumulations** - are located.

Association Name	Association Details	Definition
coalbasin_coalbasin point	*Multi.:* 0..1 *Role:* hasCoalBasinPoint *Table:* CoalBasinPoint	Relation between the descriptive part and the geographical representation (as point) of **coal basin**
coalbasin_coalbasin poly	*Multi.:* 0..1 *Role:* hasCoalBasinPoly *Table:* CoalBasinPolygon	Relation between the descriptive part and the geographical representation (as polygon) of **coal basin**
coalbasin_coalclass	*Multi.:* 0..* *Role:* hasCoalClass *Table:* CoalClass	Each **coal basin** consists of at least one **coal class**, which is described both in a local/ reported and in a harmonized classification system. This information might be missing at this level, hence the possibility to have a multiplicity of 0 coal classes.
coalbasin_coaldepo sit	*Multi.:* 0..* *Role:* hasCoalDeposit *Table:* CoalDeposit	A **coal basin** identifies the larger, geologic region in which smaller economic entities - such as **coal deposits** - are located.
coalbasin_geologic agevalue	*Multi.:* 1 *Role:* hasGeologicAge *Table:* GeologicAgeValue	**GeologicAgeValue** is the code list for the attribute geologic age, found in **CoalBasin**

Coal Basin – Polygon Feature

Database name: CoalBasinPolygon

Definition: Collection of polygon features that are the geographical representation of a **coal basin**. This feature is meant to point to locations of coal basins of which a polygon delineation is available. If a delineation of the coal basin is not available it will be stored in the feature class **CoalBasinPoint**. Descriptive information is available in the object class **CoalBasin**.

Stereotype: «Polygon»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
Shape_Length *Shape_Length*	esriFieldTypeDouble	ArcGIS system field
Shape_Area *Shape_Area*	esriFieldTypeDouble	ArcGIS system field
FK: Coal Basin *FK_CoalBasin*	esriFieldTypeString	Foreign key: references a **coal basin** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalbasin_coalbasinpoly	*Multi.:* 1 *Role:* toCoalBasin *Table:* CoalBasin	Relation between the descriptive part and the geographical representation (as polygon) of **coal basin**

Coal Basin – Point Feature

Database name: CoalBasinPoint

Definition: Collection of point features that store the geographical representation of a **coal basin**. This feature is meant to point to locations of coal basins of which a polygon delineation is not available. If a delineation of the coal basin is available it will be stored in the feature class **CoalBasinPolygon**. Descriptive information is

	available in the object class **CoalBasin**.
Stereotype:	«Point»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
FK: Coal Basin *FK_CoalBasin*	esriFieldTypeString	Foreign key: references a **coal basin** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalbasin_coalbasinpoint	*Multi.:* 1 *Role:* toCoalBasin *Table:* CoalBasin	Relation between the descriptive part and the geographical representation (as point) of **coal basin**

Coal Class

Database name:	CoalClass
Definition:	Descriptive table on the coal classes that are found in a **coal basin** or **coal deposit** (Extension: or in a **coal seam** or **coal mine**). Both reported and harmonized coal class are included. The calorific value is also included here.
Stereotype:	«ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Coal Class *PK_CoalClass*	esriFieldTypeString	Primary key: uniquely identifies a **coal class**
FK: Belongs To *FK_BelongsTo*	esriFieldTypeString	Foreign key: references a **coal deposit** or a **coal basin** (Extension: or a **coal seam** or a **coal mine**)
reported class *reportedClass*	esriFieldTypeString	Coal class as it is reported in the source data. The classification system used is explained in **reportedClassSystem**.
harmonized class *harmonizedClass*	esriFieldTypeString	Coal class as it is defined by the harmonized classification system in the EuCoRes project: values are found in the code list **HarmonizedClassValue**.
calorific value (MJ/kg) *calorificValue*	esriFieldTypeDouble	Gross calorific value (moist, ash-free basis), in megajoule per kilogram
classification system of the reported class *reportedClassSystem*	esriFieldTypeString	Specifications of the classification system of the reported class (references a key in the **EndNote** database)
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalbasin_coalclass	*Multi.:* 1 *Role:* belongsTo *Table:* CoalBasin	Each **coal basin** consists of at least one **coal class**, which is described both in a local/reported and in a harmonized classification system. This information might

Association Name	Association Details	Definition
		be missing at this level, hence the possibility to have a multiplicity of 0 coal classes.
coalclass_coalclassdetail	*Multi.:* 0..1 *Role:* hasCoalClassDetail *Table:* CoalClassDetail	Extension -- A **coal class** can be expanded with **details** on physical, chemical or other properties.
coalclass_coalresclass	*Multi.:* 0..* *Role:* hasCoalResClass *Table:* CoalResClass	Estimated quantitative amount of a **coal class** for one or several **coal resource classes**. The local/reported classes and estimates are indicated, as well as the mapping to UNFC.
coalclass_harmonizedclassvalue	*Multi.:* 1 *Role:* hasHarmonizedClass *Table:* HarmonizedClassValue	**HarmonizedClassValue** is the code list for the attribute harmonized class, found in **CoalClass**
coaldeposit_coalclass	*Multi.:* 1 *Role:* belongsTo *Table:* CoalDeposit	Each **coal deposit** consists of at least one **coal class**, which is described both in a local/reported and in a harmonized classification system. This information might be missing at this level, hence the possibility to have a multiplicity of 0 coal classes.
coalmine_coalclass	*Multi.:* 1 *Role:* belongsTo *Table:* CoalMine	Extension -- Each **coal mine area** covers at least one **coal class**, which is described both in a local/reported and in a harmonized classification system. This information might be missing at this level, hence the possibility to have a multiplicity of 0 coal classes.
coalseam_coalclass	*Multi.:* 1 *Role:* belongsTo *Table:* CoalSeam	Extension -- Each **coal seam** consists of at least one **coal class**, which is described both in a local/reported and in a harmonized classification system. This information might be missing at this level, hence the possibility to have a multiplicity of 0 coal classes.

Coal Class Details

Database name: CoalClassDetail

Definition: Extension -- Descriptive table that gives more details on **coal class**. These parameters form the basis of the classification.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Coal Class Detail *PK_CoalClassDetail*	esriFieldTypeString	Primary key: uniquely identifies **coal class details**
FK: Coal Class *FK_CoalClass*	esriFieldTypeString	Foreign key: references a **coal class**
coal rank *coalRank*	esriFieldTypeString	Degree of coalification, according to ISO11760 and based on vitrinite reflectance (or alternatively on volatile matter yield, moisture content, gross calorific value): values are found in the code list **CoalRankValue**.
vitrinite reflectance (%) *vitriniteReflectance*	esriFieldTypeDouble	Mean random vitrinite reflectance, in percent
volatile matter yield (wt%, daf) *volatileMatterYield*	esriFieldTypeDouble	Mean amount of volatile matter, in weight percent of dry and ash-free coal
bed moisture (wt%)	esriFieldTypeDouble	Average moisture content of the in-situ coal,

Name: Alias *DB Name*	Data Type	Definition
bedMoisture		in weight percent
coal grade *coalGrade*	esriFieldTypeString	Grade of coal, according to ISO11760 and based on the amount of impurities (ash yield): values are found in the code list **CoalGradeValue**.
ash yield (wt%, dry) *ashYield*	esriFieldTypeDouble	Average non-combustible residue of coal, in dry weight percent
coal type *coalType*	esriFieldTypeString	Coal type, according to ISO11760 and based on petrographic composition (maceral groups) of the organic matter: vitrinite content, liptinite content and inertinite content: values are found in the code list **CoalTypeValue**.
vitrinite content (vol%, mmf) *vitriniteContent*	esriFieldTypeDouble	Average vitrinite content, in volume percent on a mineral matter free basis
liptenite content (vol%, mmf) *lipteniteContent*	esriFieldTypeDouble	Average liptinite content, in volume percent on a mineral matter free basis
inertinite content (vol%, mmf) *inertiniteContent*	esriFieldTypeDouble	Average inertinite content, in volume percent on a mineral matter free basis
mineral matter content (vol%) *mineralMatterContent*	esriFieldTypeDouble	Average mineral matter content, in volume percent
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalclass_coalclassdetail	*Multi.:* 1 *Role:* toCoalClass *Table:* CoalClass	Extension -- A **coal class** can be expanded with **details** on physical, chemical or other properties.
coalclassdetail_coalgradevalue	*Multi.:* 1 *Role:* hasCoalGrade *Table:* CoalGradeValue	Extension -- **CoalGradeValue** is the code list for the attribute coal grade, found in **CoalClassDetail**
coalclassdetail_coalrankvalue	*Multi.:* 1 *Role:* hasCoalRank *Table:* CoalRankValue	Extension -- **CoalRankValue** is the code list for the attribute coal rank, found in **CoalClassDetail**
coalclassdetail_coaltypevalue	*Multi.:* 1 *Role:* hasCoalType *Table:* CoalTypeValue	Extension -- **CoalTypeValue** is the code list for the attribute coal type, found in **CoalClassDetail**

Coal Deposit

Database name: CoalDeposit

Definition: Descriptive table on phenomena that allow the classification of economic and sub-economic **coal resources**. Geometry information (polygon or point) can be found in the feature classes **CoalDepositPolygon** and **CoalDepositPoint**.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Coal Deposit *PK_CoalDeposit*	esriFieldTypeString	Primary key: uniquely identifies a **coal deposit**
FK: Coal Basin *FK_CoalBasin*	esriFieldTypeString	Foreign key: references a **coal basin**

Name: Alias *DB Name*	Data Type	Definition
name *name*	esriFieldTypeString	Name of the coal deposit
area (km2) *area*	esriFieldTypeDouble	Area of the coal deposit, not necessarily identical to the area as calculated by the geometry features, in square kilometre
upper boundary (m) *upperBoundary*	esriFieldTypeDouble	Average depth of the upper boundary of the coal deposit, in meter below sea level (*cfr.* elevation CRS - in case 'from surface level', in meter below surface level)
lower boundary (m) *lowerBoundary*	esriFieldTypeDouble	Average depth of the lower boundary of the coal deposit, in meter below sea level (*cfr.* elevation CRS - in case 'from surface level', in meter below surface level)
status *status*	esriFieldTypeString	Status of the coal deposit: values are found in the code list **StatusValue**
elevation CRS *elevationCRS*	esriFieldTypeString	Vertical coordinate reference system (CRS) in which the elevation is measured: values are found in the code list **ElevationCRSValue**.
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalbasin_coaldeposit	*Multi.:* 1 *Role:* toCoalBasin *Table:* CoalBasin	A **coal basin** identifies the larger, geologic region in which smaller economic entities - such as **coal deposits** - are located.
coaldeposit_coalactivit y	*Multi.:* 0..* *Role:* hasCoalActivity *Table:* CoalActivity	Extension -- A **coal deposit** can be subject to several forms of **activities**: going from exploration over exploitation to abandonment.
coaldeposit_coalclass	*Multi.:* 0..* *Role:* hasCoalClass *Table:* CoalClass	Each **coal deposit** consists of at least one **coal class**, which is described both in a local/reported and in a harmonized classification system. This information might be missing at this level, hence the possibility to have a multiplicity of 0 coal classes.
coaldeposit_coaldeposi tpoint	*Multi.:* 0..1 *Role:* hasCoalDepositPoint *Table:* CoalDepositPoint	Relation between the descriptive part and the geographical representation (as point) of **coal deposit**
coaldeposit_coaldeposi tpoly	*Multi.:* 0..1 *Role:* hasCoalDepositPoly *Table:* CoalDepositPolygon	Relation between the descriptive part and the geographical representation (as polygon) of **coal deposit**
coaldeposit_coalseam	*Multi.:* 0..* *Role:* hasCoalSeam *Table:* CoalSeam	Extension -- A **coal deposit** can consist of several **coal seams**
coaldeposit_elevationc rsvalue	*Multi.:* 1 *Role:* hasElevationCRSValue *Table:* ElevationCRSValue	**ElevationCRSValue** is the code list for the attribute elevation CRS, found in **CoalDeposit**
coaldeposit_statusvalu e	*Multi.:* 1 *Role:* hasStatus *Table:* StatusValue	**StatusValue** is the code list for the attribute status, found in **CoalDeposit**

Coal Deposit – Polygon Feature

Database name: CoalDepositPolygon

Definition: Collection of polygon features that are the geographical representation of a **coal deposit**. This feature is meant to point to locations of coal deposits of which a polygon delineation is available. If a delineation of the coal deposit is not available it will be stored in the feature class **CoalDepositPoint**. Descriptive information is available in the object class **CoalDeposit**.

Stereotype: «Polygon»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
Shape_Length *Shape_Length*	esriFieldTypeDouble	ArcGIS system field
Shape_Area *Shape_Area*	esriFieldTypeDouble	ArcGIS system field
FK: Coal Deposit *FK_CoalDeposit*	esriFieldTypeString	Foreign key: references a **coal deposit** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coaldeposit_coaldepositpoly	*Multi.:* 1 *Role:* toCoalDeposit *Table:* CoalDeposit	Relation between the descriptive part and the geographical representation (as polygon) of **coal deposit**

Coal Deposit – Point Feature

Database name: CoalDepositPoint

Definition: Collection of point features that are the geographical representation of a **coal deposit**. This feature is meant to point to locations of coal deposits of which a polygon delineation is not available. If a delineation of the coal deposit is available it will be stored in the feature class **CoalDepositPolygon**. Descriptive information is available in the object class **CoalDeposit**.

Stereotype: «Point»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
FK: Coal Deposit *FK_CoalDeposit*	esriFieldTypeString	Foreign key: references a **coal deposit** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coaldeposit_coaldepositpoint	*Multi.:* 1 *Role:* toCoalDeposit *Table:* CoalDeposit	Relation between the descriptive part and the geographical representation (as point) of **coal deposit**

Coal Grade Value

Database name: CoalGradeValue

Definition: Code list for coal grade: grade of coal, according to ISO11760 and based on the amount of impurities (ash yield)

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
coal grade *coalGrade*	esriFieldTypeString	Primary key: uniquely identifies a **coal grade**
description *description*	esriFieldTypeString	More elaborate description of the coal grade value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalclassdetail_coalgradevalue	*Multi.:* 0..* *Role:* toCoalClassDetail *Table:* CoalClassDetail	Extension -- **CoalGradeValue** is the code list for the attribute coal grade, found in **CoalClassDetail**

Coal Mine

Database name: CoalMine

Definition: Extension -- Descriptive table on excavations for the extraction of coal. A **coal deposit** and a mine are linked through a **coal activity**, which describes the actual process of mining. Geometry information (polygon or point) can be found in the feature classes **CoalMinePolygon** and **CoalMinePoint**.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Coal Mine *PK_CoalMine*	esriFieldTypeString	Primary key: uniquely identifies a **coal mine**
name *name*	esriFieldTypeString	Name of the coal mine
status *status*	esriFieldTypeString	Status of the coal mine: values are found in the code list **StatusValue**
opening date *openingDate*	esriFieldTypeString	Opening date of the coal mine
closure date *closureDate*	esriFieldTypeString	Closure date of the coal mine. In case still open, add NULL here.
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalmine_coalactivity	*Multi.:* 1..* *Role:* hasCoalActivity *Table:* CoalActivity	Extension -- A **coal mine** can be subject to several forms of **activities**: going from exploration over exploitation to abandonment.
coalmine_coalclass	*Multi.:* 0..* *Role:* hasCoalClass *Table:* CoalClass	Extension -- Each **coal mine area** covers at least one **coal class**, which is described both in a local/reported and in a harmonized classification system. This information might be missing at this level, hence the possibility to have a multiplicity of 0 coal classes.
coalmine_coalminepoi nt	*Multi.:* 0..1 *Role:* hasCoalMinePoint *Table:* CoalMinePoint	Extension -- Relation between the descriptive part and the geographical representation (as point) of **coal mine**
coalmine_coalminepol y	*Multi.:* 0..1 *Role:* hasCoalMinePoly *Table:* CoalMinePolygon	Extension -- Relation between the descriptive part and the geographical representation (as polygon) of **coal mine**

Association Name	Association Details	Definition
coalmine_statusvalue	*Multi.:* 1 *Role:* hasStatus *Table:* StatusValue	Extension -- **StatusValue** is the code list for the attribute status, found in **CoalMine**

Coal Mine – Polygon Feature

Database name: CoalMinePolygon

Definition: Extension -- Collection of polygon features that are the geographical representation of a **coal mine**. This feature is meant to point to locations of coal mines of which a polygon delineation is available. If a delineation of the coal mine is not available it will be stored in the feature class **CoalMinePoint**. Descriptive information is available in the object class **CoalMine**.

Stereotype: «Polygon»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
Shape_Length *Shape_Length*	esriFieldTypeDouble	ArcGIS system field
Shape_Area *Shape_Area*	esriFieldTypeDouble	ArcGIS system field
FK: Coal Mine *FK_CoalMine*	esriFieldTypeString	Foreign key: references a **coal mine** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalmine_coalminepoly	*Multi.:* 1 *Role:* toCoalMine *Table:* CoalMine	Extension -- Relation between the descriptive part and the geographical representation (as polygon) of **coal mine**

Coal Mine – Point Feature

Database name: CoalMinePoint

Definition: Extension -- Collection of point features that are the geographical representation of a **coal mine**. This feature is meant to point to locations of coal mines of which a polygon delineation is not available. If a delineation of the coal mine is available it will be stored in the feature class **CoalMinePolygon**. Descriptive information is available in the object class **CoalMine**.

Stereotype: «Point»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
FK: Coal Mine *FK_CoalMine*	esriFieldTypeString	Foreign key: references a **coal mine** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalmine_coalminepoint	*Multi.:* 1 *Role:* toCoalMine *Table:* CoalMine	Extension -- Relation between the descriptive part and the geographical representation (as point) of **coal mine**

Coal Rank Value

Database name: CoalRankValue

Definition: Code list for coal rank: degree of coalification, according to ISO11760 and based on vitrinite reflectance (or alternatively on volatile matter yield, moisture content, gross calorific value)

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
coal rank *coalRank*	esriFieldTypeString	Primary key: uniquely identifies a **coal rank**
description *description*	esriFieldTypeString	More elaborate description of the coal rank value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalclassdetail_coalrankvalue	*Multi.:* 0..* *Role:* toCoalClassDetail *Table:* CoalClassDetail	Extension -- **CoalRankValue** is the code list for the attribute coal rank, found in **CoalClassDetail**

Coal Resource Class

Database name: CoalResClass

Definition: Descriptive table on estimates of coal resources (amount). The reported resource class as well as the mapping to UNFC is included.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Coal Resource Class *PK_CoalResourceClass*	esriFieldTypeString	Primary key: uniquely identifies a **coal resource class**
FK: Coal Class *FK_CoalClass*	esriFieldTypeString	Foreign key: references a **coal class**
reported resource class *reportedResourceClass*	esriFieldTypeString	Coal resource class as it is reported in the source data. The classification system used is explained in **ReportedClassSystem**.
UNFC code(s) *UNFCCode*	esriFieldTypeString	Mapping of the reported resource class to the UNFC classification system
amount (Mt) *amount*	esriFieldTypeDouble	The quantified estimate of coal, in megaton
amount estimation date *amountEstimationDate*	esriFieldTypeString	Date of the estimation of the coal amount
classification system of the reported class *reportedClassSystem*	esriFieldTypeString	Specifications of the classification system of the reported class (references a key in the **EndNote** database)
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalclass_coalresclass	*Multi.:* 1 *Role:* toCoalClass *Table:* CoalClass	Estimated quantitative amount of a **coal class** for one or several **coal resource classes**. The local/reported classes and estimates are indicated, as well as the mapping to UNFC.

Coal Seam

Database name: CoalSeam

Definition: Extension -- Descriptive table on individual coal strata found in a **coal deposit**. Geometry information (polygon) can be found in the feature class **CoalSeamPolygon**.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Coal Seam *PK_CoalSeam*	esriFieldTypeString	Primary key: uniquely identifies a **coal seam**
FK: Coal Deposit *FK_CoalDeposit*	esriFieldTypeString	Foreign key: references a **coal deposit**
upper boundary (m) *upperBoundary*	esriFieldTypeDouble	Average depth of the upper boundary of the coal seam, in meter below sea level (*cfr.* elevation CRS - in case 'from surface level', in meter below surface level)
lower boundary (m) *lowerBoundary*	esriFieldTypeDouble	Average depth of the lower boundary of the coal seam, in meter below sea level (*cfr.* elevation CRS - in case 'from surface level', in meter below surface level)
thickness (m) *thickness*	esriFieldTypeDouble	Average thickness of the coal seam, in meter
elevation CRS *elevationCRS*	esriFieldTypeString	Vertical coordinate reference system (CRS) in which the elevation is measured: values are found in the code list **ElevationCRSValue**.
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coaldeposit_coalseam	*Multi.:* 1 *Role:* toCoalDeposit *Table:* CoalDeposit	Extension -- A **coal deposit** can consist of several **coal seams**
coalseam_coalclass	*Multi.:* 0..* *Role:* hasCoalClass *Table:* CoalClass	Extension -- Each **coal seam** consists of at least one **coal class**, which is described both in a local/reported and in a harmonized classification system. This information might be missing at this level, hence the possibility to have a multiplicity of 0 coal classes.
coalseam_coalseampoly	*Multi.:* 0..1 *Role:* hasCoalSeamPoly *Table:* CoalSeamPolygon	Extension -- Relation between the descriptive part and the geographical representation (as polygon) of **coal seam**
coalseam_elevationcrsvalue	*Multi.:* 1 *Role:* hasElevationCRS *Table:* ElevationCRSValue	Extension -- **ElevationCRSValue** is the code list for the attribute elevation CRS, found in **CoalSeam**

Coal Seam – Polygon Feature

Database name: CoalSeamPolygon

Definition: Extension -- Collection of polygon features that are the geographical representation of a **coal seam**. Descriptive information is available in the object class **CoalSeam**.

Stereotype: «Polygon»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
Shape *Shape*	esriFieldTypeGeometry	ArcGIS system field
Shape_Length *Shape_Length*	esriFieldTypeDouble	ArcGIS system field
Shape_Area *Shape_Area*	esriFieldTypeDouble	ArcGIS system field
FK: Coal Seam *FK_CoalSeam*	esriFieldTypeString	Foreign key: references a **coal seam** (at the same time the primary key)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field
Shape_IDX *Shape_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalseam_coalseampoly	*Multi.:* 1 *Role:* toCoalSeam *Table:* CoalSeam	Extension -- Relation between the descriptive part and the geographical representation (as polygon) of **coal seam**

Coal Type Value

Database name: CoalTypeValue

Definition: Code list for coal type: coal type, according to ISO11760 and based on petrographic composition (maceral groups) of the organic matter: vitrinite content, liptinite content and inertinite content

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
coal type *coalType*	esriFieldTypeString	Primary key: uniquely identifies a **coal type**
description *description*	esriFieldTypeString	More elaborate description of the coal type value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalclassdetail_coaltypevalue	*Multi.:* 0..* *Role:* toCoalClassDetail *Table:* CoalClassDetail	Extension -- **CoalTypeValue** is the code list for the attribute coal type, found in **CoalClassDetail**

Country

Database name: Country

Definition: Descriptive table on the status of available data for all countries in the European Union (and other neighbouring countries). Geometry information (polygon) can be found in the GISCO database.

Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Country *PK_Country*	esriFieldTypeString	Primary key: uniquely identifies a **country**
country status *countryStatus*	esriFieldTypeString	Status of the available data per country: values are found in the code list **CountryStatusValue**
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
country_countrystatusvalue	*Multi.:* 1 *Role:* hasCountryStatus *Table:* CountryStatusValue	**CountryStatusValue** is the code list for the attribute country status, found in **Country**

Country Status Value

Database name: CountryStatusValue
Definition: Code list for country status: status of the available data per country
Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
country status *countryStatus*	esriFieldTypeString	Primary key: uniquely identifies a **country status**
description *description*	esriFieldTypeString	More elaborate description of country status value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
country_countrystatusvalue	*Multi.:* 0..* *Role:* toCountry *Table:* Country	**CountryStatusValue** is the code list for the attribute country status, found in **Country**

Elevation CRS Value

Database name: ElevationCRSValue
Definition: Code list for elevation CRS; vertical coordinate reference system (CRS) in which the elevation is measured. Heights and depths can also be measured relative to the surface level. In that case choose the value 'from surface level'.
Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
elevation CRS *elevationCRS*	esriFieldTypeString	Primary key: uniquely identifies an **elevation CRS**
description *description*	esriFieldTypeString	More elaborate description of the elevation CRS value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
borehole_elevationcrsvalue	*Multi.:* 0..* *Role:* toBorehole *Table:* Borehole	Extension -- **ElevationCRSValue** is the code list for the attribute elevation CRS, found in **Borehole**
cbmaccumulation_elevationcrsvalue	*Multi.:* 0..* *Role:* toCBMAccumulation *Table:* CBMAccumulation	**ElevationCRSValue** is the code list for the attribute elevation CRS, found in **CBMAccumulation**
coaldeposit_elevationcrsvalue	*Multi.:* 0..* *Role:* toCoalDeposit *Table:* CoalDeposit	**ElevationCRSValue** is the code list for the attribute elevation CRS, found in **CoalDeposit**
coalseam_elevationcrsvalue	*Multi.:* 0..* *Role:* toCoalSeam *Table:* CoalSeam	Extension -- **ElevationCRSValue** is the code list for the attribute elevation CRS, found in **CoalSeam**

Geologic Age Value

Database name: GeologicAgeValue
Definition: Code list for geologic age: relates the coal bearing sediments of the coal deposit to time
Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
geologic age *geologicAge*	esriFieldTypeString	Primary key: uniquely identifies a **geologic age**
description *description*	esriFieldTypeString	More elaborate description of the geologic age value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalbasin_geologicagevalue	*Multi.:* 0..* *Role:* toCoalBasin *Table:* CoalBasin	**GeologicAgeValue** is the code list for the attribute geologic age, found in **CoalBasin**

Harmonized Class Value

Database name: HarmonizedClassValue
Definition: Code list for harmonized class: coal class as it is defined by the harmonized classification system in the EuCoRes project
Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
harmonized class *harmonizedClass*	esriFieldTypeString	Primary key: uniquely identifies a **harmonized class**
description *description*	esriFieldTypeString	More elaborate description of the harmonized class value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	Association Details	Definition
coalclass_harmonizedclassvalue	*Multi.:* 0..* *Role:* toCoalClass *Table:* CoalClass	**HarmonizedClassValue** is the code list for the attribute harmonized class, found in **CoalClass**

Lithological Layer

Database name: LithologicalLayer
Definition: Extension -- Descriptive table with information on the lithology of the **borehole**. Each (relevant) layer is described together with average depth and thickness.
Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	Data Type	Definition
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
PK: Lithologic Layer *PK_LithologicLayer*	esriFieldTypeString	Primary key: uniquely identifies a **lithological layer**
FK: Borehole *FK_Borehole*	esriFieldTypeString	Foreign key: references a **borehole**
average depth (m)	esriFieldTypeDouble	Average depth of the lithological layer, in meter

Name: Alias *DB Name*	**Data Type**	**Definition**
averageDepth		below surface level
average thickness (m) *averageThickness*	esriFieldTypeDouble	Average thickness of the lithological layer, in meter
description *description*	esriFieldTypeString	Description of the segment, including the description method
source reference *sourceReference*	esriFieldTypeString	Source of the data (references a key in the **EndNote** database)
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	**Association Details**	**Definition**
borehole_lithologicallayer	*Multi.:* 1 *Role:* toBorehole *Table:* Borehole	Extension -- The lithology of a **borehole** core is described per (relevant) **layer**.

Status Value

Database name: StatusValue
Definition: Code list for status
Stereotype: «ObjectClass»

Attributes

Name: Alias *DB Name*	**Data Type**	**Definition**
OBJECTID *OBJECTID*	esriFieldTypeOID	ArcGIS system field
status *status*	esriFieldTypeString	Primary key: uniquely identifies a **status**
description *description*	esriFieldTypeString	More elaborate description of the status value
OBJECTID_IDX *OBJECTID_IDX*		ArcGIS system field

Associations

Association Name	**Association Details**	**Definition**
cbmaccumulation_statusvalue	*Multi.:* 0..* *Role:* toCBMAccumulation *Table:* CBMAccumulation	**StatusValue** is the code list for the attribute status, found in **CBM Accumulation**
cbmconcession_statusvalue	*Multi.:* 0..* *Role:* toCBMConcession *Table:* CBMConcession	Extension -- **StatusValue** is the code list for the attribute status, found in **CBM Concession**
coaldeposit_statusvalue	*Multi.:* 0..* *Role:* toCoalDeposit *Table:* CoalDeposit	**StatusValue** is the code list for the attribute status, found in **CoalDeposit**
coalmine_statusvalue	*Multi.:* 0..* *Role:* toCoalMine *Table:* CoalMine	Extension -- **StatusValue** is the code list for the attribute status, found in **CoalMine**

3.4.3.3 Data included from the GISCO database[10]

GISCO is the acronym for Geographical Information System (GIS) at the European Commission. It is a service by Eurostat, which promotes the use of GIS within Eurostat and the Commission and manages the geographical reference database of the commission. The reference database is accessible to anyone in the Commission. With ArcGIS desktop software a spatial database connection can be made with the GISCO database and the spatial layers can be used for analysis and cartography.

In the EuCoRes project some of the data from the GISCO database will be used for cartographic purpose, i.e. they will serve as background and reference information for the thematic maps on coal and CBM. It concerns the following feature classes and tables:

- **CNTR_BN_01M_2010**: feature class with country boundaries (worldwide). It will be used in the maps to display country boundaries distinguishing in coastline borders (blue line) and borders between neighbouring countries (black line);
- **CNTR_RG_01M_2010**: feature class with polygons representing the country surfaces (worldwide). It will be used in the maps as background layer to show the country surfaces and joined with the CNTR_AT table labels with country names can be placed on maps. This feature class will also be used to display thematic information on coal and CBM on country level (join with source data needed);
- **CNTR_CAPT_PT_2010**: feature class with the capitals of the countries represented as points (worldwide). Can be used on the maps as reference layer, including labels with the capital names;
- **CNTR_LB_2010:** feature class with label points of the countries (worldwide). It can be used to report information on country level;
- **STTL_PT_V3**: feature class with settlements represented as points (EU27 + EFTA). Joined with the table STTL_V3_AT it can be used on the maps as reference layer, showing point and label with the settlements name;
- **SUPP_GRAT_LI**: feature class with meridians and parallels (worldwide). Can be used as background layer showing latitude and longitude lines;
- **CNTR_AT**: table with country information including names. Joined with the CNTR_RG_01M_2010 feature class it can serve to display country names as labels on the maps;
- **STTL_V3_AT**: table with settlement information including settlement names and population figures. Joined with the feature class STTL_V3_PT it can be used to show subsets of settlements on the map (*e.g.*. only settlements with a population > 1.000.000 people) as reference information;
- **STTL_PT_V3_AT**: explicit defined relationship class between point feature class STTL_PT_V3 and table STTL_V3_AT

It was decided to make a physical copy of these feature classes and tables into the EuCoRes database, rather than making a database connection. This allows the map documents for the

[10] http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/introduction

project to be based completely on the data present in the EuCoRes database, without depending on external data sources like the GISCO database. The flip side of the coin is that updates in the source data (GISCO database) are not automatically reflected in the EuCoRes database. Since the nature of the selected reference feature classes from the GISCO database is static, the need of updates is rather low.

To distinguish the GISCO data from the EuCoRes data, the names of the feature classes, tables and the grouping feature dataset received the prefix "GISCO_", the structure is as shown in Figure 33. Also the metadata for these data was taken over from the GISCO database and can be viewed through ArcCatalog.

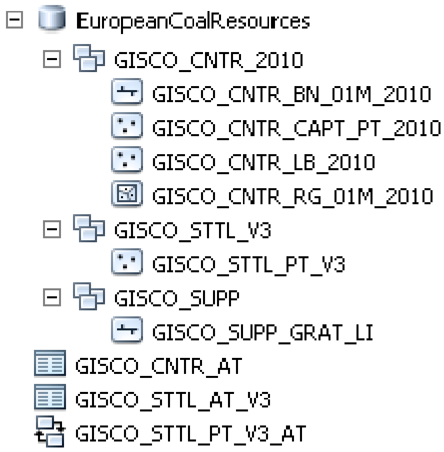


Figure 33 – Structure of GISCO data in the EuCoRes File Geodatabase

3.4.3.4 Editing the database model in Sparx Systems Enterprise Architect

Sparx Systems Enterprise Architect is a tool that allows us to visually model our database ('conceptual level'), based on the Unified Modelling Language or UML[11], and can be used as a basis to implement the database in ArcGIS ('physical level').

For that purpose, the software has an ArcGIS extension directly built into the software (so there is no need to download a plugin). For full instructions on how to use Enterprise Architect for ArcGIS, the reader is referred to the video demonstration and ArcGIS tutorial on the Sparx Systems website[12]. The link between the Sparx Systems software and the ArcGIS software is very rigid. In order to be able to implement the schema directly into ArcGIS, it is advised to have a thorough look at the tutorials. Also make sure Enterprise Architect has been updated to at least version 9.3 build 933.

The most important cases in which the implementation into ArcGIS will not work are:

- The package structure is altered incorrectly
- ArcGIS system fields are missing
- Stereotypes are not set correctly
- Specific (ArcGIS) tagged values are not set correctly
- Object names are not unique
- Relationship names are not unique and cardinalities are not set

Another problem with loading the schema into ArcGIS is that, when errors occur, they usually are undefined. Therefore it is advised to check your schema in ArcGIS each time you apply the slightest change.

In order to structure the model, it is possible to add un-stereotyped packages to the ArcGIS Workspace. However these will not be retained in ArcGIS: only the feature classes (point, polygon,…) and their relationship classes will reside inside the packages with the stereotype 'FeatureDataset'. All other objects (which are descriptive tables) and all other relationship classes will reside directly under the File Geodatabase (in alphabetical order).

[11] Unified Modeling Language (or UML) is a standardized general-purpose modeling language in the field of object-oriented software engineering. It includes a set of graphic notation techniques to create visual models of object-oriented software-intensive systems. The standard is managed, and was created, by the Object Management Group. It is the de facto industry standard for modeling software-intensive systems. UML resource page of the Object Management Group: http://www.uml.org/.

[12] http://www.sparxsystems.com/arcgis

Export to an ArcGIS XML Workspace document[13]

Once the database model is complete, the software can output it into an XML file (eXtensible Mark-up Language) that can be read by ArcGIS:

1. Make sure all open diagrams are saved.
2. In the project browser, select the top level package 'ArcGIS Workspace'
3. Invoke the publisher (Figure 34):

   Extensions > ArcGIS > Export to ArcGIS Workspace XML
4. Select a filename & location and select 'ArcGIS' for XML type.
5. Click 'Export'

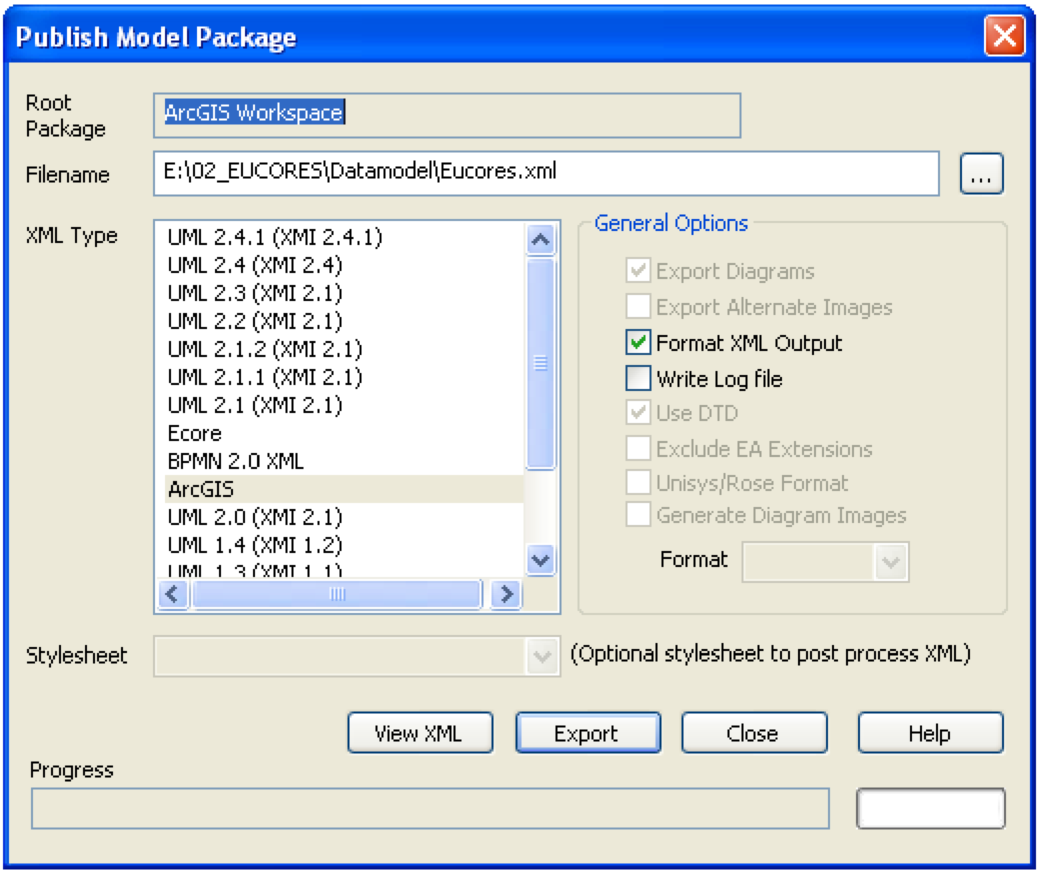


Figure 34 – Publish database schema to ArcGIS-compatible XML

[13] http://www.sparxsystems.com/bin/arcgis-enterprise-architect-uml-modeling-tutorial.pdf

3.4.3.5 Creating the database in ArcGIS[14]

The first step is to create the empty database:

1. Open ArcCatalog
2. Connect to the folder where you wish to install your database (Figure 35).

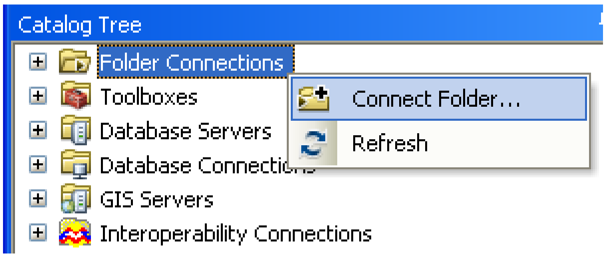


Figure 35 – Connect to a folder in the Catalog Tree

3. In this folder, create a new File Geodatabase (Figure 36):

   right click on the folder > New > File Geodatabase

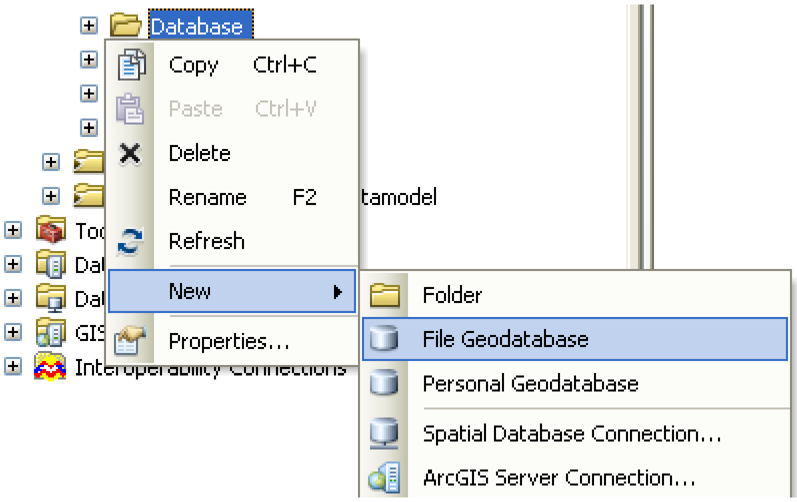


Figure 36 – Create a new File Geodatabase

4. Import the XML file created by Sparx Systems Enterprise Architect (Figure 37):

   right click on the File Geodatabase > Import > XML Workspace Document >

   Select 'Schema Only' and browse to the file location > Next > Finish

[14] http://www.sparxsystems.com/bin/arcgis-enterprise-architect-uml-modeling-tutorial.pdf

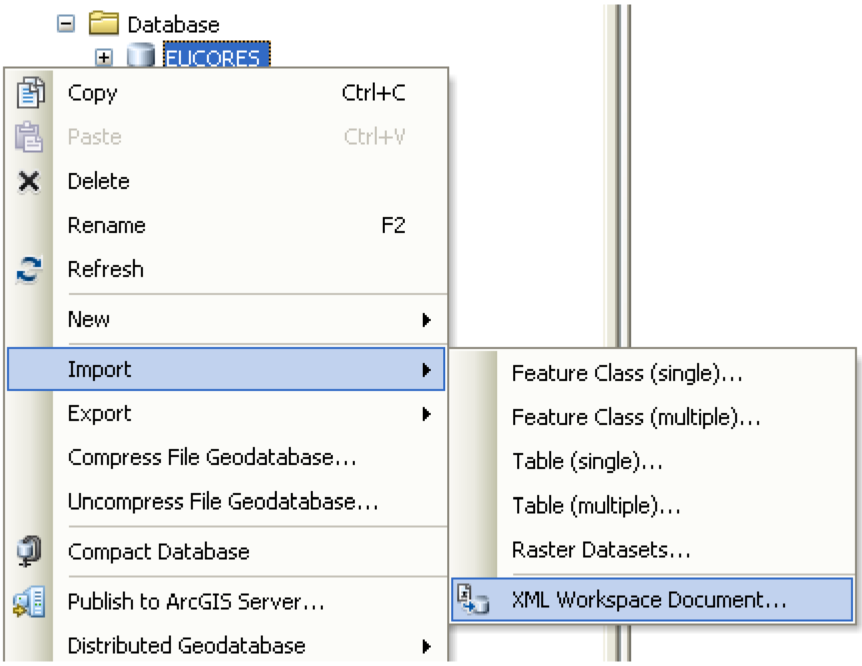


Figure 37 – Import the XML file with the database schema

The database is now shown in the Catalog Tree and the main window (Figure 38).

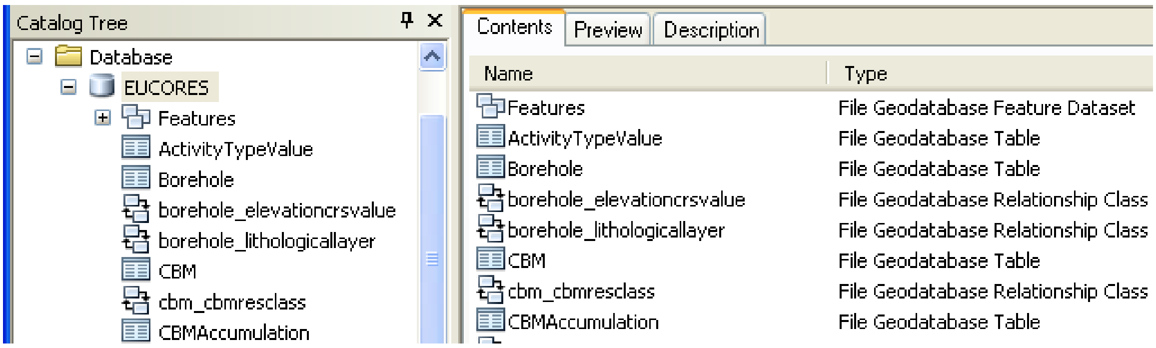


Figure 38 – The database in the Catalog Tree

3.4.3.6 Data loading

This chapter is written assuming the database is empty and data is loaded into the database from scratch. In case the database is already in use and updates are required, the reader is referred to the next chapter.

In general there are two types of data that will be loaded into the database: spatial data and descriptive data. The loading of **spatial data** is done in the ArcGIS software by making use of the "Simple data loader" wizard[15]. However, in order to do it correctly, certain rules apply. More detailed instructions can be found at the end of this chapter. For loading **descriptive data** into the database, the following options exist:

(1) Automated data loading (data-input templates and custom ModelBuilder tools):
   a. Custom tool 1: Load Code List Values
   b. Custom tool 2: Load Country Values
   c. Custom tool 3: Load Data

(2) Manual data loading:
   a. Append tool
   b. ArcGIS edit session

Remark: *Data from the GISCO reference database see 3.4.3.3 page 105 should just be copied into the EuCoRes database through ArcCatalog.*

The first section discusses **data input templates**. These are Excel files that allow for a more intuitive approach for data loading. These templates are used by (custom made) tools. In order to get a clear understanding of these tools, the **ArcGIS ModelBuilder** is discussed first. This is an easy-to-use application to create, edit, and run custom tools. An important building block in these custom tools is the **ArcGIS Append tool**. Therefore it is discussed separately. Finally the structure and use of and the access to the **custom tools** is discussed.

The ArcGIS Append tool, used as a building block in the custom made tools, can also be used as a stand-alone tool for manual data feed. The most basic manner of data loading however is by performing an **ArcGIS edit session**.

Lastly, some basic rules that apply to **spatial data loading** are discussed.

Data input templates

Instead of directly inputting data into the database, data providers or the database manager can use data input templates – Excel files that are easier to manage and that allow for a more intuitive approach for data loading. These files are used directly by the custom tools to load data into the database.

There are three different files:

- codelists.xlsx
- country.xlsx
- data-loading-template.xlsx

[15] http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//003n0000003t000000

These files are so-to-say a copy of the descriptive tables in the database. The file 'codelists.xlsx' covers all code list tables, the file 'country.xlsx' covers the country table, and the file 'data-loading-template.xlsx' covers all other descriptive tables.

Notice! The code lists and the country table are already filled in in the Excel files. Code lists are fixed and are updated rarely. Therefore this file is not to be altered. Country status values can change when new data is available.

The set-up of the Excel files is as follows:

(1) The document has one worksheet per descriptive table in the database.
(2) Each column represents one attribute. The headers indicate the attribute name (alias) in bold, together with an indication if the attribute is a key, a reference to Endnote or a reference to a code list, or gives the data type. The following colour codes are used:

yellow	primary key
green	foreign key
pink	endNote reference
blue	reference to a code list

Some considerations when filling in the database (instructions also found in the 'WELCOME' tab):

(2) Keep the file structure intact
The structure of the file cannot be altered: the names of the worksheets as well as the column headers should remain unchanged. Adding new columns is pointless.

(3) Unique primary key
The primary key can be chosen freely. The use of a hierarchical system is suggested (this suggestion also pops up in a text box whey trying to input a key). An example system is given in the next paragraph. The only real restriction is that the primary key must be unique. In case this condition is violated, an error message pops up.

(4) Data validation
Data validation applies to many columns (foreign keys and code list references).
This implies two things:
- Always keep the file 'codelists.xlsx' open. Attributes referring to a code list have data validation leading to this file. When not opened, the data validation fails.
- Never copy/paste data plainly, but always use the 'paste values' option.

(5) EndNote references
These should not be left empty: where there is data, there is a data source.

(6) Only fill in data
Do not insert empty lines, block titles, *etc.* in between. It is also good practise to make sure that the rows below the last data entry are really empty.

(7) Comments
Comments inserted in the 'comments' field behind the black line will not be included in the database but are merely for communication purpose.

(8) Questions?
When in doubt, contact the database manager.

Primary and foreign keys proposal

The nature of the keys can vary. First of all have a look at the keys used in the data source. If these are unique and meaningful, it is advisable to use these. Otherwise here a hierarchical system is suggested that starts with a two-letter country code (ISO 3166), followed by (only when applicable):

- A letter code for the coal basin
- A letter or number code for the Coal Deposit, CBM Accumulation or Borehole
- A serial code for the different Lithological Layers or Coal Seams: L1, L2, …; S1, S2, …
- A letter code for the Coal Mine or CBM Concession
- A concatenation of the deposit and the mine codes (when needed followed by a letter or number code) for the Coal or CBM Activity
- A letter code for the Coal Class and the CBM (Coal Class Detail can have a primary key identical to the foreign key to Coal Class)
- A letter or number code for the Coal and CBM Resource Class

This is illustrated by a fictive example for Belgium (BE).

- There is one coal basin that receives the letter code BA: BE_BA
- Linked to this coal basin exists a borehole with the letter code BORE: BE_BA_BORE
- This borehole has two lithological layers (L1 and L2): BE_BA_BORE_L1 and BE_BA_BORE_L2
- The coal basin further has one coal deposit that receives the letter code DEP: BE_BA_DEP
- This coal deposit has two coal seams (1 and 2): BE_BA_DEP_S1 and BE_BA_DEP_S2
- Linked to this coal deposit exists a coal mine with the letter code MIN: BE_BA_MIN
- Two coal activities link the mine and the coal deposit together (ACT1 and ACT2): BE_BA_DEP_MIN_ACT1 and BE_BA_DEP_MIN_ACT2
- Information on coal classes is available at the levels: Coal Basin, Coal Deposit and Coal Seam. All objects have hard coal and thus get the suffix HC: BE_BA_HC, BE_BA_DEP_HC, BE_BA_DEP_S1_HC, BE_BA_DEP_S2_HC
- For one coal class description, details are available, *i.e.* for the coal deposit. These details get the same key as the coal class description itself: BE_BA_DEP_HC
- Only for the same coal class description, resource figures are available. These get a sequential number R1 and R2: BE_BA_DEP_HC_R1 and BE_BA_DEP_HC_R2.

ArcGIS ModelBuilder[16]

ModelBuilder is a part of the geoprocessing framework of ArcGIS. It is an easy-to-use application to create, edit, and run models. Models are *"workflows of geoprocessing tools (including scripts, custom tools and other models), feeding the output of one tool into another tool as input"*.

It is a very visual application (interface: Figure 39; examples: Figure 43, Figure 45, Figure 47) that can be used not only for the construction and execution of these models, but also allows them to be transformed into a new tool ("a custom tool"), thus extending the ArcGIS functionality. This new tool then exists next to the other tools in the ArcToolbox and can be used by non-experts, because the developer can limit the input freedom.

Models are also a clear way of unambiguously documenting a workflow, making repetition of a calculation very straightforward.

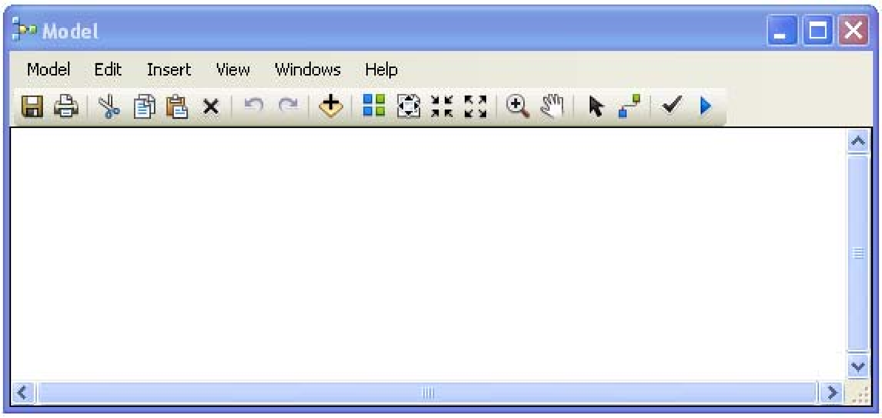


Figure 39 – The ModelBuilder interface with drop-down menus, toolbar and canvas (workspace).

The Append tool

The *Append* tool is used for both **manual data input** and as **building block in the custom tools**. It is available in the ArcToolbox (Figure 40) under Data Management Tools > General > Append.

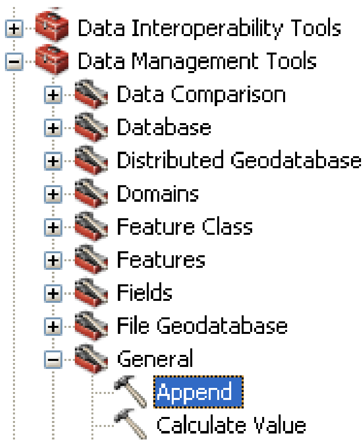


Figure 40 – Append tool

[16] http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//002w00000001000000

Next to the custom data loading tools, the Append tool is used to load data into the database in a generic way. Data should still be available in a spread sheet like Excel.

All input fields in the Append dialog box can be found in Figure 41:

- 'Input Datasets' refers to the spread sheet (*e.g.* Excel). Select the correct worksheet (tab).
- 'Target Dataset' refers to the table inside the database that should be updated.
- 'Schema Type' determines whether or not the schemas of the input and target datasets match. Choose NO_TEST.
- When the schema type is set to NO_TEST, in the 'Field Map' a list of attributes appears. These are the attributes from the table in the database. By right-clicking them, the matching column from the Excel table can be chosen (Figure 42).

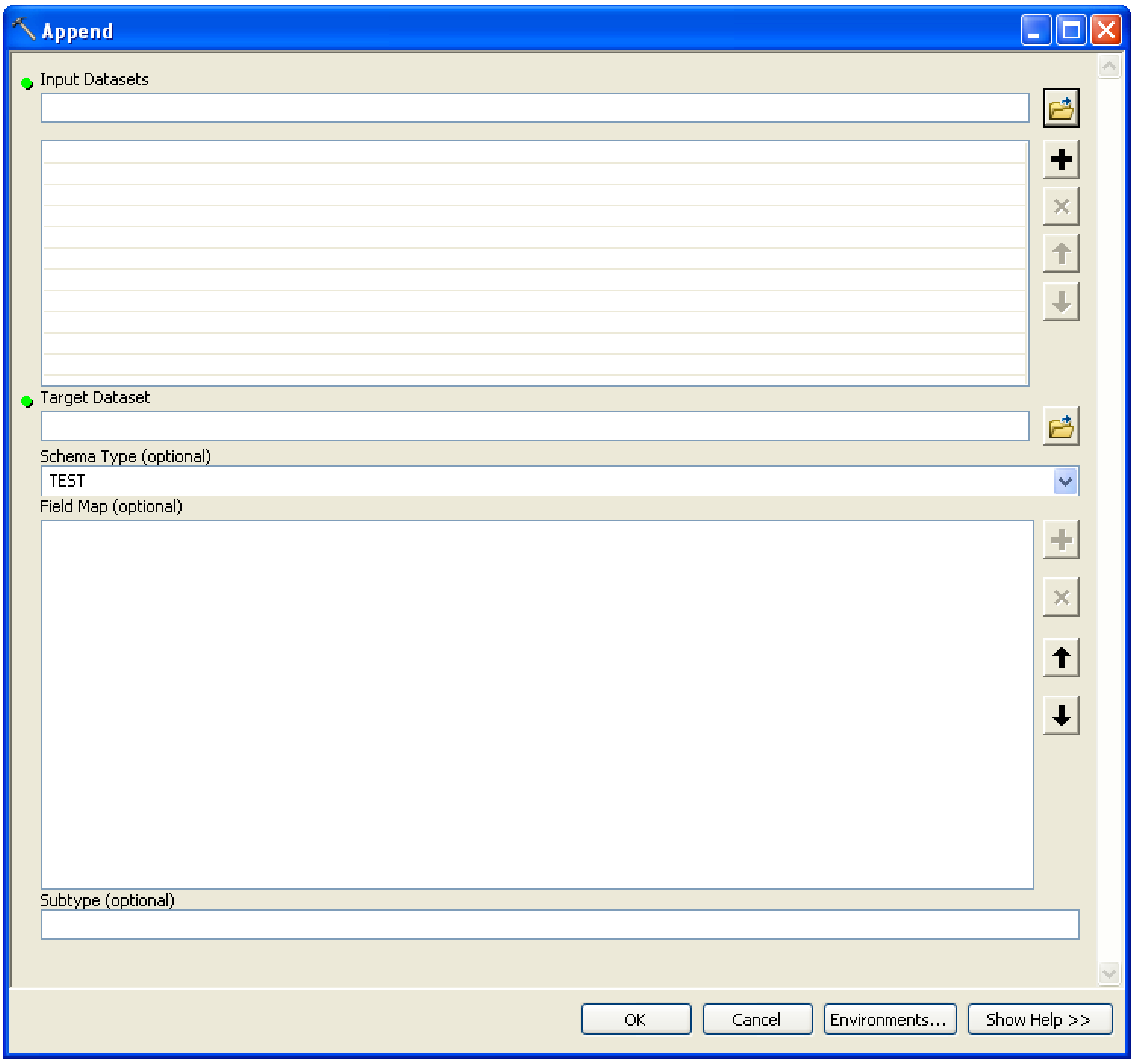


Figure 41 – Append tool: dialog box

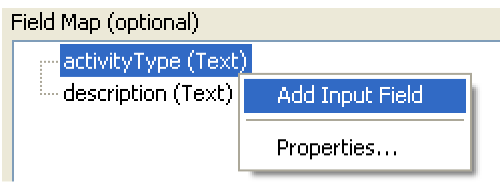


Figure 42 – Field Map: set the attribute mapping

Custom tool 1: Load Code List Values

The values for the code lists are stored in an Excel file named 'codelists.xlsx'. **As code lists are supposed to be fixed, this file is not to be altered**. It is however always possible that at a given point in time, these code lists change. In that case it is probably best to update the database (see next chapter). When an entirely new database is created, with other code list values, this Excel file can be changed and then loaded into the database as was explained in this section. However it is important to leave structure (worksheet and column names) intact. In case the database schema is altered and additional code lists must be entered in the database, the user must do this manually, by using the Append tool (see page 114).

Figure 43 gives a schematic of the custom tool *Load Code List Values*. The tool is a repetition of the *Append* tool (see page 114): it is repeated nine times: once for each code list. The *Append* tool itself is indicated in yellow squares. Other coloured balloons indicate input parameters, which were also explained in Figure 41 – Append tool: dialog box.

The parameters in the white balloon are (1) the path to the source file, i.e. the location where 'codelists.xlsx' is stored and (2) the path to the destination database. Parameters in light blue balloons indicate individual worksheets in this source file that correspond with the nine code lists. Parameters in the dark blue and green balloons indicate the destination tables in the database: before (dark blue) and after (green) the *Append* tool has run.

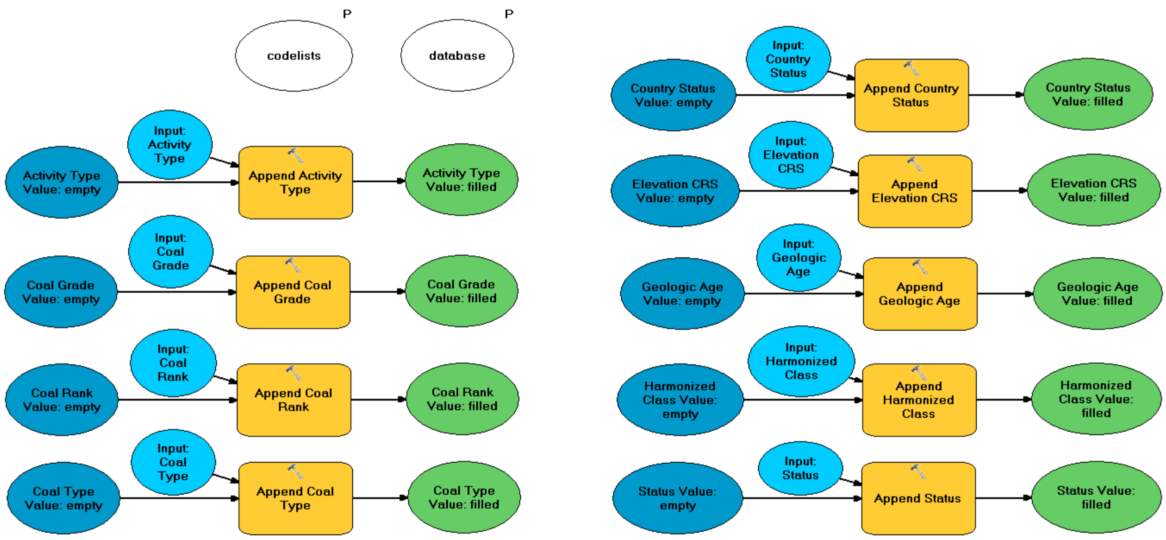


Figure 43 – Custom tool: schema of *Load Code List Values*

The user only sees the parameters indicated by a 'P' in the schema: the path of the Excel file and the path of the database. The GUI is shown in Figure 44. To enter the values for the code lists into the database, simply browse to the location of the Excel file and the location of the database and click OK.

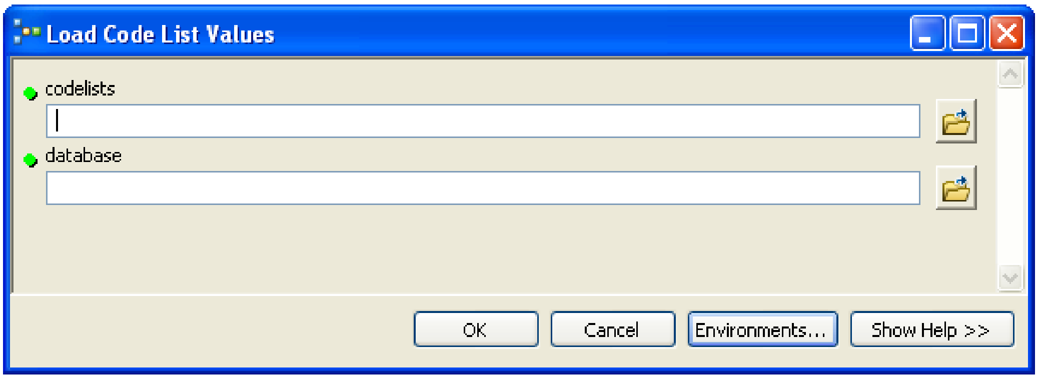


Figure 44 – *Load Code List Values* tool

Custom tool 2: Load Country Values

The values for the data status of the countries are stored in an Excel file named 'country.xlsx'. It is always possible that these values change. In that case it is probably best to update the database (see next chapter). When an entirely new database is created, this Excel file can be changed and then loaded into the database as will be explained in this section. However it is important to leave structure (worksheet and column names) intact. In case the database schema is altered, the user must enter the dataset manually, by using the Append tool (see page 114).

Figure 45 gives a schematic of the custom tool *Load Country Values*. The tool is a simplification of the *Append* tool (see page 114): the field mapping has already been programmed. The *Append* tool itself is indicated in the yellow square. Other coloured balloons indicate input parameters, which were also explained in Figure 41 – Append tool: dialog box.

The parameters in the white balloon are (1) the path to the source file, i.e. the location where 'country.xlsx' is stored and (2) the path to the destination database. The parameter in the light blue balloon indicates the individual worksheet in this source file that contains the dataset. Parameters in the dark blue and green balloon indicate the destination table in the database: before (dark blue) and after (green) the *Append* tool has run.

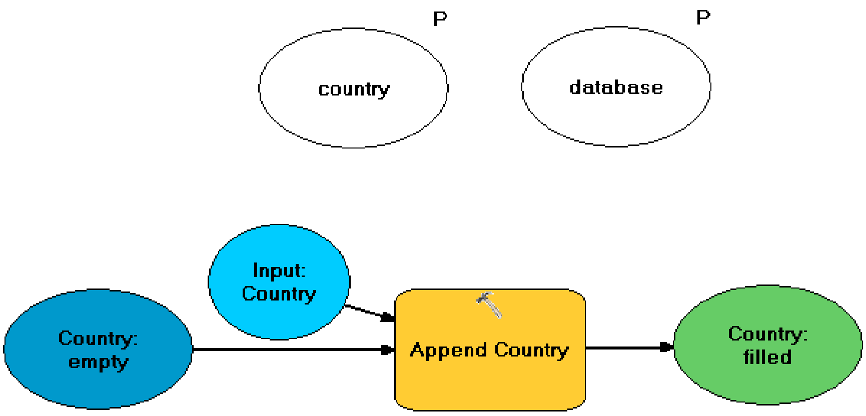


Figure 45 – Custom tool: schema of *Load Country Values*

The user only sees the parameters indicated by a 'P' in the schema: the path of the Excel file and the path of the database. The GUI is shown in Figure 46. To enter the values for the data status into the database, simply browse to the location of the Excel file and the location of the database and click OK.

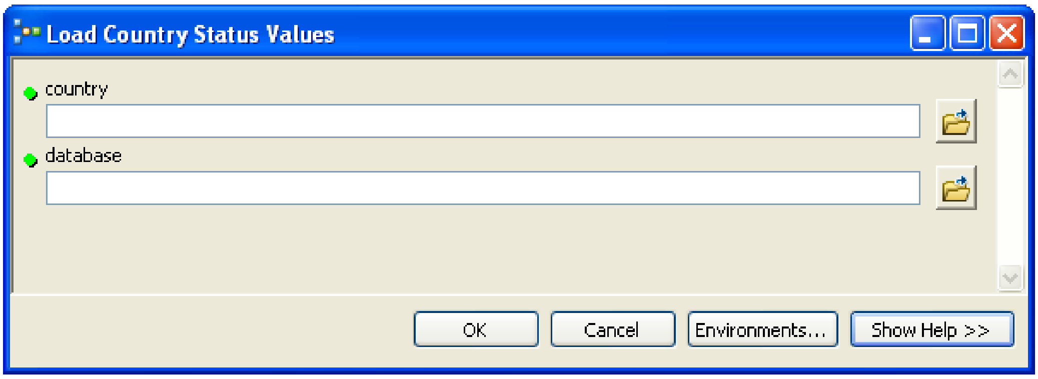


Figure 46 – *Load Country Values* tool

Custom tool 3: Load Data

Once code lists are entered into the database, the rest of the descriptive tables can be added too. The values for these tables are stored in an Excel file named ‘data-loading-template.xlsx’. **It is advisable to use one Excel document per country or per data source.** It is always possible that these values change. In that case it is probably best to update the database (see next chapter). In case the database schema is altered, the user must enter the dataset manually, by using the Append tool (see page 114).

Figure 47 gives a schematic of the custom tool *Load Data*. The tool is a repetition of the *Append* tool (see page 114): it is repeated 15 times: once for each descriptive table in the database. The *Append* tool itself is indicated in yellow squares. Other coloured balloons indicate input parameters, which were also explained in Figure 41 – Append tool: dialog box.

The parameters in the white balloon are (1) the path to the source file - the location where ‘data-loading-template.xlsx’ is stored and (2) the path to the destination database. Parameters in light blue balloons indicate individual worksheets in this source file that correspond with the data tables. Parameters in the dark blue and green balloons indicate the destination tables in the database: before (dark blue) and after (green) the *Append* tool has run.

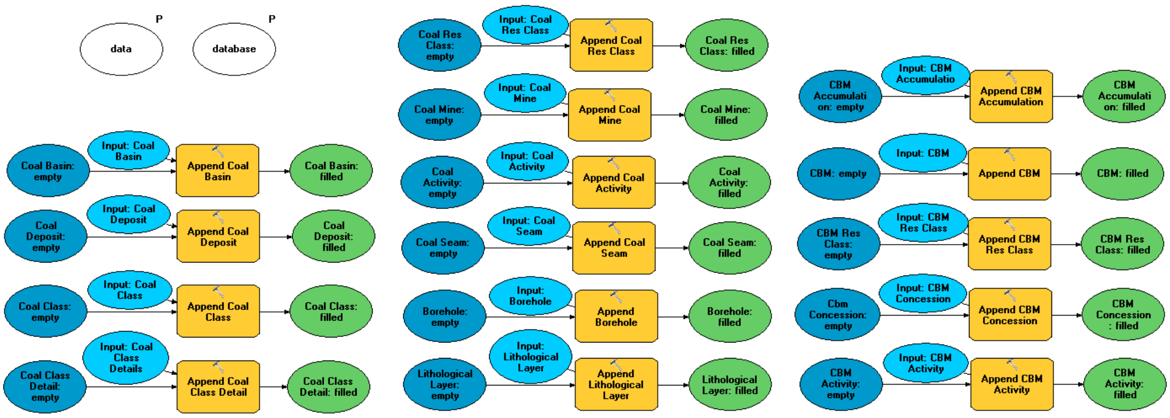


Figure 47 – Custom tool: schema of *Load Data*

The user only sees the parameters indicated by a ‘P’ in the schema: the path of the Excel file and the path of the database. The GUI is shown in Figure 48. To enter the values for the descriptive tables into the database, simply browse to the location of the Excel file and the location of the database and click OK.

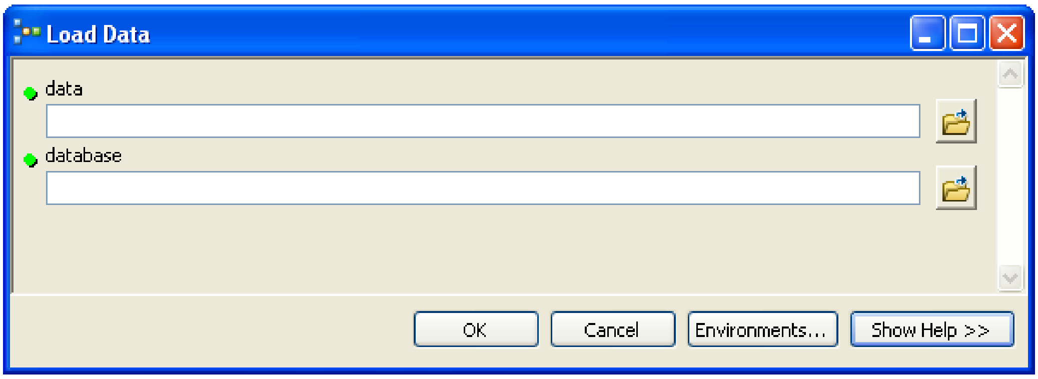


Figure 48 – *Load Data From Template* tool

Accessing custom tools in the EuCoRes toolbox

The custom made EuCoRes toolbox is by default not present in the ArcToolbox list. To add it:

1. Open ArcCatalog
2. Open the ArcToolbox via the Toolbar (Figure 49) or via Geoprocessing > ArcToolbox

Figure 49 – Open the ArcToolbox via the Toolbar

3. Add the EuCoRes toolbox(Figure 50):

   right click an empty space inside the ArcToolbox > Add Toolbox… > browse > open

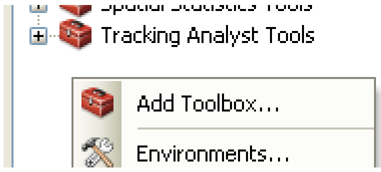


Figure 50 – Add the EuCoRes toolbox to the ArcGIS toolbox list

The EuCoRes toolbox now appears in the ArcToolbox tree (Figure 51).

Figure 51 – The EuCoRes toolbox

ArcGIS Editing Session[17]

A database can be edited in an ArcGIS Edit session. During such an edit session, also descriptive tables can be updated. A step-by-step approach can be found on page 121.

Be aware that edits are temporary until they are saved. Quitting an edit session without saving data irreversibly undoes all changes. 'Save Edits' (Figure 55) permanently saves any changes made up till then. Selecting 'Stop Editing' (Figure 56) before saving any edits provides the user with a choice to approve or ignore the changes made.

Spatial data

The above mentioned options exist solely for the descriptive tables. The number of formats of spatial data is too divers to create generic loading tools. In essence what is required to load spatial data is a set of shapefiles that fulfil the following requirements:

- **Projection system is ETRS89**
  This can be achieved using the Project tool[18] (ArcToolbox > Data Management > Feature > Project) that allows to project spatial data from one coordinate system to another.
- **PointZ**
  Point features have a stored Z-coordinate (PointZ feature)
- **Multipart polygons**
  Spatially separate polygons belonging to the same feature should share the same attributes and be stored as a single feature (*e.g.* a country with off-shore islands should still be stored as a single country). This can be achieved using the Dissolve tool[19] (ArcToolbox > Data Management > Generalization > Dissolve) that can be used to aggregate single part polygons (spatially separate polygons are stored as separate features) to multipart polygons (spatially separate polygons are stored as a single feature).
- **A 'linkable' ID**
  A one-on-one link should exist between the primary key in the descriptive tables and the foreign key in the spatial dataset.

[17] http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/About_edit_sessions/001t0000000q000000/
[18] http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/Project/00170000007m000000/
[19] http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/Dissolve/00170000005n000000/

3.4.3.7 Database update

Several reasons for updating the data in the database exist: a mistake was encountered and needs to be corrected; a full update is available for a given country or data provider; new data is received and needs to be added to the database; …

In case of minor updates, an ArcGIS edit session is more advisable. When major updates are required, re-loading the data is a more advisable option.

ArcGIS edit session for minor updates[20]

When only a small number of values needs to be updated, an ArcGIS edit session is the most advisable approach. During such an edit session descriptive tables can be updated. In order to do so, start an edit session:

1. First display the Editor toolbar (Figure 52):

   Go to Customize > Toolbars > Select 'Editior'

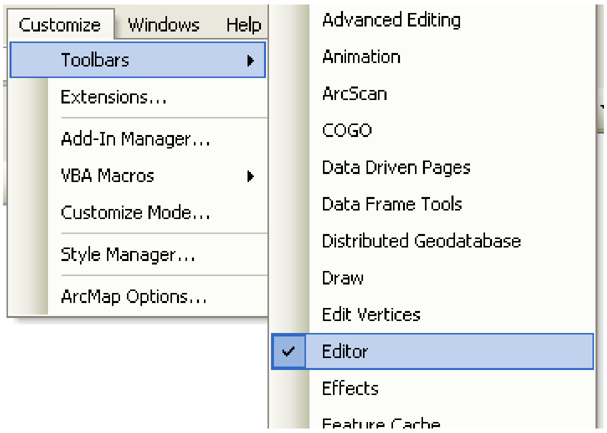


Figure 52 – Display the Editor toolbar

2. In the Editor Toolbar start an edit session (Figure 53): Editor > Start Editing

Figure 53 – Start an edit session

3. To edit a data table (Figure 54): right-click the data table you want to edit > Open

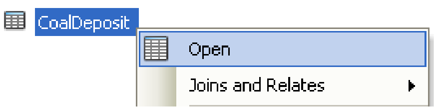


Figure 54 – Edit a data table

[20] This is a very concise description on edit sessions in ArcGIS. Full details can be found on: http://resources.arcgis.com/en/help/main/10.1/index.html#//01m500000003000000

4. The attribute fields are now ready for editing. Just place your cursor in a cell and rewrite the values.
5. Once all updates are complete, save the changes made during the edit session (Figure 55) and stop the edit session (Figure 56).

   Editor > Save Edits

   Editor > Stop Editing

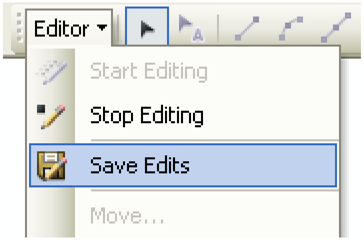


Figure 55 – Save changed made during and edit session

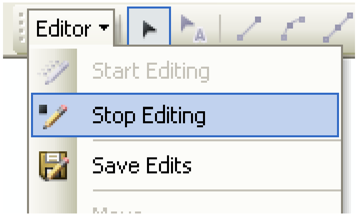


Figure 56 – Stop an edit session

Be aware that edits are temporary until they are saved. Quitting an edit session without saving data irreversibly undoes all changes. 'Save Edits' permanently saves any changes made up till then. Selecting 'Stop Editing' before saving any edits provides the user with a choice to approve or ignore the changes made.

Re-loading data for major updates

When new information in available for an entire country or data provider, it is best practice to work with the data template in Excel.

1. Update the new data in the Excel file as discussed on page 112.
2. Delete the old data from the database:
   a. Start an edit session (Figure 53): Editor > Start Editing
   b. Right-click the data table you want to edit > Open (Figure 54)

      Select the data rows you want to delete (these are all rows belonging to a given country or data provider) > right click > Delete Selected (Figure 57)
   c. Repeat step b for all descriptive tables containing data for that country or data provider)

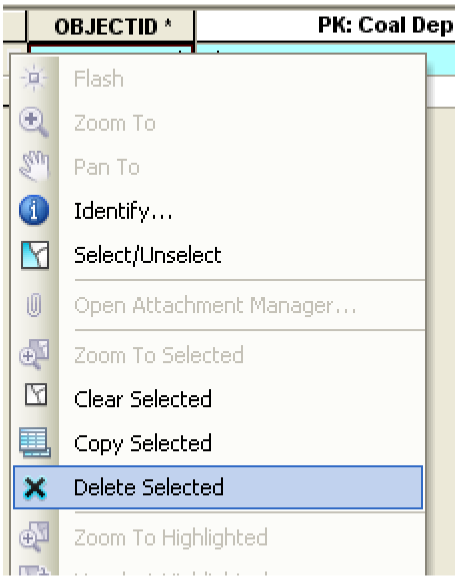


Figure 57 – Delete selection during an edit session

d. Save the changes made during the edit session (Figure 55) and stop the edit session (Figure 56).

   Editor > Save Edits

   Editor > Stop Editing

e. Load the new data in the database, by following the steps on page 118 (Custom tool 3: Load Data).

In case only one table needs to be updated (*e.g.* coal class details have become available afterwards), a similar procedure can be followed. But instead of using the custom tool 'Load Data' (page 118), use the Append tool (page 114).

3.4.3.8 Metadata

INSPIRE compliant metadata for discovery is available for all objects: the geographic 'feature classes' as well as the descriptive 'object classes'. This metadata describes general information for the data layers, like origin, date, contact persons and geographical extent.

To make sure that it is in line with both the INSPIRE Implementing Rules on Metadata (Commission Regulation (EC) No 1205/2008 of 3 December 2008)[21] and the INSPIRE Metadata Implementing Rules: Technical Guidelines based on EN ISO 19115 and EN ISO 19119[22], metadata was created with the tool EUOSME (version 1.0.3)[23].

The European Open Source Metadata Editor (EUOSME) is a web application to create INSPIRE-compliant metadata in any of 22 European languages. It has been developed by the Joint Research Centre as part of the EuroGEOSS project[24]. The editor is a GUI which allows the user to fill in all required metadata elements. At the end the user can generates an XML file.

XML files are named after the objects they describe, with the prefix 'MD_'.

Important to note is that the **Lineage** of the data very complex is to describe, as data is collected throughout the European Union, and it is provided by data providers at voluntary base. Each of these provided datasets was formatted to fit the data model as much as possible. However, seeing the diversity of data sources, detailed information on the lineage and data quality of the source data is different per country and therefore also stored per country in so called **Country Fiches**. More info can be found in chapter 3.5 *Metadata fiches per Country*.

Additional documentation on the data model, feature catalogues and a technical user guides can be found throughout this chapter3.3.

[21] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:326:0012:0030:EN:PDF

[22] http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/metadata/MD_IR_and_ISO_20090218.pdf

[23] http://inspire-geoportal.ec.europa.eu/editor/

[24] www.eurogeoss.eu

3.5 Metadata fiches per Country

3.5.1 Objective

The information that was provided and compiled for the database was of different quality and could only in rare cases directly be included into the database. Differences in data quality are often related to different data sources. Differences in standards and procedures that were used in the past and present can also lead to significant differences in data quality. In some cases different data could be included in the database by converting information to a common reporting unit or reference standard. In some cases information had to be combined for different coal deposits by calculating average values or limiting the provided data *e.g.* to maximum values. In most cases the database model allows reporting of the original (non-harmonized) data along with the results of processing and harmonization. However, any transformation, interpretation or other processing of the original data is prone to error and thus it is necessary to describe differences in data sources, data quality and to keep track of any transformations that were performed on original data in order to include them in the database.

3.5.2 Approach

To document the source, type and quality of all data that were provided for the database and collected from public resources or literature, individual metadata files were created for each country that provided information that could be included in the database. These documents were prepared to keep track of any performed transformations, interpretations and processing of data that were necessary to compile and harmonize the provided/available data for the database. A standard structure of these metadata files was used for all countries, which is described in the next section.

3.5.3 Result

The following section describes the structure of these documents.

The documentation of data sources, data quality and data processing is divided into three sections, “Descriptive information”, “Spatial information” and “Recommendations”.

Descriptive information

This section provides information on data sources, data quality and data processing, transformation and interpretation of the descriptive information that is included in the database. With “descriptive information” it is meant: all non-spatial information on resources of coal and/or CBM, which was available from public sources, international energy reports or provided by international organisations such as the European Association of Coal and Lignite (EURACOAL).

Spatial information

This section provides information on the data sources, data quality and data processing of spatial information that is included in the database. The documentation of spatial data is described according the spatial features: coal basins, coal deposits, CBM accumulations, coal mines and boreholes when available.

Recommendations

In this section recommendations are given to improve the information provided in the database. Improvements can be recommended at various levels, for descriptive as well as for spatial data, like: data quality, harmonisation of the classifications, completeness of the information, more recent resources figures, more accurate location information (*e.g.* polygons instead of points),…

3.6 Set of maps

3.6.1 Objective

The objective of this task is to create a set of maps to illustrate the content of the database, i.e. location of major EU coal basins and deposits, estimations of the resources of coal and CBM potential on basin level, differentiated in a clear manner by coal type and classes like described in the common classification and terminology (see 3.1 p. 14). The advantage of a database based on a common European classification and terminology for coal typology and for CBM reservoirs is that presented figures on maps between the different member states can be compared directly.

Overview maps on European level shall be presented on A0 format while more detailed (sub-sectional) maps shall be created on an A3 format.

3.6.2 Approach

The maps are created and saved digitally as editable ArcGIS map documents (.mxd file type) and in non-editable pdf-format. Next to this, the maps are printed on A0 and A3 format paper (five times with a resolution of at least 300dpi). The electronic maps documents allow for easy and identical reproduction. They contain the entire symbology of each layer included and all required map elements (scale bar, legend, …). At the same time the digital file is directly linked to the presented georeferenced data, so that future adjustments (*e.g.* new symbology or update of data) can easily be made without having to rebuild the entire map.

Apart from the thematic map documents, a set of map templates with a uniform layout (EU logo, banner, disclaimer, scale bar, legend, background reference data…) are produced for different paper sizes and orientations. This allows producing *“ad hoc”* maps with new specific thematics. From ArcGIS v.10 the mxt-format for templates is no longer supported so the templates are saved as normal map documents (mxd-format).

Apart from the map documents also layer files (.lyr file type) will be created which contain symbolised geographical data and the necessary joins to tables with attributes to base the symbology on.

3.6.3 Result

In the most ideal case it should be possible to create maps (templates) that can be applied in the same way for all of the EU countries. This requires that:

1. the database is filled completely (at least with Core elements, see Core-section of the European coal resources database model p.77);
2. all data is provided within the harmonised classification and terminology;
3. all data has a comparable quality level (for spatial as well as for descriptive information).
4. all data applies to comparable time periods.

Unfortunately these assumptions do not apply to the current status of the database. There is a high variability of data between countries and even within the country. Most common problems that occur are:

1. Incompleteness of information:
    - spatial information is missing, *e.g.* basin geometry for a country is missing, basin geometry for a brown coal is missing, some deposit descriptive information cannot be linked to a delineation,…;
    - Coal or CBM resource information only available on basin level or only on deposit level (different between countries);
    - Resource information provided is incomplete, *e.g.* in Poland the resource information available is limited to anticipated resources and does not include extractable reserves;
    - Metadata is missing.
2. Resource information is not reported according the harmonised classification, i.e. only available in the classification used within the country and mapping is not possible;
3. Spatial and descriptive information often have different sources and the link between both is not provided --> matching of the data based on name information or through analogue maps is required, this matching process is not always successful;
4. High variability in resolution of spatial data;
5. Differences in the age of resource information: recent vs. old.

Therefor was opted to create country specific *"ad hoc"* maps to represent the data that are stored in the database. This makes it possible to show what kind of data the database contains for the most important coal producing countries. The resulting maps illustrate the high variability of the present data included in the database.

Since CBM can be seen as a rather new source of fossil energy there is not much resource data is available yet which explains limited number of maps on this topic.

Table 20 and Table 21 list up the different map documents and layer files generated including a short description of their content.

Table 20 – Description of mxd-documents

Name	Description
A(x)_(orientation).mxd	Map template for A0, A3 or A4 paper format with portrait/landscape orientation. Can be used to create new thematic maps. It contains EU logo, legend, scale bar, banner + title, disclaimer, background reference data: country polygons, country boundaries, and graticule of meridians and parallels. Standard extent is set to Europe.
A0_EU_CBM_resources	Map on A0, portrait, showing the CBM resources (local classification) on country level in bar chart representation. Extent = Europe. ***Notes:*** *Data availability is fragmented*
A0_EU_CoalBasins.mxd	Map on A0, portrait, showing the location of the coal basins that are spatially represented in the database, either as polygon or as point feature. Extent = Europe.
A0_EU_CoalClass.mxd	Map on A0, portrait, showing the coal basins differentiated by harmonized coal class (Brown Coal or Hard Coal). Extent = Europe.
A0_EuCoRes_DataStatus.mxd	Map on A0, portrait, showing the status of the data in the database per country, classified as 'no data', 'no known resources' or 'available data loaded'. Extent = Europe.
A3_BE_coalClass.mxd	Map on A3, landscape, showing the coal basin differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Belgium. ***Notes:*** *Spatial information for 1 out of 4 basins; Coal class information for 1 basin*
A3_BG_coalClass.mxd	Map on A3, landscape, showing the coal deposits differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Bulgaria. ***Notes:*** *No spatial information for basins; Spatial delineation for 6 deposits, point information for 13 deposits*
A3_CZ_HC_and_BC_reserves.mxd	Map on A3, landscape, showing the hard coal and brown coal reserves (local classification) on basin level in bar chart representation. Extent = Czech Republic. ***Notes:*** *Spatial information for 12 out of 13 basins (all polygons); Reserve information for 3 basins, based on deposit information; Reported resource class = 'JORC Reserves', 'Extractable Reserves', 'Reserves within mining limits'*
A3_CZ_CBM_resources.mxd	Map on A3, landscape, showing the potentially exploitable CBM resources (local classification) on basin level in bar chart representation. Extent = Czech Republic. ***Notes:*** *Spatial information for 12 out of 13 basins (all polygons); Resource information for 1 basin; Reported resource class = 'potentially exploitable resources'*
A3_CZ_coalClass.mxd	Map on A3, landscape, showing the coal deposits and one coal basin differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Czech Republic. ***Notes:*** *Spatial information for 12 out of 13 basins (all polygons); Spatial delineation for 19 deposits, point information for 1 deposit; Coal class information for 12 deposits and 1 basin*
A3_CZ_deposit_status.mxd	Map on A3, landscape, showing the status of activity in the coal deposits. Extent = Czech Republic. ***Notes:*** *Spatial information for 12 out of 13 basins (all polygons); Spatial delineation for 19 deposits, point information for 1 deposit*
A3_DE_BC_resources.mxd	Map on A3, portrait, showing the Geologische Vorräte (resources + reserves, local classification) on basin level in bar chart representation. Extent = Germany. ***Notes:*** *Spatial delineation for 6 basins, point information for 3 basins; Resource information for 8 basins; Reported resource class = 'Geologische Vorräte'*
A3_DE_CBM_resources.mxd	Map on A3, portrait, showing the total gas in place (local classification) on basin level in bar chart representation. Extent = Germany. ***Notes:*** *Spatial delineation for 6 basins, point information for 3 basins; Resource information for 2 basins; Reported resource class = 'total gas in place'*
A3_DE_coalClass.mxd	Map on A3, portrait, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Germany. ***Notes:*** *Spatial delineation for 6 basins, point information for 3 basins; Coal class information for 8 basins*
A3_DE_deposit_status.mxd	Map on A3, portrait, showing the status of activity in the coal deposits. Extent = Germany. ***Notes:*** *Spatial delineation for 6 basins, point information for 3 basins; Deposit status information for 12 deposits*

A3_ES_HC_and_BC_resources.mxd	Map on A3, landscape, showing the total recursos for hard coal and brown coal (local classification) on basin level in bar chart representation. Extent = Spain. ***Notes:*** *Spatial information for 10 out of 19 basins (all polygons); Resource information for all 19 basins; Reported resource class = 'Total recursos'*
A3_ES_CBM_resourses.mxd	Map on A3, landscape, showing the CBM resources (local classification) on basin and CBM accumulation level in bar chart representation. Extent = Spain. ***Notes:*** *Spatial information for 10 out of 19 basins (all polygons); Resource information for 1 basin (Asturias II) and 2 accumulations; Reported resource class = 'CBM resources' (basin) and 'Recursos de gas' (accumulations)*
A3_ES_coalClass.mxd	Map on A3, landscape, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Spain. ***Notes:*** *Spatial information for 10 out of 19 basins (all polygons)*
A3_FR_basins	Map on A3, portrait, showing the location of the coal basins. Extent = France. ***Notes:*** *Spatial information for 8 out of 24 basins*
A3_GR_BC_resources.mxd	Map on A3, portrait, showing the brown coal reserves (local classification) on deposit level in bar chart representation. Extent = Greece. ***Notes:*** *No spatial information for basins; Spatial information for 88 out of 91 deposits: 59 points and 29 polygons; Resource information for 8 deposits, of which 1 has no spatial information; Reported resource class = 'Measured geological reserves', 'Potential reserves'*
A3_GR_coalClass.mxd	Map on A3, portrait, showing the coal deposits differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Greece. ***Notes:*** *No spatial information for basins; Spatial information for 88 out of 91 deposits: 59 points and 29 polygons; Coal class information for 12 deposits, of which 3 have no spatial information*
A3_GR_deposit_status.mxd	Map on A3, portrait, showing the status of activity in the coal deposits. Extent = Greece. ***Notes:*** *No spatial information for basins; Spatial information for 88 out of 91 deposits: 59 points and 29 polygons; Deposit status information for 32 deposits*
A3_HU_HC_and_BC_resources.mxd	Map on A3, landscape, showing the total hard coal and total brown coal (resources + reserves, local classification) on basin level in bar chart representation. Extent = Hungary. ***Notes:*** *Resource information for 5 out of 6 basins; Reported resource class = 'resources', 'economically extractable reserves'*
A3_HU_CBM_resources.mxd	Map on A3, landscape, showing the CBM in place (local classification) on basin level in bar chart representation. Extent = Hungary. ***Notes:*** *Resource information for 1 basin; Reported resource class = 'CBM in place'*
A3_HU_coalClass.mxd	Map on A3, landscape, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Hungary. ***Notes:*** *Coal class information for 5 out of 6 basins*
A3_HU_deposit_status.mxd	Map on A3, landscape, showing the status of activity in the coal deposits. Extent = Hungary. ***Notes:*** *Deposit status information for 7 out of 8 deposits*
A3_IE_HC_resourses.mxd	Map on A3, portrait, showing the total hard coal (resources + reserves, local classification) on basin level in bar chart representation. Extent = Ireland. ***Notes:*** *Reported resource class = 'measured reserves', 'measured reserves + resources'*
A3_IE_coalClass.mxd	Map on A3, portrait, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Ireland.
A3_IT_HC_resourses.mxd	Map on A3, portrait, showing the hard coal resources (local classification) on basin level in bar chart representation. Extent = Italy. ***Notes:*** *Reported resource class = 'Resources'*
A3_IT_coalClass.mxd	Map on A3, portrait, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Italy.
A3_NL_HC_resourses.mxd	Map on A3, portrait, showing the hard coal resources (local classification) on basin level in bar chart representation. Extent = Netherlands. ***Notes:*** *Reported resource class = 'resources P50'*
A3_NL_CBM_resourses.mxd	Map on A3, portrait, showing the CBM resources (local classification) on basin level in bar chart representation. Extent = Netherlands. ***Notes:*** *Reported resource class = 'CBM resources P50'*

A3_NL_coalClass.mxd	Map on A3, portrait, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Netherlands.
A3_PL_HC_and_BC_resourses. mxd	Map on A3, portrait, showing the total hard coal and total brown coal (resources + reserves, local classification) on basin level in bar chart representation. Extent = Poland. ***Notes:*** *Spatial delineation for 3 basins, point information for 1 basin; Resource information for 4 basins, brown coal resources based on deposit information*
A3_PL_CBM_resourses.mxd	Map on A3, portrait, showing the CBM resources (local classification) on basin level in bar chart representation. Extent = Poland. ***Notes:*** *Spatial delineation for 3 basins, point information for 1 basin; Resource information for 3 basins; Reported resource class = 'resources'*
A3_PL_coalClass.mxd	Map on A3, portrait, showing the coal deposits differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Poland. ***Notes:*** *Spatial delineation for 3 basins, point information for 1 basin; Spatial delineation for 228 out of 236 deposits; Coal class information for all 236 deposits*
A3_PL_deposit_status.mxd	Map on A3, portrait, showing the status of activity in the coal deposits. Extent = Poland. ***Notes:*** *Spatial delineation for 3 basins, point information for 1 basin; Spatial delineation for 228 out of 236 deposits*
A3_PT_HC_and_BC_res.mxd	Map on A3, portrait, showing the hard coal and brown coal resources (local classification) on basin level in bar chart representation. Extent = Portugal. ***Notes:*** *Spatial information for 9 out of 13 basins (all points); Resource information for 5 basins; Reported resource class = 'resources'*
A3_PT_coalClass.mxd	Map on A3, portrait, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Portugal. ***Notes:*** *Spatial information for 9 out of 13 basins (all points); Coal class information for 9 basins, of which 1 has no spatial information*
A3_RO_HC_resourses.mxd	Map on A3, landscape, showing the hard coal resources (local classification) on basin level in bar chart representation. Extent = Romania. ***Notes:*** *Spatial information for 1 out of 6 basins; Resource information for 1 basin; Reported resource class = 'total geological resources'*
A3_RO_coalClass.mxd	Map on A3, landscape, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Romania. ***Notes:*** *Spatial information for 1 out of 6 basins; Coal class information for 1 basin*
A3_RS_HC_and_BC_resourses. mxd	Map on A3, portrait, showing the total hard coal and total brown coal (resources + reserves, local classification) on basin level in bar chart representation. Extent = Republic of Serbia. ***Notes:*** *Resource information for 29 out of 52 basins; Reported resource class = 'Indicated Resources', 'Inferred Resources', 'Measured Resources', 'Probable Reserves', 'Proved Reserves'*
A3_RS_coalClass.mxd	Map on A3, portrait, showing the coal basins differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Republic of Serbia.
A3_SI_BC_reserves.mxd	Map on A3, landscape, showing the brown coal reserves (local classification) on deposit level in bar chart representation. Extent = Slovenia. ***Notes:*** *No spatial information for basins; Spatial delineation for 1 deposit, point information for 49 points; Reserve information for 1 deposit; Reported resource class = 'reserves'*
A3_SI_coalClass.mxd	Map on A3, landscape, showing the coal deposits differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Slovenia. ***Notes:*** *No spatial information for basins; Spatial delineation for 1 deposit, point information for 49 points; Coal class information for 24 deposits*
A3_SK_BC_resources.mxd	Map on A3, landscape, showing the total geological resources (local classification) on deposit level in bar chart representation. Extent = Slovakia. ***Notes:*** *No spatial information for basins; Resource information available for 4 out of 18 deposits; Reported resource class = 'Geological Resources'*
A3_SK_coalClass.mxd	Map on A3, landscape, showing the coal deposits differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = Slovakia. ***Notes:*** *No spatial information for basins; Coal class information for 4 out of 18 deposits*

A3_UK_HC_resources.mxd	Map on A3, portrait, showing the resources in place (local classification) on deposit level in bar chart representation. Extent = United Kingdom. ***Notes:*** *Spatial information for 26 out of 39 deposits; Resource information for 28 deposits, of which 7 have no spatial delineation; Reported resource class = 'resource in place'*
A3_UK_CBM_resourses.mxd	Map on A3, portrait, showing the total CBM resources (resources + reserves, local classification) on CBM accumulation level in bar chart representation. Extent = United Kingdom. ***Notes:*** *Spatial information for 20 out of 27 CBM accumulations (all polygons); Resource information for all 27 CBM accumulations; Reported resource class = 'CBM resource' + 'CBM reserve'*
A3_UK_coalClass.mxd	Map on A3, portrait, showing the coal deposits differentiated by harmonised coal class (Brown coal or Hard Coal). Extent = United Kingdom. ***Notes:*** *Spatial information for 26 out of 39 deposits; Coal class information for 37 deposits, of which 24 have spatial information*
A3_UK_deposit_status.mxd	Map on A3, portrait, showing the status of activity in the coal deposits. Extent = United Kingdom. ***Notes:*** *Spatial information for 26 out of 39 deposits; Deposit station information for 38 deposits, of which 25 have spatial information*

Table 21 – Description of lyr-files

Name	Description
GISCO_CNTR_BN_01M_2010 .lyr	Layer built on feature class *GISCO_CNTR_BN_01M_2010*, to display the country boundaries. Differentiation between inland boundaries (grey: 115R-115G-115B) and coastal boundaries (blue: 126R-183G-224B).
GISCO_CNTR_RG_01M_2010 .lyr	Layer built on feature class *GISCO_CNTR_RG_01M_2010*, to display the country polygons in 10% grey.
GISCO_SUPP_GRAT_LI.lyr	Layer built on feature class *GISCO_SUPP_GRAT_LI*, to display the graticule of meridians and parallels in light blue (181R-207G-219B).
GISCO_STTL_PT_V3.lyr	Layer built on feature class *GISCO_STTL_PT_V3*, to display the major settlements (> 250000 inhabitants) with a 60% grey square marker symbol and city name as label.
EU – Coal Basin – polygon.lyr	Layer built on the feature class *CoalBasin – polygon feature* with a 60% grey representation of the coal basin polygons for the use on the A0 overview map of the coal basins in Europe: A0_EU_CoalBasins.mxd
EU – Coal Basin – point.lyr	Layer built on the feature class *CoalBasin – point feature* with a larkspur blue representation of the coal basin points for the use on the A0 overview map of the coal basins in Europe: A0_EU_CoalBasins.mxd
EU – DataStatus.lyr	Layer built on feature class *GISCO_CNTR_RG_01M_2010* joined to the *country* table to be able to symbolise the different countries with their status value: Available data loaded – tzavorite green; No data – mango; No known resources – 20% grey.
Coal Basin – gray line.lyr	Layer built on the feature class *CoalBasin – polygon* with a 40% grey outline representation of the coal basin polygons. Taken from Poland.
Coal Class – point.lyr	Layer built on the feature class *Coal Basin – point* joined with the *Coal Basin* and *Coal Class* table, to be able to symbolise the harmonized coal classes: hard coal – 80% grey; brown coal – burnt umber; not reported – 40% grey. Taken from Portugal.
Coal Class – polygon.lyr	Layer built on the feature class *Coal Deposit – polygon* joined with the *Coal Deposit* and *Coal Class* table to be able to symbolise the harmonized coal classes: hard coal – 80% grey; brown coal – burnt umber; not reported – 40% grey. Taken from Czech Republic.
Status – point.lyr	Layer built on the feature class *Coal Deposit – point* joined with the *Coal Deposit* table to be able to symbolise the status of activity: active – green (115R-178G-115B); planned exploitation – tzavorite green; exploration – mango; inactive – topaz sand; closure process – rose quartz; abandoned – medium coral light; not reported – 40% grey. Taken from Greece.
Status – polygon.lyr	Layer built on the feature class *Coal Deposit – polygon* joined with the *Coal Deposit* table to be able to symbolise the status of activity: active – green (115R-178G-115B); planned exploitation – tzavorite green; exploration – mango; inactive – topaz sand; closure process – rose quartz; abandoned – medium coral light; not reported – 40% grey. Taken from Poland.
CBM resource – polygon.lyr	Layer built on the feature class *Coal Basin – polygon* joined to the *Coal Basin*, *CBM* and *CBM resources class* tables, with a blue (40R-146G-199B) bar chart representation of the CBM resources on a 40% grey background. Taken from Poland.
CBM resource – point.lyr	Layer built on the feature class *CBM Accumulation – point* joined to the *CBM Accumulation*, *CBM* and *CBM resources class* table, with a blue (40R-146G-199B) bar chart representation of the CBM resources. Taken from United Kingdom.
HC resource – polygon.lyr	Layer built on the feature class *Coal Basin - polygon* joined to the *Coal Basin*, *Coal Class* and *Coal Resource Class* tables, with an 80% grey bar chart representation of the hard coal resources on a 40% grey background. Taken from Poland.
HC resource – point.lyr	Layer built on the feature class *Coal Basin - point* joined to the *Coal Basin*, *Coal Class* and *Coal Resource Class* tables, with an 80% grey bar chart representation of the hard coal resources. Taken from Portugal.
BC resource – polygon.lyr	Layer built on the feature class *Coal Basin – polygon* joined to the *Coal Basin*, *Class* and *Coal Resource Class* tables, with a burnt umber bar chart representation of the brown coal resources on a 40% grey background. Taken from Poland.
BC resource – point.lyr	Layer built on the feature class *Coal Basin – point* joined to the *Coal Basin*, *Class* and *Coal Resource Class* tables, with a burnt umber bar chart representation of the brown coal resources. Taken from Poland.

4 Conclusions

The overall objective of this project was the creation of a digital "harmonised" geographical database containing comparable information on locations and estimations of the EU's potential resources of coal (brown coal and hard coal) as well as coalbed methane (CBM) based on a common classification and terminology for coal typology and for CBM reservoirs.

In this ambitious project three major challenges were faced. The first challenge was to find a way to harmonise the coal/CBM resource information from various sources, each of them reporting according to a specific classification system, by formulating a common classification and terminology for coal typology and CBM. The second major challenge was the development of a common data model for Coal and CBM data. And the last challenge was the collection of relevant data to fill the harmonised database schema.

The final formulation of the common classification and terminology for coal typology and CBM was based on:

1. an extensive literature study of the existing systems;
2. the by that time available realistic data;
3. feedback from coal experts from different member states.

The lack of examples from the field during the formulation of the common classification and terminology can be seen as a weak point but here was opted to use a common denominator of the most important coal classification systems in use, in order to minimise the transformation effort. For the classification of coal resources and reserves it was decided in favour of a widely used classification like UNFC rather than reinventing the wheel.

During the development of the common data model (the second major challenge) in order to improve "interoperability" attention was being paid to the following conditions:

1. a wide variety and complexity of coal and CBM information needs to be compiled and harmonised to the interoperable model without too much effort i.e. to avoid difficult transformations leading to excessive costs;
2. the data model must show some degree of conceptual simplicity finding the common denominator across all stakeholders and without compromising the overall scope and minimum degree of detail necessary to report on Coal and CBM resources;

The common classification and terminology was incorporated in the data model which is inspired by the draft INSPIRE data specifications for Mineral Resources and Energy Resources and also by expert knowledge and literature. The INSPIRE Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), requires that existing datasets falling in scope of one/more of the 34 spatial data themes (coal and CBM data can be classified into Mineral Resources and Energy

Resources) should be exchanged following the Implementing Rules drafted from the data specifications. Therefor was chosen not to deviate too much from these specifications, it means that data shared through INSPIRE should be easy to transform in the EuCoRes model.

A remark that can be made concerning the maintenance process of a centrally stored database depending on input from data providers, like the EuCoRes database, is that this requires an extra effort of the providers to deliver their data in parallel with the obligations from INSPIRE to exchange similar data.

There the knowledge of the existing data sources was limited at the development stage of the model; it was decided to build in some flexibility to deal with a variety of input data:

- a distinction is made between Core (essential) and Extension (additional) information to accommodate to the various levels of detail of source data;
- reporting of coal or CBM resources is possible at different levels depending on the availability (*e.g.* coal resources can be reported on basin level if deposit level information is lacking);
- geometric information (location) can be provided as polygons or if this is not available as point information (*e.g.* it can happen that deposits are only referenced by points instead of by polygons in the source data);
- the possibility exists for storing coal typology and resource information in the original (local) typology and classification together with their equivalents in the harmonised topology and classification. This allows loading data for which (at this stage) harmonisation is not feasible.

This flexibility makes it possible to load various kinds of data (impossible to harmonise without an unrealistic cost) but the disadvantage is that the database content is not really comparable between different sources. The philosophy behind is, that when better harmonised data becomes available the database can be updated with it.

It was clear from the beginning the data collection would be challenge. This can be explained by following possible reasons:

- this kind of data is simply not available since coal is out of the picture for some member states, they do not have an active/significant coal producing industry;
- data is only available in archives (no recent estimations) and/or in analogue format and it requires a large effort to digitise it and in many cases an expert interpretation is needed;
- the high working cost and the limited time to collect and to process data to a useful format are not justifiable for the providers in these times of a general European crisis;
- in many cases information on CBM does not exist because it is a rather new domain in energy resources.

Despite these difficulties the EuCoRes database was filled with information for the most important coal producing countries in Europe. The data sources varied from public reports, literature, analogue maps, data provided by member states, data published on internet,... Thanks to the build in flexibility of the data model these data could be entered in the database. The actual content of the database is illustrated with a set of maps.

The final conclusion that can be drawn is that this database will not be definite, but its status can be updated as future changes can have a profound influence. Examples of such changes are an increasing knowledge of existing basins/deposits, higher availability of data with higher quality and higher degree of harmonisation (*e.g.* under influence from INSPIRE directive), improved exploitation feasibility due to technological progress or due to change of economic conditions, extensions of the model for different energy sources *e.g.* shale gas.

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